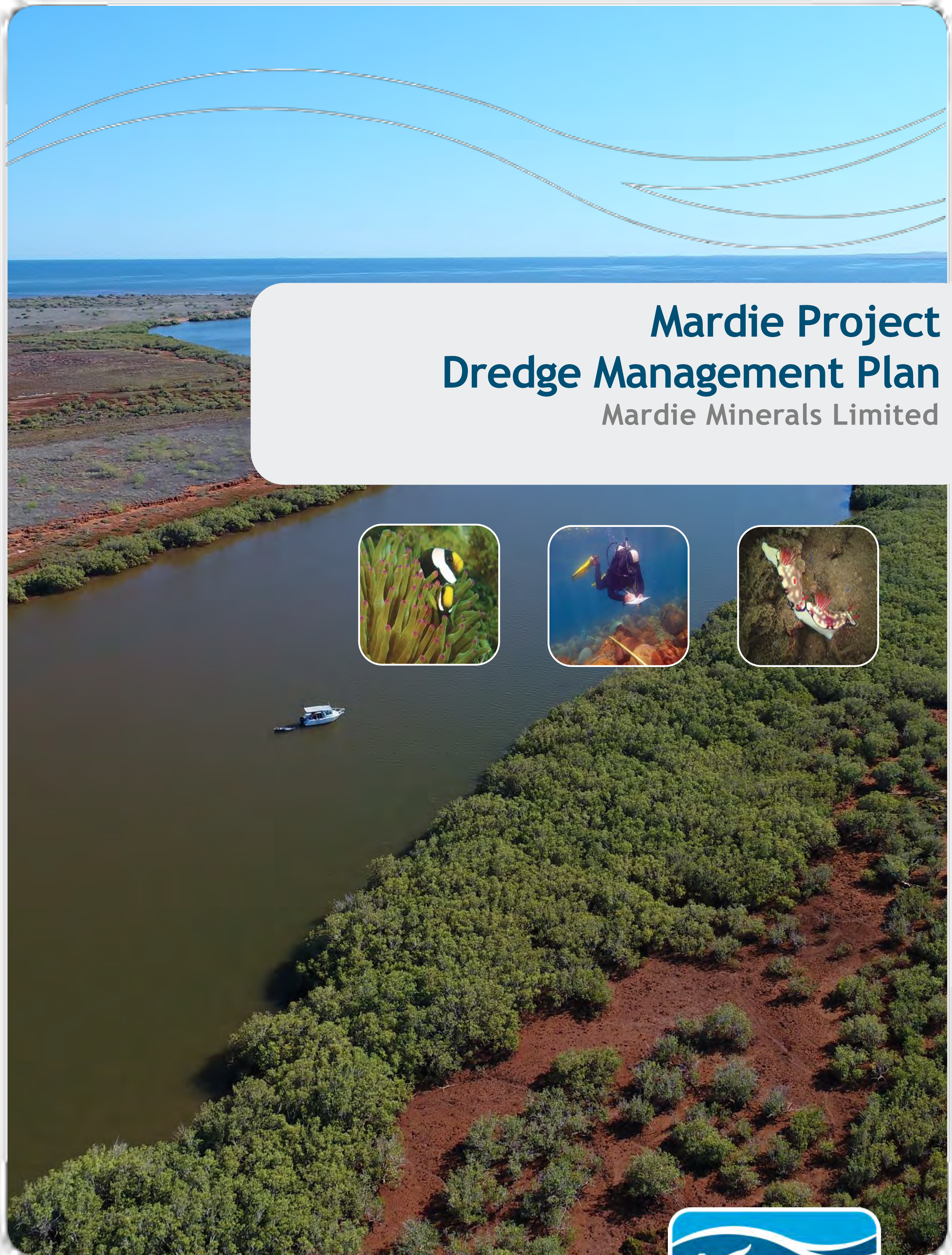

Mardie Project
Dredge Management Plan

Mardie Minerals Limited

CLIENT: Mardie Minerals Pty Ltd

STATUS: Rev 7 **REPORT No:** R190043

ISSUE DATE: 12 May 2023

O2 MARINE

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Version Register

Version	Status	Author	Reviewer	Change from Previous Version	Authorised for Release (signed and dated)	
Rev 0	Final	J.Abbott C Del Deo	C.Lane	Update Monitoring Program	C. Lane	20/04/2020
Rev 1	Final	J.Abbott C Del Deo	C.Lane	Update Monitoring Program	C. Lane	10/11/2020
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Rev 3	Final	J Abbot	Multiple through optimised proposal referral and public consultation	Changes to dredging method & subsequent implications	C Lane	12/08/2022
Rev 4	Final	R Stevens	EPA/DCCEEW	Includes updates from comments through regulator review of optimised proposal	C Lane	23/11/2022
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Rev 7	Final	R Stevens		Includes updates from comments through regulator review of optimised proposal	C Lane	12/05/2023

Transmission Register

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Acronyms and Abbreviations

Acronyms/Abbreviation	Description
BCH	Benthic Community Habitats
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DPIRD	Department of Primary Industry & Regional Development
DMP	Dredge Management Plan
DWER	Department of Water and Environment Regulation
EPA	Environmental Protection Authority
EPO	Environmental Protection Outcomes
ESD	Environmental Scoping Document
ha	Hectares
ktpa	Thousand tons per annum
m^3	Cubic meters
mAHD	Meters Australian Height Datum
MEQ	Marine Environmental Quality
MFO	Marine Fauna Observer Dedicated MFO: A suitably trained and dedicated person engaged undertake marine fauna observations and mitigation measures associated with dredging during humpback whale southern migration, July to November. The person will have demonstrated knowledge and experience in marine fauna species observation, distance estimation and reporting. They will not have any other duties while engaging in visual observations. Trained MFO: A crew member trained in marine fauna species observations and mitigation measures, consistent with Project environment management plans. The trained MFO will be on duty on Project vessels during dredging and may have other vessel duties. Crew will be scheduled so that they are able to conduct MFO duties while not undertaking other tasks.
MTs	Management Targets
Mtpa	Million tons per annum
MWQMP	Marine Water Quality Monitoring Program
PASS	Potential Acid Sulfate Soils
PER	Public Environmental Review
The Proponent	Mardie Minerals Pty Ltd
The Proposal	The Mardie Project
SOP	Sulphate of Potash
SOPEP	Shipboard Oil Pollution Emergency Plan
SOW	Scope of Works
TMF	Tiered Management Framework
TTS	Temporary Threshold Shift
UAV	Unmanned Arial Vehicle
ZoHI	Zone of High Impact
ZoI	Zone of Influence

Acronyms/Abbreviation	Description
ZoMI	Zone of Moderate Impact

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1. Introduction

1.1. Short Summary of the Proposal

Table 1: Short Summary of the Proposal

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 southwest 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, 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.).

1.2. Proponent

The proponent for the proposal is Mardie Minerals Pty Ltd which is a wholly owned subsidiary of BCI Minerals Pty Ltd. Proponent details are provided in **Table 2**.

Table 2: Proponent Details

Company Name:	Mardie Minerals Pty Ltd
Australian Business Number (ABN):	50 152 574 457
Address:	1 Altona Street West Perth
Key Contact (Role):	Julie Mahony (Manager Environment Approvals)
Key Contact Details:	Email: Julie.Mahony@bciminerals.com.au Phone: +61 8 6311 3427

1.3. Project 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.

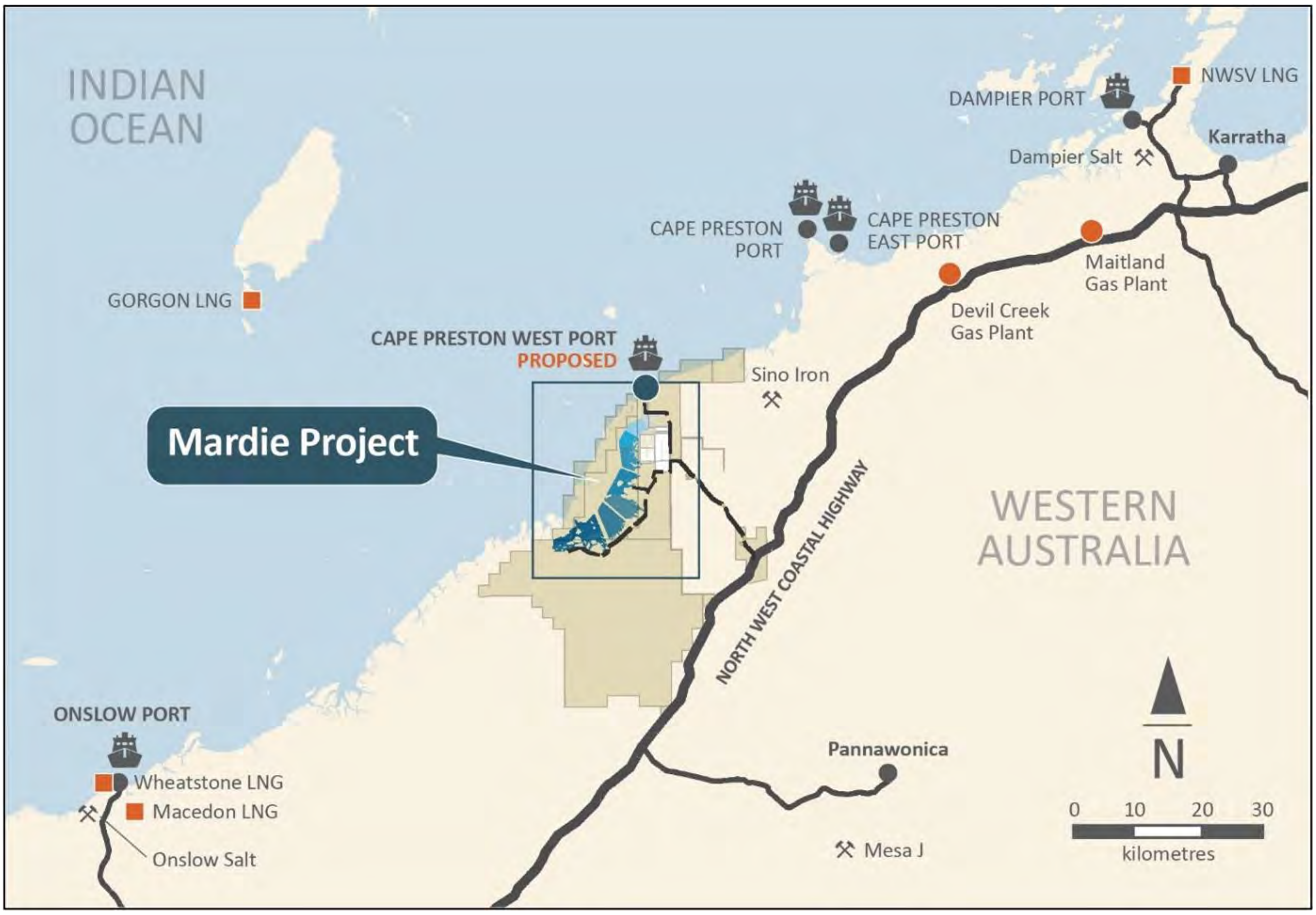


Figure 1: Project Location

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 up to 4.4 Million tonnes per annum (Mtpa) of salt (NaCl) and 110 kilotonnes per annum (ktpa) of Sulphate of Potash (SoP) are being targeted, sourced from a 150 Gigalitre per annum (GLpa) seawater intake. To meet this production, the following infrastructure will be developed (**Figure 2**):

- Seawater intake, pump station and pipeline;
- Concentrator ponds;
- Drainage channels;
- Crystalliser ponds;
- Trestle jetty and transhipment berth/channel;
- Bitterns disposal pipeline and diffuser;
- Processing facilities and stockpiles;
- Administration buildings;
- Accommodation village,
- Access / haul roads;
- Desalination plant for freshwater production, with brine discharged to the evaporation ponds; and

- Associated infrastructure such as power supply, communications, workshop, laydown, landfill facility, sewage treatment plant, etc.

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 flood 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 which will provide the water required to support the Project. The high salinity output from the plants will be directed to a concentrator pond with the corresponding salinity.

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 road alignment that services the Mardie Station homestead.

1.3.1. Marine Infrastructure and Activities

Salt and SOP produced at the project will be exported offshore through the specially constructed port operations (**Figure 3**).

A 2.4 km long trestle jetty will be constructed to convey salt and SOP to the transhipment berth pocket for loading onto the transhipping barge. 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 4.7 km long channel out to deeper water. The depth of dredging, varying from approx. 4m inshore at jetty to less than 0.5m offshore at end of channel. The dredge spoil is inert and will be transported to shore with a majority of the material reused in the development.

1.4. Purpose

The purpose of this Dredge Management Plan (DMP) is to ensure compliance with Ministerial Statement (pending). Ministerial Statement (pending) includes project specific Environmental Protection Outcomes (EPO)s, and the Proponent has proposed Management Targets (MTs) and specific management and monitoring actions to ensure that these EPOs are achieved.

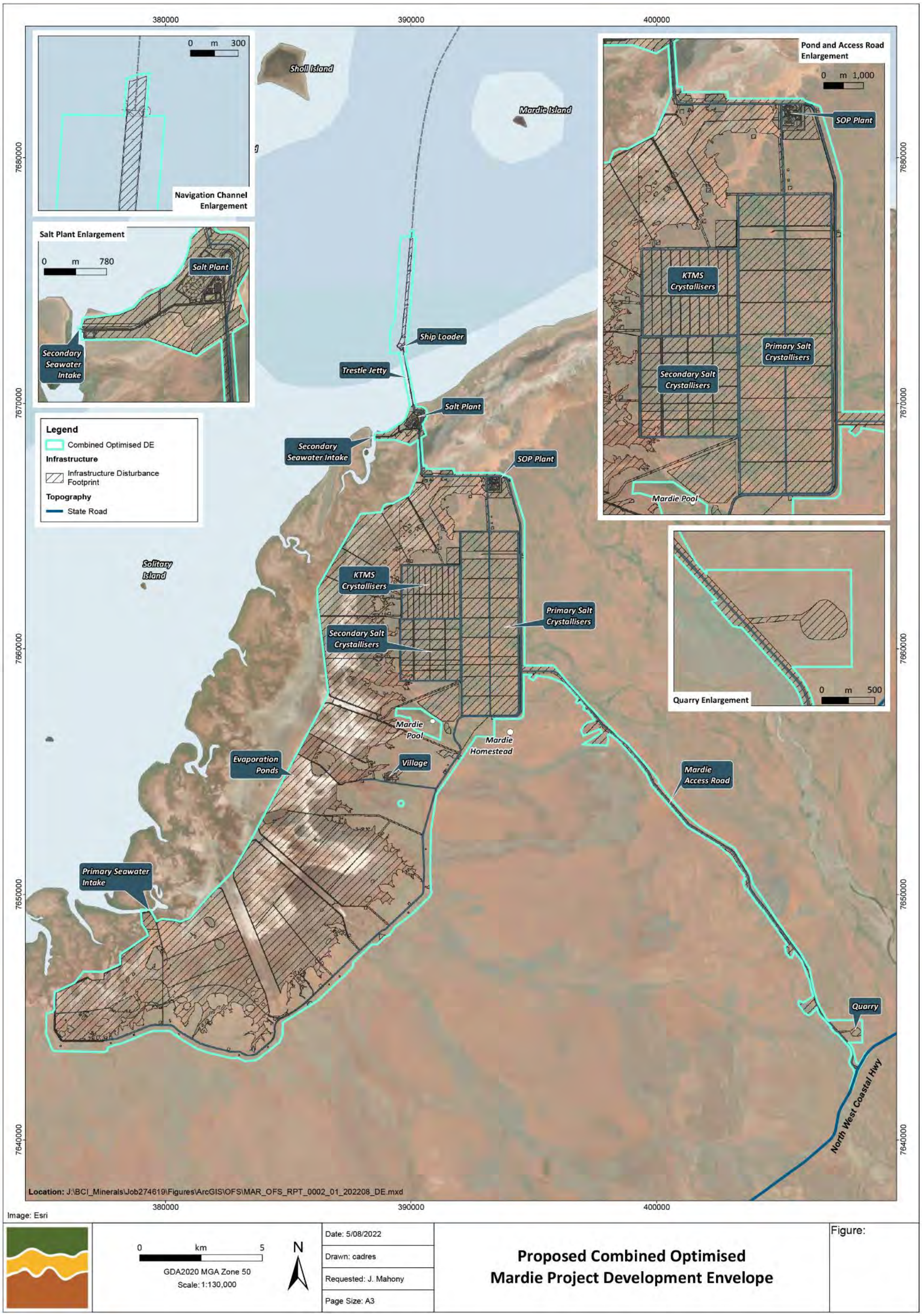
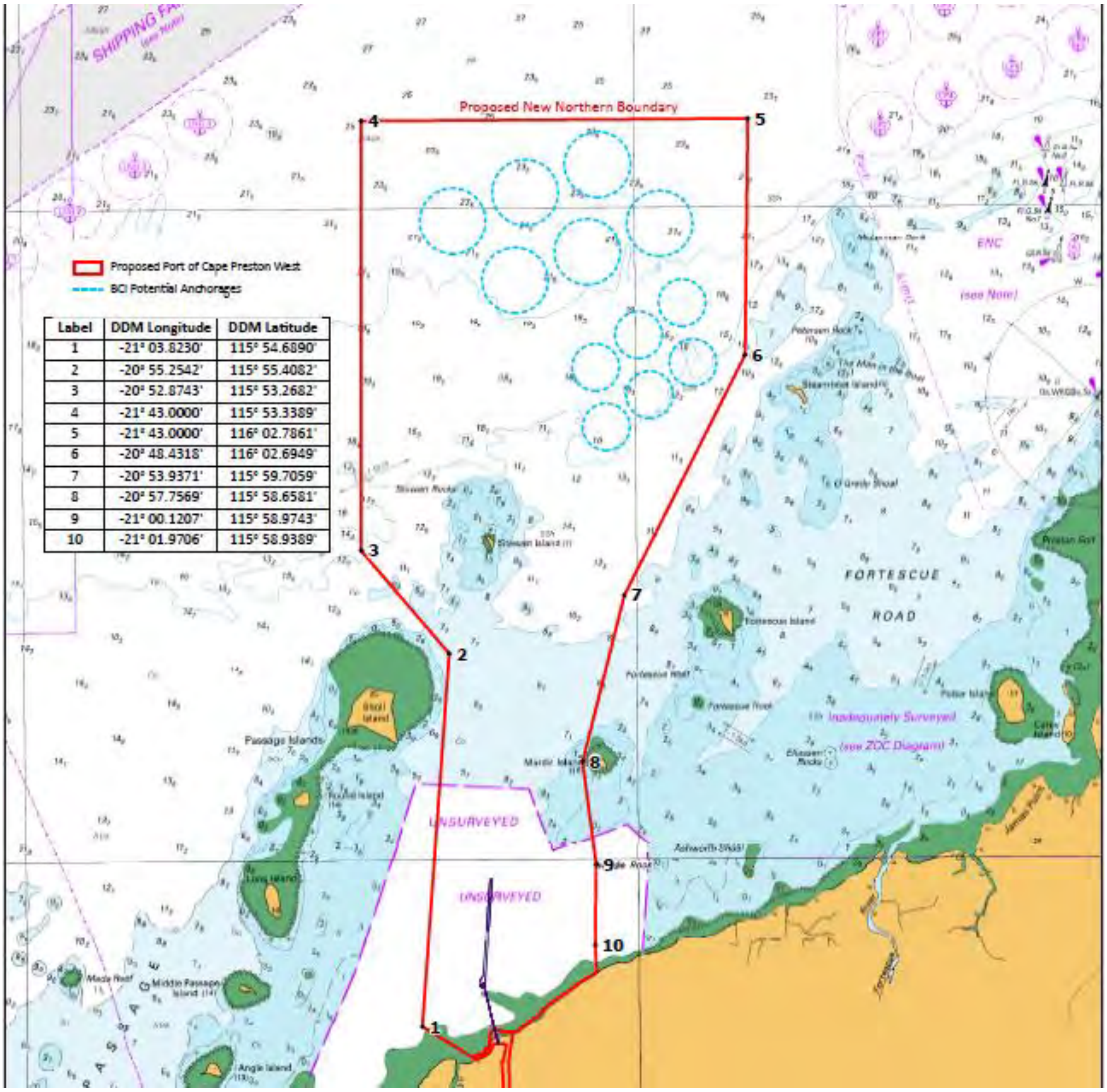


Figure 2: Indicative location of ponds and infrastructure



Label	DDM Longitude	DDM Latitude
1	-21° 03.8230'	115° 54.6890'
2	-20° 55.2542'	115° 55.4082'
3	-20° 52.8743'	115° 53.2682'
4	-21° 43.0000'	115° 53.3389'
5	-21° 43.0000'	116° 02.7861'
6	-20° 48.4318'	116° 02.6949'
7	-20° 53.9371'	115° 59.7059'
8	-20° 57.7569'	115° 58.6581'
9	-21° 00.1207'	115° 58.9743'
10	-21° 01.9706'	115° 58.9389'

Figure 3: Mardie project offshore export operations

2. Existing Environment

This section describes the existing environment at the site of the Project and surrounding waters, as it relates to the purpose and scope of this plan. The description is based on information derived from historical sources and from investigations conducted as part of the environmental impact assessment process for the Mardie Project.

2.1. Climate

The Project is located in the southern Pilbara region, which has a tropical monsoon climate with distinct wet and dry seasons. The Pilbara coast is the most cyclone prone area along the Australian coastline, with the cyclone season running from mid-December to April and peaking in February - March (Sudmeyer, 2016).

2.1.1. Wind

The dry season extends from May to October, and is characterised by warm to hot temperatures, easterly to south-easterly winds from the continental landmass, clear and stable conditions as the subtropical high-pressure ridge migrates over this area. In the afternoons, the winds generally shift 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.

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. 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.

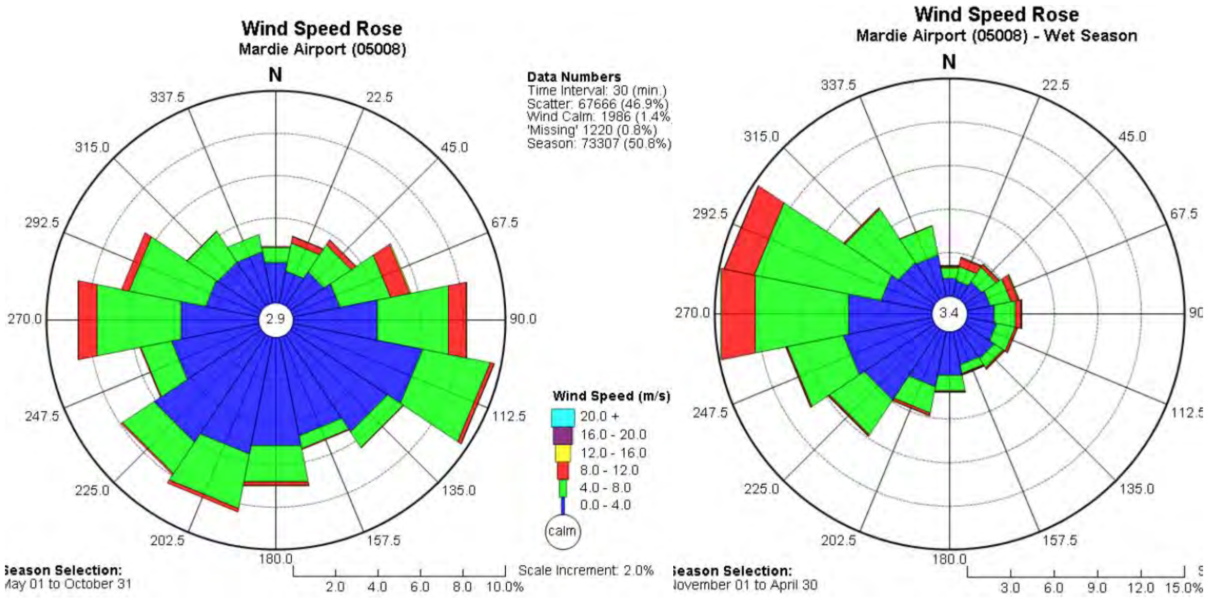


Figure 4: Wind Rose plots for Dry Season (left) and Wet Season Months (right) based data from Mardie airport.

2.1.2. Temperature and Rainfall

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 (**Figure 5**). 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. 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.

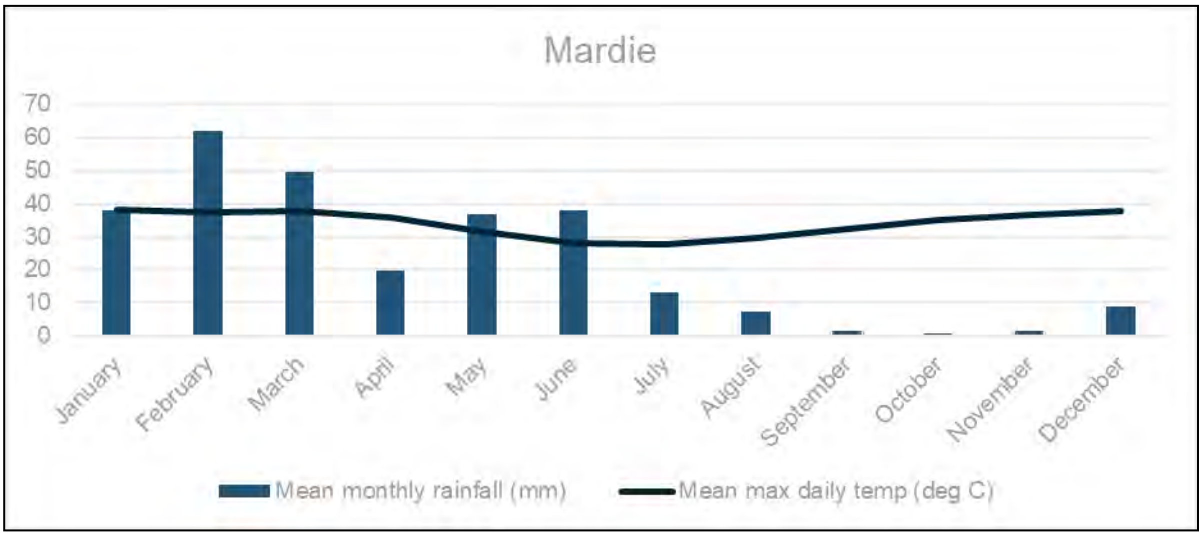


Figure 5: Climate Statistics for Mardie (BOM)

2.1.3. Tropical Cyclones and Storm Surge

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.

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.

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.

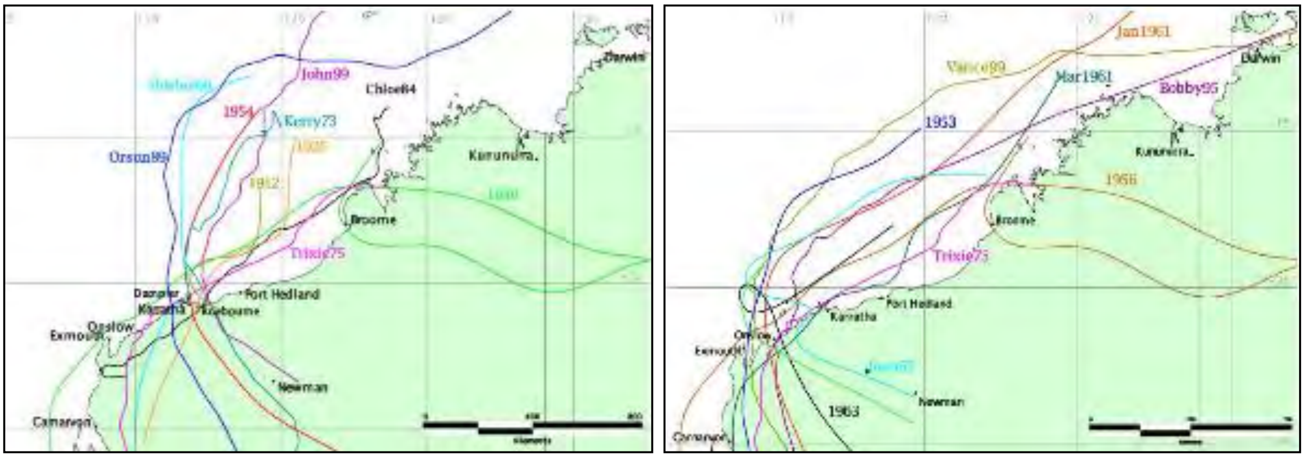


Figure 6: Tracks of notable cyclones impacting Karratha (left) and Onslow (right)

2.2. Coastal

2.2.1. Bathymetry

The offshore components of the Mardie Project (jetty and dredge channel) are situated in an area shown as unsurveyed on marine charts (**Figure 3**). Mardie Minerals has conducted several detailed bathymetric studies over the previously unsurveyed area, as well as surrounding areas to verify chart soundings (e.g. Surrich Hydrographics 2019). The jetty will extend from the shoreline at approximately +1.5 mLAT, out to an area at 0 mLAT (**Figure 7**). The berth pocket at the end of the jetty has a design depth of -6.7 mLAT and the dredge channel -3.9 mLAT.

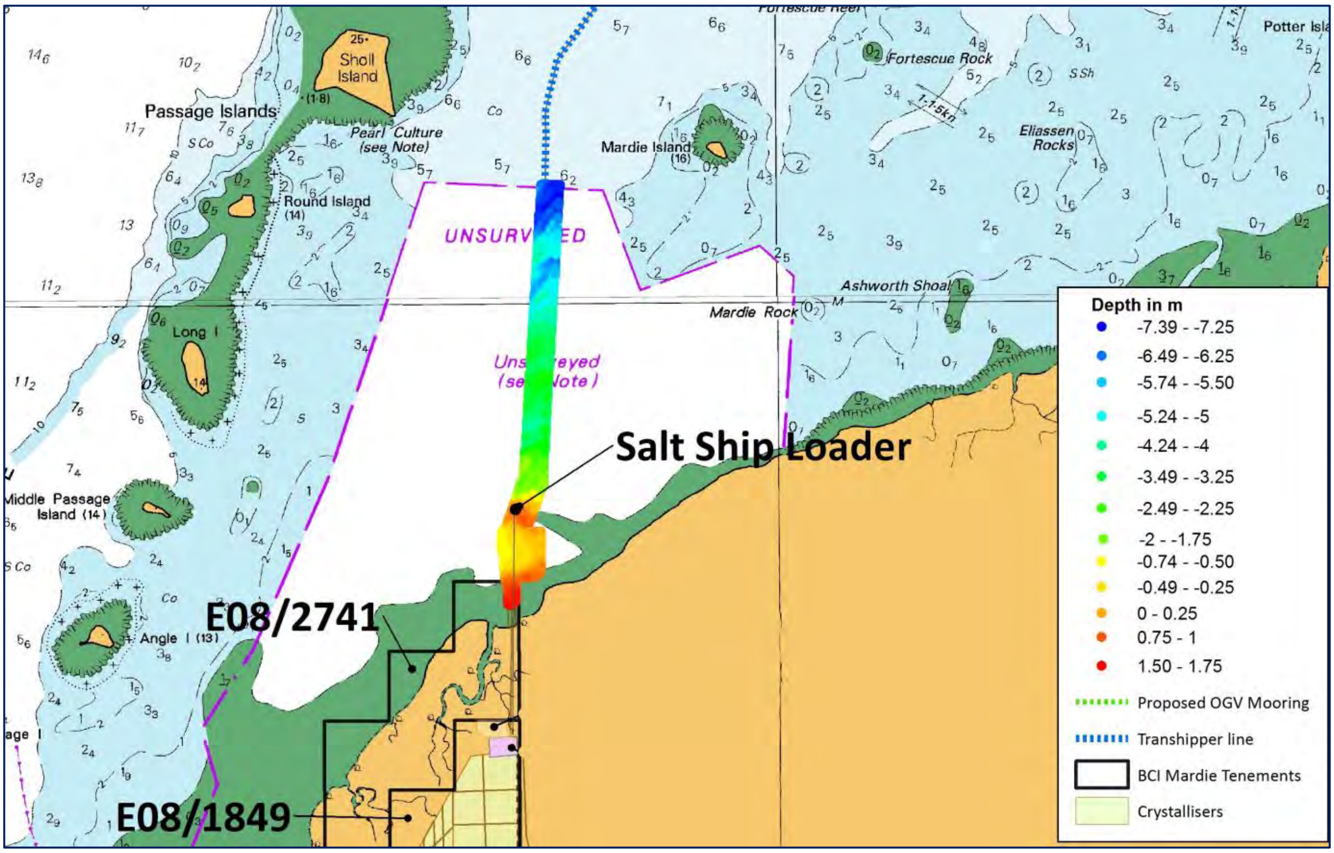


Figure 7: Bathymetry of jetty and dredge channel

2.2.2. Tides

The Mardie project location experiences a semi-diurnal tide (two highs and two lows a day) and the tidal planes have been defined by the National Tide Centre (NTC) based on field measurements completed for the project in late 2018 (O2 Marine 2020). The Mardi Gauge (MardiLAT18) datum definition completed by the NTC shows that the offset between LAT and MSL is 2.75 m, and the total tidal range is 5.185 m. The mean tide range is 3.6 m in springs and 1 m in neaps.

Measured data from an inshore Aquadopp in November 2018 (**Figure 8**) illustrates water level time series through the spring and neap cycles. It is noted that the instrument could not measure tide levels below -2 m MSL.

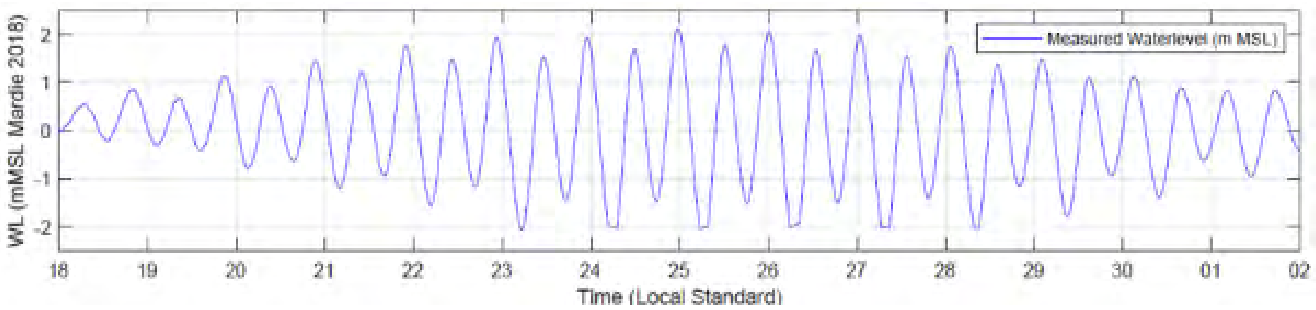


Figure 8: Measured water level data from inshore Aquadopp location November 2018

2.2.3. Waves

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 south to 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 9**.

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 form 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 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.

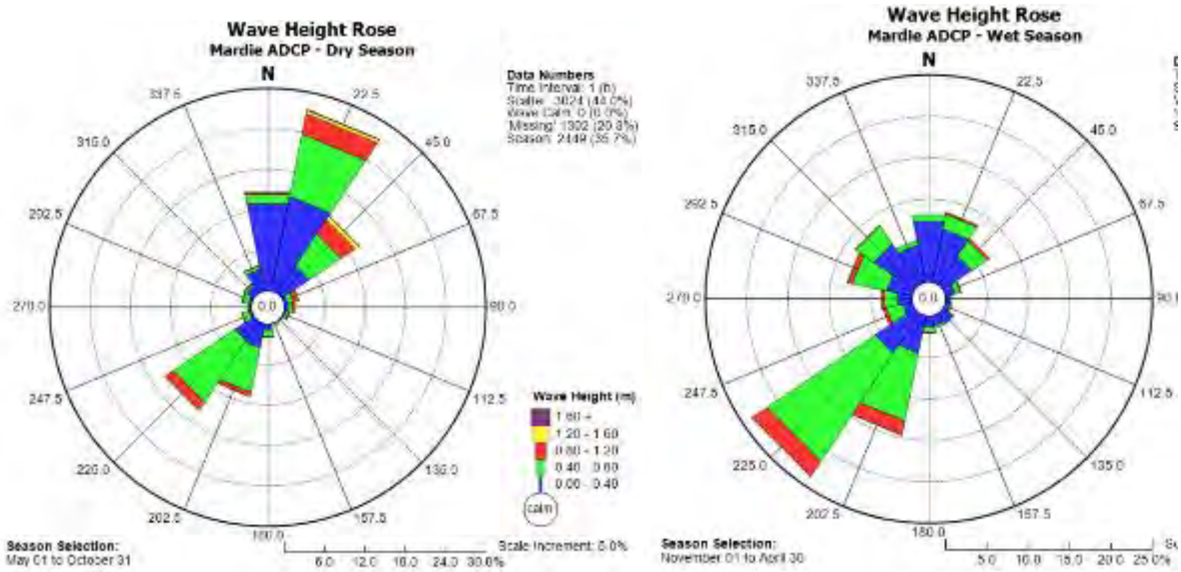


Figure 9: Wave conditions offshore of the Mardie Proposal location for Dry Season months (left) and Wet Season Months (right) based on measured data April 2018 – January 2019

2.3. Substrate and BCH

The project area is located in shallow (<6 m) nearshore waters located approximately 5 km offshore, north from the Mardie Coastline and southwest from the Fortescue River-mouth. The seafloor in this area is generally comprised of unconsolidated silt, sand and gravel.

O2 Marine (2019b) identified the nearshore subtidal zone to support benthic primary producers such as sparse patches of macroalgae, seagrass and corals (**Table 3** and **Figure 10**). The majority of the subtidal benthic substrata is abiotic, characterised by bare sand and silt with limited limestone pavement and ridges. Many of the limestone ridges also occur around the offshore islands and support assemblages of macroalgae, corals and sponges. Whilst the extensive subsea plains of sand/silt are often bare of any sessile mega-benthic taxa (such as coral and macroalgae), these habitats do support smaller infaunal species and surface-dwelling echinoderms and filter feeders such as hydroids.

Table 3: BCH classes recorded at Mardie (O2 Marine 2019b)

BCH Class	Description	Example Image
Bare / bioturbated sand	**Bare Silt / Sand** Typically comprises of silt or sand with no or occasional very sparse macroalgae. Silt areas often comprised of bioturbation (burrows formed by living organisms). Sand areas often contain traces of shell grit. This habitat comprises 89% of the mapped subtidal BCH and is also widely dispersed across the region.	
	Sand / Sparse (<5%) Macroalgae Fine silt/sand and bioturbated bedform with a very patchy distribution of macroalgae and invertebrates. Macroalgae (*Phaeophyta*) was the dominant cover, but was very sparse, generally comprising <1% of the overall cover. Class was differentiated from the other macroalgal classes due to the very sparse nature of the cover and the much finer grained, and often bioturbated sediments. This habitat comprises 1% of the mapped subtidal BCH. It was also observed on the eastern fringing waters of Round Island, whilst the largest contiguous area was observed closer to the mainland in the shallow waters between Angle Island and the mainland.	
Filter feeder/ macroalgae/ seagrass	**Sand / Sparse (<5%) Filter Feeders** Sparse filter feeder habitat occurs where the relief is flat and is associated with fine to coarse sands. Although only present in sparse densities (<5% cover), hydroids are most common where there is no bedform, whilst sponges occur where there is some bioturbation. This habitat comprises 2% of the mapped subtidal BCH and is widely dispersed throughout the region.	

BCH Class	Description	Example Image
Filter feeder/ macroalgae/ seagrass	**Low (5-10%) Cover Macroalgae / Filter Feeders** Flat to low relief constituting either fine to coarse sands, including shell grit on occasions. Macroalgae, hydrozoan and sponge species are equally dispersed throughout this habitat although benthic cover is low (3-10%). Occasional very sparse (<1%) cover of *Halophila* sp. seagrass was also observed at some locations. This habitat comprises 6% of the mapped subtidal BCH and follows a patchy distribution throughout the region. This habitat was also observed in small patches fringing the shallow waters of Long Island, Mardie Island and close to the mainland.	
Coral/ macroalgae	**Low (5-10%) Cover Coral** Flat to low relief rock and rubble with coarse sand. Low (3-10%) cover of soft and hard corals, including *Faviidae, Dendrophyllidae, Mussidae and Octocroals*. Sparse macroalgae was also present. This habitat comprises 1% of the mapped subtidal BCH. This habitat was also found fringing Mardie Island and in small isolated patches between Angle Island and the mainland. It was generally recorded in waters between 1-3 m depth.	
	Moderate (10-25%) Cover Coral / Macroalgae Low to moderate relief rock and rubble/coarse sand. Low to moderate cover (3 – 25%) of soft and hard corals with macroalgae. Corals largely consisted of *Faviidae, Poritidae, and Octocorals,* while *Phaeophyceae* dominated the macroalgae communities. This habitat class comprises only 1% of the mapped subtidal BCH. However, it was also recorded in larger areas in fringing shallow waters south of Mardie Island and adjacent to the mainland coast.	

BCH Class	Description	Example Image
Coral/ macroalgae	**Dense (>25%) Cover Macroalgae / Coral / Filter Feeders** This habitat class occurs on low relief substrate with fine to coarse sands and areas of exposed limestone reef. Dense assemblages (>75%) of macroalgae and hydrozoan species predominately in waters at depths of 2.2-4.0 m. This habitat also supported sparse juvenile corals (*Faviidae, Dendrophyllidae, Mussidae)* with occasional larger coral (*Poritidae*) bommies (1–2 m diameter). This habitat class comprised <1% of the mapped subtidal BCH. It was also identified in the waters fringing the eastern outer edge of Long Island, Round Island and Sholl Island.	
	Dense (>25%) Cover Coral Dominated Low relief limestone reef and rubble substrate which supports high coral cover (25-75%) of diverse coral species, including *Faviidae, Dendrophyllidae, Mussidae, Portitidae*, and *Octocoral* species. This habitat class was only recorded at one location and, as such, comprises <1% of the mapped subtidal BCH. However, it was also recorded in a much larger area fringing the northern edge of Mardie Island.	

A total of 79 ha of benthic community habitat (BCH) will be cleared (i.e. directly impacted) by dredging and a further 202 ha is predicted to recover from the dredging operations. This BCH includes 35 ha (cleared) and 133 ha (recoverable) of filter feeder / microalgae / seagrass habitat and 10 ha (cleared) and 103 ha (recoverable) of coral / macroalgae habitat[1].

A baseline sediment assessment of the Mardie Project identified that of the Contaminants of Potential Concern (CoPC) analysed, only arsenic and nickel (95% UCL of mean) concentrations exceeded the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018). However, some concentrations of metals and nutrients were naturally higher than recorded for marine sediment programs in other areas of the Pilbara (O2 Marine, 2019a).

All sediment samples collected within the dredge footprint were non-PASS (O2 Marine, 2019a) and baseline sediment results indicate that dredge sediments are suitable for onshore disposal. As per the

[1] Although seagrass was identified in the impact area, it was present only in extremely low densities (i.e. almost undetectable), making coral the primary benthic community of concern with respect to dredging impacts. Seagrass, macro algae and filter feeder communities will still be monitored, however, these habitats are given less weight when identifying impacts from the proposed dredge activities and will be used to validate predicted impact to BCH.

recommendations of O2 Marine 2019a (Appendix 5-1 the Sediment Quality Assessment Report), a revised site-specific EQC has been developed for the Mardie Project area (refer Table 18 in O2 Marine 2019a).

Sediments will be monitored throughout the dredging and post-dredging operations for the presence of ASS and CoPC (refer to **Section 6.2** for further information). In the event that testing identifies higher risk PASS material is encountered during dredging, then this material will be well mixed with material containing predominantly calcareous materials to ensure that the natural ANC of the marine sediments is sufficient to buffer overall acid generating processes.

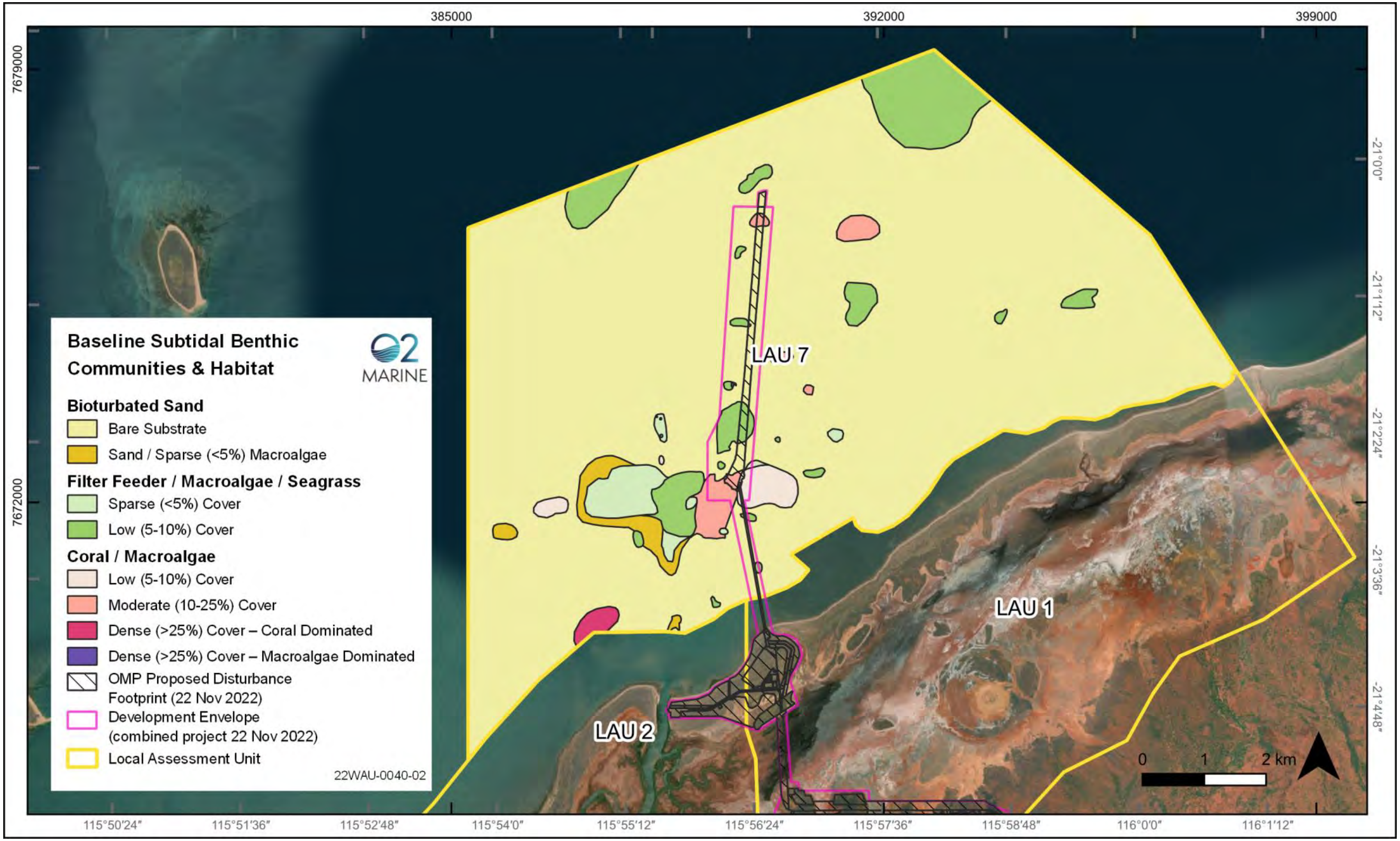


Figure 10: Project Subtidal Benthic Community Habitats (O2 Marine 2019b).

2.4. Marine Water Quality

Nearshore waters typical of this region are characterised by variable turbidity and high sedimentation rates, with associated highly variable light regimes and seawater temperatures. Offshore waters exhibit fewer extremes in the water quality, but still display occasional high levels of sedimentation and turbidity, low light and variable seawater temperatures (Pearce *et al*, 2003).

Light, turbidity, seawater temperature and sedimentation rates are typically weather dependent and show a strong seasonal transition from the dry to the wet seasons. Large daily tidal ranges (>5 m), strong winds (gusts >50 km/h) and increased wave activity (such as associated with cyclonic activity) can impact background conditions resulting in increased turbidity (in the form of increase suspended sediment concentration (SSC) due to coastal runoff and wind/wave driven sediment resuspension. In summary, waters in the vicinity of the project area are subject to naturally elevated levels of turbidity and a reduced light climate heavily influenced by discrete weather events (Pearce *et al*, 2003).

O2 Marine (2020a) identified the following from marine water quality baseline studies conducted at the Mardie Project study area.

- Salinity levels recorded a median value of 37.5 ppt, and appeared to be indicative of a sheltered bay, which was thought to be due to the influence of the Passage Islands which act as a natural barrier and appear to restrict mixing with lower salinity oceanic waters;
- Turbidity and SSC were found to be higher at the inshore monitoring location than at the offshore location, which is consistent with other Pilbara water quality investigations (Jones *et al*. 2019; MScience 2009; Pearce 2003);
- Derived Daily light Integral (DLI) around the coastal islands was highest during wet season and lowest during the dry season and correlated with seasonal change in solar elevation angle, which is a primary factor influencing the amount of available benthic light in these areas. Conversely, DLI was low year-round at the inshore location (i.e., dredging area). Factors influencing benthic light levels are different between the islands and dredging area. However, the lowest light levels in both areas corresponded closely with high SSC and turbidity levels, associated with the passing of several Tropical Cyclones and low-pressure systems over the sampling period;
- Importantly, the recently published WAMSI (Jones *et al*. 2019) SSC and DLI thresholds for *possible* and *probable* effects on coral were found to be poorly suited as criteria for monitoring dredging effects in the Mardie Project area. Frequent natural exceedances of SSC and DLI thresholds indicates that these thresholds are unsuitable for use as water quality and dredge activity monitoring criteria in the Mardie Project area. It is noted that Jones *et al.* (2019) recognises these potential limitations of the thresholds and advises that WAMSI is in the process of developing thresholds for turbid water coral communities. Once these new turbid water thresholds are available, they should be evaluated against the baseline data collected in this program and as part of the pre-dredging baseline to determine suitability for use in dredge monitoring;
- Laboratory analysis of marine water samples showed no evidence of contamination and the current allocation of maximum and high levels of ecological protection are appropriate for the marine waters of the Mardie Project area.

2.5. Marine Fauna

O2 Marine (2020d) undertook an assessment of the likelihood of occurrence for threatened marine mammal species identified through the desktop review, based on the list of species provided in the ESD (Preston, 2018).

Listed threatened marine mammals with high potential to occur or are known to occur off the Mardie coast (on occasion) include:

- Marine Mammals:
  - Humpback whale (*Megaptera novaeangliae*);
  - Dugong (*Dugong dugong*); and
  - Australian humpback dolphin (*Sousa sahulensis*).
- Marine Turtles:
  - Loggerhead turtle (*Caretta caretta);*
  - Green turtle (*Chelonia mydas*); and
  - Flatback turtle (*Eretmochelys imbricate*)
- Elasmobranch:
  - Green sawfish (*Pristis zijsron)*

Ecological windows for key species are presented in **Table 4** with a description of marine fauna presented below.

2.5.1. Marine Mammals

Humpback Whale

Humpback whales migrate annually from Antarctic feeding grounds to the Kimberley coast for calving during the winter. Humpback whales predominantly occur offshore in open oceanic environments. However, they are known to stopover in the lee of the offshore islands and have been observed on several occasions during the humpback southerly migration, within 5 km of the Mardie Project Marine Development Envelope, by O2M staff in 2018. The southern migration is the period when they are closest to shore at an average of 36 km, with the peak occurring between August and September in the Mardie region. The Project area is a shallow embayment (i.e., generally <5m deep) and could not be considered critical habitat for any whale species.

Dugong

Dugong (*Dugong dugong*) are found throughout the Pilbara region, particularly close to the coast or in the lee of reef-fringed islands and often in areas where seagrass has previously been recorded. Although dugong have been previously recorded in the nearshore waters of the Mardie coastline, the nearest known dugong aggregations have been recorded near Cape Preston in the North and Coolgra Point in the South, generally in areas that consistently support extensive seagrass meadows (O2 Marine, 2020d).

No dugong were observed in the waters around Mardie during over 700 hours of vessel-based observations. O2 Marine (2020d) concluded that this was most likely due to the lower value of the subtidal BCH in the area as suitable feeding or foraging habitat for dugong. However, surveys for seagrass (and dugong) were not undertaken during peak seagrass season (October-December). Nevertheless, dugong may be present in the Project area and management measures have taken the precautionary approach that consider impacts to this species.

Australian Humpback Dolphin

The Australian humpback dolphin was the only conservation significant species known to occur in the Project area, with records of Australian humpback dolphins (*Sousa sahulensis)* reported throughout the year at the Montebello Islands (Raudino *et al* 2018) and in the Mardie Project area. They are likely to be one of the most common dolphin species occurring in the Project area. This species together with the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) are likely to be the most abundant dolphin species in the Mardie Project area inside the 20 m isobath.

2.5.2. Marine Reptiles

Turtles

Only a small part of potential marine turtle nesting beach lies within the development envelopes, a narrow section of the beach labelled as 'Mardie Creek East'. The Pendoley Environmental (2019) survey identified only very minor nesting effort by flatback turtles (*Natator depressus)* and a single hawksbill turtle (*Eretmochelys imbricata*), along the 15 km stretch of coastline to the east of the creek. These results indicated that the mainland beaches are not currently a regionally important rookery. The results of the temperature loggers also confirmed that mainland beaches were significantly warmer than the offshore islands, impacting the success rate of any marine turtle nests on these beaches. More recently the Pendoley Environmental Pre-construction survey (2022) found that the marine turtle nesting activity was greatest on Sholl and Long islands, which accounted for 71% of all tracks. With the exception of the single hawksbill nest recorded on the mainland in December during the 2018/18 survey (albeit past the peak of the hawksbill nesting season), turtles nested most successfully on the offshore islands during both the 2018/19 and 2021/22 surveys (Pendoley Environmental, 2019; 2022).

During the 2021/22 survey the number of nesting flatback nesting females routinely monitored was estimated to be 90 (Pendoley Environmental, 2022), which is similar to the 2018/19 results of 50 turtles each for Sholl and Long island (Pendoley Environmental, 2019). Hawksbill turtles were as similarly represented in the October survey as they were in the December survey. Green turtle nesting activity was greatest in December, but minor compared to the nesting of the flatback and hawksbill turtles during the survey period (Pendoley Environmental, 2022). Over the survey period there was no recorded green turtle activity on the mainland, due to the lack of nesting site conditions favoured by green turtles, which include clear sandy seabeds, a deep-water approach and deep sand (>1 m) on nesting beaches (Pendoley Environmental, 2022).

Mean hatch success of flatback clutches was greater in 2021/22 (65%) than 2018/19 (49%), as was emergence success (56% in 2021/22 compared to 42% in 2018/19; Pendoley Environmental, 2019;2022). During the 2021/22 survey events 50% of the marked nests were lost due to erosion or changes in the shape of the sand pit. A further 14% were inundated during spring high tides and resulted in very low hatch success rates (Pendoley Environmental, 2022). Variation in nesting success may be related to the varying nesting habitat characteristics between the island and mainland monitoring sites. For example, the island sites featured a wide supratidal zone, a well-defined primary dune, and fine-medium grained sand size that may have facilitated the successful deposition of a clutch, whereas the mainland sites featured a narrow supratidal zone, little or no primary dune development, and medium-coarse grained sand size that may have hindered successful clutch deposition.

The main species recorded on the offshore islands was flatbacks, with relatively less nesting effort seen for hawksbill and green turtles at the same locations (Pendoley Environmental, 2019; 2022). The snapshot monitoring data from Round, Middle, and Angle islands confirmed similar species composition and abundance at these sites. These results are consistent with turtle activity throughout the Pilbara where Flatback and Hawksbill nesting is dominant on nearshore island habitat, and Flatback turtles are the most common mainland nesting species (Pendoley et al., 2016).

Baseline artificial light results found the overhead skies at the Proposal are typically very dark and representative of pristine, natural dark skies unaffected by artificial light. The only light source visible from all mainland and offshore light monitoring sites was the Sino Iron facilities located over 30 km away on the easterly horizon. However, artificial lighting is considered to have an impact on marine turtles and will be managed using the Mardie Project Illumination Plan.

Seasnakes

The short-nosed sea snake (*Aipysurus apraefrontalis*) has not been previously recorded in the Mardie Project area. This species is typically found in coral reef habitats, which in the waters of the Project area are largely confined to the nearshore islands with fringing coral reefs and/or isolated reef patches. However, recent modelling and surveys undertaken by have found the species may utilise nearshore habitats (Udyawer et al. 2020). Therefore, the project has the potential to impact the habitat of this species and the precautionary approach has been applied for the species

2.5.3. Elasmobranchs

Sawfish

The Northwest Marine Region is considered a particularly important area for two sawfish species, green sawfish (*Pristis zijsron*) and freshwater sawfish (*Pristis pristis*) because the region and adjacent inshore coastal waters and riverine environments contain nationally and globally significant populations of sawfish species (DSEWPaC 2012). However, relatively little is known about the distribution and abundance of sawfish species in north-western Australia (Morgan, 2011).

Green sawfish occupy estuaries, mangrove creeks and river mouths for their first few years of life (Morgan et al. 2015, 2017). In the Pilbara, green sawfish are known to utilise the mouths of major river systems as pupping and nursey areas (i.e., Ashburton River), before juveniles migrate into adjacent creeks at approximately 3 to 6 months old, and then further offshore to mature at a length of about 3 m (Morgan, 2011). Pupping normally occurs in the tidal creeks between September to October, however the Project area is unlikely to represent a nursery site based on recent field surveys (Morgan et al 2022).

The Mardie coastline contains creeks, mangroves and rivers which is suitable habitat for the green sawfish. No sawfish recorded during the recent sawfish survey completed within the Proposal by Murdoch University and O2 Marine (Lear and Morgan 2022). The habitats surveyed included mangrove creeks and mudflats, which are known sawfish habitats and are similar to habitats where sawfish are found elsewhere in the region. The lack of sawfish recorded in this study indicates that the area is not likely a major habitat or a pupping ground for any species of sawfish. The occasional sightings of Green Sawfish in the general region and abundance of this species in nearby nursery habitats (e.g., Ashburton River) suggests that this area is likely an occasional foraging habitat along the migratory corridor for juvenile and sub-adult. Freshwater sawfish are known migrate along this coastline, with several sightings of adult freshwater sawfish in this region and to the south of the study site that all were likely originally pupped in the Fitzroy River region of the Kimberley. Previous research has suggested that juvenile sawfish do not readily migrate past solid barriers along the coastline which would force them to swim into deeper water (D. Morgan and K. Lear, unpublished data; Lear and Morgan, 2022).

Acoustic tracking of green sawfish from the Ashburton showed that the species does not travel more than 700m upstream from the mouth of the river. In the Western Pilbara they are assumed to be present in all tidal creeks. In the Project area larger systems are represented by the Robe River and Fortescue River. Green sawfish are currently known from Exmouth Gulf, Whim Creek, Beagle Bay, Pender Bay, King Sound in WA. Tidal mangrove systems, river estuaries, and rivers of the King Sound provide ideal nursery habitat for juveniles <0.5m (Whitty et al, 2011 and Whitty, 2017, Elhassan 2018).

Manta Rays

Manta ray presence has been recorded within the waters of the Proposal area. As these records are not from targeted studies, the species are unidentified and there is no data to determine occupancy rates or abundance. Based on their general ecology, it is reasonable to assume that the species recorded is more likely to be the reef manta ray (*Mobula alfredi*), rather than the giant manta ray (*Mobula birostris*). In contrast to the pelagic giant manta ray, reef manta rays have a more localised distribution and inhabit shallower waters closer to the coast. Reef manta rays are distributed throughout the Pacific and Indian Ocean. The Australian distribution is ~30°S on the east and west coastlines, with a continuous distribution north from Shark Bay (WA) (26°S) to the Solitary Island Marine Park (NSW) (26°S) (Armstrong et al. 2020). Giant manta rays are found throughout the Atlantic, Pacific and Indian Oceans, in tropical, subtropical, and temperate waters (Armstrong et al. 2020a). Information on the global distribution of giant manta rays and their population sizes is lacking. Manta ray are filter feeders (Couturier et al. 2012) and therefore are potentially at risk from the proposal if water quality is not adequately managed and therefore potentially impacting the food web which supports them.

2.5.4. Commercial Fisheries Species

Bluespotted Emperor

Bluespotted emperor (*Lethrinus punctulatus*) is endemic to north-western Australia and found in the waters off WA from Geraldton to the Kimberly region, with some occurrences in the NT. The Pilbara region has the highest relative abundance of the bluespotted emperor, with commercial catch of this species concentrated across the continental shelf from 115°E to 120°E, being a major component of the catch of the Pilbara Fish Trawl Fishery (Newman et al. 2004). Spawning and nursey areas of the species are thought to be restricted to the west Pilbara, being the area from which the species disperse more widely from (Newman et al. 2020). Juvenile phase for the bluespotted emperors is directly associated with inshore macroalgae beds, often in water depths less than 10 m (DPIRD Draft Report, *unpublished*). Two cohorts per year are recruited in the inshore macroalgae beds in the Dampier Archipelago, with the biannual recruitment corresponding with the biannual peaks in spawning (DPIRD Draft Report, *unpublished*). Adult bluespotted emperors in the western Pilbara have high abundance in the continental shelf waters adjacent to large expanses of inshore macroalgae beds. The adults are also found in coral reef or lagoon habitats, over hard coral, gravel, or rubble substrates (DPIRD Draft Report, *unpublished*; Harvey et al. 2021).

Western King Prawn

Western king prawns are distributed throughout the temperate, subtropical, and tropical waters of Australia. The species occurs from SA, WA, NT, Queensland (QLD) and northern New South Wales (NSW) (Grey et al. 1983). Spawning occurs in offshore waters, with post-larval and juvenile western king prawns occupying shallow waters, often in shallow tidal flats with sand or mud substrate. They are often associated with mangrove habitats and seagrass beds. Juveniles can inhabit areas with higher salinity. Juvenile western king prawns spend about three to six months in the nursery grounds before they reach maturity and migrate offshore, entering the trawl fishing grounds (Penn and Stalker 1979). This migration takes place in April/May of each year and spawning occurs from August to May, with juveniles present in shallow embayments from September to April, with peak abundance in January.

Brown Tiger Prawn

Brown tiger prawns are generally regarded as endemic to Australia and are distributed around the northern coast, from central NSW in the east to Shark Bay in WA. They are found in tropical and subtropical waters (Ward et al. 2006). Brown tiger prawns spawn in offshore waters, and post-larval brown tiger prawns occupy shallow seagrass and algal communities, generally in water less than 2 m deep (Ovenden et al. 2007). Juvenile brown tiger prawns are generally found in dense patches of seagrass, with higher densities of juveniles found in seagrass beds that are in close proximity to mangroves. Tiger prawn recruitment and landings are significantly correlated with macroalgae and seagrass bed cover (Loneragan et al. 2013). Larger juveniles and adult brown tiger prawns are less dependent on seagrass and macroalgal beds, with larger juveniles moving further offshore into deeper waters, and adults often being found over mud or sand substrates in waters less than 30 m depth. Most spawning females are found in water 13 to 20 m deep (Kangas and Sporer 2015).

Table 4: Ecological windows (Dark blue represents full duration of presence, light blue represents timing of specific behaviour)

Species presence	J	F	M	A	M	J	J	A	S	O	N	D	Data Source
Dugong													DoE (2022)
Australian humpback dolphin													Raudino et al 2018; Hanf et al. (2022)
Indo Pacific bottlenose dolphin													Hanf et al. (2022)
Humpback whale													Irvine et al. (2018), Jenner et al. (2010)
- Northward migration													Jenner et al. (2010)
- Southward migration													Jenner et al. (2010)
- Southward peak calves													Irvine et al. (2018); Jenner et al. (2010)
Flatback turtle													DoEE (2017)
- Foraging													DoEE (2017)
- Nesting and inter-nesting													DoEE (2017)
-Peak nesting													DoEE (2017); Pendoley Environmental (2022)
Green turtle													DoEE (2017)
- Foraging													DoEE (2017)
- Nesting and inter-nesting													DoEE (2017)
-Peak nesting													DoEE (2017); Pendoley Environmental (2022)
Hawksbill turtle													DoEE (2017)
- Foraging													DoEE (2017)
- Nesting and inter-nesting													DoEE (2017)
-Peak nesting													DoEE (2017); Pendoley Environmental (2022)
Green sawfish[1]													Morgan et al. (2015); Morgan et al. (2017); Lear and Morgan (2022)
Reef manta ray													Armstrong et al. (2020a);(2020b)
Giant manta ray													Armstrong et al. (2020a); (2020b)
Coral spawning[2]													Gilmour et al. (2016)

[1] Sawfish pupping occurs before the wet season in northern WA, green sawfish pupping occurs during Spring to early Summer (late dry season and pre-cyclone season). Evidence from the Mardie Sawfish Report suggests that the Project area is not a major nursey or pupping ground. It is likely that the Proposal area is part of the migratory corridor for juvenile-subadult green sawfish. Further surveys are required to determine the timing and migratory footprint for sawfish (Lear and Morgan 2022) and therefore the assumption is that they could possibly be present at any time.

[2] Subtidal BCH identified families Faviidae, Acroporidae, Merulinidae, Poritidae, Dendrophyliidae, and was generally dominated by *Turbinaria sp*. and Faviidae family (*Favites, Favia, Cyphastrea spp.*) with occasional larger >1m diameter Poritid bommies (O2 Marine 2019b). Non-*Acropora* species in the Pilbara primary spawning period is autumn (peak in March), with the potential for spring spawning (October-December). *Acropora* species in the Pilbara spawning occurs predominately in autumn. Brooding corals have not yet been investigated in the Pilbara and probably occurs over several months through spring to autumn, and possibly into winter months (Gilmour et al.2016). *Porites* in the Pilbara region spawn during the summer months (Gilmour et al. 2016).

3. Dredging Program

3.1. Scope of Works

The scope of dredging elements of the Project includes:

1. Mobilisation and installation of dredge equipment including a Cutter Suction Dredge (CSD) and a seabed leveller (Plough, Beam, Rake) that is towed behind a small tug or multicat
2. Mobilisation and installation of all pipeline (floating/submerged and land based) including required booster stations in order to discharge all of the dredge materials recovered by the CSD to the onshore dredge material disposal area
3. Preparation of the onshore dredge material disposal area;
4. Testing sediments prior, during and post dredging
5. Dredging of the Berth Pocket and pumping of dredged materials to the onshore dredge material disposal area;
6. Dredging of the approach channel and pumping of dredged materials to the onshore dredge material disposal area;
7. Sea bed levelling to even irregularities in the seabed, including those created by the dredging process. Material is not removed but relocated within the development envelope.
8. Dredged materials handling at the onshore dredge material disposal area as required;
9. Pre- and post-dredge hydrographic survey(s); and
10. Demobilisation and site clearance upon completion of the Works.

3.2. Sequence of Works

The project allows for dredging works to be carried out 24 hours per day, 7 days per week, during suitable weather conditions. The planned project sequence is as follows:

1. Equipment preparation, inspection, certification prior to departing for site;
2. Preparation of all relevant detailed management plans to ensure compliance with conditions and specifications;
3. Pre-dredge hydrographic survey and land survey for the disposal area;
4. Mobilisation of all plant and equipment;
5. Site set-up, including preparation of onshore dredge disposal area;
6. Commence and complete dredging of access channel and berth pocket, and disposal of dredged materials;
7. Progressive hand-over hydrographic surveys for each section;
8. Final land-survey of “as-placed” dredged materials;
9. Demobilisation and site clearing.

3.3. Preliminary Construction Schedule

Under the current project schedule, dredging construction activities are planned to commence in accordance with this plan as soon as practicable once all required internal and external approvals are granted. Dredging and onshore spoil disposal is proposed to be undertaken over a period of between 10 and 18 months (weather-dependent). A preliminary project schedule is presented in **Table 5**.

Table 5: Preliminary project construction schedule

Project Schedule Milestone	Estimated Duration
Project Preliminaries	6 weeks
Mobilisation & Installation	17 weeks
Dredging and spoil disposal	30 - 40 weeks (weather and environmental window dependent)
Final land survey	2 weeks
Demobilisation and site clearance	5 weeks

3.3.1. Ecological Windows

The following measures will be applied during key ecological windows (refer **Table 4**):

- Dredging will not occur at any time over a period extending from 3 days before until 7 days after the predicted night of a coral mass spawning.
- Dredging will avoid the turtle nesting, hatching and post-hatching window (October-March).
- Dedicated MFOs will be used during the southern migration of humpback whales (July - November) (refer to Section 7.3.2 for description for dedicated MFO). During the southern migration, humpback whale mother-calf pairs are most likely to utilise inshore waters thus representing the most sensitive time where they could be impacted by dredging activities.
- During all periods of dredging, appropriate mitigation measures for low visibility condition (e.g., dusk to dawn) will be applied (refer Section 7.3.2).

3.4. Pre and Post Dredge Hydrographic Survey(s)

Each identified dredge section (separable portion) within the dredging program will have an individual pre-dredge hydrographic survey performed to determine as accurately as possible the total volume which is to be removed. Upon completion of dredging in each section, a post-dredging hydrographic survey will be carried out to determine if the specifications for that section has been met. Both surveys (pre- and post) will serve to calculate the final volumes removed.

3.5. Dredging Methodology

3.5.1. Dredging Operations

Dredging of the proposed transhipment approach channel, turning basin and berthing pocket for the project will most likely be conducted using conventional marine dredging plant and equipment such as a Cutter Suction Dredger (CSD) pumping via submerged or floating pipeline to the onshore dredge material disposal area.

Dredging would commence at the southern limit of the proposed access channel (within the approved disturbance envelope) working towards the jetty berth, with the channel dredging to occur once the turning basin has been completed.

A CSD (**Figure 11**) is typically a stationary dredge and consists of a U-shaped pontoon, which is held in position by a fixed spud and two anchors.

The soil is loosened by rotating a cutting head (the “cutter”). The cutter head, which is hydraulically driven, encloses the suction intake of a centrifugal dredge pump. The cutter head is mounted at the extremity of a fabricated steel structure (the ‘ladder’), which is attached to the main hull by heavy hinges, enabling rotation in the vertical plane. The ladder assembly is lowered and raised by means of the ladder winch controlled from the operator’s cabin.

During the dredging activities, the CSD swings around the main spud with the help of its side winches. The operation of the cutter section consists of cutting the seabed with the cutter head and pumping the mixture of water and materials by means of the centrifugal pump into the suction mouth.

The anchors, to achieve this movement, will be placed in such a manner to minimise intermediate relocation. The total area which a dredge can cover without re-locating its anchors is called the “cut”. Depending on the width and length of the dredge area, several “cuts” might be needed. Each “cut” will then have an overlap with another cut to cover the entire dredge area

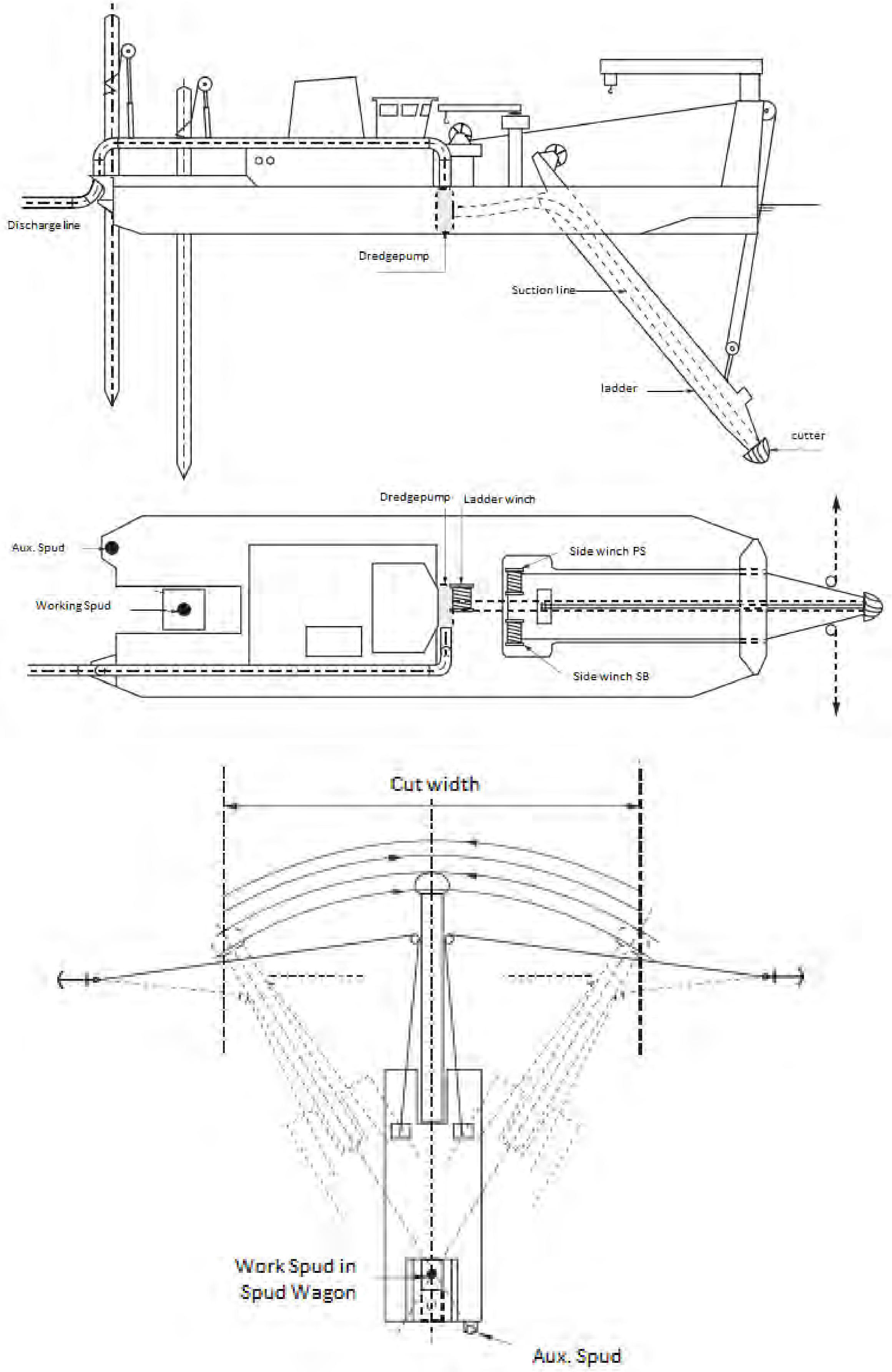


Figure 11: Example of a Cutter Suction Dredge proposed for Project dredging.

After loosening and suction, the soil is pumped through a floating and/or submersed pipeline, which is connected to the rear end of the CSD, to the allocated dredge material disposal area.

To enable the dredged materials to be transported hydraulically over a length of approximately 5-6 km and to generate a constant flow of material in the pipeline, floating and onshore booster stations will be installed at various locations. The positioning of the boosters are important to guarantee a stable system and to maintain a minimum required pressure level throughout the pipeline alignment.

The total length of the pipeline, the diameter of the pipeline, the constitution of the material transported and the capacity of the CSD determine the capacity and locations of the required booster stations.

Seabed leveling will be conducted by a plough or similar array, towed behind a small tug or multicat where dredging operations cannot be completed (due to pumping limitations) and once dredge operations are completed. The bed leveller will even irregularities on the seabed including those created by the CSD. This process relocates material within the development envelope as opposed to material removal outside of the navigable area. Relocation of seabed leveling material is typically within a short distance of the dredge disturbance area due to the low speed of the operation (~1-2 knots).

Pre dredging, dredging and post dredging operations will require fauna observations. The monitoring protocols and procedures have been informed by underwater acoustic modelling to determine appropriate exclusion areas around the noise-making activities (Talis, 2019). No Temporary Threshold Shift (TTS) in significant marine fauna is expected from dredging activities, only behavioural response; therefore the proposed exclusion zones are conservative and based on limiting behavioural response where possible. The monitoring and management actions required to protect marine fauna from project dredging activities are outlined in **Table 11** and **Section 7.1.4**.

3.6. Dredge Plume Modelling

Baird Australia Pty Ltd was engaged to undertake dredge plume modelling in relation to the proposed dredge scope at Mardie. The objectives of the modelling were to:

1. Determine the location, extent and duration of a potential dredge plumes;
2. Model realistic sediment plume outputs over the proposed dredge period relevant to the scale of the dredging (including potential worst-case impact scenarios) to guide appropriate management (discussed in this document); and
3. Assess the likely dredge plume impact in relation to turbidity on biota and BCH.

The results of the dredge plume modelling were used to inform the monitoring and management programs for Marine Water Quality and Benthic Communities and Habitat, which are defined in **Section 7**. The results of the modelling are presented in **Figure 12**.

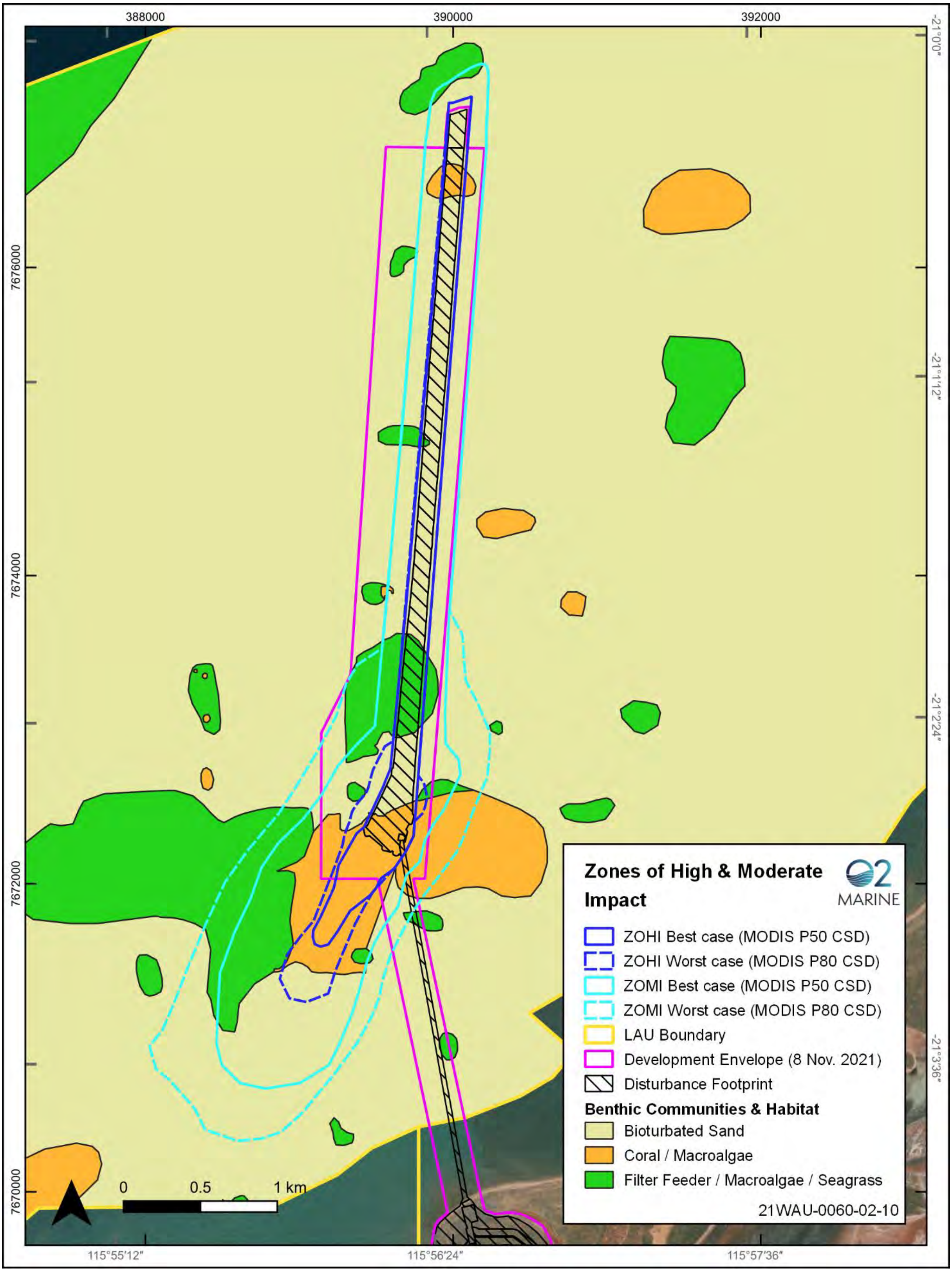


Figure 12: Zones of High and Moderate Impact for best and worst case based on Baird (2022) hydrodynamic modelling

3.7. Onshore Spoil Disposal

Dredge material will be pumped through a floating or submerged pipeline from the dredge site to the spoil disposal area (**Figure 17**) where the spoil will be utilised to extend and raise the port stockyard area. No dredge material will be disposed of offshore.

3.7.1. Spoil Area

The area in which the dredge material will be disposed (the Spoil Disposal Area, SDA), is located along the southern side of the salt stockyard, where it is intended to establish the salt wash plant, stockpiles and reclaimers for the Mardie Project. The dredge material will be used to support the raising of the salt stockyard area from its current level to an even basement of 4.2 mAHD.

Bund design

The containment cells will be designed, constructed and operated to provide adequate initial storage capacity and surface area to hold the dredged materials during the filling operations and to retain the suspended solids so that the quality of discharged decant water will meet the criteria provided in **Table 20**.

Bund walls will be constructed with stable slopes to a minimum height of 5.0 mAHD, which will allow dredge material to consolidate, while maintaining adequate capacity for water management as well as minimum 300 mm freeboard for storm events. The walls will initially use locally competent materials but may be supplemented with suitable dredge material already within the containment cells for bund wall raises. Bund walls along the southern side of the SDA that may encounter intertidal flows will be appropriately armoured with erosion-resistant material such as gravels and rocks overlying a geomembrane layer. Bund walls will be suitably maintained throughout the dredging phase and until covered with natural material. Those armoured bund walls that will remain throughout the project life will also be properly maintained over that period.

Management and Monitoring of PASS Risk

All sediment samples collected within the dredge footprint recorded no potential acid sulfate soils (PASS) (O2 Marine, 2019a). Therefore, baseline sediment results indicate that dredge sediments reflect natural background conditions and are suitable for onshore disposal.

To ensure the baseline assessment is appropriate, dredge materials will be tested weekly for PASS. In the unlikely event that higher risk PASS material are encountered during dredge spoil placement, the material will be well mixed with other spoil containing predominantly calcareous materials to ensure that the natural ANC of the marine sediments is sufficient to buffer any acid generating processes of the higher risk material. Monitoring of the sediments and water from the disposal area is discussed in **Section 7.4**.

Containment and Closure

Once testing confirms the spoil material is sufficiently consolidated, the containment cells will be capped with competent material and the area used as part of the stockyard development. Remaining risks to groundwater and BCH will be assessed and addressed through the respective Groundwater and BCH Monitoring and Management Plans if considered necessary.

4. Roles and Responsibilities

Table 6: Project Roles and Responsibilities

Position	Responsibility
Proponent (as Principal)	• Overall responsibility for implementation of this DMP. • Overall responsibility for complying with all relevant legislation, standards and guidelines. • Ensures dredging activities are conducted in an environment safe for both site personnel and the public. • Reports on environmental performance for the project to relevant DMAs and to the Key Stakeholders. • Responsible for the implementation of the environmental monitoring programs and inspections. • Prepares environmental monitoring reports. • Responsible for environmental compliance reporting in accordance with Ministerial Conditions (pending). • Responsible for reporting all environmental non-compliance incidents in accordance with Ministerial Conditions (pending).
Dredging Contractor	• Prepares and implements an environmental management plan in accordance with the requirements of this DMP. • Implements the management actions of this DMP. • Ensures adequate training of all staff within its area of responsibility. • Ensures all equipment is adequately maintained and correctly operated. • Responsible for reporting all environmental incidents to Proponent Environmental Advisor within 24 hours in accordance with incident reporting procedures.
All persons involved in the project.	• Comply with the requirements of this DMP. • Comply with all legal requirements under the approvals documents and relevant Acts. • Exercise a Duty of Care to the environment at all times. • Report all environmental incidents.

5. Environmental Factors and Objectives

The key environmental factors and objectives to be managed under this DMP have been derived from the Statement of Environmental Principles, Factors and Objectives (EPA 2018), which outlines objectives aimed at protecting all environments (Themes) including: Sea, Land, Water, Air and People (**Table 7**).

Correspondence provided by the EPA, dated 13 June 2018 (case number CMS17264), outlines that of the environmental factors relevant to the proposal, three factors under theme 'Sea' are of potential significance and are relevant to the dredging scope. As a result, project specific Environmental Protection Outcomes (EPOs) and Management Targets (MT) have been derived for these three factors: Benthic Communities and Habitats; Marine Environmental Water Quality; and Marine Fauna (**Table 8**).

Table 7: Factors and Objectives (EPA 2018).

Theme	Factor	Objective
Sea	Benthic Communities and Habitats	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.
	Coastal Processes	To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.
	Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected.
	Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.
Land	Flora and Vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
	Landforms	To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.
	Subterranean Fauna	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.
	Terrestrial Environmental Quality	To maintain the quality of land and soils so that environmental values are protected.
	Terrestrial Fauna	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Water	Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.
	Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water so that environmental values are protected.
Air	Air Quality	To maintain air quality and minimise emissions so that environmental values are protected.
People	Social Surroundings	To protect social surroundings from significant harm.
	Human Health	To protect human health from significant harm.

Table 8: Potential Environmental Impacts, Environmental Protection Outcomes and Management Targets for Mardie Project.

Environmental Factor	EPA Objective	Potential Environmental Impact Pathway	Environmental Protection Outcome (EPO)	Management Target	Management Measures
Benthic Communities and Habitats	To protect BCH so that biological diversity and ecological integrity are maintained.	• Direct loss of BCH through dredging.	• No irreversible loss of BCH outside of the worst-case ZoHI.	• No irreversible loss of BCH outside of the best-case ZoHI.	**Table 9**
		• Indirect impacts on BCH associated with changes to water quality (increased suspended sediment and/or sedimentation).	• No irreversible loss of BCH outside of the worst-case ZoHI. • No negative change from the baseline state of BCH outside of the worst-case ZoHI and ZoMI.	• No negative change from the baseline state of BCH outside of the best-case ZoHI and ZoMI	
		• Indirect impacts on BCH associated with leaks or spills of hydrocarbons or chemicals.	• No irreversible loss, or serious damage to BCH outside of the worst-case ZoHI.	• Manage vessel bunkering, chemical storage and spill response to minimise impacts to the marine environment.	
		• Indirect impact to BCH health due to Introduced Marine Pests (IMP).	• No irreversible loss, or serious damage to BCH resulting from IMP introduced through project vessels.	• Manage project vessels activities to prevent IMP impacts on the environment.	
Marine Environmental Quality	To maintain the quality of water, sediment and biota so	• Contamination of water resulting from a vessel/hydrocarbon spill (i.e. bunkering operations).	• N/A.	• Manage vessel bunkering, chemical storage and spill response to minimise impacts to the marine environment.	**Table 10**

Environmental Factor	EPA Objective	Potential Environmental Impact Pathway	Environmental Protection Outcome (EPO)	Management Target	Management Measures
	that environmental values are protected.	• Disturbance of contaminants and Potential Acid Sulphate Soils (PASS) during marine construction activities (dredging). • Monitoring of the dredge materials prior to dumping, dewatering and consolidation of onshore disposal runoff into the surrounding terrestrial area, intertidal and subtidal habitats.	• Dredge spoil material will not cause harm to BCH or marine environment quality. • No dredge material will be dumped offshore.	• Assess and manage marine sediment PASS to maintain the quality the marine and land environment. • Assess and manage sediment disposal area to maintain the quality of the marine and land environment. • Minimise potential for failure of dredge transport pipeline and containment bunds.	
Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.	• Disturbance, Injury or death of marine fauna as a result of dredge operations.	• No reported negative impacts of marine fauna attributable to dredging works.	• Manage dredge operations so no injury or death of marine fauna occurs.	**Table 11**
		• Injury or death of marine fauna due to vessel movement (strike).		• Manage vessel speed so no injury or death of marine fauna occurs as a result of vessel strike.	
		• Indirect impacts on marine fauna habitat through decreased water quality.		• Manage dredge activities to minimise turbid plumes as to not impact marine fauna habitats.	
		• Noise impacts from dredging operations		• Manage dredge activities to minimise noise and impacts from noise • Comply with marine noise management procedures EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales	

Environmental Factor	EPA Objective	Potential Environmental Impact Pathway	Environmental Protection Outcome (EPO)	Management Target	Management Measures
		• Disturbance, Injury or death from contaminated water from hydrocarbon spills.		• Manage vessel bunkering, chemical storage and spill response to minimise impacts to marine fauna.	
		• Introduced Marine Pests (IMP) translocation from construction or operational vessels.		• All relevant vessels to comply with Commonwealth Department of Agriculture and Water Resources – Australian Ballast Water Management Requirements.	

6. Management

The potential environmental impacts identified above in **Table 8**, have been assigned monitoring and management actions to measure compliance against the EPOs[2] and MT. Management measures for each environmental factor (EPA, 2018) are detailed below.

6.1. Benthic Communities and habitats

Management proposed to minimise potential impacts on the environmental factor 'Benthic Communities and Habitat' are described in **Table 9**.

Table 9: Management actions to minimise impacts on Benthic Community Habitats

Environmental Factor	Benthic Communities and Habitats
Activity	Capital Dredging and Maintenance Dredging
Potential Impacts	• Direct loss of BCH through dredging (capital and maintenance). • Indirect impacts on BCH associated with changes to water quality (increased suspended sediment and/or sedimentation). • Indirect impacts on BCH associated with leaks or spills of hydrocarbons or chemicals. • Indirect impact to BCH health due to Introduced Marine Pests (IMP).

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
No irreversible loss of BCH outside of the best-case ZoHI.	6.1	• Undertake a HAZID risk assessment with all parties to ensure potential impacts on	• Proponent / Contractor	• Minutes of HAZID	• Prior to commencement of dredging.	• N/A - Completed

[2] EPOs identified in Table 8 are not presented in the following tables as it is assumed that if the MT is achieved then the corresponding EPO will also be achieved.

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
		BCH are known and understood.				
	6.2	• Utilise a satellite-based vessel monitoring system on dredge vessel to ensure no works outside the approved disturbance area.	• Contractor	• Inspection of satellite-based vessel monitoring system. • Daily dredge logs submitted to the proponent throughout construction.	• Prior to and during dredge operations. • Weekly throughout construction	• Cessation of dredging activities; and • Maintenance of tracking system.
No negative change from the baseline state of BCH outside of the best-case ZoHI and ZoMI	6.3	• Monitor dredge operations (duration, intensity, overflow rates etc) to minimise and control SSC where possible.	• Contractor	• Daily dredge logs submitted to the proponent throughout construction.	• Weekly throughout construction	• Modify or cease dredging activities if required.
	6.4	• Implement Benthic Habitat Monitoring Program (BHMP) as per **Section 7.2**	• Contractor	• BCH Assessment Report including data (photographs)	• Quarterly during baseline period (12 months) • Reactive during dredging, following level 3 management trigger. • Within 12 months following completion of dredging.	• Determine source of impact and modify dredge operations if required. • If impacts are detected, then continue monitoring on an annual basis for up to 5 years post-dredging to monitor recovery. • Where BCH has not shown evidence of recovery within the authorised ZoMI after 3 years, consider options for restoration (artificial reef, seagrass transplantation)

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
						• In the event the water quality triggers are exceeded at the outer boundary of the authorised ZoMI, the pre- and post-dredging BCH surveys will consider a variety of health measures of BCH in the areas outside the authorised ZoMI and ZoHI, which can be used to provide evidence that this EPO has or has not been met.
	6.5	• Implement the Marine Water Quality Monitoring Program (MWQMP), refer **Section 7.1**	• Contractor/ Proponent	• Telemetered Water Quality Data (i.e., DLI) • Water Quality Report	• Data recorded hourly provided daily. • Monthly	• Determine source of impact and modify dredge operations if required.
	6.6	• Undertake plume validation monitoring with Aerial Multisectoral Imagery	• Proponent	• Plume Validation Report	• At Start of Dredging. • Quarterly during dredging, and • Following a Level 2 management trigger (Table 14)	• Investigate other data sources to validate plume model (e.g., MODIS imagery).

Manage vessel bunkering, chemical storage and spill response to minimise impacts to the marine environment.	6.7	• Develop and implement project specific management procedures:
		  • Chemical Storage and Handling Procedure.
		  • Vessel Bunkering Procedure.
			• Contractor	• Approved Management Procedures/Plans	• Prior to commencement of work.	• Develop and implement management procedures.
						• Update procedures where necessary.

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
		• Shipboard Oil Pollution Emergency Plan (SOPEP).				
	6.8	• All project vessels to maintain adequate spill response equipment on board. • All crew to be trained in emergency spill response.	• Contractor	• Pre work inspection • Monthly Inspections • Crew training logs	• Prior to commencement of works • Monthly during dredge operations • Refresh training regularly throughout project	• Source spill response equipment. • Train all vessel crew.
Manage project vessels activities to prevent IMP impacts on the environment.	6.9	• All relevant vessels should comply with Commonwealth Department of Agriculture and Water Resources – Australian Ballast Water Management Requirements, the National Biofouling Management Guidelines for commercial vessels.	• Contractor	• Vessel management procedures.	• Prior to vessel entering Australian Waters or moving from one Australian port to the project site.	• Vessels are not to mobilise to project site without approved IMP documentation.
	6.10	• All vessels that mobilise to the project site are required to complete the WA Department of Fisheries (DoF's) 'Vessel Check' risk assessment (https://vesselcheck.fish.wa.gov.au)	• Contractor	• A copy of the Vessel Check report is to be submitted to PPA for assessment along with any supporting documentation including antifoul certificates and inspection reports.	• Prior to dredge entering Australian Waters or moving from one Australian port to the project site.	• Vessel are not to mobilise to project site without approved IMP documentation.

6.2. Marine Environmental Quality

Management proposed to minimise potential impacts on the environmental factor 'Marine Environmental Quality' are described in **Table 10**.

Table 10: Management actions to minimise impacts on Marine Environmental Quality

Environmental Factor	Marine Environmental Quality
Activity	Capital Dredging and Maintenance Dredging
Potential Impacts	• Contamination of water resulting from a vessel/hydrocarbon spill (i.e., bunkering operations). • Disturbance of contaminants and Potential Acid Sulphate Soils (PASS) during marine construction activities (dredging and disposal).

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
Manage vessel bunkering, chemical storage and spill response to minimise impacts to the marine environment	7.1	• Develop and implement project specific management procedures: • Emergency Response Procedure • Chemical Storage and Handling Procedure. • Bunkering Procedure. • 3. Shipboard Oil Pollution Emergency Plan (SOPEP).	• Contractor	• Approved Management Procedures	• Prior to commencement of work.	• Develop and implement management procedures. • Update procedures where necessary.
	7.2	• All vessel equipment to be designed and operated to prevent	• Contractor	• Monthly Inspections	• Monthly	• Rectify any equipment that is damaged or

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
		spills and leaks through the provision of in-built safeguards such as, but not limited to, relief valves, overflow protection, and automatic and manual shut-down systems.		• Approved vessel management procedure which includes emergency response procedures		missing as soon as practicable. • Dredge operations not to commence prior to development and approval of vessel management procedures.
	7.3	• The proponent is to be notified immediately in the event of a hydrocarbon spill of any volume. An incident report will be submitted for each spill.	• Contractor	• Approved vessel management procedure which includes emergency response procedures • Verbal communication • Incident Report	• Immediately verbal communication. • Incident report submitted within 24 hrs of incident.	• Dredge operations to cease until spill investigation is complete, and or Proponent has given authority to proceed.
	7.5	• Inspections of all dredge equipment and pipelines to check for leaks or damage	• Contractor	• Approved vessel management procedure which includes emergency response procedures • Daily inspections • Vessel and Site Environment Safety and Health inspection checklist	• Prior to the commencement of dredging • Daily throughout dredging	• Cease works if significant spillage or damage observed • Activate spill response actions (control drainage, clean up) as required; and • Undertake incident investigation and implement recommendations • Continue MWQMP
Assess and manage marine sediment PASS to maintain the quality the marine and land environment.	7.5	• Undertake a sediment investigation to investigate PASS in dredge sediment. environment.	• Proponent	• Assessment included in referral support document.	• Completed	• NA - Completed
Assess and manage dredge disposal to	7.6	• Undertake sediment monitoring of dredge	• Contractor	• Sediment samples collected monthly	• During dredging	• Dredging to halt if EQC are breached until

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
maintain quality to marine and land environment		materials during and post operations. • Monitoring program of the deposited sediments, dewatering and consolidation phase of the materials.		during dredge and post dredge operations	• Post dredging (through to consolidation and capping of spoil disposal area).	management controls are reviewed and considered adequate to the altered risk profile; increase detailed sampling of discharge and receiving water quality • PASS will be well mixed with material containing calcareous materials. • Determine source of impact and modify dredge operations if required.
	7.7	• Implement the monitoring program for discharged decant water from spoil disposal area and receiving tidal creek (refer section 7.4).	• Proponent	• Continuous monitoring of key water quality parameters, with monthly screening of other PASS indicators and CoPC	• During dredging • Post dredging (through to consolidation and capping of spoil disposal area).	• Cease discharge and/or implement additional treatment measures.

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
Minimise potential for failure of dredge transport pipeline and containment bunds	7.8	• Develop and implement project specific management procedures: ◦ Emergency Response and Management Procedures • Inspections of all dredge transport pipelines and containment pipelines to check for leaks or damage	• Contractor	• Approved Management Procedures • Daily inspections • Vessel and Site Environment Safety and Health inspection checklist	• Prior to commencement of work. • Prior to the commencement of dredging • Daily throughout dredging	• Develop and implement management procedures. • Update procedures where necessary. • Cease works if significant spillage or damage observed • Activate spill response actions (control drainage, clean up) as required; and • Undertake incident investigation and implement recommendations • Continue MWQMP

6.3. Marine Fauna

Management proposed to minimise potential impacts on the environmental factor 'Marine Fauna' are detailed in **Section 7.3** and summarised in **Table 11**.

Table 11. Management actions to minimise impacts on Marine Fauna

Environmental Factor	Marine Fauna
Activity	Capital Dredging and Maintenance Dredging
Potential Impacts	• Disturbance, injury or death of marine fauna as a result of dredge operations. • Injury or death of marine fauna due to vessel movement (strike). • Indirect impacts on marine fauna habitat through decreased water quality. • Disturbance, injury or death from contaminated water from hydrocarbon spills. • Direct impacts from underwater noise from dredging operations • Direct impacts from light pollution • Introduced Marine Pests (IMP) translocation from construction or operational vessels.

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
Manage dredge operations so no	8.1	• Implement a soft start procedure prior to activating below surface operations.	• Contractor	• Daily dredge logs.	• Each occasion, prior to activating cutter head.	• Dredge operations not to commence unless a soft start procedure has been implemented.

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
injury or death of marine fauna occurs.	8.2	• Implement marine fauna monitoring and management outlined in **Section 7.3**	• Contractor	• Marine Fauna Observer (MFO) daily records • Final summary report • Refer to **Section 7.3**	• Prior to commencement of dredging. • Daily • Refer **Section 7.3**	• Dredge operations not to commence unless at least one crew member is a trained MFO. • Where marine fauna are observed within an Exclusion zone then dredging will cease immediately • Investigate why dredge operations were not ceased and apply required correction actions.
	8.3	• Report any injured or deceased marine fauna (whale, dugong, turtle, manta ray or dolphin, fish) or indications of coral mass spawning on the project site	• Contractor	• Verbal/written communication • Incident Report	• Site manager to be notified immediately upon observation • DBCA notified as soon as possible, but within 24 hours. • Full incident report completed within 72 hours.	• Investigate fauna death and apply required corrective actions and or modifications to dredge operations.
Noise impacts from dredging operations	8.4	• Implement marine fauna monitoring and management outlined in **Section 7.3** • Soft starts procedure outlined in **Section 7.3** • Ensure all vessel equipment and machinery is in good condition and subject to regular maintenance. When in transit, all Project vessels will be operated in accordance with EPBC	• Contractor	• Refer to **Section 7.3**	• Daily • Refer to **Section 7.3**	• Where marine fauna are observed within an exclusion zone then dredging will be ceased immediately.

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
		Regulations 2000- Part 8 Division 8.1 • Minimise the duration of run-time for vessel engines, thrusters and dredging plant by avoiding stand-by or running mode to the degree practical and consistent with safe operations				
Manage vessel speed so no injury or death of marine fauna occurs as a result of vessel strike.	8.5	• Implement marine fauna monitoring and management as outlined in **Section 7.3**	• Contractor	• Refer to **Section 7.3**	• Refer to **Section 7.3**	• Where marine fauna are observed with an Exclusion Zone then dredging will be ceased immediately • Investigate fauna death and apply required corrective actions and or modifications to dredge operations.
	8.6	• Vessels to operate at a safe speed with a maximum speed of 8 knots to avoid interaction with marine fauna at all times within project boundaries.	• Contractor	• Vessel GPS monitoring system	• Continuous throughout vessel operations.	• Investigate why vessel was recorded in excess for the defined speed limit and amend vessel operations and activities as appropriate.
Manage dredge activities to minimise turbid plumes as to not impact marine fauna habitats.	8.7	• Implement the Marine Water Quality Monitoring Program (MWQMP), refer **Section 7.1**	• Contractor/ Proponent	• Telemetered Water Quality Data (DLI) • Water Quality Report	• Data recorded hourly provided daily. • Monthly	• Determine source of impact and modify dredge operations if required.

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
Manage dredge activities, including maintenance, to minimise light spill, in accordance with Project Illumination Plan	8.8	• Implement the Mardie Illumination Plan	• Contractor/ Proponent	• Routine inspections • Light monitoring at set locations	• Daily • October - March	• Address non-compliant light sources immediately • Review lighting on vessels
Manage vessel bunkering, chemical storage and spill response to minimise impacts to marine fauna	8.9	• Develop and implement project specific management procedures: ○ Chemical Storage and Handling Procedure. ○ Bunkering Procedure. ○ Shipboard Oil Pollution Emergency Plan (SOPEP).	• Contractor	• Approved Management Procedures	• Prior to commencement of work.	• Develop and implement management procedures • Update procedures where necessary.
	8.10	• All vessel equipment to be designed and operated to prevent spills and leaks through the provision of in-built safeguards such as, but not limited to, relief valves, overflow protection, and automatic and manual shut-down systems.	• Contractor	• Vessel management procedure • Monthly Inspections	• Prior to commencing dredging. • Monthly	• Rectify any equipment that is damaged or missing as soon as practicable. • Dredge operations not to commence prior to development and approval of vessel management procedures.
	8.11	• The proponent is to be notified immediately in the event of a hydrocarbon spill of any volume. An incident report will be submitted for each spill.	• Contractor	• Verbal communication • Incident Report	• Immediately verbal communication. • Incident report submitted with 24 hrs of incident.	• Dredge operations to cease until spill investigation is complete, and or Proponent has given authority to proceed.
All relevant vessels to comply with	8.12	• All relevant vessels should comply with Commonwealth Department of Agriculture	• Contractor	• Vessel management procedures.	• Prior to vessel entering Australian Waters or moving	• Vessels are not to mobilise to site without

Management Targets	Management Actions			Environmental Performance		
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
Commonwealth Department of Agriculture and Water Resources – Australian Ballast Water Management Requirements.		and Water Resources – Australian Ballast Water Management Requirements, the National Biofouling Management Guidelines for commercial vessels.			from one Australian port to the project site.	approved IMP documentation.
	8.13	• All vessels that mobilise to the project site are required to complete the WA DPIRD's 'Vessel Check' risk assessment (https://vesselcheck.fish.wa.gov.au)	• Contractor	• A copy of the Vessel Check report is to be submitted to PPA for assessment along with any supporting documentation including antifoul certificates and inspection reports.	• Prior to dredge entering Australian Waters or moving from one Australian port to the project site.	• Vessels are not to mobilise to project site without approved IMP documentation.

7. Environmental Monitoring

7.1. Marine Water Quality Monitoring Program

7.1.1. Monitoring Rationale

The Marine Water Quality Monitoring Program (MWQMP) is to be implemented to ensure the EPOs for Benthic Community Habitats, Marine Environmental Quality and Marine Fauna are met.

Marine dredging activities have the potential to increase suspended sediment and sedimentation in marine waters. This change in water quality has potential to indirectly impact BCH by reducing light penetration through the water column and smothering of biota due to sedimentation.

To assist the design of the MWQMP and to select suitable monitoring locations, a validated hydrodynamic model undertaken at the project area by BCIM (Baird 2022) was used to model sediment plumes generated by dredge operations within the proposed dredge footprint. A brief presentation of the model results is presented in **Section 3.6**. The proposed dredge footprint is shown in **Figure 13**.

The model result show that the dredge plume impacts are most pronounced with dredging occurring at the nearshore, which is associated with dredging large volumes of material over a comparatively small spatial area with a high proportion of fine content in the sediment. For the offshore section of the channel, the dredging requirements are spread out over a much larger area and the dredge plumes impacts significantly less due to sediments possessing a much high grain size and quicker settling rate (Baird 2021). Moreover, the model shows a preferential plume direction along a north-east to south-west axis, with dredge plume impacts elongated to the southwest driven by the stronger flood tides in comparison to ebb tide.

The proposed monitoring locations have been selected based on the predicted plume distribution and aligned along the predicted plume direction north-east to south-west axis. The proposed monitoring locations are shown in **Figure 14.**

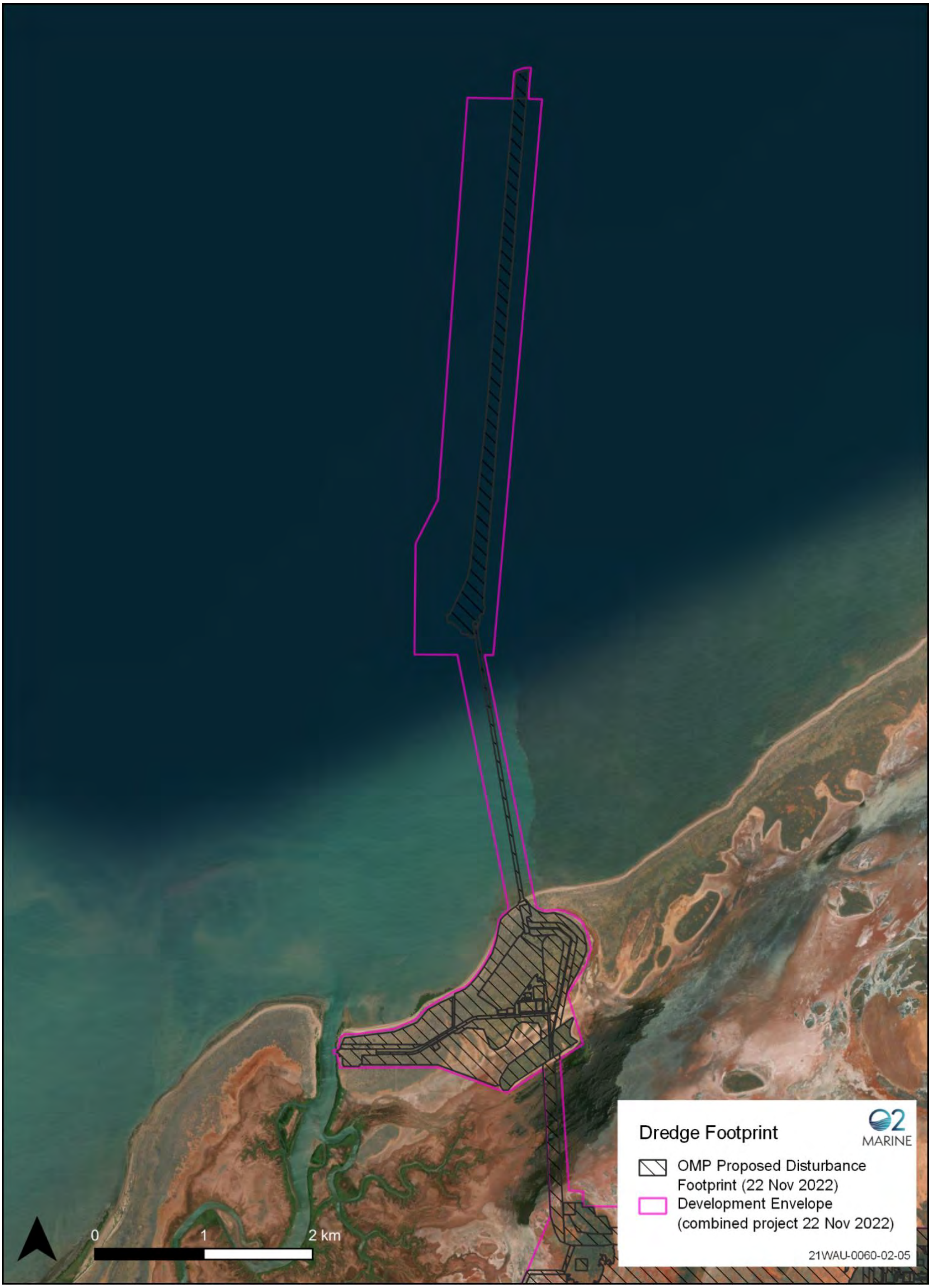


Figure 13: Proposed footprint of dredging disturbance area

7.1.2. Predicted Zone of Impact and Thresholds

The model was used to develop “best-case” and “worst-case” zonation the dredging area (**Figure 14**). The best-case and worst case were derived using WAMSI threshold limit for Suspended Sediment Concentration (SSC) derived for corals (Fisher et. al. 2019) as presented in **Table 12.** The modelled SSCs were assessed against a combination of the 7, 14 and 28-day thresholds, which were applied across the model domain throughout the construction period. This resulted in the definition of likely best and worst-case Zones of High Impact (ZoHI) (irreversible loss) and Zone of Moderate Impact (ZoMI) (recoverable impact).

While the WAMSI threshold are considered appropriate to develop the modelled suspended sediment concentration to define the different zones of potential impact for dredging, these thresholds have been developed in an offshore low turbidity environment and therefore are not considered to be suitable to be used as trigger thresholds for a dredging program in an inshore environment with high turbidity levels such as the Mardie Project. Therefore, to monitor the effects of dredging activities of the project and to establish triggers for management actions, project specific threshold for SSC will be derived relative to turbidity (NTU) baseline conditions of the project area.

Prior the commencement of dredging, a site-specific calibration of SSC vs Turbidity (NTU) with an R^2 >0.7 shall be derived. The site-specific nature of calibrations has been emphasised by a number of previous studies including Fisher et. al. (2019), Sternberg et. Al. (1986,1991) and today many of the best practice guidelines for the analysis of suspended sediment state the need for site specific calibrations, see for example Judd (2012).

The calibration coefficient will be applied to the real time NTU data allowing post conversion to SSC and monitoring of established triggers.

Trigger values for monitoring will be derived in accordance with the WAMSI recommendation for coral monitoring using 12 months of baseline data which will be collected within 24 months prior the commencement of the dredging.

Table 12: Threshold Limits for Modelled Suspended Sediment Concentration used to define ZoMI and ZoHI regions through the dredge program (from Fisher et. al., 2019)

Threshold	Running Mean Period	ZoMI Threshold (>SSC)	ZoHI Threshold (>SSC)
Running Mean (SSC)	7 day	14.7 mg/l	24.5 mg/l
	14 day	11.7 mg/l	18.0 mg/l
	28 day	9.3 mg/l	13.2 mg/l

7.1.3. Telemetered In-situ Water Quality Monitoring.

Telemetered In-situ instruments will be installed to provide continuous one-hour interval water quality data throughout the dredge program. This data will be transmitted to an online data portal, to enable live updates allowing responsive monitoring and management. Each water quality sensor will be weighted to the seabed and positioned approximately 0.5m above the seabed. Each station will be tethered to a special designed telemetry marker boy (with navigation lighting) containing a battery and 3G/satellite telemetry components. Monitoring stations will be designed to be relocated as required based on dredge location.

7.1.4. Monitoring Locations & Frequency

In-situ monitoring stations will be installed either side (east and west) of dredge operations along the predicted plume southwest-northeast axe to monitor potential plume impacts on BCH. Impact monitoring stations and corresponding reference site locations are identified below in **Table 13** and **Figure 14** respectively.

Monitoring stations located at the ZoMI/ZoI best case scenario boundary location will be used to monitor EPO's and MT's associated with recoverable impacts on BCH. While stations at the ZoMI/ZoI worst-case scenario location will be used to monitor EPO's and MT's associated with no negative change of BCH from baseline conditions.

Monitoring stations will be installed 8 weeks prior to commencement of dredging and will removed no less than 30 days post dredge completion.

Table 13: Indicative Water Quality Monitoring Stations

Station ID	Zone of Impact Boundary
RNE	Reference site - Northeast
RNW	Reference site - Northwest
RSE	Reference site - Southeast
RSW	Reference site - Southwest
ZHSE	Zone of High Impact / Zone of Moderate Impact (Best Case) – Southeast Boundary
ZHSW	Zone of High Impact / Zone of Moderate Impact (Best Case) – Southwest Boundary
ZME	Zone of Moderate Impact / Zone of Influence (Worst Case) – East Boundary
ZMN	Zone of Moderate Impact / Zone of Influence (Best Case) – North Boundary
ZMNE	Zone of Moderate Impact / Zone of Influence (Best Case) – Northeast Boundary
ZMSW	Zone of Moderate Impact / Zone of Influence (Best Case) – Southwest Boundary
ZMW	Zone of Moderate Impact / Zone of Influence (Worst Case) – West Boundary

7.1.5. Parameters and Procedures

Each monitoring station will measure turbidity (NTU) and photosynthetic active radiation (PAR) captured at 10 bursts every 30 minutes which will be interrogated to derive Daily Light Integral (DLI) data throughout the dredging program. NTU and PAR measurements every 30 minutes will be based on the median value from the 10 burst measurements. DLI and NTU daily values will be calculated midnight to midnight for each calendar date. DLI values will be calculated from PAR values based on the following equation:

$$DLI = \frac{1}{1 \cdot 10^6} \int_0^{24} PAR \, dt$$

The derived coefficients from the SSC/NTU calibration will be used to convert NTU to SSC to allow comparison against WAMSI thresholds. Turbidity and DLI data will be downloaded daily using the telemetry system incorporated within the instrument buoy.

Turbidity sensors will be calibrated during regular maintenance and in accordance with manufacturer specifications to ensure accurate datasets are acquired. Water quality monitoring locations are focussed on the Eastern Side of the plume, as these habitats are dominated by coral habitats, which are the primary habitat for the benthic habitat monitoring program detailed in **Section 7.2**.

7.1.6. Data analysis

The likelihood of a link between dredging and water quality decline will be assessed in terms of the following factors:

1. Correct instrument function and operation;
2. Locations of and status of dredging activities in relation to the site(s) at the time of the exceedance;
3. Hydrodynamic conditions, for example wind, tide, wave and swell state at the time of the exceedance; and
4. Assessment against background conditions (reference site) and extreme weather events in the region.

Table 14: Environmental Protection Outcomes, Management Targets and Management Criteria for protection of BCH from dredging

Sites	Early Warning (Level 1)	Management Target (Level 2)	Environmental Protection Outcome (Level 3)
Zone of High Impact / Zone of Moderate Impact Boundary			
ZHSW ZHSE	**Not Applicable**	Rolling mean DLI for either 7, 14 or 28 days to remain above the 20th percentile of seasonal baseline data* for the same period. **AND** Median DLI to remain above the 20th percentile of reference site data for the same period. **AND** Rolling mean daily# NTU for either 7, 14 or 28 days to remain below the 80th percentile of seasonal baseline data* for the same period. **AND** Median daily NTU to remain below the 80th percentile of reference site data for the same period.	Rolling mean DLI for either 7, 14 or 28 days to remain above the 5th percentile of seasonal baseline data* for the same period. **AND** Median DLI to remain above the 5th percentile of reference site data for the same period. **AND** Rolling mean daily# NTU for either 7, 14 or 28 days to remain below the 95th percentile of seasonal baseline data* for the same period. **AND** Median daily NTU to remain below the 95th percentile of reference site data for the same period
Zone of Moderate Impact / Zone of Influence Boundary			
ZMNE ZMN	**Not Applicable**	Rolling mean DLI for either 3, 10 or 21 days to remain above the 20th percentile of seasonal baseline data* for the same period. **AND** Median daily DLI to remain above the 20th percentile of reference site data for the same period. **AND** Rolling mean daily# NTU for either 3, 10 or 21 days to remain below the 80th percentile of seasonal baseline data* for the same period. **AND** Median daily NTU to remain below the 80th percentile of reference site data for the same period.	Rolling mean DLI for either 7, 14 or 28 days to remain above the 20th percentile of seasonal baseline data* for the same period. **AND** Median daily DLI to remain above the 20th percentile of reference site data for the same period. **AND** Rolling mean daily# NTU for either 7, 14 or 28 days to remain below the 80th percentile of seasonal baseline data* for the same period. **AND** Median daily NTU to remain below the 80th percentile of reference site data for the same period.
ZMW ZME ZMSW	Rolling mean DLI for either 3, 10 or 21 days to remain above the 20th percentile of seasonal baseline data* for the same period.	Rolling mean DLI for either 7, 14 or 28 days to remain above the 20th percentile of seasonal baseline data* for the same period. **AND**	Rolling mean DLI for either 7, 14 or 28 days to remain above the 5th percentile of seasonal baseline data* for the same period. **AND**

Sites	Early Warning (Level 1)	Management Target (Level 2)	Environmental Protection Outcome (Level 3)
	AND Median daily DLI to remain above the 20th percentile of reference site data for the same period. **AND** Rolling mean daily# NTU for either 3, 10 or 21 days to remain below the 80th percentile of seasonal baseline data* for the same period. **AND** Median daily NTU to remain below the 80th percentile of reference site data for the same period.	Median daily DLI to remain above the 20th percentile of reference site data for the same period. **AND** Rolling mean daily# NTU for either 7, 14 or 28 days to remain below the 80th percentile of seasonal baseline data* for the same period. **AND** Median daily NTU to remain below the 80th percentile of reference site data for the same period.	Median DLI to remain above the 5th percentile of reference site data for the same period. **AND** Rolling mean daily# NTU for either 7, 14 or 28 days to remain below the 95th percentile of seasonal baseline data* for the same period. **AND** Median daily NTU to remain below the 95th percentile of reference site data for the same period

*Baseline seasonal (i.e., Summer, Winter & Transitional) percentile values (i.e. 5th, 20th, 80th & 95th) will be calculated from 12 months of baseline data collected prior to dredging. Baseline data to be collected in the vicinity of the dredging area for at least 12-months prior to dredging.

Rolling mean daily NTU is to be calculated once per calendar day

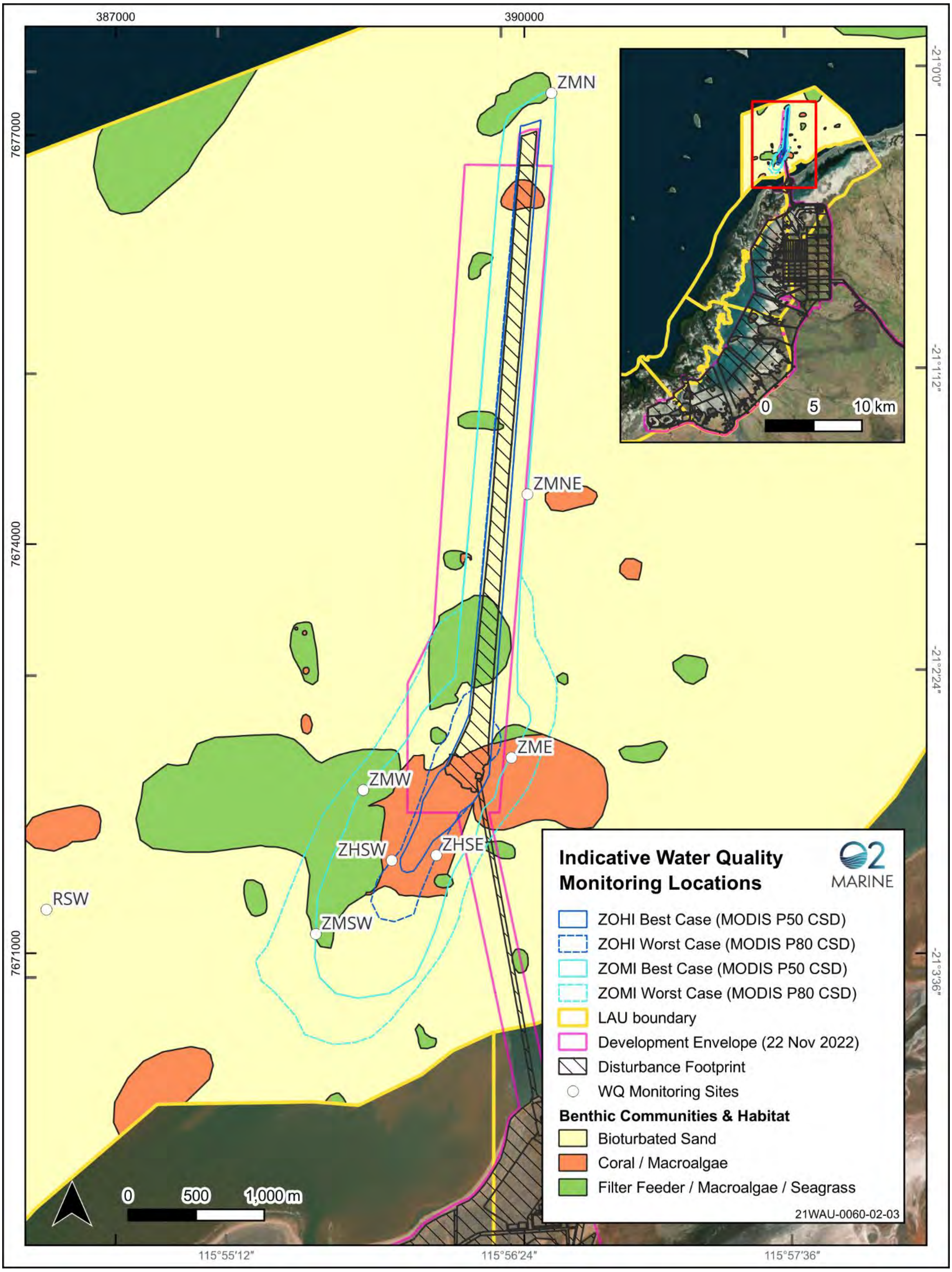


Figure 14: Indicative Water Quality Monitoring Locations

7.1.7. Tiered Management Framework

A Tiered Management Framework (TMF) has been developed based on monitoring and reporting against the three trigger levels to ensure EPOs and MTs for protection of BCH are achieved during dredging**.** The TMF presented in (**Figure 15)** will be implemented by the Proponent/Contractor.

Where EPOs for coral are not achieved, the CEO will be notified within 24 hours of the determination and a report will be sent within seven days of the determination, including any management actions which have been undertaken.

7.1.8. Recommencement Criteria

In the event that dredging is ceased as a result of failure to achieve the nominated water quality criteria (i.e., Management Action Level 3), then an Interim Reactive BCH Survey will be undertaken to evaluate the extent of impact (if any) to BCH arising from the dredging activities. In this instance, dredging may only recommence under the following circumstances:

1. Interim reactive BCH survey confirms that no impact to BCH has occurred as a result of dredging activities;
2. BCH impacts have been confirmed and reported to DWER. DWER subsequently advise that dredging in the affected area can continue under certain conditions; OR
3. Dredging can be undertaken in other unaffected areas without impacting on BCH. Monitoring as per the Benthic Habitat Monitoring Program in **Section 7.2.**

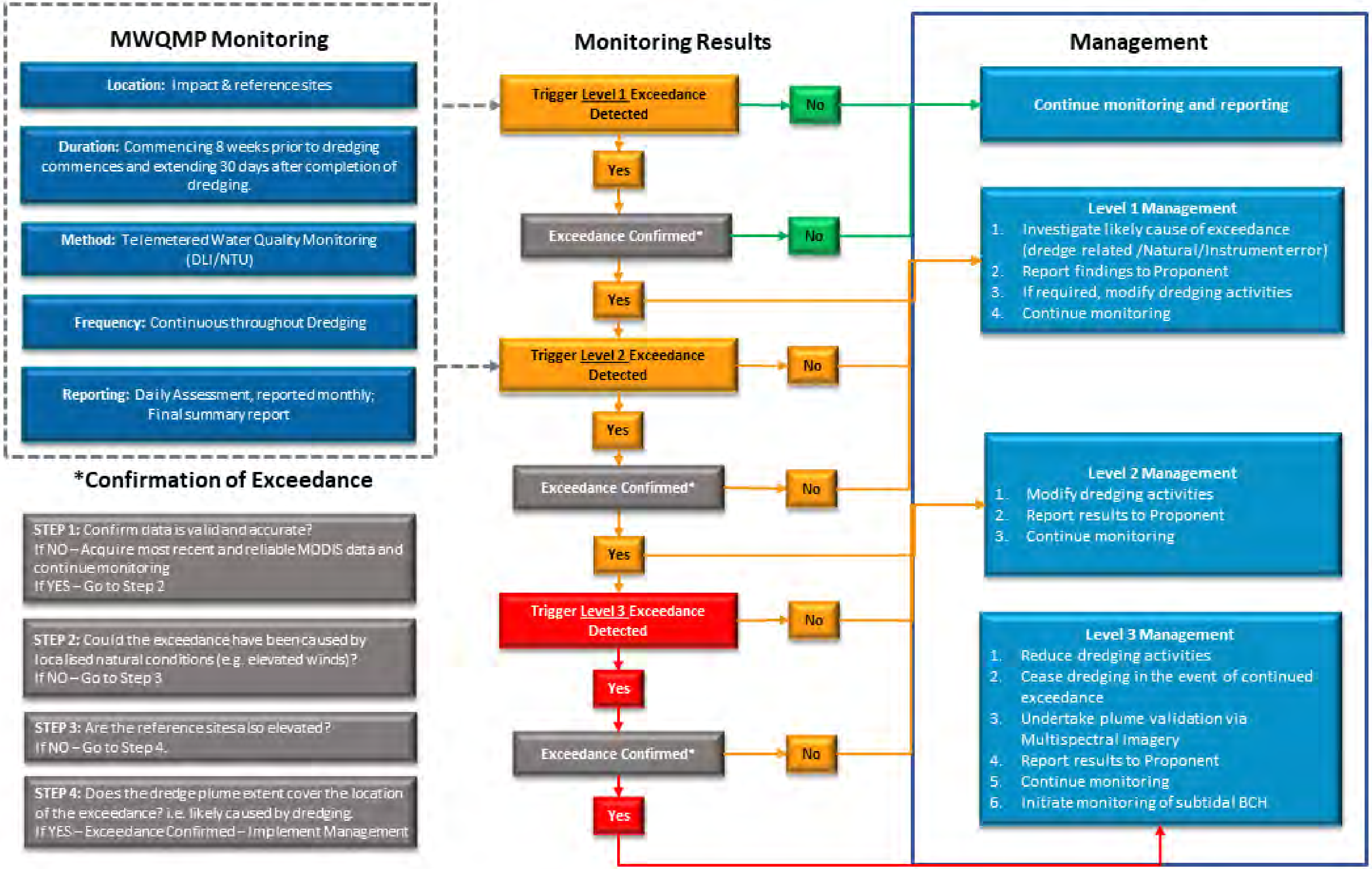


Figure 15: Tiered Management Framework for Marine Water Quality Monitoring

7.1.9. Aerial Plume Validation

Aerial multispectral imagery will be used to quantitatively assess and validate plumes models. High spatial resolution multispectral imagery validated with real-time Total Suspended Solids (TSS) samples will be captured via Unmanned Aerial Vehicle (UAV) at the start of dredging and on a quarterly basis during dredge operations. This data will allow assessment of TSS levels from dredge plumes, which are not likely to be visible via broad scale MODIS imagery due to the method of dredging and expected small scale plumes. This data will increase the accuracy of impact assessment on BCH and will help inform the predictive plume model. Multispectral imagery verification will also be implemented in the event that a Level 3 Trigger exceedance is breached (**Figure 15**). A dredge plume validation report will be prepared following each survey event.

7.2. Benthic Habitat Monitoring Program

7.2.1. Objectives

The Benthic Habitat Monitoring Program (BHMP) together with the WQMP will aim to provide an evaluation of the EPOs for BCH which are:

1. Recoverable Impacts to BCH within the Zone of Moderate Impact (ZoMI); and
2. No Negative Change to the Baseline State of BCH within the Zone of Influence (ZoI).

7.2.2. Monitoring Rationale

As identified in Section 2.3, coral communities are the most vulnerable (of those BCH present in the impact area) to the effects of increased SSC and the associated decline in benthic light availability. Therefore, coral health has been selected as the lead indicator for monitoring of benthic community health within the ZoMI and ZoI. Seagrass, algae, and filter feeder habitats have been selected to validate the impact at the coral sites.

Unfortunately, percent cover of BCH in the vicinity of the dredging area is generally very low (i.e., <5%) and the proportion of coral within this community is expected to be extremely low (i.e. <1%). Therefore, a standard Before After Control Impact (BACI) design focussed on overall percent cover of BCH is unlikely to achieve a statistical power to determine if any observed changes can be definitively related to dredging impacts.

Therefore, to account for the low benthic cover and to achieve a statistical power of 0.8, the BHMP will focus on monitoring of individual (tagged) coral colonies before, during and after dredging activities at the designated impact and control sites. Presence and absence surveys will also be conducted for filter feeder and seagrass habitats, with results mapped. The BHMP is designed to identify and measure changes in condition of individual colonies that are attributable to dredging activities, and which are greater than the changes occurring naturally at control sites. Additional benthic cover information will also be collected to inform multiple lines of evidence assessment.

7.2.3. Effect Size

The EPOs and associated proposed effect size for assessment of dredging-related impacts to hard coral, filter feeder, macro algae and seagrass BCH are:

1. No irreversible loss of, or serious damage to, BCH outside of the ZoHI;
2. Protection of at least 70% of baseline BCH (within tagged colonies) on each designated reef formation within the ZoMI; or
3. No detectable reduction of net live coral cover (within tagged colonies) within the ZoI.

7.2.4. Monitoring Locations

Indicative monitoring locations have been selected in areas of at least moderate benthic coral cover and these are presented in **Figure 16 a**nd include:

> Four (4) locations within the ZoMI (ZM1, ZM2, ZM3, and ZM4) to assess recoverable impacts; and
> Two (2) locations within the ZoI and ZoMI (ZI4 and ZM5) to assist in validating potential impact; and
> Three (3) locations within the ZoI (ZI1, ZI2 and ZI3) to assess no change from baseline state.

A further three (3) reference monitoring locations are required to be determined as suitable control locations. No monitoring is proposed within the ZoHI.

7.2.5. Frequency

Baseline Surveys

BCH surveys to establish suitable BCH types for and to facilitate baseline condition assessment will be undertaken quarterly and commence at least 12 months prior to commencement of dredging. Sites selected will ensure representative BCH types are stratified into the survey program to ensure post dredge impacts can be adequately assessed for all communities present.

During Dredging (Reactive) Surveys

During dredging, BCH surveys are only required in the event that a level 3 management event (i.e., DLI EPO Trigger as defined in **Table 14**) is triggered.

Post-Dredging Survey

One post-dredging survey will be undertaken within 12 months following completion of dredging to evaluate status of EPOs within the ZOMI and the ZOI. Where dredging impacts are detected in areas outside of the ZOHI, then post-dredging BCH surveys will continue, on at least an annual basis, for up to 5 years, or until BCH that is impacted as a result of dredging is considered to have recovered to a pre-dredging (baseline) condition based on DWER and DCCEEW review of the outcomes of the monitoring program.

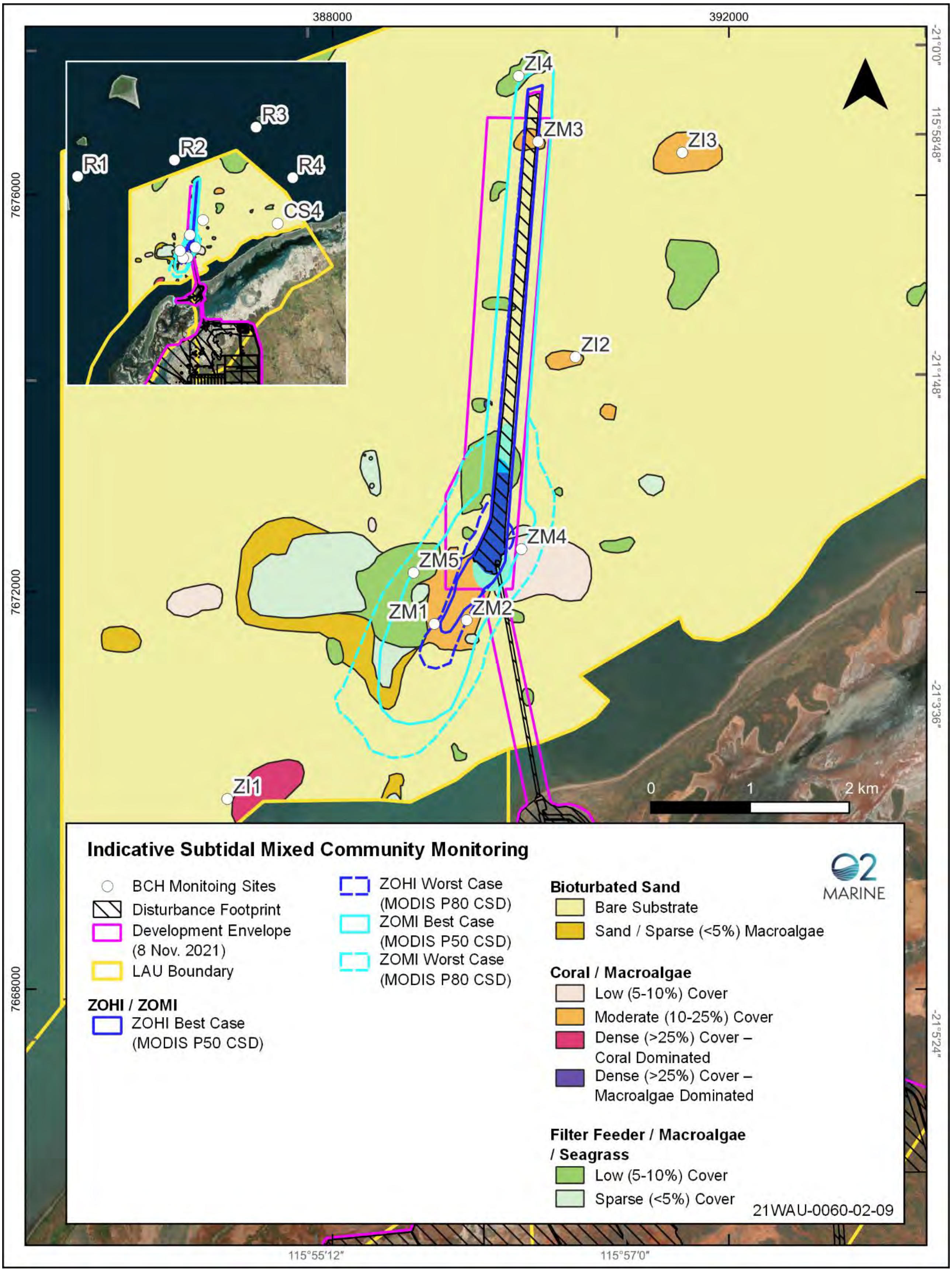


Figure 16: Indicative BCH Monitoring Locations.

7.2.6. Survey Methods

Seagrass, Algae and Filter Feeder BCH

Although seagrass was identified in the LAU, it was present only in extremely low densities (i.e., almost undetectable), making coral the primary benthic community of concern with respect to dredging impacts. The seagrass, algae and filter feeder monitoring sites (ZI4 and ZM5) will be used to validate the predicted impacts to coral habitats. Seagrass/ algae and filter feeder monitoring for community health will involve implementation of a standard before / after / control / impact (BACI) design. Diver based survey At least three (3) 50 m transects radiating in different bearings at each monitoring location, capturing still images within a 25 x 25 cm quadrat at each metre along the transects using an underwater camera. Still camera shots are taken within <1 m of the substrate. Analyse of still images using Coral Point Count software (or similar). Interrogating data to calculate simple statistics of community composition to inform assessment against baseline and reference data for benthic cover (all habitats) and shoot density (seagrass).

Individual Colonies

At each site, a total of 80 colonies will be selected, across five permanent transects (i.e., 16 colonies per transect). Colonies will be selected on the basis of an initial appraisal of condition (i.e., no obvious signs of mortality, bleaching or excessive mucous production) and targeted between the size range conducive to photography: 11-75 cm. Where larger colonies (<75 cm) are present, these colonies will be divided into smaller (0.5 m) sections along the transect for separate evaluation. Where possible, colonies will be selected from a broad range of species, representative of different family groups and morphologies at each site, including sensitive genera (e.g., *Acropora*) and less sensitive genera (e.g. *Turbinaria*).

Colonies will be selected from within 1 m either side of the permanent transects. Using the permanent transect as a reference point, the locations of colonies will be recorded using bearings and offset distances from the tape to enable re-location during subsequent surveys. Where there are limited colonies recorded, additional colonies may be added by searching the area between 1-2 m either side of the transect.

Sub-lethal indicators will be recorded for each colony *in-situ* using the classification details provided in **Table 15**. Digital photographs will be collected at distances which allow the colony to maximise the field of view on the image. A set of Coral Reference Photographs taken during the first baseline survey showing the original image of each of the corals with the location bearings and distances from the transect will be used to compare against each colony to ensure that the correct corals are assessed on each sampling occasion. Colonies will be photographed from the same orientation/perspective (from start of transect) and distance. Where an area of colony is covered in sediment, it will not be cleared away from the colonies before photographs are taken. Where macroalgae obscure a colony, the macroalgae will be moved to allow a clear photograph to be taken, unless the macroalgae are growing on or within the colony and its removal would damage either the coral or the macroalgae.

Table 15: *In-situ* classification details of sub-lethal indicators to be recorded for each colony during each survey.

Indicator	1	2	3	4	5
Partial Mortality Sediment deposition	<10%	10-30%	30-60%	60-80%	>80%
Coral colour	paling	focal bleaching	non-focal bleaching	partial bleaching	total bleaching
Mucous Production	Presence/absence				
Disease	Presence/absence & Type (i.e., White syndrome, black band, brown band, other)				
Predation/Type	Presence/absence & Type (i.e., Fish scars, Polychaetes, Tremetodes, other)				

Line Intercept Transect

A tape measure will be run over each 20 m permanent transect, then a suitably qualified coral specialist will identify and record benthic cover type and form located directly beneath the tape measure for each transect. Data will be used to calculate percentage benthic cover type across the monitoring location.

7.2.7. Data Analysis

Image Analysis

Each individual image will be analysed using coral point count with excel extensions (CPCe) to determine the extent of live coral cover for each coral colony. Sixty (60) points will be assessed per image and coral condition (i.e., live/dead) will be recorded for each point.

The sub lethal indicators recorded in the field will be evaluated to determine the metrics presented in **Table 16**. The mean of the scores from the assessment of partial mortality, coral colour and sediment deposition will be compared to the baseline record. A shift of three points on the six-point classification (including zero) will constitute an adverse change in sub-lethal coral indicators. The incidence of colonies exhibiting evidence of coral mortality, bleaching, mucous production, predation and disease will be calculated by summing the number of colonies with evidence of these effects divided by the total number of colonies. This will be expressed as a percentage reduction in coral condition from the baseline level.

Table 16: Post-processing data for the following indicators.

Indicator	Analysis Description
Partial Mortality	Total mean partial mortality[1] scores from CPCe
Colony mortality	Proportion of colonies in Category 5
Coral colour	Total mean coral colour scores[1]
Colony bleaching	Proportion of colonies in Category 4 & 5
Sediment deposition	Total mean sediment cover[1] scores
Sedimentation	Proportion of colonies in Category 5
Mucous production	Proportion of colonies with evidence of the presence of mucous
Disease	Proportion of colonies with evidence of the presence of coral disease
Acanthaster	Incidence of *Acanthaster* species along transects
Drupella	Proportion of colonies with evidence of the presence of *Drupella*
Predation	Proportion of colonies with evidence of predation

[1] All colonies included in the assessment (i.e., colonies scoring zero are included in calculating the mean)

Line Intercept Transect

The percentage of benthic species cover that directly intercept the tape measure length of each 20 m transect using the line-intercept method will be calculated into a proportion of each benthic group (i.e., 20 m equals 100%). The benthic groups used will be calculated manually in excel to determine the relative abundance, mean, standard deviation, standard error and the Shannon-Weaver diversity Index of each benthic cover type at each site. Line intercept data will not be used for EPO assessment.

7.2.8. Statistical Analysis

The process for analysis of lethal and sub-lethal data and comparison against the EPOs is shown in **Table 17**.

The first step of the analysis is a statistical paired-samples t-test of gross negative change in coral colour/bleaching, partial/colony mortality and coral cover at the impact location. This uses a null hypothesis of no difference between the impact location at time 'x' during dredging compared to baseline to test the one-tailed alternative hypothesis that the negative change at the impact location is significantly greater than the negative change at reference locations.

This is followed by a similar test, but of net negative change at the impact location (i.e., factoring in change in cover that occurred concurrently at reference locations). Specifically, the (one-tailed) hypothesis being tested is that difference in the negative change is greater at the impact location than at the reference locations. The appropriate statistical test is a two-(independent)-sample t-test between the average of the impact locations and the average of reference locations. This uses a null hypothesis of no difference between the impact location at time 'x' during dredging compared to baseline to test the one-tailed alternative hypothesis that the negative change recorded between baseline and time 'x' at impact locations is greater than the negative change recorded at impact locations.

The t-tests of changes within sites proposed here are equivalent to the main interaction test (before–after × control–impact) in a standard Multiple Before–After, Control–Impact (MBACI) design (Keough and Mapstone 1997; Downes et al. 2002; Quinn and Keough 2002). The only difference is that there will only ever be one measurement in the "after" (during dredging) period that is being assessed, so there is additional temporal imbalance compared to a usual MBACI design. The statistical analysis is also based on an asymmetrical design, characterised by a before versus after contrast at multiple control sites but only a single impact site. The impact sites for the tests may be grouped together to form an additional balanced statistical test where three sites represent each of the impact zones and provide greater confidence that EPOs have been achieved for the Project. Results will be compared against the results from the control reference sites to confirm impact.

A conventional Type I error rate of 0.05 will be applied across the tests. Type II error rates of statistical power will be determined during the baseline study.

Table 17: The process for evaluation of EPOs

Name	Description	Objective
Average Baseline	Calculate average measurements for each colony across each site over multiple sampling times before dredging	To determine natural levels of change before dredging
Gross Change	Subtract the Average Baseline from recent dredging survey for each colony/transect and average across each site	To calculate the average change from baseline to recent dredge survey at each impact and control site
Test of Gross Change	Paired-sample t-tests performed between baseline and recent dredge survey averages where negative change was recorded at impact site.	A statistically significant negative change might provide evidence supportive of a dredging-related impact.
Test of Net Change	Two-(independent)-sample t-test performed to compare negative changes between impact and control sites where negative change was recorded at impact site.	A statistically significant negative change might provide evidence supportive of a dredging-related impact.
Multiple Lines of Evidence	Detailed interrogation of all data collected using supportive univariate and multivariate analyses where Test of Net Change is exceeded	To rigorously assess whether the detected change at an affected reef was due to dredging or simply the result of natural change

Multiple Lines of Evidence

In the event that management criteria are exceeded, a series of investigations and statistical analyses will be initiated in a structured decision-making framework to rigorously assess whether the detected change at an affected reef was due to dredging or simply the result of natural change.

The first step will be an assessment of the magnitude of change (effect size and its confidence interval) in coral cover for the individual colonies between the impact and reference locations, from before dredging to the current survey period (that is, whether the difference in coral cover between the affected reef and the control reefs had increased or remained consistent since dredging). The purpose of this method is to compare the effect size during baseline with the effect size after dredging. A confidence interval approach provides important information for decision-making not gained from a test of a null hypothesis and focuses on the magnitude of change, with some measure of uncertainty. A larger mean effect size (+- CI) following dredging may provide evidence supportive of the dredge impact hypothesis.

A comparison of trends in mean coral cover through time will then be compared among the impact and reference locations. Evidence supportive of the dredge impact hypothesis would be a decline in cover at the impact location following dredging, but no corresponding decline at the reference location.

An inference assessment will then be undertaken, which includes the collation and synthesis of all available circumstantial evidence supporting or refuting the conclusion that either dredging or a natural agent of disturbance resulted in an observed decline in coral cover at the impacted location.

Multiple lines of evidence, based on causal indicators, are used to assess the impact hypothesis and may apply a variety of univariate or multivariate analysis. With lines of evidence there is a need to seek evidence not only to support the impact prediction, but evidence to rule out plausible alternative predictions, such as that the observed difference was due to natural processes (Beyers 1998; Downes et al. 2002). Potential natural or other anthropogenic causes of impact within the Project area may include thermal bleaching from warm water temperatures, natural mortality, pollution, predation, cyclonic events, salinity change and anthropogenic causes for elevated turbidity (e.g. ship propeller disturbance, maintenance dredging). Potential natural and anthropogenic causes not related to the dredging activities will be monitored and noted during routine surveys as part of the MQMP, and in some cases during the reactive monitoring program. A reactive monitoring program will be activated when there is a potential for a decline in BCH occurring, such as a spill, cyclone, or bleaching event, triggered.

A number of factors are relevant to the likelihood and level of severity of an impact occurring, including existing stress levels, age, size and health status of colonies, associated biota and adaptations to localised conditions. Differences in the physical characteristics between reference and impact locations and how this could affect the scale of effect observed between the corals should also be considered. The data will be compiled to provide a weight of evidence as to whether or not dredging activities were reasonably considered to cause or contribute to the impact.

It is predicted that for the project during the assessment: 35 ha (cleared) and 133 ha (recoverable) of filter feeder / microalgae / seagrass habitat and 10 ha (cleared) and 103 ha (recoverable) of coral / macroalgae habitat. To verify this, continuation of the post-dredging surveys on an annual basis (Maximum of five years) as required to identify evidence of BCH recovery within the authorised ZoMI. Where BCH has not shown evidence of recovery within the authorised ZoMI after 3 years, consider options for translocation, artificial reef, seagrass transplantation and/or restoration. In the event the water quality triggers are exceeded at the outer boundary of the authorised ZoMI, the pre- and post-dredging BCH surveys will consider a variety of health measures of BCH in the areas outside the authorised ZoMI and ZoHI, which can be used to provide evidence that this EPO has or has not been met.

7.2.9. Reporting

Baseline Report

The Baseline Report will be prepared following the final quarterly baseline survey be completed prior to commence of dredging. The results of the baseline surveys will be summarised and assessed with the intention to characterise natural background changes in the condition of coral communities in the areas likely to be affected by capital dredging and in the reference locations.

The report is proposed to also include a summary of the weather and marine water quality conditions (i.e., benthic light availability), which will be recorded during the pre-dredge period (Refer **Section 7.1**). This information will be used to develop understanding of how the condition of coral communities in the areas likely to be affected by capital dredging and control locations are influenced by natural processes.

Reactive Survey Reports (If Required)

In the event that level 3 management criteria are triggered, a reactive survey investigation will be immediately (i.e., within 72 hours) undertaken. The investigation will consider relevant field observations, comparison of reference sites, water quality and sediment deposition data collected, dredge operations and metocean conditions to delineate impacts detected from natural causes or other anthropogenic sources as part of a multiple lines of assessment approach. Each reactive survey report will include:

1. A summary of data collected during the survey;
2. Comparison of coral community condition with baseline and against reference locations;
3. Multiple lines of evidence assessment (including the outcomes from the Marine Environmental Quality Monitoring & Management Plan);
4. Evaluation of whether coral EPOs been achieved or not; and
5. Recommendations for additional investigations / management / monitoring if required.

>

Where EPOs for coral are not achieved, the CEO will be notified within 24 hours of the determination and a report will be sent within seven days of the determination, including any management actions which have been undertaken.

Post-Dredging Report

The post-dredging report will be prepared following completion of each annual post-dredging survey. The Post-dredging report will include:

1. A summary of data collected during the survey;
2. Comparison of coral community condition with baseline and against reference locations;
3. Multiple lines of evidence assessment (including the outcomes from the Marine Environmental Quality Monitoring & Management Plan);
4. Evaluation of whether coral EPOs been achieved or not;
5. Evaluation of the effectiveness of the BHMP and WQMP; and
6. Recommendations for additional investigations / management / monitoring if required.

7.3. Marine Fauna Management

7.3.1. Management Zones and Observers

Risk of noise exposure, interaction or collision with vessels to marine fauna from dredging resulting in injury or fatality will be managed through the use of management zones (i.e., observation and exclusion zones) and there will be at least one suitably trained Marine Fauna Observers (MFOs) on duty at all times during dredging works and during humpback whale migration, July to November, there will also be a dedicated MFO .These measures focus on species particularly at risk who bask/rest on the surface and/or are air breathers but will be implemented for other marine fauna species if observed. The monitoring protocols and procedures have been informed by Australian National Guidelines for Whale and Dolphin Watching 2017 (Commonwealth of Australia, 2017), and the management zones have been informed using EPBC Policy Statement 2.1. These zones are presented in (**Table 18**). These distances are of a conservative nature for managing potential noise impacts as EPBC Policy statement 2.1 zones are designed for seismic surveys. CSD is non-impulsive and has a lower source level (72dB-

185dB re 1µPa rms at 1 m (CEDA 2011)) than seismic shots (220dB-262dB re 1µPa peak-to-peak at 1 m (CEDA 2011)).

Table 18: Dredging observation and exclusion zones

Marine Fauna Group	Observation Zone (meter)	Exclusion Zone Dredging (metres)
Whales	3000	500
Dolphins	3000	500
Dugongs	3000	500
Turtles	3000	500
Manta rays*	3000	500

Note: The noise modelling from Talis (2019) found that dredging and barging operation effect on sawfish is not expected to result in any behavioural disturbances, and TTS threshold level were no expected to be exceeded. Sawfish are not included in observations as they are highly cryptic and non-surface breathers and unlikely to be detected by observers.

*Based off the limited knowledge of manta rays and elasmobranch hearing it is thought that elasmobranch hearing band width ranges from 25 to 1500 Hz and heave thresholds ranging from ~90 to 170 dB re 1uPa (Mickel and Higgs), which is similar to turtles.

7.3.2. Marine Fauna Observers

Dedicated Marine Fauna Observer

Training and qualifications

One Dedicated MFO will be used prior to and throughout dredging operations during humpback whale southern migration, July to November.

The dedicated MFO will be suitably trained, and dedicated persons engaged to undertake marine fauna observations and mitigation measures associated with dredging. The person will have demonstrated knowledge and experience in marine fauna species observation, distance estimation and reporting. They will not have other duties while engaging in visual observations.

Dedicated MFOs will be suitably trained and qualified, adhering to the requirements of the Wildlife Conservation (Closed Season Marine Mammals) Notice 1998. MFOs must demonstrate a knowledge of marine wildlife species in the North-west region, including Threatened and Migratory Species listed under the EPBC Act, and BC Act and priority listing, including morphological and behavioural characteristics.

Evidence of personnel suitability will be kept on record through staff curriculum vitas, training certificates and in-field record keeping, which may be used in future audits. Information will include:

> MFO names and contact details
> Details of MFOs training (including provider and course dates)
> Previous experience as MFOs on dredge surveys
> Other MFO experience.

Shifts

Dedicated MFO shifts will be set prior to field mobilisation to prevent observer fatigue which could reduce the quality of observations and data recording. This will be done so making sure they are on shift during dredge operations and resting when the dredge is not operating. From a health and safety perspective, having coordinated shifts will ensure that observers have amenity breaks and reduced weather exposure.

Platform

MFOs observations will be undertaken from a suitable elevated point that provides appropriate vantage of the Management Zones and with unimpeded views around the noise source. This point may need to shift pending the location of the noise source on any given day (i.e., site construction activities).

Trained Marine Fauna Observers

Training and Qualifications

Trained MFOs are crew members trained in marine fauna species observations and mitigation measures, consistent with the Project environmental management plans. Trained MFOs will be on duty on Project vessel during dredging and related activities, and may have other vessel duties. There will be always at least one Trained MFO on duty during dredging operations. Crew will be scheduled so that they are able to conduct MFO duties while not undertaking other tasks.

All vessel crews engaged in by the Client for dredging operations of the Project will attend a minimum of one marine fauna induction to become familiar with the range of conservation significant marine fauna that could be present in the operational area and the risks the dredging works may present to this fauna. All commitments made by the Client to manage vessel interactions with conservation significant marine fauna will be included in the induction. The content of the induction will be updated as required to ensure it remains current and reflects the marine fauna being observed in the operational area and any vessel interactions with these fauna that have occurred. This marine fauna induction can be combined with other crew inductions that may be required

Protocols and Procedures

MFO observations will be undertaken from a suitable elevated point that provides appropriate vantage of the Management Zones and with unimpeded views around the noise source. This point may need to shift pending the location of the noise source on any given day (i.e., site construction activities).

To mitigate the potential impacts of the proposed works on significant marine fauna the Contractor must implement the following management and monitoring protocols during dredging and disposal works:

- A 30 minute soft-start for dredging operations apply at all times. Prior to the soft start process commencing a 30 minute MFO checks must be conducted within the exclusion zones.
- Dredging activities must not commence until a suitably trained MFO has verified that no cetaceans, dugongs, manta rays, marine turtles or other protected species have been observed within the Exclusion zone during the 30-minute soft-start period immediately prior to the commencement of dredging.

- The 30 minute soft-start procedure will be implemented following a shut-down or lengthy break. The procedure will involve slowly lower the cutterhead to the seabed and start at low revolutions, gradually increasing the cutter speed in a controlled manner, to passively disturb and deter resident fauna
- A suitably trained MFO must monitor the observation radius of 3 km (Observation Zone) around the dredging activities continuously during these works to identify if there are any cetaceans, dugongs, manta rays, marine turtles or other protected species.
- If a suitably trained MFO observes target marine fauna within the Exclusion zones, then dredging activities must be suspended within 2 minutes of the sightings or as soon as safely possible.
- Dredging activities that have been suspended must not recommence until the sighted marine fauna have moved beyond their respective Exclusion zone or not sighted for at least 30 minutes
- Dredging activities that have been suspended for more than 15 minutes must recommence with soft-start procedures.
- During periods of low visibility e.g., between dusk and dawn, where a distance out to 3 km cannot be clearly viewed, dredging may be undertaken, provided that all other limitations are met and that during the preceding 24-hour period:
  - there have not been 3 or more marine fauna shutdowns; and
  - a 2-hour period of continuous observation was undertaken in good visibility (to a distance of 500 m) and no cetaceans, marine reptiles and sawfish were sighted.
  - if marine fauna is detected in the exclusion zone during poor visibility, operation must cease until visibility improves to enable full visual monitoring of the management zones
- Monitor and log the occurrence of sick, injured and dead turtles and within the development envelope.

It is vital to ensure the protection of marine fauna for the duration of the project. The frequency and location of the observer are paramount to ensure the safety of the marine fauna, with the continuity of the project depending on their response to potential interactions with marine fauna.

7.3.3. Noise Management

Protocols and Procedures

The use of trained MFOs for the duration of dredging and dedicated MFOs for humpback whale migration, management zones (observation and exclusion zones), soft start and shut down measures described in Sections 7.3.1 and 7.3.2 above will be implemented to manage the potential impacts of underwater noise. To further mitigate vessel noise and vibrations during dredging of the Project will be managed by implementing the following measures:

- All equipment and vessels should be operated and be maintained in accordance with appropriate industry and equipment standards including specifications for noise levels and manufacturer's specifications.
- Avoid, where possible, leaving engines and thrusters in standby or running mode unnecessarily.
- Regular monitoring will be conducted to assess compliance with noise and vibration levels.

The soft-start procedure will be implemented when re-starting all below surface operations. The soft start aims to gradually increase the level of dredging activity following a shut-down or lengthy break, with the expectation that nearby animals respond to the soft start via avoidance to the sound and have an early opportunity to move away before the equipment is in full operation, at a louder sound exposure level. The soft start procedure for the proposed dredging activity includes:

> Slowly lower the cutterhead to the seabed and start at low revolutions.
> Gradually increase the cutter speed over 30 minutes before reaching full capacity.

7.3.4. Vessel Strike Avoidance

The distances have considered the Australian National Guidelines for Whale and Dolphin Watching (Commonwealth of Australia, 2017) (**Table 19**).Vessel speeds below have been informed considering both the Australian National Guidelines for Whale and Dolphin Watching (Commonwealth of Australia, 2017) and the National Strategy for Reducing Vessel Strikes on Cetaceans and other Marine Megafauna (DoEE 2017).

> Vessel captain and crew must maintain a vigilant watch for all protected marine fauna species and slow down, or alter course, as appropriate, to avoid striking any protected species. The presence of a single individual at the surface may indicate the presence of submerged animals in the vicinity; therefore, precautionary measures should always be exercised
> Transiting vessels captain and crew must maintain a vigilant watch for all protected marine fauna species. If protected fauna is identified within 500 m of the vessel, the operator must steer a course away from the animal at 8 kn or less until the 500 m minimum separation distance has been established.
> A suitably trained MFO must maintain a watch for cetaceans (i.e., whales, and dolphins), dugongs, marine turtles or other protected marine species during dredge or ancillary vessel transits. If any of these organisms are sighted within 300 m of the vessels the maximum vessel speed must be limited to 6 kn, and the observation recorded. The dredge vessels speed limit of 8 kn applies at all other times.
> Project vessels will not travel faster than 6 kn within 300 m of a whale (caution zone) and not approach closer than 100 m from a whale (no approach zone)
> Project vessels will not travel faster than 6 kn within 150 m of a dolphin (caution zone) and not approach closer than 50 m from a dolphin (no approach zone), with the exception of animals bow-riding
> Should a travelling dolphin enter the no approach zone, including with an attempt to 'bow ride', the vessel shall either maintain its course and speed, or maintain its course and gradually slow down
> Vessels must maintain a separation distance of 100 m from dugongs and 50 m from marine turtles
> No approach zones are a zone of total vessel exclusion. Caution zones are those where speed must be no more than 6 knots (**Table 19**). They cannot be entered by a vessel if there is an animal that is injured, stranded, entangled or distressed, or if a single calf or pod of calves are present.

Table 19: Vessel approach distances (Commonwealth of Australia, 2017)

Marine Fauna Group	Caution Zone (metres)	No Approach Zone (metres)	Frequency	Responsibility
Adult whales	300	100 to the side of the whale 300 m in front or to rear of the whale	Entire duration of dredging	Contractor
Adult dolphins	150	50 to the side of the dolphin 150 m in front or to rear of the dolphin	Entire duration of dredging	Contractor

7.3.5. Records and Reporting

Field Log

Trained MFOs will use pre-designed datasheets to record observer effort, fauna observations and mitigation measures. They will be based on those developed by the Australian Government to record marine fauna sightings made during seismic surveys. Datasheets will include:

> Location, date and start time of survey
> Name, qualifications and experience of MFOs involved in the survey
> Location, times and reasons when observations were hampered by poor sighting conditions
> Location and time of start-up delays, power downs, or stop work procedures as a result of marine fauna sightings
> Location, time and distance of any fauna sightings including species where possible.

Reportable Incidents

All employees of Mardie and contractor shall immediately report all environmental incidents as a non-conformance (i.e., performance indicators are not met or management actions are not followed) to the site supervisor who will investigate the incident with both the Mardie Project Manager and Contractor Project Manager.

Reportable incidences are injury to wildlife as a results of the Project activities or general observations of injured wildlife not related the Project activities to be reported to the Contractor Project Manager. The Contractor Project Manager is to notify the Client, who will notify the Department of Biodiversity Conservation and Attractions (DBCA) and Department of Climate Change, Energy, the Environment and Water (DCCEEW), but within 24 hours and a full incident report completed within 72 hours.

Completion Report

On completion of the program, the contractor will submit a completion report to the Client, which will allow compliance auditing. The completion report will comprise:

> All logs detailing marine fauna sightings during dredging
> All environmental incident reports (including injured wildlife reports).

Response

A log detailing marine fauna sightings and activities will be maintained on all vessels.

Any incidents that relate to marine fauna injury or mortality will be documented and reported to DBCA as soon as possible, within 24 hours and a full incident report within 72 hours.

7.4. Spoil Disposal Monitoring

Monitoring of the dredge spoil and return water will be undertaken to ensure that the EPOs and MTs for protection of marine environmental quality are achieved and potential acidification in the SDA is managed. The monitoring approach is based on weekly sampling of the dredge spoil, weekly water quality sampling of the return water quality and continuous in-situ monitoring of key stressors in the receiving environment. The EPOs, MTs and associated trigger levels were adopted assuming the potential for a temporary, localised reduction in marine environmental quality (recoverable impacts) in the immediate vicinity of the return water discharge. Trigger levels were also developed for management of potential acidification in the onshore management area.

7.4.1. Environmental Protection Outcomes, Management Targets and Trigger Levels

Dredge Spoil Quality

Dredge spoil trigger levels are based on O2 Marine (2019b) which derived site-specific environmental quality criteria (EQC) for metals and nutrients in sediment for the Mardie Project area in accordance with DEC (2006) and EPA (2016) and are presented in **Table 20**.

Table 20: Environmental quality criteria (EQC) for metals and organic nutrients in whole sediment at the Mardie Project area

Analyte	Level of Ecological Protection (LEP)			
	Max	High	Moderate	Low
Units	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Aluminium	10,620	17,750	17,750	26,625
Antimony	0.5	2	2	25
Arsenic	30	36	36	54
Cadmium	0.1	1.5	1.5	10
Chromium	44.5	80	80	370
Cobalt	11.8	20.4	20.4	30.6
Copper	13.5	65	65	270
Iron	42,320	73,700	73,700	110,550
Manganese	415	565	565	847
Mercury	<0.01	0.15	0.15	1
Nickel	22.3	35.8	35.8	52

Analyte	Level of Ecological Protection (LEP)			
	Max	High	Moderate	Low
Silver	0.1	1	1	3.7
Vanadium	59	104	104	157
Zinc	27.4	200	200	410
Total Nitrogen	392	660	660	990
Total Phosphorus	383	635	635	952
Nitrite+Nitrate	0.2	0.2	0.2	0.3
Reactive Phosphorus	0.2	0.4	0.4	0.6

Return Water Quality

The Environmental Protection Outcomes (EPOs), Management Targets (MTs) and trigger levels to be applied for protection of the receiving environment and management of acidification during tail water discharge from the SDA are presented in **Table 21**. Water quality monitoring locations are displayed in **Figure 17**.

The MT and Trigger Level 2 for the receiving tidal creek has been allocated a temporary high level of ecological protection during tailwater discharge in accordance with EPA (2016) which provides for application of a lower level of ecological protection where short-term compliance with a higher lower ecological protection (i.e. Maximum) may not be achieved. However, The EPO requires a maximum level of ecological protection to be met within one month of completion of the discharge to ensure the long-term integrity of ecosystem is not compromised.

Table 21: Proposed Environmental Protection Outcomes, Management Targets and Trigger Levels for protection of marine environmental quality and intertidal BCH from potential tail water discharge impacts

Monitoring Location: SDA discharge point		Monitoring Location: Receiving tidal creek			
Located at the tail water discharge location within the SDA, prior to discharge		Sample locations TC1-7 and AM1-2. Insitu data logging at TC4			
Early warning: High Level of Ecological Protection	Trigger Level 1	Management Target: High Level of Ecological Protection	Trigger Level 2	Ecological Protection Outcome: A Maximum Level of Ecological Protection will be achieved	Threshold Level 1
	Physicochemical Turbidity: Median* <80th percentile of reference pH: >6.5 TTA: <40 mg/L		Physicochemical Turbidity: Median* <80th percentile of reference pH: Median >20th percentile and <80th percentile of reference		Physicochemical: No detectable change from natural background

Monitoring Location: SDA discharge point		Monitoring Location: Receiving tidal creek			
			DO: Median* <90th percentile of reference TTA: Median <80th percentile of reference	with one month upon completion of tailwater discharge.	
	Contaminants Dissolved metals: 99% Species Protection Level (SPL)		Contaminants Dissolved metals: 99% Species Protection Level (SPL)		Contaminants: No detectable change from natural background
	Sedimentation Sediment accretion mean from anyimpact sites >5 cm compared to mean from suitable reference locations		Sedimentation Sediment accretion mean from mangrove impact sites** >8 cm compared to mean from suitable reference locations Sediment accretion mean from algal mat impact sites** >6.5 cm compared to mean from suitable reference locations	-	Sedimentation Sediment accretion mean from mangrove** impact sites >10 cm compared to mean from suitable reference locations Sediment accretion mean from algal mat*** impact sites >8 cm compared to mean from suitable reference locations

*Median calculated based on a rolling 14-day period

** Sites TC3-7

*** Sites AM1-2

7.4.2. Dredge Spoil Monitoring and Management

Representative samples of dredge spoil material will be collected weekly during dredge and spoil disposal activities and analysed for physical properties (particle size distribution), PASS indicators (pH, EC, pH_{FOX}, Chromium reducible sulfur suite), metals (Al, Ag, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Sb, V and Zn) and key nutrients (TN, TIN, TP, FRP). Due to the absence of anthropogenic contaminants as identified in baseline sediment sampling (O2 Marine 2019b), there is no requirement to monitor for organic CoPC.

Sampling for PASS indicators (pH, EC, pH_{FOX}, Chromium reducible sulfur suite) will continue at a bi-monthly frequency once spoil disposal activities have ceased to ensure that PASS is identified as the reclaimed area dries out, allowing treatment to be undertaken post dredging. This will ensure adequate sampling during the drying out process, prior to the reclaimed area completely drying out.

In the unlikely event that higher risk PASS material are encountered during dredge spoil placement, the material will be well mixed with other spoil containing predominantly calcareous materials to ensure that the natural ANC of the marine sediments is sufficient to buffer any acid generating processes of the higher risk material. Based on the natural, clean sediments there is a very low risk of any contaminants being identified, however where contaminants exceed trigger levels return water discharge will cease until adequate dilutions or remediation can be effected prior to continuing release. Release will only be reinstated once the tailwater within the pond returns to levels which are considered to achieve the triggers as presented within **Table 21**.

7.4.3. Return Water Quality Monitoring and Management

Monitoring

Water quality monitoring will be conducted to ensure that the integrity and functions of the receiving environment (intertidal creeks) will not be impacted by the discharge of decant water. The proposed monitoring schedule is outlined as per the following table (**Table 22**). Water quality monitoring at the receiving sites will commence at least 3 months prior to the commencement of operations within the SDA. Water sampling at each site will include three replicates collected during each sampling event.

Sediment accretion will be conducted using sediment sticks (i.e. metal stakes driven into the ground and secure to withstand tidal inundation regimes) inserted into the ground at each of the water quality sampling sites. Measurement will be collected from the base to top of the sediment stick on the seaward facing edge and compared against the trigger. Due accessibility issues within the sampling area due to tidal restrictions for vessels and access via other means, suitable reference sites will be identified and sampling commencing at least 3 months prior to the commencement of operations within the SDA.

Table 22: Proposed SDA monitoring schedule

Aspect	Site Names	Monitoring Schedule
Discharge water quality	Discharge point	Continuous (half-hourly) for turbidity, pH (telemetered) Daily for TTA/TA Monthly for Dissolved Metals
Receiving water quality	Intertidal mudflat impact sites[1] (TC1, TC2 & MF1); Tidal Creek impact sites (TC3-7); Algal mats[1] (AM1 & AM2) and Reference Creek (RC1 & RC2)	Continuous (half-hourly) for turbidity, pH, EC, DO (telemetered - Sites TC4 and RC1 only) Monthly for TTA/TA and Dissolved Metals Monthly for sediment accretion

1: Note that these sites are supratidal and may not have sufficient water during sampling activities

Management

Sediment dredge spoil sampling, return water and sedimentation monitoring data will be reviewed daily/weekly/monthly upon collection off data and laboratory results against the Trigger Levels (**Table 21**). If Trigger Level 1 is exceeded the approval holder and dredge contractor are to be notified and monitoring shall continue. At any point Trigger Level 1 is exceeded, sampling frequency (water sample collection and sedimentation) will be increased to weekly until Trigger Level 1 is achieved. If Trigger Level 2 is exceeded the dredge program will be reviewed and modified as appropriate. In addition, the following modifications to the return water are also to be considered:

> Elevate the point of discharge from the onshore management area to either stop release of water or reduce the proportion of fine sediments released;
> Modify the flow path onshore (i.e. increase retention time) to reduce the proportion of fine sediments released;
> Installation of silt curtain or sediment screens to reduce the marine extent of the discharge water plume; and/or
> Addition of hydrated lime slurry to reduce pH levels of the return water (only for exceedance of the Trigger Level 2 acid measures). The dredging contractor shall ensure that lime and dosing equipment can be readily obtained to minimise any potential downtime should this contingency action be required.
> Include oxygenation or aeration of within the bunded area to increase DO levels prior to discharge.
> Where sedimentation trigger is exceeded consider moving the discharge point, or pipeline to avoid the impacted area, reduce discharge flow rates, or consider alternative point. If trigger criteria not able to be met additional biological monitoring of adjacent mangal communities may be required.

Management of return water will continue until the Trigger Levels are no longer exceeded. Discharge from onshore management area will cease if Trigger Level 2 is exceeded for two consecutive days (continuous monitored parameters) or weeks (weekly monitoring parameters). In this instance daily monitoring will continue and discharge from the onshore management area will only recommence after Trigger Level 1 is no longer exceeded. In addition, detailed investigations on the likely causes of the exceedance and the recommended changes to the dredge program or onshore management area is required within 7 days of any continued exceedance of Trigger Level 2.

Upon completion of dredging and discharge activities, sampling will continue to ensure that a Maximum level of ecological protection is reinstated at the impact sites with sampling data compared against Threshold Level 1. Where Threshold Level 1 is not achieved, the CEO will be notified within 24 hours of the determination and a report will be sent within seven days of the determination, including any management actions which have been undertaken.

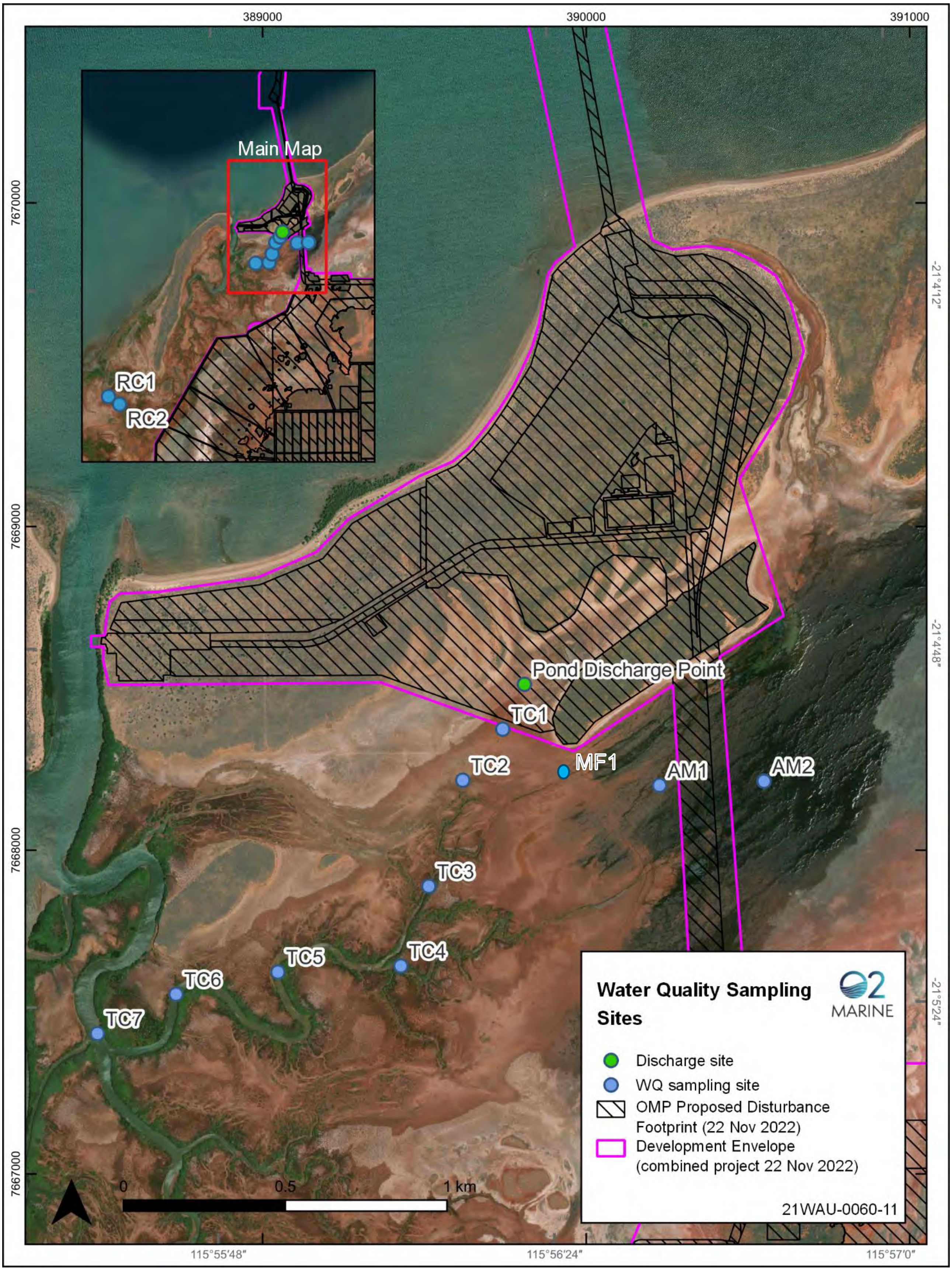


Figure 17: Indicative Onshore spoil disposal areas and water quality monitoring locations

8. Reporting

8.1. Compliance Reporting

Compliance reporting will be conducted and distributed in accordance with the requirements of the Ministerial Statement, as identified in the Mardie Project Compliance Assessment Plan.

8.2. Additional Reporting

A summary of the additional reports that are expected to inform compliance reporting commitments (**Section 8.1**) are listed in **Table 23**.

Table 23: Reporting Requirements throughout Dredging Scope.

Name of Report	Content	Timeframe	Responsibility	Recipient
Baseline Benthic Community Habitat Survey Report	Results and discussion of pre-dredge benthic habitat surveys. Recommendations for any amendments to the monitoring program.	Prior to commencement of dredging.	Proponent	DWER, DCCEEW
Reactive Benthic Habitat Survey Report	Results and discussion of reactive survey. Evaluation of monitoring results against EPO.	Immediately following water quality EPO breach.	Proponent	DWER, DCCEEW
Post Dredging Benthic Community Habitat Survey Report	Results and discussion of post-dredge benthic habitat survey. Describe BCH status and any further management required.	Within 12 months following completion of dredging.	Proponent	DWER, DCCEEW
Marine Water Quality Monitoring Report	Summary of monthly telemetered water quality data. Discuss any management actions implemented during period.	Monthly	Proponent	Internal
Dredge commencement Plume Verification Report	Results of plume verification with multispectral camera at commencement of dredging.	Within first month of dredging	Proponent	DWER, DCCEEW
Quarterly Plume Verification Report	Results of quarterly aerial plume verification with multispectral camera.	Quarterly following dredge commencement	Proponent	DWER, DCCEEW
Reactive Plume Verification Report	Results of reactive aerial plume verification with multispectral camera. Following a level 2 management target exceedance.	Two weeks following level 2 management target exceedance	Proponent	DWER, DCCEEW
Final Marine Water Quality Monitoring Report	Summary of all water quality data collected over the construction period. Discussing trends, exceedances and implemented management actions.		Proponent	DWER, DCCEEW
Marine Fauna Observer Logs	Logs continuous monitoring for Marine Fauna during dredge	Daily during dredge operations	Contractor	Proponent

Name of Report	Content	Timeframe	Responsibility	Recipient
	operations. Outlines necessary management actions where required.			DWER , DCCEEW
IMP Risk Assessment	Department of Primary Industries and Regional Development (DPIRD) 'Vessel check risk assessment', copy of Vessel Check report, supporting documentation including antifoul certificates and inspection reports. Statement from lead inspector on marine pest status of the vessel.	Within 72 hours of inspection.	Contractor	DPIRD
Vessel Quarantine Report	Checklist of vessel components checked during vessel inspection. Statement from lead inspector.	Within 14 days of inspection or risk assessment.	Contractor	DRIRD

9. References

ANZG (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Armstrong A.J., Armstrong A.O., Bennett M.B., McGregor F., Abrantes K.G., Barnett A., Richardson A.J., Townsend K.A and Dudgeon C.L. (2020a) The geographic distribution of reef and oceanic manta rays (Mobula alfredi and Mobula birostris) in Australian coastal waters. Journal of Fish Biology. 96(3):835–840. doi: 10.1111/jfb.14256

Armstrong A, Armstrong A.O., McGregor F, Richardson A.J., Bennett M.B., Townsend K.A., Hays G.C., Keulen M.V., Smith J and Dudgeon C.L. (2020b) Satellite tagging and photographic identification reveal connectivity between two UNESCO world heritage areas for reef manta rays. Frontiers in Marine Science. 7(725):1-18. doi:10.3389/fmars.2020.00725.

Baird (2020a). Mardie Project Hydrodynamic Model Report, 12979.101.R1.Rev1. Prepared for BCIM February 2020.

Baird (2020b). Mardie Project Dredge Plume Modelling Report. 12979.101.R4.RevB. Prepared for BCIM March 2020.

Beyers, D.W. (1998). Causal inference in environmental impact studies. Journal of the North American. Benthological Society 17: 367–373.

CEDA (Centeral Dredging Association) (2011) CEDA Position Paper: Underwater Sound in Relation to Dredging. Avialable from: https://www.iadc-dredging.com/wp-content/uploads/2017/02/article-ceda-position-paper-underwater-sound-in-relation-to-dredging-125-4.pdf

Commonwealth of Australia. (2017). Australian National Guidelines for Whale and Dolphin Watching 2017. Commonwealth of Australia 2017

Couturier L.I.E., Marshall A.D., Jaine F.R.A., Kashiwagi T, Pierce S.J., Townsend K.A., Weeks S. J., Bennett M.B. and Richardson A.J. (2012) Biology, ecology and conservation of the Mobulidae. Journal of Fish Biology. 80:1075-1119. doi: 10.1111/j.1095-8649.2012.03264.x,

DEC (2006). Background quality of the marine sediments of the Pilbara coast. Department of Environment and Conservation, Marine Technical Report Series, No. MTR 1.

DoE (Department of the Environment). (2022). Dugong dugon in Species Profile and Threats Database. Department of the Environment, Canberra. Available from: https://www.environment.gov.au/sprat

DoEE (Department of the Environment and Energy). (2017). Recovery Plan for Marine Turtles in Australia. Australian Government, Canberra. Available from: http://www.environment.gov.au/marine/publications/recovery-plan-marine-turtles-australia-2017.

Downes, B.J., Barmuta, L.A., Fairweather, P.G., Faith, D.P., Keough, M.J., Lake, P.S., Mapstone, B.D. and Quinn, G.P.(2002) Monitoring Ecological Impacts: Concepts and practice in flowing waters. Cambridge University Press, Cambridge, UK.

DPRID (Department of Primary Industries and Regional Development) (unpublished) Draft Resource Assessment Report Norther Coast Demersal Scalefish Resource. Department of Primary Industries and Regional Development, Perth, Western Australia.

EPA (Environemental Protection Authority) (2016). Technical Guidance for Protecting the Quality of Western Australia's Marine Environment. Environmental Protection Authority, Western Australia

EPA (Environmental Protection Authority) (2018). Statement of Environmental Principles, Factors and Objectives, EPA, Western Australia.

Fisher R, Jones R, Bessell-Browne P, (2019) Effects of dredging and dredging related activities on water quality: Impacts on coral mortality and threshold development Report of Theme 4 - Project 4.9, prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 94 pp.

Grey D.L., Dall W and Baker A (1983). A Guide to the Australian Penaeid Prawns. Northern Territory Department of Primary Production, Darwin.

Hanf D, Smith J, Hodgson A.J., Kobryn H and Bejder L.B. (2022) Dolphin distribution and habitat suitability in coastal north Western Australia: Applications of a broadscale, opportunistic dataset. Frontiers in Marine Science. 8(733841):1-18. doi: 10.3389/fmars.2021.733841

Harvey E.S., McLean D.L., Goetze J.S., Saunders B.J., Langlois T.J., Monk J, Barrett N, Wilson S.K., Holmes T.H., Ierodiaconou D, Jordan A.R., Meekan M.G., Malcolm H.A., Heupel M.R., Harasti D, Huveneers C, Knott N.A., Fairclough D.V., Currey-Randall L.M.,Travers M.J., Radford B.T., Rees M.J., Speed C.W., Wakefield C.B., Cappo M and Newman S.J. (2021). The BRUVs workshop – An Australia-wide synthesis of baited remote underwater video data to answer broad-scale ecological questions about fish, sharks and rays. Marine Policy. 127(1004430). doi: 10.1016/j.marpol.2021.104430.

Irvine L.G., Thums M, Hanson C.E., McMahon C.R and Hindell M.A. (2018) Evidence for a widely expanded humpback whale calving range along the Western Australian coast. Marine Mammal Science. 34(2):294-310. doi: 10.1111/mms.12456

Jenner K.C.S., Jenner M.N., Gales N and Double M.C. (2010) Satellite tracking of south-bound female humpback whales in the Kimberley region of Western Australia. Final Report for the Australian Marine Mammal Centre.

Jones R, Fisher R, Bessell-Brown P, Negri A, Duckworth A (2019) Theme 4 | Synthesis Report: Defining thresholds and indicators of coral response to dredging-related pressures. Western Australian Marine Science Institution (WAMSI). Perth, Western Australia pp. 36.

Kangas M, McCrea J, Fletcher W, Sporer E and Weir V (2006). Exmouth Gulf Prawn Fishery. ESD Report No. 1. Department of Fisheries, Western Australia. 128pp.

Kangas M and Sporer E (2015). Brown Tiger Prawn (Penaeus esculentus) In: Management implications of climate change effect on fisheries in Western Australia Part 2: Case studies. FRDC Project 2010/535. Fisheries Research Report 261 eds. Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L and Chandrapavan A. Department of Fisheries, Western Australia. pp. 25-34

Lear K and Morgan (2022) Sawfish Monitoring Project- Mardie Salt. eds Hanf D. Report Prepared for Mardie Minerals Pty Ltd.

Loneragan N.R., Kangas M, Haywood M.D.E., Kenyon R.A., Caputi N and Sporer E (2013).Impact of cyclones and aquatic macrophytes on recruitment and landings of tiger prawns penaeus esculentus in Exmouth gulf, Western Australia. Estuarine, Coastal and Shelf Science. 127:46–58. doi: 10.1016/j.ecss.2013.03.024.

Mickel M.F., and Higgs, D. M (2022) Towards a new understanding of elasmobranch hearing. Marine Biology. 169(12):1-14. doi: 10.1007/s00227-021-03996-8

Morgan D.L., Allen M, Ebner B, Whitty J and Beatty S (2015). Discovery of a pupping site and nursery for critically endangered green sawfish Pristis zijsron. Journal of Fish Biology. 86(5):1658–1663. doi: 10.1111/jfb.12668

Morgan D.L., Ebner B, Allen M, Gleiss A, Beatty S and Whitty J (2017). Habitat use and site fidelity of neonate and juvenile green sawfish Pristis zijsron in a nursery area in Western Australia. Endangered Species Research. 34:235–249. doi: 10.3354/esr00847

MScience (2009) Wheatstone LNG Development: Baseline Water Quality Assessment Report. Report to URS Australia Pty Ltd, November 2009.

Newman S, Wakefield C, Skepper C, Boddington D and Blay N (2020). North Coast Demersal Resource Status Report 2019. In: Status Report of the Fisheries and Aquatic Resources of Western Australia 2018/19: The State of the Fisheries eds. Gaughan DJ and Santoro K. Department of Primary Industries and Regional Development, Western Australia. pp. 159-167

Newman SJ, Young GC and Potter IC (2004). Characterisation of the inshore fish assemblages of the Pilbara and Kimberley coasts. Department of Fisheries, Research Division, WA Marine Research Laboratories, North Beach.

O2 Marine (2019a). Mardie project – Sediment Sampling and Analysis Plan Results. Prepared for Mardie Minerals Pty Ltd. Report Number R190033.

O2 Marine (2019b). Mardie Project – Subtidal Benthic Communities and Habitat Baseline Assessment. Prepared for Mardie Minerals Pty Ltd. Report Number R190045.

O2 Marine (2020a). Mardie Project – Marine Water Quality. Prepared for Mardie Minerals Pty Ltd. Report Number R190056.

O2 Marine (2020b). Mardie Project Marine Fauna Review. Report Prepared for Mardie Minerals Pty Ltd.

Ovenden J.R., Peel D, Street R, Courtney A.J., Hoyle S.D., Peel S.L. and Podlich H (2007). The genetic effective and adult census size of an Australian population of tiger prawns (Penaeus esculentus). Molecular Ecology. 16(1):127-138. doi: 10.1111/j.1365-294X.2006.03132.x.

Pearce, A. F.; Buchan, S.; Chiffings, T.; D'Adamo, N.; Fandry, C. B.; Fearns, P. R. C. S.; Mills, D. J.; Phillips, R. C.; Simpson, C. A review of the oceanography of the Dampier Archipelago, Western Australia. In: Wells, F. E.; Walker, D. I.; Jones, D. S. Editors, editor/s. (2003) The Marine flora and fauna of Dampier, Western Australia: proceedings of the Eleventh International Marine Biological Workshop; 24 July-11 Aug. 2000; Dampier, Western Australia. Perth, W.A.: Western Australian Museum; 2003. 13-50.

Pendoley Envrionmetal (2019). Mardie Salt Project: Marine Turtle Monitoring Program 2018/19. Prepared for BCI Minerals Ltd. Report Number: RP-59001

Pendoley Envrionmental (2022). Mardie Salt Project: Pre-Construction Marine Turtle Monitoring Program 2021/22. Perpared for BCI Minerals Ltd. Report Number: J59003

Pendoley, K.L., Whittock, P.A., Vitenbergs, A and Bell, C. (2016) Twenty years of turtle tracks: marine turtle nesting activity at remote locations in the Pilbara, Western Australia. Australian Journal of Zoology. 6

Penn J.W and Stalker R.W (1979). The Shark Bay Prawn Fishery (1970-1976). Department of Fisheries Wildlife Western Australia Report 38: 1-38.

Raudino, H.C., Hunt, T.N and Waples, K.A. (2018) Records of Australian humpback dolphins (Sousa sahulensis) from an offshore island group in Western Australia. Marine Biodiversity Records. 11(14):1-6. doi: 10.1186/s41200-018-0147-0

Sudmeyer, R (2016) ‘Climate in the Pilbara’, Bulletin 4873, Department of Agriculture and Food, Western Australia, Perth

Udyawer, V., Somaweera, R., Nitschke, C., d’Anastasi, B., Sanders, K., Webber, B.L., Hourston, M. and Heupel, M.R. (2020) Prioritising search effort to locate previously unknown populations of endangered marine reptiles. Global Ecology and Conservation 22: e01013.

Ward R.D, Ovenden J.R, Meadows J.R.S, Grewe P.M and Lehnert S.A. (2006). Population genetic structure of the Brown tiger prawn, Penaeus esculentus, in tropical northern Australia. Marine Biology. 148(3). doi: 10.1007/s00227-005-0099-x.

Whitty J.M., Morgan D.L., Peverell S.C., Thorburn D.C and Beatty S.J. (2009). Ontogenetic depth partitioning by juvenile freshwater sawfish (Pristis microdon: Pristidae) in a riverine environment. Marine Freshwater Resource. 60:306–316

Appendix A Example Marine Fauna Observation Log

MARINE FAUNA OBSERVATION RECORD

Date: ______ Vessel: ______

Dredge method: ______ dredge type: ______

Marine Observer: ______ Sign: ______

Marine Observer: ______ Sign: ______

OBSERVATION AND EXCLUSION ZONES (m)		
Fauna	OBSERVATION	EXCLUSION
Whales	500	300
Dolphins	500	300
Dugongs	500	300
Turtles	500	300

Definitions:	
	Height – Platform plus observer eye height
Time – To be filled out in 24hr	**Distance** – Of observer to animal
Sea State – Beaufort scale	**Condition** – Animal distressed, calm, injured, dead
Species certainty– Certain or uncertain	**Group composition - number in each age class** – Adult / juvenile / calf
Number – Number of individuals	**Condition** – Animal distressed, calm, injured, dead
Notification – Method and whom	**Behaviour** – Travelling, foraging, resting, socialising, unknown

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	Time	Full or low light?	Observer	Weather	Sea State	Dredging lat. dd.ddd	Dredging long. dd.ddd	Is Marine Fauna within the Observation Zone? If Yes – fill in next page		Is Marine Fauna in the Exclusion Zone? If Yes, fill in next page	
								Yes	No	Yes	No
Example record	08:00-08:30	Full Light	LW	Sunny	2	S 19.21675	E 146.21675	Yes			No

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	Time (24hr)	Zone (Ob or Ex)	Whale / Dolphin / Dugong / Turtle	Species	Species certainty	Number	Time Entered (your vision / the mitigation zone)	Time Exited (your vision / the mitigation zone)	Observer lat. dd.ddd	Observer long. dd.ddd	Height (of observer on vessel)	Distance (of animal from observer)	Distance of animal from dredging	Condition	Group composition	Behaviour	Action Taken	Stop Work?		Notification/ Comments
																		Y	N	
Example record	08:14:00	Ob	Dugong	Dugong	Certain	2	08:14:00	08:17:00	S 19.24487	E 146.87501	5	50	450	calm	1 adult, 1 calf	travelling	Alerted crew of dugongs in observation area & keeping eyes on it to confirm do not resurface closer or in exclusion zone		N	NA