Port Hedland Spoilbank Marina: Dredging Environmental Management Plan

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1. Introduction

1.1. Project Summary

The Town of Port Hedland, together with LandCorp and the Pilbara Development Commission, have been progressing planning for the development of a marina in Port Hedland. They have developed a concept design for a marina on the western side of the Spoilbank, adjacent to the Port Hedland Yacht Club. The Department of Transport (DoT) are responsible for the coordination of the design of marine facilities, which plan to provide a new boat launching facility, up to 80 boat pens, jetties, amenities and parking infrastructure. The Project will require dredging and onshore disposal of approximately 800,000 m^3 of dredging material.

1.1. Purpose of this Plan

The purpose of this DEMP is to outline the Environmental Protection Outcomes (EPO)s and Management Targets (MTs) associated with the dredging and dredge material disposal to be undertaken for the Spoilbank Marina development, Port Hedland. Detailed management and monitoring actions are included to ensure that the project EPOs are achieved.

1.2. Document Review

This DEMP should be reviewed on an as required basis. It is considered that review and revision should at least occur in response to the following circumstances:

- Engagement of dredging contractor;
- New information relating to potential environmental impacts comes to hand;
- Finalisation of dredge material disposal strategy;
- Significant changes to dredging or material disposal methods; and
- Following the first three months of construction, to determine the effectiveness and rigor of monitoring and management actions against EPOs and MTs.

Upon review of the DEMP, the document will be revised where appropriate and the revision status of the document will be updated as required.

1.3. Proponent Details

The proponent for the proposal is the Department of Transport (DoT). Proponent details are provided in Table 1.

Table 1 Proponent Details

Company Name:	Department of Transport
Australian Business Number (ABN):	59 167 963 715
Address:	1 Essex Street, Fremantle 6160
Key Contact (Role):	Jason Bradford
Key Contact Details:	Phone: +61 8 9435 7563 Email: Jason.Bradford@transport.wa.gov.au Email: Matthew.Spence@transport.wa.gov.au

1.4. Legislation, Regulation and Guidelines

Commonwealth Environment Protection and Biodiversity Conservation Act (1999)

The Environmental Protection and Biodiversity Conservation Act (1999) (EPBC Act) establishes a process for the assessment and approval of proposed actions that are likely to have a significant impact on matters of national environmental significance or on Commonwealth land.

Other Commonwealth legislation, regulation and guidelines

Other applicable Commonwealth legislation and guidelines include, but are not limited to, the following Acts, Regulations (and relevant amendments):

- Protection of the Seas (Prevention of Pollution from Ships) Act 1983;
- Australian Ballast Water Management Requirements Version 7 2017;
- Biosecurity Act (2015);
- Biosecurity Regulations (2016); and
- National Water Quality Management Strategy (Commonwealth Government of Australia 1992).

State legislation, regulation and guidelines

The key Western Australian legislation, regulation and guidelines relevant to dredging at the Port of Port Hedland include:

- Biodiversity Conservation Act 2016
- Port Authorities Act 1999;
- Navigable Waters Regulations 1958;
- Shipping and Pilotage (Port and Harbour) Regulations 1967
- Western Australian Marine Act 1982;
- Pollution of Waters by Oil and Noxious Substances Act 1987;
- Marine and Harbours Act 1981;
- Environmental Protection Act 1986;
- Environmental Protection Regulations 1987;
- Fisheries Resource Management Act 1994 (the State Act addressing Introduced Marine Pests);
- Western Australia Environmental Protection Authority Technical Guidance - Assessment Guidelines of Marine Dredging Proposals (WA EPA, 2016a);
- Western Australia Environmental Protection Authority Technical Guidance - Protecting the Quality of Western Australia's Marine Environment (WA EPA, 2016b); and
- Western Australia Environmental Protection Authority Technical Guidance – Protection of Benthic Communities and Habitats (WA EPA, 2016c).

1.5. Proposal Description

The Port Hedland Spoilbank Marina development (the proposal) is located in Port Hedland in the Pilbara region of Western Australia (Figure 1). The proposal is located on Lot 5751 and Lot 5550 on a site commonly known as the 'Spoilbank', located approximately 1.5 km east of the Port Hedland town centre. The spoilbank is an artificial coastal landform created in the late-1960s and early-1970s as a result of disposing of dredged material associated with Port Hedland's inner harbour and shipping channel development.

The proposed action aims to replace the existing boat ramp located on Richardson Street (which will be closed) and redirect boating activities away from the high use areas of the Port of Port Hedland's inner harbour navigation channel. Noting this, DoT considers that the net vessel movements in Port Hedland would not significantly increase as a result of implementing the proposed action, but only result in the relocation of boating to a safer and less frequented environment. The proposal will be situated largely within the footprint of the existing Port Hedland Yacht Club facility, in the south west corner of the Spoilbank. The proposed infrastructure works are outlined below:

- Harbour basin, berth facilities (up to 80 pens), boat launching area and entrance channel;
- Capital dredging works resulting in up to 900,000 cubic metres (m3) of dredge material and dredged to a maximum depth of -2m CD (chart datum) / -5.9m AHD. Dredge material will be used onsite as fill material to raise the ground level prior to landscaping - no ocean disposal of dredge material will occur as part of this proposed action;
- Construction of the marina's breakwaters, revetments and sand trap. Materials for the construction of these structures will be sourced from local quarry operations; and
- Car/trailer parking, amenities (public and pen holders), public open space and upgrading of associated infrastructure.

Table 2 Location and proposed extent of physical and operational elements

Element / Location	Proposed Extent
Physical Marine Element	
Harbour Basin and Entrance Channel	Approximately 5.7 ha
Breakwater and revetment walls	Approximately 5 ha
Sand Trap	Approximately 7 ha
Physical Terrestrial Element	
Parking and trailer bays	Approximately 3.5 ha
Public Open Space	Approximately 3.5 ha

Dredging will occur within six zones (Table 3 and Figure 2).

Table 3 Proposed extent and volume of dredging zones

Zone	Design Depth (m CD)	Area (ha)	Dredge Volume for Design (m^3)
Primary Channel	2.5 m	2.75	108,500
Harbour Basin	2.5 m	2.99	332,000
Breakwater[1]	2.5 m	2.11	107,000
Revetment[1]	2.5 m	2.30	110,000
Sand Trap	2.0 m	6.83	100,000
Project Total		**16.9ha**	**757,500**

[1] Dredging for the breakwater and revetment will be undertaken to enable foundation of the footings.

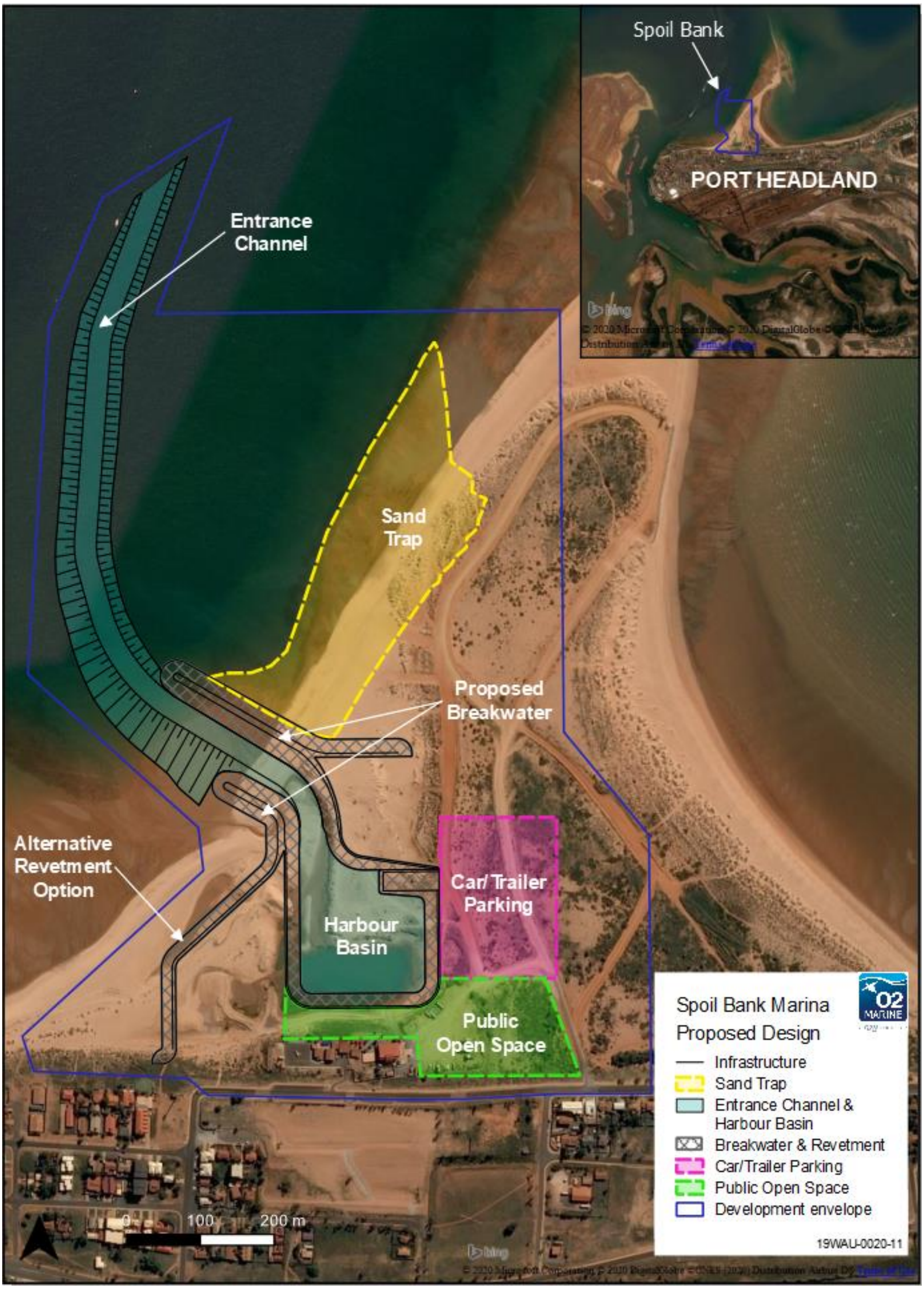

Figure 1 Concept design for Spoilbank Marina

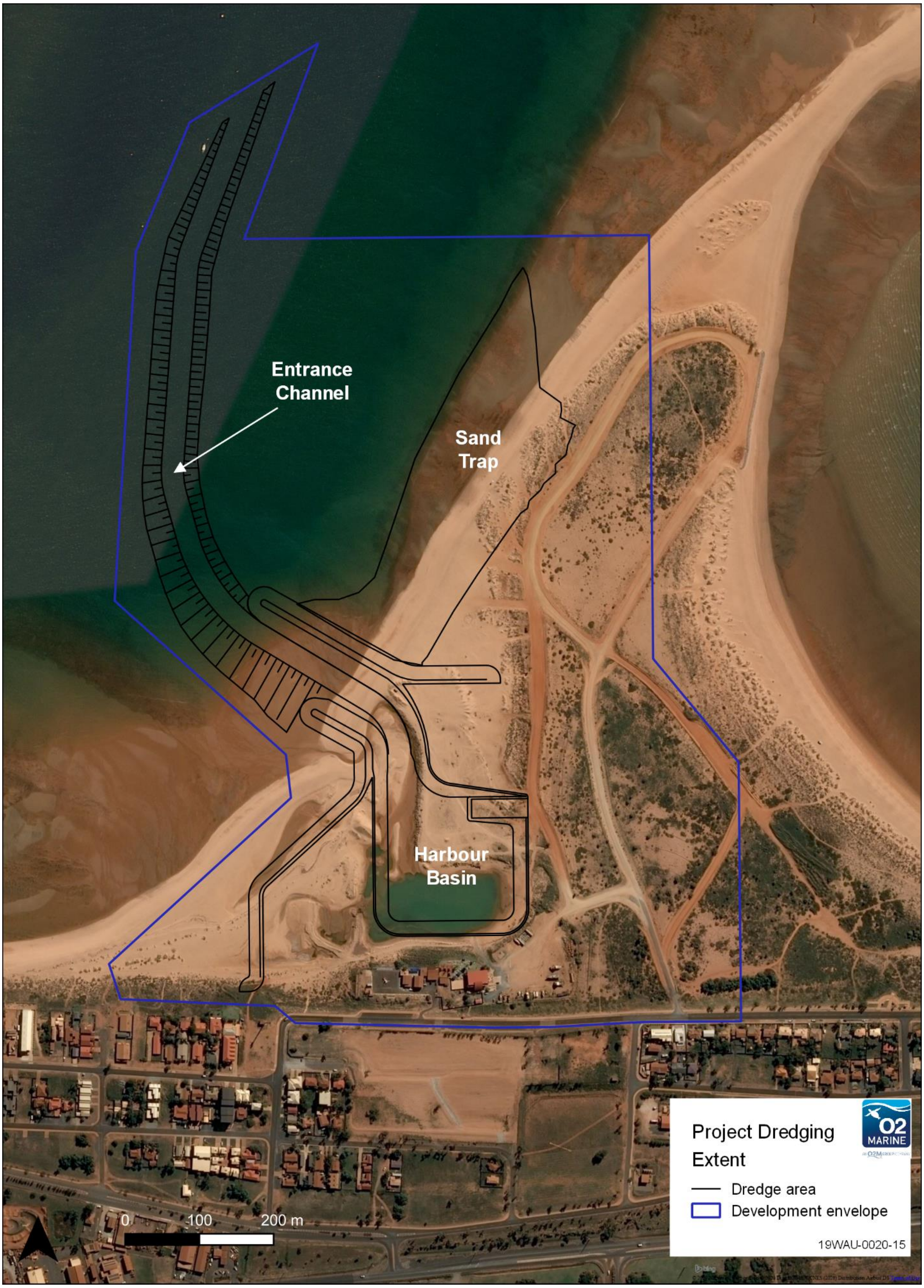

Figure 2 Dredging areas for the Spoilbank Marina

2. Environmental Setting

2.1. General Environment

2.1.1. Climate and Oceanography

The Wet Season (October to April) is very hot, with average monthly maximum temperature of 36.1°C (Bureau of Meteorology, 2019). During the Dry Season (May to September) the average monthly maximum temperature is 28.8°C. North-westerly winds prevail during the Wet Season and a strong south-easterly wind regime dominates during the Dry Season. The mean annual rainfall is 318 mm of which 79% falls during the Wet Season and is typically associated with scattered thunderstorms frequent cyclone events, including moderate to severe events every 5 to 10 years which cause extreme event winds, waves, water levels, currents and sediment transport that can be significantly higher than during ambient conditions (Baird 2019).

The passage of thunderstorms can also result in water level surges and localised flooding. The Pira coastline is also the most cyclone-prone area within Australia. Since 1910, Port Hedland has been impacted by 49 cyclones which are often associated with elevated water levels, high wave energy and widespread flooding (BOM 2019a). The nearshore waters of Port Hedland range in temperature from ~30.1°C (in March) to ~23.2°C (in August) and generally have a low nutrient level (Seatemperature.org 2019).

Port Hedland experiences large, semi-diurnal tides with a Spring tide rage of 7.9 m and a Neap tide range of 1.5 m. Flood tide currents have a maximum speed of 1.5 kn and flow in an easterly direction, ebb tides are directed to the north-west (PPA 2019).

2.1.2. Geomorphology

The Pilbara coast has a relatively wide continental shelf with a low relief slope between the shoreline and the edge of the shelf approximately 200 km offshore which has a water depth of ~150 m (RPS 2014 and Jones 1973). Across the coastal platform shallow sandbars, platforms, reefs and ridges are common. Occasional flooding causes the erosion and the dispersal of terrestrial sediment across the nearshore and the development of silty tidal flats (RPS 2014).

2.1.3. Water Quality

Nearshore environments, in water depths shallower than 5 to 10 m CD, are characterised by variable turbidity, high sedimentation rates and highly variable light and temperature conditions. Much of the variability observed in marine water quality conditions is attributable to season, weather, tide and influence of both ‘true’ marine waters, and intertidal creek waters exiting the Port of Port Hedland.

2.2. Benthic Communities Habitat

In November 2019 O2 Marine undertook a benthic habitat mapping survey for this project (O2 Marine 2019a). This survey was completed across two areas in: 1) A detailed survey focusing on the proposed Spoilbank Marina footprint, and 2) The Spoilbank Local Assessment Unit (LAU) where broadscale ground-truthing was undertaken to validate the existing benthic habitat data.

Six Benthic Community Habitat (BCH) sub-classes were identified during the field survey based on the relative species density and substrate. However, to facilitate comparison with previous habitat mapping, sub-classes were combined into three broad BCH classes which had the following coverage across the Spoilbank LAU:

- Bare Sand (90.4 % - 6413.7 ha);
- Mixed assemblage (8.3% - 587.9 ha); and
- Mixed assemblage with seagrass (1.3% - 90 ha).

The benthic cover was generally sparse to low across more than 95% of the study area. All habitats identified within Spoilbank LAU are considered to be widespread across the turbid nearshore environments of the Pilbara region and as such do not represent habitats of particular regional or conservation significance. Sparse seagrass communities were observed in the vicinity of the Project area, and in the Spoilbank LAU to the west. Corals were also observed in proximity of the project area as a component of both mixed assemblage BCH classes.

2.2.1. Identified Habitat

Bare Sand

The bare sand habitat can support microphytobenthic algal communities and benthic infauna. It is also likely that some areas of bare or unvegetated substrate will support more complex ephemeral BCH at different times, particularly in shallow water areas where the benthos is constantly changing in response to physical disturbance from wave mobilisation of sediments, storm events and sedimentation following large runoff events.

Mixed Assemblage

The mixed assemblage benthic habitat includes corals, macroalgae, sponges and other species of filter-feeders present with different percentage coverage. Corals are particularly important as benthic primary producer, providing habitat and a food source for a wide variety of marine species (Moberg and Folke 1999), moreover corals perform an important role as nutrient recycler. The associated macroalgae are also an important component of tropical reef ecosystems as they contribute to the productivity of a system as a food source, provide habitat for a range of economically and ecologically important species, contribute to local sediments and play an important role in the nutrient cycle from decomposition (Kendrick & Olsen 2017). The mixed assemblage habitat was found predominantly on hard substrate along the shoreline and represented less than 9% of the Spoilbank LAU and generally had a low level of biodiversity. Therefore, the likely contribution of these coral communities to local and regional ecosystem is considered to be limited.

Mixed assemblage with seagrass

The mixed assemblage with seagrass benthic habitat includes mixed communities with sparse seagrass mixed at corals, macroalgae and other filter feeders, as well as sparse to very sparse seagrass on bare sand substrate. Seagrasses are known to provide an important role within the marine ecosystem providing carbon storage, filtering nutrients and particles from the water column, stabilising sediments and providing high primary productivity (McKenzie et al. 2006). Seagrass can also provide an important source of foraging habitat for dugong, turtles and commercially fisheries, such as prawns. However, the sparse distribution and low cover of seagrasses observed within the Spoilbank LAU suggests that their contribution to ecosystem services in a regional context is limited.

2.3. Sediment Characteristics

A sediment assessment of materials to be dredged was carried out by O2 Marine in November 2019 (O2 Marine 2019b). This assessment was used to provide a preliminary determination of the dredged sediment characteristics for the program and is briefly summarised below. CMW Geosciences also undertook a detailed geotechnical assessment of both marine and onshore development areas in November 2019. Results from this assessment were provided directly to DoT.

The aim of the November 2019 sediment investigation was to identify the physico-chemical characteristics of the marine sediment (subtidal and intertidal) within the proposed dredge footprint, inner basin and onshore development envelop. The particle size fractions of the sediments from the three dredging zones of were dominated by medium grained sand (0.06 – 2 mm), with the channel recording slightly higher proportions of silt/clay compared to the basin and sand trap (Table 4). The basin recorded the highest proportion of gravel (28%), with the channel the lowest (4%). Deeper samples (particularly in the Channel) recorded a higher proportion of silt/clay when compared to the large amount of shallow samples (≤1 m below seabed) which were dominated by sand.

Table 4 Mean (and standard deviation) percentages for sediment size fractions obtained from the Channel, Harbour Basin and Sand Trap

Size Fraction	Channel	Basin	Sand Trap
Gravel (>2 mm)	4% (±3)	28% (±17)	14% (±16)
Sand (0.06-2.00 mm)	76% (±11)	64% (±15)	79% (±16)
Silt (2-60 µm)	9% (±9)	2% (±5)	3% (±4)
Clay (<2 µm)	11% (±4)	6% (±4)	4% (±5)

All contaminants of potential concern (and some additional tested parameters) were found to be below the ANZG (2018) Default Guideline Values, NEPM (2013) Health Investigation Levels (HILS) and NAGD (2009) Screening Levels. At six (6) locations, Aluminium or Iron exceeded locally derived background levels, however these were determined to be largely natural occurrences, with a strong correlation of Aluminium and Iron to the <63 µm size fractions (clay and silt). All hydrocarbons (TRH, BTEXN, PAH) and pesticides were below the Laboratory Practical Quantitation Limits (PQLs). Organotins were almost all entirely below the PQLs except for four sites which were all well below the guideline value.

All sediment samples were tested for potential (PASS) and actual (AASS) acid sulfate soils using a screening test and selected samples were also subject to chromium suite analysis. PASS were detected within the deeper horizons sampled at three sites (C02 – northern end of Channel, B12 – Basin and S29 – Sandtrap), however, results show that the natural acid neutralising capacity of the sediments provide sufficient buffering for acid-generating processes, indicating the risk of acid sulfate soils is low.

3. Construction Works

The proposed project will involve both marine and terrestrial construction works. The works relating to the dredge and return water management are listed below:

1. Preparation of the Dredge Material Management Area (DMMA);
2. Mobilisation of a Cutter Suction Dredge (CSD);
3. Installation of pipeline between the dredge and DMMA;
4. Dredging of the Channel, Basin, Sand Trap, Breakwater (to establish foundation) and Revetment (to establish foundation);
5. Construction of breakwater and revetment;
6. Management of dredge material at the DMMA to ensure appropriate distribution and management of return water turbidity;
7. Dredge return water discharge from the DMMA to the receiving environment;
8. Pre- and post-dredge hydrographic surveys; and
9. Demobilisation and site clearance.

3.1. Sequencing of the Works

The project proposes that all works be carried out 10 hours per day, 6 days per week. The planned project sequence is as follows, whereby the tasks listed below may occur concurrently or overlap :

1. Preparation of all relevant Project Management Plans;
2. Equipment preparation; inspection; certification;
3. Pre-dredge hydrographic survey and terrestrial survey of the proposed DMMA;
4. Mobilisation of all plant, equipment and site facilities;
5. Site set-up including construction of pipeline(s), road crossings and over-paths (if required);
6. Preparation of DMMA;
7. Dredging and discharge of materials to the DMMA;
8. Progressive hydrographic surveys of areas dredged;
9. Final hydrographic and terrestrial survey to document completed works; and
10. Demobilisation and site clearing.

3.2. Preliminary Construction Schedule

Under the current project schedule, dredging construction activities are planned to commence in mid-2020 once all required internal and external approvals are granted. Dredging and material placement is proposed to be undertaken over a period of approximately 18 months (Table 5).

Table 5 Preliminary project construction schedule

Project Schedule	Duration (weeks)
Project Preliminaries	5
Mobilisation & Installation	8
Dredging & Material Disposal (Channel and Sandbank)	12
Land-Side Excavation	12
Dredging & Material Disposal (Harbour Basin)	24
Demobilisation & Site Clearance	4

3.3. Mobilisation and Site Installation

All plant and equipment including pipeline will be transported via sea and/or public road to the Project Site in Port Hedland, WA. Other required marine and civil works equipment (e.g. work boats and crew transfer vessels) may be sourced locally. Appropriate hydrographic and terrestrial survey support will be secured to undertake the required works. The range of equipment which is intended to be utilised on this project includes items listed in Table 6.

Table 6 Proposed Plant and Equipment

Equipment	Name	From	Transport
Cutter Suction Dredge	TBA	TBA	Sea / Road
Booster Station	N/A	TBA	Road
±2 km of dredge pipeline	N/A	Various, interstate	Road
Civil plant	N/A	Port Hedland	Road
Auxiliary plant and equipment	Various	Various, local and interstate	Road

The project site facility shall be located on the Port Hedland Spoilbank. The lay-down area will need to provide sufficient storage space to store the containers with spare parts, pipeline, booster stations, etc. A basic site office with relevant amenities, and area for plant maintenance will be set-up. The site office will contain all the requirements under the contract as well as the superintendent's office (if required).

3.4. Deployment of Cutter Suction Dredge and Pipeline Installation

It is anticipated that the CSD will have installed appropriate dredge control software (e.g. DREDGEPACK) to ensure close control on the dredging operations. Floating and submersible pipeline will be installed from the back of the dredge to the shore connection. The pipeline will traverse the shore to the DMMA. To allow mobile plant and light vehicle access there may be a need to construct traffic ramps over some sections of the pipeline. There may be a requirement for a land-based booster pump.

3.5. Hydrographic Surveys

A detailed hydrographic survey shall be completed prior to commencement of the works to enable control of dredging works and enable calculation of dredge volumes. Subsequent hydrographic surveys will be conducted to determine if the specifications for that section have been completed.

3.6. Dredging

A CSD consists of a U-shaped pontoon, which is held in position by a fixed spud and two anchors (Figure 3).

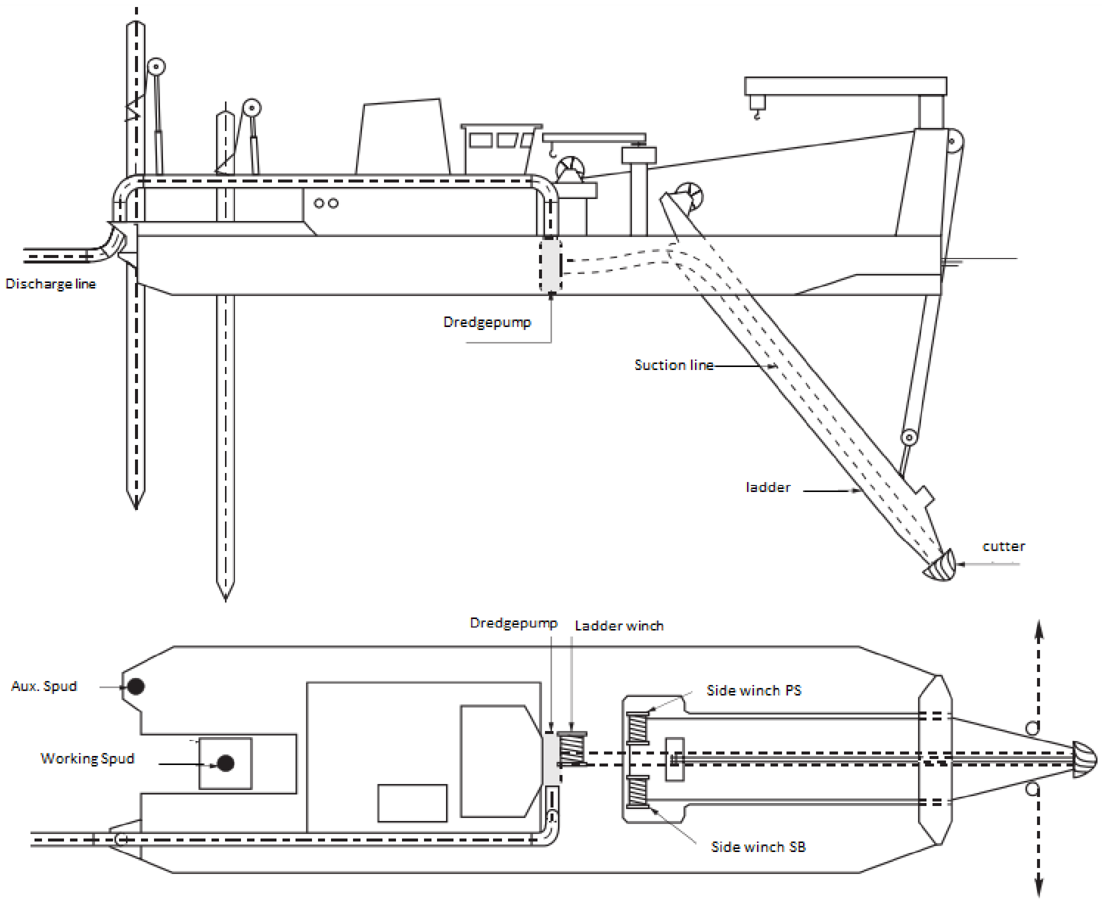

Figure 3 Cutter Suction Dredge schematic

The area to be dredged is loosened by rotating the cutting head. The cutter head 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 hinged off the main hull. The ladder assembly is lowered and raised by means of a winch.

During dredging, the CSD arcs around the main spud with the help of side winches. 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.

Following cutting of the seabed the mixture of water and materials is drawn into the suction mouth by the force of the centrifugal pump on the dredge. The dredged material is then pumped through a floating and/or submersed pipeline, which extends from the back of the CSD and to the discharge location.

Booster pump stations may be installed along the length of the discharge pipeline if required to generate a constant flow of material in the pipeline. The total length of the pipeline, the diameter of the pipeline, the characteristics of the material transported and the capacity of the CSD will determine the requirement and location of any booster pumps.

3.6.1. Project Specific Dredge Specifications

The majority of material is expected to be dredged using a medium sized CSD. With the remaining expected to be removed using a land-based excavator (Baird, 2019). Dredging production rates have been adopted based on upper limit estimates from previous similar projects, and based on a medium-sized CSD, these are: 3,300m^3/day for sand, 630m^3/day for rock, 1250m^3/day for red beds (Baird, 2019). An indicative dredging schedule (used for modelling) has been developed (Table 7). A detailed construction schedule will be finalised once the preferred dredging contractor has been selected. The indicative schedule assumes:

- 10-hour dredge operations (daylight hours 8am to 6pm) over a 6-day working week (Monday to Saturday);
- Upper limit production rates are achieved for the dredging and construction activities; and
- No dredging during the Port Hedland turtle nesting season (December–March inclusive);
- No downtime occurs during the production schedule.

Table 7 Indicative dredging schedule

Activity	Indicative Month
Site establishment Year 1	Month 1 (April Year 1)
Entrance Channel Dredging (CSD)	Month 2–Month 5 (May–Aug Year 1)
Landside Entrance Structures (Excavator)	Month 5–Month 8 (Aug–Nov Year 1)
Site establishment Year 2	Month 9 (April Year 2)
Harbour Basin Dredging (CSD)[1]	Month 10 – Month 16 (May – Nov Year 2)

1. Assumption that no land-based excavation is undertaken inside Harbour Basin.

3.7. Onshore Dredge Material Disposal

Dredge material will be disposed onshore within the proposed DMMA (Figure 4). The DMMA will be bunded into sections and barge-boards used to control flow and settlement rates through each section. Controlling and managing the filling process will be achieved by monitoring and spreading the fill material using earthmoving equipment such as bulldozers and hydraulic excavators. After the fines have settled out, the return water will be discharge to the ocean via a weir structure designed to release water from the surface of the ponded water within the bund. The plume modelling has assumed a total suspended sediment concentration in the return water of 25 mg/L, comprising 50% clay and 50% fine silt, discharging at a constant rate throughout the entire dredging period (Baird, 2019).

Figure 4 Proposed dredge material management areas

3.7.1. Potential Acid Sulfate Soils

The Sediment Quality Assessment (O2 Marine 2019b), identified a small presence of PASS within the proposed dredge areas. However, the natural acid neutralising capacity (ANC) of the sediments was found to provide sufficient buffering for any acid-generating processes and the material was considered unlikely to require treatment (i.e. lime dosing) during onshore placement within the DMMA.

Onshore Placement of PASS Material

In the event that higher risk PASS material (i.e. material containing a high proportion of clay/silt fines or with a strong sulfuric smell) is encountered during dredge material placement in the DMMA, 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 any acid generating processes of the higher risk material.

Discharge Water Quality Monitoring and Management

Although the PASS risk is low, monitoring of the discharge water from the DMMA shall be undertaken weekly to confirm acid levels. Should the pH readings of the discharge water drop below 6 and the TTA (total titratable acid) is greater than 40 mg/L, then dilute hydrated lime slurry shall be added to the DMMA to ensure pH levels of the discharge water return to acceptable limits. If the pH and TTA observations continue to exceed the criteria limits then return water discharge shall cease, and additional liming will take place as required to achieve the desired pH. The dredging contractor should ensure that lime and dosing equipment can be readily obtained to minimise any potential downtime. Further details of the discharge water quality monitoring program are provided in Section 7.2

4. Roles and Responsibilities

The roles and responsibilities for the implementation of the DEMP are summarised in Table 8.

Table 8 Roles and responsibilities of key personnel

Position	Responsibility
Proponent (Department of Transport)	• Overall responsibility for implementation of this DEMP • 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 key stakeholders • Responsible for environmental compliance reporting • Responsible for reporting all environmental non-compliance incidents
Proponent's Representative	• Complies with the requirements of this DEMP • Provides advice on dredging and dredge material management related environmental issues • Oversee implementation of environmental controls, monitoring programs, inspections, audits and management actions in this DEMP • Completes compliance reporting requirements • Responsible for the implementation of the environmental monitoring programs and inspections • Prepares environmental monitoring reports • Provides advice with respect to environmental issues as required
Dredging Contractor	• Undertakes dredging and excavation works • Prepares and implements an environmental management plan in accordance with the requirements of this DEMP • Implements the management actions of this DEMP • Ensures adequate training of all staff within their area of responsibility • Ensures all equipment is adequately maintained and correctly operated • Responsible for reporting all environmental incidents to the DoT within 24 hours in accordance with DoT incident reporting procedures
All persons involved in the project.	• Comply with the requirements of this DEMP • 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 DEMP have been derived from the Statement of Environmental Principles, Factors and Objectives (EPA 2016), which outlines objectives aimed at protecting all environments (Themes) including: Sea, Land, Water, Air and People. The project specific Environmental Protection Outcomes (EPOs) and Management Targets (MTs) for each of these key factors and are outlined in Table 9.

Table 9 Key environmental factors, potential environmental impact pathways and management outcomes

Environmental Factor	EPA Objective	Potential Environmental Impact Pathway	Environmental Protection Outcome (EPO)	Management Target (MT)	Management Measures
THEME: SEA					
Benthic Communities and Habitats (BCH)	To protect BCH so that biological diversity and ecological integrity are maintained.	Direct impacts of BCH due to removal within the dredge and breakwater footprint	No irreversible loss, or serious damage to BCH outside of the Zone of High Impact (ZoHI) (Figure 5)	Dredging operations do not occur outside the defined dredge footprint	Table 10
		Indirect impacts of benthic communities and habitats due to reduction in available light caused by increase in suspended sediments released into the water column during dredging and discharge of dredge return water	No irreversible loss of BCH outside of the Worst Case ZoHI (Figure 5)	No irreversible loss of BCH outside of the Best Case ZoHI (Figure 5)	
			No reduction in the BCH outside of the Worst Case ZoMI (within the ZoI) (Figure 5)	No reduction in the BCH outside of the Best Case ZoMI (Figure 5)	
		Turbidity impacts on BCH arising from return water discharge	Maintain a 'Moderate Level of Ecological Protection' at point of dredge return water discharge	High Level of Ecological Protection for water quality at discharge point DSC.	
Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected	Disturbance of contaminants in sediments during dredging and return water discharger has the potential to deteriorate water quality and contaminate marine organisms	Marine environmental quality shall be maintained to a 'Moderate Level of Ecological Protection' during dredging and disposal and return to a High Level of Ecological Protection	Marine environmental quality during dredging and disposal shall be maintained to a 'Moderate Level of Ecological Protection'	Table 11

		Changes to the physico-chemical properties of the water column as a result of dredging and return water discharge	within one month following completion of dredging and return water discharge		
		Hydrocarbon release into the marine environment from a vessel spill and or bunkering operations			
Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.	Injury or death of marine fauna as a result of dredge operations.	No reported negative impacts on marine fauna attributable to marine or terrestrial construction works	No incidences of marine fauna injury or death as a result of turbidity impacts	Table 12
				No incidences of marine fauna injury or death as a result of dredge operations	
		Injury or death of marine fauna due to vessel movement (strike).		No incidences of marine fauna injury or death as a result of vessel strike	
		Disturbance to turtle nesting due to marine or terrestrial construction works (noise and light).		No disturbance to turtle nesting as a result of marine or terrestrial construction works	
		Turbidity impacts on marine fauna.		No incidences of marine fauna injury or death as a result of turbidity impacts	
		Introduced Marine Pests (IMP) translocation from construction vessels.		No introduction and/or spread of invasive marine species	

6. Management

The potential environmental impacts identified in Table 9, have been assigned monitoring and management actions to measure compliance against the EPOs[2] and MTs. Environmental impacts are expected to vary throughout the dredging program depending on the dredge effort and location (sediment material, depth etc). Therefore, it is proposed that the below management measures (Table 10) be reviewed after an initial three (3) months to assess effectiveness and rigor against EPOs and MTs.

6.1. Benthic Communities and Habitats

Management proposed to minimise potential impacts on the environmental factor 'Benthic Communities and Habitat' are described in Table 10.

Table 10 Management actions to minimise impacts on Benthic Communities and Habitats

Environmental Factor	Benthic Communities and Habitats					
Activity	Dredging and return water discharge					
Potential Impacts	• Direct loss of benthic communities and habitats due to dredging activities; • Indirect impacts of benthic communities and habitats due to reduction in available light caused by increase in suspended sediments released into the water column during dredging and discharge of dredge return water; and • Turbidity impacts on BCH arising from return water discharge.					
Management Targets	**Management Actions**			**Environmental Performance**		
	Item	**Actions**	**Responsibility**	**Reporting/Evidence**	**Timing**	**Contingency**
Dredging operations do not occur outside the defined dredge footprint.	1.1	Employ high-resolution positioning system to control dredge operations	Contractor	• Inspect positioning and vessel monitoring system • Dredge reports submitted throughout works period	• Prior to and during dredge operations • Weekly throughout dredging	• Cessation of dredging and relocation of dredge; and • Services of positioning system

[2] EPOs identified in **Table 9** 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.

No irreversible loss of BCH outside of the Best Case ZoHI, and No negative change from the baseline state of BCH outside of the Best Case ZoMI	1.2	Implement the Marine Water Quality Monitoring Program (MWQMP) described in Section 7.1	Proponent	• Satellite Imagery Assessment to determine turbidity impacts. • MWQMP monthly reports and final report	• Daily assessment of Satellite imagery • Monthly reports • From 8 weeks before dredging commences to 2 weeks after dredge completed	• Implement tiered management framework as described in Figure 6
	1.3	Undertake pre-and post-dredging BCH assessment surveys to confirm presence/absence of benthic habitat within the ZoMI and ZoI	Proponent	• Pre-dredging BCH survey report • Post-dredging BCH survey report	• Pre-dredging survey at least one month prior to commencement of dredging (complete) • Post-dredging survey within 6 months following completion of dredging	• If construction works have resulted in reduction in BCH cover or extent within the ZoMI and ZoI then a second post-construction BCH survey should be conducted after another 6 month period. • If coral or seagrass has not shown evidence of recovery after the second post-construction BCH survey, annual surveys should continue for up to 5 years till recovery has been demonstrated
	1.4	Undertake inspection and maintenance of erosion, sediment control and drainage structures particularly following heavy or prolonged rainfall.	Contractor	• Site ES&H inspection checklist	• Daily	• Investigate reasons for erosion and/or drainage damage and undertake correction works
	1.5	No unplanned alterations are made to existing on-site drainage infrastructure that could lead to potential water quality impacts off site.	Contractor	• Site ES&H inspection checklist	• Daily for the duration of return water discharge.	• Investigate reasons for erosion and/or drainage damage and undertake correction works
	1.6	If required, install scour protection measures in areas where scouring is likely to occur on containment bunds	Contractor	• Site ES&H inspection checklist	• Daily for the duration of return water discharge.	• Investigate reasons for erosion and/or drainage damage and undertake correction works
	1.7	Maintain discharge pipeline to minimise leakage	Contractor	• Pre-mobilisation equipment checklist • Equipment maintenance schedule/documentation	• Prior to commencement of dredging and daily thereafter	• Cease dredge operations and repair leakage

					• Weekly whilst dredging	
High Level of Ecological Protection for water quality at the discharge point	1.8	Implement the Discharge Water Quality Monitoring Program (DWQMP) described in Section 7.2	Proponent	• Water Quality Monitoring. • Monthly reports and final report	• Weekly monitoring • Monthly Reports • 8 Weeks following dredge completion.	• Implement tiered management framework as described in Figure 7

6.2. Marine Environmental Quality

Management proposed to minimise potential impacts on the environmental factor 'Marine Environmental Quality' are described in Table 11.

Table 11 Management actions to minimise impacts on Marine Environmental Quality

Environmental Factor	**Marine Environmental Quality**					
Activity	Dredge Return Water Discharge					
Potential Impacts	• Disturbance of contaminants in sediments during dredging and return water discharger has the potential to deteriorate water quality and contaminate marine organisms; • Changes to the physico-chemical properties of the water column as a result of dredging and return water discharge; and • Hydrocarbon release into the marine environment from a vessel spill and or bunkering operations.					
Management Targets	**Management Actions**			**Environmental Performance**		
	Item	**Actions**	**Responsibility**	**Reporting/Evidence**	**Timing**	**Contingency**
Maintain water quality to meet a High Level of Ecological Protection criteria at the point of discharge	2.1	Implement the MWQMP described in Section 7.1	Proponent	• Return water quality results • Monthly reporting	• Weekly Physico-chemical and laboratory results reported monthly	• Implement tiered management framework as described in Figure 6
	2.2	Inspections of all dredge equipment and pipelines to check for leaks or damage	Contractor	• Vessel and Site ES&H inspection checklist	• Daily throughout dredging	• Cease discharge if significant spillage or damage observed • Activate spill response actions (control drainage, clean up) as required; and • Implement recommendations from incident investigations.
Manage vessel bunkering, chemical storage and spill response to ensure no	2.3	Document vessel bunkering management	Contractor	• Vessel management procedures	• Prior to commencement of dredging	• Dredge operations not to commence prior to development and proponent approval of vessel bunkering management procedure

adverse impacts to the marine environment.	2.4	Undertake vessel maintenance and bunkering in accordance with dredging contractors approved vessel management systems	Contractor	• Vessel management procedures	• For the duration of dredging	• Vessel bunkering management systems to be reviewed and refined (if required) in the event of an identified procedural breach or hydrocarbon spill
	2.5	Implement industry standard hydrocarbon management practices (chemical handling, storage, segregation and spill response)	Contractor	• Vessel management procedures • The proponent and Pilbara Ports Authority is to be notified immediately in the event of a hydrocarbon spill of any volume	• Prior to commencement of dredging • Immediately	• Dredge operations not to commence prior to development and approval of vessel management procedures • Investigate spill event and review management actions and responses

6.3. Marine Fauna

Management proposed to minimise potential impacts on the environmental factor 'Marine Fauna' are described in Table 12.

Table 12 Management actions to minimise impacts on marine fauna

Environmental Factor	Marine Fauna					
Activity	Dredge and return water discharge					
Potential Impacts	• Injury or death of marine fauna as a result of dredge operations; • Injury or death of marine fauna due to vessel movement (strike); • Disturbance to turtle nesting due to marine or terrestrial construction works (noise and light); • Turbidity impacts on marine fauna; and • Introduced Marine Pests (IMP) translocation from construction vessels.					
Management Targets	Management Actions		Environmental Performance			
	Item	Actions	Responsibility	Reporting/Evidence	Timing	Contingency
No reported incidences of marine fauna injury or death as a result of dredge operations	3.1	Implement marine fauna monitoring and management as outlined in the Port Hedland Spoilbank Construction Environmental Management Plan (CEMP).	Contractor	• As per CEMP	• As per CEMP	• Assess marine fauna incident and modify management where necessary.
No reported incidences of marine fauna injury or death as a result of vessel strike	3.2	Implement marine fauna monitoring, management and vessel movements as outlined in the Port Hedland Spoilbank Construction Environmental Management Plan (CEMP).	Contractor	• As per CEMP	• As per CEMP	• Assess marine fauna incident and modify management where necessary.
No disturbance to turtle nesting as a result of marine or terrestrial construction works	3.3	All project vessels are to reduce light spill impacts where possible from sunset to sunrise (globe type, light angle, blinds, automatic shutoff etc)	Contractor	• HSE Inspection Checklist	• Monthly	• Investigate ways vessel can further reduce lighting impacts on turtles. • Implement modifications on vessel were appropriate

No reported incidences of marine fauna injury or death as a result of turbidity impacts.	3.4	Implement the MWQMP described in Section 7.1	Proponent	• Satellite Imagery assessment, • MWQMP monthly reports and final report	• Commence at least eight weeks prior to the start of dredging and continue until at least two weeks following completion of dredging or return water discharge	• Implement tiered management framework as described in Figure 6
Manage vessel activities to prevent the introduction of Introduced Marine Pests into and within State waters.	3.5	All vessels that mobilise to the project site are required to complete the Department of Primary Industry and Regional Development (DPIRDs) Vessel Check 2.0 assessment.	Contractor	• A copy of the Vessel Check 2.0 report is to be submitted to PPA for assessment along with any supporting documentation including antifoul certificates and inspection reports.	• Prior to dredge entering Western Australian Waters from overseas or interstate.	• Vessel are not to enter Western Australia without approved IMP documentation.
	3.6	All construction vessels are shall 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 dredge entering Australian Waters or moving from one Australian port to the Port of Port Hedland.	• Vessel are not to mobilise to Port Hedland without approved documentation

7. Monitoring

7.1. Marine Water Quality Monitoring Program

7.1.1. Rationale

A validated hydrodynamic model was used to model the sediment plumes generated by construction and dredging at the site (see Baird 2020). The hydrodynamic modelling is considered to be conservative (tending toward predicting a greater impact) and assumes constant dredging activity with no down time for maintenance/weather or modification of the program to manage water quality impacts. The best-case impact predictions were derived using background median SSC value of 7.8 mg/L, whilst the worst-case predictions were derived using a background 80th percentile SSC value of 8.7 mg/L, based on the locally measured data presented in Cardno (2019). The modelled SSCs were assessed against a combination of the 7, 14 and 28 day (Jones *et al.* 2019) thresholds[3], 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*).

Satellite imagery (e.g. MODIS) shall be used to provide a twice daily measurement of SSC and to enable post-processing to determine the benthic light climate (i.e. Daily Light Integral) using the downwelling irradiance model described in Strydom et al. (2017). The light attenuating properties of sediment in water have been found to be a more important parameter for impact prediction on corals than SSC or turbidity measurements (Jones et al., 2019). Trigger levels shall be used to determine if the EPOs and MTs have been met and shall be based on latest research from the Western Australian Marine Science Institution (WAMSI) Dredging Science Node for the protection of coral (Jones et al, 2019). The trigger levels for coral were used instead of seagrass, as they are more conservative and therefore offer protection for both habitats.

The benthic light climate may be expressed as the Daily Light Integral (DLI) which describes the number of photosynthetically active (in the 400–700 nm range) photons that are delivered to a specific area over a 24-hour period and is expressed in units of mol photons m-2 d-1. If the 14 day running mean DLI drops below 2.5 then coral mortality is ‘possible’ (i.e. ZoMI / recoverable impact) and if it drops below 1.1 then coral mortality is ‘probable’ (i.e. ZoHI / Irreversible loss) (Jones et al., 2019). The threshold for possible coral mortality shall be used to determine the boundary of areas of recoverable impact whereas the probable coral mortality threshold shall represent areas of permanent loss.

7.1.2. Monitoring Locations & Duration

Analysis of the satellite imagery will be undertaken while dredging is underway and shall commence at least eight weeks prior to the start of dredging, and continue until at least two weeks following completion of dredging.

To monitor EPO’s and MT’s associated with *recoverable impacts*, assessment of SSC and DLI will be derived from the satellite imagery for specific locations, positioned on the predicted best-case ZoMI boundary (ZoMI-1 and ZoMI-2) (Figure 5). Whereas, to monitor EPO’s and MT’s associated with no negative change from baseline conditions assessment of SSC and DLI will be derived from the satellite imagery for specific locations, positioned on the predicted worst-case ZoMI boundary (ZoI-1 and ZoI-2) (Figure 5). In addition, SSC and DLI will be derived from the satellite imagery for a reference location (REF1) located at the mouth of a tidal creek ~7 km to the west (Figure 5).

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[3] For any location, an exceedance was recorded if either the 7, 14 or 24 day threshold values were exceeded at any time during the dredging period

Contingency Monitoring

In-situ light and turbidity instruments shall be installed at two locations (i.e. ZoI-1 and site ZoI-2), 12 weeks prior to the commencement of dredging, and continuing for at least three months of the dredging period. These instruments shall be used to validate the SSC and DLI values derived from the satellite imagery. The accuracy of the satellite imagery analysis in resolving SSC and DLI within the Project area will be evaluated monthly following installation of the in-situ instruments. In the event that the satellite imagery analysis fails to provide accurate correlation with the measured data (i.e. <90% accuracy) then telemetered instruments will be installed at each monitoring location specified in Figure 5 for real-time measurement of benthic light (i.e. DLI) and turbidity.

7.1.3. Environmental Protection Outcomes, Management Targets and Trigger Levels

Satellite imagery derived DLI will be assessed against the trigger levels presented in Table 13 Dredging impact management targets

Monitoring Locations: ZoMI-1 & ZoMI-2		Monitoring Locations: ZoI-1 & ZoI-2	
Located at best-case ZoMI boundary		Located at worst-case ZoMI boundary	
<u>Management Target</u> No negative change from baseline state on BCH	**Trigger Level 1** - 14 day running mean DLI <2.5; AND - 14 day running median DLI of an impact site >20th percentile of reference site.	<u>Management Target</u> Early warning for no negative change from baseline state on BCH	**Trigger Level 2** - 7 day running mean DLI <2.5; AND - 7 day running median DLI of an impact site <20th percentile of reference site.
<u>Environmental Protection Outcome</u> Recoverable impact on BCH	**Trigger Level 2** - 14 day running mean DLI <1.1; AND - 14 day running median DLI of an impact site <20th percentile of reference site.	<u>Environmental Protection Outcome</u> No negative change from baseline state on BCH	**Trigger Level 3** - 14 day running mean DLI <2.5; AND - 14 day running median DLI of an impact site <20th percentile of reference site.

A Tiered Management Framework (TMF) has been developed based on monitoring and reporting against the three trigger levels presented in **Error! Not a valid bookmark self-reference.** to ensure EPOs and MTs for protection of BCH are achieved during dredging. The TMF presented in Figure 6 will be implemented by the Proponent/Contractor.

. SSC values will be measured but used to provide contextual information only.

Table 13 Dredging impact management targets

Monitoring Locations: ZoMI-1 & ZoMI-2		**Monitoring Locations: ZoI-1 & ZoI-2**	
Located at best-case ZoMI boundary		Located at worst-case ZoMI boundary	
Management Target No negative change from baseline state on BCH	**Trigger Level 1** - 14 day running mean DLI <2.5; AND - 14 day running median DLI of an impact site >20^{th} percentile of reference site.	Management Target Early warning for no negative change from baseline state on BCH	**Trigger Level 2** - 7 day running mean DLI <2.5; AND - 7 day running median DLI of an impact site <20^{th} percentile of reference site.
Environmental Protection Outcome Recoverable impact on BCH	**Trigger Level 2**[4] - 14 day running mean DLI <1.1; AND - 14 day running median DLI of an impact site <20^{th} percentile of reference site.	Environmental Protection Outcome No negative change from baseline state on BCH	**Trigger Level 3** - 14 day running mean DLI <2.5; AND - 14 day running median DLI of an impact site <20^{th} percentile of reference site.

A Tiered Management Framework (TMF) has been developed based on monitoring and reporting against the three trigger levels presented in **Error! Not a valid bookmark self-reference.** to ensure EPOs and MTs for protection of BCH are achieved during dredging. The TMF presented in Figure 6 will be implemented by the Proponent/Contractor.

[4] Level 2 management applies at this location as any impacts within the ZoMI must be confirmed through post-dredging BCH survey to be considered an exceedance of the EPO.

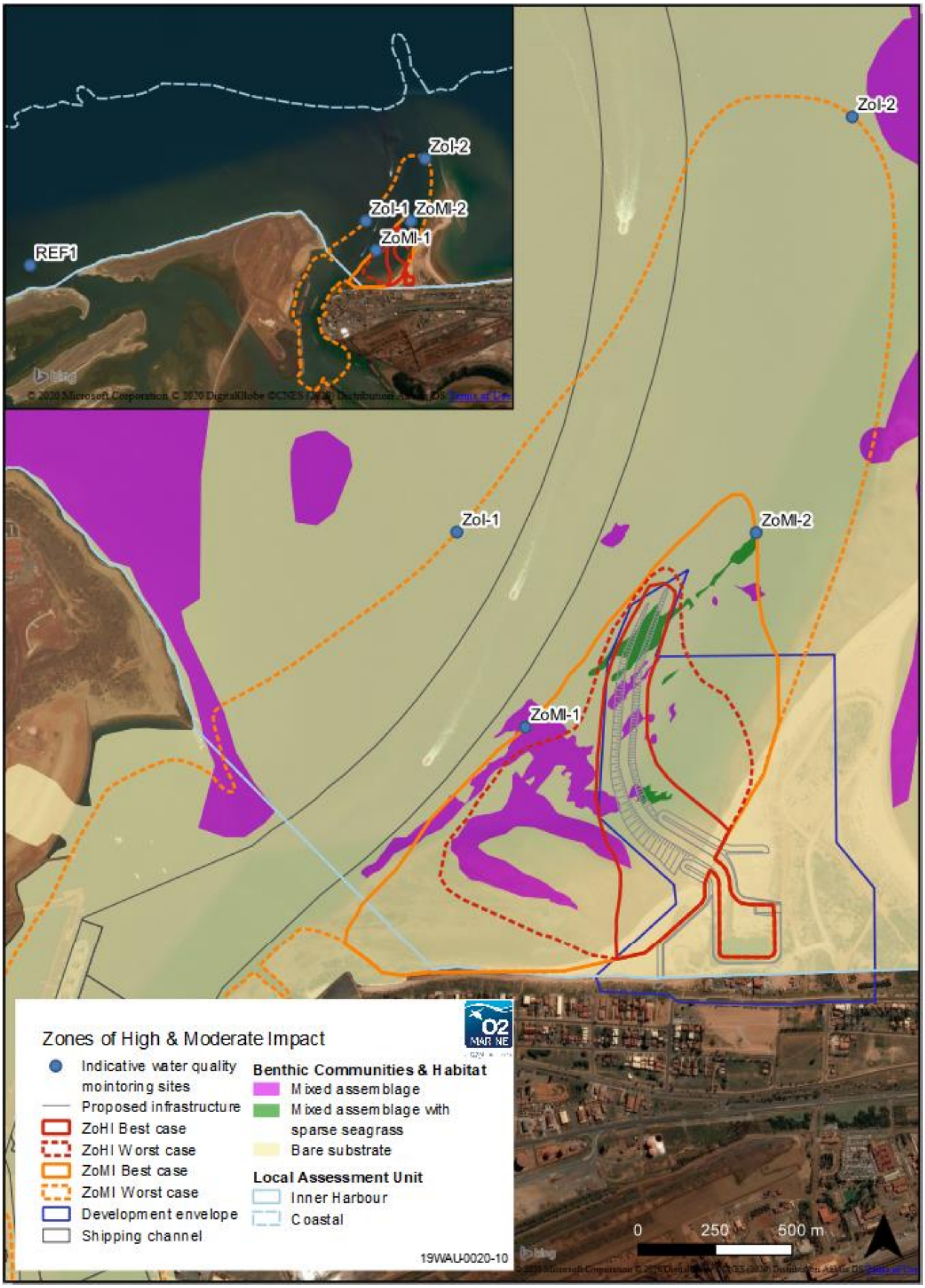

Figure 5 Proposed water quality monitoring sites

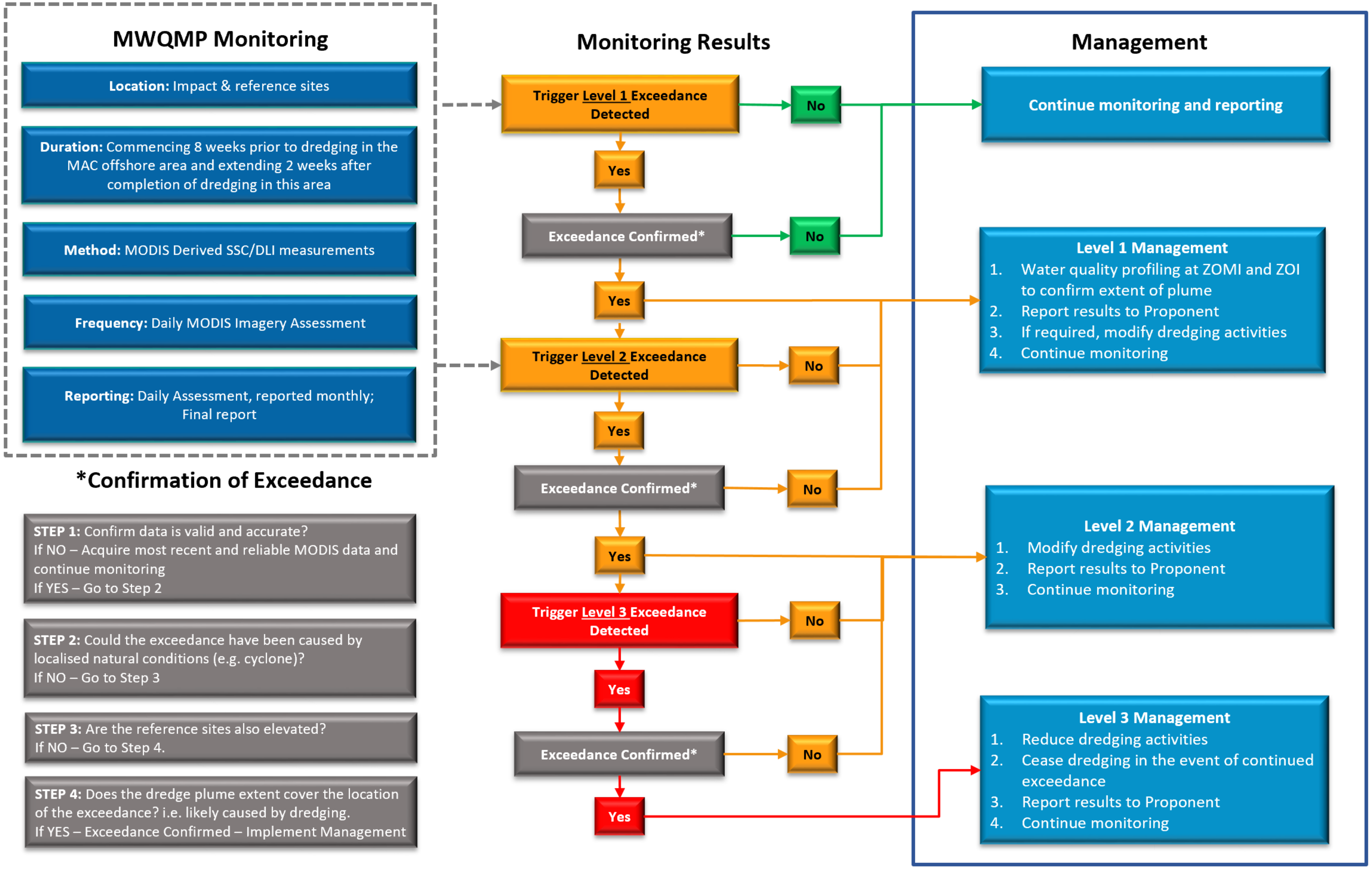

Figure 6 Tiered marine water quality monitoring program

7.2. Return Water Quality Monitoring Program

7.2.1. Monitoring Rationale

Monitoring of the return water from the DMMA will be undertaken to ensure that the EPOs and MTs for protection of marine environmental quality are achieved and potential acidification in the DMMA is managed. The monitoring approach is based on weekly monitoring of the return water quality. 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 DMMA.

7.2.2. Monitoring Locations & Frequency

DMMA return water will be monitored at the point of release into the receiving environment on a weekly basis. The water quality sampling will commence at least two weeks prior to return water discharge and will continue until return water discharge from the DMMA has been completed.

7.2.3. Parameters and Procedures

Turbidity, pH and dissolved oxygen will be measured weekly using a handheld multiparameter sonde. Return water samples will be collected weekly for laboratory analysis of total titratable acidity (TTA) and dissolved metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Zn).

7.2.4. Environmental Protection Outcomes, Management Targets and Trigger Levels

The EPOs, MTs and trigger levels to be applied for protection of marine environmental quality are presented in Table 14. A tiered management approach has been developed based on monitoring and reporting against these trigger levels to ensure EPOs and MTs for protection of marine environmental quality (Figure 7).

Table 14 Return water discharge impact management targets

Monitoring Location: DMMA Return Water Discharge	
Located at the return water discharge location within the DMMA, prior to discharge	
Early warning: High Level of Ecological Protection	Trigger Level 1
	Physico-chemical Turbidity: 80^{th} percentile of baseline data collected in-situ 3 months prior to construction, refer Section 7.1.2 Dissolved Oxygen = <70% Saturation
	Contaminants Dissolved metals: 99% Species Protection Level (SPL) **Acidification** pH: <7 TTA: <45mg/L
Management Target: Moderate Level of Ecological Protection	**Trigger Level 2**
	Physico-chemical Turbidity: 95^{th} percentile of baseline data collected in-situ 3 months prior to construction, refer Section 7.1.2 Dissolved Oxygen = >60% Saturation
	Contaminants Dissolved metals: 95% SPL **Acidification** pH: <6.5 TTA: <40mg/L
Management Target: Moderate Level of Ecological Protection	**Trigger Level 3 (Responsive sampling 24hours following Level 2 exceedance)**
	Physico-chemical Turbidity: 95^{th} percentile of baseline data collected in-situ 3 months prior to construction, refer Section 7.1.2 Dissolved Oxygen = >60% Saturation
	Contaminants Dissolved metals: 95% SPL **Acidification** pH: <6.5 TTA: <40mg/L

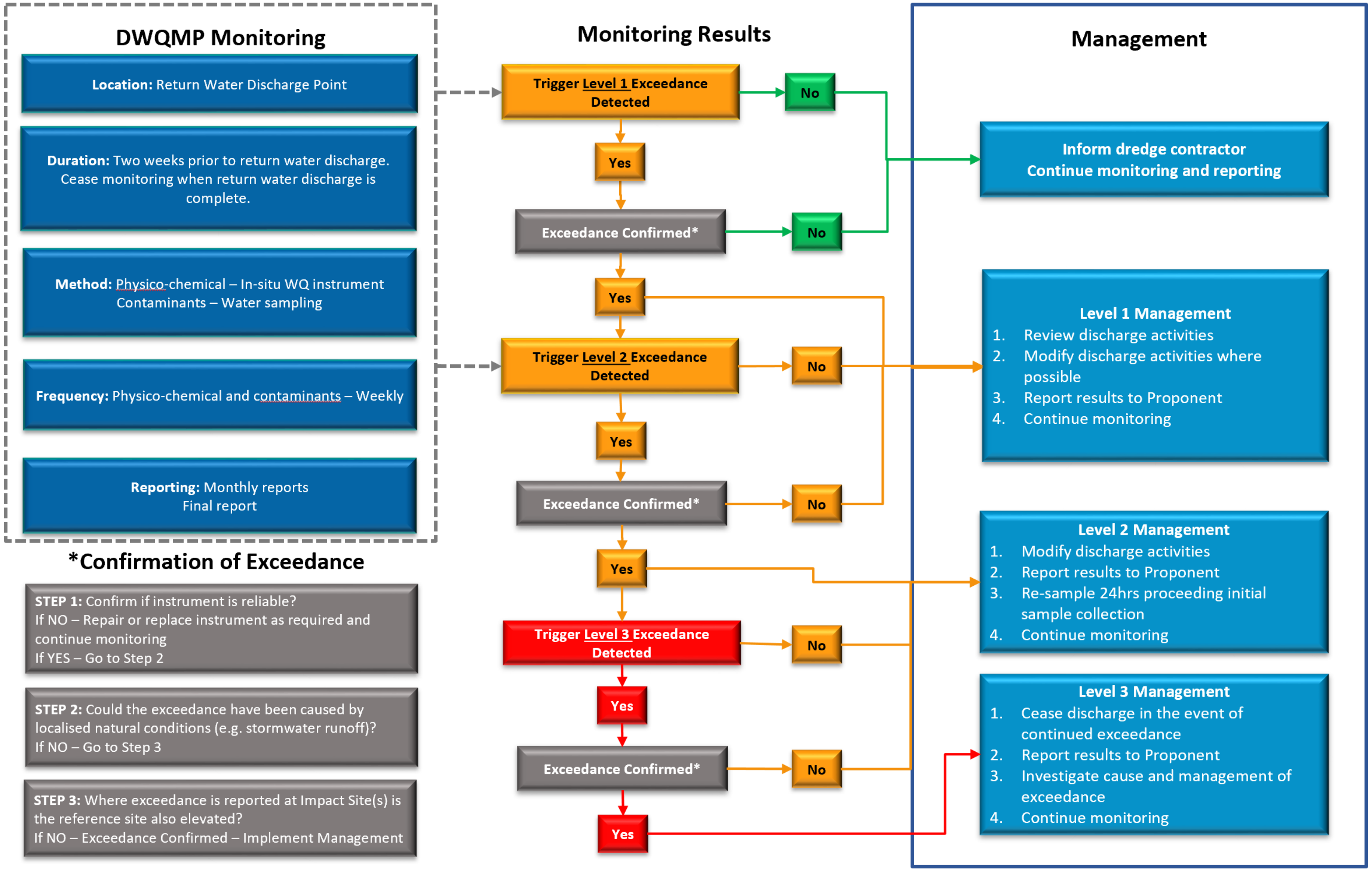

Figure 7 Tiered management of return water

8. Error! Reference source not found.**Reporting**

A summary of the reporting requirements to be prepared by the Proponent for the project are provided in Table 15. All project vessels operating within the Port of Port Hedland are required to adhere to all reporting requirements outlined in the 2020 Port Handbook, Port of Port Hedland (PPA, 2020).

Table 15 Project Reporting requirements.

Name of Report	Content	Timeframe	Recipient
Non-compliance Summary Report	Identify which EPO has not been achieved Detail the monitoring results that led to determination that the EPO was not being achieved Describe the investigation being undertaken into the cause of the EPO not being achieved Identify any corrective or contingency management actions proposed to be implemented or being implemented	Within 7 days of determining that an EPO has not been achieved	Proponent
Non-compliance Investigation Report	Identify which EPO has not been achieved Detail the findings of the investigations undertaken into the cause of the EPO not being achieved	Within 30 days of determining that any EPO has not been achieved	Proponent
Close-out Report	Statement of compliance with the relevant EPO Comparison of the actual and predicted dredge-related pressures and resultant environmental impacts and effects.	Within 3 months following the completion of dredging.	Proponent

8.1. Additional Reports

A summary of the additional reports that are expected to inform and demonstrate that MTs have been met are listed in Table 16.

Table 16 Reporting requirements during dredging and dredge material disposal

Topic	Content	Timeframe	Responsibility
Benthic habitat baseline survey	Results and discussion of pre-dredge benthic habitat survey	Prior to commencement of dredging (completed)	Proponent
Benthic habitat post-dredging survey	Results and discussion of post-dredge benthic habitat survey within the ZoMI	Within one-year following completion of dredging.	Proponent
Marine water quality monitoring	Summary of water quality health relative to the EPOs and MTs	Monthly. Final report within one-month following cessation of dredging	Proponent
Return water quality monitoring	Summary of discharge water quality monitoring relative to the EPOs and MTs.	Monthly. Final report within one-month following cessation of return water discharge.	Proponent
Site and vessel inspection checklists/Logs	Site ES&H inspection – (e.g. dredge pipe integrity, erosion, bund integrity, dust, drainage).	Daily during Construction	Contractor

	Vessel ES&H inspection – (e.g. equipment inspection, navigation equipment systems, speed, MFO personnel, bunkering log). Dredge operation log – (e.g. operations times, types of operations, soft start times, GPS positioning, dredge volumes). MFO Logs – (e.g. dredge operation time, MFO name, fauna species, distance from vessel, management response)		

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