Mardie Project: Introduced Marine Pest Risk Assessment

Mardie Minerals Pty Ltd

CLIENT: Mardie Minerals Pty Ltd

STATUS: Rev 1 **REPORT No.:** R190001

ISSUE DATE: 27/02/2020

O2 MARINE

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Version Register

Version	Status	Author	Reviewer	Change from Previous Version	Authorised for Release (signed and dated)	
Rev A	Draft	M.Wellington	K. Neil		C Lane (On file)	28/02/2019
Rev B	Draft	M.Wellington	R. Stevens Neil.Dixon	Inserted client supplied Introduction Updated Figures Corrected comments from client	C Lane (On file)	14/05/2019
Rev 0	Final	M.Wellington	R. Stevens		C Lane (On file)	13/06/2019
Rev 1	Final	M.Wellington	R. Stevens	Update with updated Project description and maps	C Lane	27/02/2020

Transmission Register

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Acronyms and Abbreviations

Acronyms/Abbreviation	Description
AFC	Anti-Foulant Coating
ALARP	As Low As Reasonably Practical
ANZECC	Australia and New Zealand Environment and Conservation Council
AS/NZ ISO	Australia/New Zealand International Standards Organisation
BCI	BCI Minerals Ltd
BHD	Back-Hoe Dredge
CCIMPE	Consultative Committee on Introduced Marine Pest Emergencies
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	Department of Agriculture and Water Resources
DPIRD	Department of Primary Industries and Regional Development
EPA	Environmental Protection Authority
IMO	International Maritime Organisation
IMP	Introduced Marine Pests
IMS	Introduced marine species
LAT	Lowest Astronomical Tide
LEP	Level of Environmental Protection
LPoC	Last Port of Call
MARS	Maritime Arrivals Reporting System
MDET	Monitoring Design Excel Template
NIMPCG	National Introduced Marine Pest Coordination Group
PAR	Pre-Arrival Report
SOP	Sulfate of Potash
WA	Western Australia

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2 Introduction

2.1 Project Description

2.1.1 Proposal Summary

Table 1 Proposal Summary

Proposal Title	Mardie Project
Proponent Name	Mardie Minerals Pty Ltd
Short Description	Mardie Minerals Pty Ltd is seeking to develop a greenfields high quality salt and sulphate of potash (SOP) project and associated export facility at Mardie, approximately 80 km south west of Karratha, in the Pilbara region of WA. The Proposal will utilise seawater to produce a high purity salt product, SOP and other products derived from sea water. The Proposal includes the development of a seawater intake, concentrator and crystalliser ponds, processing facilities and stockpile areas, bitterns disposal pipeline and diffuser, trestle jetty export facility, transhipment channel, drainage channels, access / haul roads, causeway, desalination (reverse osmosis) plant, borrow pits, pipelines, and associated infrastructure (power supply, communications equipment, offices, workshops, accommodation village, laydown areas, sewage treatment plant, landfill facility, etc.).

2.1.2 Proposal Description

Mardie Minerals Pty Ltd (Mardie Minerals) seeks to develop the Mardie Project (the Proposal), a greenfields high-quality salt project in the Pilbara region of Western Australia (Figure 1) Mardie Minerals is a wholly-owned subsidiary of BCI Minerals Limited.

The Proposal is a solar salt project that utilises seawater and evaporation to produce raw salts as a feedstock for dedicated processing facilities that will produce a high purity salt, industrial grade fertiliser products, and other commercial by-products. Production rates of 4.0 Million tonnes per annum (Mtpa) of salt (NaCl), 100 kilotonnes per annum (ktpa) of Sulphate of Potash (SoP), and up to 300 ktpa of other salt products are being targeted, sourced from a 150 Gigalitre per annum (GLpa) seawater intake. To meet this production, the following infrastructure will be developed:

- Primary seawater intake pump station;
- Concentrator ponds;
- Crystalliser ponds;
- Processing facilities and stockpiles;
- Causeway, trestle jetty and transhipment berth/channel;
- Bitterns disposal pipeline, seawater intake (for dilution) and diffuser;
- Drainage channels and flood protection levees;
- Administration buildings;
- Accommodation village;

- Access / haul roads;
- Desalination plant for freshwater production;
- Boat launching facility and port stockyard; and
- Associated infrastructure including power supply, communications, workshop, laydown, landfill facility, sewage treatment plant.

Seawater for the process will be pumped from a large tidal creek into the concentrator ponds. All pumps will be screened and operated accordingly to minimise entrapment of marine fauna and any reductions in water levels in the tidal creek.

Concentrator and crystalliser ponds will be developed behind low permeability walls engineered from local clays and soils and rock armoured to protect against erosion. The height of the walls varies across the project and is matched to the storm risk for the area.

Potable water will be required for the production plants and the village. The water supply will be sourced from desalination plants across the Proposal. The high salinity brine output from the plants will be directed to concentrator ponds or a lined process pond.

A trestle jetty will be constructed to convey salt (NaCl) from the salt production stockpile to the transhipment berth pocket, approximately 2.2 km offshore. The jetty will not impede coastal water or sediment movement, thus ensuring coastal processes are maintained.

Dredging of up to 800,000 m^3 will be required to ensure sufficient depth for the transhipper berth pocket at the end of the trestle jetty, as well as along a 4.5 km long channel out to deeper water. The average depth of dredging is approximately 1 m below the current sea floor. The dredge spoil is inert and will be transported to shore for use within the development.

The production process will produce a high-salinity bittern that, prior to its discharge through a diffuser at the far end of the trestle jetty, will be diluted with seawater to bring its salinity closer to that of the receiving environment.

Access to the project from North West Coastal Highway will be based on an existing public road alignment that services the Mardie Station homestead and will require upgrading..

The majority of the power required for the project (i.e. approximately 95%) is provided by the sun and the wind, which drives the evaporation and crystallisation processes. In addition, the Proposal will require diesel and gas to provide additional energy for infrastructure, support services and processing plant requirements.

The Proposal will be developed within three development envelopes. The boundaries of these development envelopes are shown in Figure 1 & Figure 2 and described in Table 2.

Table 2 Location and proposed extent of physical and operational elements

Element	Ref.	Proposed Extent
Physical Elements		
1. Ponds & Terrestrial Infrastructure Development Envelope – concentrator and crystalliser ponds, processing plant, access / haul road, desalination plant, causeway, administration, accommodation village, laydown, other infrastructure.	Fig. 2	Disturbance of no more than 11,142 ha within the 15,667 ha Ponds & Terrestrial Infrastructure Development Envelope.
2. Marine Development Envelope – trestle jetty, seawater intake and pipelines.	Fig. 2	Disturbance of no more than 7 ha within the 53 ha Marine Development Envelope.
3. Dredge Channel Development Envelope – berth pocket, channel to allow access for transhipment vessels, bitterns outfall diffuser.	Fig. 2	Disturbance of no more than 555 ha within the 304 ha Dredge Channel Development Envelope.
4. Mangrove Disturbance	Fig. 2	Disturbance of mangrove communities limited to 17 ha of Scattered Canopy mangroves and 0 ha of Closed Canopy mangroves
Operational Elements		
Desalination Plant discharge	Fig. 2	Discharge to ponds or bitterns stream
Dredge volume	Fig. 2	Dredging is only to occur within the Dredge Channel Development Envelope. Dredging of no more than 800,000 m3 of material from the berth pocket and high points within the dredge channel, with the material to be deposited within the Ponds & Terrestrial Infrastructure Development Envelope.
Bitterns discharge	Fig. 2	Discharge of up to 3.6 gigalitres per annum (GLpa) of bitterns with a specific gravity of no more than 1.25 via a diffuser within a Low Ecological Protection Area. Bitterns will be diluted prior to discharge.
Pond seawater intake		Up to 150 GL per annum, from a screened intake with a maximum average intake flow rate at the screen of less than 0.15 m/s. Seawater abstraction will only occur when water levels are at mean sea level or higher.

Figure 1 Mardie Project Regional Location

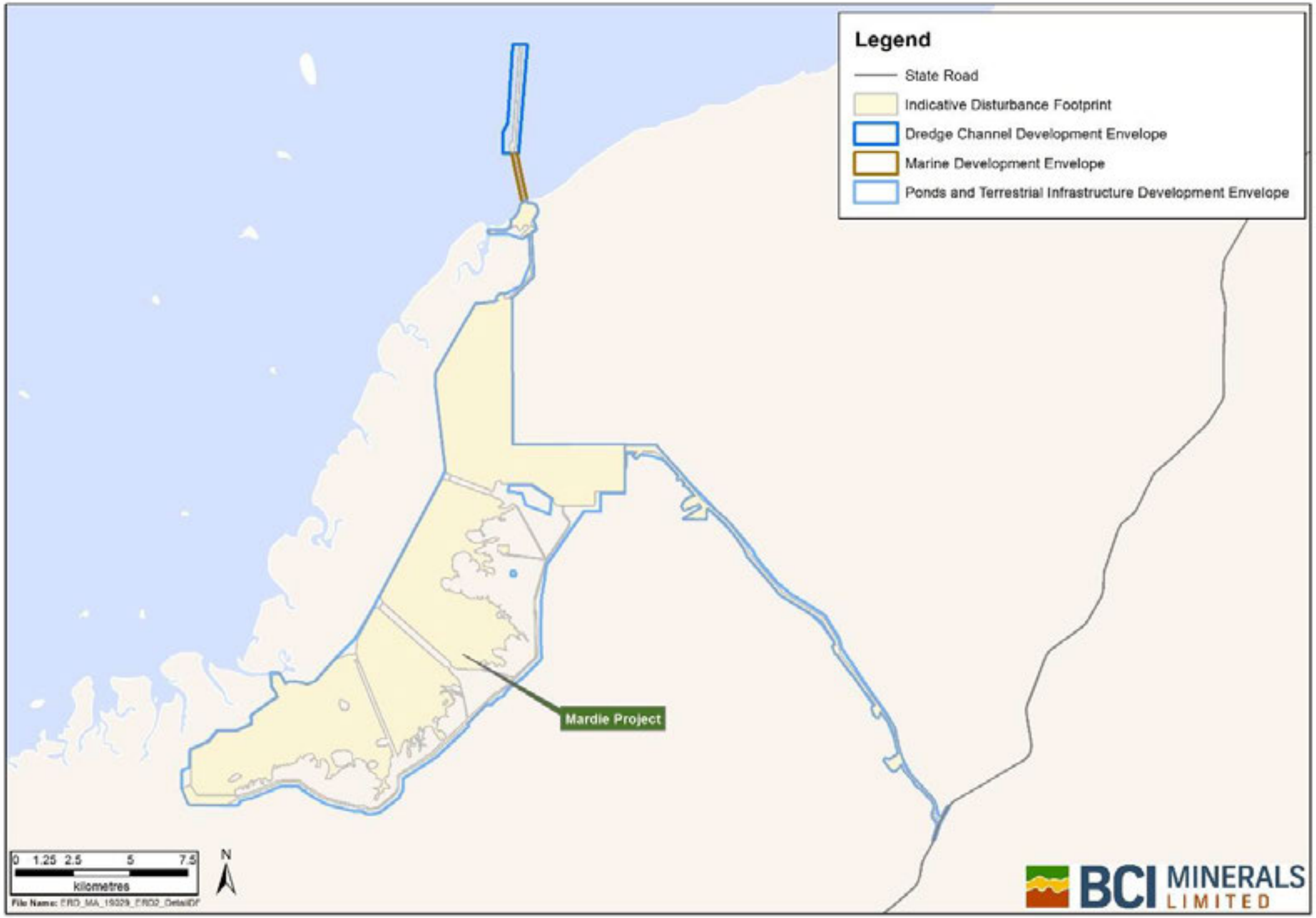

Figure 2 **Mardie Project Development Envelopes**

2.2 Scope and Objectives

The scope of this report is to undertake a desktop Introduced Marine Pests (IMPs) investigation and risk assessment that is aligned with the National System for the Prevention and Management of Introduced Marine Pest Incursions (the National System). Specifically, the document includes the following key elements:

> Review of the history and current status of IMPs in the Mardie region and on the Pilbara coast;
> Analysis of risk and likelihood of introduction of IMPs during the construction phase and operational life of the project through dredge vessels, construction plant and other vessels;
> Analysis of potential impacts to the project and the wider marine environment of a potential marine pest introduction;
> Assessment of possibility of IMP transfer using the National System Monitoring Design Excel Template (MDET);
> Risk assessment of IMP translocation due to the proposed development; identification of relevant management controls to reduce risk.

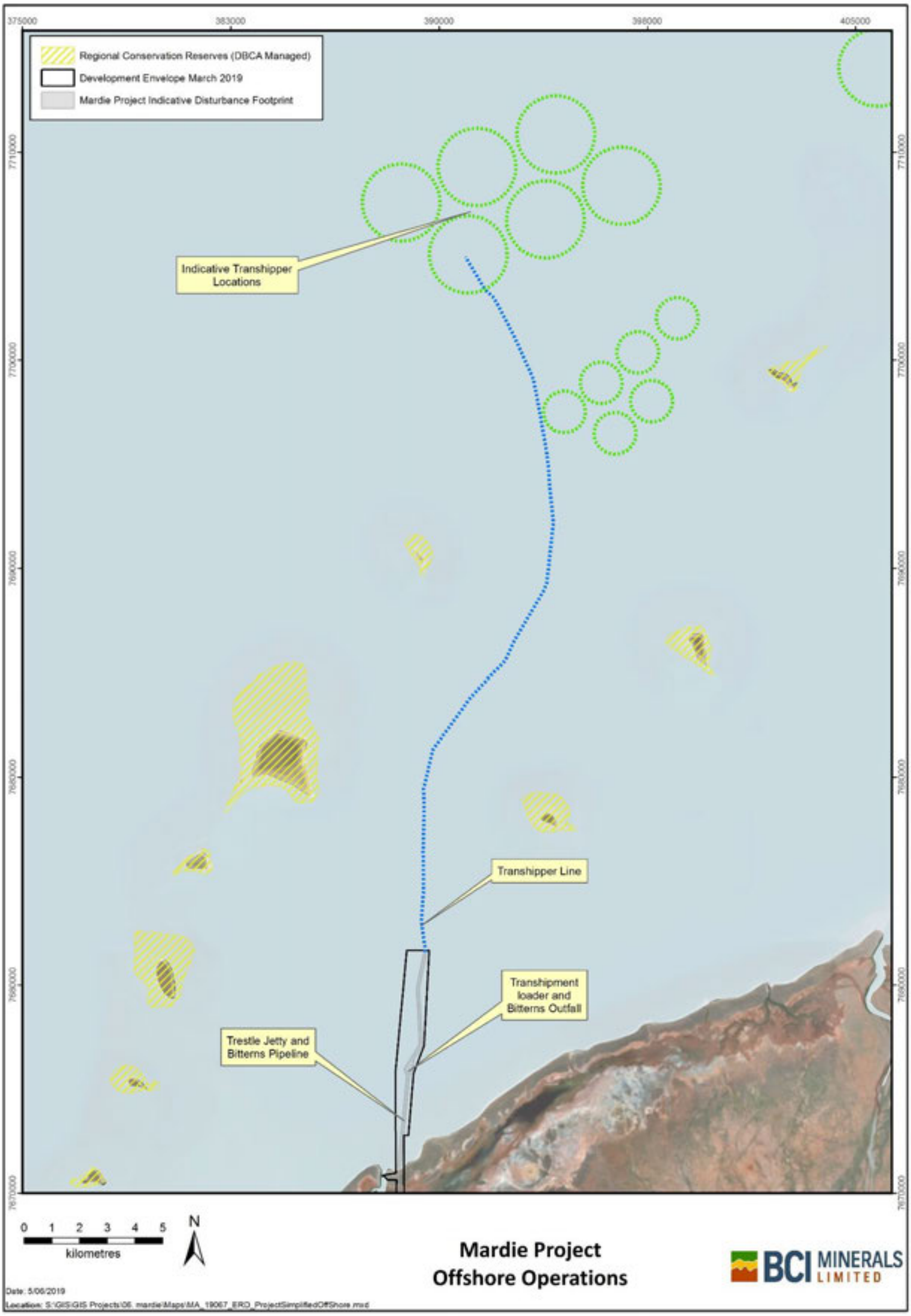

Figure 3 Proposed Mardie Project site indicating location of major marine and terrestrial facilities.

3 Regulations and Guidelines for Introduced Marine Species

3.1 Defining Introduced Marine Pests

Introduced Marine Species (IMS) are animals, plants, algae and other biota existing in a region beyond their natural geographical range, to which they have generally been translocated by human activity. Australia currently has over 250 known IMS but only a small proportion have become IMPs. IMPs are IMS that harm the marine environment, social amenity or industries that use the marine environment, or have the potential to do so if they were to be introduced, established, or spread in Australia's marine environment (DAWR 2018). Some examples of the impacts of IMPs include:

- Competition with native species for resources;
- Predation on native species;
- Alteration of trophic interactions and food-webs;
- Loss of commercial and recreational fisheries harvest;
- Human illness;
- Reduced coastal aesthetics;
- Damage to marine and industrial infrastructure; and
- Reduced aquaculture productivity.

The National Introduced Marine Pests Coordination Group (NIMPCG) developed the national system for the management of marine pests in Australia which has been agreed to by all federal and state governments. Part of this strategy involved developing a database of introduced marine species worldwide, which identified 55 species considered to present the greatest threat to the Australian marine environment (NIMPCG 2009a, 2009b).

3.2 Laws, Guidelines and Policies

A number of International, Federal and State Regulations and Guidelines can be used within federal and state waters to enforce biosecurity. These include the following:

3.2.1 International

- International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 (the Ballast Water Management Convention); and
- International Convention on the Control of Harmful Antifouling Systems on Ships (IMO 2001).

3.2.2 Federal

- Biosecurity Act (2015) and Biosecurity Regulations (2016);
- Biosecurity Amendment (Ballast Water and Other Measures) Act 2017 (Amendment Act);
- Biosecurity (Ballast Water and Sediments) Determination 2017;
- Biodiversity Conservation Act 2016;

- Australian Ballast Water Management Requirements 2017;
- National Biofouling Management Guidelines (Commonwealth of Australia 2009) (Voluntary Guidelines); and
- MarinePestPlan 2018-2023 (DAWR, 2018) has been released recently and the National System is currently in the review and update process.

3.2.3 State

Within Western Australia, the Department of Primary Industries and Regional Development (DPIRD) is the lead agency responsible for developing and implementing the necessary management arrangements and biosecurity control activities to restrict the introduction and translocation of IMP species in the aquatic environment. Several Acts and Regulations can be used within WA state waters (within three nautical miles) to enforce biosecurity. These include the following:

- *Aquaculture Resources Management Act (2016) Part 6;*
- *Fish Resources Management Act (1994) and Regulations (1995);*
- *Pearling Act (1990);*
- *Ports Authority Act (1999) and Regulations (2001);*
- *Biosecurity and Agricultural Management Act (2007);*
- *Biodiversity Conservation Act (2016);*
- *Environmental Protection Act (1986);*
- Pilbara Coastal Water Quality Consultation Outcomes (Department of Environment 2006);
- Pilbara Inshore Islands Management Plan (in draft); and
- Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves.

4 Existing Environment

4.1 Description of Environment

Identifying the environmental conditions and habitat type at the proposed project area (Mardie) provides valuable information on the suitability of the conditions for potential IMP introduction, survival, translocation and reproduction. These environmental factors will be utilised in **Section 4** to determine which IMP trigger list species are compatible to the Mardie region as a suitable receiving environment and the level of associated risk.

4.1.1 Climatology

The southern Pilbara region has a tropical monsoon climate with distinct wet and dry seasons. The dry season extends from May to October, and is characterised by warm to hot temperatures, easterly to southeasterly winds from the continental landmass, clear and stable conditions as the subtropical high-pressure ridge migrates over this area. In the afternoon, the wind direction shifts to north-westerly, particularly later in the dry season, associated with the onset of the land sea breeze as the temperature difference between the continent and the ocean increases throughout the day. In the wet season the wind climate is dominated by westerly and north-westerly winds. Wind rose plots for the Dry Season months (May to October) and Wet Season months (November to April) are presented in **Figure 4** based on analysis of the measured wind records from Mardie Airport over the period 2011 - 2018.

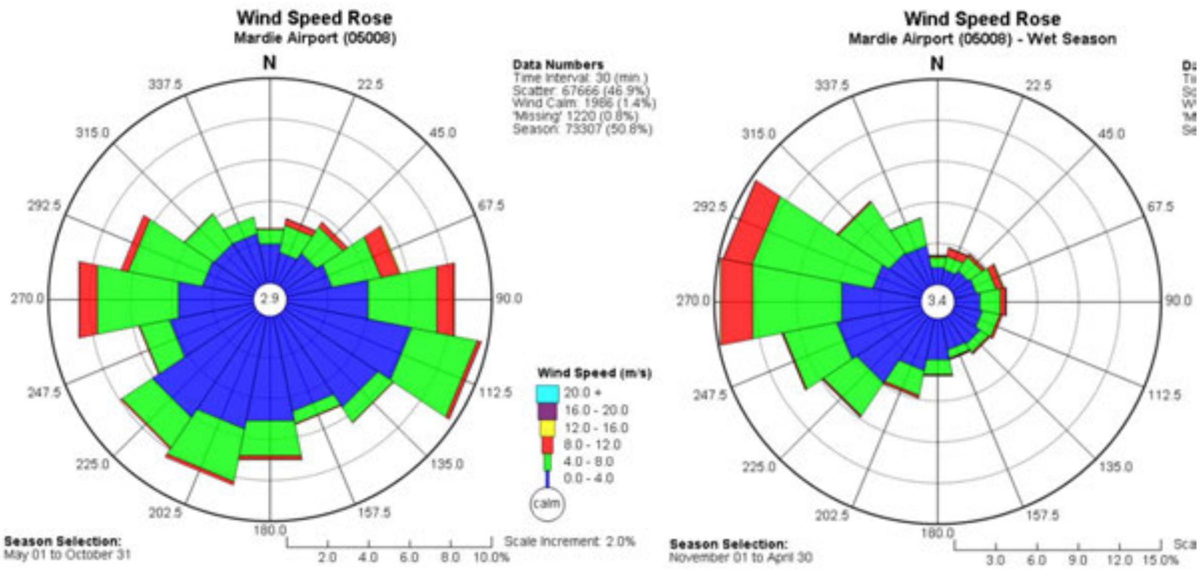

Figure 4 **Wind Rose plots for Dry Season (left) and Wet Season Months (right) based on analysis of the measured data from Mardie airport**

Climate statistics for the town of Mardie are presented in **Figure 5** from the BoM site which is approximately 16km inland. Maximum daily temperatures at Mardie average 33.9 °C throughout the year, peaking at 38.0 °C in January and falling to 27.7 °C in July. The Pilbara is influenced by northern rainfall systems of tropical origin. These systems are responsible for heavy falls during the summer months, while the southern low-pressure systems sometimes bring limited winter rains. The annual average rainfall is only 128 mm, and the mean monthly rainfall has a bimodal distribution, peaking in January to March and also May to June, with very little rainfall from July to December (**Figure 5**). Daily rainfall can reach over 300 mm during extreme events that may occur one to two times per decade. Evaporation rates in the region are high, estimated to exceed by ten times the annual rainfall.

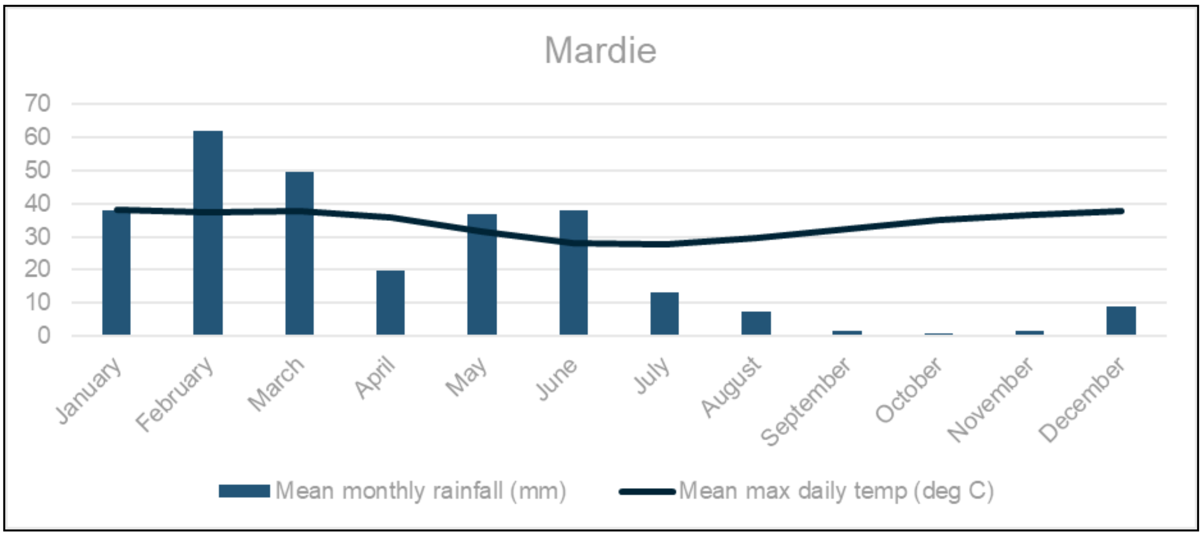

Figure 5 **Climate Statistics for Mardie (BOM).**

The Australian cyclone season extends from November through to April with an average of 10 cyclones per year, although not all make landfall. Tropical cyclone winds can generate extreme coastal water levels through storm surge and these systems are frequently associated with heavy rainfall that can cause significant flooding. The Pilbara region of Western Australia has a high exposure to tropical cyclone events, with a typical cyclone track recurving and making landfall on the coastline between Broome and Exmouth. The season typically runs from mid-December to April, peaking in February and March. The Karratha to Onslow coastline is the most-cyclone prone section of the Australian coast, typically experiencing one landfalling event every two years. The northwestern coastline of Western Australia is highly vulnerable to the occurrence of storm surge. This is due to the frequency of tropical cyclones, the wide continental shelf and relatively shallow ocean floor over the North West Shelf, as well as the low-lying nature of much of the coastline. In addition, tropical cyclone events are strongly associated with flooding due to widespread heavy rainfall.

Historical events of significance impacting between Karratha and Onslow include: Trixie 1975, Chloe 1984, Orson 1989, Olivia 1996, John 1999, Monty 2004, Clare 2006 and Glenda 2006 (**Figure 6**). In late March 2019 the passage of TC Veronica tracked west over the region from offshore of Karratha losing intensity as it continued west offshore of Mardie as a tropical low system.

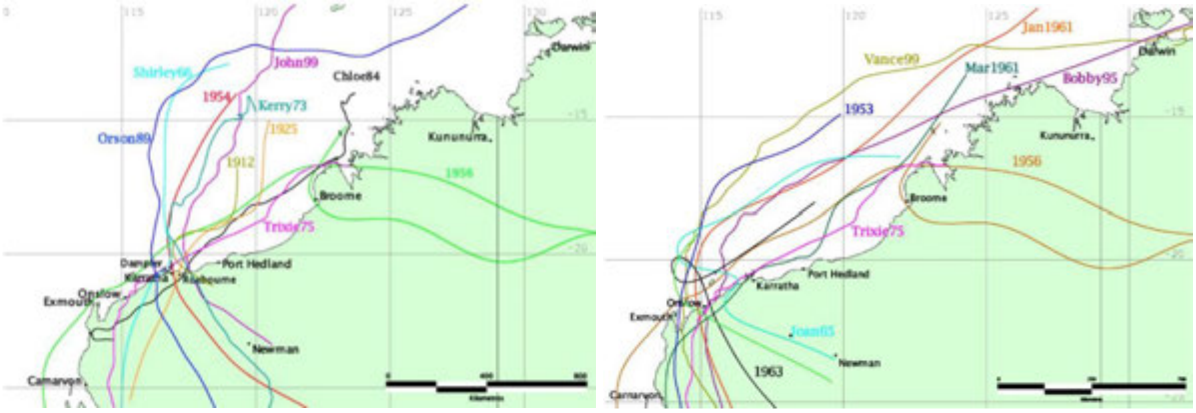

Figure 6 **Tracks of notable cyclones impacting Karratha (left) and Onslow (right)**

4.1.2 Oceanography

The astronomical tide is the periodic rise and fall of the sea surface caused by the combination of the gravitational force exerted by the moon and the Sun upon the Earth and the centrifugal force due to rotations of the Earth and moon, and the Earth and the Sun around their common centre of gravity. Tides are subject to spatial variability due to hydrodynamic, hydrographic and topographic influences. At the study area, the tides are characterised by amplification of tidal range due to the shallow bathymetry over the North West Shelf and complex hydrographic and topographic features. The tide levels recently analysed from data near the project site indicates that the mean spring tide range exceeds 3.5 m and the maximum tide range is ≈ 5.1 m.

The northwest shelf of Western Australia experiences waves generated from three primary sources: Indian Ocean swell, locally generated wind-waves and tropical cyclone waves. Along the shoreline the ambient (non-cyclonic) wave climate is generally mild. In dry season months low amplitude swell originating in the Indian Ocean propagates to the site and occurs in conjunction with locally generated sea waves of short period (<5s). In the wet season the wave climate is locally generated sea waves from the southwest. In general, the significant wave height is dominated by locally generated sea conditions within the range of 0.5m to 1m at short wave periods (Tp< 5 s). Measured data from an ADCP instrument deployed approximately 15km offshore for the project has been analysed to characterise the wave conditions in the wet and dry seasons as shown in **Figure 7**.

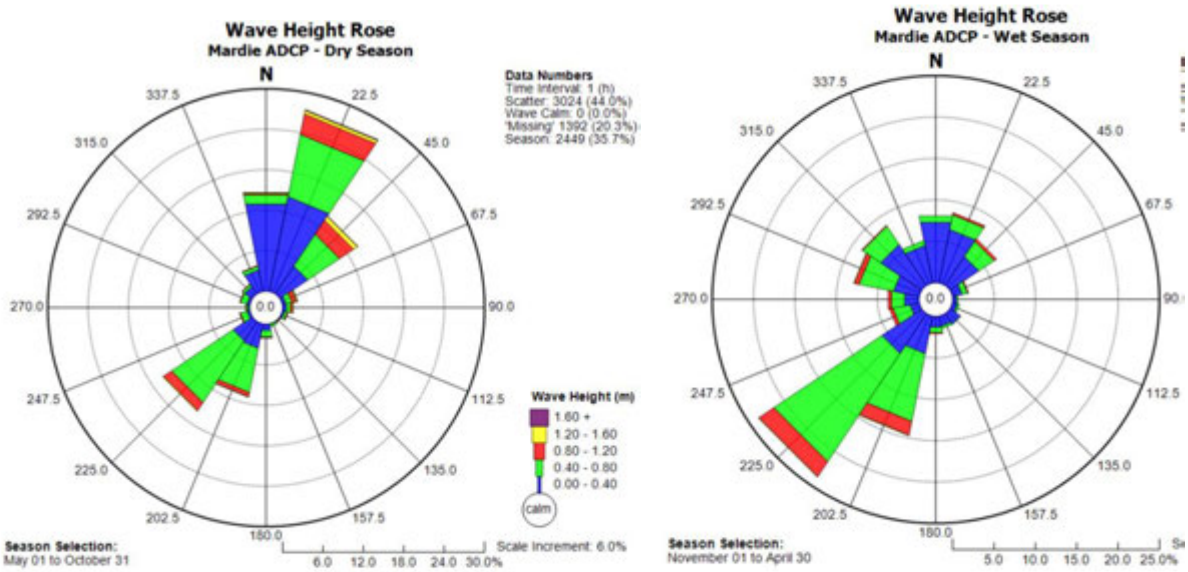

Figure 7 **Wave conditions offshore of the Mardie project location for Dry Season months (left) and Wet Season Months (right) based on measured data April 2018 – January 2019.**

Whilst the non-cyclonic ambient wave conditions are generally mild, in contrast the strong winds in a tropical cyclone can generate extreme wave conditions. It is noted that the offshore island features would provide some natural protection from extreme wave conditions depending on the direction of propagation. Extreme cyclonic waves contribute to the total water level through wave run-up which is the maximum vertical extent of wave uprush on a beach and is comprised of both wave set-up and swash. The impact of cyclonic waves on the study site is dependent on the prevailing water level conditions and direction of cyclone approach. If coincident with a spring tide and storm surge, waves could propagate beyond the typical position of the beach and induce erosion of the shoreline as well as sediment transport.

4.1.3 Water Characteristics

A risk assessment of IMP species can be informed by identifying the physical water characteristics at the project area. Water quality (including salinity, temperature and turbidity) of the receiving environment has a notable influence on the survivorship of marine species, including IMPs. If the range of tolerance to each of the water quality factors are known for each potential IMP, the likelihood of survival at the project site can be calculated.

Salinity

Variable salinity is common in nearshore waters of the west Pilbara (Pearce et al. 2003). During the summer monsoonal season, salinity may be impacted by freshwater flows from nearby Fortescue River, Robe River and local watercourses (**Figure 8**). O2 Marine (2019b) identified high nearshore salinities within the study area, ranging between 34-46 ppt over an annual period, with an annual median of 39.3 ppt. Freshwater flow from nearby watercourses during the summer monsoon season or large tropical lows have the potential to reduce nearshore salinity. However, rapid mixing with offshore marine waters is likely to occur due to the strong mixing processes in the area. The proposed bitterns outfall has been projected to discharge up to 3.6GL per annum in a dedicated offshore mixing zone.

Temperature

Studies in the area have demonstrated higher temperatures in inshore waters than offshore during summer, while the inverse is correct during winter (Pearce et al. 2003). O2 Marine (2019b) identified a temperature range between 18-33 °C at the study area, whilst nearby water quality studies (i.e. Cape Preston) have identified temperatures that range between 18 °C in winter to 31.5°C in the summer (CALM 2005). With a wide temperature range, some IMP species may be unable to survive or reproduce successfully.

Turbidity

Nearshore waters are often more turbid than deeper offshore waters at Mardie due to a variety of factors. Turbidity also varies temporally and at smaller localised scales. Tide is particularly influential on turbidity, which is naturally higher during spring than neap tides, due to increased current velocities (Jones et al. 2015). Large inshore areas of shallow, flat bathymetry are affected by wind driven waves and currents which easily resuspend fine sediments in the area. In addition, blooms of the cyanobacteria *Trichodesmium spp* occur commonly in the area which increases the turbidity of surface waters (Maunsell 2006; RPS 2008).

Turbidity data collected by O2 Marine (2019b) identified high levels (i.e. Mean 15.2 NTU) in the inshore areas surrounding the proposed Mardie Port, with much lower turbidity levels (i.e. Mean 2.2 NTU) observed further offshore surrounding the Passage Islands.

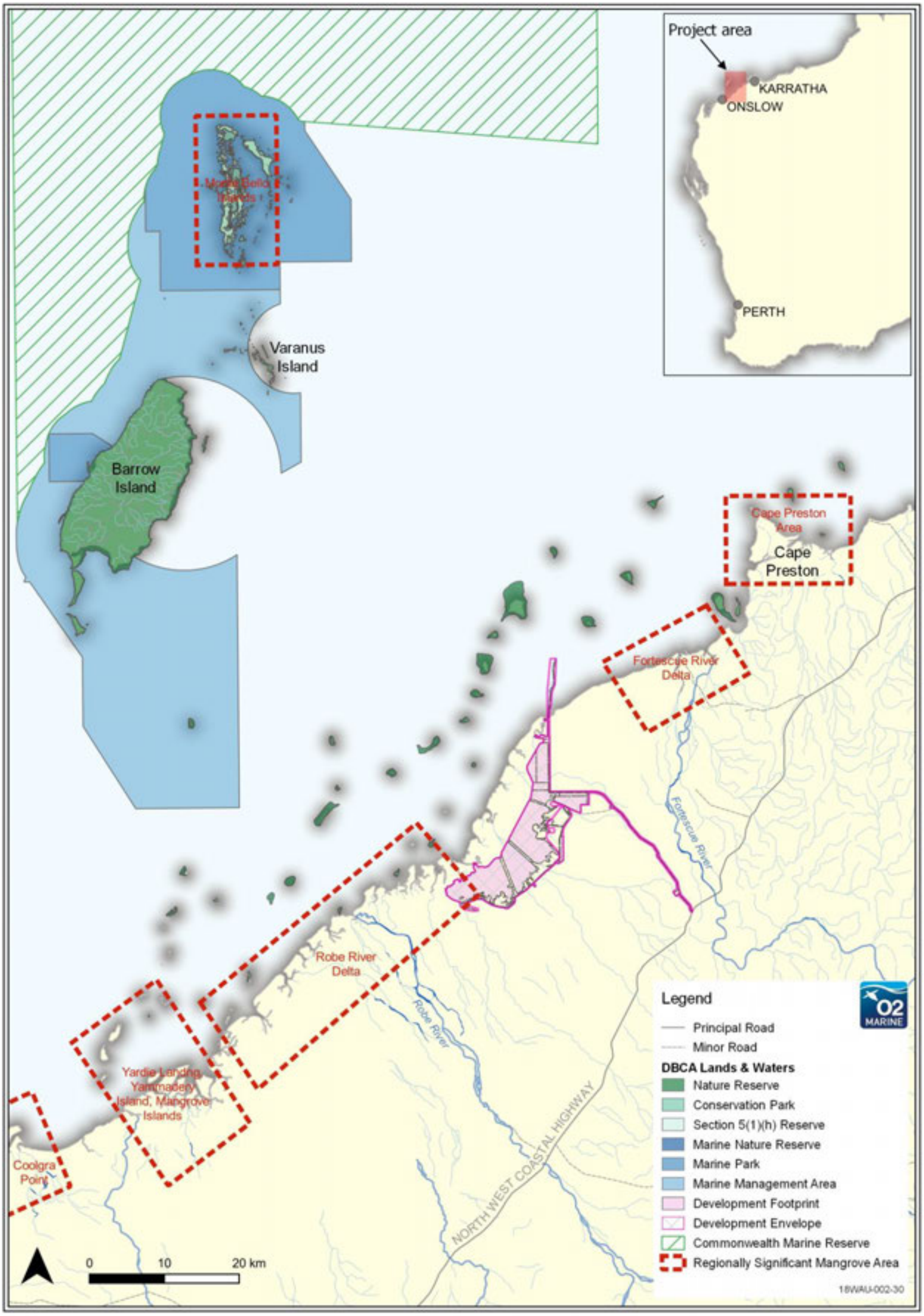

Figure 8 Regional map indicating project footprint and proximity to reserves and areas of interest.

4.2 Description of Benthic Communities and Habitats

As part of project assessments, O2 Marine (2019c, d) undertook subtidal and intertidal benthic communities and habitat investigations which identified the following key classes occurring within the wider project area:

- Mangroves;
- Samphire/Samphire Mudlfats;
- Foreshore Mudflats/Tidal Creeks
- Rocky and Sandy shorelines;
- Bare Sand;
- Filter Feeder/Macroalgae/Seagrass; and
- Coral/Macroalgae.

Surveys conducted by O2 Marine (2019c, 2019d) of the proposed development site have demonstrated the major subtidal habitat types to mainly consist of fine sands and silt that are largely devoid of biotic cover aside from occasional macroalgae, coral, filter feeder, seagrass and crab burrows (bioturbation). Shallow areas just below the intertidal zone had a slightly higher cover of macroalgae and some loose rocky rubble substrate and limestone pavement was also recorded. Some localised patches of soft and hard corals have also been found with a mixture of macroalgae, sponge and hydroid communities.

Construction of the project will alter the habitat available for marine pest settlement. Dredging of up to 500,000 m^3 for the transhipping channel will remove existing soft substrate and create deeper areas of new soft substrate, creating a potential niche environment that was not previously available. These disturbed areas have potential to be colonised by opportunistic marine pests. In addition, trestle jetty pylons and outfall/intake pipelines will create new areas of hard substrate that were not previously available to sessile/sedentary marine species.

4.3 Introduced Marine Species and Pests in Western Australia

In 2008, Huisman et al. reported on 102 marine and estuarine species that were known to be introduced and established in Western Australia at the time. Sixty species were considered to have been introduced by anthropogenic activity. Three of these species introduced to Western Australia were listed on the Australian National IMS list (NIMPCG (2009a, 2009b): the dinoflagellate *Alexandrium minutum*, the bivalve *Musculista senhousia* and the polychaete *Sabella spallanzanii* (Wells, 2018).

Six marine pest alerts for WA were current at the time of this report, including observations of Asian Green Mussel *Perna viridis* on a vessel at Barrow Island (Figure 2), Asian Paddle Crab *Charybdis japonica* in Perth, Black Striped Mussel *Mytilopsis sallei*, European green crab *Carcinus maenas*, Japanese Kelp *Undaria pinnatifida* and Northern Pacific seastar *Asterias amurensis*. None of these pest species are known to have established self-sustaining populations in WA waters but all represent a serious threat.

Wells (2018) conducted a review of invasive marine species in the Pilbara based on results of publicly available studies and found that only one species listed on the Australian National IMS list, the ascidian

Didemnum perlucidum, has established a self-sustaining population. Fourteen other introduced marine species are present and listed in **Table 3** below.

Table 3 Introduced Marine Species established in the Pilbara (adapted from Huisman et al. 2008)

Group	Species	Onslow	Barrow Island	Dampier	Port Hedland
Bryozoans	*Amathia distans*				x
	Amathia vidovici				x
	Bowerbankia gracilis				x
	Bugula neritina			x	x
	Bugula stolonifera				x
	Savignyella lafonti		x		x
	Tricellaria occidentalis		x		
	Zoobotryon verticillatum				x
Crustaceans	*Amphibalanus amphitrite*			x	x
	Amphibalanus reticulata		x	x	x
	Megabalanus ajax		x	x	
	Megabalanus rosa		x	x	x
	Megabalanus tintinnabulum	x	x	x	x
Hydroids	*Antenella secundaria*				x
Ascidians	*Didemnum perlucidum*		x	x	

4.4 Introduced Marine Pests at Mardie

The Mardie area has not been surveyed specifically for IMPs, however BCH community surveys by O2 Marine have not identified any so far (O2 Marine, 2019d). Additionally, nearby at Cape Preston, URS conducted an IMP survey and found no marine pest species listed by the National IMP Coordination Group (URS, 2009).

Regionally, the IMP species *Didemnum perlucidum* is found at Barrow Island, approximately 50km to the north-west of the project site at Mardie. This species is listed as an IMP by NIMPCG (2009a, 2009b), which indicates that is has potential to cause harm to the environment it is introduced to, however has been widely found in marine industrial area across WA.

5 Risk Assessment Procedure

The Australian Government has set the first of five themes of change as “Implementing a risk–based approach to biosecurity management” (DAWR, 2019). Following this theme, prevention and management of potential marine pest incursions due to project activities should be carried out using a risk-assessment framework. This section highlights the main considerations and processes taken to determine the likelihood and consequence of IMP introduction through different activities in construction and operations activities associated with the project.

5.1 Resources at Risk

The consequence or level of impact of IMP translocation is dependent on the value and sensitivity of the receiving environment and the value and susceptibilities of the project assets.

5.1.1 Natural Resources

The project site is adjacent to areas of conservation significance such as mangroves and coral reef ecosystems. Mangroves are present along the coastline of Mardie and coral reefs are found around the Passage Islands, the closest of which is 6.5 km from the proposed transhipment dredge channel. Some of these ecosystems have a formal level of protection including terrestrial parks or proposed state marine parks. These include the Marine Park and Marine Management Area at Barrow Island and the Pilbara Inshore Islands Nature Reserve (Great Sandy Island Nature Reserve) (**Figure 8**). Results of the Pilbara Coastal Water Quality Outcomes (2006) give the area a high Level of Ecological Protection (LEP) and the mangroves are determined to have a Maximum LEP. These areas are recognised to have socio-economic, environmental and cultural values based on significant consultation with stakeholders. Regionally significant mangrove communities are also found in the area (EPA, 2001). In addition, the region hosts a number of important marine species with conservation status including Humpback whales (Megaptera novaeangeliae), Short-nosed Sea Snake (Aipysurus apraefrontalis), Dugong (Dugong dugon) and Loggerhead turtle (Caretta caretta), as well as several other turtle species listed under the Wildlife Conservation Act 1950, repealed recently by the Biodiversity Conservation Act 2016. CALM (2005) also identifies a number of marine fauna of conservation significance in the area.

5.1.2 Port Resources

If the introduction of a marine pests occurs, impacts on project operations could be substantial, due to regulatory bodies imposing requirements which can include altering shipping activities, eradication programs and long-term monitoring. Some pest species can result in damage to infrastructure or reduced functionality of vessels and equipment which may require dry-dock inspections and cleaning on a regular basis. For example, water intakes can become so fouled by colonial ascidians like *Didemnum* spp that they are no longer functional. Regular maintenance of this infrastructure would be required. The Mardie Project will have a number of water intakes for its seawater requirements.

5.2 Risk Factors

There is a diverse range of factors that may affect the likelihood of an IMP arriving and establishing at the project. For a successful marine pest introduction to take place they need to be transported from a location where already present, and the receiving environment must be suitable for their survival.

5.2.1 Transportation Risk Factors

The most common forms of transport vector for an IMP are biofouling on vessels, debris and submersible equipment, or in ballast water/sediment and seacocks/sea strainers (CSIRO 1998). The individual IMP(s) must attach to - or be taken in by - the vessel at the location of origin and then survive the journey to the project site as a 'passenger'. The survival and translocation risk of the IMP depends on:

- Frequency and duration of vessel visits;
- Vessel operating speeds (e.g. stationary or slow- moving vessels in port areas allow fouling pests to attach, while transit times between ports will affect survivorship in ballast water));
- Type of vessel operations (i.e., direct contact with seabed brings higher risk);
- Origin location (Last Port of Call - LPoC);
- Level of hull biofouling and prevention (anti-foulant coatings);
- Capacity and use of ballast water throughout journey. Time on voyage from LPoC – length of time species can survive in ballast water
- Presence and size of internal vessel areas such as sea chests, anchor cable lockers, propeller shafts;
- Inspection of internal areas and treatment systems used; and
- Dry docking - duration since the last dry-docking or removal from the water.

These risk factors are incorporated into several private sector and government supplied risk assessments, including DPIRD biosecurity Vessel Check Biofouling Risk Assessment, which is a requirement for vessels entering the Port of Port Hedland by Pilbara Ports Authority (PPA, 2018). Under the Biosecurity Act 2015, all vessels are required to use the Marine Arrivals Reporting System (MARS) which includes ballast water management requirements. In a likelihood assessment for IMP risk in the Indian Ocean Territories completed by McDonald et al. (2015), vessel types were rated in terms of their IMP translocation potential, based on a combination of the above factors. The analysis focussed on vessel characteristics and risk of carrying pests, rather than being geographically specific. As such, where congruence in vessel types exist between that and this assessment, risk ratings are considered transferable for use here. The vessel types proposed for use in construction and operations of the Mardie Project and their relative risk ratings are found in **Table 4** below. Note that the back-hoe dredge was not included McDonald et al. (2015) but the same assessment process was used to determine its risk rating.

Table 4 **Vessels for use in the Mardie Project and their relative risk ratings (adapted from McDonald et al., 2015), with one (1) the lower risk and three (3) the higher.**

Number	Project Phase	Vessel/Equipment Type	Relative Risk Rating
Not determined	Operations	Bulk Carrier	1
4	Construction & Operations	Crew transfer vessels	1
1	Operations	Transhipment Vessel	2
5	Construction	Barge	2
1-2	Construction	Tug	2
1	Construction	Back – Hoe (equipped to dredge)	2
1	Construction	Jack – up Barge	3
1	Construction	Barge (Dredging)	3

5.2.2 Receiving Environment Risk Factors

Risk nodes are the areas to which potential IMP translocation may occur. The conditions at this receiving environment are risk factors which can influence the likelihood of marine pest introduction. These factors include:

- Similarity of the receiving environment to the marine pest's location of origin (habitat/substrate type, bioregional matching, physico-chemical conditions, temperature and salinity regimes);
- availability of substrate/habitat;
- availability of prey/food/nutrients;
- presence of predators;
- competition with local/native biota;
- water quality (temperature and salinity regimes); and,
- distance of project site to high risk areas (ports, harbours, aquaculture facilities).

The vessels listed in **Table 4** have not yet been contracted and as such, the origin locations of these vessels are unknown. However, it is likely that at least some of the construction vessels and the bulk carriers will be sourced from China and southeast Asian ports, which share similar environmental conditions with the project site in the Pilbara. Many IMP species on the NIMPCG list (Appendix A) either originate from or are established in large southeast Asian ports such as Singapore. These include the Asian Green Mussel (*Perna viridis)* and Black-Striped Mussel (*Mytilopsis sallei)* (Crib et al. 2009*).* There is a greater likelihood for introduction of such species to Mardie due to the bioregional matching.

The Port of Dampier, 90 km to the north east of the project site was ranked the highest likelihood port in WA for the introduction of a non-indigenous marine species (McDonald 2008). The Sino Iron Ore export facility is located 40km to the north-east representing the closest port facility to the proposal, while Barrow Island is located 50km to the north-west.

The existing environment and potential IMP settlement substrate are described in **Section 3.2**. As noted above, the project will increase areas of hard substrate (jetty pilings and intake/outfall pipelines) as well as change some of the substrate (depth and composition) in the area by dredging. These dredged, disturbed and constructed areas and surfaces are more likely to be colonised by opportunistic invasive marine species before a native community is established (Wells and McDonald, 2010).

5.3 Risk Areas at Mardie

5.3.1 Vectors and nodes

Nodes are the locations to, or from which, a potential marine pest is transported. Nodes can be broad like a port or region, or as refined as a structure within a port or harbour such as a mooring or pylon. Nodes with IMP translocation risk for the Mardie Project include:

> Anchorage/mooring areas;
> Trestle Jetty pilings and structure in intertidal and sub-tidal zones;
> Outfall and intake pipelines in intertidal and sub-tidal zones;
> Substrate surrounding and below the trestle jetty;
> Transhipment channel with increased/deeper area of soft bottom substrate and reduced coverage of existing benthic communities; and
> Transhipment turning basin.

Vectors are the mechanism by which a potential marine pest can be translocated from donor to receiving node. Primary vectors of concern include biofouling on a vessels hull and other surfaces, ballast water, or other internal water or sediment carried by a vessel or marine equipment.

The construction phase will include relatively large numbers of vessels arriving in a short time frame (identified in Table 2). Some of these will originate directly from southeast Asian ports and some will originate from domestic (Australian) waters. All of these may act as primary vectors for pest introduction across any of the receiving nodes at Mardie.

During the operations phase of the project, bulk carriers will act as a primary vector (the first point of entry to the project) with LPoC assumed to be China or southeast Asia. Therefore, the only primary node (where an IMP could first be introduced) during the operations phase is the offshore anchorage/mooring area. From that point, the transhipment vessel may act as a secondary vector, at risk of transferring any introduced pests to secondary nodes of the transhipment channel/basin, the trestle jetty and substrate nearby the jetty. Due to the proximity of other ports to the project, non-project vessels which use the moorings/ anchorages used by project vessels may also act as secondary vectors moving any IMPs between Mardie and nearby Port of Dampier, Cape Preston, or Barrow Island.

The bulk carriers are the highest risk vector during the operations phase, while the jack-up barge and dredge are considered the highest risk vectors during the construction phase of the project (**Table 4**).

5.4 IMP Risk Species for Mardie

This section identifies marine pest species which are most likely to be introduced to Mardie as a result of the Project. This is based on the Australian National priority trigger list for marine pests that are considered to be at risk of introduction and causing harm in Australian waters (NIMPCG, 2009a; 2009b). The approach utilises the National Monitoring Design Excel Template (MDET) v2.5 (DAWR, 2018) which provides environmental tolerance ranges for each of the 54 species on the national list. Specifically, the list provides tolerance ranges for temperature, salinity and available substrate type. A buffer of 60 metres around proposed infrastructure location was allowed, to select possible substrate types for possible initial colonisation by invasive species. The environmental conditions at Mardie are detailed in **Section 3**. If one of the species life-stages was found not to tolerate the conditions, all life stages for that species were excluded from the table due to the inability for it to reproduce (in line with Wells, 2018). Following this methodology, 27 species from the list were selected as having risk of becoming an IMP at Mardie (**Table 5**).

Table 5 NIMPCG (2009a;2009b) listed IMP species that are at risk of translocation to Mardie, Western Australia

Species phylum	Species name	Hard Substrate	Soft Substrate (epifauna)	Soft Substrate (infauna)	Plankton/pelagic
Ballast Water					
Bacillophyta/diatoms	*Chaetoceros concavicornis*				✔
	Chaetoceros convolutus				✔
Cnidaria	*Blackfordia virginica*				✔
Ctenophore	*Beroe ovata*				✔
	Mnemiopsis leidyi				✔
Dinophyceae	*Alexandrium monilatum*			✔	✔
Ballast Water and Hull Fouling					
Annelida	*Hydroides dianthus*	✔			✔
Ascidiacea	*Didemnum spp.*	✔			✔
Chlorophyta	*Caulerpa racemosa*	✔	✔		✔
	Caulerpa taxifolia	✔	✔		
	Codium fragile spp. tomentosoides	✔	✔		✔
Crustacea/Brachyura	*Hemigrapsus sanguineus*	✔			✔
	Hemigrapsus takanoi/penicillatus	✔	✔		✔
	Rhithropanopeus harrisii	✔	✔		✔
	Balanus eburneus	✔			✔
Mollusca/Bivalvia	*Crassostrea gigas*	✔			✔

Species phylum	Species name	Hard Substrate	Soft Substrate (epifauna)	Soft Substrate (infauna)	Plankton/pelagic
	Ensis directus			✔	✔
	Mya arenaria			✔	✔
	Mytilopsis sallei	✔	✔		✔
	Perna viridis	✔			✔
Mollusca/gastropoda	*Crepidula fornicata*	✔	✔		✔
	Rapana venosa	✔	✔		✔
Pisces	*Siganus luridus*	✔			✔
	Siganus rivulatus	✔			✔
Rhodophyta	*Bonnemaisonia hamifera*	✔	✔		✔
	Grateloupia turuturu	✔			✔

The habitat composition at the Mardie Project site is predominantly soft substrate, however hard substrate (coral reefs, rocky rubble, limestone pavement) is also found in localised areas. Habitats available at Mardie, therefore, have potential to support all of the NIMPCG trigger list species identified from environmental tolerances. This is particularly the case for species that have life stages relevant to soft substrate.

5.5 Risk Assessment

This document sets to determine the hazards, likelihood and scale of potential consequences and suggests controls regarding introduction of marine pests to Mardie due to the progression of construction and operations of the 'Mardie Project' in the Pilbara. This section details the methodology used, which is consistent with the Australian and New Zealand Standard for Risk Management (AS/NZS ISO 31000:2018).

5.5.1 Methodologies for IMP Risk Assessment

Within the overarching framework, various methodologies and factors to consider for risk assessment of marine biosecurity have been discussed and implemented in the past. These include focus on environmental matching between donor and recipient ports (ICES, 1996; Hilliard and Raaymakers, 1997), species - specific assessments (Carlton et al 1995; Hayes and Hewitt, 1998) or Quantitative Import Risk Assessments (Kellar 1993; Morley, 1993) among others. At a basic level, species – specific assessment requires identification of environmental conditions and infection status at donor and recipient ports for each species.

WA state fisheries currently employ their own 'Vessel Check' biofouling risk assessment which is implemented by Pilbara Ports Authority at the Port of Port Hedland. Separate Ballast Water risk assessments are also currently utilised by several major Pilbara Ports. Those risk assessments are implemented on an operational vessel basis rather than at a project scale (i.e., before the vessel arrives, they are required to submit a risk assessment to the port).

5.5.2 Risk Assessment Methodology

The approach utilised in this risk assessment aims to rank the likelihood and consequence associated with different hazards at a project scale using best-of-knowledge estimates. **Figure 9** visualises the process whilst the below provides an overview.

IMP Risk Assessent Process

Step 1: Identify key risk and hazard activities

Step 2: Rate associated risk (Table 6) of translocating IMP (Table 5) to values (Section 3.2)

Step 3: Determine likelihood and consequnce (Table 8) of translocating IMP (Table 5) to values (Section 3.2) using examples (Table 9)

Step 4: Determine management and mitigation required (Table 10)

Step 5: identify risk controls to ensure ALARP

Figure 9 Introduced Marine Pest Risk Management Process

Activities that present hazards or key risk activities associated with the project were first identified. These activities were divided into the different phases of the project – construction and operation. Each of the hazards was rated independently using **Table 6** based on the consequences resulting from translocation of selected IMP species (**Table 5**) on the values at the site (**Section 3.2**). This also considered the availability of suitable habitat for the IMP species considered most likely to be encountered. The likelihood of successful IMP translocation arising from each of the hazardous activities was then estimated using **Table 7**. This considered IMP translocation risk rating based on vessel type (i.e. vector), node of introduction and phase of works.

The likelihood and consequences are used to calculate a level of ‘grading’ for each risk. Grading hazards independently is used to determine priority and requirements for dealing with the risks identified. Each grading is calculated according to the following equation and the resulting matrix is detailed in

Table 8: *Grading = (Likelihood Rating) * (Consequence Rating).* Examples of considerations when assessing levels consequence and likelihood are found in

Table 9.

The risk grading level determines the level of management and mitigation needed to be taken for each hazardous activity. This is achieved by using

Table 10 which details the acceptability of each risk grading level. For example, extreme risks are completely unacceptable and any activity posing this risk must be terminated or avoided. However, low risk activities may be deemed to proceed with caution and monitoring. There are a range of controls to lower the risk grading level that a manager can use. In their simplest form these are elimination, substitution, engineering controls, administrative controls and risk retainment. Controls revolve around lowering either the consequence (severity) or the likelihood of the hazard.

After careful risk analysis, grading and determining levels of acceptability, matters that are deemed to have all relevant controls or treatments applied are provided a risk ranking of 'As Low as Reasonably Practicable' (ALARP).

Table 6 Consequence ratings for assessment of hazardous project activities relating to IMPs.

Consequence	Negligible	Minor	Moderate	Major	Catastrophic
Environment-ecosystem	No impact or, if impact is present, then not to an extent that would draw concern from a reasonable person. No impact on the overall condition of the ecosystem.	Impact is present but not to the extent that it would impair the overall condition of the ecosystem, sensitive population or community in the long-term.	Impact is present at either a local or wider level. Recovery periods of 5 - 10 years anticipated	Impact is significant at either a local or wider level or to a sensitive population or community. Recovery periods of 10 - 20 years are likely.	Impact is clearly affecting the nature of the ecosystem over a wide area OR impact is catastrophic and possibly irreversible over a small area or to a sensitive population or community Recovery periods of greater than 20 years likely OR condition of an affected part of the ecosystem irretrievably compromised.
Environment-perception	No media attention.	Individual complaints.	Negative regional media attention and regional group campaign.	Negative national media attention and national campaign	Negative and extensive national media attention and national campaigns.

Table 7 Likelihood of marine pest introduction to Mardie

Likelihood	Frequency	Probability (%)
Almost certain	Expected to occur more or less continuously throughout a year (e.g. more than 250 days per year)	95-100 % chance of occurring
Likely	Expected to occur once or many times in a year (e.g. one to 250 days per year)	71-95 % chance of occurring

Likelihood	Frequency	Probability (%)
Possible	Expected to occur once or more in the period of one to 10 years	31-70 % chance of occurring
Unlikely	Expected to occur once or more in the period of 10 to 100 years	5-30 % chance of occurring
Rare	Expected to occur once or more over a timeframe greater than 100 years	0-5 % chance of occurring

Table 8 Hazard risk grading matrix

		CONSEQUENCE				
		Catastrophic	Major	Moderate	Minor	Negligible
LIKELIHOOD	Almost Certain	Extreme	Extreme	High	Serious	Medium
	Likely	Extreme	High	High	Medium	Medium
	Possible	High	High	Medium	Medium	Low
	Unlikely	High	Medium	Medium	Low	Low
	Rare	Medium	Medium	Low	Low	Low

Table 9 Example of Risk Assessment considerations

LIKELIHOOD	CONSEQUENCE
Suitability of habitat for IMPs under consideration Proximity of habitat to vector Is this a known risk vector? Has this hazard occurred previously elsewhere (locally)? Frequency of event – once/rarely/often	Perceived relative ecological value of area Relative commercial and recreational value of area Sensitivity of area (Mardie is low productivity and highly turbid with dynamic salinity range) Susceptibility of project infrastructure (seawater intakes, transhippers)

Table 10 Risk Grading levels and their relative 'acceptability' including guidance on risk mitigation.

Grade	Risk Mitigation Actions
Low	These risks should be recorded, monitored and controlled by the responsible manager. Activities with unmitigated Environment, Health and Safety risks that are graded above this level should be avoided.
Medium	Mitigation actions to reduce the likelihood and consequences to be identified and appropriate actions (if possible) to be identified endorsed by Director / Manager level.
High	If uncontrolled, a risk event at this level may have a significant impact on the operation of a business unit. Mitigating actions need to be very reliable and should be approved and monitored in an ongoing manner by the General Manager.
Extreme	Activities and projects with unmitigated risks at this level should be avoided or terminated. This is because risk events graded at this level have the potential to cause serious and ongoing damage to the organisation, the community or the environment. Reporting emerging or continuing risks exposures at this level to the General Manager. The Chairman should be advised of identified or emerging strategic risks which have been graded at this level.

5.5.3 Risk Assessment Results

Results of the Introduced Marine Pest Risk Assessment for the Mardie Project are summarised in **Table 11.**

Table 11 IMP Risk assessment for the construction and operation phases of the proposed Mardie Project

Current Risk						Project Management Risk			
Activity or Element	**Impact**	**Current Controls**	**Consequence**	**Likelihood**	**Risk Level**	**Proposed Treatment / Management**	**Consequence**	**Likelihood**	**Risk Level**
Construction phase									
De-ballasting of Construction Vessels	Introduction of IMP via ballast water	Biosecurity Act 2015, Ballast Water Management Requirements, Pre-Arrival Reports (PAR), Maritime Arrivals Reporting System (MARS)	Moderate	Possible	Medium	Ballast exchange in accordance with legislation (Biosecurity Act 2015) and sub-legislation (regulations and guidelines). Use MARS for vetting of international vessels and recommend for domestic vessels. Confirm exchange of Ballast Water at sea or treatment in pre-arrival forms prior to allowing site entry. Consider use of passive or active monitoring at site to demonstrate efficacy of management measure application. Consider identifying suitable open ocean contingency for emergency ballast discharge for pre-entry clearance to avoid impacts on construction vessel arrivals.	Moderate	Rare	Low
Anchoring/mooring/berthing of Construction Vessels	Introduction of IMP via dislodgment of biofouling	Antifoulant coating on vessel hulls	Moderate	Unlikely	Medium	Industry-specific vessel appraisal prior to entering Project site. Undertake in/out of water inspection where required for risk management. Suggest AFC requirements (age, type etc) during vessel tender process. Consider use of passive or active monitoring at site to demonstrate efficacy of management measure application.	Moderate	Rare	Low
Use of Jack-up barge for jetty/pile driving	Introduction of IMP through dislodgement of biofouling	None known to project	Moderate	Possible	Medium	Source from Australian waters where possible. Review supporting documentation of barge, vessel and equipment prior to construction works to identify operational history and fouling management. Conduct inspection if required to inform risk. Suggest AFC requirements (age, type etc) during vessel tender	Moderate	Rare	Low

Current Risk						Project Management Risk			
Activity or Element	**Impact**	**Current Controls**	**Consequence**	**Likelihood**	**Risk Level**	**Proposed Treatment / Management**	**Consequence**	**Likelihood**	**Risk Level**
	or direct transfer					process. Reject or replace equipment that is suspect of IMP.			
Use of barge or similar at site	Introduction of IMP via dislodgment of biofouling	Antifoulant coating (AFC)	Moderate	Possible	Medium	Source from Australian waters where possible. Industry-specific vessel appraisal prior to entering project site. Undertake in/out of water inspection where required for risk management. No sediments to be transferred to site. Suggest AFC requirements (age, type etc) during vessel tender process.	Moderate	Rare	Low
Use of BHD to dredge turning basin and transhipment channel	Introduction of IMP via ballast discharge or dislodgement of biofouling	Back-Hoe transported dry (limits risk of biofouling).	Moderate	Unlikely	Medium	Complete DPIRD IMS 'Vessel Check' risk assessment and recommend submission of a domestic MARS risk assessment. Dry-dock inspection and regular monitoring of fouling on hull of vessel. Suggest AFC requirements (age, type etc) during vessel tender process. Reject or replace equipment that is suspect of IMP.	Moderate	Rare	Low
Use of immersible construction materials (pylons, pipework, jetty)	Introduction of biofouling IMP through dislodgement or direct introduction	None	Moderate	Rare	Low	Review supporting documentation of equipment prior to construction works to identify operational history and fouling management. Construction materials and equipment to be kept dry (above waterline) at LPoC			Low
						Operational Phase			
Anchoring of Operational Vessels	Introduction of IMP via ballast water or dislodgement of biofouling	Transhipper anchorage points restricted to offshore anchorage. Antifoulant coating on vessel hull.	Moderate	Possible	Medium	Industry-specific vessel appraisal prior to entering Project site (MARS for international vessels). Undertake in/out of water inspection where required for risk management. Suggest AFC requirements (age, type etc) during vessel tender process. Adhere to existing IMO/Australian guidelines on management of translocation risk for biofouling pest species.	Moderate	Rare	Low

Current Risk						Project Management Risk			
Activity or Element	**Impact**	**Current Controls**	**Consequence**	**Likelihood**	**Risk Level**	**Proposed Treatment / Management**	**Consequence**	**Likelihood**	**Risk Level**
Use of Transhipper Vessel	Introduction of IMP through transfer from bulk carrier (ballast water) or biofouling	Vessel to undertake 5 yearly dry-dock inspection	Moderate	Unlikely	Medium	Recommend ballast exchange occurs in accordance with current legislation. Flushing of ballast waters on route not nearby trestle jetty. Recommend regular monitoring of sea strainers and ballast chambers. Recommend regular monitoring of biofouling on vessel hull and other high-risk areas. Recommend submission of a domestic MARS risk assessment.	Moderate	Rare	Low
Use of immersible equipment (e.g. anchors/ moorings/rope)	Introduction of biofouling IMP through dislodgement or direct introduction	None	Moderate	Rare	Low	Reject or replace equipment that is suspect of IMP. Suggest AFC requirements (age, type etc) during tender process.	Moderate	Rare	Low
Use of Support Vessels	Introduction of IMP via biofouling	Antifoulant coating on vessel hulls	Moderate	Unlikely	Medium	Regular maintenance of AFC; clean on arrival. Undertake in/out of water inspection where required for risk management. Suggest AFC requirements (age, type etc) during vessel tender process. Recommend submission of a domestic MARS risk assessment.	Moderate	Rare	Low
De-ballasting of Operational Vessels	Introduction of IMP via ballast water	Biosecurity Act 2015, Ballast Water Management Requirements, Pre-Arrival Reports (PAR), Maritime Arrivals Reporting System (MARS)	Moderate	Unlikely	Medium	Recommend ballast exchange occurs in accordance with current legislation. Confirmation of exchange at sea, treatment or other risk management measure application required prior to site entry. Maintain passive monitoring at site to demonstrate efficacy of management measure application. Seek advice and aim to identify a suitable open ocean contingency discharge for emergency ballast discharge	Moderate	Rare	Low

6 Discussion and Recommendations

All IMP risk species with potential to be translocated to and survive at Mardie (**Table 5**), with the exception of *Caulerpa taxifolia,* have at least one planktonic life history stage. These species have the potential to be transferred via ballast water in either construction or operations vessels. Species that have lifestages that require hard substrate have a reduced likelihood of survival/establishment at the primary node (bulk carrier anchorage) due to habitats in the area assumed to be dominated by soft sediment. Hard substrates will however be available at some secondary nodes (trestle jetty, nearby coral reef, limestone pavement habitats). Successful establishment of an IMP on these habitats is less likely during project operations as translocation would rely on secondary node transfer.

Introduced Marine Pests have the potential to cause significant impacts to the existing environment at Mardie, as well as damaging the socio-economic setting. Currently, one IMP on the national trigger species list (*Didemnum perlucidum*) has been found in the broader area, at Barrow Island and the Port of Dampier. This species presents some risk of impacting upon the marine facilities at the proposed Mardie Project, including potential for water intake biofouling. It could also result in negative impacts on Benthic Communities and Habitat. Measures should be taken to minimise further spread of *Didemnum perlucidum* through activities associated with construction and operations of the Mardie Project. Controls are also needed to avoid introduction of any new pest species that could affect the values of the Mardie Project area and/or present a translocation risk to other nearby operational facilities.

To inform relevant controls to manage pest introduction, the risk of marine pest introduction for the Mardie Project has been assessed in this report. Most of the risk is based on the introduction of marine species by vessels that have originated from, or spent time in international and foreign waters, especially south-east Asian ports such as Singapore – due to bioregional matching between these areas and the Pilbara. IMPs have the potential to be translocated to Mardie through the de-ballasting of construction and operational vessels upon arrival on-site, or by biofouling dislodgement from vessels or equipment.

For International Vessels entering Australian and Territorial Sea waters, state and national biosecurity legislation and standard industry practices are current IMP risk management controls. For example, the Maritime Arrivals Reporting System (MARS) requires pre-arrival reporting regarding ballast water biosecurity. Bulk Carriers will be required to use MARS during the operations phase of the project, while Federal protocols will require all vessels arriving from international waters to use MARS prior to arrival on site during the construction phase. Other management controls have been recommended including the implementation of the DPIRD “Vessel Check” biofouling risk assessment, dry-dock inspections following relevant guidelines, sourcing construction equipment from low risk/domestic locations were feasible and regular maintenance of operational vessel AFC.

The construction phase is the highest risk phase of the project. It will create new areas of hard intertidal and subtidal substrate which could be colonised by IMPs such as Asian Green Mussel *Perna viridis* or Black Striped Mussel *Mytilopsis sallei*. Two construction vessels - the Jack-Up Barge (pile driving) and the barge associated with dredging are both slow moving and have direct contact with the substrate, presenting the greatest likelihood of IMP translocation to project if these vessels are sourced from high risk international ports in southeast Asia (**Table 4**). Additionally, the dredged channel and turning basin at the end of the transhipment jetty have higher potential for successful IMP settlement than the surrounding undisturbed substrate. Recommended risk management controls for the barge and Jack-up Barge vessels include regular dry-dock inspections and below and above water monitoring for biofouling to confirm low risk of IMPs introduction.

During the operational phase of the project, the bulk carrier anchorages (primary node) are at greatest risk of IMP introduction where soft substrates are to be the dominant habitat type. Seven high risk species for these soft substrates that have potential of being introduced and surviving (from MDET) are *Alexandrium monilatum, Ensis directus, Mya arenaria, Mytilopsis sallei, Crepidula fornicate, Rapana venos* and *Bonnemaisonia hamifera.* All potential hard substrates are secondary nodes and have a lower risk of IMP translocation. Controls to mitigate risk of these taxa being introduced and secondarily transferred have been identified to include regular dry dock maintenance of AFC across vessel hulls and all niche environments (e.g. sea chests/strainers) and use of passive monitoring to enable early warning of any of concern of introductions.

7 Conclusion

Risks of IMP introduction as a result of the Mardie Project has been assessed and management recommendations in this report should reduce the 'unmitigated risk' for all activities to a low 'residual risk'. Key points during the risk assessment process were;

> Colonial ascidian Didemnum perlucidum presents a risk of impacting on the Mardie project given its introduction into nearby areas such as Barrow Island;
> Vessels are required to comply with international, federal and state marine pest legislation; and
> Construction phase presents higher risk of IMP introduction than the operational phase of the project.

Other management controls have been recommended including;

> The implementation of the DPIRD "Vessel Check" biofouling risk assessment;
> Dry-dock inspections following relevant guidelines;
> Sourcing construction equipment from low risk/domestic locations where feasible; and,
> Regular maintenance of operational vessel AFC.

The controls prescribed in this report should be considered for inclusion in the Construction/Operations Environmental Management Plans for the Mardie Project.

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Appendix A NIMPCG Species Trigger list

Species phylum	Species name
Crustacea/Copepoda	*Acartia tonsa*
Dinophyceae	*Alexandrium catenella*
Dinophyceae	*Alexandrium minutum*
Dinophyceae	*Alexandrium monilatum*
Dinophyceae	*Alexandrium tamarense*
Echinodemata	*Asterias amurensis*
Crustacea/Cirripedia	*Balanus eburneus*
Crustacea/Cirripedia	*Balanus improvisus*
Ctenophore	*Beroe ovata*
Cnidaria	*Blackfordia virginica*
Rhodophyta	*Bonnemaisonia hamifera*
Crustacea/Brachyura	*Callinectes sapidus*
Crustacea/Brachyura	*Carcinus maenas*
Chlorophyta	*Caulerpa racemosa*
Chlorophyta	*Caulerpa taxifolia*
Bacillophyta/diatoms	*Chaetoceros concavicornis*
Bacillophyta/diatoms	*Chaetoceros convolutus*
Crustacea/Brachyura	*Charybdis japonica*
Chlorophyta	*Codium fragile spp. tomentosoides*
Mollusca/Bivalvia	*Corbula amurensis*
Mollusca/Bivalvia	*Crassostrea gigas*
Mollusca/gastropoda	*Crepidula fornicata*
Ascidiacea	*Didemnum spp.*
Dinophyceae	*Dinophysis norvegica*
Mollusca/Bivalvia	*Ensis directus*
Crustacea/Brachyura	*Eriocheir sinensis*
Rhodophyta	*Grateloupia turuturu*
Dinophyceae	*Gymnodinium catenatum*
Crustacea/Brachyura	*Hemigrapsus sanguineus*
Crustacea/Brachyura	*Hemigrapsus takanoi/penicillatus*
Annelida	*Hydroides dianthus*
Mollusca/Bivalvia	*Limnoperna fortunei*
Annelida	*Marenzelleria spp.*
Ctenophore	*Mnemiopsis leidyi*
Mollusca/Bivalvia	*Musculista senhousia*
Mollusca/Bivalvia	*Mya arenaria*
Mollusca/Bivalvia	*Mytilopsis sallei*
Mollusca/Bivalvia	*Perna perna*
Mollusca/Bivalvia	*Perna viridis*
Dinophyceae	*Pfiesteria piscicida*
Crustacea/Copepoda	*Pseudodiaptomus marinus*

Species phylum	Species name
Bacillophyta/diatoms	*Pseudo-nitzschia seriata*
Mollusca/gastropoda	*Rapana venosa*
Crustacea/Brachyura	*Rhithropanopeus harrisii*
Annelida	*Sabella spallanzanii*
Phaeophyta	*Sargassum muticum*
Pisces	*Siganus luridus*
Pisces	*Siganus rivulatus*
Crustacea/Copepoda	*Tortanus dextrilobatus*
Pisces	*Tridentiger barbatus*
Pisces	*Tridentiger bifasciatus*
Phaeophyta	*Undaria pinnatifida*
Mollusca/Bivalvia	*Varicorbula gibba*
Rhodophyta	*Womersleyella setacea*