Cairns Shipping Development Project: Dredge Management Plan

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Contents

Contents

List of Figures

List of Tables

1 Introduction

This Dredge Management Plan (DMP), identifies the preferred means of addressing environmental issues associated with dredging operations for the Cairns Shipping Development Project (CSD Project). This DMP has been updated since approval of the EIS, to respond to the Coordinator General's Environmental Report (CGER) and draft conditions issued for downstream approvals. It will be further updated following review and endorsement from the Technical Advisory Group (TAG) appointed to the project, prior to submission for final approval from approving agencies.

This document should be read in conjunction with the Northern Sands Site Based Management Plan (Ports North, 2018) which describes in detail how the Northern Sands Dredge Material Placement Area (DMPA) will be managed. Independent Acid Sulfate Soil Management Plans and Groundwater Management Plans have also been prepared which should also be taken into consideration when reading this DMP.

The DMP will be used to guide site establishment, construction, and de-mobilisation phases of the Project, including long term post-dredging monitoring and reporting. The principal objectives of this DMP are as follows:

- To minimise impacts to water quality, marine flora and fauna and their habitats during capital dredging, placement and dredge tailwater release activities;
- To adopt best practice management for the handling and storage of all waste materials on board the dredge vessels;
- To manage the risk of translocation of marine organisms by the dredge vessels;
- To minimise the risk of an environmental incident occurring such as an oil spill, vessel collision or similar to prevent damage to the surrounding marine environment and the public during dredging;
- To reduce or minimise nuisance noise on surrounding sensitive receptors from the dredging and associated activities such as the operation of dredge booster pumps;
- To minimise the air emissions produced during dredging and associated activities and thereby minimise potential effects on the natural airshed; and
- To document monitoring and reporting requirements pre, during and post dredging.

This DMP provides guidance for the dredge contractor, who will develop their own DMP and Construction Environmental Management Plan; the Contractors DMP will be required contractually to comply with the objectives of this DMP together with approvals issued for the project.

NOTE: This plan will be implemented in conjunction with a Fine Sediment Methodology (FSM) and Site Based Management Plan (SBMP) for the Northern Sands Dredged Material Placement Area.

Concurrence Table/Statement

This document addresses the DMP requirements as set out in the following approvals:

- *EPBC 2012/6538*
- *EA0001463*
- *EA0001462*
- *MPP18-01392*
- *DA8/8/1511*
- *DA8/10/779*
- *DA18-05*
- *DA18-09*
- *RAA2018CA0021*

2 Scope

The scope of this DMP covers dredging-related works associated with the Project as follows:

- Capital dredging by the Trailer Suction Hopper Dredge (TSHD) and Backhoe dredger (BHD) vessels;
- Establishment and operation of a dredge pump out temporary mooring and pipeline for hydraulic placement of the dredge material at the Northern Sands DMPA (for material dredged by the TSHD);
- Management of the supernatant dredge tailwater from the Northern Sands DMPA into the Barron River;
- Placement of dredge material at the Tingira Street DMPA at the port (for material dredged by the BHD); and
- General operation of the dredge vessels upon mobilisation during the dredging campaign and during de-mobilisation.

Figure 2-2 shows the proposed channel design. Figure 2-3 shows the proposed land-based Northern Sands DMPA and associated infrastructure. Figure 2-4 shows the location of the Tingira Street DMPA.

The DMP does not address the construction of wharf side maritime structures, or other land-based aspects of the project. The operation of Northern Sands DMPA prior to, during and post-placement is also addressed separately in the Northern Sands Site-based Management Plan. It also does not apply to operational (maintenance) dredging issues which will be addressed as part of amendments to the port's existing Long Term Dredging and Disposal Management Plan (Worley Parsons 2010). Maintenance dredging is subject to a range of existing approvals under Commonwealth and Queensland legislation.

The Contractor will prepare a detailed Construction Environmental Management Plan (CEMP) for land-based aspects of the project (including Tingira St DMPA), that is consistent with the objectives of this DMP. This will provide detailed work method statements for at least the following issues:

- Vegetation clearance plans;
- Fauna management;
- Erosion and sediment control measures;
- Rehabilitation plans;
- Cultural heritage management;
- Water quality management;
- Noise and air quality management; and
- Traffic management.

An overview of the various reports and management plans that will direct the environmental performance and monitoring of the capital dredging project (and their scope) are illustrated in Figure 2-1.

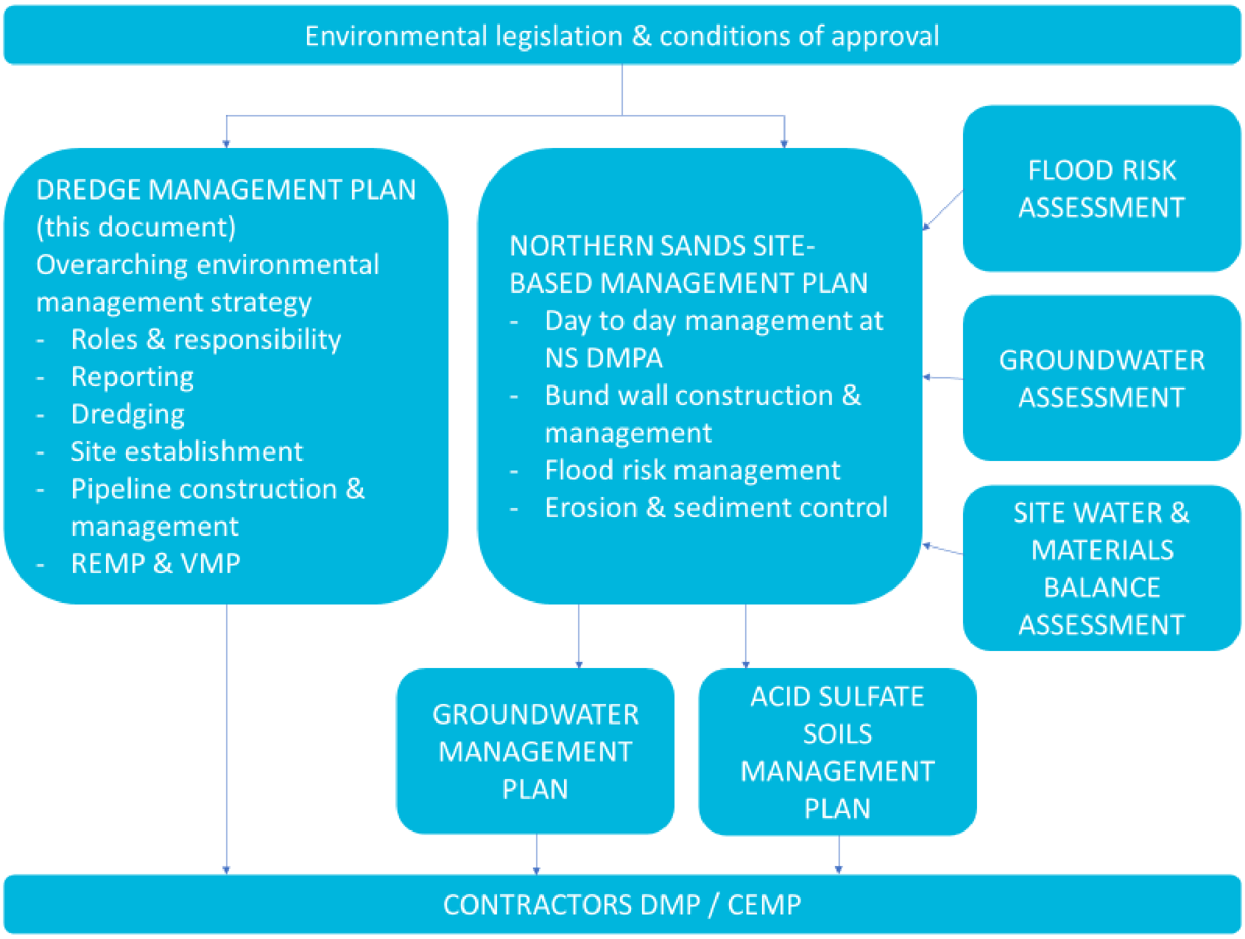


Figure 2-1 Project Reports and Management Plans

The DMP contains procedures, guidance and commitments to management and mitigation measures, along with complementary monitoring that will be required to be carried through into more detailed approvals (such as tidal works approvals under the *Planning Act 2016*, a marine park approval for the proposed temporary vessel mooring, an environmental authority for dredging under the *Environmental Protection Act 1994*) and by the selected dredge contractor for the works as part of the contractor's Operational Environmental Management Plans.

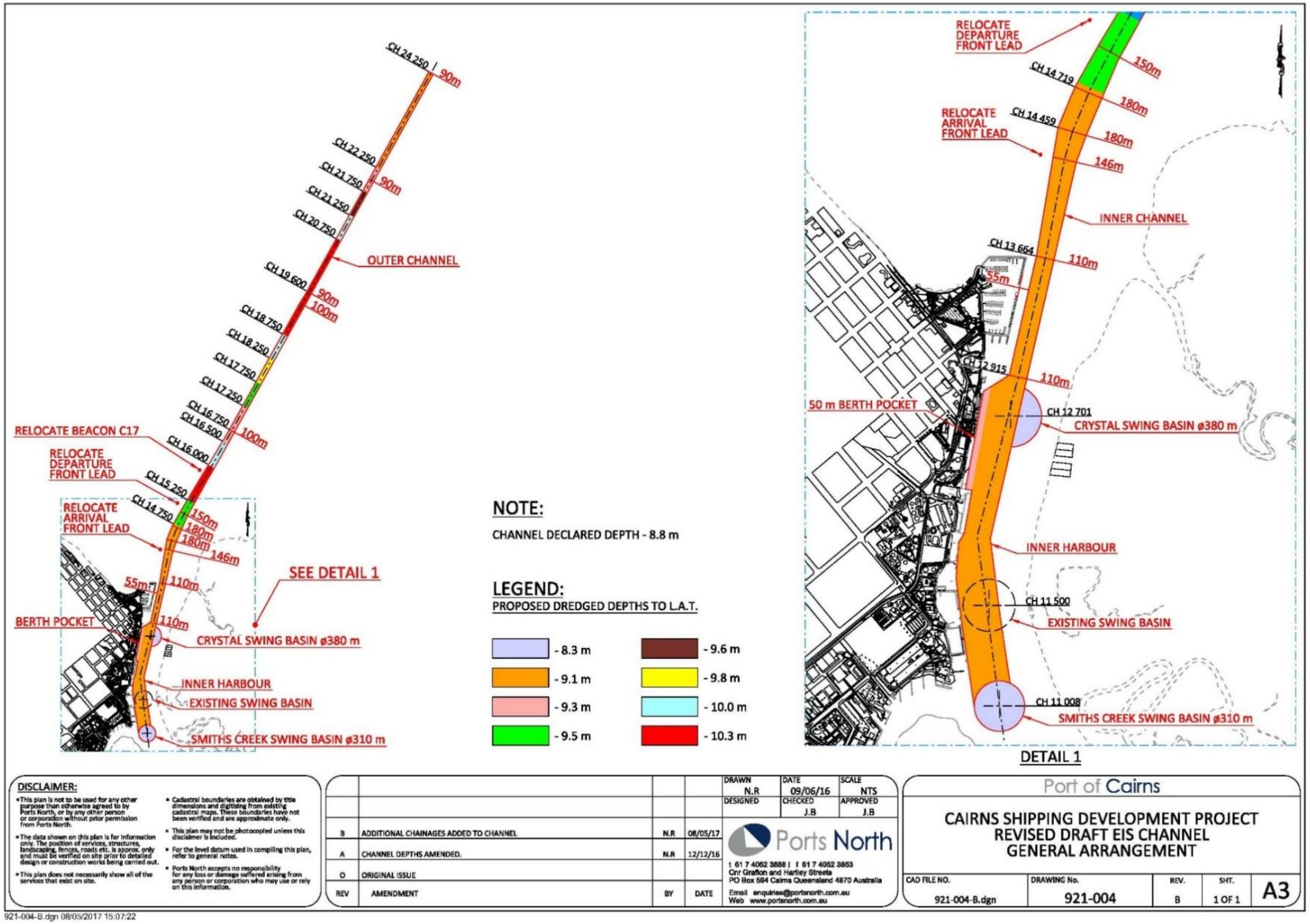
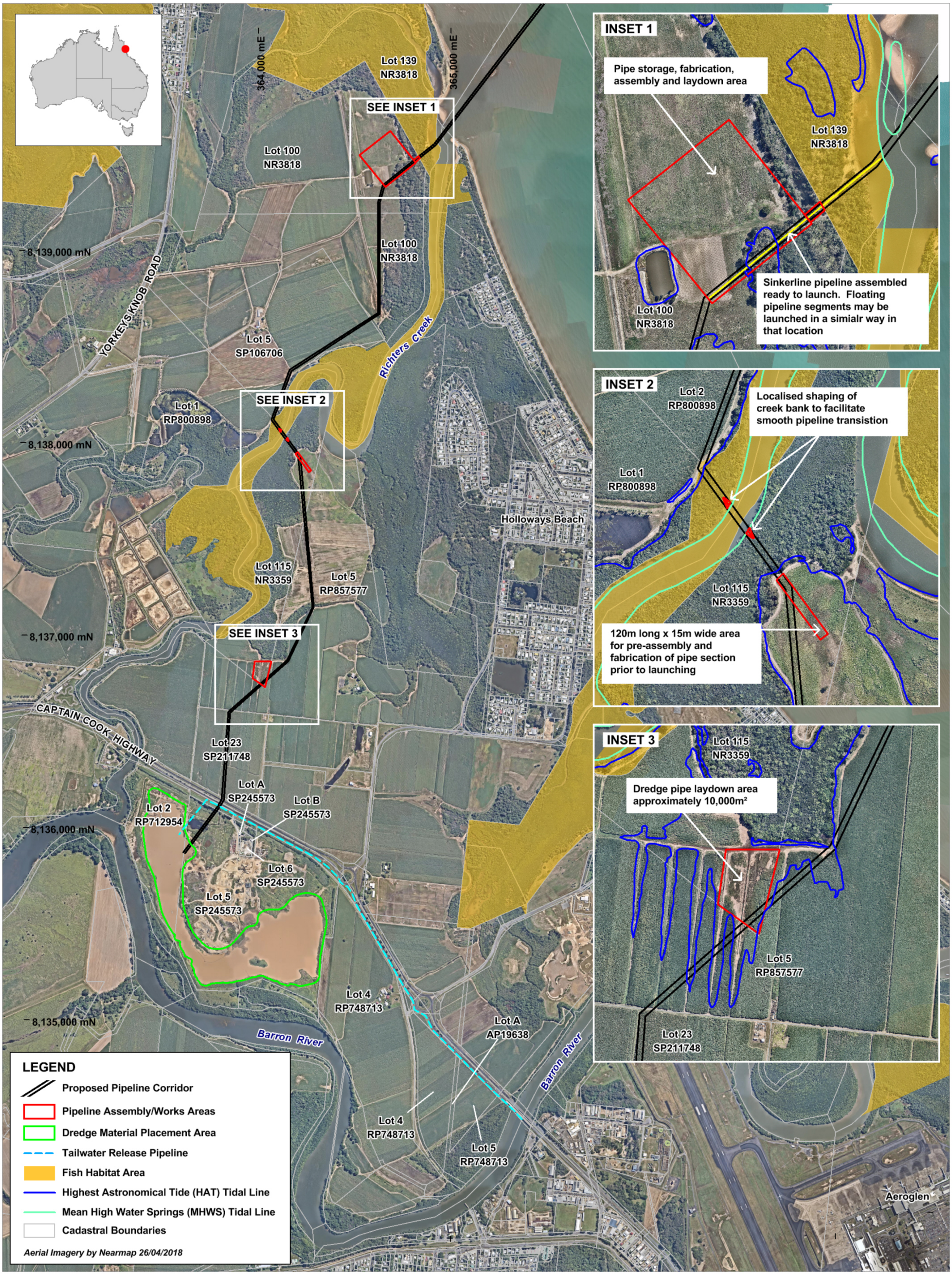


Figure 2-2 Proposed Dredge Design



Title:
Dredged Material Deliverable Pipeline Within Yorkeys Creek FHA

Figure: 2-3

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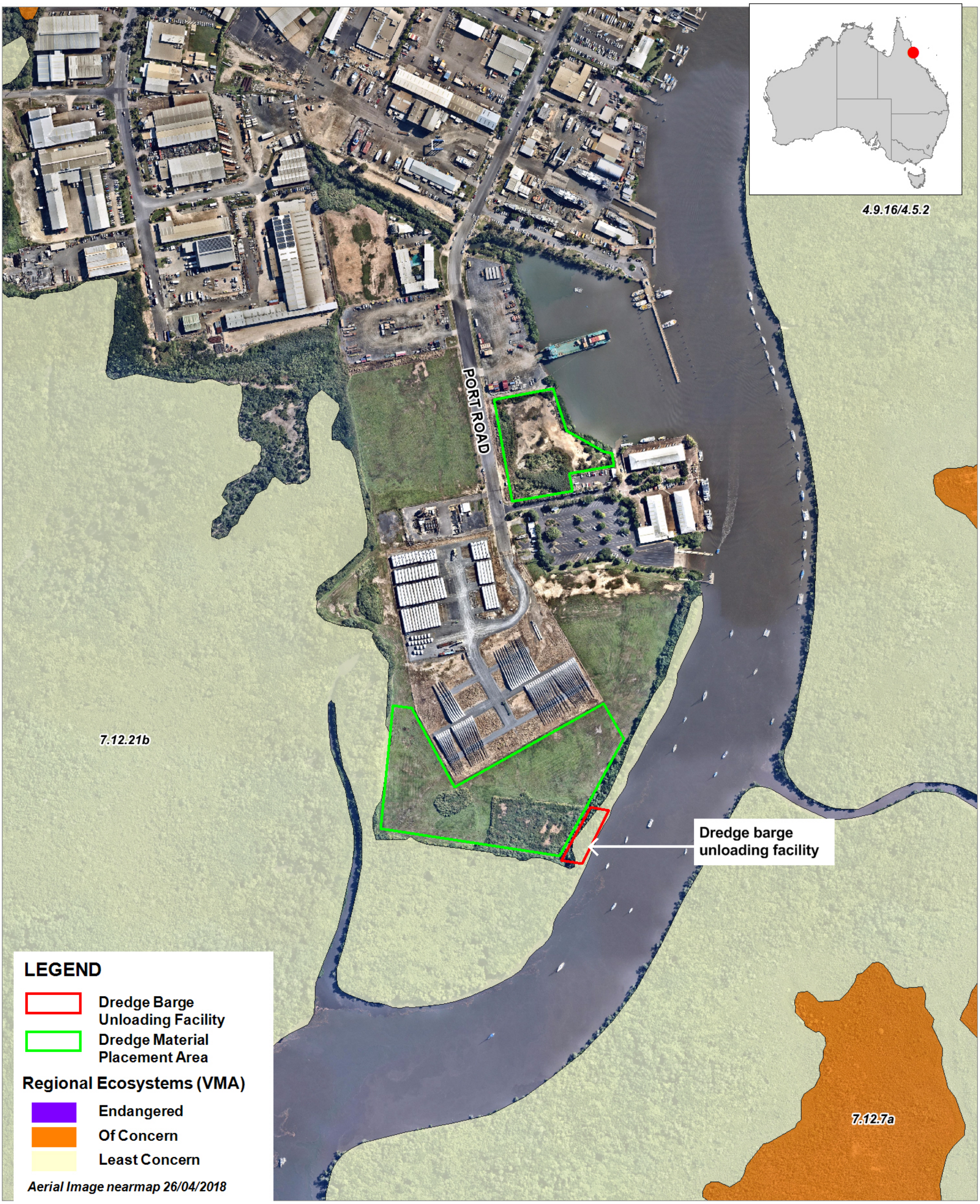

Title:

Dredging-related infrastructure: Portsmith

Figure: 2-4

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BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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3 Legislation

The DMP has been developed in accordance with, and takes into account, legislative requirements set out in Acts and Regulations at Commonwealth and State level that are listed below. Further, while some consents and approvals have not yet been issued for the Project, the DMP has been developed to include measures that Ports North believes is necessary for protection of sensitive environments that could be affected by the dredging and land-based placement activity.

Commonwealth legislation considered in development of this DMP (including Acts implementing relevant international conventions) includes:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983;* and
- *Great Barrier Reef Marine Park Act 1975* and Regulations.

The following State legislation is relevant to the proposed dredging:

- *State Development and Public Works Organisation Act 1971;*
- *Coastal Protection and Management Act 1995 and Coastal Management Plan;*
- *Environmental Protection Act 1994 and Environmental Protection Policies;*
- *Fisheries Act 1994* and Regulations;
- *Marine Parks Act 2004 and Marine Parks (Great Barrier Reef) Zoning Plan;*
- *Transport Operations (Marine Safety) Act 1994 and Regulations;*
- *Transport Operations (Marine Pollution) Act 1995 and Regulations;*
- *Nature Conservation Act 1992* and Conservation Plans; and
- *Planning Act 2016* and Regulations.

It also takes into account approval conditions and proponent commitments issued with the CGER Report (Appendices 1 to 6), approval conditions under the EPBC Act and subsequent downstream approvals.

4 Project Description and Stages

The following sections describe the project and identify, at a broad scale, the dredging aspects of the CSDP.

Figures 2-1 to 2-3 show the location of the works relevant to this application. The individual scope of each element is discussed in further detail below. This detail represents a combination of information from the Revised Draft Environmental Impact Statement for the CSD Project (Revised EIS; especially Chapter A3 and Appendix AC) and information provided from the appointed dredging contractor.

Dredging works are to be undertaken for the Project to widen and deepen the existing navigation channel and cruise shipping swing basin as well as to provide a new turning basin in the inner port. Two different dredging methods based on the sea bed material are proposed for the project which is summarised in Table 4-1.

Table 4-1 Proposed Dredging Methods

Sea Bed Material	Proposed Dredging Method
Very soft to firm clay in outer channel and part of inner port	Trailing suction hopper dredger (TSHD)
Firm to stiff clay in inner port and inner channel	Backhoe dredger (BHD) with barges and tug boats

During the preparation of the revised Draft EIS (refer Chapter A2 Project Background) the volume of material to be dredged was established using a 3-dimensional (3D) surface model of seabed levels obtained from Hydrographic Survey of the existing channel and proposed widening areas undertaken following the 2016 annual maintenance dredging campaign.

The total volume of capital dredge material was calculated as the volume between the approved maintenance dredging levels and the proposed capital design dredge levels.

The Calculated volumes of dredge materials for the proposed channel profile were as follows:

- Total volume of capital dredge material – 791,064 m^3
- Volume of 'soft' clays in capital dredge volume – 698,755 m^3
- Volume of 'stiff' clays in capital dredge volume – 92,309 m^3

In addition to the measured volume, the Revised Draft EIS included contingency volume allowances taking the total dredge volume to 1,000,000m^3 consisting of 900,000 m^3 of soft clays and 100,000 m^3 of stiff clays to allow for survey accuracy and dredging tolerance. The soft clay contingency also included for potential additional siltation that might occur, in the channel widening and extension areas as well as existing channel areas not subject to annual maintenance dredging, between the time of the survey and the anticipated mid-2019 dredge date. A worst case contingency estimate was made for dredging volumes for the DMPA concept design and impact assessment purposes.

A review of the channel batter slope design, dredge volumes and contingency was carried out between August and October 2018. This utilised further Hydrographic Surveys conducted by Ports North following the 2017 and 2018 annual maintenance dredging, a study of erosion profiles in the area of the outer channel widening and a full Port and channel multibeam survey by Port of Brisbane in

September 2018. Further geotechnical slope stability assessment was also undertaken by Golder Associates, based on a review of existing channel batter slopes and the geotechnical investigations completed for the revised Draft EIS since the original batter slopes were adopted.

The design refinements result in a significant dredge volume reduction. For the purposes of a most likely pre-capital dredging surface level the post 2017 maintenance dredging survey profile has been adopted and the volume from this surface to the refined design lines remeasured by both Golder Associates and Ports North's Registered Hydrographic Surveyor, using 3D volume models. Golders measured volumes are as follows:

- Total volume of capital dredge material – 539,864 m^3
- Volume of 'soft' clays in capital dredge volume – 466,138 m^3
- Volume of 'soft' clay above the approved maintenance dredging levels in the existing channel – 118,321 m^3
- Volume of 'stiff' clays in capital dredge volume – 73,726 m^3
- Volume of 'stiff' clays above the approved maintenance dredging levels in the existing channel – 3,672 m^3
- Total Volume between 2017 survey surface and the revised channel design – 661,858 m^3

Dredging will be completed in a 12 week period notwithstanding that the targeted in-situ volume to be dredged (740,000m^3) is less than the 900,000m^3 approved for dredging in that period. This will allow for higher production rates to be achieved early in the dredging campaign and for a slower production rate towards the end of the campaign to ensure achievement of tailwater water quality standards when the relative proportion of water volumes within the DMPA is reduced.

The total pumping mixture is based on the addition of water to the in-situ dredged material volume to facilitate pumping of the material through the 8km delivery pipeline. This results in the in-situ dredged material being "bulked up" by a factor of 2.66. Based on the adopted average in-situ density of 960kg/m^3 the density of the slurry material delivered to the DMPA is 360kg/m^3.

Delivery of the planned in-situ volume to be dredged to the DMPA will require 284 loads over the 12 week period. Based on achieving production rates of 4 loads per day over the first 9 weeks of the campaign the production rate can slow to an average of 1.5 loads per day over the last 3 week period.

Prior to the delivery of each load the delivery pipeline is required to be "primed" by filling with seawater.

Following placement the delivery pipeline is required to be 'flushed'.

4.1 Dredging Plant - TSHD

4.1.1 Dredging

In the outer channel and part of the inner port, a medium-size TSHD will be mobilised - the dredging contractor has nominated the vessel 'Balder R' which has a 6000m^3 hopper capacity. A TSHD is a self-propelled sea- going hydraulic dredger equipped with a hopper and dredging installations to fill and unload the hopper. The dredging takes place at the draghead on the seabed which is connected to a suction pipe to fill the hopper. The dredging process and hopper filling takes place while the TSHD is sailing along the dredged areas. The trailing speed during dredging is in the order of 1 to 2 knots.

The dredging process of TSHD involves the following sequences:

- Position TSHD at the dredging area;
- Lower the suction pipe(s) with draghead at the end;
- Suction is commenced and uptake via the draghead and hopper filling simultaneously while sailing;
- When the hopper is filled, suction is stopped and the draghead (s) are raised back onto the deck and the TSHD sails to the temporary mooring at the dredged material pump out site in Trinity Bay; and
- TSHD connects to the dredged material discharge pipeline at the temporary mooring and the dredged material is pumped as a slurry to the Northern Sands DMPA.

When the hopper is empty, and the pipeline has been pumped clean of solid material with water, the TSHD disconnects from the dredged material pipeline and mooring and returns to the dredging area to recommence the cycle.

As inferred from the above, prior to the dredging and placement process, a range of site preparation works will be required as outlined in the sections below:

- Installation of a temporary pump out position markers and flexible pipe lifting devices;
- Installation of a dredge pipeline from the temporary mooring to the Northern Sands DMPA; and
- Installation of a booster pump at the mouth of Richter's Creek to assist the dredge vessel to convey the dredge material slurry to the DMPA.

4.1.2 Dredge Pump Out

Pump-out will be undertaken by a dredge vessel in an area between 2.7 and 3.7 km from Yorkeys Knob. The dredge vessel will utilise an automatic dynamic positioning system, which controls the adjustable rudder propellers and the bow thrusters at minimum energy, to hold position during pump-out operations. Once stationed in position the dredge crew will pick up a small rubber buoy attached to the delivery pipe via a toe line connected to a wire lift line and will winch up a segment of flexible pipe laying on the seabed, using an on board winch. This end of the delivery pipe will be hydraulically connected and locked to the dredge pump line via a ball joint.

Sea bed disturbance will be minimised by selecting the dredge pump out location in sufficient depth of water, based on a pre-dredge survey, to ensure at least 2m of water under the vessel.

Any structures installed for the mooring (i.e. anchor blocks) would be removed after the works are complete.

4.2 Dredge Material Delivery Pipeline and Booster Pumps

4.2.1 Offshore Pipeline Route

The dredge material delivery pipeline will run from the offshore pump-out facility through to the Northern Sands DMPA. The route selected for the pipeline was preferred on the basis of least direct and indirect impacts to terrestrial and marine vegetation (clearing), farming operations, visual amenity and community infrastructure. The dredge material delivery pipeline from the offshore pump-out facility will consist of approximately 7.5 km of a 0.8m diameter steel pipe. The marine section of the pipeline will be submerged, whilst the landward section will be constructed above ground and suspended on low (<0.5 m) plinths.

The submerged pipeline will remain on the seabed as, once sunk, it will always be filled with seawater and/or dredged material. The length of the submerged pipeline will be up to 4 km. The seaward end of the pipe will consist of flexible pipeline, which will lay flat on the seabed when not in use and will be lifted to the surface for connection to the dredge for pump out. A small buoy anchored to the seafloor will be used to locate the pipe end and retrieve the lift wire to winch it up.

Those pipe segments to be used offshore will be transported to the pipeline string fabrication and launching areas at Richters Creek (Lot 100).

Offshore pipeline components will be constructed in approximately 300 m long strings (up to 400 m if possible) which can be towed by a tug or multi-cat vessel offshore, joined with other strings and sunk into position on the seabed. Transportable Pipe-welding facilities will be set up in the vacant area of Lot 100 adjacent Richters Creek.

A crane-mounted on a large barge will position the strings offshore, join the strings and sink that section and progressively install the delivery pipeline. Similar plant and methodology will be utilised for the demobilisation of the pipeline once dredging works are complete.

During construction and decommissioning, there will be temporary exclusion of access to the pipeline area, including along the beach at the landfall site. This will be necessary to avoid safety risks to the public. The pipeline-related activities are expected to commence in April 2019 and continue until demobilisation is completed in October through to December 2019.

4.2.2 Onshore Pipeline Route

The pipeline will make landfall immediately north of the mouth of Richters Creek on Unallocated State Land (adjacent to Lot 139/NR3818) and will require minor sand shaping works to assist pipe string launching and provide access through the sandbar that forms off the mouth of the creek. Above the low water mark, the submerged pipeline will require a construction corridor of sufficient width (15 m wide) to allow side-by-side unloading and placement. This will require some clearing of melaleuca wetlands and mangrove associations.

Within the intertidal area at the mouth of Richters Creek, a hydrographic survey will be undertaken prior to and following disturbance of any sand banks to verify that the original profile has not been significantly disturbed. If needed, an excavator or small scale bed leveller will be used to reprofile disturbed areas. Any land-based areas will be reprofiled using an excavator; material at or adjacent to the site will be used; no fill material will be imported.

The pipeline then traverses grasslands and cane paddocks to an upstream crossing of Richters Creek located at the narrowest section of fringing mangroves. This creek crossing will require a straight run of corridor along the final crossing alignment on the southern bank to assemble the pipeline before it is launched across the creek, positioned and sunk.

The pipeline crossing will require clearing of some mangrove vegetation and reprofiling of the banks to avoid sharp pipe bends. Additionally, to install the section of pipeline across Richters Creek, a corridor of around 120 m by 10 m will be required along the crossing alignment on the eastern side of the creek crossing in unused grassland. This will enable the pipe segment to be assembled, fabricated, launched and sunk into position across the creek bed.

From the creek crossing, the pipeline will traverse the fallow cane paddocks as much as possible.

At Captain Cook Highway, the pipeline will pass beneath the road, utilising an existing stormwater culvert. The culvert beneath the highway has a width of 3,300 mm and height of 1,200 mm. As the pipe diameter will be no more than 1,000 mm, this will be able to pass through without further modification. However, at the southern end of the crossing, the pipe will also need to pass beneath the existing tramway. Due to clearance restrictions, this will require temporary removal of part of the tramway, including the existing stormwater pipe, and trenching through the existing formation. The tramway will be regraded higher to allow for the dredge pipe and reinstated. This work will take 1-2 weeks.

4.2.2.1 Vegetation clearance

The proposed methodology for pipeline installation at both Richters Creek mouth and crossing will involve having the vegetation checked for fauna by a qualified spotter/catcher prior to removal (i.e. for protected flora requiring relocation, and presence of fauna requiring relocation). Vegetation will be progressively removed from within the corridor by plant & equipment working from landside toward the creek, with vegetation likely to be cut off at ground level and removed, mulched, stockpiled and used in erosion and sediment control and reinstatement. Subject to future confirmation with DAF, portions of the removed mangrove (i.e. Rhizophora) vegetation such as trunks or root masses may be set aside and utilised to cover the profiled bank surface at completion of site use, so as to assist bank stabilisation and afford some habitat structure whilst recolonization of mangrove plants occurs. Erosion and sediment controls will also be put in place (e.g. sediment fences, geotextile) to minimise any discharge of sediment to the waterway during temporary works. Following removal of the pipeline, the disturbed area will be re-profiled to its original condition to allow for the regrowth of removed vegetation. Any native vegetation removed will be rehabilitated using local species.

In total, no more than 0.41ha of marine plants (mangroves and melaleuca wetland) will be cleared within the discharge and delivery pipeline footprint. The dredge contractor may not clear vegetation beyond that approved, as outlined in Table 4-2.

Table 4-2 area of vegetation approved for clearing for purposes of dredge-related infrastructure

Area	Proposed Clearing (m^2)			
	Mangroves	Corymbia woodland	Eucalypt and melaleuca woodland with scattered mangroves, samphire	*Hibiscus tiliaceus*
Richters Creek mouth (lots 139 and 100) delivery pipeline and laydown/assembly area	-	7, 256	1,650	
Richters Creek crossing 9USL and Lot 115) delivery pipeline	1, 650	-	-	
Barron river discharge pipeline (USL)	770	-	-	
Northern Sands DMPA	-	-	-	333
Tingira St	1,836	-	-	-
Total	**4,256**	**7,256**	**1,650**	**333**

4.2.3 Booster Pump

The dredge vessel alone will not have the capacity to pump the dredge material to the Northern Sands DMPA due to the distance. Consequently, two booster pumps will be used to supplement the pumping capacity of the vessel. This will include one floating station and one onshore station located as follows:

- Floating booster station located along offshore pipeline route just before the surf zone at the mouth of Richters Creek;
- Onshore booster pump on Lot 2/RP800898, immediately prior to the Richters Creek crossing; and
- A second onshore booster pump on Lot 115/NR3359 prior to crossing of Captain Cook Highway may be required subject to the contractor confirming the availability and performance of the intended single on-shore booster station.

The floating booster station proposed is the cutter suction dredge, Wombat, which will operate by bypassing the cutter head and coupling the delivery pipe directly to and from the on-board dredge pumps. The Wombat is a shallow draft flat barge and will be anchored to the seafloor for the duration of the dredging campaign. The station is linked either side to small lengths of floating line linked to the submerged pipeline.

The onshore booster station will be placed in cleared grassland areas or cane headlands, in consultation with landowners to minimise interference with farming operations and may be accompanied by earthern acoustic bunds, or lined fence panels to ameliorate noise. Additional noise modelling will be undertaken by the Contractor to confirm the EIS modelling results and implement additional noise controls if impacts at sensitive receptors are identified.

4.2.4 Placement Activity

The Northern Sands DMPA is an existing pit which is a consequence of historic sand extraction activities on the Barron Delta. Sand extraction in the proposed DMPA will be completed prior to the hand over of the DMPA site to Ports North for the purposes of placement of the dredged material. Sand extraction and other approved activities associated with the Northern Sands operation will continue on site external to the DMPA area.

At the anticipated time for earliest commencement of placement (June 2019), the volume of the void below nominal ground level (RL 3.5m AHD) is estimated to be approximately 2,230,000$m^{3.}$ with a surface area of approximately 40 Ha.

The existing void capacity will be enhanced via the construction of temporary bund walls, with a crest level of RL 4.5m AHD which will provide a total volume of 2,630,000m^3. The bunded void will provide sufficient capacity to accept the "bulked up material" and the volume of retained water required to meet WQ limits prescribed for discharge of displaced fresh water from the void, transport water and supernatant generated by the consolidation of the placed material as well as a min 600mm freeboard.

The ground levels surrounding the void vary as a result of historic extraction and waste management activities on the site. Mounds (up to RL 9.0) adjacent to the Barron River currently exceed the approved land form for the site (Mounds to RL 5.0 are permitted along the southern Boundary of Lot 5). As part of the development of the DMPA these mounds will be reduced to the approved height of RL 5.0. Bunds are only required where the surface level is lower than RL 4.5. As the land levels vary around the perimeter of the void, based on a notional surface level of RL 3.5, the bunds where required will have a nominal height of 1.0m.

The general arrangement of the bund walls is shown in Figure 4-1.

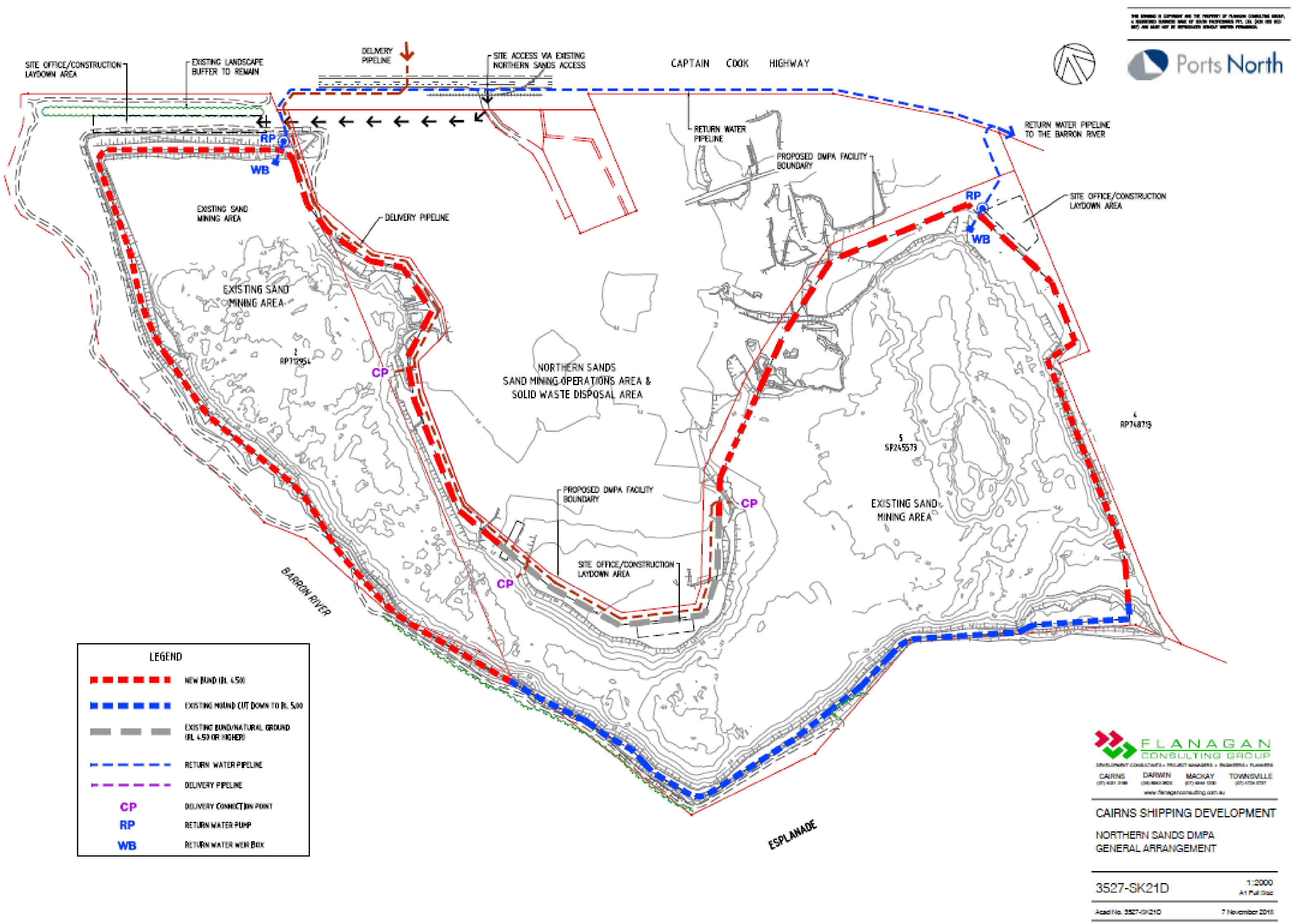


Figure 4-1 General Arrangement of Bund Walls at Northern Sands

Tailwater is proposed to be discharged via pumping to an outfall in the Barron River immediately adjacent to the Captain Cook Highway bridge.

Bunding will be constructed using mostly in-situ soils within the DMPA area supplemented if necessary with additional material from Northern Sands stockpiles or imported to site from quarry suppliers if required to meet engineering quality standards. The bund walls have been designed by and will be certified by a Registered Professional Engineer Queensland (RPEQ) and include Level 1 Geotechnical supervision. Construction of the bund walls and accompanying erosion and sediment controls are addressed in the Northern Sands SBMP.

4.2.5 Post-placement

4.2.5.1 Northern Sands

Following completion of dredge material placement, dewatering will continue via the discharge pipeline for a short period (no more than 3 months). The discharge pipeline will then be removed. To manage surface water within the DMPA following removal of the discharge pipeline, a section of the southern boundary bund will remain for the 1st wet season, to provide a preferential outflow (rainfall)/inflow (flooding) path. Post wet-season, the southern section of the bund will be lowered to RL3.5m. Water will be allowed to accumulate during the 2nd wet season post-placement, and if required, dewatering will be undertaken to encourage dry season surface crusting. The need for dewatering will be determined by settlement rates and rainfall occurrence. Post the 2nd wet-season, when further settlement has occurred, all bunds will be removed to RL3.5m or natural surface, whichever is higher (except for bunds approved under Northern Sands existing development approval at RL5.0m along the southern boundary of Lot 5. Excess bund material will be used as fill to allow the land form to fall towards the lake.

4.2.5.2 Other infrastructure

At the completion of dredging, the delivery pipe line and equipment will be demobilised from site as soon as possible. The tail water discharge pipeline, pumps and weir boxes will however stay in place for dewatering up to a period of 2 months following placement of material.

Prior to removing the delivery pipeline it will be flushed with seawater to ensure it is free of all dredged material. The pipelines will be removed, dismantled and transported to the temporary storage area.. Any damage to intertidal areas such as the Richters Creek pipeline crossings will be repaired and rehabilitated, as agreed with the Department of Agriculture, Fisheries and Forestry (DAF) and in accordance with approval conditions.

The submerged pipeline will be disconnected from the booster pump and onshore pipeline and filled with compressed air. This forces all the water from the pipeline, allowing the submerged pipe to float back to the surface. The ball joints or bolted connections will then be disconnected from the seaward end, allowing each pipe string to be separated and towed back to shore by multi-cat / tug. Once onshore, the pipe strings will be cut back into pipe components of sufficient size to allow for their removal from site.

The onshore and tailwater water pipelines will also be disassembled back into their components in the field before they are removed. Soil plinths supporting the pipeline and any earthen acoustic bunding will be flattened and the local landform re-established and stabilised and any disturbance to paddocks and internal tracks made good, in accordance with landowner agreements.

Any native vegetation cleared to construct the delivery pipeline or laydown areas will be rehabilitated using the species list for the site (Appendix 4 of the CSDP terrestrial Ecology Assessment, Technical Report (May 2017).

4.3 Dredging Plant - BHD

4.3.1 Dredging

For dredging of firm to stiff clay in the inner port area and parts of the channel, a medium-size BHD with ancillary vessels will be mobilised. BHD is a mechanical dredger, similar to an excavator which is mounted on a barge. The dredging contractor has nominated the use of the vessel ‘Apai’ which is a non-propelled ‘backacter’ style which is a stationary dredger anchored by three spud piles and has capability to self-adjust position through a combination of spud and arm movement for fine scale adjustment at the worksite. It will be moved and positioned over larger distances using a tugboat or multicat during operations. It works by dredging the seabed using the bucket at the end of the excavator arm and placing the dredged material into a hopper barge which is moored alongside for placement at the preferred dredge material placement area.

The dredging process of BHD will involve the following sequences:

- Position BHD at the dredging area;
- Excavation using bucket (18m^3 size) fixed at the end of the excavator arm;
- Load the dredged material into a hopper barge or barge mounted skips moored alongside the BHD;
- Tug boat tows hopper barge when it is full to the Tingira Street DMPA;
- Barge mounted excavator (moored to shore) transfers material to heavy haulage vehicles for short hauling, then end dumping at placement site or transfer of skips to flat top haulage vehicles for dumping at placement sites; and
- Tug boat tows hopper barge back to the BHD.

4.3.2 Placement

The Tingira Street DMPA will utilise two existing areas of reclaimed port land at the southern end of Tingira Street, Portsmith (Lot 27/SP218291 and Lot 733/SP21891). This DMPA will receive stiff clays from the dredging campaign, placed as a surcharge platform in order to consolidate and to improve the underlying ground conditions for future ports use. The material will be transported to the site by barge, unloaded by cranes or excavators to heavy vehicles and then placed across the site. Material will be placed to a depth of approximately 2-3 m, incorporating a self-draining surface with geotechnically stable batters and erosion and sediment control measures. The final height of the placement will correspond to surcharge loading requirements for consolidating the underlying soft soils required for the intended port use of the land within a 1-2 year timeframe. Once consolidation is complete, the upper layer will be stripped off and relocated to an adjacent area as part of a continuous land improvement program. Additionally, the Tingira Street site may be used as a pipe storage facility subject to final transport logistics arrangements.

Placement of stiff clays at the site will utilise a new offloading facility at the southern part of the site.

5 Baseline Condition of Sensitive Receivers

Chapter B7 (Marine Ecology) of the approved EIS provided a full assessment of the baseline conditions of potential sensitive receivers as a result of dredging activity. This is summarised below and has been updated where more recent information is available.

The data collection undertaken during the EIS consisted of desktop review, consultation with local representatives and field surveys (mostly conducted 2015 to 2016). The surveys were undertaken to fill information gaps identified through the desktop review and consisted of the following:

- ***Soft sediment habitat types and epifauna communities***. Soft sediment habitats within and adjacent to the project areas were mapped using acoustic techniques. Single beam sonar data were analysed using Quester Tangent Corporation (QTC) software packages and a preliminary acoustic habitat class map was derived. Ground- truthing was then carried out to assess the sediment types within each acoustic habitat class, and to characterise epibenthic communities within each habitat class. Sediment types were sampled through grab based sampling and subsequently subject to sieve analysis to determine particle grain size distribution. Epibenthic communities were sampled using either a towed underwater video camera, or beam trawl, which was deployed at a total of 25 sites. The relative abundance of taxa recorded at each site (as recorded on a single transect line, standardised for four minutes) was then assessed.
- ***Side-scan acoustic surveys at locations in Trinity Bay and the Barron River***. The presence of hard and structural habitat was investigated using side-scan sonar in the pipeline alignment offshore from Richters Creek and throughout the Lower Barron River. Remote assessments of seagrass communities along the northern beaches were also conducted.
- ***Benthic infauna communities***. A total of 47 sites were sampled at representative areas within the project areas and additional 'control' areas outside the disturbance footprint but within the study area and surrounds. Replicate 1.28 m2 van Veen grab samples were collected at each site, sieved through a 0.5 mm screen and preserved in a 10 percent buffered formalin solution. Samples were sent to Stephen Cook (Dardanus Scientific) for identification and enumeration of each taxa. Summary statistics for abundance and taxa richness were derived, and multivariate statistical analysis was used to explore spatial patterns in community structure.
- ***Shoreline Assessment***. Intertidal communities were surveyed during spring low-tide periods to assess the major community constituents of rocky shores at East Trinity, False Cape, and Rocky Island.
- ***Coral Surveys***. Surveys of coral community composition and gross reef geomorphology were undertaken at Double Island and Rocky Island. Methods focused on i) quantifying benthic communities at various distances from the reef edge, and ii) mapping an indicative boundary of the reef edge and different reef habitats (i.e. ecotones). This was undertaken using a combination of photographic transects for Coral Point Count analysis, together with GPS and GIS mapping tools.
- ***Fishing and Crabbing Surveys***. A single dry season survey of commercially and recreationally significant fish and crab species was conducted at 8 sites in East Trinity and Trinity Inlet, while seasonal surveys were conducted at 4 sites in the Barron River.

- ***Baseline mapping of seagrass and benthic macroinvertebrate communities***. James Cook University (JCU) conducted baseline mapping assessments of seagrass and macroinvertebrate communities specifically for this EIS. These assessments focused on Trinity Inlet, Cairns Harbour and Trinity Bay. Specific methodologies can be found in the relevant JCU reports (McKenna et al. 2013, Rasheed et al. 2013, Jarvis et al. 2014, York et al. 2016).

With the exception of the seagrass and macroinvertebrate surveys, all field sampling activities were undertaken by qualified environmental scientists from BMT. BMT was also responsible for preparation of the EIS assessments, in conjunction with Flanagan Consulting Group.

5.1 Existing Situation

The study area contains the following important marine and estuarine ecological values:

- A wide diversity of marine habitat types including sandy beaches, mangrove forests, saltmarshes, intertidal shoals, seagrass meadows, subtidal soft sediment habitats, rock walls and rocky shores.
- An extensive area of mangroves exhibiting a range of species and community types, some of which are limited in their distribution elsewhere.
- Seagrass beds that represent one of the only two major seagrass areas between Hinchinbrook Island and Cooktown.
- Mangroves, saltmarsh seagrass meadows and 'unvegetated' soft sediment habitats and other associated wetlands that have been recognised as important nursery areas for juvenile fish and prawns of commercial importance.
- Habitats for a wide range of fish and shellfish species of direct economic significance.
- A range of habitat types that significantly underpin the biodiversity values of the region.
- Potential feeding areas for marine turtles, dugongs and dolphins, which are listed as threatened or migratory under Commonwealth and/or Queensland legislation.

The dredge area (channel and swing basins) is mostly unvegetated with benthic communities that are regularly disturbed by maintenance dredging and propeller wash. The majority of the proposed dredge area is within the existing channel.

5.2 Environmental Impact Assessment Findings

5.2.1 Direct impacts – Capital Dredging

No reef communities or other features of high fauna biodiversity value were identified in the existing channel or proposed dredge areas in surveys undertaken in 2015 to support the EIS. The dredge footprint did not support seagrass meadows, however approximately 9 ha of the dredge footprint overlapped with seabed areas are known to have supported seagrass and as such, these areas represented potential habitat for seagrass. In the most recent monitoring conducted in December 2018, seagrass occurred within some of this footprint, although this was all within the existing permitted area for maintenance dredging.

Of the 9 ha of historic seagrass within the EIS-approved channel footprint, 6 ha fell within the existing channel footprint and is the subject of marine plant disturbance permit 2006CA0478. The total area of potential seagrass habitat in the footprint was ~ 1% of the cumulative historical extent of seagrass meadows in the Cairns region and ~2% of the meadow extent mapped in 2015.

Ports North commissioned TropWATER to conduct updated marine plant habitat assessments in the area of capital works interest with the specific objective of the habitat assessments to:

> Determine the presence/absence, density and distribution of marine plants within and adjacent to the proposed channel expansion footprint that are not covered by Ports North's existing marine plant disturbance permit prior to capital works.

The Cairns whole of port annual seagrass monitoring and additional Shipping Development Project surveys were conducted between October and December 2018. Survey site intensity was increased in areas that fell within the footprint of the proposed capital dredging areas which are not covered by Port Norths existing marine plant permit (Figure 5-1 – Blue outline). Additional sites were conducted at specific locations where new channel markers/beacons are required.

Sampling methods followed those for the established Cairns long-term seagrass monitoring program, and for other areas around Queensland. Methods applied depended on depth, visibility and logistical and safety constraints.

Intertidal areas were surveyed by helicopter while subtidal assessments were conducted using a boat based underwater digital camera system mounted on a $0.25m^2$ drop frame. Seagrass and algae density, cover and species composition was determined from three random placements of the $0.25m^2$ quadrat at each site. At all sites where macro algae was detected, composition was identified into five functional groups: erect macrophytes, erect calcareous, filamentous, encrusting and turf mat. A Van Veen sediment grab (grab area $0.0625\ m^2$) was used at each site to confirm sediment type and species viewed on the video screen.

Maps were generated in ArcGIS utilising recent aerial and satellite imagery. A precision estimate (in metres) was assigned for the habitat regions mapped based on the mapping methodology used in determining the boundary. Boundaries were based on the mid-point between the last site where a particular habitat (seagrass/algae) type was present and the next site where it was absent. The mapping precision estimate was used to calculate a range of area for each region and was expressed as a reliability estimate (R) in hectares.

No seagrass was found within the footprint of the proposed capital dredging works which are not covered by the existing marine plant permit (Figure 5-1).

Seagrass and algae were however, found in large areas either side of the existing channel and channel upgrade areas; there is a large seagrass meadow on the esplanade side of the channel as well as a large seagrass meadow that runs along Bessie Point up to False Cape. These results are not presented in Figure 5-1.

Macro algae was found at two sites within the footprint, at the southern end near Admiralty Island. There was no algae found in the thin wedge of widening of the channel at the bend (Figure 5-2). The algae was classed as erect macrophyte and percent cover was considered low (1% and 20% cover at the two sites). Some assessment sites directly adjacent to the existing channel and channel upgrade area recorded the presence of macro algae (Figure 5-2). These also had low percent cover (1 – 5%). Total area of the macro algae recorded was 2.81 ± 1.93 ha.

Figure 5-1 Seagrass presence/absence within areas of interest (blue area). * This figure contains only a subset of the total habitat assessment sites conducted in 2018.

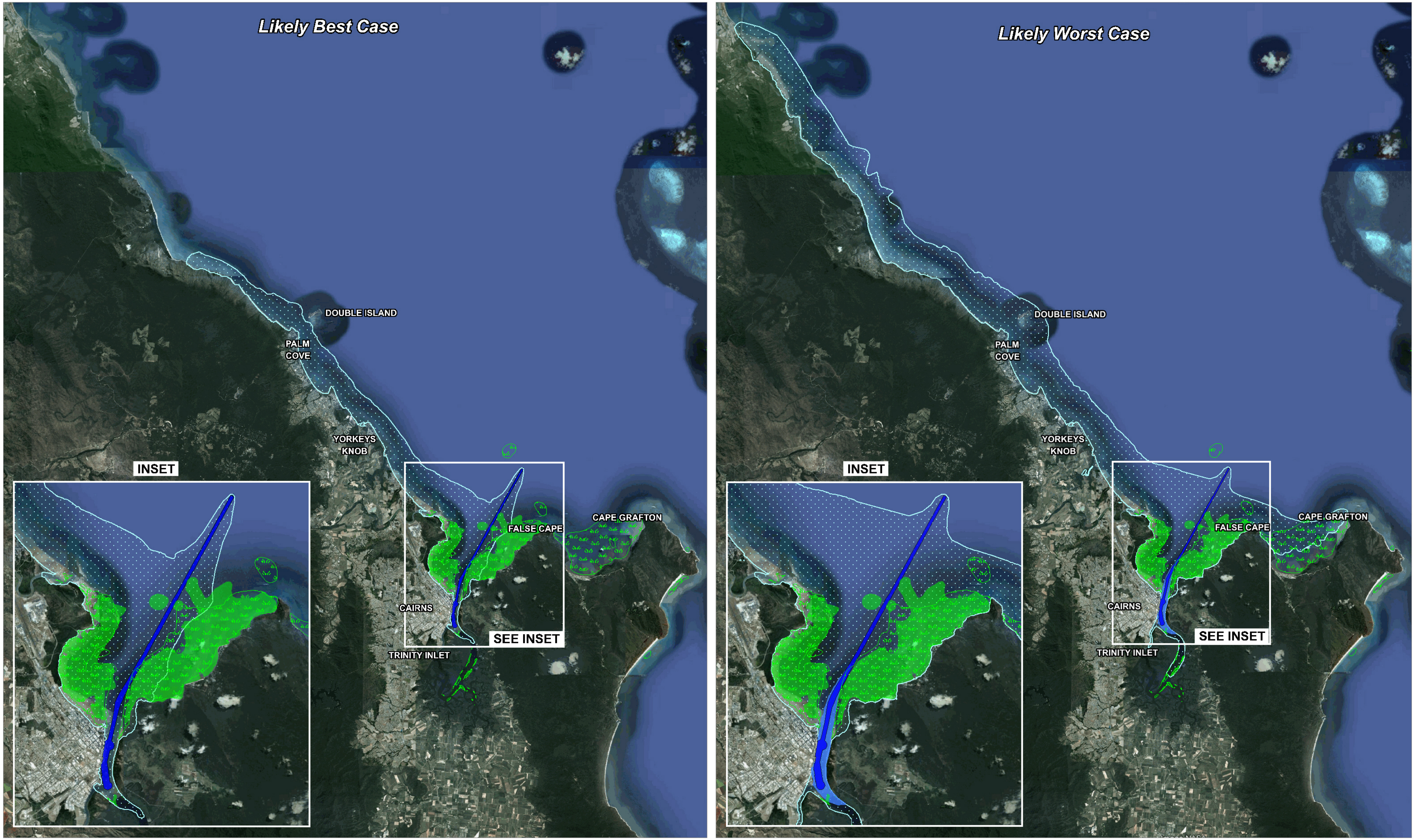
Figure 5-2 Algae presence/absence within areas of interest (blue area) as well as algal footprint. * This figure contains only a subset of the total habitat assessments sites conducted in 2018.

Initially, dredging will cause a temporary loss of the soft bottom benthic biota from within the dredge footprint, since benthic communities typically inhabit the surface sediments that will be extracted by dredging. Benthic biota will soon recolonise the dredge footprint but will continue to be regularly subject to similar disturbance through the ongoing annual maintenance dredging regime. While in this modified state, it would be expected that benthic communities within both the existing channel/harbour and proposed new dredge areas will support similar benthic communities and ecological functions as that currently found in the existing channels. Initial passive recolonisation of dredged areas may occur immediately after dredging, followed shortly by the commencement of recolonisation through larval dispersal or active invasion (within hours to days) (WBM 2004). While initial recolonisation will occur in a short time frame, 'recovery' (a return to comparable numbers of species and total individuals) would be in the order of months to years (i.e. 6-24 months) (Ports North, 2017).

5.2.2 Indirect Impacts – Water Quality and Sensitive Receptors

The zones of likely impact (Refer to Figure 5-3 and Figure 5-4) within the predicted dredge plume do not coincide with any coral reefs (e.g. Rocky Island and Double Island) or mangrove forests under best or worst case scenarios modelled in the EIS (the current dredge volumes are equivalent of the best case modelled). While the zone of Influence coincides with coral reefs, this zone includes areas where detectable turbidity changes could occur, but adverse ecological effects are not expected. The zone of influence for turbidity and deposition also coincides with known historic seagrass meadows, those recorded in surveys during the EIS phase, and most recently in 2018. There is a zone of high impact for turbidity and deposition located within the channel that intersects areas that are known to support seagrass, and impacts are expected within the channel footprint. re There is a zone of low to moderate impact for turbidity and deposition predicted to occur adjacent to the channel, and this zone coincides in some areas with past or present seagrass distributions, and will be subject of the WQ RMP, to ensure modelled impact predictions are monitored, verified, and managed via this DMP. Sediment deposition rates are predicted to be well below seagrass thresholds, except in the dredge channel, which does not presently support seagrass. On this basis, impacts to seagrass communities are expected to be low. In terms of tailwater discharge into the Barron River, Chapter B5 and B7 concluded that significant impacts to benthic marine invertebrates or species of commercial fisheries significance are not expected as a result of suspended sediments in tailwater. Furthermore, impacts are not expected to riparian or benthic fauna communities from saline tailwater discharge, as salinity is predicted to increase marginally and these communities regularly experience full seawater salinity conditions.

Table 5-1 provides a summary of the area of seagrass and coral reef within the modelled plume extent. This includes both existing (2018 data) and historical (1994 to 2015 data) seagrass occurrence. For further information, refer to Chapter B7 of the revised EIS, which details the survey methodology, baseline description and predicted impacts to sensitive receptors.



LEGEND

Historic Seagrass Extent (1984 - 2015)

2018 Seagrass Extent

Zones of Impact

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Title:

Zones of Impact - Turbidity - Capital Dredging
Likely Best Case (left) and Likely Worst Case (right)

Figure: **5-3**

Rev: **A**

N

0 2 4km
Scale - Inset

0 5 10 km
Scale - Main Map

BMT
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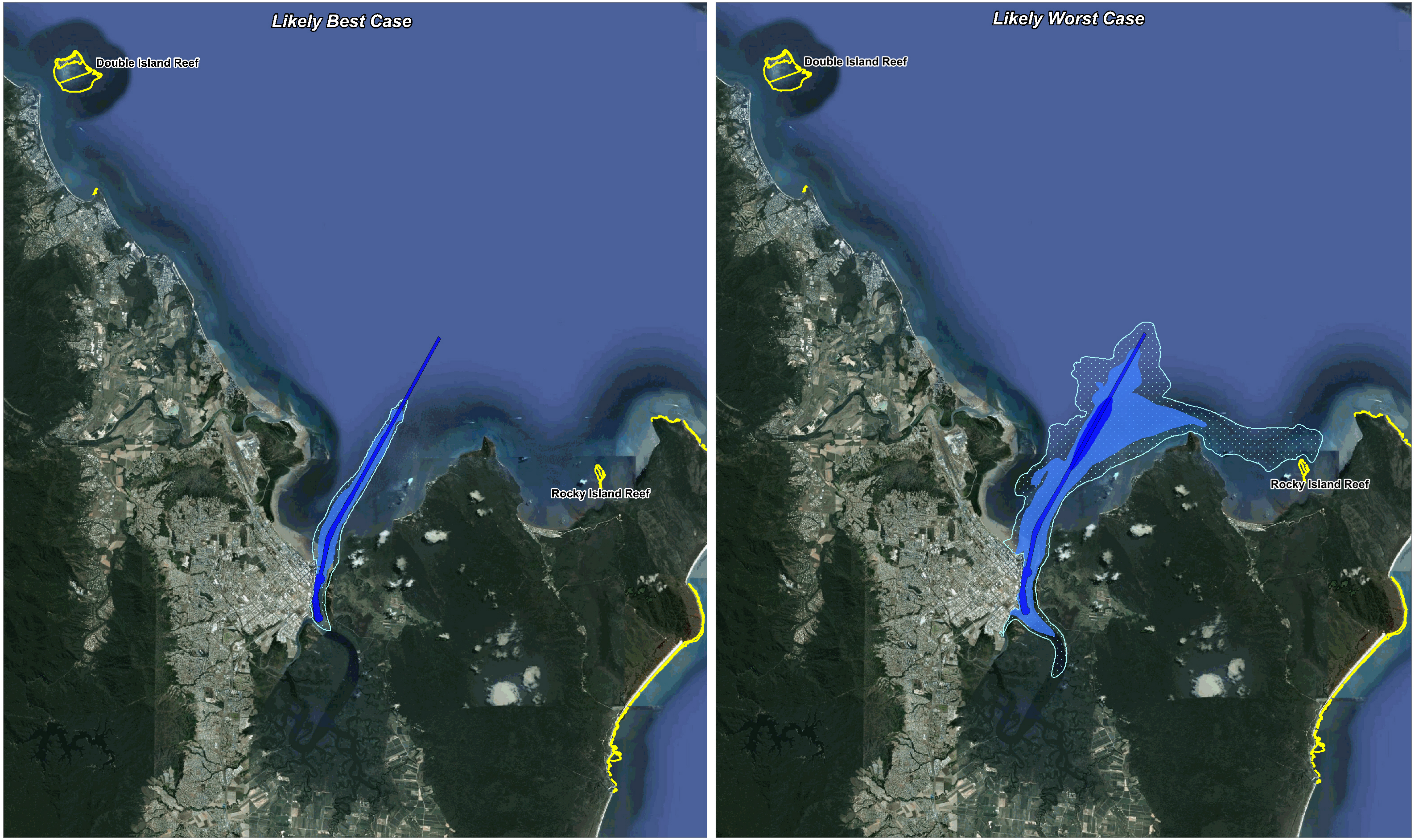

LEGEND

Coral Reefs

Zones of Impact

Zone of Influence (no ecological impacts)

Zone of Low to Moderate Impact

Zone of High Impact

Title:

Zones of Impact (Corals) - Sediment Deposition
Likely Best Case (left) and Likely Worst Case (right)

Figure: **5-4**

Rev: **A**

N

0 km 5 10
Approx. Scale

BMT
www.bmt.org

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Table 5-1 Seagrass and Coral Reef Areas within Modelled Plume Extent (Worst Case Scenario)

Zone	Historic seagrass extent (1994-2015)	2018 seagrass extent	Coral reefs	Mangroves
Zone of Influence	2,951	1,951	0	0
Zone of Low to Moderate Impact	0.2	4.2	0	0
Zone of High Impact	9	0.4	0	0

5.2.3 Secondary Impacts – Marine flora and fauna

The change in habitat conditions in the dredge channel is predicted to have highly localised secondary effects to marine flora and fauna. Alterations in the composition and abundance of benthic fauna assemblages can be expected within the dredged area immediately after dredging (i.e. prior to recolonisation), resulting in a temporary loss of prey items for fish and invertebrates in the dredge footprint, which represents a minor impact. Longer term changes in habitat conditions (e.g. sediment types, water depths) as a result of dredging, and associated changes to benthic macroinvertebrate communities, are not expected and will not lead to significant impacts.

6 Ports North Environmental Management Framework

The dredging and associated placement works associated with the CSDP will be undertaken in accordance with the Port's overarching environmental management framework as outlined below.

6.1 Environmental Policy

The Ports North Environmental Policy has the following commitments to demonstrate environmental leadership:

- Implement and maintain an environmental management system to meet the standard set by AS/NZ ISO14001:2004, as a tool for continual improvement in environmental performance.
- Comply with relevant environmental laws, regulations, policies, procedures, and standards.
- Identify, assess and minimise environmental risk and impacts of port activities.
- Integrate environmental considerations and principles of sustainable development into management processes and decision making.
- Maintain emergency, fire protection, security systems and infrastructure to protect the environment.
- Strive to use resources efficiently, minimise waste and prevent pollution.
- Apply sufficient and appropriate people and resources to achieve this Environmental Policy.
- Define, measure, and report regularly against objectives and targets and review the effectiveness of performance.
- Communicate this policy to staff and stakeholders to build collaborative relationships to promote superior environmental outcomes.
- All construction contractors should be familiar with this policy and actively promote achievement of these commitments in consultation with Ports North.

6.2 Environmental Management System

Ports North maintains an Environmental Management System (EMS) that is consistent with international standard ISO14001:2004. This EMS identifies all risks including safety, business and environment as well as management controls or actions to prevent or minimise impacts. A register of risks and treatment plans is maintained for all significant risks. A key element of the EMS is the commitment to conducting environmental audits of all construction activities so that risks associated with these are identified so that Ports North can verify relevant permits, licences and project objectives are being achieved.

The Construction Contractor(s) will be required as a condition of the works contract to establish and implement relevant management plans, procedures, and reporting so as to enable Ports North to ensure project permit and approvals requirements are met. Ports North will inform the appointed contractor of requirements to ensure the project objectives are being achieved consistent with the EMS framework.

6.3 Incident Management

Ports North have a system in place for recording, reporting and investigating incidents that result in, or have the potential to result in, adverse environmental impacts. This ensures that all environmental incidents and near miss events are investigated in an effective and timely manner to ensure the cause is identified and corrective actions completed.

All Construction Contractors will have an obligation to report events that have or may cause environmental harm to Ports North and to respective agencies as required under applicable laws and conditions.

Any breach of an environmental approval condition must be reported to the environmental authority within 24 hours of the Contractor and/or Ports North becoming aware of a breach.

6.4 Environmental Monitoring

Ports North undertake a range of monitoring programmes to manage potential impacts from the organisation's activities at the Port of Cairns. These include monitoring of water quality, sediment, biosecurity, land contamination, and marine habitats.

These programmes will continue in addition to CSDP specific monitoring outlined later in this DMP and any resultant conditions of approval which will be implemented by both Ports North and its Dredge Contractor as part of project implementation.

Monitoring that is required to be undertaken specifically for dredging works includes (but is not limited to:

- Sediment plume-associated modelling (SPAM) – in accordance with Condition G15 of the EA for capital dredging, dredge delivery pipeline and Tingira St DMPA;
- Hydrographic surveys prior to and within 2 months of dredging completion;
- Dredge plume extent, duration and zone of influence/impact on sensitive receptors (within 6 months of dredge completion);
- Marine megafauna observations;
- Surface water quality and sensitive receptor monitoring prior to, during and post-dredging;
- Groundwater monitoring (water level, electric conductivity, major ions, pH and metals) at the Northern Sands DMPA;
- Noise monitoring in the event that the administering authority requests monitoring to be undertaken;
- Acid sulfate soil validation monitoring of placed dredge material;
- Monitoring of pipeline earthworks for Cultural Heritage items; and
- All environmental complaints/complements/ incident reports received.

Table 6-1 Monitoring requirements under approval conditions

Monitoring and Survey Requirement	Responsibility	Timing
Pipeline landfall inspections (sediment accumulation, emissions and impacts to tidal land)	Dredge Contractor	From pipeline construction through to decommissioning
Plume tracking and validation	Environment Supervisor	During dredging campaign
Acid sulfate soil testing of dredged material in hopper	Groundwater and Acid Sulfate Soil Advisor	During dredging campaign
Sediment plume-associated/sensitive receptor water quality monitoring	Environment Supervisor	During dredging campaign
End-of-pipe tailwater monitoring	Dredge Contractor	During tailwater discharge
Seagrass response validation	Seagrass Advisor	Before, during and after dredging campaign
Noise monitoring (pump-out and booster pumps)	Dredge Contractor	During dredging campaign
Coral validation monitoring	Environment Supervisor	Before, during and after dredging campaign
Barron River marine species surveys	Environment Supervisor	Before, during and after dredging campaign
Ant Plant Surveys	Environment Supervisor	Before pipeline construction
Groundwater monitoring (during placement)	Groundwater and Acid Sulfate Soil Advisor	During placement
Groundwater monitoring (post-placement)	Groundwater and Acid Sulfate Soil Advisor	Up to 2 years after placement

6.5 Notifications

Table 6-2 Notification requirements under approval conditions

Notification Requirement	Responsibility	Timing
DAF notification – construction of dredged material delivery pipeline and tailwater discharge pipeline	Dredge Contractor	5-20 days before construction
CRC pre-start – construction of dredged material delivery pipeline and tailwater discharge pipeline	Dredge Contractor	5 days before construction
DAF notification – construction of Tingira Street DMPA	Dredge Contractor	5-20 days before construction
DAF/DES/DoEE/CRC notification – commencement of dredging and placement	Dredge Contractor	5-20 days before commencement
DAF notification – commencement of demobilisation of dredged material delivery pipeline and tailwater discharge pipeline	Dredge Contractor	5-20 days before commencement
DAF notification – demobilisation of dredged material delivery pipeline and tailwater discharge pipeline	Dredge Contractor	15 days after demobilisation
DAF notification – commencement of demobilisation of dredged material delivery pipeline and tailwater discharge pipeline	Dredge Contractor	5-20 days before commencement
DAF notification – demobilisation of dredged material delivery pipeline and tailwater discharge pipeline	Dredge Contractor	15 days after demobilisation
DAF notification – commencement of demobilisation of dredged material delivery pipeline and tailwater discharge pipeline	Dredge Contractor	5-20 days before commencement

6.6 Auditing

Formal environmental auditing will be undertaken during capital dredging and placement by a suitably qualified person (a minimum of 5 yrs construction environmental auditing experience and/or certified auditing qualifications) at least monthly and/or after a major non-conformance. The audit must be conducted in accordance with *International Standard 14001: Environmental Management Systems* protocols; an auditing scope and schedule will be developed for each audit and will be expected to include:

- General observations of status of environmental controls for the project;
- General environmental management measures are in place and actively managed e.g. training records, registers etc;
- Monitoring and measurement results during the audit period;
- Compliance with legislative obligations, including conditions of approval;

- Compliance with the requirements of this DMP (and the Contractors DMP) and other relevant plans e.g. ASSMP, GWMP, SWMBA, CEMP, CHA's;
- On-site environmental management controls are effective in managing environmental risk and are being maintained e.g. erosion and sediment controls are adequate;
- Non-conformances are being identified and recorded;
- Appropriate corrective actions are being undertaken in the event of non-conformances;
- Relevant records are being maintained e.g. marine mammal observations; and
- Opportunities for improvement.

6.7 Responsibilities

This section outlines the key responsibilities for all parties involved in the delivery of the capital dredging project. A summary of key roles and responsibilities is provided in Figure 6-1.

6.7.1 Ports North

Ports North are the overall project sponsor and have a role in ensuring that those undertaking the works have appropriate management systems in place to meet legislative requirements and to prevent environmental harm occurring. Their responsibilities include:

- Engaging and managing the Dredging Contractor;
- Finalisation of existing approval applications (other than those identified in the scope of the Dredging Contractor);
- Oversight and overall responsibility for legislative compliance, monitoring and environmental performance;
- Ensuring the dredge contractor has all appropriate environmental management systems and reporting protocols in place;
- Stakeholder engagement and liaison;
- Implementation of cultural heritage agreements or plans;
- Formulation and organisation of TAG Meetings, including the provision of regular project updates and monitoring/auditing results;
- Development and approval of framework management plans and monitoring programs required under relevant Federal, State and Local permits and authorities with support from the appointed Environmental Consultant; and
- Reporting any environmental incidents or non-conformances to relevant authorities, in accordance with relevant legislation and approvals.

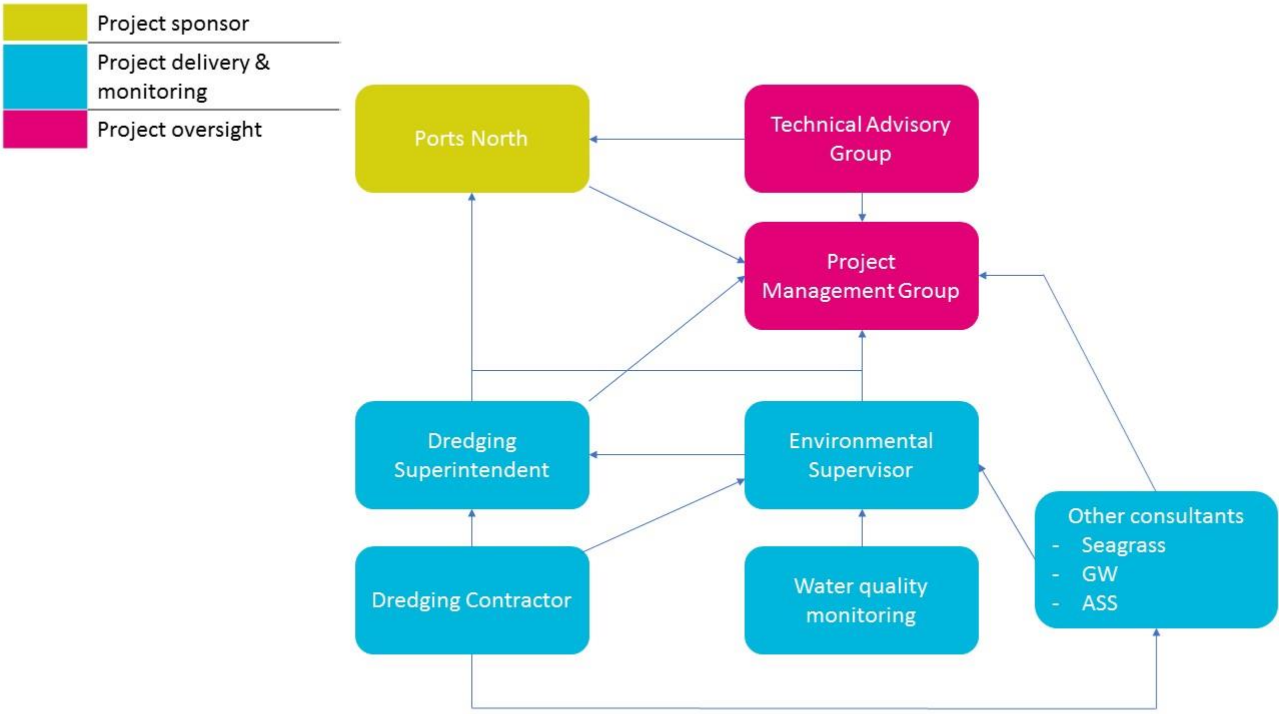

Figure 6-1 Project Responsibilities

6.7.2 Dredge Contractor

Rhode Nielsen (RN) are the appointed Dredge Contractor for the project, and will be conducting the capital dredging works, including pipeline installation and preparation of the two DMPA's. They will be responsible for compliance with legislative requirements and the delivery of the management measures outlined in this DMP. They will prepare their own DMP, that details how RN will deliver the requirements of this document. Their responsibilities include:

- Compliance with all relevant legislation and approvals during dredging and placement operations;
- Detailed design including associated engineering drawings certified by an RPEQ and other requirements of permits and approvals related to regulated structures and works;
- Pre-construction surveys as well as in situ calculation and tracking of material dredged and placed;
- implementation of detailed management plans:
  - Construction environmental management plan (CEMP) principally related to the Northern Sands and Tingira Street including how they will comply with existing approvals including Species Management Plans and Cultural Heritage Agreements and Plans;
  - Operational dredge management plan (DMP) principally related to dredging, dredge pipelines and tailwater discharge and how they will comply with existing approvals for these activities;
  - Adherence to detailed environmental management plans (i.e. DMP, SBMP, GWMP, ASSMP, SWMBA);
  - Managing dredging, delivery of material and tailwater discharge from the Northern Sands DMPA such that water quality limits/objectives/targets are met;

    - Implementing the Groundwater Management Plan and Acid Sulfate Soil Management Plan such that performance objectives and limits are met;
- Assist the Dredging Superintendent, PN and Environmental Supervisor with reporting when required;
- Assist the Dredging Superintendent, PN and Environmental Supervisor in investigating and responding to non-conformances or complaints received;
- Provide PN with regular performance reports;
- General environmental management in accordance with various management plans and approvals; and
- Notify the Dredging Superintendent, Environmental Supervisor and PN in the event of an environmental incident within the timeframes specified in this document.

6.7.3 Technical Advisory Group

Prior to finalisation, the DMP will be reviewed by an advisory panel of experts reporting to Ports North, and then submitted to the administering authority at least 50 business days prior to the commencement of dredging. The TAG members have been appointed by and are funded by Ports North and include:

- Independent Chair;
- Experts in the field of:
    - Coral biology;
    - Seagrass biology;
    - Marine megafauna biology (turtles, dugongs and cetaceans);
    - Dredging operations;
    - Groundwater and acid sulfate soils;
    - Coastal hydrodynamics and sediment transport; and
    - Water quality.

The TAG has been established as a requirement of approvals issued under the Queensland State approvals, to meet conditions thereof. The Group functions as a consultative mechanism for the capital dredging and will assist Ports North and regulators to access technical and local knowledge to ensure compliance with monitoring and approval conditions. The advice to be provided by the TAG will assist Ports North in reconciling technical outputs of the monitoring with any responses to various stakeholder interests. The primary objective of the Group is the review of the Dredge Management Plan, (and the sub-ordinate plans), monitoring designs, and to provide advice to Ports North and regulators on the management response to the outcomes of the monitoring results, to ensure consistency with the DMP and project approval conditions.

The purpose of the TAG is to:

- Provide technical advice to Ports North and regulatory agencies on risk management techniques to minimise the impacts of dredging and marine construction works associated with the CSD Project on the marine ecology of Trinity Inlet/Bay and surrounds.
- Provide input, review, and comment to the CSDP Project Management Team on applications for various approvals (especially associated with the Environmental Authority for dredging.
- The TAG will provide science-based advice on marine ecological issues to assist in defining and implementing management techniques to assist Ports North in ensuring the project meets all approval conditions and adopts leading practice during:
  - The detailed design phase - including input to applications, or updates to versions of Plans that support the various approvals, and
  - The marine construction works (dredging, transport of material and tailwater discharge from placed dredged material).
- Provide independent, expert based input on the scientific basis underlying the contingency measures in the DMP.
- Provide independent, expert based input to the application for Environmental Authority in relation to the suitability of water quality triggers for managing the dredging activity.
- Provide advice and endorsement of the proposed management and monitoring strategies associated with the dredging and marine construction works to address conditions associated with regulatory agency marine environmental permits and approvals. These will include baseline data collection, monitoring program design, and identification of specific monitoring indicators to identify changes to coastal ecosystems.
- Provide advice, review, and endorsement of the Reactive Monitoring Programs (RMPs) as described in this document with appropriate triggers and corrective actions, designed to avoid or minimise impacts.
- Review and provide expert advice and endorsement on the Validation Monitoring Programs (VMPs) as described within this document, designed to confirm EIS predictions.
- Provide input on the effectiveness of implementation of the environmental management plans associated with the dredging and marine construction works including the Dredge Management Plan and provide input where corrective actions may need be implemented.
- Review environmental performance of the dredging against criteria and triggers and evaluate corrective actions.

Their scope of works before, during and following capital dredging includes:

- Prior to commencement of dredging:
  - Provide independent expert input into the preparation of the DMP and contingency measures, including:
    - Review and comment on the scope of work for the Technical Advisors in relation to ecological surveys, setting of water quality triggers and ecological health indicators, and preparation of the DMP.

  - Critically review and comment on the DMP, including the monitoring trigger levels and indicators that have been set.
  - Endorse the final DMP for submission by Ports North as required to support the approval applications, for approval by Regulators prior to implementation of the Plans.
- During dredging:
  - Receive updates on monitoring from the Technical Advisors and any mitigation responses to level 1 triggers.
  - In the event that level 2 water quality triggers are exceeded, provide real-time advice to Ports North on biological response triggers and mitigation measures.
  - In the event that level 3 water quality triggers are exceeded, provided real-time advice to Ports North on whether dredging should be suspended.
  - Provide technical advice to inform Ports Norths response in the event that it receives and has need to investigate and respond to any complaints or incidents relating to the dredging or project dredging.
- On completion of dredging:
  - Critically review monitoring results and mitigation measures.
  - set the framework for the review, and also provide review/ input, and endorsement of the post dredging compliance report.

6.7.4 Dredging Superintendent

The dredging superintendent will act on behalf of PN to ensure that the dredge contractor is meeting their contractual obligations. Their role includes:

- Oversee and implement dredge contract;
- Direct dredge contractor in the event of non-conformance with legislation or approved plans;
- Direct dredge contractor in the event of non-conformance with dredging specifications; and
- Report on performance of dredge contractor to PN.

6.7.5 Environmental Supervisor

The environmental supervisor will act on behalf of PN to oversee environmental management of the project by the Dredge Contractor. They will also be responsible for ensuring the monitoring/validation programs outlined in this document are carried out. Their responsibilities include:

- Oversight of environmental management, reporting and compliance matters on behalf of Ports North;
- Assisting PN and the Dredge Contractor to set up reporting and management frameworks for the project;
- Minimum monthly auditing of the dredge contractor performance;
- Providing regular performance reports to TAG and relevant approval authorities;

- Preparing post-dredging reporting to the satisfaction of relevant approval authorities; and
- Vegetation (terrestrial, riparian, marine) condition assessments along Barron River and Pipeline alignment (to identify any signs of saline damage).

6.7.6 Project Management Group

The Project Management Group (PMG) will have representatives from the dredge contractor, PN, TAG, Environmental Supervisor and Dredging Supervisor.

In the event of any performance limits being exceeded during dredging (e.g. tailwater, surface water quality limits), this group will meet as soon as possible (generally within 24 hrs) and agree management measures to be applied to bring performance within approved limits. The agreed actions will be recorded and form part of any reporting to approval agencies.

6.7.7 Groundwater/acid sulfate soils Supervisor

A separate consultant will be appointed by PN to oversee delivery and monitoring of the Groundwater Management Plan and Acid Sulfate Soils Management Plan. Their responsibilities include:

- Groundwater monitoring, including well management triggers;
- ASS and NAGD testing, including validation during and after placement; and
- Oversight, implementation and auditing of compliance with GMP and ASSMP.

6.7.8 Water Quality Monitoring

A consultant will be appointed by Ports North to monitor marine water quality. Their responsibilities include:

- Marine water quality monitoring prior to and during the works at sensitive receptors and validation of plumes at dredging and tailwater site.
- Set up and maintain water quality data management website, including data processing and sending trigger alert alarms to the dredge contractor.

6.7.9 Seagrass Monitoring

A consultant will be appointed by Ports North to develop, monitor and implement seagrass monitoring pre, during and post dredging. Their responsibilities include:

- Development and implementation of the seagrass monitoring program;
- Seagrass receiving environment survey (pre dredging surveys including quantification of seagrass directly removed in dredge footprint);
- Quarterly meadow surveys; and
- Annual whole of port seagrass monitoring (post dredging surveys including verification of seagrass condition/response at/adjacent dredge footprint).

7 DMP – General Requirements

7.1 Overview

The strategies, actions and requirements in this section represent the commitments to management and monitoring for the CSD Project as they relate to dredging and associated activities. These measures and commitments will be required to be addressed by the dredge contractor in addition to any statutory approval requirements and conditions for the project (noting in the event of an inconsistency, the statutory approval requirement will prevail).

Unless specifically stated, commitments to activities such as environmental monitoring may be undertaken by the dredge contractor, by Ports North or by a third party contracted by Ports North depending on the procurement approach taken for the works.

As such, the focus of the DMP is on outlining the management and monitoring commitments including the performance measures to be achieved with the responsibility for implementing the commitments to be further developed as part of the procurement strategy for the project and subsequently as part of the operational dredge management plan prepared by the dredge contractor. Its purpose is also to define monitoring and EIS validation requirements.

7.2 Purpose

The overall purposes of the environmental strategies within the DMP are to:

- Identify potential and actual environmental aspects and impacts associated with the works;
- Describe the appropriate measures to prevent, monitor and manage possible effects;
- Outline the corrective action(s) to be undertaken if an undesirable impact or unforeseen level of impact occurs; and
- Outline monitoring, auditing and reporting actions.

7.3 General Requirements

This section of the DMP outlines the general environmental requirements of the DMP that the appointed dredge contractor would be expected to fulfil. Ports North's role with respect to this section would be to ensure these requirements are addressed and met by the contractor as part of the contract and to ensure activities are being carried out consistently with any existing procedures or protocols within Port Limits or under relevant corporate environmental policies or strategies, and all approvals, conditions and licences.

The general requirements are stated below in Table 7-1.

Table 7-1 General Requirements for Dredging

General Requirements – Dredging	
Objective	To ensure dredging operations and associated activities comply with relevant environmental duties and obligations as set out in legislation and with the environmental permit requirements.
Applicability	All capital dredging works and associated activities
Performance Criteria	All relevant permit and licence conditions will be met.
Implementation Strategy	The dredge contractor will need to address the following requirements: **<u>General Method Statement</u>** A general method statement will need to be prepared outlining the intended scope of works and methodology to be employed. At a minimum, the method statement should include the following: • Description of the general scope of works (noting this may need to be by stage only) • References to International Dredging Standards. Company Standards (such as quality, OHS and environment management systems), how they apply to the current project and any other project specific document • Responsibilities of the contractor and key staff (on the dredge vessel and on shore) • Provide a clear map of the areas where the proposed dredging activities are to take place consistent with regulatory approvals • Provide a general description of the dredging process and the specifics of the plant to be used in the dredging process including the proposed dredging methods, dredging control, dredging patterns, vessel navigation routes to be used and vessel operations while at the pump out location including ancillary activities such as waste management and fuel bunkering • Include specific method statements in accordance with the requirements of this DMP **<u>Contractors DMP</u>** Contractors DMP must address the following: • Environmental commitments – including a commitment by senior management of the contractor to achieve specified and relevant environmental goals • Identification of environmental issues and potential impacts • The relevant conditions of all environmental approvals • Control measures for routine operations to minimise the likelihood of environmental harm • Method statements for each element of the project e.g. dredging, NS management, Tingira st management, rehabilitation etc. • Contingency plans and emergency procedures for non-routine situations • Organisational structure and responsibility • Effective communication • Staff training • Record Keeping • Periodic review of environmental performance and continual improvement.
	<u>Maintenance of Measures, Plant and Equipment</u> The dredge contractor must ensure that all measures, plant and equipment necessary to undertake the activity are operated and maintained in a proper and efficient condition. This includes appropriate servicing and maintenance of engines and emission control devices such that emissions comply with relevant guidelines and standards. **<u>Complaint Response (General Requirements)</u>**

<table>
<tr><th colspan="2">General Requirements – Dredging</th></tr>
<tr><td></td><td>All complaints received by the dredge contractor related to environmental issues such as noise, air, or water quality must be recorded including investigations undertaken, conclusions formed and actions taken. Notification about the complaint and any associated response must be provided to Ports North in a timely fashion.
The complaint response procedure will include:
• The time, date name and contact details of the complainant
• Reasons for the complaint
• Any investigations undertaken
• Conclusions formed
• Any actions taken.
<u>Reasonable and Practicable Measures</u>
The dredge contractor must take all reasonable and practicable measures to prevent and/or minimise the likelihood of environmental harm being caused.
<u>Notifications of Commencement</u>
The dredge contractor must inform Ports North and regulatory agencies of its intention to commence dredging within timeframes identified in any approvals granted.
<u>Signage</u>
Before dredging commences and during the whole operation, the dredge contractor will be responsible for displaying a sign that shows the name of the dredge vessel and the relevant permit numbers (to be provided) at on-shore locations accessible to the public to inform stakeholders about the activity, as applicable under respective approvals.</td></tr>
<tr><td>Monitoring</td><td>Refer monitoring requirements as outlined in the specific environmental strategies in Section 8.
The dredge contractor must keep records of all monitoring results for which they are responsible (Refer to
• Table 6-1 for further detail) required by this DMP or as part of regulatory agency permit requirements. This shall include, but not be limited to:
- bathymetric survey results
- marine mammal observations
- end-of-pipe tailwater water quality
- noise quality
- cultural heritage inspections
• The dredge contractor must keep records on the volume and size distribution of material removed from the approved dredge footprint area. These records must be provided to Ports North in the timeframe specified in any approvals.
• The dredge contractor must also keep records of megafauna sighted and/or any incidents with megafauna as required in any approvals granted.
• The dredge contractor will be required to undertake bathymetric surveys pre, during (progress check) and post dredging and at the dredge pump out area and its respective surroundings.</td></tr>
<tr><td>Reporting</td><td>Refer reporting requirements as outlined in the specific environmental strategies in Section 8. This may include the development of further plans of management, monitoring and survey reports, reporting on compliance matters or similar.
• The dredge contractor is responsible for ceasing activities and notifying Ports North if it becomes aware of material or serious environmental harm (as defined in the Environmental Protection Act 1994) as a result of carrying out of the dredging and associated works. The contractor must also contact the relevant agencies as per</td></tr>
</table>

General Requirements – Dredging	
	approvals/legislation after becoming aware of any release of contaminants not in accordance with the condition of any approvals granted. • Any compliance breach must be reported as soon as practicable within 24 hours to the administering authority. Records must be kept including the full details of the breach and any subsequent actions undertaken. An annual compliance report is required as a condition of any controlled action approval under the *Environment Protection and Biodiversity Act 1999*.
Auditing	Refer auditing requirements as outlined in the specific environmental strategies in **Section 8**. • Formal reviews of environmental performance are to be undertaken at least monthly during dredging and placement of dredged material (informal review should be continuous) • Audits may be conducted at other times by Ports North and/or regulatory authorities in accordance with approval conditions • A third party audit may be requested by the Minister if necessary as a condition of any controlled action approval under the *Environment Protection and Biodiversity Act 1999*.
Corrective Actions	Refer corrective actions as outlined in the specific environmental strategies in **Section 8**.

8 Specific Environmental Strategies

8.1 Introduction

This section outlines the specific environmental strategies of the DMP which include:

- Water Quality and Marine Ecology;
- Marine Megafauna;
- Marine Sediment Quality;
- Dredge Pipeline – Terrestrial and Aquatic Ecology;
- Dredge Pipeline – Erosion and Sediment Control;
- Vessel Wash Down Management;
- Ballast Water and Marine Pest Incursion Management;
- Vessel Waste Management;
- Fuel Management;
- Noise Quality;
- Air Quality;
- Landscape and Lighting; and
- Emergency Planning and Procedures for Environmental Incidents.

For each element identified, an environmental management strategy, measures and actions have been developed to address potential risks that may arise. Each element has a stated environmental objective, performance criteria, management actions, monitoring, reporting and corrective actions.

8.2 Water Quality and Marine Ecology

This section summarises the measures that will be implemented to minimise impacts to water quality and marine ecology. This section excludes specific measures for protection of marine megafauna which are outlined in **Section 8.2.2.2**.

Objective	To minimise impacts to water quality and protect marine ecological values of the study area including seagrass, corals, benthic habitats and the estuarine habitats of the Barron River.
Potential Impacts	The principal impacts to be managed under this section include: • Impacts to water quality (from capital dredging and tailwater release); • Impacts to seagrass, corals and other marine habitats (from capital dredging); and • Impacts to environmental values and riparian vegetation including marine plants along the Barron River (from tailwater release as surface water and groundwater) and adjacent to the Tingira Street DMPA.
Performance Criteria	Performance criteria are set out in this section for the following: • Tailwater management discharge; and • water quality limits and trigger values for receiving environments for surface water and ground water are not exceeded • The volumetric discharge from the Northern Sands DMPA is not to be exceeded (87ML/Day)
Monitoring & Reporting	Receiving Environment (REMP) and Validation (VMP) Monitoring Programs (this includes validation of the Sediment Plume Associated Monitoring or SPAM)) as set out in this section for: • Capital dredging (marine water quality and ecology); and • Tailwater management (surface waters and groundwater).

<table>
<tr><th>Implementation Strategies</th><th>Responsibility</th><th>Timing</th><th>Corrective Actions</th></tr>
<tr><td>See Section 8.2.1, which includes strategies related to:
• Dredge footprint and logistics;
• Overflow from the TSHD;
• TSHD Operations at the Temporary Mooring and Pump Out;
• Tailwater management;
• Timing of the dredging; and
• Receiving Environment Management Program and corrective actions.</td><td>Ports North
Dredge Contractor</td><td>Implementation to occur at all times during the dredging campaign</td><td>Refer section below.</td></tr>
</table>

8.2.1 Surface Water Quality Limits

The Environmental Authority (EA) for an Environmentally Relevant Activity 16 (1) (d) (dredging) under the *Environmental Protection Act 1994* for capital dredging, dredge delivery pipeline and Tingira St DMPA has been issued by the Department of Environment and Science (DES). This EA sets surface water quality limits (Condition WT1) at receptors sensitive to dredging. The parameters to be monitored to meet the licence conditions are benthic Photosynthetically Active Radiation (PAR) and turbidity. These are provided in Table 8-1 and Table 8-2. The turbidity limits are based on the 80th and 95th percentile of site-specific baseline data collected during the dry season.

Table 8-1 Sensitive Receptor Water Quality Limits – Benthic PAR (Seagrass Meadows)

Monitoring Location Name	Coordinates (GDA94 decimal degrees)		Quality Characteristics (units)	Limit	Limit Type	Minimum Monitoring Frequency
	Latitude	Longitude				
Halodule uninervis meadow(s)	-16.90082	145.79601	PAR (mol m^{-2} day $^{-1}$) in areas with the seagrass *Halodule uninervis* present	5	14 day rolling average*	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
	-16.90082	145.79601	Turbidity (Nephelometric Turbidity Unit (NTU))	Monitor Only	Monitor Only	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
Zostera muelleri meadow(s)	-16.88818	145.77116	PAR (mol m^{-2} day $^{-1}$) in areas with the seagrass *Zostera muelleri* present	6	14 day rolling average	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
	-16.88818	145.77116	Turbidity (Nephelometric Turbidity Unit (NTU))	Monitor Only	Monitor Only	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)

14 day rolling average is calculated by averaging the total daily PAR recorded over the previous fourteen days

Total Daily PAR is determined by recording the cumulative total of benthic light received at a site in a 24 hr period

Monitoring must be in accordance with the methods prescribed in the latest version of the administrative authority's Monitoring and Sampling Manual, including the PAR methods. The 2017 version, or more recent updates of this manual must be used.

PAR measurements must be taken just above the canopy height of the surrounding seagrass and at less than one (1) meter above the seabed

Mol m^{-2} day^{-1} refers to mols per square metre per day

Table 8-2 Sensitive Receptor Water Quality Limits - Turbidity

Monitoring Location Name	Coordinates (GDA94 decimal degrees)		Quality Characteristics (units)	Limit	Limit Type	Minimum Monitoring Frequency
	Latitude	Longitude				
Palm Cover (Double Island)	-16.74080	145.69710	Turbidity (NTU)	57	15-day rolling median	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
				125	6-day rolling median	
Yorkeys Knob	-16.80330	145.74470	Turbidity (NTU)	58	15-day rolling median	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
				100	6-day rolling median	
Trinity Bay	-16.89110	145.79450	Turbidity (NTU)	40	15-day rolling median	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
				173	6-day rolling median	
Upper Trinity Inlet	-16.96150	145.79650	Turbidity (NTU)	12	15-day rolling median	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
				26	6-day rolling median	
False Cape	-16.86190	145.84110	Turbidity (NTU)	82	15-day rolling median	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
				144	6-day rolling median	
Cape Grafton	-16.86620	145.90130	Turbidity (NTU)	121	15-day rolling median	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
				248	6-day rolling median	

Monitoring must be in accordance with the methods prescribed in the latest version of the administrative authority's Monitoring and Sampling Manual, including the background information on water quality instruments using in situ water quality instruments

All determinations must employ analytical practical quantification limits of sufficient sensitivity to enable comparisons to be made against the limits relevant to the particular water or sediment quality characteristic

Limits derived from the 80th and 95th percentile of site-specific baseline dry season water quality data

The 15 and six (6) day daily rolling median is calculated using the median of the daily median over the previous 15 or six (6) days.

In addition, reference site monitoring locations for seagrass and turbidity have been reviewed and endorsed by the TAG (Refer to Figure 8-1). These sites are listed in Table 8-3, along with reference values to be used in the ‘inference assessment’ (discussed in Section 8.2.4.1.6) to assess if turbidity or PAR is near the bounds of natural variability.

While the term ‘control site’ is used in the EA and in the DES (2018) sampling manual, the sites in Table 8-3 are not true control sites as they may periodically have some influence from dredge plumes. However, they can still be used as ‘reference sites’ when the dredge is not operating in the vicinity. Therefore, the term ‘reference site’ has been used in lieu of ‘control site’ in this DMP.

Table 8-3 Reference Sites – BPAR and Turbidity

Monitoring Location Name	Coordinates (GDA94 decimal degrees)		Quality Characteristics (units)	Reference Value	Value Type	Minimum Monitoring Frequency
	Latitude	Longitude				
Halodule uninervis reference site	-16.91500	145.77924	PAR (mol m^{-2} day $^{-1}$) in areas with the seagrass *Halodule uninervis* present	5	14 day rolling average	Continuous data logging (at least every 10 minutes) during dredging and for 2 weeks after dredging ceases)
			Turbidity (NTU)	Monitor Only	Monitor Only	
Zostera muelleri reference site	-16.87438	145.84537	PAR (mol m^{-2} day $^{-1}$) in areas with the seagrass *Zostera muelleri* present	6	14 day rolling average	
			Turbidity (NTU)	Monitor Only	Monitor Only	
Mission Bay – WQ and seagrass reference site	-16.88100	145.87146	PAR (mol m^{-2} day $^{-1}$) in areas with the seagrass *Zostera muelleri* present	6	14 day rolling average	
			Turbidity (NTU)	14	15-day rolling median	
				45	6-day rolling median	
Offshore WQ reference	-16.77889	145.81073	Turbidity (NTU)	9	15-day rolling median	
				27	6-day rolling median	

Reference values for turbidity are derived from the 80th and 95th percentile of site-specific baseline dry season water quality data

The EA for placement of dredge material at Northern Sands sets surface water release limits for the release of tailwater in the Barron River. Limits have been set for surface water at the 'end of pipe', as described in Table 8-4 below. The Dredge Contractor will be responsible for monitoring and reporting of tailwater discharge at the end-of-pipe (most likely at the weir box), and to ensure both water quality and volumetric release limits are met. **Note that the EA sets a volumetric release limit of 87 Megalitres (ML) per day.**

Table 8-4 End of Pipe Tailwater Release Limits

Monitoring Location Name	Release Points (GDA94 Decimal Degrees)		Quality characteristic (units)	Limit	Limit Type	Minimum Monitoring Frequency
	Latitude	Longitude				
End of Pipe	-16.869º	145.735º	pH	6.5-8.5	Range	Continuous data logging during releases
			Dissolved Oxygen	60-105%	Range	Continuous data logging during releases
			Turbidity	50 nephelometric turbidity units (NTU)	Maximum	Continuous data logging during releases
			Total Suspended Solids	mg/L monitor only	N/A	Weekly during releases
			Ammonia N	460 µg/L	Maximum	Weekly during releases
			Electrical conductivity or salinity	µS/cm or mg/L monitor only	N/A	Continuous data logging during releases
			Temperature	Monitor Only	N/A	Continuous data logging during releases

In addition to end-of-pipe monitoring, water quality will be monitored at locations upstream and downstream of the release point in the Barron River and Thomatis/Richters Creek as part of the Tailwater REMP (Section 8.2.4.3). These sites are not compliance sites but will act as 'sentinel sites' – which are sites located between the disturbance source and the sensitive receptor and serves to provide early warning of developing adverse conditions. Monitoring will be in accordance with the methods prescribed in the latest version of the administrative authority's Monitoring and Sampling Manual, including the background information on water quality instruments using in situ water quality instruments.

While limits for the Tailwater REMP have not been specified in the EA conditions, limits have been developed using a similar methodology to EA limits using baseline data collected at a number of sites in the Barron River and Thomatis/Richters Creek between 2014 and 2018. These limits are provided in Table 8-5.

Table 8-5 Barron River Sentinel Site Water Quality Limits

Monitoring Location Name	Coordinates (GDA94 decimal degrees)		Quality Characteristics (units)	Limit	Limit Type	Minimum Monitoring Frequency
	Latitude	Longitude				
WQ1 (Upper Barron River)	-16.85902	145.70975	Turbidity (NTU)	11	15-day rolling median	Continuous data logging (at least every 10 minutes) during tailwater discharge and for two weeks after tailwater discharge ceases)
				23	6-day rolling median	
			Salinity (ppt)	19	15-day rolling median	
				23	6-day rolling median	
WQ2 (Thomatis/ Richters Creek)	-16.85106	145.71736	Turbidity (NTU)	35	15-day rolling median	
				89	6-day rolling median	
			Salinity (ppt)	29	15-day rolling median	
				32	6-day rolling median	
WQ3 (Mid-Barron River)	-16.87118	145.72631	Turbidity (NTU)	40	15-day rolling median	
				105	6-day rolling median	
			Salinity (ppt)	25	15-day rolling median	
				30	6-day rolling median	
WQ4 (Lower Barron River)	-16.86028	145.74483	Turbidity (NTU)	42	15-day rolling median	
				94	6-day rolling median	
			Salinity (ppt)	31	15-day rolling median	
				32	6-day rolling median	

Limits derived from the 80th and 95th percentile of site-specific baseline dry season water quality data

The 15 and six (6) day daily rolling median is calculated using the median of the daily median over the previous 15 or six (6) days.

Monitoring must be in accordance with the methods prescribed in the latest version of the administrative authority's Monitoring and Sampling Manual.

8.2.2 Surface Water Quality and Ecology Standard Mitigation Measures

A range of standard mitigation measures will be committed to and required to be undertaken by Ports North and its appointed dredge contractor from the outset of the project to meet the conditions in Section 8.2.1. Use of a selection of mitigation measures from a range of possible options will be informed by the experience of the contractor, operational requirements, and direction from Ports North and where triggered, advice from the appointed Technical Advisory Group (TAG) (see further description below).

The standard mitigation measures are summarised as follows:

- Dredge Footprint and Logistics:
  - The dredge operates at all times within the approved dredge footprint.
  - Accurate electronic position system used to track dredge movements at all times.
  - Hoppers are not overloaded.
  - Hopper compartments are maintained water tight during all dredging activities.
  - If required, use of high pressure jets on dragheads and in the hopper to loosen materials is restricted to dredging areas only.
- Overflow from the TSHD:
  - Overflow during dredging by the TSHD is limited to durations no greater than the modelled most likely 'worst case' scenario which includes an average 30 minute overflow duration per cycle. In practice, overflow duration is likely to be less than 15 minutes to optimise loads, as there is no additional benefit for overflow to occur for a longer duration.
  - Where water quality performance targets are not achieved, additional reductions in overflow can be implemented.
  - The hopper is only loaded to a level that reduces the loss of material during travel to the pump-out location.
  - The dredge is fitted with a 'green valve' in order to minimise the spatial extent of turbidity plumes generated by dredge operation. The green valve ensures that any overflow from the dredge vessel is released under the keel of the vessel rather than close to the surface and is stripped from entrapped air pockets.
- TSHD Operations at the Temporary Mooring Pump Out:
  - The dredge will be positioned in sufficient water depth, be aligned with prevailing weather and held stationary with bow thrusters. Modelling identified that propeller wash would not have a significant impact to sensitive receptors.
- Tailwater Management:
  - Dredged tailwater is to be managed in the Northern Sands DMPA site to meet the water quality discharge performance requirements in Table 8-4.
  - Correlations between turbidity (NTU) and suspended solids (TSS) will be investigated to develop an operational indicator of suspended solid concentration that can be field measured.

- Timing of the Dredging:
  - Capital dredging of the channel by the TSHD will be undertaken outside of the following months (October to February) based on the following reasons:
    - Within Cairns Harbour *Zostera muelleri* seagrass biomass is typically greater in late spring, a key growing season for this species (McKenzie 1994). High water temperatures (and sometimes reduced salinity during flood events) during summer months can lead to seagrass stress, potentially reducing their resistance to other stressors such as low light conditions. During winter months, seagrass biomass is at a minima within Cairns Harbour (McKenzie 1994).
    - October and November are known periods of coral spawning in the region (noting that impacts to coral species and communities are not predicted as part of the project).
  - Receiving Environment Monitoring Programs and Corrective Actions:
    - Develop and implement a Receiving Environment Monitoring Programs (REMPs) with appropriate triggers and corrective actions for dredging and dredge tailwater release.
    - Develop and implement a Validation Monitoring Programs (VMPs) to confirm the findings of the EIS as well as validate the CSDP has not had a significant impact on environmental values including relevant Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES).
    - These two programs are further defined in Section 8.2.4 below.

8.2.3 Groundwater Quality

Groundwater quality performance triggers have been developed for receiving water quality values potentially affected by seepage into groundwater from the DMPA.

The groundwater triggers have been derived from baseline monitoring background values established through the pre-dredging period and based on the predicted changes in water level and salinity. The triggers are protective of the groundwater quality for the most sensitive Environmental Value established at each monitoring well location beyond the Northern Sands property boundary.

These will be approved when the GWMP is submitted and signed off by the approving authority (DES).

8.2.4 Receiving Environment Monitoring Programs (REMPs)

8.2.4.1 Capital Dredging REMP

The overall aim of the Capital Dredging REMP will be to avoid or otherwise minimise impacts to sensitive marine environments that could be affected by capital dredging activities.

The proposed design of the program is benchmarked and generally consistent with guidance provided in *Water Quality Review and Monitoring* (SKM 2012) developed as part of the Great Barrier Reef Marine Park Authority's (GBRMPA) Strategic Assessment. This monitoring program will be overseen by the Technical Advisory Group (TAG) that has been formed to guide the project.

The Capital Dredging REMP will have two interlinked components:

- A dredge plume turbidity monitoring program; and

- Benthic PAR monitoring program for seagrass sensitive receptor sites.

Note that a quarterly seagrass monitoring program at the two key seagrass meadows will be undertaken as part of the Validation Monitoring Program in Section 8.2.4.4.

8.2.4.1.1 Monitoring Equipment and Parameters

At each dredge plume turbidity monitoring site, a water quality logger will be fitted with turbidity sensors designed for long-term deployments in the marine environment with anti-fouling guards and sensor wiping apparatus to prevent interference to sensors from marine growth. These loggers will be deployed using purpose-built monitoring buoys anchored to the seabed to maintain position. With the loggers installed in each monitoring buoy, the sensors will be located at a depth of approximately 1 m below the water surface.

At benthic PAR monitoring sites, PAR sensors will be deployed on a bottom-mounted frame. These sensors will measure light levels reaching seagrass beds and will provide information on the PAR these receptors are receiving during the project. A terrestrial PAR sensor will also be deployed in a secure location at a terrestrial site out of the water near the project. This sensor will be fixed to a structure (e.g. roof or post) in an unobstructed area in full sunlight, which can be accessed on a routine basis for data downloading and servicing. This is necessary to inform the inference assessments about any reductions in Benthic PAR due to water column turbidity rather than low incident light reaching the water surface due to cloudy days.

Turbidity and PAR instruments will be programmed to log data once every ten minutes.

Secondary (twin) sensors will be deployed at each site for each parameter (i.e. turbidity and PAR) for redundancy and QA/QC purposes. This will allow spikes in data to be validated with another nearby sensor, and potentially rule out biofouling, sensor drift or malfunction which may provide erroneous readings. Telemetry and other appropriate equipment will be installed to ensure dredge management can be reactive within a timely manner and flag exceedances in real time. This data will be available to key project personnel, with provision for alerts via mobile text message or email of any exceedance under the REMP where required.

8.2.4.1.2 Equipment Failure at Compliance Sites

In the event of failure of the monitoring equipment at a compliance site during dredging, the following will be undertaken:

- A spare monitoring buoy will be available for rapid deployment (within 24 hours in case of equipment failure of deployed equipment).
- If spare equipment is not available, then equipment from one of the reference sites will be relocated to the compliance site while replacement equipment is sourced.
- At PAR sites, if equipment fails or needs to be relocated to another site, non-telemetered PAR loggers will be deployed to continue to collect data.
- Telemetered equipment is fitted with a GPS tracker, and the moment the instruments cease recording or the GPS tracker indicates a buoy has moved from the fixed location, an automatic notification will be issued to Ports North, the Dredge Contractor and the Environmental

Representative. Instruments will either be recovered or spare monitoring equipment deployed, as per the timeframes above. DES will be notified of the remedial measures undertaken.

- If there was an exceedance of a compliance limit that was attributable to dredging at the time of equipment failure, then the dredge mitigation measures would continue to be implemented as a precautionary approach until the equipment is fixed.

8.2.4.1.3 Data Handling

Real-time monitoring data will be automatically downloaded (once per hour) from each site remotely via telemetry. This data will be stored and processed using a web-based platform that will allow:

- Manual and automatic data processing – including QA/QC data checking and flags.
- Display of real-time data in graphs and tables.
- Sending of alerts (email and text message) when trigger levels are exceeded.
- Storage and export of historical data.

The raw data will be processed and, following a QA/QC process, the following will be calculated:

- The 6-day and 15-day rolling medians will be calculated using the median of the daily median over the previous 15 or six (6) days of the 10-minute turbidity data (and the salinity data for Barron River sites). These values will be updated on a daily basis.
- At PAR sites, the total daily PAR will be calculated by summing the 10-minute integrated PAR measurements over each calendar day (midnight to midnight). Following this, the 14-day rolling average will be calculated daily using the previous 14 days of total daily BPAR data.

8.2.4.1.4 Data QA/QC

The following will be undertaken to ensure data quality and to minimise any data loss from the real-time monitoring equipment:

- At each site, two independent sensors (turbidity and PAR) will be installed. This is to minimise the chances of data loss due to the biofouling or failure of a sensor.
- Sensors and equipment will be cleaned and calibrated regularly (approximately once every 2-3 weeks, depending on weather conditions). All sensors will be calibrated as recommended by the manufacturer using standard solutions prepared from National Institute of Standards and Technology (NIST) traceable reagents.
- Accuracy and precision checks will be undertaken in accordance with manufacturer instructions. Re-calibration of instruments will be undertaken if accuracy and precision tests fail to meet data quality objectives.
- When sensors are retrieved from the field a report on their condition and appearance will be completed. This will identify if a sensor has been biofouled or has any other noticeable issues. This data will be used to assist in the post-processing assessment of the data.
- A calibration log will be kept and made available upon request – the log will contain all calibration details including before and after calibration (should any back calculation be necessary) and details of standards used during calibration.

Data Quality Control Procedures

As real-time data is automatically downloaded by the web-based platform, any potential outliers and questionable data will be assigned a quality code which will then be examined further. Rules to flag potential outliers and questionable data will be as follows:

- If any individual turbidity or PAR measurement is >100% higher or lower than adjacent measurements (e.g. brief spike in turbidity or PAR).
- If turbidity or PAR is outside the bounds of typical readings:
  - Negative turbidity or turbidity higher than 1,000 NTU.
  - Negative PAR or PAR greater than 3,000 µmol/m^2/s.
- The data will be automatically plotted on the web-based platform as a time series and visually scanned for outliers and evidence of failed sensors, including data which has been assigned a poor-quality code. Obvious failures will result in the data being quarantined from the dataset.
- The use of twin sensors will assist investigations into the validity of potential outliers and questionable data. The two data sources will undergo automatic processing by the monitoring website as follows:
  - Data from the two concurrent sensors will be downloaded and compared.
  - If the difference in readings is within 20%, then the average value will be used.
  - If the difference is greater than 20%, then the minimum value will be used for turbidity or the highest value will be used for PAR (this assumes that biofouling would increase turbidity values and decrease PAR values).
- If both twin sensors are readings unusually high or low (or if only one sensor is in use), data will then be examined with consideration to the meteorological conditions at the time (with data from the Bureau of Meteorology) to determine whether rainfall or wind conditions may have affected the measurements in question. If high rainfall or strong winds does not accompany spikes in turbidity or low PAR, the data will be considered potentially erroneous and subjected to further scrutiny. Dredge activity will also be examined.

Data from nearby sites will also be examined to isolate the logger that might be behaving incorrectly.

- Finally, recalibration of the equipment for subsequent deployments will identify whether an individual sensor could be responsible for erroneous readings (for example, a turbidity wiper inoperable).
- Samples for laboratory analysis of turbidity will also be taken regularly (during servicing trips every 2-3 weeks) to ensure that sensors are reading correctly. Should data not be reading correctly, an appropriate offset can be placed on the data on the monitoring website to ensure data displayed is correct.

8.2.4.1.5 Monitoring Locations

Monitoring locations (marine sites) have been approved by the TAG and are shown in Figure 8-1.

These monitoring sites include:

- **Compliance sites** (referred to as **'concern'** sites in the EA) - sites where a sensitive receptor occurs within the zone of influence of a dredge plume. Compliance sites are listed in Table 8-1 and Table 8-2, and shown in Figure 8-1.
- **Reference site** - while the term 'control site' is used in the EA and in the DES (2018) sampling manual, the term 'reference site' has been used in lieu of 'control site' in this DMP as these sites may periodically have some influence from dredge plumes. However, they can still be used as 'reference sites' when the dredge is not operating in the vicinity. Reference sites are listed in Table 8-3 and shown in Figure 8-1.
- **Sentinel site** - site that is situated between the disturbance source and the sensitive receptor and serves to provide early warning of developing adverse conditions. Sentinel sites include the tailwater monitoring sites in the Barron River and Thomatis/Richters Creek which are listed in Table 8-5 and shown in Figure 8-1.

Reference sites should be located in similar environments to the compliance sites to allow comparison of data, but outside of the zone of influence of dredging. The issue is that Trinity Bay is a unique environment where fine sediments deposit and as a result Trinity Bay is a naturally turbid environment. Marine waters outside of Trinity Bay are less turbid, which makes locating reference sites outside of Trinity Bay problematic.

In terms of marine water quality sites, the proposed reference site at Mission Bay represents a comparable environment that is outside of the zone of dredge plume influence. Another reference site is proposed in offshore waters (Offshore WQ Control), however turbidity at this location is much lower than nearshore turbid areas. As such, this site will be used to assess whether dredge associated deposited sediment become mobilised east from the dredge site to offshore waters.

To provide additional reference site data, the proposed approach is for compliance sites to act as reference sites depending on prevailing weather conditions. For example, during sustained SE winds (typical during winter months), the compliance sites to the SE of the channel (i.e. False Cape and Cape Grafton) would act as reference sites. During sustained northerly winds, the compliance sites to the north of the channel (i.e. Yorkey's Knob and Palm Cove) would act as reference sites.

The four monitoring sites in the Barron River (upstream and downstream of the discharge point) will act as sentinel sites to provide early warning of developing adverse conditions in the Barron River. Data from these sentinel sites will also be used to assess the mixing zone as per Condition WT4 of the EA for Northern Sands.

For the seagrass PAR monitoring sites a similar approach has been taken. There are two compliance sites that have been prescribed where continuous benthic PAR will be collected to manage to maintain seagrass light requirements during dredging (1) at a *Zostera muelleri* meadow to the west of the channel and (2) in a *Halodule uninervis* meadow to the east of the channel. In order for effective inference assessment during dredging, it will be important to have similar seagrass PAR monitoring sites to refer to in case of potential issues with light at the compliance sites. As it is not possible to have sites within similar seagrass at the depth of these meadows and outside of the Zone of Influence that experience similar environmental conditions, two reference sites (*Halodule* and a *Zostera* site) have been added at a distance from the compliance sites where they will be unlikely to be influenced by the dredge plume at the same time. This will allow an ability to put any localised changes in PAR at the impact sites into the broader context of potential harbour wide changes to light not associated with the dredging activity. In addition, the proposed Mission Bay reference site also contains seagrass and provides an addition seagrass PAR control site for reference.

LEGEND

- Historic Seagrass Extent (1984 - 2015)
- 2015 Seagrass Extent
- Dredging Zone of Influence (likely case)
- Northern Sands DMPA
- Tailwater Discharge Point

Monitoring Sites

- WQ Compliance Sites
- WQ Reference Sites
- Seagrass Compliance Sites
- Seagrass Reference Sites
- WQ and Seagrass Reference Sites
- Tailwater Monitoring Sites

Title:
Proposed REMP Monitoring Sites

Figure: 8-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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0 5 10 km
Approx. Scale

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8.2.4.1.6 Triggers

The REMP employs a range of trigger levels for further investigation and instigation of corrective actions. Monitoring of the two key components (water quality and benthic PAR) of the REMP would be completed in parallel.

A schematic of the proposed REMP and how it would function during dredging is shown in Figure 8-2.

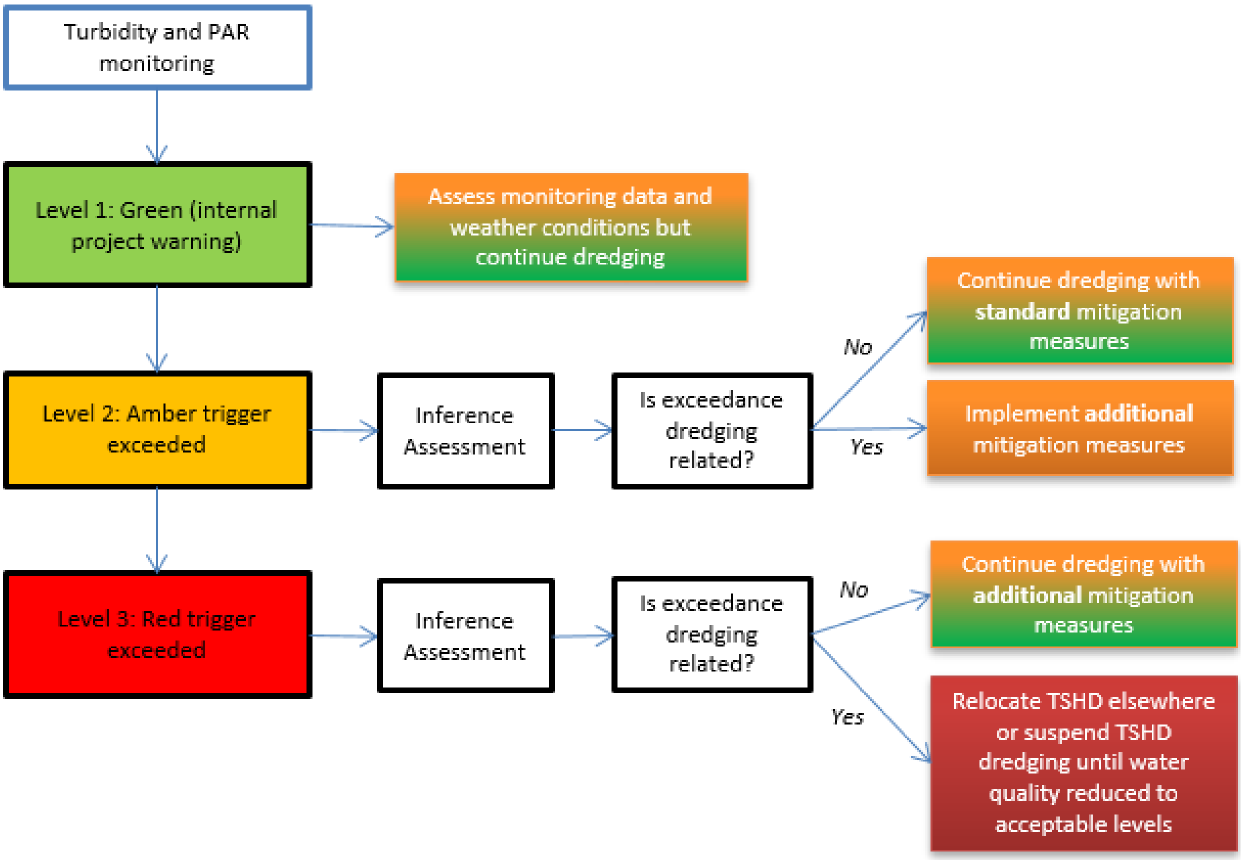


Figure 8-2 Schematic of the REMP

As shown on Figure 8-2, the REMP will have three trigger levels which are described as follows:

- **Level 1: Green warning level** – Turbidity and PAR levels exceed an initial warning level of 20% below the compliance limits in Section 8.2.1. Dredging to continue, but the internal project team is notified of deteriorating water quality conditions.
- **Level 2: Amber warning level** – Turbidity and/or PAR levels exceed a secondary warning level of 10% below the compliance limits in Section 8.2.1. This triggers an 'inference assessment' by the Project Management Group (PMG – Section 6.7.6) involving assessment of water quality measured at compliance locations compared to 'reference' location(s) to assist in determining if increased turbidity and/or PAR levels are due to natural weather events (e.g. storm or high wind events) or are attributable to dredging. Also, monitoring equipment would be checked to ensure it is functioning appropriately. Exceedance of a level

2 trigger level that is attributable to dredging (from the inference assessment) means that the dredger will need to review its operations and/or take corrective actions to control a water quality impact. There are several practical mitigation measures and corrective actions that can be employed by the dredger to minimise impact, as detailed in Section 8.2.4.1.6. Dredging with standard mitigation measures (Section 8.2.2) can resume once monitored water quality reduces below level 2 triggers.

- **Level 3: Red (compliance level)** – Turbidity and/or PAR levels exceed the compliance limits in Section 8.2.1. This triggers an 'inference assessment' involving assessment of water quality measured at compliance locations compared to 'reference' location(s) to assist in determining if increased turbidity and/or PAR levels are due to natural weather events (e.g. storm or high wind events) or are attributable to dredging. Also, monitoring equipment would be checked to ensure it is functioning appropriately. Exceedance of a level 3 trigger level that is attributable to dredging (from the inference assessment) means that immediate action would be required by the dredge operator to suspend TSHD dredging or otherwise implement other mitigation measures such as moving the dredge away from the area where the exceedance occurs. Dredging would not be able to resume in the non-compliant area until monitored water quality reduced back to acceptable levels (below level 3).

The 'inference assessment' triggered by exceedance of Level 2 and Level 3 triggers would involve the following:

- PMG members to meet within three (3) business hours (9am-5pm).
- PMG to assess monitoring data at exceedance site(s) to determine if exceedance could be due to equipment issues.
- PMG to assess weather data from Bureau of Meteorology (BOM) website and monitoring data from reference sites to determine if exceedance is from natural weather event.
- If PMG concludes that the exceedance could be dredging-related, PMG to decide on appropriate mitigation measure(s) to implement, taking into consideration location of exceedance, weather forecast, dredging schedule and other relevant factors.

Note that the dredge contractor will be monitoring the real-time water quality data on a continual basis and will likely implement immediate management actions prior to the PMG meeting.

Response procedures corresponding to the Level 1-3 trigger levels are shown in Figure 8-3 to Figure 8-5.

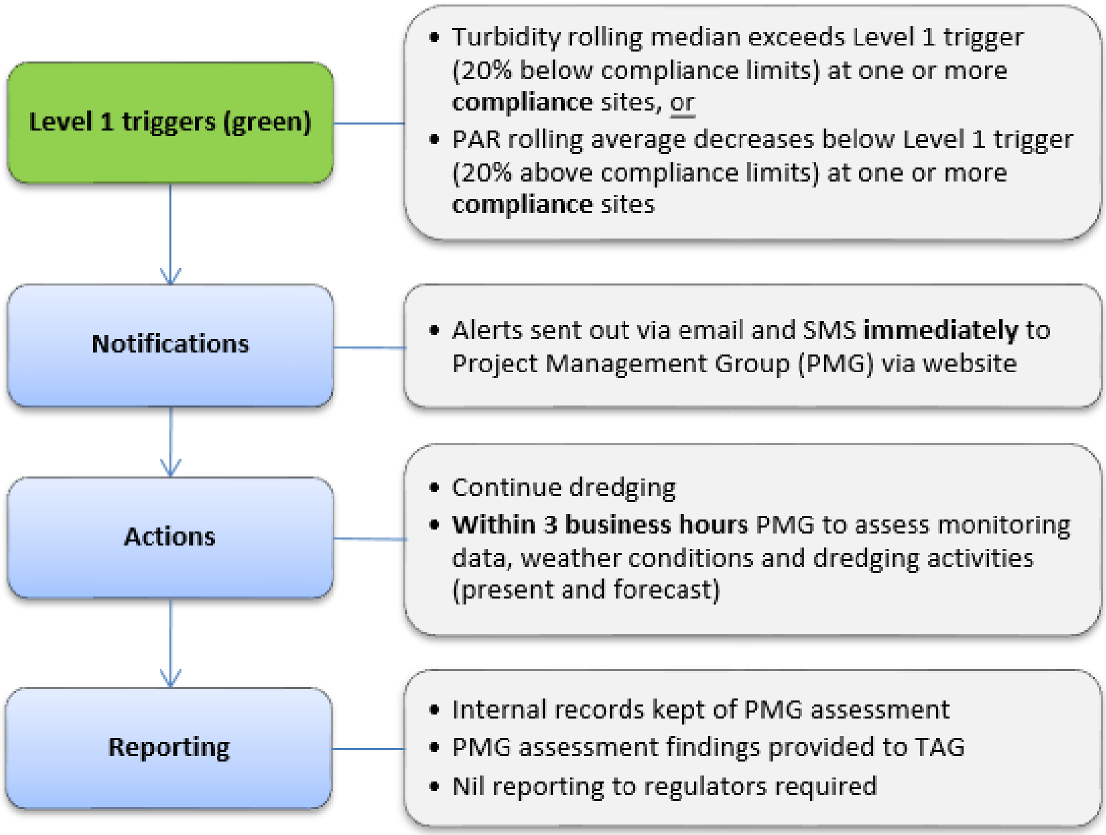


Figure 8-3 Level 1 (green) trigger response procedure

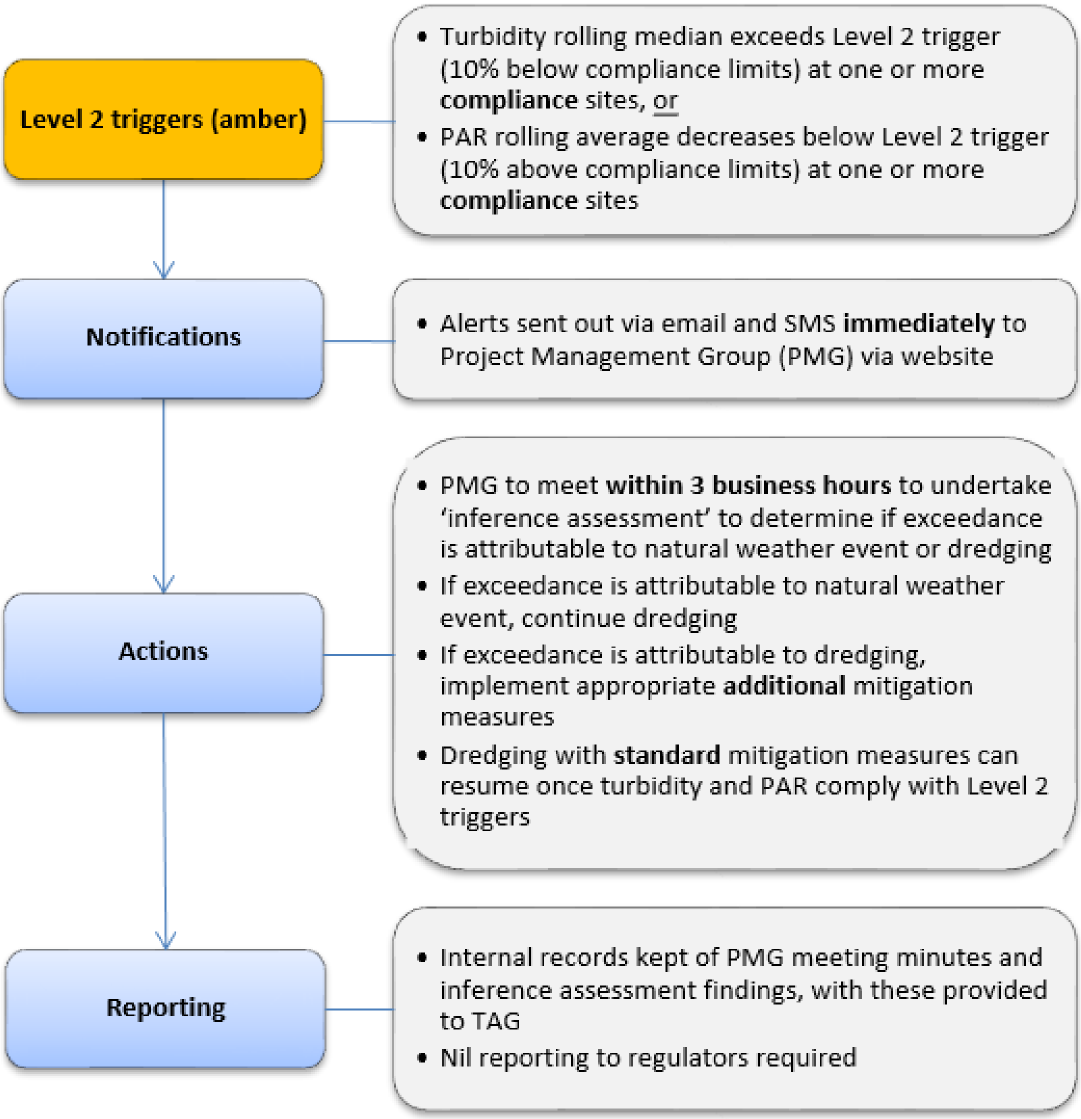


Figure 8-4 Level 2 (amber) trigger response

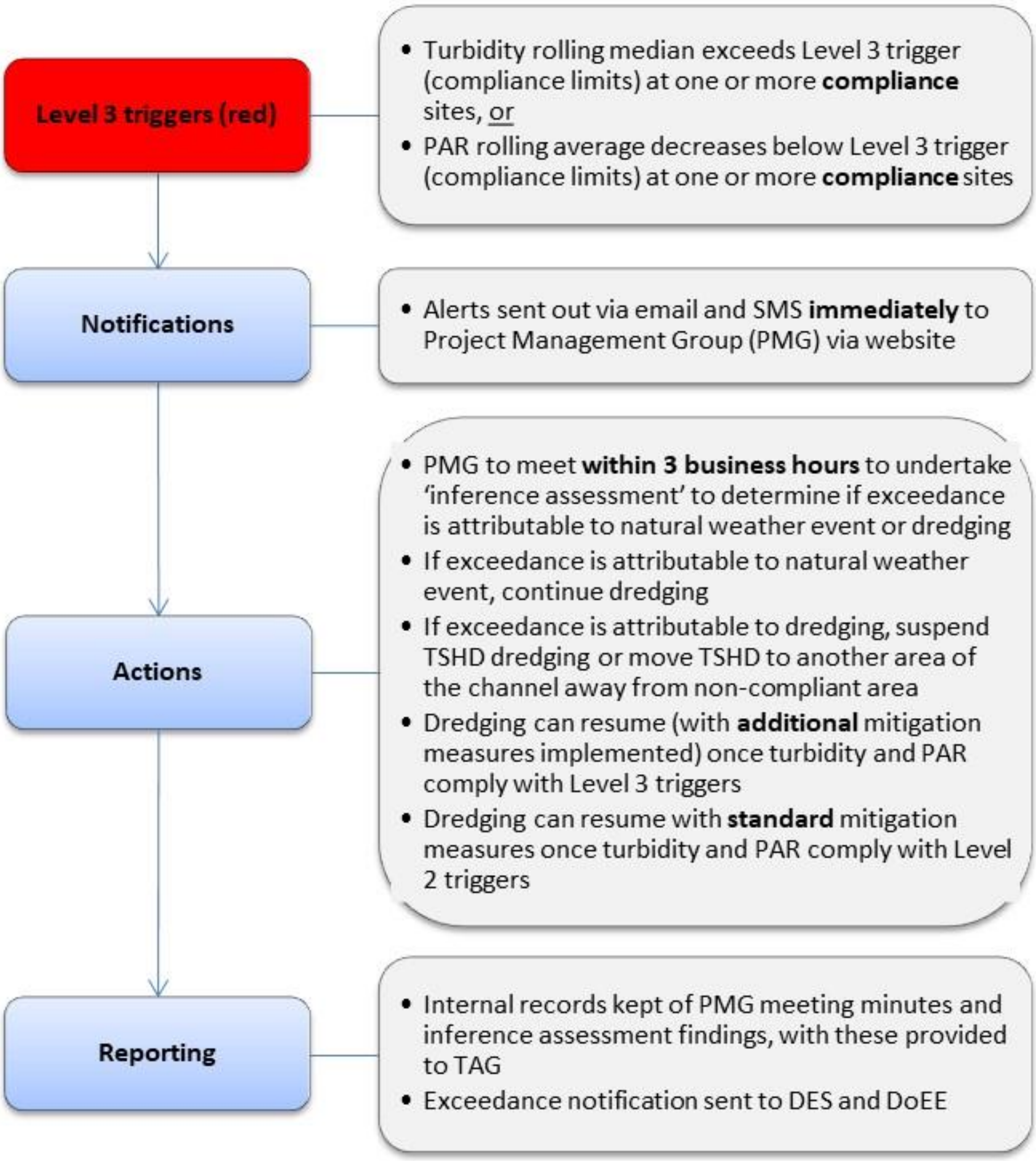


Figure 8-5 Level 3 (red) trigger response

8.2.4.1.7 Management Measures

The REMP will be used in 'real time' to guide the dredging campaign.

Once management action (Level 2) triggers are exceeded that are attributable to dredging, the dredge contractor will be responsible for taking actions to ensure impacts are avoided at sensitive receptors and impacts are controlled prior to defined trigger level exceedance (level 3). The decision on which mitigation measures to implement will be decided by the Project Management Group (PMG).

The sections below set out the range of potential additional mitigation measures and corrective actions that can be implemented by the dredger to bring turbidity and PAR levels below trigger levels.

<u>Preferential Movement of the Dredge to Other Segments</u>

The dredger will have some flexibility in terms of the sequencing of channel dredging. While a sequential pattern has been adopted for the EIS modelling, if impacts are detected at a particular sensitive receptor a change to this 'normal' pattern can be adopted. Particularly given that the key impacts are light deprivation, preferentially dredging other segments whilst allowing suspended sediments in a particular area to settle can be an important strategy to ensure seagrass and coral environments are obtaining necessary light to maintain photosynthetic processes. Dredging sensitive areas during night-time hours is also a potential mitigation assuming plume impacts are dispersing quickly.

Opportunistically, it should also be noted that the dredge vessel will need to undertake routine maintenance, refuelling and crew changes. During these 'down time' periods of the dredge, there will be environmental benefits accrued related to settlement of fines and allowance of greater light penetration back into surrounding environments (assuming background turbidity levels are also low). To a certain extent, the dredger can plan such maintenance to maximise environmental benefits.

Dredging on High Tides

A component of the overall turbid plume generated by the dredge is through the operation of the propellers. This impact is generally greater where there is less underkeel clearance between the bottom of the dredge vessel (particularly when fully laden) and the seabed that is being dredged.

Based on this principle, an additional mitigation measure that can be employed by the dredge contractor is to dredge particularly sensitive areas of the channel (e.g. near sensitive receptors) on higher tides which maximise underkeel clearance. This approach will help to reduce the amount of turbidity generated by the dredge, also reducing the amount of displaced sediment that can be resuspended by natural wave and wind action.

Implementation of this approach can be factored into the program based on the trigger levels (pending Regional Harbour Master approval and shipping schedules).

Reducing Overflow Dredging

As outlined above, overflow during dredging by the TSHD should be limited to durations no greater than the modelled most likely 'worst case' scenario which includes an average 30-minute overflow duration per cycle. In practice, the duration of overflow is expected to be less than 15 minutes for most cycles.

However, if water quality performance targets are not being achieved, additional reductions in overflow can be implemented by the dredge operator. While this will affect production of the dredge and extend the overall duration of dredging, this strategy can be effective to reduce the extent and duration of plumes generated by dredging as well as reduce the overall amount of 'spilled' dredged material that is available for resuspension by natural wind and wave events.

Temporary Suspension of Dredging

Suspension of dredging is generally a last resort option if all other mitigation measures and corrective actions as outlined above have been unsuccessful to control impacts and the compliance (red) trigger has been exceeded.

The work method for TSHD operations is designed to operate 24/7 so as to minimise the overall duration of the campaign which has both cost and environmental benefits compared to a longer-term dredge operation or intermittent capital dredge operations that involve multiple deployments of vessels.

Notwithstanding this, suspension of dredging operations will be undertaken if compliance trigger levels (level 3) are exceeded at any monitoring site and dredging (with standard mitigation) not re-commenced until water quality levels are below Level 3 (red) trigger levels.

8.2.4.2 Northern Sands – DMPA REMP

Once the dredge material passes from the pipeline into the northern sands site, three key areas require management to ensure that obligations under the Tailwater REMP, and project specific conditions applicable to the DMPA (i.e. groundwater, water level (flood, remobilisation), acid sulfate soil), can be managed to ensure compliance. These are detailed further in the Northern Sands SBMP but summarised below for completeness.

The three components are described below, and set out in detail in the respective management plans as follows:

Groundwater

Risks associated with potential impacts related to groundwater are assessed to be predominantly low (refer to the GWA Report for further risk assessment). The primary mitigation for managing saline intrusion into groundwater will be to limit the water level in the lake until sufficient dredged material has been placed in the lake to create a low permeability barrier between the saline water in the lake, and the surrounding aquifer.

Groundwater monitoring will be carried out to assess changes in water level and water quality parameters, to assess whether such changes are within the expected range. The proposed groundwater monitoring network will make use of some of the existing monitoring bores at the site and will also include additional bores located around the perimeter of the lake. The bores making up this network consist of shallow (upper sand layer) and deep (underlying stiff clay layer) wells located within the site to assess lateral migration of salinity and water levels; ‘sentinel’ monitoring wells located offset at the boundary of the expected zone of increased salinity; and, ‘secondary’ monitoring wells located beyond the sentinel wells to determine the extent of increased salinity if saline plumes extend beyond the sentinel sites.

The groundwater monitoring network will be used to collect both groundwater level and water quality data prior to, during, and after placement of dredged material. Pressure/electrical conductivity transducers will be installed in selected bores to enable near real-time monitoring of groundwater level, electrical conductivity and pH and to allow a greater understanding of the natural variability of these parameters. Trigger levels for water level and water quality parameters have been set relative to background values established through the pre-dredging period and based on the predicted changes in water level and salinity.

Details of the proposed monitoring and sampling for different phases of the program are summarised in Table 8-5.

Table 8-6 Groundwater Monitoring

Monitoring Phase	Parameter	Sampling Frequency	Sites
During placement of dredged material	Water level and electrical conductivity	Hourly (data logger) and manually during weekly sampling events	All “A” and “B” series internal and sentinel wells*
	pH	Hourly (data logger) and manually during weekly sampling events	All “A” and “B” series internal and sentinel wells*
	Major Ions	Weekly	All “A” and “B” series internal and sentinel wells*
	Metals (dissolved)**	When pH less than Weekly	All “A” and “B” series internal and sentinel wells*
Up to 24 months after placement of dredged material[1]	Water level and electrical conductivity	Hourly (data logger) and manually during monthly sampling events	All “A” and “B” series internal and sentinel wells*
	pH	Hourly (data logger) and monthly during sampling events	All “A” and “B” series internal and sentinel wells*
	Field physicochemical parameters (EC, pH, DO, redox, temp)	Weekly for 2 months then monthly during sampling events	All “A” and “B” series internal and sentinel wells*
	Major ions	Monthly	All “A” and “B” series internal and sentinel wells*
	Metals (dissolved)**	Monthly	All “A” and “B” series internal and sentinel wells*

*Monitoring in the secondary wells will be commenced should water level and/or electrical conductivity trigger levels be exceeded in sentinel wells

**Metals testing is required only at wells when the pH values show a decrease to below 5.5

[1] The duration of post-work monitoring will be determined based on periodic review of results and the need for any corrective actions, noting a full 24 months of monitoring may not be required if the risk of impacts are considered negligible following an initial period.

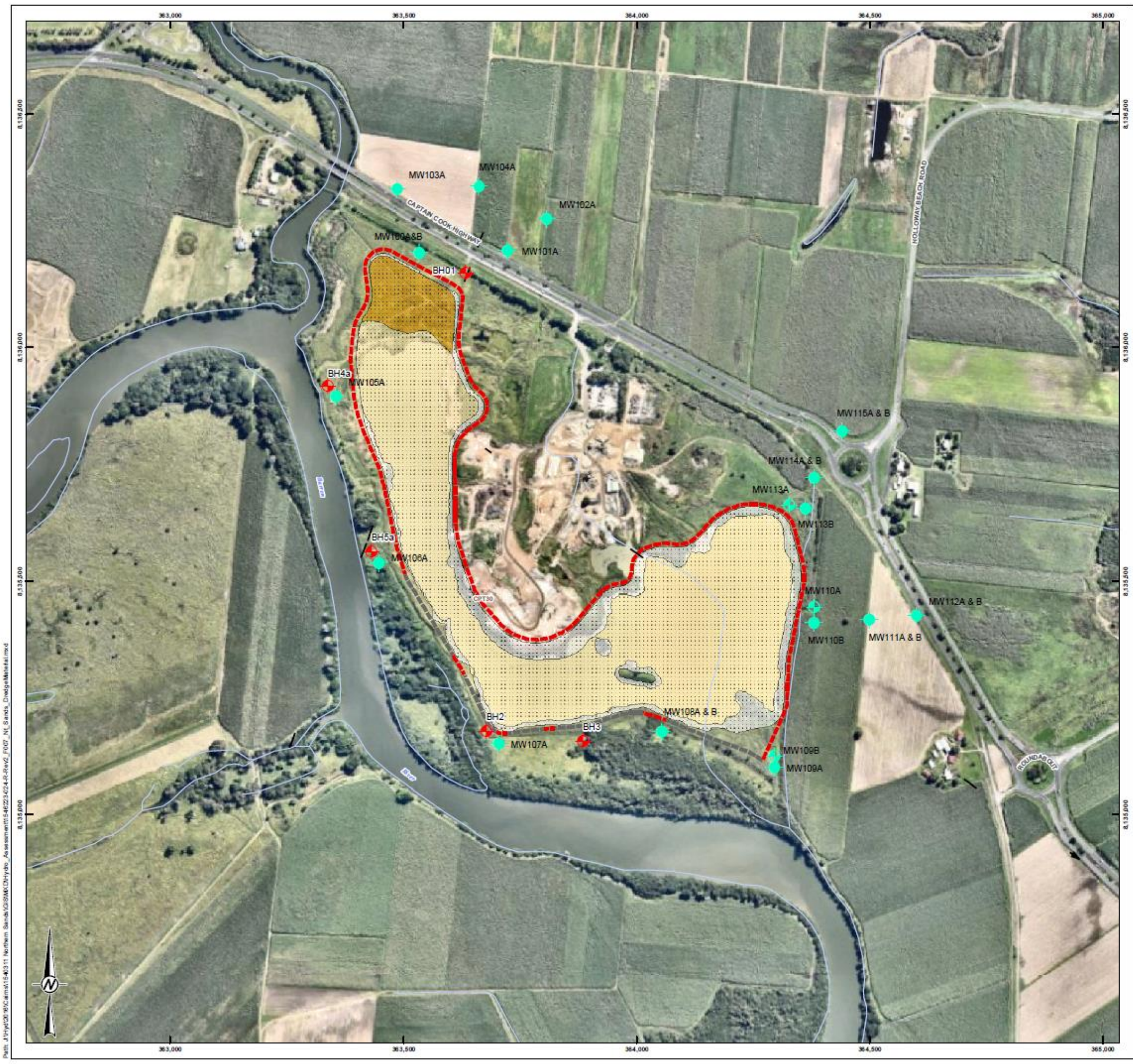


Figure 8-6 groundwater monitoring bores

Water Balance Management

As described in the Groundwater and Tailwater sections, management of the water level within the NS DMPA is a critical action requiring consideration of the three conflicting aspects of:

- Maximising residence time of proposed tailwater so as to ensure efficient sediment deposition and consequential attainment of suitable TSS for discharge;
- Maintaining lake level at least height possible to reduce driving head and consequential impacts to groundwater salinity intrusion; and
- Ensuring sufficient void volume for provision of stormwater volume, remobilisation risk, bund flood impacts).

These components are outlined in the SWMBA.

Acid Sulfate Soil

Risks associated with the placement of dredge material comprising components of which have the potential to generate acid sulfate soils, are to be managed via the Acid Sulfate Soil Management Plan.

8.2.4.3 Tailwater Management REMP

Tailwater monitoring and management will address two potential impact issues:

- The release of the supernatant dredge tailwater from the Northern Sands DMPA as surface water discharge.
- The passive release of the tailwater into surrounding groundwater through seepage from the Northern Sands DMPA dredge pit (refer to the Groundwater Management Plan).

It should be noted that surface water quality and groundwater impacts are not predicted for mechanical placement of stiff material at the Tingira Street DMPA and as such are not dealt with here.

Tailwater - Surface Water Component

Surface water quality monitoring locations for tailwater discharged from the Barron River DMPA are listed in Table 8-4 and Table 8-5 and shown on Figure 8-1.

These monitoring sites include:

- At the end of the tailwater discharge pipe – this is a compliance site.

Receiving environment - at locations upstream and downstream of the discharge point in the Barron River and Richters/Thomatis Creek (refer to Figure 8-1).

The Barron River monitoring sites have been selected (and approved by the TAG) based on the locations of previous water quality data collection sites, and the outputs of water quality modelling with respect to areas potentially influenced by total suspended solids and salinity impacts from tailwater discharge.

As there are no seagrass or corals that are predicted to be affected by the proposed tailwater release, the Barron River monitoring sites will act as 'sentinel sites' (refer to Section 8.2.4.1.5) and the focus of the monitoring program will be on physical and chemical attributes of water quality. Water quality instruments capable of continuous logging of turbidity and salinity/conductivity will be deployed.

The REMP for tailwater management would operate with similar trigger levels to the Capital Dredging REMP with a focus on the end-of-pipe tailwater discharge quality, as follows:

- **Level 1: Green warning level** – tailwater quality exceeds Level 1 thresholds (i.e. 10% below the compliance limits in Section 8.2.1). Tailwater discharge continues, but this alerts the internal project team to deteriorating tailwater quality.
- **Level 2: Amber (warning level)** – tailwater quality exceeds the warning level triggers (i.e. 5% below the compliance limits in Section 8.2.1). Exceedance of a level 2 trigger level means that corrective actions to control a water quality impact are needed. There are several practical mitigation measures and corrective actions that can be employed to manage tailwater impacts including:
    - Increasing retention time in the DMPA prior to discharge to induce greater settlement of suspended solids.
    - Installation of baffles and silt curtains in sedimentation ponds to reduce suspended solid concentrations.
    - Use of flocculants and similar agents to reduce suspended solid concentrations.
    - Use of lime and similar agents to raise/lower pH and reduce acidity/alkalinity.
    - Aerating surface waters if algal blooms or other nutrient related blooms are detected.
- **Level 3: Red (compliance Level)** – whereby dredge tailwater would not be permitted to be released from the site until relevant tailwater discharge limits can be met.

Response procedures corresponding to the Level 1-3 trigger levels are shown in Figure 8-7 to Figure 8-9.

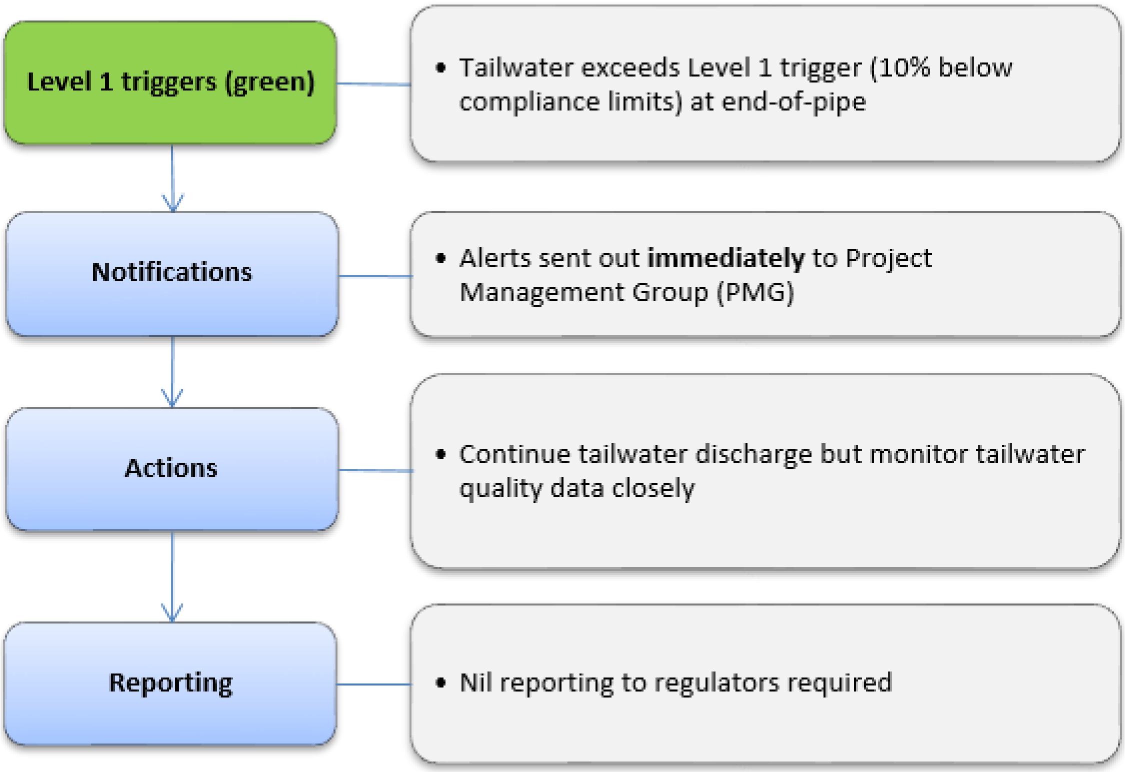


Figure 8-7 Level 1 (green) trigger response

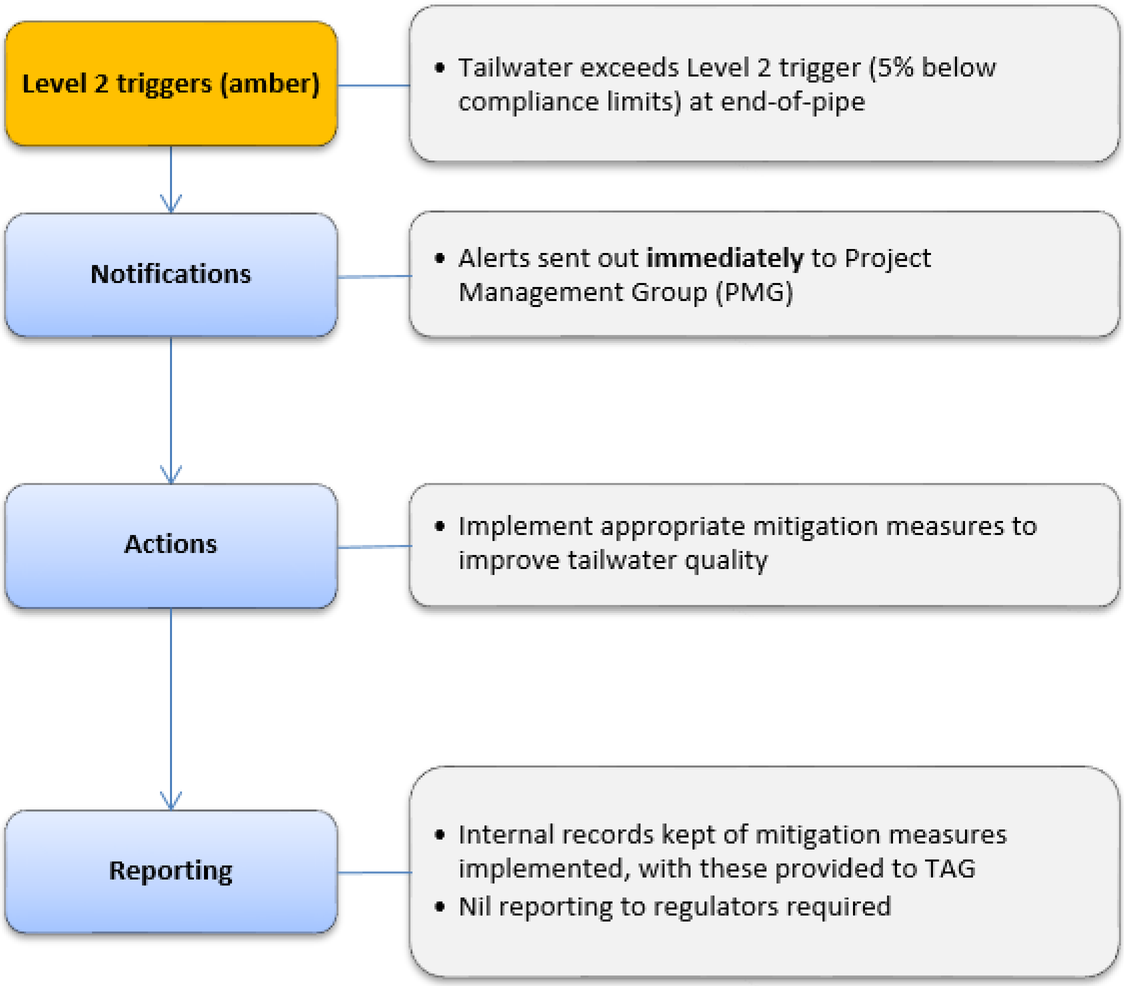


Figure 8-8 Level 2 (amber) trigger response

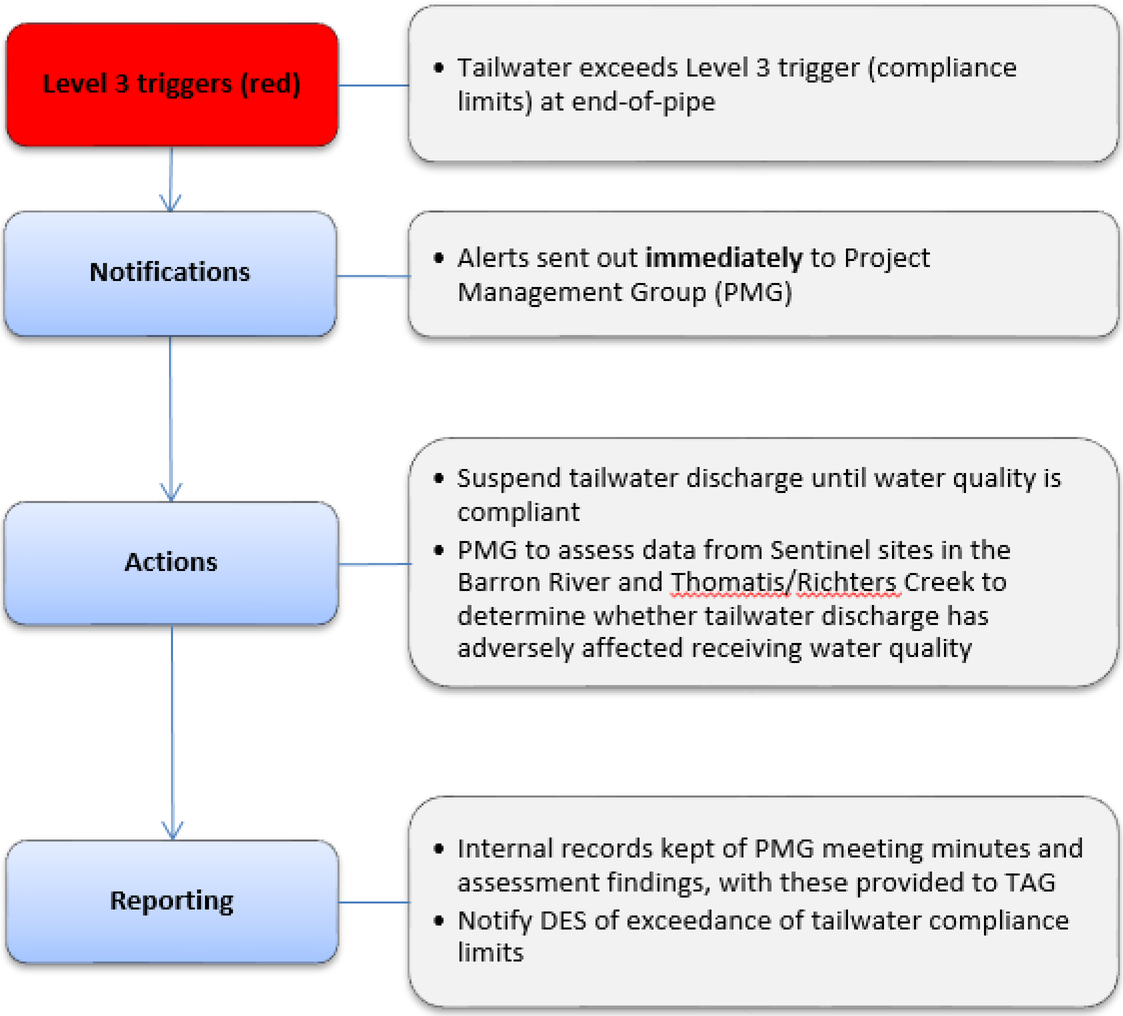


Figure 8-9 Level 3 (red) trigger response

8.2.4.4 Validation Monitoring Programs (VMPs)

Separate to impact monitoring described above, monitoring will be undertaken specifically targeted at validation of the dredge plume source assumptions that underpin the water quality impact assessments. This 'validation' monitoring would be undertaken at the commencement of the TSHD and BHD capital dredging that was modelled as part of the CSDP. In addition, validation monitoring of the key sensitive receptor habitats (seagrass and coral) will be conducted to ensure the outcome of protecting these habitats is being achieved.

The methodologies associated with this monitoring component will be governed by the goal of obtaining data for the dredge plume model validation. It will involve a combination of vessel-mounted ADCP (or similar) and in-situ water quality measurements and sampling for laboratory analysis, specifically targeted at characterising the dredge plume intensity and spatial dimensions on top of the ambient suspended sediment climate.

The validation monitoring campaigns will occur early on during the operation of the key capital dredging equipment, namely the:

- TSHD dredging of the outer shipping channel; and

- BHD dredging in the inner port and inner channel.

Outcomes of the monitoring will be spatial and temporal maps of the dredge plume during the validation exercise, quantification of the plume sediment characteristics and quantification of the range of plume generation source rates associated with the monitored dredging operations. These results will directly feed into water quality model simulations to validate the model configuration used in the EIS.

8.2.4.4.1 Fine Sediment Monitoring

The plume validation measures will form the basis of confirming the fine sediment spill volume required to meet Commonwealth approval conditions i.e. the amount of fine sediment returned to the marine environment over the course of the project. A separate methodology for calculating the fine sediment generated by the project has been developed and has been peer reviewed (Appendix A).

8.2.4.4.2 Biological Validation

The Validation Monitoring Program (VMP) will monitor seagrass and corals as biological indicators of changes to marine ecosystems and to ensure that water quality management measures have achieved their intended outcomes in protection of sensitive receptor habitats. Negligible impacts are expected to other ecological receptors (i.e. fish, prawns, mangroves etc.), and for this reason, will not be monitored in the VMP.

The aim of this component of the VMP is to monitor any changes to seagrass and reef habitats and communities, and on the basis of this information, validate the predictions outlined in the impact assessment study.

The monitoring program design for the VMP will involve sampling at multiple reference and potential impact locations before and after the dredging campaign. Sampling will be undertaken at least once before and after the dredge campaign.

Seagrass Monitoring

The goal of this program is to validate the predictions in the EIS, to satisfy regulatory requirements for protection and management of seagrass and to provide information useful to validate seagrass PAR thresholds are having their desired effect during the REMP and the CSDP. There is a long established ambient seagrass monitoring program for the port of Cairns that provides a long term reference for the range of expected natural change for the seagrass meadows in the vicinity of the CSDP. The CSDP is able to build on this program that provides a statistical basis for the range of expected conditions for the local seagrass meadows over an 18 year monitoring period and a sampling design with established power to detect change. In addition, the monitoring design provides a reference for meadows and seagrass areas both within and outside the likely zones of impact so that changes at compliance seagrass areas are able to placed in the context of local, and region wide seagrass changes.

The monitoring program examines seagrass area, biomass and species composition changes within and adjacent to the channel expansion footprint, and at the locations identified in

Figure 8-1. Annual monitoring will examine all seagrass meadows in the project area and will be undertaken prior, immediately post, and annually for 2 years post dredging. These will be undertaken in late spring/summer, during the growing period to enable a direct comparison between years. During 2019 the two major seagrass meadows adjacent to the channel will be monitored quarterly (Refer to Appendix B).

The seagrass monitoring program will consist of the following sampling events:

- Pre-dredge baseline 2018 including channel footprint and major seagrass areas within the port limits.
- Quarterly assessments of the 2 major seagrass meadows adjacent to the channel footprint that incorporate pre, during and post-dredge periods March/June/September/December 2019.
- Annual whole of Port seagrass monitoring to assess broader seagrass condition and place changes to meadows closest to channel into perspective. Also includes annual assessment of seagrass seed banks in the 2 Harbour meadows that are assessed quarterly in 2019.
- Seagrass condition will be assessed in reference to the Annual long-term seagrass monitoring program benchmarks for seagrass and comparison of "impact" and reference seagrasses.

- Long term ambient seagrass monitoring is also expanded from monitoring meadow subsets to full port surveys in 2019, 2020 and 2021 (only 2021 would be full survey as part of normal ambient program) to have full assessments of seagrass for 2 years post dredging to ensure compliance with post dredge monitoring requirements.

Sampling methods for the program will follow those used in the established Cairns, Mourilyan, Karumba and Thursday Island long-term seagrass monitoring programs undertaken by JCU. This will include:

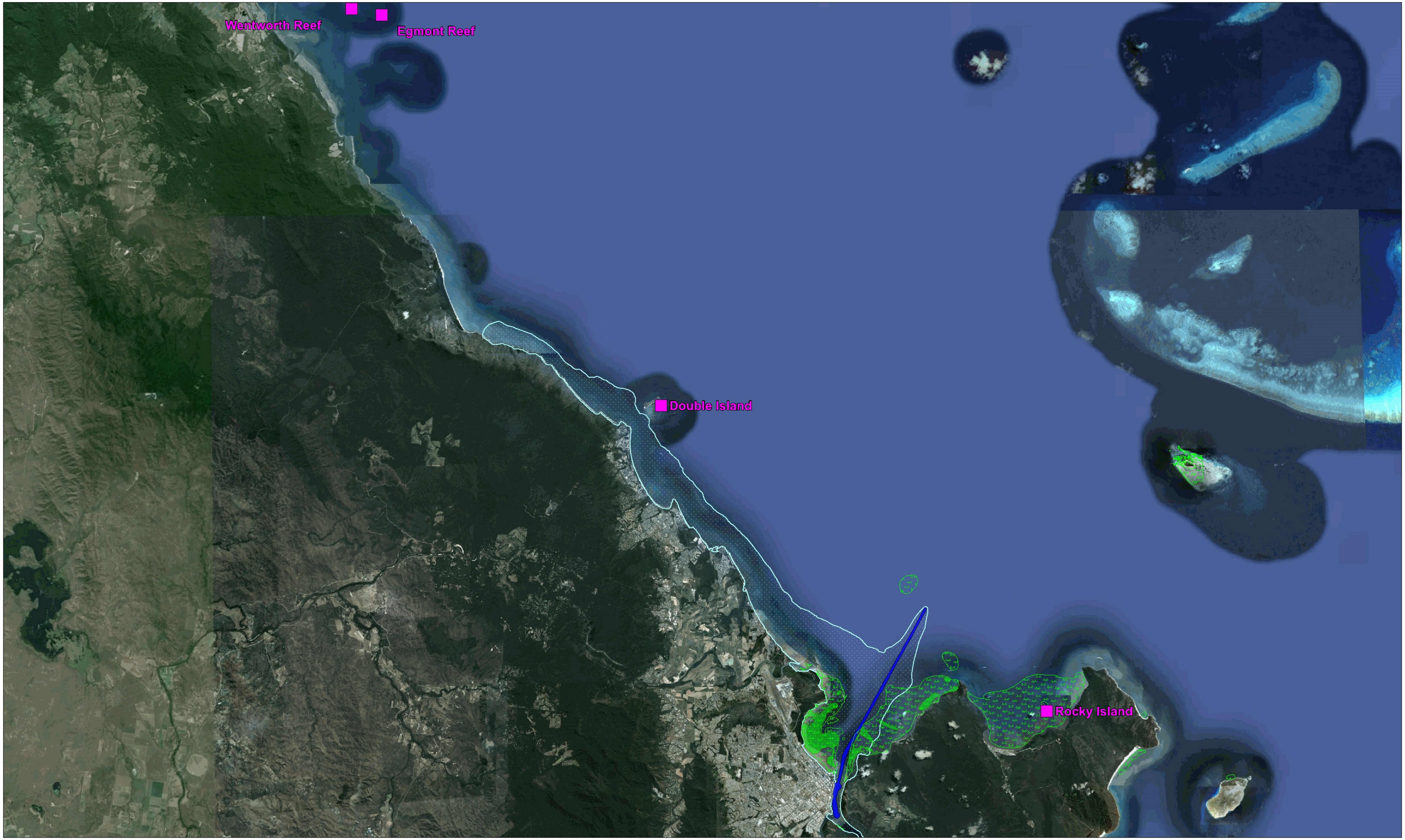
- Helicopter sampling for intertidal areas; and
- Boat based underwater digital camera mounted on a drop frame for subtidal areas.

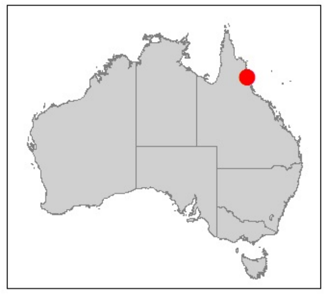
Seagrass biomass, species composition, macro-algal cover, sediment types and changes to seagrass meadow area will be recorded using methods consistent with the established long term seagrass monitoring program In addition water quality data including benthic PAR, temperature and turbidity recorded as part of the DMP will be used to assist in interpretation of seagrass changes. A detailed scope of works for the seagrass monitoring is provided in Appendix B.

Coral Monitoring

Coral monitoring will examine changes in community among reefs in the zone of influence (Double Island and Rocky Island) and reference locations (Wentworth and Egmont reefs). The reference locations are the closest equivalent habitats to Double Island reef that are outside of the potential dredge plume (Figure 8-10). Rocky Island and Double Island communities are fundamentally different and may be affected differently by plumes; therefore, should be analysed separately. A coastline reference site as an additional or replacement site (to Wentworth or Egmont Reefs) is to be evaluated for inclusion in the coral monitoring methodology. All locations except for Rocky Island (which only exists to -3m) will be surveyed at the -2 m and -5 m depth contours. At each depth stratum, downward facing still imagery will be collected and quantified. Benthic cover will be quantified from a minimum of 600-point identifications per stratum, per location. The arrangement of photo-quadrats and/or transects within sites, within locations will be allocated to maximise statistical power.

Photos selection and point allocation will be randomised at each stratum within each site. Point-identifications of coral and macroalgae will be made to genus with other cover types identified to major benthic categories. Incidents of bleaching or disease or recent mortality will be quantified per image. ANOVA will be used to investigate changes in total coral cover, total macroalgal cover and disease incidence, while non-parametric and PERMANOVA approaches will be used to examine changes in community data among sites, strata, and locations as appropriate. Sampling intervals will include one event prior to dredging and one event immediately after dredging.





LEGEND

- Historic Seagrass Extent (1984 - 2015)
- 2015 Seagrass Extent
- Dredging Zone of Influence (likely case)

Monitoring Sites

- Coral Monitoring Sites

Title:
Proposed Coral Validation Monitoring Program Locations

Figure: 8-10

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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0 10 20km
Approx. Scale

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Tailwater Management Validation

The Tailwater Management VMP will seek to validate the modelled extent and concentrations of TSS (and corresponding NTU values) from tailwater discharge in the Barron River and Thomatis / Richters Creek system. In addition before, during and post placement surveys of evidence of saltwater impacts to marine vegetation will be made at a number of sampling points downstream of the Barron River.

Details of the tailwater validation program are provided in Appendix A.

8.2.5 Post -dredge reporting

Monitoring reports will be provided to relevant approval agencies outlining the results of the above REMP and VMP immediately post, 6 months post and 2 years post -dredging activity, in accordance with approval requirements.

This will contain:

- The results of all monitoring undertaken and the associated methodology;
- Details of the type and extent (in hectares) of sensitive receptors present in the channel and swing basin footprints that were removed as a result of dredging undertaken for the action;
- An assessment as to whether any sensitive receptors (delineated by type and extent) present outside of the channel and swing basin footprints identified in the EIS:
  - Are vulnerable or likely to experience sub-lethal impacts as a result of the action; and
  - Have experienced lethal impacts as a result of the action.

8.3 Marine Megafauna

This section outlines requirements that are to be met associated with the management of potential interactions between dredge equipment and marine megafauna (i.e. cetaceans, dugong and sea turtles).

Objective	• To minimise the risk of disturbance or injury to marine fauna, including mammals and sea turtles resulting from the dredging and placement activities. • To establish and maintain awareness of the importance of protecting marine fauna including mammals and sea turtles.
Potential Impacts	• Injury to marine megafauna from vessel strike. • Injury to marine megafauna from draghead operation. • Disturbance of marine megafauna from vessel lighting.
Performance Criteria	• No incidents of vessel related disturbance to marine mammals and sea turtles. • All members of the dredging team to complete an induction, which will include information on marine mammal and sea turtle management requirements. • Vessel masters and spotters trained in marine mammal and sea turtle interaction procedures.
Monitoring & Reporting	• Monitoring of marine mammals and turtle activity to be performed by a person from the bridge of each vessel. • A record of sighted animal to be maintained, indicating the sighting of each individual animal and actions taken. • Down-time to be reported as Environmental Delay in the equipment daily report. • Immediate reporting of any incident involving injured or killed animals to Ports North and regulatory agencies (including CRC, Queensland Marine Parks, Queensland Department of Environment and Science and the Department of Environment and Energy) via the injured animals hotline (1300 ANIMAL (1300 264 625) • Details of the incident are to be compiled into an incident report. • Incident reports, once complete, to be provided directly to Queensland Marine Parks, Queensland Department of environment and Science and Department of environment and Energy

Implementation Strategies	Responsibility	Timing	Corrective Action
Prior to commencement of dredging activities, employees responsible for marine megafauna spotting will receive training to become a suitably qualified marine observer.	Dredge contractor	Prior to commencement of dredging	• In the event of an environmental incident, appropriate emergency response measures shall be implemented to ensure environmental harm from the event is minimised. • The dredge contractor is to report any sick, injured or dead marine mammals to the RSPCA on Queensland 1300 ANIMAL (1300 264 625) immediately. • Assist in capture of injured animals per advice from regulatory agencies. • An investigation into the incident is to be undertaken and further strategies to reduce the likelihood of marine mammal strike put in place if necessary, as advised by regulatory agencies. • Supplementary monitoring to be undertaken to confirm compliance after taking remediation action.
A lookout will be maintained for cetaceans while the dredge sails between the dredging area and DMPA. In the event that a cetacean (except dolphins) is sighted, vessel speed and direction will be adjusted to avoid impact in the observed individual (within the safety constraints of the vessel).	Dredge contractor	During dredge carriage from dredging area to DMPA	
Marine mammals' observation and response procedures including the application of exclusion zones will be implemented when dredge or other ancillary vessels are under-way.	Dredge contractor	At all times during dredge operation and carriage	
Marine mammals (except dolphins which are highly mobile) and turtles observation and response procedures are to include the provision for standing-by until marine mammals pass, and/or altering course to provide a 300m exclusion zone to such fauna. Dredging operations or transport of the material to the pump-out area shall be amended where these fauna are observed within the 300m caution zone of the operating dredge until the animals have moved further than 300 m or have not been sighted for 15 minutes. Amending of operations may include slowing activity, reducing vessel speed, pausing while the mammals moves beyond the exclusion zone or moving a vessel away. Any measures should be consistent with the *Queensland Guidelines for watching marine mammals*.	Dredge contractor	At all times during dredge operation and carriage	

Implementation Strategies	Responsibility	Timing	Corrective Action
Turtle excluders must be fitted during all operations. A visual inspection of the excluders will be made when the draghead is recovered after each load. The inspection shall note damage and/or excessive wear which may inhibit the effectiveness of the device.	Dredge contractor	At all times during dredge operation and carriage	
Suction of the draghead will minimised when not in contact with the seabed. This should include initiating dredge pumps as late as possible in descent of the head and running pumps at the lowest possible speed.			
Where practicable, water jets on the draghead will be switched on before the dredge pump is started and will remain on until the dredge pump is stopped to direct sea turtles away from the draghead thus avoiding direct contact.	Dredge contractor	At all times during dredge operation and carriage	
Light levels from the dredging works will be limited to those lights that are necessary for the safe operation of the vessel and the health and safety of those on board.	Dredge contractor	At all times during dredge operation and carriage	

8.4 Marine Sediment Quality

This section outlines requirements that are to be met associated with marine sediment quality, and outlines controls that will be implemented to minimise impacts to water quality, seabed and marine flora and fauna through the disturbance of marine sediments.

Objective	• To minimise impacts to water quality, seabed and marine flora and fauna through the disturbance of contaminated marine sediments or marine sediments containing PASS		
Potential Impacts	• Acid generation if Potential Acid Sulfate Soil (PASS) material is allowed to oxidise over extended periods between dredging and placement.		
Performance Criteria	• Dredge sediments remain waterlogged or are exposed to air for periods less than 24 hours.		
Monitoring & Reporting	• Ports North to be notified in the event of any dredge material required to be stored in the hopper longer than 24 hours.		
Implementation Strategies	**Responsibility**	**Timing**	**Corrective Action**
Dredge material should ideally remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidisation.	Dredge Contractor	At all times during dredge operation and carriage	• If dredge material is required to be stored in hopper or dump barges for longer than 24 hours (e.g. in case of vessel breakdown), material is to be tested for acid sulfate soil (ASS) and treated (if necessary) prior to placement at the DMPA. • Ports North to be notified of situation prior to placement.

8.5 Dredge Pipeline – Terrestrial and Aquatic Ecology

This section outlines requirements that are to be met associated with installation and operation of the dredge pipeline and associated impacts on terrestrial and aquatic ecology at or near the beach and along the pipeline alignment to the Northern Sands DMPA.

Objective	• To protect environmental values of terrestrial and aquatic ecology that may be affected by the temporary dredge pipeline installation and operations.
Potential Impacts	• Impacts to terrestrial flora and fauna habitats including protected plants and animals. • Impacts to aquatic flora and fauna habitats including marine plants such as mangroves and saltmarsh.
Performance Criteria	• Impacts are avoided, minimised or otherwise reduced to an acceptable level. • Disturbed areas are fully remediated and restored following the completion of the works. • Only vegetation approved for removal is cleared (refer to Table 4-1).
Monitoring & Reporting	• Immediate reporting of any incident involving injured or killed animals to Ports North and regulatory agencies. • Details of the incident are to be compiled into an incident report.

Implementation Strategies	Responsibility	Timing	Corrective Action
Implement the following standard measures to protect flora and fauna • Standard soil and water management (i.e. an Erosion and Sedimentation Control Plan will be prepared to guide all earthworks). • Site inductions (during construction, commissioning and operation, all staff should undertake an environmental site induction which canvasses the flora and fauna values of the site, and actions to minimise impacts). • Implement controls for the management of fuel oils or similar hazardous material associated with equipment and operation (including booster pumps). • Fence off areas of vegetation to be retained using flagging tape or similar. • Vegetation to be removed is to be pegged out and inspected prior to removal. • Spotters/catchers are to inspect vegetation to be removed for nests prior to removal. • Mark areas to be protected on maps.	Dredge contractor	During installation and operation	• Ensure contractor plans address terrestrial ecology issues as outlined in this element. • If erosion and sediment control measures are ineffective and/or an unintentional release of contaminant occurs, review of procedures and rectify immediately.
<u>Ant Plant</u> Due to the high frequency of occurrence of *M. beccarii* (Ant plant) within the mangroves associated with Richters Creek pipeline crossing and *Melaleuca* wetland areas, it is unlikely that clearing of this species can be completely avoided. As a mitigation measure, any individuals that are to be directly impacted are translocated to suitable nearby habitat prior to clearance in accordance with Species Management Program Guidelines	Environmental Supervisor	Prior to undertaking the works and during installation	• Ensure the contractor undertakes survey prior to carrying out the works. • Implement and undertake monitoring to determine the success of this mitigation measure.

Implementation Strategies	Responsibility	Timing	Corrective Action
	Dredge contractor/Environmental Supervisor	Prior to undertaking the works As part of de-mobilisation works	• Ensure contractor does not operate during breeding season (as far as practicable). • Prepare a Beach Stone Curlew Management Plan (Environmental Supervisor) • Ensure the landform is restored as part of the decommissioning phase of the works.
Beach Stone Curlew Due to the likely presence of breeding *E. magnirostris* (Beach stone-curlew) at the mouth of Richters Creek and Tingira St, site set up, bund construction and pipeline construction work has been planned so that the construction of this section of the delivery pipeline is completed outside of the breeding season for this species (September to February). As per operational works approval (dredge-related infrastructure) conditions, a Beach Stone Curlew Management Plan will be prepared for works at the mouth of Richters Creek and Tingira St to avoid unnecessary impacts to Beach Stone Curlew habitat or breeding areas. The Management Plan will be approved by DES. • Management and actions to avoid impacts to habitat used by the Beach stone curlew. • Avoid disturbance to the nest where possible; if unavoidable, relocate chicks/eggs. • Prepare a Species Management Program and obtain a damage protection permit (if required)			

Implementation Strategies	Responsibility	Timing	Corrective Action
Spectacled Flying Fox To minimise impacts on *P. conspicillatus* (Spectacled flying fox), any new fences will have a plain wire as a top strand, rather than barbed wire to reduce the risk of entanglement. This mitigation will reduce the consequence and likelihood of risk of impact on this species.	Dredge contractor	During installation	• Ensure the contractor has implemented the required action and audit where necessary as part of site supervision. • Minimise operations during breeding season (if possible).
Rehabilitation of all areas of natural vegetation, beach and landforms that are to be cleared or modified for the construction of the inlet and tailwater pipelines in accordance with approval conditions. All areas of native vegetation cleared to construct the pipeline and laydown area is to be revegetated using the species list in Appendix 4 of the CSDP Terrestrial Ecology Assessment (Biotropica, 2017). A separate Rehabilitation Plan is to be prepared prior to decommissioning of the pipeline by a suitability qualified person.	Dredge contractor & Ports North Ports North	As part of de-mobilisation works Within 6 months of decommissioning the pipeline	• Ensure the landform and vegetation is restored in accordance with all approval conditions as part of the decommissioning phase of the works. Maintain the rehabilitation for 12 months after decommissioning of the pipeline or until established, whichever occurs first.

8.6 Dredge Delivery Pipeline – Erosion and Sediment Control

This section outlines requirements that are to be met associated with installation and operation of the dredge delivery pipeline along the beach and foreshore, along the terrestrial pipeline alignment corridor, across Richters Creek and into the Northern Sands DMPA. The dredge contractor is to prepare a detailed erosion and sediment control plan for the pipeline and Northern Sands/Tingira St DMPAs in accordance with the FNQROC Development Manual and Best Practice Erosion and Sediment Control Guidelines (IECA Australasia, Nov 2008).

Objective	• To minimise the release of sediments or other contaminants into waters from the installation and operation of the dredge pipeline (note that leaks or other incidents are addressed in **Section 8.14**). • To avoid or otherwise minimise impacts on coastal processes from installation and operation of the dredge pipeline.
Potential Impacts	• Release of sediment, wastes, degreasers or wash down materials into the environment. • Localised impacts on coastal processes from the pipeline including scour, erosion and/or accretion.
Performance Criteria	• Preparation of a detailed erosion and sediment control plan for the pipeline and Northern Sands DMPA in accordance with the FNQROC Development Manual and Best Practice Erosion and Sediment Control Guidelines (IECA Australasia, Nov 2008). • Application of best practice erosion and sediment controls (ESC), in accordance with the erosion and sediment control plan • Regular inspection of ESC measures and devices. • No inappropriate use of degreasers, fuels, oils or wash down in sensitive environments.
Monitoring & Reporting	• Visual inspection that erosion and sediment controls have been appropriately installed prior to the commencement of pump-out activity • Visual inspection for sedimentation and any discharge or contamination of waters on at least a weekly basis, particularly after rain events along the length of the pipeline during pump-out operations • Visual inspection for blowouts during pressure testing, for the length of the pipeline • Visual monitoring of beach processes and any associated erosion or accretion as a result of the pipeline on a fortnightly basis. • Notification and response to any spills or contaminants releases.

Implementation Strategies	Responsibility	Timing	Corrective Action
Assess and implement appropriate erosion and sediment controls along the pipeline route, and at the crossing of Richters Creek to minimise erosion of soils and associated impacts on water quality.	Dredge contractor	Prior to and during installation and operation	• Ensure the contractor has implemented the required action and audit where necessary as part of site supervision.
Undertake appropriate ASS investigation of the pipeline alignment and manage any excavation or filling in accordance with an ASS management plan.	Dredge contractor	Prior to works as part of detailed design phase During installation and operation	• Ensure the contractor has implemented the required action and audit where necessary as part of site supervision.
Implement controls for the management of fuel oils or similar hazardous material associated with equipment and operation (including booster pumps).	Dredge contractor	During installation and operation	• Ensure the contractor has implemented the required action and audit where necessary as part of site supervision. • If an unintentional release of contaminant occurs, review of procedures and rectify immediately.
Monitor and take corrective actions if the pipeline is having observable adverse impacts on coastal morphology (erosion, accretion, etc.). This should also include appropriate scour protection at the tailwater discharge point into the Barron River, as per Condition W6 of the EA for Northern Sands, which requires surface water be discharged through an effective diffuser.	Dredge contractor	During installation and operation	• Ensure the contractor has implemented the required action and audit where necessary as part of site supervision.
Rehabilitation of all areas of natural vegetation, beach and landforms that are to be cleared for the construction of the delivery and tailwater pipelines. This includes all associated site preparation.	Dredge contractor	As part of de-mobilisation works	• Ensure the landform and vegetation is restored as part of the decommissioning phase of the works.

8.7 Vessel Wash Down Management

This section outlines requirements that are to be met associated with vessel wash down procedures during operations such as wash down of the decks and wash down of the dredge head and other equipment. It does not include discharge of sewage or other waste (addressed later in this document).

Objective	To minimise the release of potential contaminants to the environment from wash down operations.		
Potential Impacts	Release of contaminated solid wastes, degreasers or wash down materials into the environment.		
Performance Criteria	No inappropriate use of degreasers or wash down in sensitive environments.		
Monitoring & Reporting	• Visual inspection for contamination of waters whilst washing deck or equipment. • Ports North to be notified in the event of any unintentional spill of contaminant associated with wash down.		
Implementation Strategies	**Responsibility**	**Timing**	**Corrective Action**
Wash down of the deck and/or dredge-head shall only be undertaken in accordance with relevant permits and approvals.	Dredge contractor	During vessel wash down	• If an unintentional release of contaminant occurs, review of procedures and rectify immediately.
Only dredge sediment to be released in approved areas as a result of vessel wash down activities	Dredge contractor	During vessel wash down	

8.8 Marine Pest Incursion Management

This section outlines requirements that are to be met by the dredge contractor associated with hull fouling, hopper water and ballast water management before leaving the port of origin, during transit between areas of operation, during operations, and following completion of dredging activities prior to departing the Port of Cairns.

Objective	To ensure risk of translocation of organisms in hopper and ballast water or on the hull of a dredge vessel is minimised.
Potential Impacts	Introduction of high risk hopper and ballast water or harmful marine organisms/pests into the Great Barrier Reef Marine Park (GBRMP) and Port of Cairns.
Performance Criteria	• No high-risk hopper and ballast water brought into Port limits. • Ensure hopper and ballast water discharge and marine pest inspections occur in accordance with Department of Agriculture and Water Resources (DAWR) standards. • No harmful marine organisms are translocated on the underkeel hull, dredge-head or within the hopper of the dredge.
Monitoring & Reporting	• Monitoring and audits may be carried out by DAWR on the dredge contractor at the prerogative of the agency. Ports North will assist the agency by facilitating access and implementing any corrective actions required as a result of direction from applicable agency. • Hopper water discharge and replacement records are to be kept in the Ship's log and made available upon request. • A record will be kept of volumes, location and time of all ballasting and de-ballasting operations.

Implementation Strategies	Responsibility	Timing	Corrective Action
In accordance with the *National Bio-fouling Management Guidance for Non-Trading Vessels* (Australian Government 2008), prior to leaving the dredge vessel's port of origin: • Assess the biofouling risk of the vessel prior to departing for Australia and take remedial action as necessary. • Undertake regular inspections of areas most prone to biofouling (e.g. damaged paint, propellers, bow and stern thrusters, sea chests and cooling pipes). • Implement a regular schedule for maintenance and dry docking to apply antifouling coatings. • Regularly ensure marine growth prevention systems are operating efficiently and effectively. • Inspect ship hull, hopper and dredge gear (especially dredge-head) to ensure that no material which may transport organisms (sediments, organic material, or waters) is retained.	Dredge contractor	Prior to leaving the vessel's port of origin	• If an unintentional release or exchange occurs, review of ballast and de-ballasting procedures and rectify immediately. • If marine pests are encountered on ships hulls or other equipment, they are to be treated and removed in accordance with DAWR instructions before commencing work.
In accordance with the International Maritime Organisation (IMO) Ballast Water Convention 2004, during transit between the Port of Origin and Port of Cairns: • No deep water ballast exchanges to occur within the GBRMP. • Any ballast tanks holding seawaters to be exchanged with a minimum of 150% of design volume with seawaters at a location as distant from the coastline or other shallow (<100 m) areas as possible but not less than five nautical miles from the coast. • Any waters held in the hopper during transit to be treated as for other ballast water.	Dredge contractor	Transit between port of origin and Port of Cairns	
During operations at Port of Cairns: • On arrival at the Port of Cairns, the dredge is to operate in accordance with DAWR and Australian Quarantine regulations. • Hull inspections to be carried out if requested by DAWR for attached marine pests. Works to not commence until ships and plant certified as free of marine pests to DAWR standards.	Dredge contractor	At all times during dredging operations and carriage	

Implementation Strategies	Responsibility	Timing	Corrective Action
Leaving Port of Cairns: • When leaving the port of operations, all relevant DAF rules pertaining to hull fouling and ballast water management are complied with.	Dredge contractor	Upon completion of all dredge operations	

8.9 Vessel Waste Management

This section outlines requirements to manage wastes generated from or incidental to the dredging operations. It is separated into three categories: (i) Solid waste and garbage, (ii) Sewage, and (iii) Hazardous waste.

8.9.1.1 Solid Waste and Garbage

Objective	To ensure that general refuse produced on-board the dredge vessel is collected, retained and transferred to an appropriate facility without unintentional material loss.
Potential Impacts	Discharge of solid waste into the environment.
Performance Criteria	• No loss of solid waste material overboard during collection or transfer. • No discharge other than at berth.
Monitoring & Reporting	• Dredge crew to carry out regular visual inspections of collection points and visual inspection of on-deck bins. • Dredge contractor to report any loss of waste material or any community complaints received about solid waste management to Ports North.

Implementation Strategies	Responsibility	Timing	Corrective Action
Vessel fitted with appropriately sized waste disposal bins.	Dredge contractor	At all times	• If practicable, take measures to retrieve material that is lost. • Review procedures causing material loss and take immediate action to rectify.
Vessel bins to be secured and fitted with secure lids to prevent material being blown overboard during storage or handling.	Dredge contractor	At all times	
Where practicable, ensure all material compacted to further prevent unintentional loss.	Dredge contractor	At all times	
Ensure the bins are collected and emptied while at berth at appropriate intervals (e.g. emptied at 75% capacity or below).	Dredge contractor	At all times	

8.9.2 Sewerage

Objective	To ensure sewage generated on-board is appropriately treated and managed.
Potential Impacts	Release of untreated sewage in nil discharge zones.
Performance Criteria	All sewage discharge to meet relevant legislative requirements (Queensland *Transport Operations (Marine Pollution) Act 1995* and Regulation).
Monitoring & Reporting	• Testing and analysis of the treatment system and resultant sewage discharge by an accredited laboratory should be undertaken at the beginning of dredge campaign. • Reports about the testing and analysis of the treatment system and sewage discharge provided to Port of Cairns including details of maintenance or correction action. • If untreated sewage is released in a nil discharge zone, the breach must be reported to Maritime Safety Queensland (MSQ) as soon as possible including estimates of the likely volume of sewage discharged and the location of the release. Depending on the volume of material discharged and the sensitivity of the location of the discharge, the dredge contractor may be directed to undertake water quality monitoring and/or clean up at its cost.

Implementation Strategies	Responsibility	Timing	Corrective Action
All sewage generated on-board is to be directed to the on-board treatment system. The system must be designed to meet the Queensland legislative standard for Grade A treated sewage.	Dredge contractor	During all at sea operations	• Ensure regular review of sewage storage system inputs and operation. • Modify procedures to meet discharge requirements.
Effluent from the treatment system is only to be discharged in appropriate locations to ensure compliance with the Queensland Transport Operation (Marine Pollution) Act and Regulation (refer to s48 of the Act and Sch. 4 of the Regulation).	Dredge contractor	During all at sea operations	
The requirements of the legislation (including relevant maps) for treated and untreated sewage discharge are to be included as part of the dredge contractors Operational Environmental Management Plan and discussed as part of the training and induction process for relevant crew.	Dredge contractor	During all at sea operations	
All effluent is to be diverted to holding tanks when operating in nil discharge areas.	Dredge contractor	During all at sea operations	
The holding tank is to be pumped out either in accordance with untreated sewage requirements under Queensland legislation or otherwise by appropriate licensed contractors while the dredge is in port.	Dredge contractor	Dredge vessel at berth	

8.9.3 Hazardous Waste

Objective	To ensure hazardous waste generated on-board is appropriately managed.
Potential Impacts	Release of hazardous waste into the environment.
Performance Criteria	No inappropriate storage or disposal of hazardous waste.
Monitoring & Reporting	• Dredge crew to carry out regular visual inspections of hazardous waste storage containers to determine their integrity and identify if any spills or leakage has or is occurring. • Incident reports to be provided to Ports North detailing any spills or incidents involving hazardous waste and clean-up operations.

Implementation Strategies	Responsibility	Timing	Corrective Action
During at sea operations all hazardous waste must be stored in an appropriate and secure manner and clearly marked in accordance with legislative requirements.	Dredge contractor	During at sea operations	• If procedures break down or a spill occurs, procedures to be reviewed and staff trained about appropriate responses.
Where required, all hazardous wastes shall be transferred to appropriate containers and transported to an appropriate facility for disposal.	Dredge contractor	As required	
Collection and transport of designated hazardous wastes is to be undertaken only by a licensed contractor.	Dredge contractor	As required	
All procedures to minimise spills or leakage during storage and transfer shall be followed. Spill response equipment must be easily identifiable and conveniently located so as to respond to a spill if it occurs.	Dredge contractor	At all times	

8.10 Fuel Management

This section outlines requirements that are to be met associated with the bunkering of fuel by the dredge vessel and booster pumps during the operation. This section deals with fuel transfer; the section below on emergency planning and procedures deals with general oil spills and response.

Objective	• To ensure bunkering of fuel to the dredge vessel is appropriately managed and spillage is prevented. • To ensure management of fuel provision and storage to booster pumps is managed and spillage is prevented • In the event of a spill, there is a rapid response to minimise impacts on the marine environment.
Potential Impacts	Release of fuel or oil into the environment.
Performance Criteria	No spills or leaks during fuel transfer operations.
Monitoring & Reporting	• Visual inspections of fuel-dispensing requirements and surrounding water are undertaken during operations and after fuel transfer. • Ports North is to be notified in the event of any unintentional spill of fuel or oil associated with fuel bunkering.

Implementation Strategies	Responsibility	Timing	Corrective Action
During fuel bunkering a licensed contractor is used and fuel levels are monitored both by the contractor and the dredge vessel.	Dredge contractor	During fuel bunkering	• If an unintentional release or spill occurs, review of procedures and rectify immediately. • Implement contingency and clean-up procedures as per relevant plans outlined in the *Emergency Planning and Procedures* element (refer **Section 8.14** below).
Dredge vessel to apply for and give notification as to the transfer of bulk liquids to Port Control as per Port of Cairns Procedures and appropriate forms.	Dredge contractor	As required	
Fuel storage and management for dredge booster pumps is in accordance with best practice standards	Dredge contractor	As required	

8.11 Noise Quality

This section outlines requirements that are to be met with regard to nuisance noise issues from dredging operations. The EAs issued for dredging, the Tingira St DMPA and Northern Sands DMPA have set the noise limits below.

Table 8-7 Noise Limits for dredging, placement of material and associated pumps

Noise level measured in dBA	Monday to Saturday			Sunday and Public Holidays		
	7am -6pm	6pm – 10pm	10pm – 7am	8am – 6pm	6pm – 10pm	10pm – 8am
	Noise measured at a sensitive place					
LAeq adj, 15 min	Bkg + 10dBA	Bkg + 5dBA	Bkg + 5dBA	Bkg + 10dBA	Bkg + 5dBA	Bkg + 5dBA
Max LpA, 15 min	Bkg + 12 dBA	Bkg + 8 dBA	Bkg + 8 dBA	Bkg + 12 dBA	Bkg + 8 dBA	Bkg + 8 dBA
	Noise measured at a commercial place					
LAeq adj, 15 min	Bkg + 13 dBA	Bkg + 10 dBA	Bkg + 10 dBA	Bkg + 13 dBA	Bkg + 10 dBA	Bkg + 10 dBA
Max LpA, 15 min	Bkg + 15 dBA	Bkg + 13 dBA	Bkg + 13 dBA	Bkg + 15 dBA	Bkg + 13 dBA	Bkg + 13 dBA

Objective	• To protect the acoustic amenity and minimise nuisance noise on surrounding sensitive receivers. • To respond effectively to any noise quality issues that arise during construction.
Potential Impacts	Acoustic nuisance to other port users and the public from dredging, dredge pump out and the operation of booster pumps.
Performance Criteria	There are no or minimal complaints lodged from the public or port users about noise associated with dredge operations.
Monitoring & Reporting	• Investigation will be required in response to any noise complaints received during the dredging operation. The need for noise monitoring will be discussed with the appropriate regulatory agencies in response to any noise complaints received during the dredging operation, and if monitoring is necessary, it is to be conducted in accordance with the DEHP Noise Measurement Manual 2000 and AS2436-2. • The results of any noise monitoring are to be provided to Ports North within 14 days following completion of the monitoring. • In the event that the monitoring indicates an exceedance of a performance criteria set out in a permit or other statutory instrument, refer to Corrective Actions.

Implementation Strategies	Responsibility	Timing	Corrective Action
A detailed noise assessment is to be conducted of: • Noise emissions from the booster pump, • Noise emissions from the construction of the pipeline. • Noise emissions from the Northern Sands DMPA tailwater pump.	Dredge Contractor	Prior to dredging	• Nil
Ensure that engines and equipment on board the dredge are properly maintained in good working order.	Dredge contractor	At all times	• In the event that response noise monitoring indicates an exceedance of the noise criteria, an investigation shall be undertaken into the noise source(s). • The investigation should include, at a minimum, assessment of the layout and positioning of noise-producing plant and activities and determine actions that could be taken to minimise noise emission levels to surrounding receptors. • Follow-up measurements are to be conducted to confirm whether excessive noise levels have continued. • If noise levels continue to exceed criteria, the dredge contractor is to submit a plan to Ports North indicating how noise can be further mitigated.
Maintain and operate all equipment on board the dredge in a safe and efficient manner.	Dredge contractor	At all times	
Carry out non-essential maintenance during day-light hours.	Dredge contractor	At all times	
Backhoe dredging in the immediate vicinity of Cityport is to be avoided during night-time hours	Dredge contractor	During works in the vicinity of Cityport	
Noise sensitive receptors should be informed of any out-of-hours construction works in advance (preferably at least one weeks' notice, except for emergency works) of works occurring	Dredge contractor	At all times	
Ensure that the following measures are implemented in relation to the **dredge booster pumps** – • Enclose the pumps with an acoustically robust enclosure including internal acoustic absorption. • Fitting industrial mufflers. • Selection of alternative (quieter) or over-specified equipment (allowing lower operating speeds for the same throughput) plant. • The pumps are enclosed as far as practicable to reduce and/or muffle noise impacts during operations. • Planned maintenance, refuelling, and similar activities occur outside of sensitive night time noise periods	Dredge contractor	At all times	
Ensure that the following measures are implemented in relation to the **tailwater pumps** –	Dredge contractor	At all times	

Implementation Strategies	Responsibility	Timing	Corrective Action
• Enclose the pumps with an acoustically robust enclosure including internal acoustic absorption. • Installation of temporary noise barriers or earth bunding. • Locating the pump further away from receptors. • Using smaller pumps in series. • Selection of alternative (quieter) or over-specified equipment (allowing lower operating speeds for the same throughput) plant.			
Ensure that the following measures are implemented in relation to the **pipeline construction and decommissioning** – • Selection of the quietest available plant (excavator and dozers) which is suitable for performing the construction and decommissioning work. • Communication with stakeholders should be undertaken prior to and during pipeline construction and decommissioning work. A pipeline construction and decommissioning plan should be developed, determining where noise generating activity will occur along the length of the pipeline route, when this work will occur and the likely duration of the work.	Dredge contractor	At all times	
The contractor staff are aware of noise requirements within relevant permits and/or approvals.	Dredge contractor	At all times	

8.12 Air Quality

This section outlines requirements that are to be met with regard to nuisance air quality issues from dredging operations, including placement of material and operation of booster stations.

Objective	• To protect the air quality of surrounding sensitive receptors. • To respond effectively to any air quality issues which arise during construction.
Potential Impacts	Nuisance caused by dust or other emission to public or other port users.
Performance Criteria	There are no or minimal complaints lodged from the public or port users about air quality associated with dredge operations including booster pump operations.
Monitoring & Reporting	• The need for air quality monitoring will be discussed with the appropriate regulatory agencies in response to any air quality complaints received during the dredging operation. • The results of any air quality monitoring, if required, are to be provided to Ports North within 14 days following completion of the monitoring. • In the event that the monitoring indicates an exceedance of a performance criteria set out in a permit or other statutory instrument, refer to Corrective Actions.

Implementation Strategies	Responsibility	Timing	Corrective Action
Ensure that engines and equipment on board the dredge are properly maintained in good working order.	Dredge contractor	At all times	• In the event that responsive air quality monitoring indicates an exceedance of the air quality criteria, an investigation shall be undertaken into potential cause(s). • Apply additional dust suppression measures • Follow-up measurements are to be conducted two weeks later to confirm whether air quality is within performance criteria. If air quality continues to exceed criteria, the dredge contractor is to submit a plan to Ports North indicating how air quality issues can be further mitigated.
Maintain and operate all equipment on board the dredge in a safe and efficient manner.	Dredge contractor	At all times	
The contractor staff are aware of air quality requirements within relevant permits and/or approvals.	Dredge contractor	At all times	

Objective	• To protect the air quality of surrounding sensitive receptors. • To respond effectively to any air quality issues which arise during construction.		
Dust suppression measures are to be applied to all disturbed areas i.e. pipeline alignment, laydown areas and DMPA's.	Dredge contractor	At all times	
Disturbed areas are to be rehabilitated as soon as possible following removal of infrastructure to minimise ongoing erosion/dust generation.	Dredge Contractor	Following removal of infrastructure	

8.13 Landscape and Lighting

This section outlines requirements that are to be met with regard to landscape and lighting requirements.

Objective	• To protect the landscape and visual values of the locality during construction and operation of the dredging and pipeline.		
Potential Impacts	Temporary impacts on landscape and visual amenity values from dredge construction and operation.		
Performance Criteria	There are no or minimal complaints lodged from the public or port users about landscape and visual amenity issues Engagement with community where complaints have been lodged.		
Monitoring & Reporting	• Review of site construction details and plant location as part of site supervision including the potential to screen plant from public view. • Following installation, review of light spillage from construction activities (mooring, pipeline, boosters) on sensitive receptors.		
Implementation Strategies	**Responsibility**	**Timing**	**Corrective Action**
Implement the following measures: • Lighting of compounds and works sites will be restricted to agreed hours and in accordance with safe navigation requirements. • Regular maintenance of site hoarding and perimeter site areas will be undertaken, including the prompt removal of graffiti. • Where feasible, construction plant, materials & machinery will be screened behind fencing or located to minimise visual impacts. • A community engagement program to manage amenity impacts at the delivery pipeline landfall site at the mouth of Richters Creek (southern part of Yorkeys Beach).	Dredge contractor	At all times	• Ensure the contractor has implemented the required action and audit where necessary as part of site supervision.

8.14 Emergency Planning and Procedures

This section outlines requirements that are to be met associated with emergency planning and procedures for environmental incidents that could result from dredging and pump-out operations. This includes, but is not limited to, ship collisions and similar incidents.

Objective	To identify and reduce the potential for an environmental incident before it occurs so as to prevent damage to the surrounding environment and the public.
Potential Impacts	Environmental incidents, including release of contaminants, such as oils and fuels, into the environment. Pipeline blow outs or leakage resulting in saltwater intruding into terrestrial environments.
Performance Criteria	• No environmental incidents occur during the dredging campaign. • In the event of an incident, there is a rapid response to minimise impacts on the environment.
Monitoring & Reporting	Ports North to be provided with copies of the following prior to the commencement of work: • The shipboard oil pollution emergency plan (as per Implementation Strategy). • The environmental incident risk assessment (as per Implementation Strategy). • Ports North is to be notified in the event of any incident while the vessel is operating in port limits..

Implementation Strategies	Responsibility	Timing	Corrective Action
A risk assessment regarding potential environmental incidents that could occur during the dredge operation (dredging, mooring, pumping, pipeline operations) is to be prepared by the dredge contractor prior to commencing work. The risk assessment should: • Identify the incidents/hazards that may occur during the campaign. • Identify the environmental consequences of the hazard occurring. • For each hazard, identify measures that can be implemented to prevent the likelihood of the hazard occurring and/or will reduce the severity of consequences. • Contingency measures that are to be implemented in the event of an incident occurring.	Dredge contractor	Prior to commencement of operations	• Review and endorsement of the risk assessment as part of the contractor management plans.
The dredge vessel has and maintains a shipboard oil pollution emergency plan (or equivalent) which outlines the role, responsibilities and actions to be followed should an uncontrolled release of oils/fuels occur.	Dredge contractor	Prior to commencement of operations	• Review and endorsement of the management plans as part of the contractor engagement. • If an incident occurs, review procedures and rectify immediately. • Implement contingency and/or clean-up procedures as set out in relevant plans.
The Contractors DMP is address: • Pipeline leakage or blow out and prospective leakage into the terrestrial environment. • Booster pump fuel leaks and/or storage of fuels in hazard areas (avoiding areas prone to flood or storm surge).	Dredge contractor	Prior to commencement of operations	
All on-board procedures are to be made available to all crew	Dredge contractor	At all times	
The vessel is to have at least two lines of communication (VHF and mobile phone) with Port Control and maintain constant contact	Dredge contractor	At all times	
Dredge contractor is to meet all requirements of the Regional Harbour Master, including Notice to Mariners	Dredge contractor	At all times	
Protocols should be developed with the Regional Harbour Master for dropping the anchor lines as part of normal operations to ensure safe passage of vessels.	Dredge contractor	Prior to commencement of operations	

9 Additional References

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McKenzie, L. J. (1994). Seasonal changes in biomass and shoot characteristics of a Zostera capricorni Ashers. Dominant meadow in Cairns Harbour, Northern Queensland. Australian Journal of Marine and Freshwater Research 45:1337-1352.

Ports North. (2017) Revised Environmental Impact Statement for the Cairns Shipping Development Project. Prepared by Flanagan Consulting Group on behalf of Ports North.

Appendix A Fine Sediment Methodology

Fine Sediment Methodology for the Port of Cairns Shipping Development Project

Reference: R.B23336.006.02.FSM.docx
Date: March 2019
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Document Control Sheet

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Synopsis: **A report outlining the Fine Sediment Methodology (FSM) proposed to meet Condition 8 of the EPBC Act controlled action approval for the Cairns Shipping Development Project.**

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
00 (Client Review)	15 February 2019	DLR		GWF	
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02	14 March 2019	DLR		GWF	

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Ports North	PDF	PDF	PDF								
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Executive Summary

Ports North is advancing to the delivery stage of the Cairns Shipping Development Project (CSDP) which involves dredging a wider and deeper entrance channel and cruise ship swing basin to allow access for larger cruise ships.

This report has been prepared to address Condition 8 'Fine sediment methodology' for EPBC controlled action approval reference EPBC 2012/6538 for the Cairns Shipping Development [Trinity Inlet] Project, Queensland.

Condition 8 states:

***8.** The approval holder must submit a Fine Sediment Methodology (FSM) to the Minister for approval. Dredging must not occur unless the FSM has been approved by the Minister. If the Minister approves the FSM, the approved FSM must be implemented. The FSM must include, but is not limited to:*

(a) a methodology for quantifying the amount (in tonnes) of fine sediment returned to the environment from:

(i) the dredging of stiff clays; and

(ii) the dredging of soft clays and from tailwater discharge at the Northern Sands Dredged Material Placement Area;

(b) written evidence of input and peer review by a suitably qualified person of the adequacy of the FSM and a table of any changes made in response to the peer review'.

A literature review as well as a review of desktop and field based approaches to measuring dredge sediment has been undertaken to determine the most suitable approaches to the FSM for the stiff clay dredging, soft clay dredging and tailwater release.

In developing the FSM design, the following general principles have been considered and applied:

- An existing 3D hydrodynamic and water quality numerical model will be used for the FSM. The numerical model is fit for purpose and has been subject to third party peer review as part of the Cairns Shipping Development EIS process;
- The existing model will be updated for the FSM, using:
  - Actual dredge logs (hypothetical dredge logs were used in the EIS);
  - Actual tailwater discharge data (flow volumes and quantities of fine sediment fractions);
  - Pre- and post dredge bathymetry data for the dredge channel to calculate the actual volume of fine sediment removed;
  - The most up to date geotechnical data for the dredge site;
- A robust field data collection program using industry accepted and proven methods will be required to inform numerical modelling assessments;
- Multiple sampling methods and approaches are proposed in order to ensure multiple sources of data to inform the results. For example, water samples will be collected and taken for laboratory analysis in parallel with field based in-situ instrumentation and the results compared against modelled outputs; and

- Outputs from the numerical modelling, in combination with interpretation of field data, will then be interrogated to calculate the quantity of fine sediment fractions returned to the environment.

A peer review of the draft FSM was been undertaken by Dr Alistair Grinham from the University of Queensland and is contained within the Appendices to this report.

The key findings of the peer review were that the methodology will provide a useful comparative approach capable of providing a defensible estimate of soft and stiff clay returned to the environment. The strengths of the approach were identified as utilising a number of different pathways to estimate the fine sediment returned to the environment which is considered prudent for estimating losses in such complex marine environments. The peer reviewer found that the methodology also acknowledges the inherent uncertainty in quantifying fine sediment returns from dredging operations and provides an appropriate, conservative estimate for each dredge method as well as the tailwater discharge.

The only significate change to the draft FSM as a result of the peer review that has been addressed in the final FSM is the inclusion of an evaluation of the relative success of individual estimation pathways at project completion.

Contents

List of Figures

List of Tables

1 Introduction

1.1 Statement of Requirement

This report has been prepared to address Condition 8 'Fine sediment methodology' for EPBC controlled action approval reference EPBC 2012/6538 for the Cairns Shipping Development [Trinity Inlet] Project, Queensland.

The relevant conditions from the approval are appended below:

***8**. The approval holder must submit a Fine Sediment Methodology (FSM) to the Minister for approval. Dredging must not occur unless the FSM has been approved by the Minister. If the Minister approves the FSM, the approved FSM must be implemented. The FSM must include, but is not limited to:*

(a) a methodology for quantifying the amount (in tonnes) of fine sediment returned to the environment from:

(i) the dredging of stiff clays; and

(ii) the dredging of soft clays and from tailwater discharge at the Northern Sands Dredged Material Placement Area;

(b) written evidence of input and peer review by a suitably qualified person of the adequacy of the FSM and a table of any changes made in response to the peer review'.

Condition 10A 'Dredging Completion Report' is relevant to and links to Condition 8. Condition 10A states that –

***10A.** 'The approval holder must submit a Dredging Completion Report (OCR) to the Department within 6 months of the completion of dredging. The OCR must include, but is not limited to:*

(c) the amount of fine sediment returned to the environment calculated in accordance with condition 8(a)(i) and condition 8(a)(ii);

Fine sediments are defined in the glossary of the controlled action approval as:

***Fine sediment** means material less than 15.6 micrometres (µm).*

Taken together, these conditions require the proponent (Ports North) to measure through some form of field measurement and/or modelling, the amount of fine sediment generated during dredging and tailwater release such that they can be reported as part of Condition 10A(c) following completion of the dredging works.

1.2 CSD Project Background and Context

Ports North is advancing to the delivery stage of the Cairns Shipping Development Project (CSDP) which involves dredging a wider and deeper entrance channel and cruise ship swing basin to allow access for larger cruise ships. The project also includes upgrading the wharf infrastructure within Trinity Inlet to cater for the larger vessels and the relocation of the cargo ship swing basin to accommodate future Navy base expansion.

The widened and deepened channel and swing basin will allow larger cruise ships up to 300 metres in length to berth at the Cairns Cruise Liner Terminal to accommodate the forecast demand for 70 additional cruise ships through the Port of Cairns' Trinity Wharves each year by 2031.

More specifically, the offshore components of the scope include the following:

- The extent of the widening varies over the channel, with the outer channel being widened up to 10 m to a new maximum width of 100 m and inner channel widened by 20 m up to a new width of a 110 m. The declared depth will be increased from -8.3 m to -8.8 m lowest astronomical tide (LAT) with a target design depth of -9.1 to -10.3 m LAT to cater for the annual siltation for the outer channel.
- In the bend of the channel, further widening will be carried out to a maximum width of 180 m to provide safe manoeuvring space for the cruise vessels while passing through the bend.
- The Crystal Swing Basin diameter will be deepened to a declared depth of -8.8 m LAT outside the direct channel alignment.
- A new Smiths Creek Swing Basin to allow for expansion capability of HMAS Cairns.
- The declared depth of the berth pockets will be -9.3 m LAT, with a width of 50 m.

A Revised EIS for the CSDP was prepared by Ports North and accepted by the Queensland Government in December 2017.

A copy of the Revised EIS and Supplementary Information is available at http://statedevelopment.qld.gov.au/assessments-and-approvals/projects-draft-environmental-impact-statement-documents.html

The State Government of Queensland through the Coordinator-General, issued the Co-ordinator General's Evaluation Report (CGER) on 28 February 2018.

A controlled action approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was subsequently granted and issued by the Australian Government Department of the Environment and Energy on 28 November 2018.

A dredge contractor was appointed by Ports North in early February and dredging works are set to commence in May/June 2019.

As per Condition 8, the FSM will need to be submitted and approved by the Minister before the dredging works can commence.

1.3 Baseline Conditions and Dredge Material Properties

The Revised EIS for the CSDP described the baseline conditions and geotechnical properties of the seabed materials to be dredged. A summary of these findings is presented below.

1.3.1 Baseline Conditions in Trinity Bay

The understanding of coastal processes and sediment movement within the Trinity Bay area where the CSDP will occur has developed over several decades and numerous studies including those referenced in Chapter B3 - Coastal Processes, of the CSDP Revised EIS.

Numerous scientific studies into the coastal processes and sedimentology of Trinity Bay have clearly demonstrated that even under calm conditions there is a very significant and multi-directional sediment movement on a large scale occurring on an ongoing basis.

As outlined in Carter *et al* 2002. water motions and therefore sediment transport within the Cairns' coastal region are strongly influenced by:

- Southeasterly trade winds in winter
- Variable north and northeasterly winds during summer
- A daily easterly coastal sea-breeze
- Diurnal tidal currents (southeast flood; northwest ebb)
- Intermittent tropical cyclones

In combination, these processes are responsible for the generally high background turbidity which is present in Cairns' coastal waters (20 – 200 mg/L) which is caused by the resuspension of mud from the seabed.

In a report by Brinkman *et al* (2004), the prevailing fine sediment "nepheloid layer" present along the Cairns shoreline was quantified and described. The study modelled the patterns of movement of the layer of material within the general confines of Trinity Bay and in the broad context along the tropical coast, in both calm and strong wind conditions. Conceptual numerical modelling suggested that the layer acts as a negatively buoyant plume that is deflected longshore alternatively northward and southward by prevailing, reversing oceanic currents, out to around the 20m depth contour. Concentrations of the layer were noted as being up to 1000mg/L (SSC) and up to 10m in thickness.

During 2018 the outputs of Reef 2050 Long Term Sustainability Plan action for WQA17 were completed by Qld Ports Association, and included a contemporary evaluation of the relative contributions of sediments at and adjacent to the Port of Cairns.

Based on this study, Trinity Bay is estimated to receive on average over 80,000 tonnes of fluvial sediment per year which contributes to a store of over 1.2 billion tonnes of existing sediment of terrigenous origin in the Bay.

Further, there is estimated to be a volume on the order of 14 million tonnes per year moving within the bay that is naturally resuspended by regular processes such as tidal currents as well as episodic wind and wave events.

Given these background conditions, distinguishing dredge-generated turbidity and total suspended solids from background conditions in the field can be problematic, particularly during poor and/or variable weather conditions.

1.3.2 Dredge Materials and Methodology

The seabed materials proposed to be dredged as part of the CSDP consist of two physically different and visually distinguishable material types originating as either terrigenous sedimentary deposits or marine sediment, as shown in Figure 1-1 and Figure 1-2.

Stiff clays are defined in the controlled action approval as follows:

***Stiff clays** means sediment to be dredged that has an undrained shear strength of greater than 50 kilopascals (kPa) (as per Australian Standard ASl726-1993).*

Particle size distribution analysis of the stiff clay material samples obtained as part of geotechnical investigations for the CSDP indicate that the stiff clay samples have fines contents (<15.6 μm) ranging from 40% to 82% by mass, with an average of 70% fines.

Soft clays are defined in the controlled action approval as follows:

***Soft clay** means any material to be dredged that is not stiff clays*

Particle size distribution analysis of the **soft clay material** samples indicated an average of around 75% fines contents (based on the <15.6 μm criteria).

Consistent with the Revised EIS, two types of dredge plant will be required to undertake the CSDP works.

The soft marine clays, muds and sediments will be dredged by a Trailing Suction Hopper Dredge (TSHD) and the stiffer clay material by a backhoe dredge (BHD).

These plant will operate in different parts of the channel (for navigational safety and based on the location and distribution of stiff and soft clays) but may be operating simultaneously during the dredge campaign.

As part of detailed design process for the CSDP, it has been determined that a smaller volume than what was approved in EPBC Condition 2 will be dredged from the channel as part of the CSDP.

The revised dredge volume of material (developed by project geotechnical consultants Golder using a 3D model of the channel) has been estimated to be approximately:

- 698,755 m^3 soft clays
- 92,309 m^3 stiff clays

- 791,064 m^3 total volume

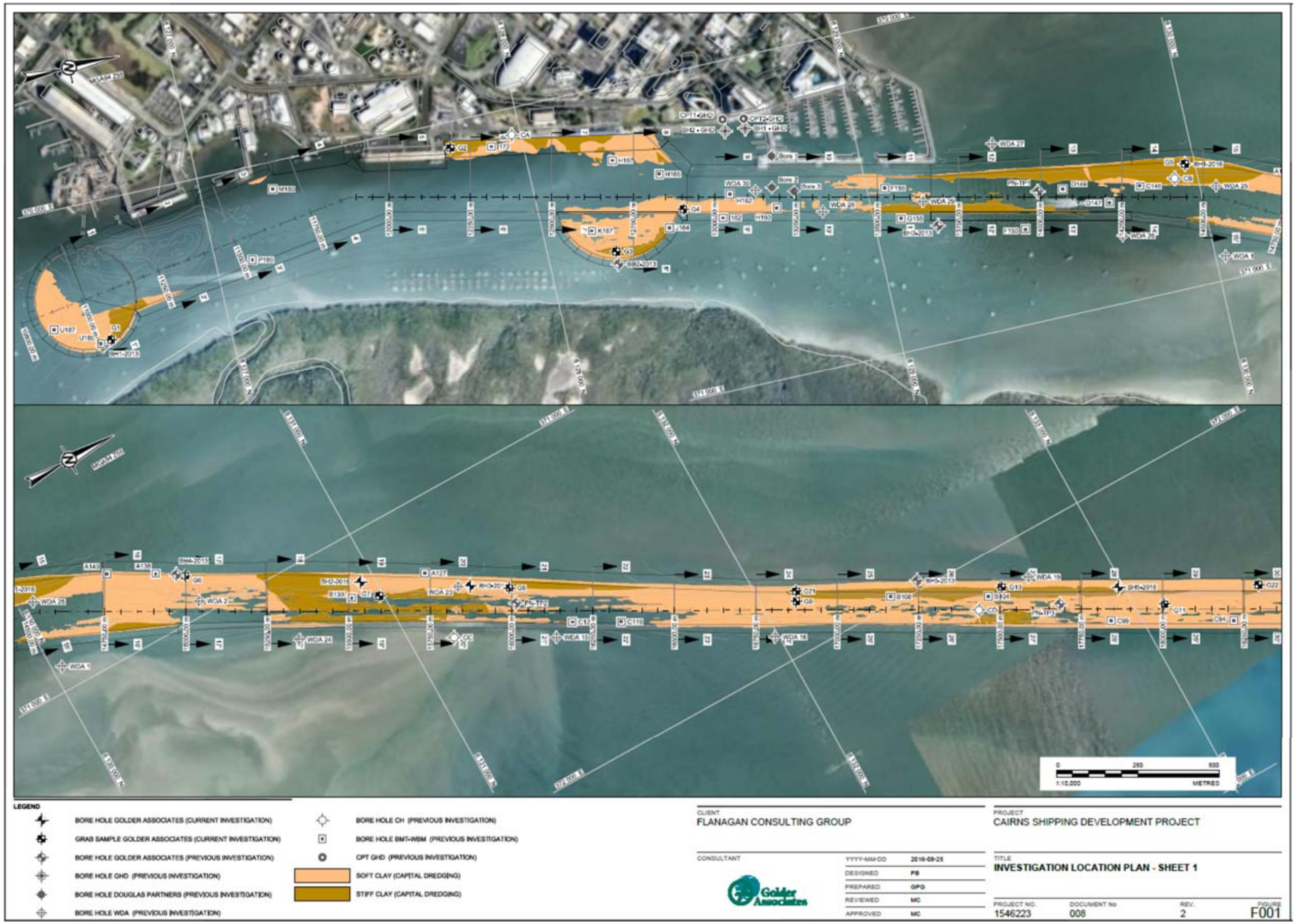

Figure 1-1 Distribution of Soft Clay and Stiff Clay in the Dredge Footprint (inner port and channel)

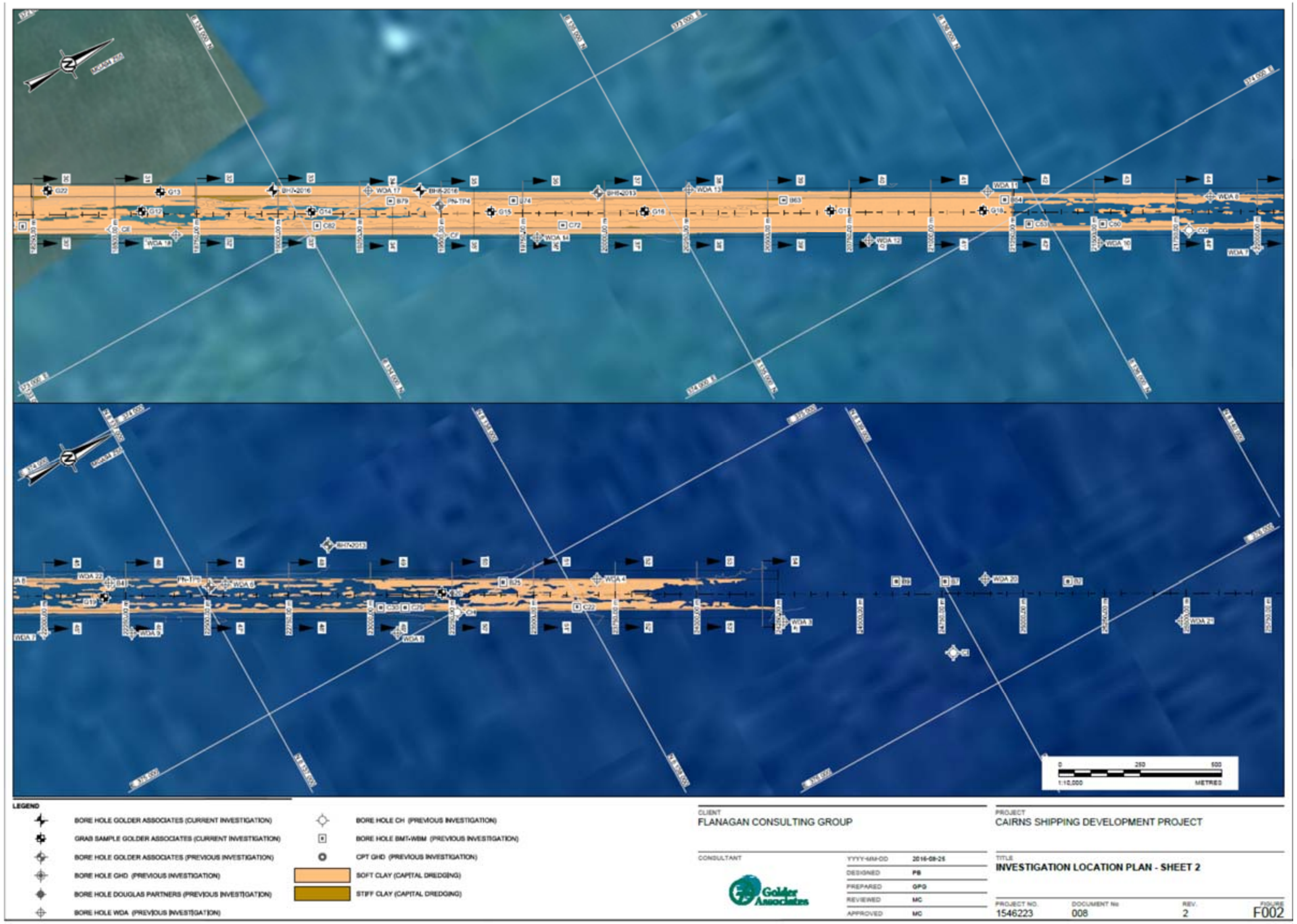

Figure 1-2 Distribution of Soft Clay and Stiff Clay in the Dredge Footprint (outer channel)

1.3.3 Preliminary Estimates of Fine Sediment Release

While it should be noted that an environmental offset under Condition 11 of the EPBC approval is only payable for the stiff clay component of Condition 8(a)(i), the FSM and reporting requirement under Condition 10A applies to all sources of fine sediment released to the environment (stiff clays, soft clays and tailwater).

The sections below outline a conservative estimate of the fine sediment (based on desktop calculations and assumptions) that could be returned to the environment from the dredging and tailwater release activities.

The spill rates from dredge plant used in the calculations are the same as those that were adopted and used in the numerical water quality modelling from the Revised EIS and are based on professional advice from expert dredge consultants and contractors (Akuna Dredging Solutions Pty Ltd, ProDredge Pty Ltd and BMT-JFA).

Collectively, these estimates provide the baseline assumptions of the likely fine sediment that could be generated and released to the environment from the action that will then be field verified and tested during construction as part of the FSM as described in Section 3 to the extent practicable as outlined in the methodology.

'Returned to the environment' in this context is not defined in the EPBC approval but is taken to mean any fine sediments that are disturbed and resuspended by capital dredging activities. This includes, for example, fine sediment disturbed and resuspended by the dredge head, fine sediment released as part of hopper overflow waters or fine sediment released as part of supernatant tailwater from the DMPA. However, it will also need to be recognised in the final accounting of the fine sediment that some of this fine sediment material will re-settle within the existing channel and thereafter be dealt with as maintenance dredge material. Accordingly, field sampling as outlined in Section 3 will seek to be undertaken outside of the channel where practicable so as not to be measuring fine sediment that is simply falling back into the channel and is not technically 'returned to the environment'.

1.3.3.1 Estimated Fine Sediment Release from Stiff Clay Dredging by BHD

The calculated fine sediment returned to the environment from the BHD operation has been estimated by multiplying the relevant numbers for all of the following terms:

- Percentage fines within stiff clay dredge material (70%)
- Fine sediment source term (spill rate) from the dredging process (3%)
- Dredge material dry density (1.6 tonnes/m^3)
- Stiff clay volume to be dredged (95,000 m^3 [rounded up from 92,309])

Multiplying the figures gives: 0.7 x 0.03 x 1.6 x 95,000 = 3,192 tonnes.

Allowing a further factor of approximately 1.5 for conservatism we have suggested a maximum of 5,000 tonnes.

1.3.3.2 Estimated Fine Sediment Release from Soft Clay Dredging by TSHD

The calculated fine sediment returned to the environment from the TSHD operations in soft clays has been estimated by multiplying the relevant numbers for all of the following terms:

- Percentage fines within soft clay dredge material (75%)
- Fine sediment source term (spill rate) from the dredging process (7%-15% - depending on time spent overflowing [note that the lower bound corresponds to 10 min overflow and upper bound to 30 min overflow]).
- Dredge material dry density (0.96 tonnes/m^3)
- Soft clay volume to be dredged (700,000 m^3 [rounded up from 698,755])

Multiplying the figures gives: 0.75 x 0.07 to 0.15 x 0.96 x 700,000 = 35,280 to 75,600 tonnes.

Allowing a further factor of approximately 1.5 for conservatism we have suggested an estimate between 50,000 tonnes and 114,000 tonnes.

1.3.3.3 Estimated Fine Sediment Release from Tailwater Discharge

Reclamation modelling undertaken as part of the EIS and detailed design process predicted the initial placed volume of the dredged material, its settlement rates and the corresponding surface water quality in the reclamation pond for the planned filling sequence.

Concurrent with that work, BMT made assumptions on an achievable tail water quality and modelled and assessed the tail water discharge impacts based on those assumptions.

The tailwater quality assumptions (which strongly correlated with the eventual conditions of approval for tailwater release imposed by the Queensland Government under the project Environmental Authority) were;

- a maximum discharge concentration of 50 NTU (which relates to a corresponding TSS concentration of approximately 85 mg/L).
- a maximum daily discharge volume of 87 megalitres per day.
- a total modelled dredge priming, pumping and flushing soil and water volume of 5,534,339 m^3
- a total pumped soil in-situ volume of 882,650 m^3

The theoretical maximum tail water discharge volume is 4,651,689 m^3 noting a large proportion of the soil is expected to remain fully saturated (retaining a mass of pore water at about 60%-70% of the mass of the soil). For simplicity and to be conservative it is assumed that all the tail water TSS is fine sediment (e.g. <15.6 µm).

Noting that TSS levels will fluctuate throughout the tailwater campaign, by adopting an average 50mg/L tailwater condition this equates to approximately 233 tonnes of fine sediment. Allowing a further factor of approximately 1.5 for conservatism we have suggested a maximum of 350 tonnes of fine sediment.

2 Literature Review and Previous Field Investigations

2.1 Background

As described in Section 1, the FSM seeks to quantify the total quantity of fine sediment released to the environment associated with dredging and tailwater discharges. In doing so, there are four key factors that need to be considered when developing a fine sediment mass estimate for material returned to the environment:

(1) It must individually consider the two sediment types as defined in Section 1;

(2) It must consider the total amount of amount of fine sediment, for the total duration of the Project program, returned to the environment due to both dredging and tailwater discharges from the onshore disposal site;

(3) It must be able to be able to distinguish sediment material generated by the Project from background/ambient sediments. This is an important consideration given that the dredge site and receiving environment of tailwaters have high ambient total suspended solid concentrations; and

(4) The physio-chemical processes controlling the behaviour of very fine particles in aquatic environments need to be considered. Clay particles in the marine environment have a cohesive nature and tend to aggregate together through the process of flocculation. This is an important consideration from a sampling/analysis perspective.

The following sections provides a review of relevant literature as well as an overview of different desktop and field based approaches used in previous dredging monitoring projects to develop a fine sediment mass estimate.

2.2 Literature Review

The process and importance of validating numerical model predictions related to dredge plumes at the start-up of a dredging project is well documented and is now a standard requirement of most environmental permits. However, there is considerably less information on methods for relating the field measurements back to the assumed sediment flux rates for dredge plant that have been utilised in the numerical modelling.

Two of the key industry-based literature sources that are relevant to this point are summarised below:

<u>**VBKO (2003) Protocol for the Field Measurement of Sediment Release from Dredgers**</u>

Most reviewed papers and articles are referenced back to a white paper (VBKO 2003), entitled "Protocol for the Field Measurement of Sediment Release from Dredgers", produced for the VBKO TASS Project by HR Wallingford and Dredging Research Ltd. The protocol was developed by HR Wallingford as a secondary outcome of an industry funded program to develop models to predict the rate of sediment release from various types of dredging plant. The primary study identified issues with varying and inconsistent approaches to the field measurement methods and thus it was an attempt to try and standardise the process.

Chapter 4 of VBKO provides details of the primary recommended method for stationary dredgers (e.g. the Backhoe dredge plant). The method is based around the use of towed Acoustic Doppler Profiler (ADP) in order to collect data with a high degree of spatial resolution. The chapter includes a section on some of the limitations of using an ADP for collection of data, in particular near bed and near surface zones. Methods for the field calibration of the ADP are provided, based around the collection of water samples in the plume through depths whilst the ADP is recording.

Secondary methods of data collection are provided in Chapter 5, in particular the use of towed arrays and profiling turbidity meters (raising and lowering of a turbidity meter through depth, and through time).

Chapter 7 of VBKO provides a description for the measurement methods for Trailing Suction Hopper Dredgers. The chapter provides a detailed protocol for the measurement of sediment release for each of the following mechanism

- Release through overflow;
- Release by Lean Mixture Overboard (LMOB) Systems;
- Resuspension by the draghead; and
- Far field plume decay.

De Wit L. (2015) 3D CFD modelling of overflow dredging plumes

De Wit's thesis in 2015 on the 3D CFD modelling of overflow dredging plumes included a field validation component in which the CFD modelling results were compared with field data collected at three separate dredging campaigns involving TSHD's. Each campaign had different sized TSHD and differing materials. The method of the field data collection, including some of the challenges encountered and data quality is described in Chapter 8 – "Validation of near field dredging plume – field scale".

The field surveys were typically carried out in accordance with the VBKO protocols for field measurements (discussed above). Data and measurements were collected both on the dredge and around the dredge during operation.

The following information from the operating dredge was collected:

- TSHD location, speed, direction, total loading and suction discharge and suction density (logged by the TSHD onboard sensors).
- Overflow mixture was sampled to determine the overflow density and PSD profile.'

Separately, plume measurements were undertaken in the field from a survey vessel using a combination of side scan sonar, ADCP's and optical back scatter instruments. Attempts to correlate the ADCP backscatter and turbidity with suspended solid concentration had varied success from the three programs.

2.3 Desktop and Field Based Approaches

Informed by the literature mentioned above, the primary methods for developing a fine sediment mass estimate can be broadly grouped as follows:

(1) Estimates of the total amount of material dredged based on:

 (a) Geotechnical data for the dredged channel;

 (b) Bathymetry survey data collected before and after dredging; and

 (c) Dredge production logs, which provide estimates of the volume of sediment dredged.

(2) Field-based measurements of sediments in the water column.

(3) Numerical modelling of sediments released to the environment by dredging and tailwater releases.

Each is discussed in the sections following.

2.3.1 Quantifying Fine Sediment Quantities in Dredged Material

The total amount of fine sediment dredged can be estimated using a variety of approaches. An understanding of the amount and types of dredged material is a critical input into the planning and implementation of dredging operations (Kemps and Massini 2017).

Geotechnical characterisation of sediments to be dredged provides an estimate of the quantity of different sediment fractions to be dredged. A variety of methodologies are routinely used to characterise sediment properties, laboratory analysis of core samples, seismic methods and in situ measurements using accelerometers (reviewed by Mills and Kemp 2017). Geotechnical data, hydrographic survey data (conducted before and after dredging) and dredge logs, are used to estimate the total quantity of different sediment classes dredged (BMT WBM 2017; Mills and Kemp 2017).

These approaches in isolation do not provide a basis for determining the amount of fine sediment fractions returned to the environment; however, these data can be used to derive source terms for dredge plume modelling (e.g. Kemps and Massini 2017; Mills and Kemp 2017; BMT WBM 2017).

2.3.2 Measuring Fine Sediments Quantities in the Water Column

Mills and Kemps (2017) reviewed several case studies to describe the state of the knowledge regarding the behaviour of dredge plumes in an Australian context, with a focus on hydraulic dredging (trailer suction and cutter suction dredging). They concluded that despite many examples of dredge plume monitoring studies in the literature *"…there is currently very little published data on the PSD development in actual dredged material at various points along the full-scale dredging production line".*

In Queensland, the primary focus of dredge plume monitoring studies over the past decade (many of which have been undertaken by BMT) has been around field validating the amount of sediment in the form of TSS or turbidity in the plume from different dredging equipment, with the notable exception of Beecroft *et al*. (2019).

While these dredge plume monitoring studies typically have not specifically sought to define the fine sediment component (e.g. less than 15.6 µm) of the overall spill budget of total suspended solids they are relevant to designing an FSM.

2.3.2.1 Case Studies

Port of Gladstone – Western Basin Capital Dredging Project

This project undertaken by BMT involved:

- Field-based measurements of sediment plume generated by dredging (trailing arm suction dredging) – examining all sediment fractions collectively.
- Field-based measurements of sediments in tailwater discharges from an on-land disposal site – examining all sediment fractions collectively.
- Numerical modelling of the behaviour of sediment plumes generated by dredging (backhoe, trailing arm suction, and cutter suction dredgers) and tailwater releases.

Between 2011 and 2014, Gladstone Ports Corporation co-ordinated an intensive program of capital dredging within the Western Basin of Gladstone Harbour. This involved the development of Jacobs Channel using both backhoe dredges to remove stiff clays and rocky material and trailing arm suction dredges to remove the bulk of unconsolidated silt from the channel alignment and in this respect mirrors the proposed operational dredging methods for channel development at the Port of Cairns. Subsequent capital dredging developments at the Wiggins Island Coal Terminal and at the Clinton Bypass channel were undertaken principally by trailing arm suction dredgers, being supplemented by cutter suction dredges at Wiggins Island. Whilst most of the sediment dredged from the Clinton By-Pass and Wiggins Island Coal Terminal was placed at sea, the major component of capital material dredged from Jacobs Channel was pumped to the Western Basin Dredged Material Reclamation at Fisherman Landing.

BMT was engaged to use its calibrated hydrodynamic model of Gladstone Harbour to predict the likely impacts of sediment resuspension dredge plumes associated with both backhoe and trailing arm suction dredging plant upon the background water quality of Gladstone Harbour. The modelling predictions were based on field measurements of turbidity, optical and acoustic backscatter within the dredging plumes created by around the operational backhoe and trailing arm dredging plant under specified tidal conditions (typically spring and neap tidal conditions). The field turbidity, optical and acoustic backscatter measurements were later converted to Total Suspended Solids (TSS) concentrations based upon the concurrent field collection and subsequent laboratory analysis of many dredge plume and background water samples. Predicted dredge plume model outputs in TSS concentrations were based upon the selective laboratory analysis of a range of near source (e.g. dredge hopper and near-field plume water) and far-field dredge plume samples for particle sizes to yield source generation rates for the various items of dredging plant.

Similar subsequent analyses based on snapshot field measurements and water sample collection and analyses for the discharged sediments from the Western Basin reclamation bunded area were used to quantify and predict the extent and concentration of sediment within the tailwater discharge plume under a range of dredging and detention scenarios.

The project did not seek to quantify the amount of different sediment fractions.

Port of Cairns – Maintenance Dredging Monitoring

This project undertaken by BMT involved:

- Field-based measurements of sediment plume generated by dredging (trailing arm suction dredging).
- Numerical modelling of the behaviour of sediment plumes generated by dredging (trailing arm suction dredger).

The extent and longevity of maintenance dredging plumes within Trinity Inlet was investigated by BMT WBM in 2016. Maintenance dredging and dredged material placement plumes created by the Port of Brisbane trailing arm suction dredger 'Brisbane' were measured during flood and ebb spring tidal conditions using a vessel mounted acoustic doppler current profiler, turbidity and optical backscatter sensors, together with the collection of water samples for TSS and particle size in conjunction with aerial drone surveillance and mapping of the dredge plumes evident at the water surface. The water quality measurements and aerial mapping photographs were undertaken at a range of times following their formation, allowing predictive hydrodynamic models of the dredging and placement plumes to be developed, calibrated and verified using sediment particle sizes, source generation rates and sediment settling rates inferred from the plume measurements.

It is envisaged that the existing BMT hydrodynamic model of Trinity Inlet would form the basis of the future predictive model used to determine the fine particle sediment losses to the environment in the forthcoming capital dredging programme at the Port of Cairns. It is anticipated that the model would be refined for the calculation of fine particle sediment losses to the environment based on several measurement snapshots to correspond with differences in the dredging plant, texture of dredged material and tidal conditions as they will occur through the term of the dredging programme.

The project did not seek to quantify the amount of different sediment fractions.

Sunshine Coast Airport Expansion - Tailwater Monitoring

This project undertaken by a dredge contractor and supervised by BMT involved:

- Field-based measurements of sediments in tailwater discharges from an on-land disposal site.
- Monitoring of surface water quality in receiving waters.

The Sunshine Coast Airport Expansion Project required a supply the sand to construct the new runway and taxiway system. Dredging was undertaken in 2018 at the Spitfire Realignment Channel in Moreton Bay to supply this sand which was pumped to an onshore placement area. The placement area had a tailwater polishing pond which discharged supernatant tailwater in the adjacent Marcoola Drain and Maroochy River.

The discharged tailwater was required to meet certain discharge quality criteria, including TSS and turbidity. The approval conditions stated that turbidity could be measured and used as the compliance limit as long as a correlation between TSS and turbidity was established. As such, the dredge contractor conducted an intensive sampling effort at the commencement of the dredge material placement phase, whereby they collected a number of samples in the tailwater polishing pond and analysed the samples for TSS and turbidity to establish a site-specific correlation. This correlation was then used by the dredge contractor to establish a turbidity compliance limit that was used as a proxy for assessing compliance with the TSS limit for the duration of the project.

If the dredge contractor had also measured flow rate from the tailwater polishing pond, then the Testability correlation and flow rate could have been used to determine total sediment loads discharged to the receiving environment. However, a breakdown of sediment fraction loads would not have been achievable with this data as no particle size data were collected.

Port of Brisbane – Offshore Dredged Material Disposal

This project undertaken by Beercroft *et al*. (2019) involved:

- Field-based measurements of sediments within the water column before, during and after dredge placement operations.
- Field-based measurements of sediments within the water column during baseline conditions were no dredging was occurring.

Beecroft *et al*. (2019) evaluated maintenance dredging operations (trailer suction dredger) with respect to natural sediment transport processes in western Moreton Bay. Monitoring investigated the contribution of dredge placement operations at the Mud Island dredged material placement area to the natural suspended sediment regime and water quality within Morton Bay. Monitoring was conducted prior, during and post dredge placements to evaluate the context of dredge material delivery with respect to natural suspended sediment drivers in proximity to the placement site and to contrast the near-bed suspended sediments concentrations and particle size characteristics. Baseline natural processes were compared to the intensive dredging activities that involved 200 placements over the duration of monitoring which was sourced mainly from the port's network of wharfs and swing basin.

Monitoring at Mud Island was conducted predominately using a Sequoia Scientific Inc. LISST-100X; a fast response Concerto conductivity, a temperature and density probe; a Pentair Greenspan MP47 turbidity sensor; and an acoustic doppler current profiler. To monitor turbidity the Pentair turbidity sensor was mounted below the surface for several days on two monitoring periods at the beginning and end of 2016. The suspended sediment concentration and particle size distribution was measured in situ by vertically profiling from the surface to 0.15 m above the bed to create a downcast profile. Wind, wave and current velocities were measured to monitor natural sediment resuspension. The in-situ particle-sizing techniques are crucial to identifying the low-density flocculated material as the key transport of fine cohesive fractions and should help establish a more robust assessment criteria for dredging operations.

2.3.3 Numerical Modelling

Numerical modelling is the primary tool used to provide quantitative predictions of dredge sediment in environmental impact assessment studies (e.g. Mills and Kemp 2017). Numerical modelling also allows the quantification and fate of dredged sediments released into the environment at spatial and temporal scales relevant to the FSM.

Examples of numerical modelling projects in a Queensland port context includes recent capital dredging projects (Cairns Shipping Development Project EIS, Port of Townsville Port Expansion

Project EIS, Port of Gladstone Western Basin Project), as well as maintenance dredging assessments for Ports of Cairns, Townsville, Gladstone and Brisbane. These projects quantified sediment releases to the environment during dredging (all projects), ocean disposal (i.e. maintenance dredging projects) and/or tailwater releases (all the capital dredging projects and maintenance dredging at Gladstone).

Dredge plume modelling can be undertaken in order to quantify the release and track the subsequent movement of different sediment fractions. This has been undertaken for the above examples, however the models were not specifically configured to separately assess the fine sediment fraction as specifically defined in the EPBC conditions for the CSDP.

2.4 Suitability of Approaches for FSM

Table 2-1 is a summary of different approaches that could be used to quantify sediment loads entering the environment.

In reviewing the various approaches presented in Table 2-1, it is concluded that there is no single tool or method that, in insolation, can adequately address all the key factors to provide a robust fine sediment mass estimate. As such a combination of methods will need to be employed.

In summary, some of the key findings are:

- The approaches used to calculate dredged material quantities do not take into account the amount of sediment returned to the environment, and therefore over-estimate fine sediment quantities.
- Field-measurements of sediments in dredge plumes all have pros and cons, most importantly being that because they represent snap-shots in time and space, they cannot provide a complete record of fine sediment quantities generated by the project.
- Numerical modelling-based approaches can provide an estimate of different fine sediment fractions returned to the environment at appropriate temporal and spatial scales, but are predictive rather than actual measurements. However, with appropriate calibration to field measurements in order to derive properly validated dredge plume source terms, numerical modelling can then provide a robust means of quantifying the total release of different sediment particle classes over the entire project, that is filling the gaps between episodic field measurements. In addition, the numerical models can provide valuable information regarding the subsequent fate of the released sediment.

Table 2-1 Approaches for Estimating Suspended Sediments in Waters

Category	Approach	What Is Assessed?	Spatial and Temporal Context	Advantages	Limitations	Case studies
Estimate of the Quantity of Dredged Material	Geotechnical data interpretation (3D mapping)	• Quantity of fine sediment fractions to be dredged, as determined through a review of existing 3D sediment model	• No. dimensions: 3D • Spatial resolution: Low resolution • Spatial extent: 3D model available for all the channel • Temporal replication: N/A (contemporary data are available)	• Provides a coarse estimate of the total amount of fine sediment to be dredged	• Does not estimate the quantity of material released to the environment • Low spatial resolution	• The use of 3D models to estimate the quantity of different sediment fractions is routinely used for dredging design
	Hydrographic surveys	• Quantity of fine sediment removed by dredging, as estimated by surveys before and after the dredging campaign	• No. dimensions: 3D • Spatial resolution: High resolution • Spatial extent: data available for all the channel • Temporal replication: N/A (contemporary data are available)	• Provides an estimate of the total amount of sediment actually dredged, which in combination with geotechnical data, provides a basis for quantifying the amount of each sediment fraction removed	• Does not measure the quantity of material released to the environment	• Hydrographic survey is the standard method for quantifying the total amount of sediment removed in most dredging projects
	Dredge production logs	• Amount of material dredged	• No. dimensions: N/A • Spatial resolution: Low resolution • Spatial extent: data available for all the channel • Temporal replication: N/A	• Provides a comprehensive description of the dredging activities undertaken, including timing, locations, operating conditions and quantities of sediment handled.	• Does not specifically estimate the quantity of material released into the environment.	• Dredge production logs are used to inform numerical model hindcast simulations of sediment plume generation by dredging projects, including both capital and maintenance dredging activities.
Measurements of Sediment Concentrations Released into the Environment	Remote sensing to quantify horizontal plume surface extent using: • Drones • Satellite captures	• Horizontal extent of visible surface plume	• No. dimensions: 2D (horizontal - surface only) • Spatial resolution depends on technology, with greater resolution by drones (measured in metres) • Spatial extent: entire plume • Temporal replication: Single measurement in time (but can take multiple measurements)	• Provides high resolution mapping of horizontal plume extent, and depending on technology, an estimate of turbidity	• Measures all sediment fractions, and does not differentiate between fines and coarser sediments • 2D only • Snap-shots in time • Capacity to detect plumes in the lower column dependent on ambient turbidity	• Wheatstone Project, Port of Cairns
	Vessel based measurements of suspended sediments using acoustic methods (Acoustic Doppler Current Profiler)	• Estimates suspended solid concentrations (SSC) in the water column based on acoustic backscatter measurements	• No. dimensions: 2D slice through the water column • Spatial resolution: measured in 100 to 100s of cms • Spatial extent: transect typically measured in 10s to 100s of metres • Temporal replication: Provides a single measurement in time	• In combination with other measurements (turbidity, total suspended solid concentrations), provide high resolution estimates of SSC through the water column	• Measures all sediment fractions, and does not differentiate between fines and coarser sediments • 2D only • Snap-shot	• Routinely used to monitor dredge plumes (e.g. Port of Brisbane, Cairns, Townsville, Gladstone) • Key tool used in the calibration and validation of numerical modelling
	Water quality measurements (fixed or profiles) using: • *in situ* turbidity measurement instrument • grab samples for laboratory analysis of total suspended solid (TSS) concentrations and particle size distribution • LISST instrument for in situ measurement of the density of different particle fractions	• Precise measurements of turbidity and TSS concentrations (all sediment fractions) and the particle size distribution of suspended sediments	**Vessel-based profiles** • No. dimensions: 1D profile through the water column • Spatial resolution: measured in cms • Spatial extent: profiles typically extent from surface to near bed • Temporal replication: Single measurement in time **Fixed instrument:** • No. dimensions: one point in space (fixed instrument) • Spatial resolution: N/A • Spatial extent: N/A • Temporal replication: User defined, can be seconds to minutes	• Provides precise measurements of fine (and other) sediment concentrations at a point in time (profiles) or space (fixed instruments) • Profile data can provide data to calibrate ADCP measurements (see above) • LISST can provides continuous measurements of fine sediment fractions discharged to the environment via tailwater	**Vessel-based profiles:** • Snap-shot • Requires significant sampling effort to measure changes in the horizontal axes • One dimensional, therefore does not provide an estimate of total quantity of fine sediment in a dredge plume **Fixed instrument:** • LISST instrument is relatively expensive and requires regular maintenance • Turbidity is a surrogate estimate of all sediment fractions • Grab samples require high labour effort	• Routinely used to monitor dredge plume behaviour (e.g. Port of Brisbane, Cairns, Townsville, Gladstone) and calibrate numerical modelling and/or ACDP-based measurements • Turbidity loggers routinely used to continuously measure sediments in tailwaters (e.g. Sunshine Coast Airport, Port of Brisbane Future Port Expansion Area)

Category	Approach	What Is Assessed?	Spatial and Temporal Context	Advantages	Limitations	Case studies
Modelling of Sediment Concentrations Released into the Environment	Numerical modelling of suspended sediments	• Predictions of suspended sediment concentrations generated by dredging	• 3-dimensional modelling, spatial resolution measured in metres • Output time-steps determined by user (typically 15 minute intervals)	• Provides precise estimates of fine (and other) sediment concentrations at appropriate spatial and temporal scales • Can be calibrated to episodic field measurements and can help 'fill the gaps' in discrete transect measurements • Allows hindcasting of entire dredging programs	• Predictive rather than measured • For most reliable results should be calibrated to location and dredge-methodology specific measurements	• Most dredging and disposal projects in Australia • Calibrated model has been developed for the Port of Cairns

3 Fine Sediment Methodology

3.1 General Approach

Based on the review of literature and previous studies, this section outlines the Fine Sediment Methodology (FSM) proposed for approval under Condition 8. The proposed FSM framework is presented in Figure 3-1.

In developing the FSM design, the following general principles have been considered and applied:

- An existing 3D hydrodynamic and water quality numerical model will be used for the FSM. The numerical model is fit for purpose and has been subject to third party peer review as part of the Cairns Shipping Development EIS process;
- The existing model will be updated for the FSM, using:
  - Actual dredge logs (hypothetical dredge logs were used in the EIS);
  - Actual tailwater discharge data (flow volumes and quantities of fine sediment fractions);
  - Pre- and post dredge bathymetry data for the dredge channel to calculate the actual volume of fine sediment removed;
  - The most up to date geotechnical data for the dredge site;
- A robust field data collection program using industry accepted and proven methods will be required to inform numerical modelling assessments;
- Multiple sampling methods and approaches are proposed in order to ensure multiple sources of data to inform the results. Water samples will be collected and taken for laboratory analysis in parallel with field based in-situ instrumentation and the results compared against modelled outputs. The proposed methods are consistent with existing plume monitoring approaches used at the Port of Cairns and elsewhere in Australia, but with the novel inclusion of laboratory analysis of particle size distribution of suspended sediments.
- Outputs from the numerical modelling, in combination with interpretation of field data, will then be interrogated to calculate the quantity of fine sediment fractions returned to the environment.

In undertaking and implementing the FSM, it is recognised that:

- There will need to be a high degree of coordination between the FSM field sampling and measurements (likely undertaken by a consultant) and the dredge contractor. It is recognised that the two dredge vessels undertaking the works (as discussed previously) are likely to be operating at the same time in different parts of the dredge footprint during the construction period and the monitoring design will need to take this into account;
- The timing of sampling events will need to take into account representative weather and tidal conditions and/or conditions that are most suitable for obtaining the required data (for example, not undertaking measurements when naturally turbid background conditions in Trinity Bay could be masking dredge-related impacts);

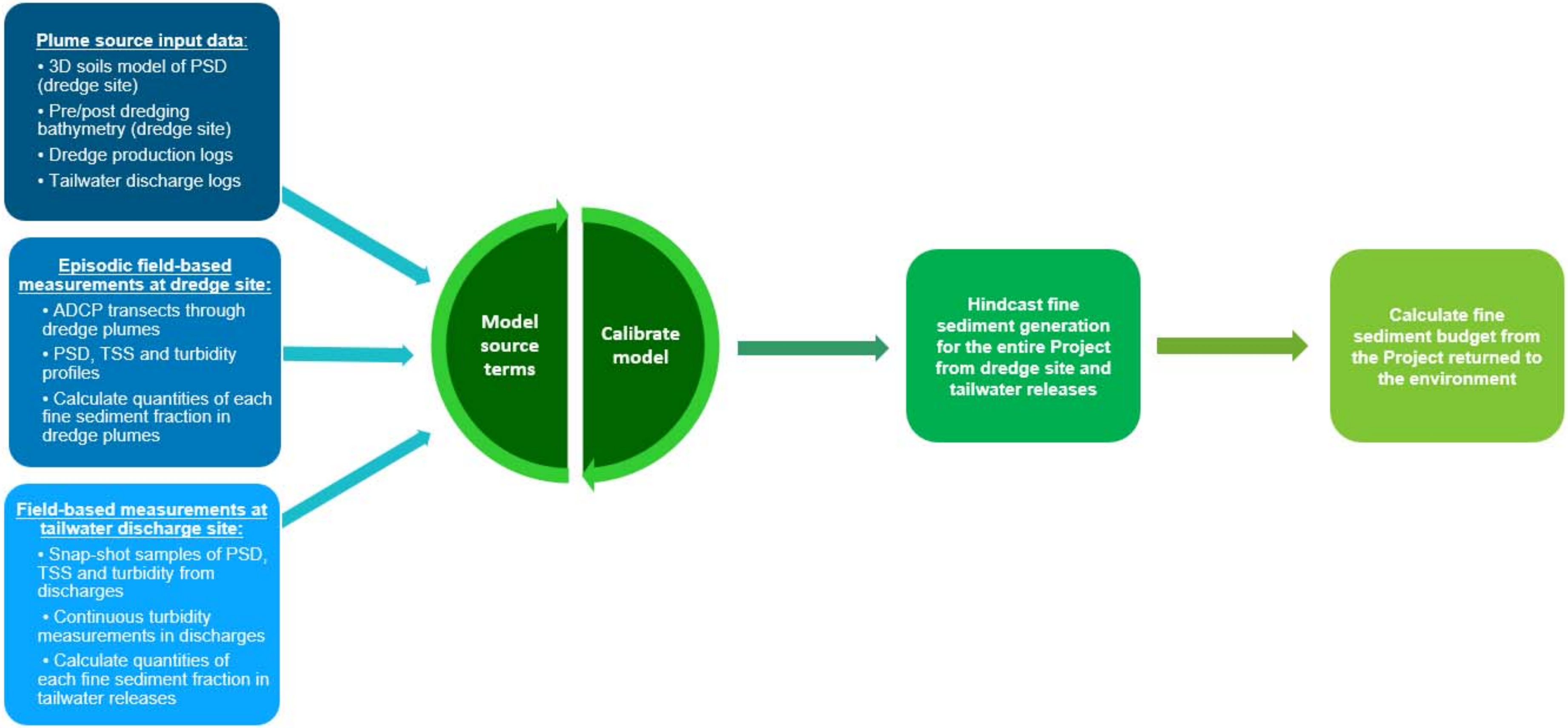

Figure 3-1 FSM Framework

- Geotechnical analysis indicates that there are differences in the distribution of sediment size fractions within and across the sediment types in the dredge areas. It is critical that sampling be designed and timed to provide representative samples of the different fine sediment types, especially the areas of stiff clays (that will be subject to environmental offsets based on the FSM calculation), which again requires the coordination between Ports North, the field team and the dredge contractor, and a review of geotechnical logs.
- Use of untested or untried equipment and technology is generally not proposed in the FSM given the need to ensure a robust and accurate validation of fine sediment release and in order to achieve the proposed project programme (with dredging set to commence in mid-2019).

The general FSM framework presented in Figure 3-1 will be applied to all project components, i.e. stiff clay dredging, soft clay dredging and tailwater discharges. There are however differences in the field data collection approaches for each of these components, in response to the following factors:

- Fixed versus moving sediment sources. It is not practical to install fixed instruments at the dredge sites as (i) both the backhoe and TSHD dredgers will move along the dredge channel to undertake works, and (ii) less critically, the dredge site is subject to tidal water movements. The tailwater discharge pipe is at a fixed location and it is therefore practical to install fixed instruments.
- Differences in dredger and plume movements. The backhoe dredge would generally operate from a more or less fixed location, thus plume generation would (by comparison with TSHD), be comparatively small scale and cyclic as the backhoe grabs a load of sediment from the seabed and is drawn through the water column to the water surface and above to be emptied in a waiting hopper barge. By comparison, the THSD is capable of generating a much larger continuous plume as it travels at slow speeds dredging and subsequently overflowing along an entire reach of the channel alignment.

The field data collection programs for each component are described in Section 3.2, and the generic modelling approach used to derive fine sediment calculations for the whole project is summarised in Section 3.3.

3.2 Field Methodologies

3.2.1 Stiff and Soft Clay Dredging

Methodology

The methodology for the measurement of the fine particle sediment returned to the environment from the dredging of stiff and soft clays would involve a program of vessel-based dredge plume monitoring to directly inform plume model validation. The suspended sediments disturbed by dredging would be identified using vessel-based acoustic and optical backscatter, turbidity, TSS and particle grain size measurements from within the dredge plumes on several occasions, corresponding to different tidal conditions and at different stages of the dredging project.

The main differences between the stiff clay dredging and soft clay dredging are expected to be the comparative larger size and the higher initial sediment concentration of the TSHD plumes. These features will require the monitoring vessel to cover a wider spatial area for measurement and quantification of the dredging plumes and to undertake the measurements over a longer time frame to account for the initial sediment concentrations and subsequent settlement times required to account for reduced plume turbidities to near background concentrations. Additionally, there will be a need to confirm the potential sediment losses from the TSHD at the pumped discharge mooring. These losses are presently expected to be comparatively small or nil.

The monitoring vessel would be equipped with an Acoustic Doppler Current Profiler (ADCP) which, when configured in backscatter echo intensity mode, allows the user to see in real time a surrogate of the suspended particle concentrations within the water column below the vessel. By undertaking cross and long section transects, the plume which may not be totally visible from the surface, will be located and its 3-dimensional characteristics measured. The ADCP would be configured with real time navigation data from a differential GPS as well as the ADCP's own inertial navigation system so that recorded backscatter intensities would be time tagged and spatially located in real earth coordinates. The collected data would be stored in an electronic file format for future playback and review.

The vessel-based plume monitoring will include the following ensemble of measurements:

- Water column profiles throughout the water column with turbidity and optical backscatter measurement instruments.
- Co-located water grab sample collection, throughout the water column (surface, mid and near-bed) for the analysis, TSS and laser-diffraction PSD analysis, with the fine particle sediments determined from the particle size analysis of collected water samples and/or by direct profiling measurements from a laser particle sizing instrument; and
- ADCP measurements, including backscatter echo intensities.

The same measurements will be conducted before, during and after dredging during each sampling campaign, and it is envisaged two sampling campaigns would be conducted (depending on locations of dredging and whether representative samples of stiff clays have been captured).

ADCP backscatter data and turbidity will be reviewed by field operators in real-time to accurately locate the survey vessel in the plume and as an initial check of data quality. It is anticipated that the dredge plume will be followed with the prevailing current and several cross and longitudinal transects conducted through the turbid plume generated by the dredging, which includes plumes both with and outside the dredge footprint. The collected data will provide a comprehensive time varying picture of the before, during and after suspended sediment concentrations at the dredging areas for initial sediment loading and model validation purposes. It would be desirable to undertake such measurements on at least one spring range flooding and ebbing tide, providing that this ties in with the dredging schedule.

It is expected that plume validation monitoring would be undertaken for each distinct capital dredging equipment type at different times through the dredging programme. Hence the BHD (used for dredging of stiff clays) and the TSHD (used to remove soft silts and clays) would be the focus of targeted plume monitoring at different times and locations. Given the overall channel length and variation in sediment properties, it is expected that targeted plume monitoring should occur for different dredging locations, possibly at different times, e.g.:

- Inner channel and swing basin reach;

- Mid channel reaches, and
- Sea channel reaches.

Targeted plume validation monitoring would occur on several separate occasions each involving around three days of field measurements to capture plume advection and dispersion behaviour under a range of tidal conditions. The difference in methodology required for the different capital dredging plant employed for the hard and soft clay removal will ultimately come down to differences in the mobility of the dredging plant and the associated size of the dredging plumes of sediment.

Outcomes Expected

- Calculation of empirical relationships between TSS, turbidity, particle grain size and acoustic backscatter.
- Characterisation of the temporal and spatial patterns of plumes generated by dredging.
- Calculations of the proportion of different sediment fractions in dredge plumes and ambient.

3.2.2 Tailwater Discharge

The placement of the dredge material on land will involve the fluidisation of the dredge material for its transport via pipeline from the TSHD hopper to the Northern Sands Dredge Material Placement Area (DMPA). The supernatant tailwater that is associated with fluidisation will need to be managed and will be monitored prior to discharge from the DMPA into the Barron River in accordance with water quality performance limits set by environmental permits and authorities.

The tailwater discharge FSM will involve the following:

Methodology

It is proposed to monitor the discharge from the DMPA into the Barron River using a recording turbidity measuring instrument which would be permanently positioned into the discharge for the duration of dredging, placement and discharge activities. The instrument would be equipped with a wiping mechanism to keep the submersible sensor optics clear of debris, slimes, or biofouling. Turbidity sensors respond well to suspensions of fine particles (in the particle size range less than 15 µm) (Guillen *et al*. 2000; Merten *et al*. 2014; Urich *et al*. 2015) and are therefore a suitable tool for examining time varying discharge and loss of fine sediment from the Dredged Material Placement Area. The instrument could either be downloaded on a weekly basis, or as needed, the recorded turbidity data could be telemetered in near real-time as a check on the performance of the dredged material placement area to detain and store fine sediment.

In addition to continuous turbidity measurements, grab water samples will be collected for the laboratory analysis of TSS and particle grain size distribution of suspended sediments. Correlation analysis will be undertaken to establish empirical relationships between the quantity of fine particles, TSS and turbidity. Together with flow rate data, the estimated fine sediment discharge over time will be based upon the integration of the particle size distribution(s) factored according to the turbidity time series measurements as a surrogate of fine sediment concentrations in the discharge.

Outcomes Expected

- Continuous records of turbidity in discharge waters, and episodic ‘grab’ samples for analysis of TSS and particle grain size.
- Calculation of empirical relationships between TSS, turbidity and particle grain size.
- Calculations of the mass of different sediment fractions in discharge waters.

3.3 Modelling Approach

An extensive description of the numerical model for Trinity Inlet and Trinity Bay and associated calibration and validation information was assessed as part of the Revised EIS for the CSDP including independent third-party review.

As part of the FSM an additional detailed calibration exercise would be undertaken for the model to determine the ‘best fit’ dredge plume source terms to match the field measurements described in Section 3.2.

The updated model with calibrated source terms can then be used to undertake a hindcast that would cover the full duration of dredging by both vessels undertaken during the CSDP using dredge logs and similar information supplied by Ports North and the dredge contractor.

Additional validation of the model would also be undertaken using the fixed instruments deployed at sensitive receptor and reference locations as part of sensitive receptors monitoring programme required under other conditions of the EPBC controlled action approval.

The validated hindcast plume model simulation of the entire Project would form the basis for accounting the fine sediment spill quantities.

The fine sediment spill modelling would also be configured so that questions about the longer-term fate of plume sediment and interaction with sensitive receptors can be answered, including the use of Lagrangian particle methods which will allow for tracking of particle ‘age’ (time since seeding) and ensure that particles are not ‘double-counted’.

The evaluation of the relative success of individual estimation pathways will be undertaken at project completion.

4 Peer Review

4.1 Peer Reviewer

A peer review of this report has been undertaken by Dr Alistair Grinham from the University of Queensland. Dr Grinham's biographical information is summarised below:

Dr Grinham has over 20 years' experience in monitoring sediment dynamics of rivers, estuaries and coastal systems. Alistair joined the School of Civil Engineering in June 2007 to develop environmental monitoring systems to better understand sediment transport and biogeochemical processing in freshwater and coastal aquatic systems. Alistair employs a multi-disciplinary approach using traditional campaign-style monitoring programs along with advanced autonomous monitoring systems to ensure data collection occurs at appropriate spatial and temporal scales. These award winning monitoring systems have been successfully applied to water quality and sediment investigations across a diverse range of water bodies, including over 15 years of ongoing programs in coastal and coral reef systems. Research areas covered during this period include: tracking environmental pollutants from source to sink; identifying sediment transport pathways; tracking sediment plumes from point sources; and, characterising benthic sediment distribution. A key strength is Alistair's ability to develop long-term industry research partnerships which he was internationally recognised for his role in leading the $2 million "Developing Port Growth – The University of Queensland and Port of Brisbane Pty Ltd Research Partnership." Alistair has over 50 peer-reviewed scientific articles and more than 50 successfully completed industry projects with a strong focus on monitoring sediment dynamics in aquatic environments.

A copy of Dr Grinham's CV is contained in Appendix A and he is considered a *suitably qualified person* in the accordance with the controlled action approval definition which is as follows –

Suitably qualified person means a person who has professional qualifications, training, skills and or experience related to the nominated subject matter and can give authoritative independent assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods and or literature.

4.2 Peer Review Comments

Dr Grinham's full peer review report is contained in Appendix B. A summary of the points raised and how they have been addressed in this report are contained in Table 4-1.

Table 4-1 Peer Review Comments and How They Have Been Addressed

Peer Review Comment	How Addressed in the FSM	Where Addressed?
Provide additional justification around the spill loss rate for BHD	The BHD 3% fines spill rate was based on advice contained in a Pro-Dredge technical memorandum (dated: 19/08/2014) – refer to Section 1.3.3.1. An independent estimate 0f 0-4% for BHD 'bucket drip' is provided in Becker et al. (2015). *Estimating source terms for far field dredge plume modelling.* Journal of Environmental Management 149 (2015) 282-293.	No action undertaken

Peer Review Comment	How Addressed in the FSM	Where Addressed?
	The BHD value will be field tested, validated and if necessary revised for use in the final spill estimates as part of the proposed FSM scope – refer to Section 3.3 (second paragraph) The BHD will target stiff-clay in-situ material while the TSHD will target overlying soft material. The fine spill component requiring an offset in the EPBC conditions is specifically linked to the stiff-clay in-situ material. The field monitoring of BHD operations should therefore specifically target operations in stiff-clay material.	
Include the evaluation of the relative success of individual estimation pathways at project completion	The recommended evaluation has been included in the FSM.	Section 3.3
Fix minor typos and standardise the units	Document has been updated.	Sections 1.1, 1.2, 1.3, 2.3, 3.2

5 References

Beecroft R, Grinham A, Albert S, Perez L (2019) Suspended sediment transport in context of dredge placement operations in Moreton Bay, Australia. Journal of Waterway, Port, Coastal and Ocean Engineering 145.

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Federal Interagency Hydrologic Modelling Conference and the 10th Federal Interagency Sedimentation Conference'. (Reno, Nevada)

Appendix A Peer Reviewer CV

Dr. Alistair Grinham

School of Civil Engineering

Dr. Alistair Grinham
Senior Research Fellow
School of Civil Engineering
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PROFESSIONAL EXPERIENCE

Dr Alistair Grinham has over 20 years' experience in monitoring sediment dynamics of rivers, estuaries and coastal systems. Alistair joined the School of Civil Engineering in June 2007 to develop environmental monitoring systems to better understand sediment transport and biogeochemical processing in freshwater and coastal aquatic systems. Alistair employs a multi-disciplinary approach using traditional campaign-style monitoring programs along with advanced autonomous monitoring systems to ensure data collection occurs at appropriate spatial and temporal scales. These award winning monitoring systems have been successfully applied to water quality and sediment investigations across a diverse range of water bodies, including over 15 years of ongoing programs in coastal and coral reef systems. Research areas covered during this period include: tracking environmental pollutants from source to sink; identifying sediment transport pathways; tracking sediment plumes from point sources; and, characterising benthic sediment distribution. A key strength is Alistair's ability to develop long-term industry research partnerships which he was internationally recognised for his role in leading the $2 million "Developing Port Growth – The University of Queensland and Port of Brisbane Pty Ltd Research Partnership." Alistair has over 50 peer-reviewed scientific articles and more than 50 successfully completed industry projects with a strong focus on monitoring sediment dynamics in aquatic environments.

EDUCATION

2007 **PhD Environmental Engineering** ***The University of Queensland, Australia***
Thesis title: Downstream effects of land use on shallow-water benthic microalgal communities in Moreton Bay, Australia and Marovo Lagoon, Solomon Islands
1997 **BSc Hons Rhodes** ***University, Grahamstown, South Africa*** Marine Biology

APPOINTMENTS

2013 – present Senior Research Fellow, School of Civil Engineering, UQ
2007 – 2013 Research Fellow, School of Civil Engineering, UQ
2004 – 2007 PhD Scholar, School of Civil Engineering, UQ

RESEARCH AWARDS

2017 - Partners in Research Excellence Awards (PIREA) for Outstanding Industry-Research Partnership – **Winner**
2017 - Universitas 21 AGM and Presidents Conference 2017 for Industry-Research Case Study – **High Commendation**
2016 - South East Queensland's Healthy Waterways Research Award – **High Commendation**
2010 - Engineers Australia Excellence Research Award – **High Commendation**
2010 - Asia Pacific ICT Alliance (APICTA) for Research & Development – **Merit Award**
2010 - Australian ICT Industry Association National iAward for Research & Development - **Winner**
2009 - South East Queensland's Healthy Waterways Research Award – **Winner**

RECENT PUBLICATIONS

Beecroft, R., **Grinham, A.,** Albert, S., Perez, L. and Cossu, R. (2019) Suspended sediment transport in context of dredge placement operations in Moreton Bay, Australia. *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 145 2: 05018011. doi:10.1061/(asce)ww.1943-5460.0000503

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For complete publication list see: http://researchers.uq.edu.au/researcher/1446

SYNERGISTIC ACTIVITIES

Dr Grinham is ideally suited to the turbidity plume tracking and environmental risk components of the proposed work, recent government or industry projects that focus on these include the following**:**

- 2017 – Tidal Energy in Australia - Assessing Resource and Feasibility to Australia's future energy mix. **Australian Renewable Energy Agency.**
- 2016 - Rapid Assessment of Metapona River Mouth, Tetere Bay, Solomon Islands. **Solomon Islands Government Ministry of Environment.**
- 2016 - Water and Sediment Quality Assessment Downstream of Gold Ridge Mine, Solomon Islands. **Solomon Islands Government Ministry of Environment.**
- 2015 – Moreton Bay sediment baseline study. **Healthy Waterwats Pty Ltd.**
- 2014 – Jejevo/Isabel B Project Marine and Sediment Quality Baseline. **Golder Associates Pty Ltd.**
- 2015 – University of Queensland and Port of Brisbane Pty Ltd Research Partnership. **Port of Brisbane Pty Ltd.**
- 2014 – Acid sulfate potential of coffee rock formations in the North West Channel. **Port of Brisbane Pty Ltd.**
- 2013 – Integration of Autonomous Underwater Vehicles and Remote Satellite Sensing for Automated and Persistent Monitoring. **CSIRO Flagships Collaboration Fund.**

For complete grants list see: http://researchers.uq.edu.au/researcher/1446

Appendix B Peer Review Report (in full)

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February 28, 2019

Alan Vico
Ports North
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Dear Alan

Re: Peer review of Fine Sediment Methodology for the Port of Cairns Shipping Development Project

As requested, I have completed a technical review as to the adequacy of the proposed fine sediment methodology and identified specific changes to be made. The proposed methodology for quantifying the fine sediment returns to the environment from the dredging of stiff and soft clays as well as the tailwater discharge is adequate. The strengths of proposed approach by BMT is in utilising a number of different pathways to estimate the fine sediment return to the environment, this is prudent for estimating losses in such complex environments. In addition, the proposed methodology acknowledges the inherent uncertainty in quantifying fine sediment returns from dredging operations and provides an appropriate, conservative estimate for each dredge method as well as the tailwater discharge.

To separate the relative contributions of material during a dredging campaign is an extremely challenging undertaking, particularly in shallow, high energy coastal zones. The high current velocities experienced within the shipping channel will be an important consideration for the field monitoring as these have the potential to transport fine sediment over extended distances during a single tidal cycle. Ambient wave conditions will potentially complicate the field monitoring component through resuspension of natural bed sediments. Capturing the range of ambient wave conditions as well as monitoring across tidal stages will be an important component of the field monitoring program to determine the relative contribution of external sediment transport dynamics.

The proposed field sampling relies on the use of proven methods in which BMT clearly has the necessary expertise to obtain meaningful validation datasets. The use of emerging monitoring techniques, for example drones or the submersible laser-diffraction instrument (LISST), are mentioned as these can provide useful additional data such as in situ floc size. However, in the case of the LISST, the instrument itself has several limitations in terms of maximum suspended sediment concentration and upper particle dimeter cut-off and given the opportunistic nature of the field sampling it is more prudent to concentrate on proven methods to ensure high quality field data is obtained.

With regards the preliminary estimates of fine sediment returns to the environment:

- The spill rate of 3% is a critical assumption in the sediment return calculation for the backhoe dredging operations, how was this rate decided upon? Given the nature of dredge material this is likely a valid assumption but for softer material the spill rates have been estimated to be as high as 9%. It is acknowledged the inclusion of a 1.5 safety factor and rounding up the expected fine sediment return mass provides a more conservative estimate but this assumption requires further justification.

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- The TSHD spill rate is assumed to range between 7-15% which would cover the expected range given the nature of this dredged material. The additional 1.5 safety factor ensures this represents a conservative estimate of fine sediment return from the TSHD dredging.

- The tailwater fine sediment return estimate is also conservative as tailwater discharge very seldom exceeds 50 mg/L TSS unless there is significant wind fetch over the dredge placement area. The Northern Sands Dredge Material Placement Area, identified in this proposal, has less than 1 km fetch in all prevailing wind directions and is unlikely to generate high TSS concentrations during placement operations.

The proposed modeling approach is state-of-the-art and will provide a useful integration tool for the field data. Another strength of the model approach is to provide the water movement volumes that will be critical in scaling the spot field measurements across the dredge campaign.

At project completion the relative success of individual components of the Fine Sediment Methodology (FSM) should be evaluated. This is implicit in the current proposal but it would useful to state this directly as it will guide methodological choices associated with the estimating fine sediment return to the environment for future dredging projects.

Specific changes to respond to are detailed below:

1. Provide additional justification around the spill loss rate for BHD,
2. Evaluation of the relative success of individual FSM components at project completion,
3. Fix minor typos and standardise the units as suggested in the attached draft.

In summary, this methodology will provide a useful comparative approach capable of providing a defensible estimate of soft and stiff clay returned to the environment. The proposal acknowledges the limitations of current monitoring practices and identifies there is a need to refine the approach, this is of value as ports work to accommodate future increases in vessel length and draft.

Yours sincerely,

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Appendix B Seagrass Validation Monitoring

Seagrass Monitoring Program for the Cairns Shipping Development Project: 2018 - 2021

Project coordinator: Skye McKenna

Key personnel:

Dr Alex Carter

Carissa Reason

Dr Michael Rasheed

Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER)

James Cook University

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Phone : (07) 4781 4262

Email: seagrass@jcu.edu.au

Web: **www.tropwater.com**

1. Program Summary

The seagrass monitoring program involves:

- Continuing the annual ambient seagrass monitoring program for the next 3 year cycle (2019 – 2021);
- Building on the ambient monitoring scope to satisfy monitoring requirements for the CSDP by:
    - o Additional sampling effort to the contracted 2018 monitoring survey to incorporate assessments of new areas to be dredged outside of existing marine plant permit area (2018);
    - o Expand annual monitoring to incorporate whole of port seagrass assessments before during and post development (2019 – 2021);
    - o Incorporate quarterly meadow monitoring of the two (2) major areas of seagrass adjacent to the shipping channel (Esplanade and Bessie Point seagrass meadows) during 2019 when dredge operations are expected to occur;
    - o Continue benthic light (photosynthetic active radiation (PAR)) monitoring in the two (2) major areas of seagrass adjacent to the shipping channel (Esplanade and Bessie Point seagrass meadows) (2019 – 2021).
    - o Continue and expand annual seagrass seed and seed viability assessments in the two (2) major areas of seagrass adjacent to the shipping channel (Esplanade and Bessie Point seagrass meadows) (2019 – 2021).

2. Background & Scope of works

Ports North is proposing to upgrade the Port of Cairns to improve shipping access and accommodate a larger class of cruise vessels. The Cairns Shipping Development Project (CSDP) will involve:

- Dredging to widen and deepen the existing outer shipping channel (Trinity Inlet);
- Widening and deepening of the existing inner harbour channel and Crystal swing basin;
- Establishment of a new shipping swing basin (Smith's Creek swing basin) to enable future expansion of the HMAS Cairns Navy base;
- Upgrade of the existing cruise shipping wharves (Trinity wharves 1 to 5);
- Partial demolition of wharf 6 to allow for extension to wharf 5;
- Relocation and installation of new navigational aids.

These upgrades within the port have the potential to impact a range of marine values, including water quality within Trinity Inlet and Trinity Bay, and significant sensitive habitats such as seagrass and coral (Environmental Impact Statement (EIS) 2017; Coordinator General’s evaluation report on the environmental impact statement (Coordinator General’s report) 2018). Water quality modelling conducted as part of the CSDP EIS predicts that seagrass meadows immediately adjacent to the channel are either in the zone of low to moderate impacts, or the zone of influence.

As part of their commitment to the environmental health of the port, Ports North in partnership with James Cook University’s TropWATER Seagrass Ecology Group have been engaged in a seagrass monitoring and research program since 2001. This program has involved annual surveys of seagrass in Trinity Bay and

Trinity Inlet, as well as regular (quarterly) assessments of seagrass condition, seed bank density and viability, and benthic light and temperature (continuously logged) since 2012, in preparation for the CSDP.

The annual monitoring program conducted between October and December each year provides a regular update of the marine environmental health of Trinity Bay and Trinity Inlet, and an assessment of seagrass condition and resilience to inform port management. The annual monitoring program has mapped up to 1480 ha of seagrass in Trinity Bay and Trinity Inlet in one survey year (2007), with the most recent survey (2017) reporting that seagrass meadows in Trinity Bay were in a satisfactory condition, while seagrasses in Trinity Inlet were in a poor condition (Reason and Rasheed 2018) (Figure 1). As the annual monitoring program only examines a sub-set of representative seagrass meadows, an updated baseline survey of all of the seagrass in the system is generally conducted every three years (2012, 2015, 2018).

As part of preparations for the CSDP, Ports North commissioned TropWATER to conduct updated seagrass surveys in the area before any dredging is to commence to determine the presence/absence and extent of seagrass in the area to assess potential impact to seagrass. Additionally, regulator recommendations and requirements outline a re-assessment of seagrass habitat during, and for at least two years post capital works (Coordinator Generals Report 2018).

This seagrass monitoring program encompasses the seagrass habitat assessments that would occur as part of the ambient long term monitoring program established in 2001, as well as capture expanded areas seagrass assessments to meet increased regulatory requirements associated with the CSDP. The objectives of the program are to:

1. Determine the presence/absence, density and distribution of seagrass within and adjacent to the proposed channel expansion footprint that are not covered by Ports North's existing marine plant disturbance permit <u>prior</u> to capital works (conducted late 2018);
2. Monitor seagrass presence/absence, density and distribution, (light) PAR and temperature adjacent to the proposed channel expansion footprint <u>before</u>, <u>during</u> and <u>after</u> capital works;
3. Monitor seagrass presence/absence, density and distribution <u>after</u> capital works for at least 2 years;
4. Provide information to inform the Reactive Management Programs (RMP) related to water quality and seagrass habitat.

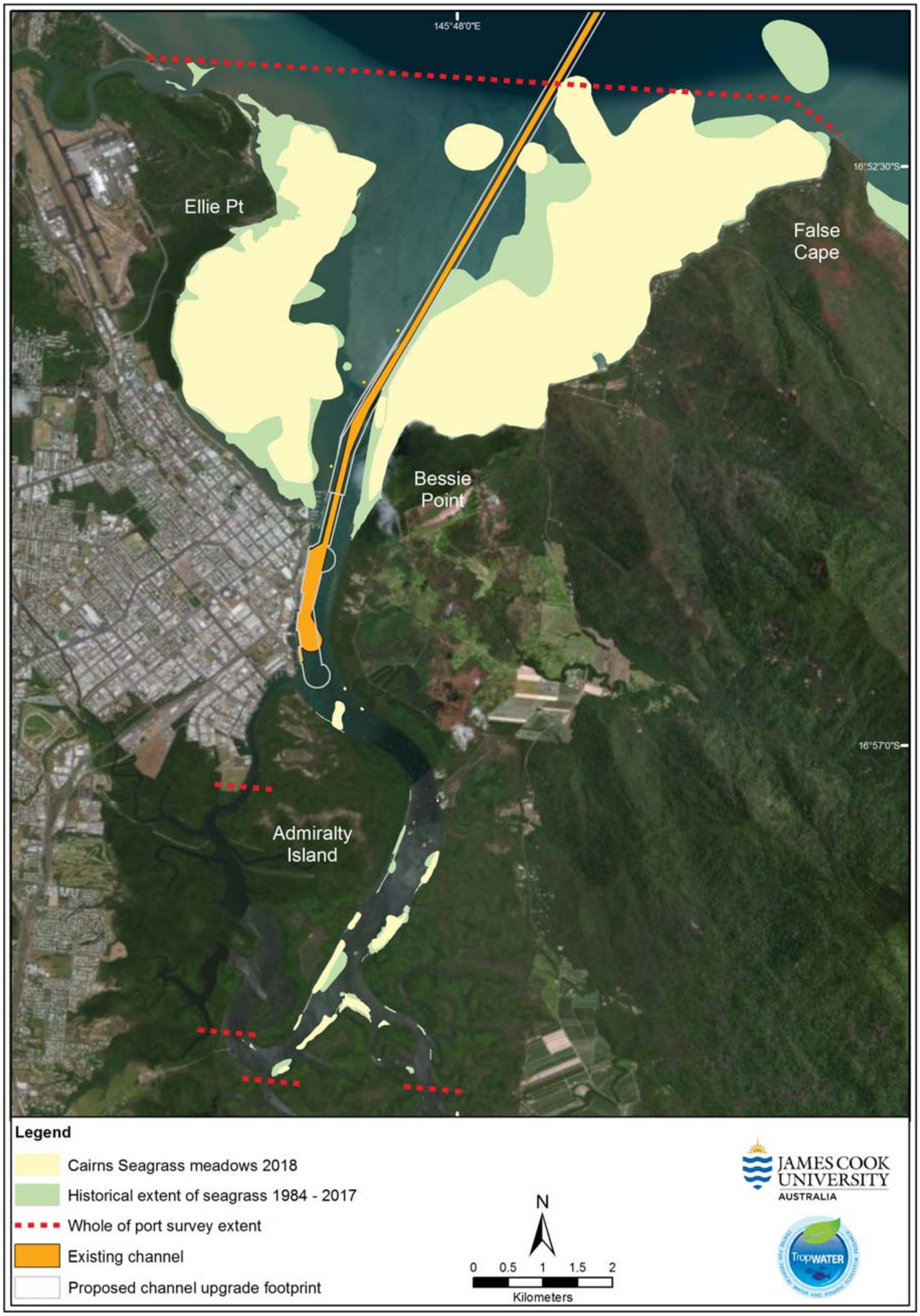


Figure 1. Location of Cairns seagrass meadows 1984 - 2018

2. Sampling approach and methods

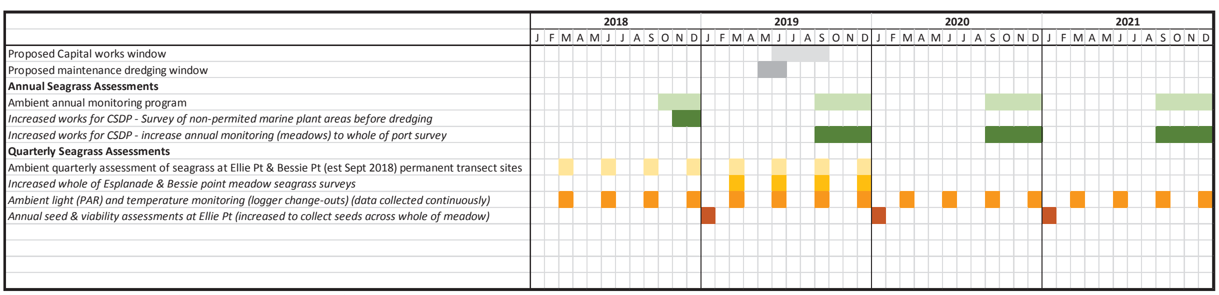
3. Sampling Approach

There are four components to this program:

1. 2018: Seagrass assessments prior to capital works of areas that fall within the footprint of the proposed capital dredging which are not covered by the existing marine plant permit (Figure 2). This is an additional scope to the already contracted seagrass monitoring in the port for 2018.
2. 2019 – 2021: Broad scale, whole of port annual seagrass assessments that encompass surveys before during and after the capital works. These surveys are to conducted in conjunction with the ambient annual monitoring program and expand the scope of these to encompass all seagrass meadows within the port;
3. 2019 – During the capital works quarterly assessments of the major meadows adjacent to the shipping channel (Esplanade and Bessie Point meadows) will be conducted – these will be expanded to whole meadow scale to ensure adequate coverage during the RMP.
4. 2018 – 2021: Quarterly PAR and temperature assessments in a subset of seagrass meadows adjacent to the capital works that encompass surveys before, during and after capital works. These surveys are a continuation of the ambient quarterly monitoring program at Ellie Point and Bessie Point.

A proposed schedule of works & activities is as follows:

Table 1. Schedule of proposed works & activities.



*a larger version of the table can be found in the Appendix

3.1.1 Components 1 & 2: Whole of Port Seagrass Assessments

This program expands the annual ambient seagrass monitoring scope during the CSDP to whole of port seagrass monitoring to ensure adequate coverage of seagrass is completed for assessments of compliance against conditions and for effective inference assessments of seagrass change for the pre, during and post project stages. The ambient program conducts whole of port seagrass assessments once every three years with a subset of the meadows monitored the other two years.

The whole of port monitoring will be conducted in spring/summer (September-December) each year (2018 – 2021). Conducting the assessment at this time of year will enable direct comparisons with previous annual and whole of port surveys. Queensland seagrass communities are seasonal, with maximum distribution and abundance usually occurring in late spring/early summer. It is important to capture seagrass at their seasonal peak to provide the most up-to-date information on seagrass at their maximum extent to correctly inform Ports North, regulators, RMP & Dredge Management Plans (DMP's).

As part of the already scheduled 2018 whole of port survey, an increased intensity of habitat characterisation sites was conducted within the proposed channel upgrade footprint that fall outside the current Ports North marine plant disturbance permit (Figure 2). There was also targeted drop camera work done at specific locations where new channel markers/beacons are required (3 x small blue dots in Figure 2).

Seagrass habitat assessments in the area as part of the CSDP are to be conducted for at least two years after capital works (Table 1) as outlined in the Coordinator General's stated conditions requirements (Schedule 1. G25) and proponent commitment (commitment 42); seagrass to be monitored annually for two years after the 2019 post-dredge survey, to identify any changes to communities as a result of the capital dredging program (State of Queensland 2018).

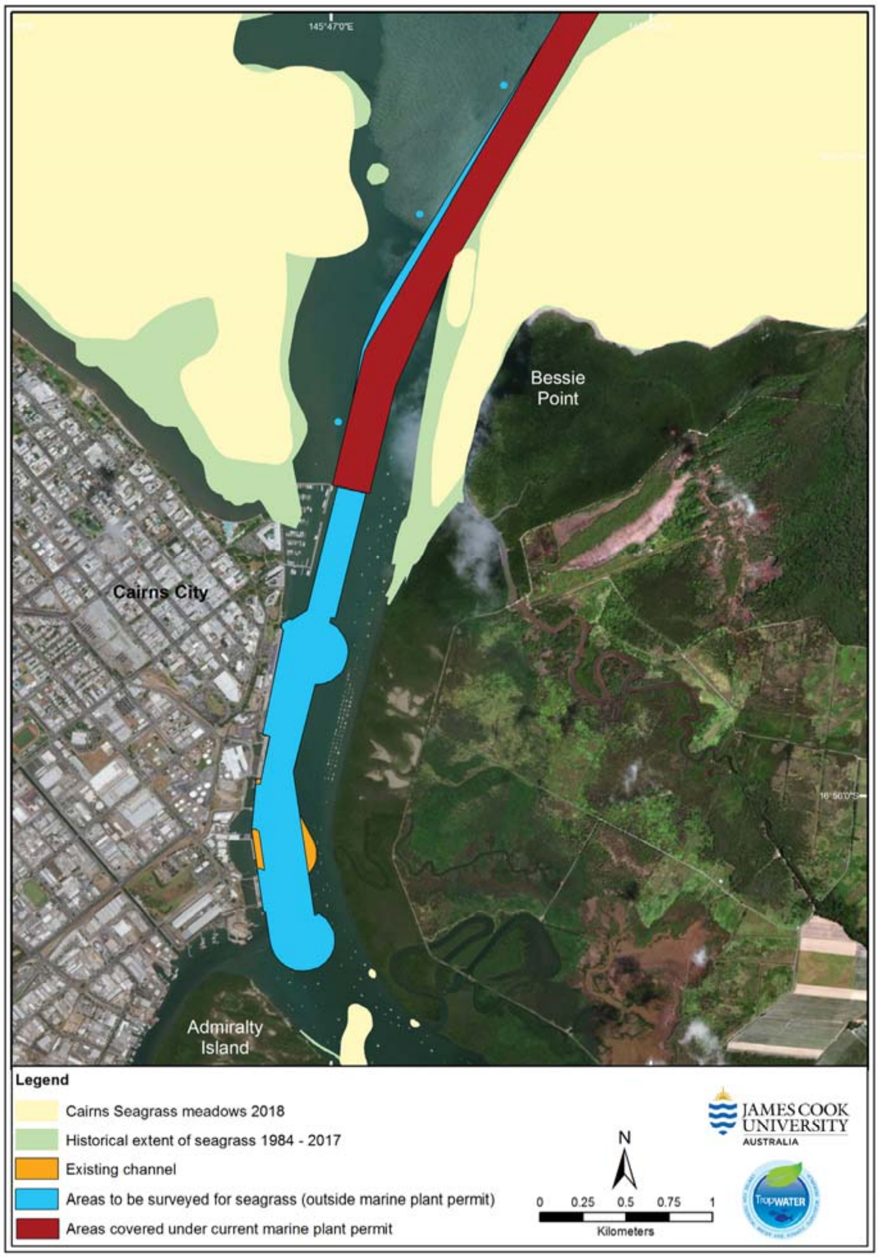


Figure 2. Location of survey areas (blue area) where seagrass habitat assessments were conducted as part of the 2018 whole of port seagrass assessment.

3*.1.2 Component 3: Quarterly seagrass assessments during the dredging program year (2019)*

For 2019, the current quarterly seagrass assessments conducted as part of the ambient program will be expanded to whole meadow scale to better quantify seagrass condition at the key meadows that inform the DMP and RMP during the CSDP. Currently these meadows are assessed at small transect sites near light monitoring stations. This program expands those assessments in 2019 to encompass the whole meadows for the Esplanade meadow (monitoring meadow 34) and Bessie Point meadow (monitoring meadows 11 & 13) (Figure 3). The expanded spatial extent of the monitoring:

- Ensures an appropriate scale for inference assessments of seagrass change. Sampling at this scale avoids the small scale variability that can occur within meadows that could lead to false conclusions on seagrass change during the dredging program.
- Quarterly monitoring of these 2 meadow areas provides regular updates on seagrass condition at the closest meadows to dredging works between scheduled annual surveys
- These meadows encompass both seagrass reference and compliance sites in the Esplanade and Bessie Point meadows assessed as part of the RMP and DMP.

Within this program the quarterly seagrass assessments that have been conducted as part of the ambient program in preparation for the CSDP would be discontinued after the December 2019 permanent transect survey.

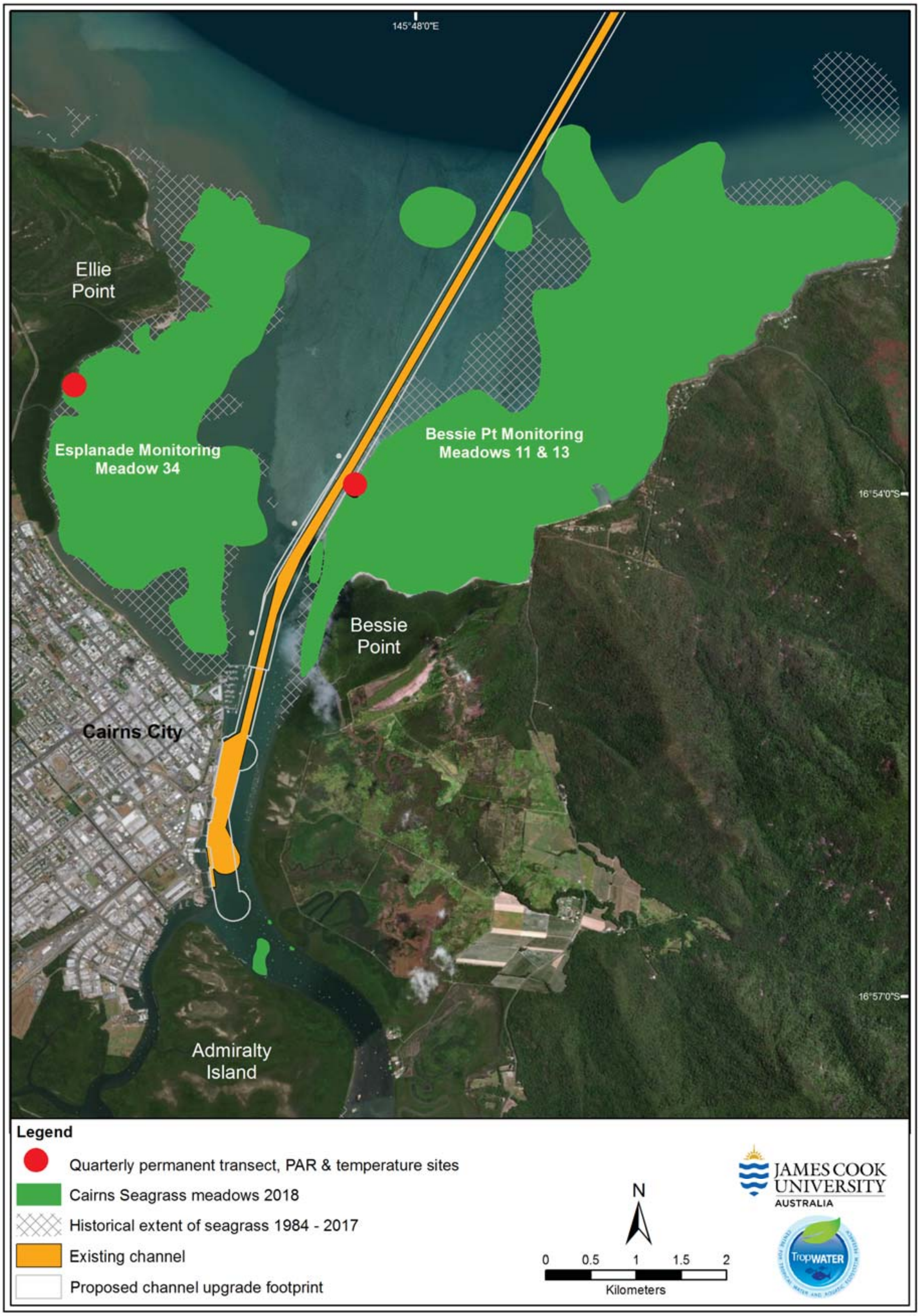


Figure 3. Location of current permanent transect monitoring sites and the expanded seagrass assessment areas (seagrass monitoring meadows 34, 11 & 13) during 2019.

3.1.3 Component 4 - light, temperature and seed bank assessment program

As part of the program, light (PAR) and temperature monitoring will continue to be conducted at the established Ellie Point and Bessie Point sites through to 2021. This information remains critical in interpreting the causes of local seagrass change to inform the long-term seagrass monitoring program. Light is one of the main driving factors in seagrass health and resilience. Costs for PAR monitoring at additional sites or conversion to telemetered data for compliance associated with the CSDP are not included in this program.

Seed density and seed viability data will continue to be collected annually, however we will expand the spatial extent of sampling to collect seeds from both the Esplanade meadow and the Bessie Point meadow with seed cores be collected across the entire meadows, rather than just around the Ellie Point initial recovery site (as currently conducted). Seed bank density and viability are key components of local seagrass resilience and recovery from future major losses that may occur, such as happened in 2011 with Tropical Cyclone Yasi.

4. Sampling Methods

Sampling methods for the program will follow those used in the established Cairns, Mourilyan, Karumba and Thursday Island long-term seagrass monitoring programs.

Two survey methods will be applied depending depth, visibility and logistical and safety constraints:

1. Intertidal areas: Helicopter survey.
2. Subtidal areas: Boat based underwater digital camera mounted on a drop frame.

4.1.1 Intertidal areas

Intertidal areas will be sampled at low tide using a helicopter. Seagrass meadow characteristics will be recorded at sites scattered within the seagrass meadow as the helicopter hovers within two metres above the seagrass (Figure). Seagrass density, cover & species composition, macro-algal cover and sediment types will determined from three random placements of a 0.25m^2 quadrat out the side of the helicopter at each site (Figure 4).

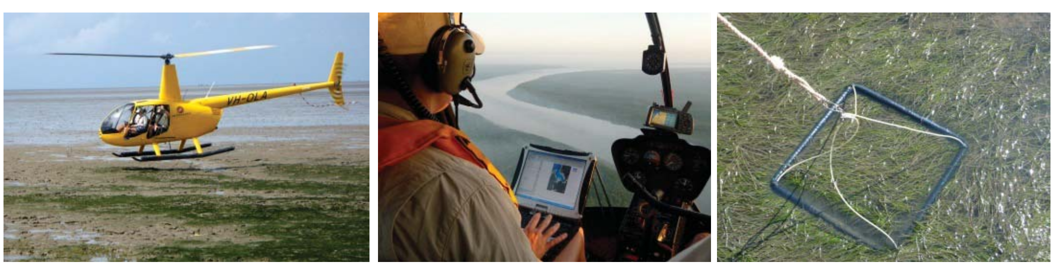


Figure 4: Helicopter intertidal mapping of exposed seagrass meadows at spring low tide.

4.1.2 Subtidal areas

Assessments of subtidal areas will be conducted from a research vessel. An underwater digital camera system with real-time monitor will be mounted to a 0.25m^2 quadrat which provides live images to the surface allowing researchers to record key seagrass and macro-algae information, and sediment type from three random placements of the quadrat (Figure 5). A Van Veen sediment grab (grab area 0.0625 m^2) will also be used at sites to confirm sediment type and species viewed on the video screen (Figure 5).

Figure 5: Subtidal assessments of seagrass using underwater digital camera system and Van Veen sediment grab.

5. Habitat Mapping and Geographic Information System

All survey data will be entered into a Geographic Information System (GIS) database for presentation of seagrass information for the Trinity Bay and Trinity Inlet areas. Satellite imagery of the Cairns area, CSDP CAD and shapefiles, with information recorded during the monitoring surveys will combined to assist with mapping seagrass meadows. Three seagrass GIS layers were created in ArcMap:

- *Habitat characterisation sites* – site data containing above-ground biomass (for each species), dbMSL, sediment type, time, latitude and longitude from GPS fixes, sampling method and any comments.
- *Seagrass meadow biomass and community types* – area data for seagrass meadows with summary information on meadow characteristics. Seagrass community types will be determined according to species composition from nomenclature developed for seagrass meadows of Queensland. Abundance categories (light, moderate, dense) will be assigned to community types according to above-ground biomass of the dominant species.
- *Seagrass landscape category* – area data showing the seagrass landscape category determined for each meadow:

Isolated seagrass patches
The majority of area within the meadows consisted of un-vegetated sediment interspersed with isolated patches of seagrass

Aggregated seagrass patches
Meadows are comprised of numerous seagrass patches but still feature substantial gaps of un-vegetated sediment within the meadow boundaries

Continuous seagrass cover
The majority of area within the meadows comprised of continuous seagrass cover interspersed with a few gaps of un-vegetated sediment.

6. Deliverables and Reporting

- Email report on completion of field tasks;
- Brief report outlining findings of the baseline survey of new dredge areas for the CSDP outside of current Marine plants disturbance footprint January 2019 – completed & delivered
- Updates on quarterly seagrass condition to CDSP Technical Advisory Group meetings
- GIS shapefiles available within 3 months of completion of field work for annual seagrass surveys;
- Draft reports containing seagrass maps, monitoring data and information will be provided within 4 months of completion of all field work for annual surveys;
- Final reports will be provided within 4 weeks of receipt of comments.

7. References

Reason, C. L. and Rasheed, M. A. 2018. Seagrass habitat of Carins Harbour: Annual monitoring report – 2017. Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) Publication 18/09. James Cook University, Cairns, 45 pp.

State of Queensland, D. o. S. D., Infrastructure, Manufacturing and Planning. 2018. Cairns Shipping Development Project: Coordinator-General's evaluation report on the environmental impact statement. Page 330 in I. Department of State Development, Manufacturing and Planning, editor, Brisbane.

8. Appendix – Schedule of works

2018	J	F	M	A	M	J	J	A	S	O	N	D
Proposed Capital works window												
Proposed maintenance dredging window												
Annual Seagrass Assessments												
Ambient annual monitoring program										■	■	■
Increased works for CSDP - Survey of non-permited marine plant areas before dredging											■	■
Increased works for CSDP - increase annual monitoring (meadows) to whole of port survey												
Quarterly Seagrass Assessments												
Ambient quarterly assessment of seagrass at Ellie Pt & Bessie Pt (est Sept 2018) permanent transect sites			■			■			■			■
Increased whole of Esplanade & Bessie point meadow seagrass surveys												
Ambient light (PAR) and temperature monitoring (logger change-outs) (data collected continuously)			■			■			■			■
Annual seed & viability assessments at Ellie Pt (increased to collect seeds across whole of meadow)												

2019	J	F	M	A	M	J	J	A	S	O	N	D
Proposed Capital works window						■	■	■	■			
Proposed maintenance dredging window					■	■						
Annual Seagrass Assessments												
Ambient annual monitoring program									■	■	■	■
Increased works for CSDP - Survey of non-permited marine plant areas before dredging												
Increased works for CSDP - increase annual monitoring (meadows) to whole of port survey									■	■	■	■
Quarterly Seagrass Assessments												
Ambient quarterly assessment of seagrass at Ellie Pt & Bessie Pt (est Sept 2018) permanent transect sites			■			■			■			■
Increased whole of Esplanade & Bessie point meadow seagrass surveys			■			■			■			■
Ambient light (PAR) and temperature monitoring (logger change-outs) (data collected continuously)			■			■			■			■
Annual seed & viability assessments at Ellie Pt (increased to collect seeds across whole of meadow)	■											

2020	J	F	M	A	M	J	J	A	S	O	N	D
Proposed Capital works window												
Proposed maintenance dredging window												
Annual Seagrass Assessments												
Ambient annual monitoring program									■	■	■	■
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Ambient light (PAR) and temperature monitoring (logger change-outs) (data collected continuously)			■			■			■			■
Annual seed & viability assessments at Ellie Pt (increased to collect seeds across whole of meadow)	■											

2021	J	F	M	A	M	J	J	A	S	O	N	D
Proposed Capital works window												
Proposed maintenance dredging window												
Annual Seagrass Assessments												
Ambient annual monitoring program									■	■	■	■
Increased works for CSDP - Survey of non-permited marine plant areas before dredging												
Increased works for CSDP - increase annual monitoring (meadows) to whole of port survey									■	■	■	■
Quarterly Seagrass Assessments												
Ambient quarterly assessment of seagrass at Ellie Pt & Bessie Pt (est Sept 2018) permanent transect sites												
Increased whole of Esplanade & Bessie point meadow seagrass surveys												
Ambient light (PAR) and temperature monitoring (logger change-outs) (data collected continuously)			■			■			■			■
Annual seed & viability assessments at Ellie Pt (increased to collect seeds across whole of meadow)	■											

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