PORT OF WEIPA MAINTENANCE DREDGING

PLAN

MARINE ENVIRONMENTAL MONITORING PLAN

Revised: March 2024

NORTH QUEENSLAND BULK PORTS

PORT OF WEIPA

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1.0 Introduction

1.1 Background

The Port of Weipa is a bulk commodities port managed by the North Queensland Bulk Ports Corporation (NQBP). The Port is located in the Gulf of Carpentaria on the north-west coast of the Cape York Peninsula, approximately 200 km from the northern tip of Australia. The Port is located within Albatross Bay, a large embayment adjacent to the town of Weipa, with the wharves and berths located in the Embley River. The port handles approximately 16 million tonnes of product annually, with a majority of this being bauxite (aluminium ore), currently mined by Rio Tinto at the Rio Tinto Alcan (RTA) mine.

The main shipping channel of the Port (South Channel) is in Albatross Bay and the inner harbour is in the Embley River. The harbour contains approach and departure channels along with four loading berths (Lorim Point East and West, Humbug Wharf and Evans Landing), two of which are dedicated solely to bauxite export, one for importing fuel and oil, and one for importing general cargo (Figure 1.1 and Figure 1.2).

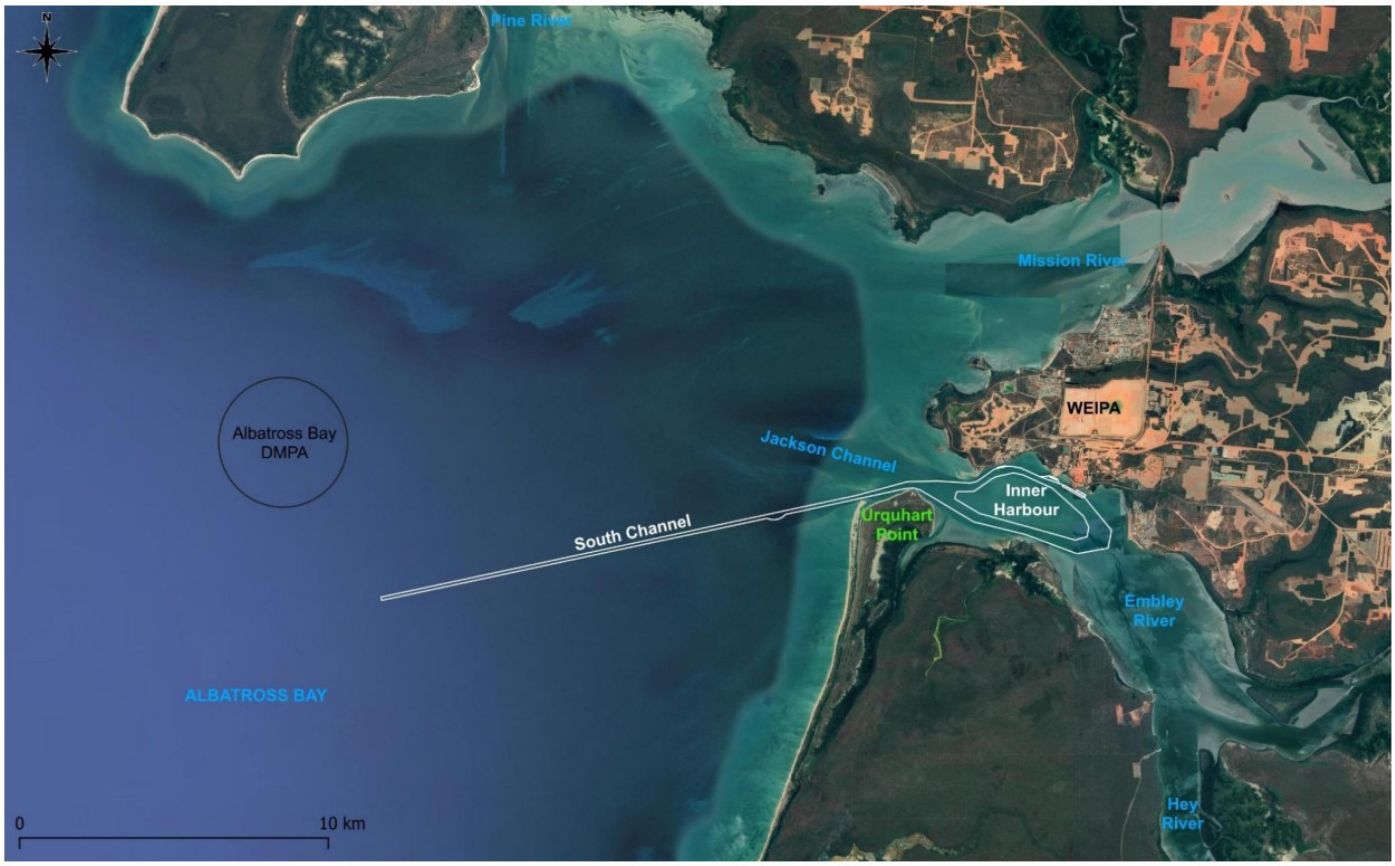

FIGURE 1.1 – PORT OF WEIPA SHOWING SOUTHERN CHANNEL AND INNER HARBOUR

FIGURE 1.2 – INNER HARBOUR SHOWING APPROACH AND DEPARTURE CHANNELS AS WELL AS LOCATION OF BERTHS

NQBP undertakes maintenance dredging and offshore placement activities within the Port of Weipa each year to maintain design depths within the navigational areas.

The environmental values surrounding the Port of Weipa have been extensively examined over a number of years for previous project approval processes and monitoring plans. The Port also undertakes non-project related monitoring that provides an ongoing understanding of the long-term ambient environmental conditions. This monitoring currently focuses on marine water quality, seagrass and invasive marine pests.

1.2 Purpose

This document provides details on the monitoring commitments relating to maintenance dredging activities at the Port of Weipa.

The marine monitoring outlined in this document is aimed at ensuring that best practice environmental management is applied to the design and execution of maintenance dredging at the Port of Weipa.

The specific aims of this monitoring plan are to:

- Assess the long-term ambient environmental health of the Port and nearby sensitive receptors and allow for the effective management of dredging and placement operations.
- Detect any impacts from maintenance dredging, both immediately after dredging campaigns and over time.
- Respond to real time environmental conditions during maintenance dredging to prevent unpredicted environmental impacts from maintenance dredging and placement.
- Collect data that will be used to drive continual improvement.

1.3 Relationship to other documents

This document supports the *Port of Weipa Long-term Maintenance Dredging Management Plan (2020-2030)* (LMDMP) and provides details on the marine monitoring requirements established under that Plan. The LMDMP sets out the process by which the results of the monitoring will be reviewed, analysed and reported.

This monitoring plan has been developed in line with the findings of the *Port of Weipa Maintenance Dredging – Environmental Risk Assessment (ELA, 2020)* to ensure monitoring is focused on the key environmental values

1.4 Continuous improvement

This monitoring plan provides the mechanism for driving continuous improvement using the data gained from each of the discrete monitoring programs for each parameter. As such the plan will be periodically reviewed to update (maintain, increase or decrease) monitoring effort and focus, based on the new and historical findings from the monitoring data.

1.5 Plan review

This monitoring plan will be reviewed annually prior to the annual maintenance program and updated every three (3) years.

2.0 Environmental setting

The area surrounding the Port of Weipa has been highly modified since the discovery of bauxite deposits in 1955 and the establishment of the Weipa township in 1963. The region supports agricultural (cattle grazing), fishing, shipping, industrial, commercial, recreational and tourism uses. Weipa has also undergone significant urban development, supporting approximately 3,000 residents, including indigenous people; some of which are Traditional Owners of the land.

The region also supports areas of international, national and state environmental significance with the Gulf of Carpentaria providing important habitat to a variety of terrestrial and marine species. The environmental values of the Port and surrounds are summarised in the Environmental Risk Assessment (ELA, 2020) and are further described in detail in GHD (2019). Figure 2.1 provides an overview of key environmental values of the marine environment. These include:

- Coastal seagrass meadows, which are seasonally variable;
- A patchy reef system across Albatross Bay and the mouth of the Embley River dominated by hard coral species adapted to environments of higher turbidity and temperature;
- The most extensive mangrove system in the Gulf of Carpentaria which provides important feeding habitat and fish nursery habitat;
- Locally important populations of a number of threatened and migratory marine species, including marine turtles, dugong, saltwater crocodile, cetaceans and sawfish; and
- Internationally important migratory shorebird roosting and feeding sites.

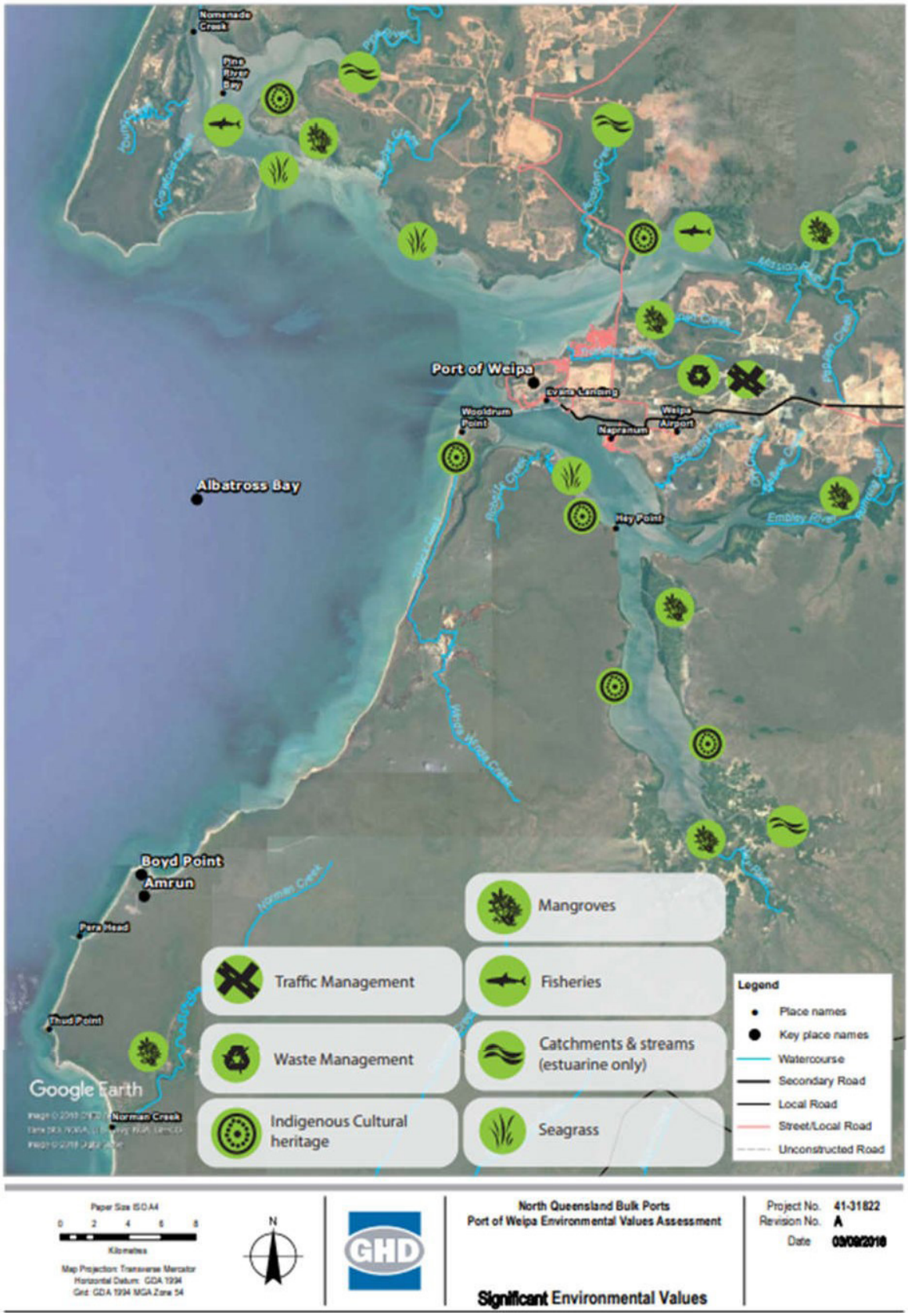

FIGURE 2.1 – PORT OF WEIPA ENVIRONMENTAL VALUES (SOURCE: GHD 2019)

3.0 Annual maintenance dredging

3.1 Sedimentation and volume

Maintenance dredging has occurred at the Port of Weipa since 1961, and annually since 2002. The approach to monitoring has been developed in consideration of the anticipated dredged sediment volume to be removed each year via maintenance dredging.

Analysis of historic bathymetric surveys and sediment transport modelling have been undertaken as part of a Sustainable Sediment Management (SSM) assessment for the Port of Weipa (SSM Appendix B & C). These analyses have included the Port's departure channel, inner harbour and berth pocket areas and allow for an improved predictive model of siltation rates and consequential annual maintenance dredging volumes.

Based on Metocean conditions over 10-year periods the modelling has determined that:

- Typical conditions are expected to occur approximately 50% of the time or five (5) years over a 10-year period, equating to approximately 400,000m³ of maintenance material per annum.
- Three (3) years of cyclone driven resuspension and siltation are predicted over a 10-year period, equating to approximately 800,000m³ of maintenance material per annum.
- Two (2) years of multiple cyclones or significant monsoonal events are predicted over a 10- year period. 2019 was an example of a year with multiple cyclones and monsoonal events which resulted in 2,500,000m³ of maintenance material.

Accordingly, management options have been considered that accommodate predicted volumes over a ten year period (Table 3.1).

Metocean conditions	Anticipated yearly volume (m³) including 15% over-dredge allowance	Total ten year forceast (m³)
Typical year	460,000	2,300,000
Cyclonic year	920,000	2,760,000
Multiple cyclone year	2,875,000	5,750,000
10 year total		**10,810,000**

TABLE 3.1 – ANTICIPATED VOLUMES OVER A 10-YEAR PERIOD BASED ON A TYPICAL, CYCLONIC OR MULTIPLE CYCLONE YEAR.

4. Monitoring framework

4.1 Framework

The monitoring detailed in this plan is an important component of the overarching Dredge Management Strategy as described in the LMDMP. NQBP will oversee the implementation of the monitoring plan, with each component being undertaken by appropriately qualified marine scientists contracted for their support.

Overall, the monitoring plan is made up of a combination of ongoing ambient monitoring (long-term monitoring) and individual dredging event related monitoring (short-term impact and real time monitoring). This three-tiered approach to monitoring is outlined in Figure 4.1.

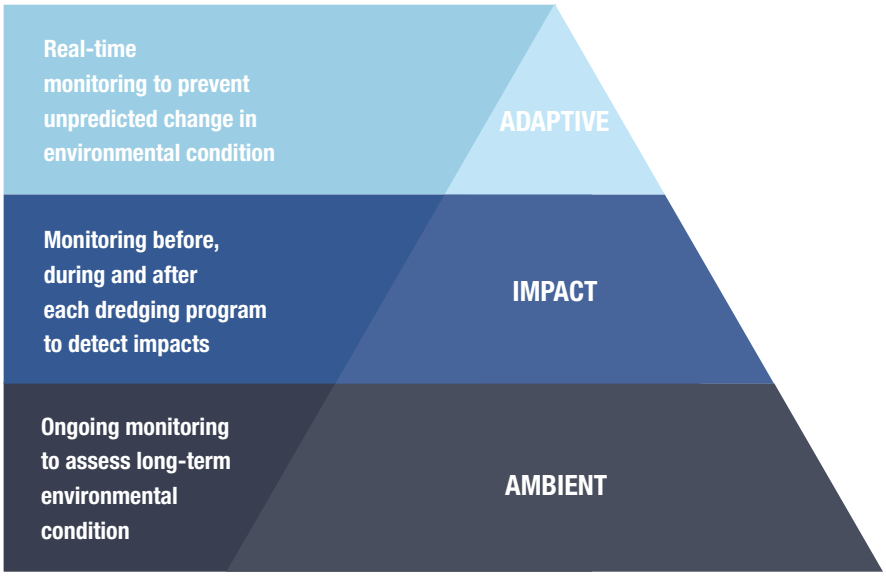

FIGURE 4.1 – THREE-TIERED APPROACH TO MARINE ENVIRONMENTAL MONITORING

A summary of the key monitoring for each tier is provided in Table 4.1.

Monitoring parameter	Ambient	Impact	Adaptive
Marine water quality - Data loggers	√		
Marine water quality - Satellite imagery		√	√
Marine water quality - Real-time instruments			√
Seagrass and benthic habitat	√	√	
Invasive marine species	√		
Benthic infauna assessment	√		
Sediment quality	√		
Marine megafauna			√

TABLE 4.1 – THREE-TIERED MONITORING REGIME

4.2 Monitoring Level

Although three scenarios have been modelled to support the prediction of dredge volumes over a 10 year period, a volume of 1,000,000m³ will determine the level of monitoring applied to each annual program, in that:

- below 1,000,000m³ reflects sediment volumes experienced both typical and general cyclonic years.
- above 1,000,000m³ reflects sediment volumes experienced in multiple cyclone years. Monitoring specific to each monitoring level is shown in Table 4.2.

Monitoring parameter	Level 1 (less than 1Mm³)	Level 2 (more than 1Mm³)
Marine water quality - Data loggers	√	√
Marine water quality - Satellite imagery	√	√
Marine water quality - Real-time instruments		√
Seagrass and benthic habitat - Annual	√	√
Seagrass and benthic habitat - Pre and Post		√
Invasive marine species	√	√
Benthic infauna assessment	√	√
Sediment quality	√	√
Marine megafauna	√	√

TABLE 4.2 – VOLUME BASED MONITORING LEVELS, SHOWING SPECIFIC MONITORING PROGRAMS

THE MAIN DIFFERENCE BETWEEN THE MONITORING LEVELS IS THAT THAT WHEN SEDIMENTATION GREATER THAN 1,000,000M³ IS EXPERIENCED AT THE PORT:

- ADDITIONAL REAL-TIME SURFACE LOGGERS WILL BE DEPLOYED AND ADDITIONAL ADAPTIVE MANAGEMENT MEASURES ADOPTED IN CONSIDERATION OF THE REAL-TIME WATER QUALITY DATA.
- ADDITIONAL SEAGRASS SURVEYS WILL BE UNDERTAKEN PRIOR TO MAINTENANCE DREDGING COMMENCING TO GAUGE THE RESILIENCE OF NEARBY SEAGRASS TO ANNUAL MAINTENANCE DREDGING AND PLACEMENT ACTIVITIES.

5.0 Ambient monitoring program

5.1 Sediment characteristics and quality

Sediments at the Port of Weipa are predominately comprised of sand and silt, with lower levels of clay and gravel (Advisian, 2018b). Sediment quality has been regularly assessed at the Port of Weipa to ensure suitability for ocean disposal under the approach outlined in the National Assessment Guidelines for Dredging (NAGD, DEWHA 2009). Assessments undertaken in accordance with the NAGD 2009 generally have a currency of five (5) years.

Maintenance dredging and placement has occurred at the Port of Weipa since the early 1960s. NQBP has previously commissioned testing of sediments for maintenance dredging in 2000, 2002, 2003, 2004, 2005, 2006/07 (capital dredging), 2009, 2013, 2018 and 2023.

These previous assessments have shown that the sediment in the Port has been suitable for ocean disposal.

5.1.1. Current state

The most recent survey found no concentrations of contaminants (including TBT, metals, hydrocarbons, BTEXN and PAHs) to be above screening level and therefore the sediment has been deemed to be suitable for unconfined ocean disposal (AMA 2023).

THE NEXT SEDIMENT CHARACTERISATION AND QUALITY ASSESSMENT WILL OCCUR PRIOR TO THE ANNUAL MAINTENANCE DREDGING PROGRAM OF 2028

5.2 Marine water quality (data loggers)

Extensive water quality monitoring has previously been undertaken at the Port to support historic applications for capital and maintenance dredging. In 2018, NQBP established the Port of Weipa Ambient Marine Water Quality Monitoring Program to characterise the natural variability in key water quality parameters within the adjacent sensitive habitats and better monitor potential impacts of the day-to-day port operations on marine water quality.

In 2018, six (6) monitoring sites in and around the coastal waters of Weipa were established (Waltham et al. 2018). Sites in the monitoring network were chosen to spatially align with the location of key sensitive receptor habitats (predominantly seagrass), along with key features in the Port (e.g. Inner Harbour, channel and DMPA). Today, three (3) of these monitoring sites remain in place and form the current ambient marine monitoring program (Figure 5.1 and Table 5.1). Annual reports and outcomes of the program can be viewed at *https://nqbp.com.au/sustainability/research-and-reports.*

The program consists of:

- Benthic data loggers – situated on the seafloor at each monitoring site, data being downloaded approximately every six (6) weeks.
- In situ physiochemical analysis – hand held water quality instrument gathering instantaneous measurements at each monitoring site, approximately every six (6) weeks.
- Water samples laboratory analysis – seawater samples collected at each monitoring site, laboratory analysis for metals, nutrients, chlorophyll a, pesticides and herbicides. Undertaken two (2) times yearly in wet and dry season.
- Planktonic community analysis – plankton tows undertaken at each monitoring site two (2) times yearly in wet and dry season.

**See the latest annual report for detailed program design and methodology https://nqbp.com.au/sustainability/research- and-reports*

FIGURE 5.1 – CURRENT LOCATIONS OF THE MARINE WATER QUALITY MONITORING PROGRAM SITES.

Site name	Latitude	Longitude
WQ1	-12.671250	141.845000
WQ2	-12.673778	141.777081
WQ4	-12.692361	141.870083

TABLE 5.1 – GPS COORDINATES FOR CURRENT MARINE WATER QUALITY MONITORING PROGRAM SITES

5.2.1 Current state – marine water quality (data loggers)

- Both suspended sediment concentration (SSC) and photosynthetically active radiation (PAR) are strongly correlated with wave conditions in Albatross Bay.
- The water column is well mixed, with depth profiles for dissolved oxygen, temperature, electrical conductivity and pH showing only minor gradients of change.
- All metals were below ANZECC 95% level of protection trigger values for marine waters. Silver, Cadmium, Copper, Nickel, Zinc, and Mercury were not detected. Lead and Arsenic were detected at low concentrations but still below ANZECC trigger guidelines.
- Particulate nitrogen (PN), particulate phosphorus (PP) and chlorophyll-*a* concentrations levels are often elevated above the relevant guidelines - this is potentially a result of seasonal variations in rainfall influencing levels of nutrient loading into local rivers from agricultural and urban runoff.

5.3 Seagrass and benthic habitat

Seagrass communities are considered sensitive receptors in the marine environment around the Port of Weipa. Seagrasses are also highly seasonal, with peak condition occurring in the dry season. Wet season growth can be minimal, and abundance can be reduced, particularly for ephemeral species (McKenna & Rasheed 2019a).

The Port of Weipa Long-Term Seagrass Monitoring Program was established in 2000 and a report is produced annually. Annual monitoring in the peak growing season (around September) provides an understanding of the condition of seagrass communities and how this varies in the long term. This information is vital to ensure effective management of seagrass habitat and ecosystem function.

Annual seagrass monitoring assesses five core seagrass meadows in areas of major port activity. Variations in biomass, area and species composition are assessed and used to determine a seagrass condition index for each site and overall. Seagrass within the greater Port limits is also remapped and assessed every third year (Figure 5.2).

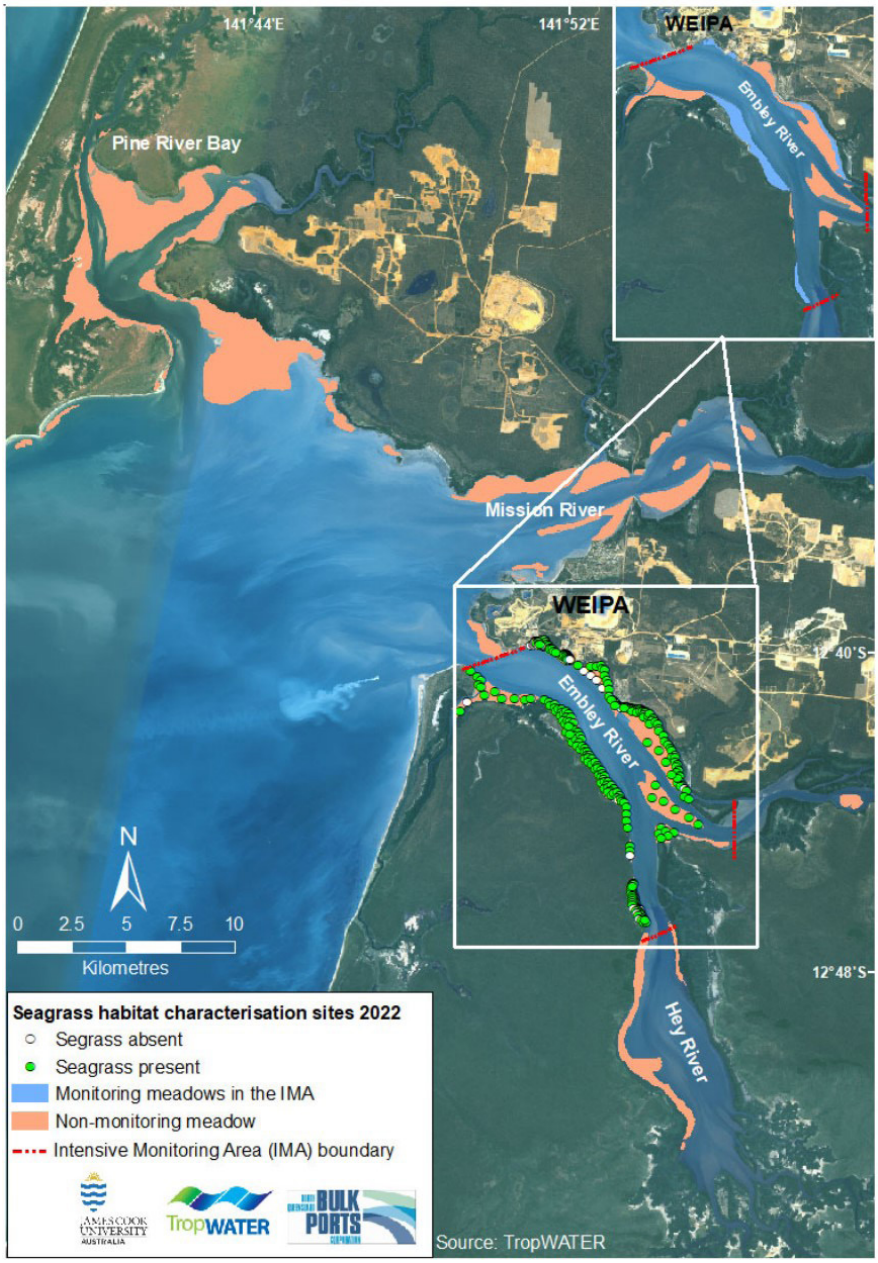

FIGURE 5.2 – LOCATION OF 2022 SEAGRASS SURVEY SITES AND MEADOWS IN THE PORT OF WEIPA

**See the latest annual report for detailed program design and methodology https://nqbp.com.au/sustainability/research- and-reports*

5.3.1 Current state – seagrass and benthic habitat

- Total area of seagrass recorded in the Intensive Monitoring Area (IMA), the region closest to the Port, in 2022 remained above the long term average for the 8th year in a row.
- Seagrasses in the Port of Weipa were found to be in an overall satisfactory condition in 2023.

A summary of the overall seagrass condition since 2016 is shown in Table 5.2 below.

Year	Seagrass condition
2016	Satisfactory
2017	Good
2018	Good
2019	Good
2020	Good
2021	Good
2022	Good
2023	Satisfactory

TABLE 5.2 – ANNUAL OVERALL SEAGRASS CONDITION (SINCE 2016) – PORT OF WEIPA AND SURROUNDS

5.4 Invasive marine species

NQBP established an invasive marine pest (IMP) monitoring program in 2002, with the objective of early detection of IMPs in the Port of Weipa, to assist in preventing establishment.

NQBP have deployed larval monitoring plates at three sites in the Point of Weipa at Evans Landing and Lorim Point Wharf east and west (Figure 5.3). Plates are retrieved and checked everything three months by port staff. Monitoring is conducted in accordance with an approved *NQBP Environmental Control Procedure ECP-120p – IMP Monitoring.*

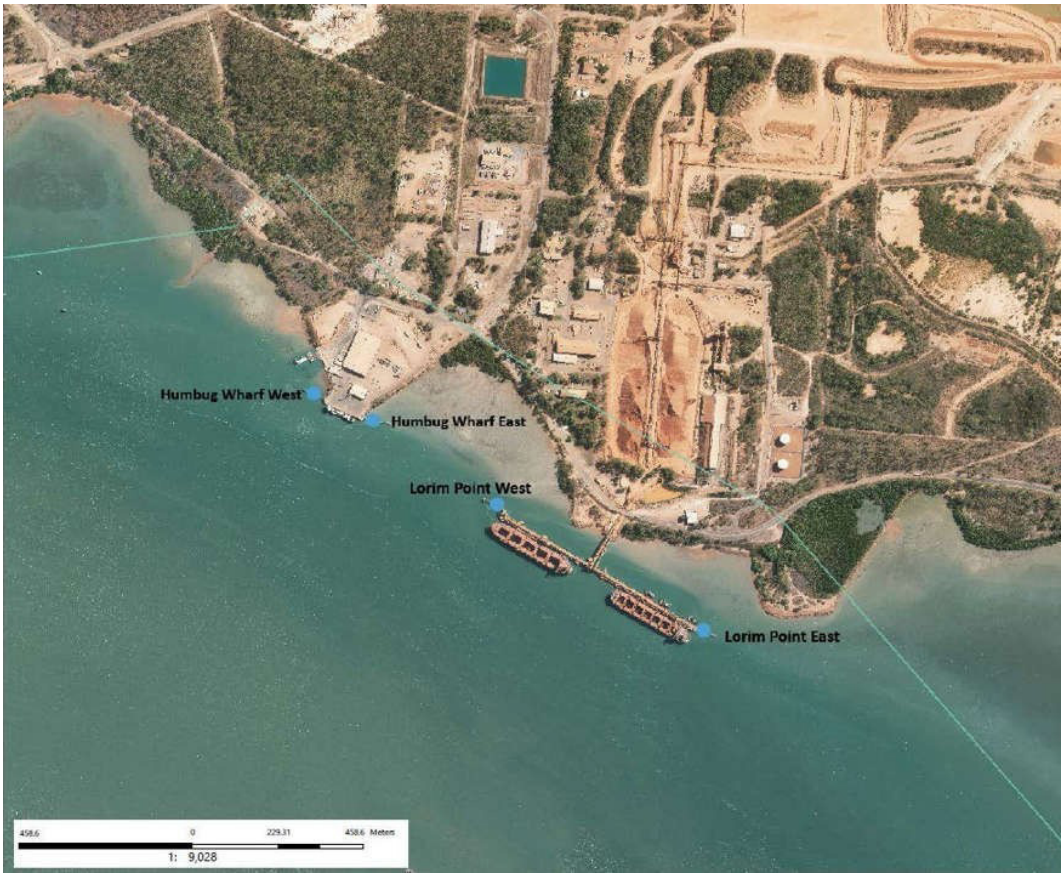

FIGURE 5.3 – IMP MONITORING LOCATIONS AT THE PORT OF WEIPA

5.4.1 Current state – invasive marine species

Biosecurity Queensland have identified seven invasive pest species with the highest chance of arriving and establishing in Queensland waters:

Species	Habitat	Location
Asian green mussel, *Perna viridis*	Hard surfaces to 10m	Detected in Queensland, no populations are known to exist
Black striped false mussel, *Mytilopsis sallei*	Hard surfaces and soft substrates	Detected Parts of Australia but populations are not known to exist in Queensland
Asian bag mussel, *Arcuatula senhousia*	Hard vertical surfaces	Not found in Australia
Brown mussel, *Perna perna*	Hard surfaces and soft substrates	Not found in Australia
Harris mud crab, *Rhithropanopeus harrisii*	Sandy and muddy substrates	Not found in Australia
Chinese mitten crab, *Eriocheir sinensis*	Lives mainly in freshwater	Not found in Australia
Japanese seaweed/Wakame, *Undaria pinnatifida*	Hard surfaces, intertidal to 20m depth	Tasmania and Victoria but populations are not known to exist in Queensland

Two introduced marine pest species are established in Queensland waters:

Species	Habitat
White colonial sea squirt, *Didemnum perlucidum*	Hard surfaces to 8m
Black scar oyster, *Magallana bilineata*	Hard surfaces to 300m

- Asian green mussel has not been detected at the Port of Weipa. A single specimen was detected at Amrun in 2018 and biosecurity investigations determined no established population.
- White colonial sea squirt has been detected in Weipa on hard and floating surfaces, not sediments.
- Recent eDNA based marine pest surveys did not detect additional invasive marine species fingerprints in Weipa.

5.5 Benthic infauna

Benthic infauna assessments have been conducted at the Albatross Bay Dredge Material Placement Area (DMPA) since 1996. Benthic communities within the area are low in abundance and diversity, with high numbers of opportunistic species that can adapt to highly variable benthic conditions.

Since 2010 benthic infauna surveys have been conducted every 5 years prior to and following maintenance dredging and placement, sampling within and around the DMPA (Figure 5.4).

AS THE APPROVED DMPA HAS BEEN RELOCATED A REVIEW OF THE SAMPLING PROTOCOL IS BEING UNDERTAKEN, WITH THE NEXT BENTHIC INFAUNA ASSESSMENT TO BE COMPLETED PRIOR TO ANNUAL MAINTENANCE DREDGING IN 2024.

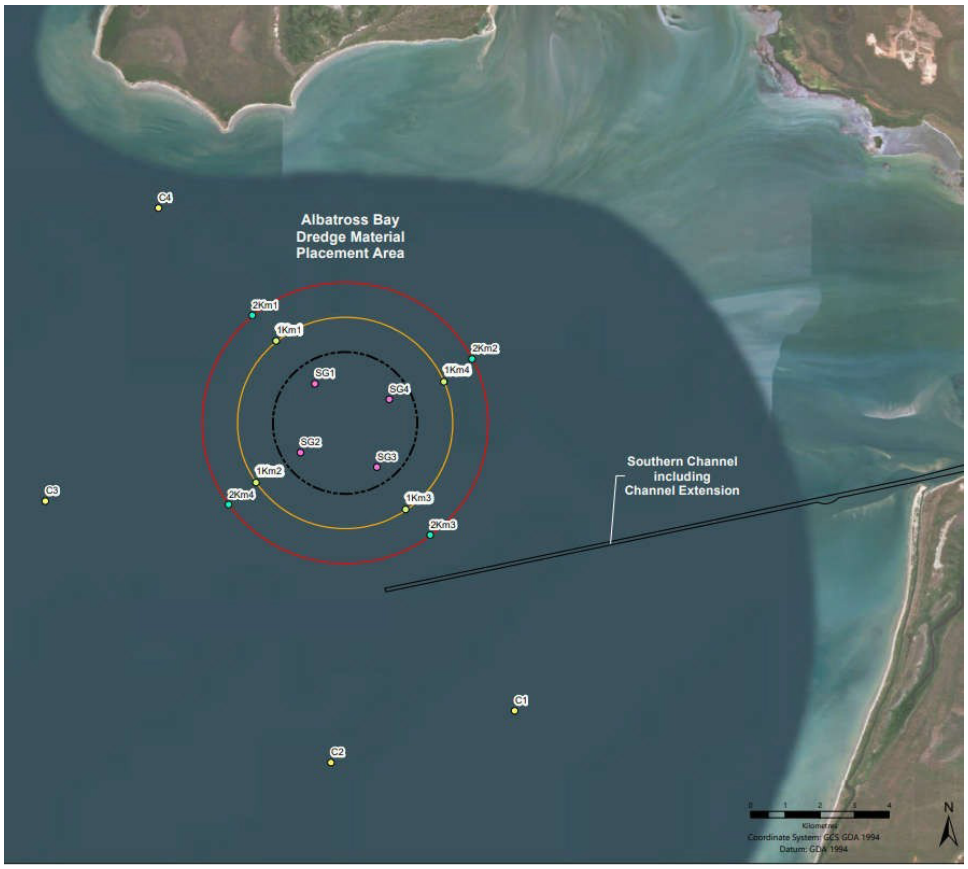

FIGURE 5.4 – PREVIOUS BENTHIC INFAUNA SAMPLING LOCATIONS FOR ALBATROSS BAY DMPA AND REFERENCE SITES.

5.5.1 Current state – benthic infauna

The families with largest variations pre and post dredging were Ampharetidae (polychaetes), Mactridae (bivalves) and Tellinidae (bivalves). This is unsurprising as both mactrid and tellinid bivalve families facilitate recruitment of other taxa, while Ampharetidae polychaetes are second stage colonists that can rapidly colonise new areas.

In the most recent surveys completed in 2019, abundance, diversity and species richness of the benthic community were low across all sites in the pre dredging survey compared to post dredging, with only 85 individuals recorded during pre-dredging surveys and 2,929 recorded post- dredging.

It is likely that the results of the 2019 survey were heavily influenced by two cyclones that occurred in the region prior to the pre dredging surveys. Cyclone Penny (January 2019) and Cyclone Trevor (March 2019) resulted in heavy rain and winds in excess of 200 km/h during the months of January – March, with the pre-dredging surveys taking place in April.

Benthic infauna will be assessed prior to maintenance dredging in 2024. The sampling protocol has been updated to reflect the new location of the DMPA.

6.0 Impact monitoring program

Impact monitoring occurs in addition to the ongoing ambient marine monitoring program, and typically occurs both prior to and following maintenance dredging and placement activities. Impact monitoring occurs in the form of:

- Marine Water Quality – Satellite Imagery
- Seagrass and Benthic Habitat – Pre and Post

6.1 Marine water quality – satellite imagery

For each annual maintenance dredging and placement program satellite derived Total Suspended Solids (TSS) concentration will be used to monitor daily sea surface turbidity at the Port of Weipa and greater Albatross Bay area (Figure 6.1).

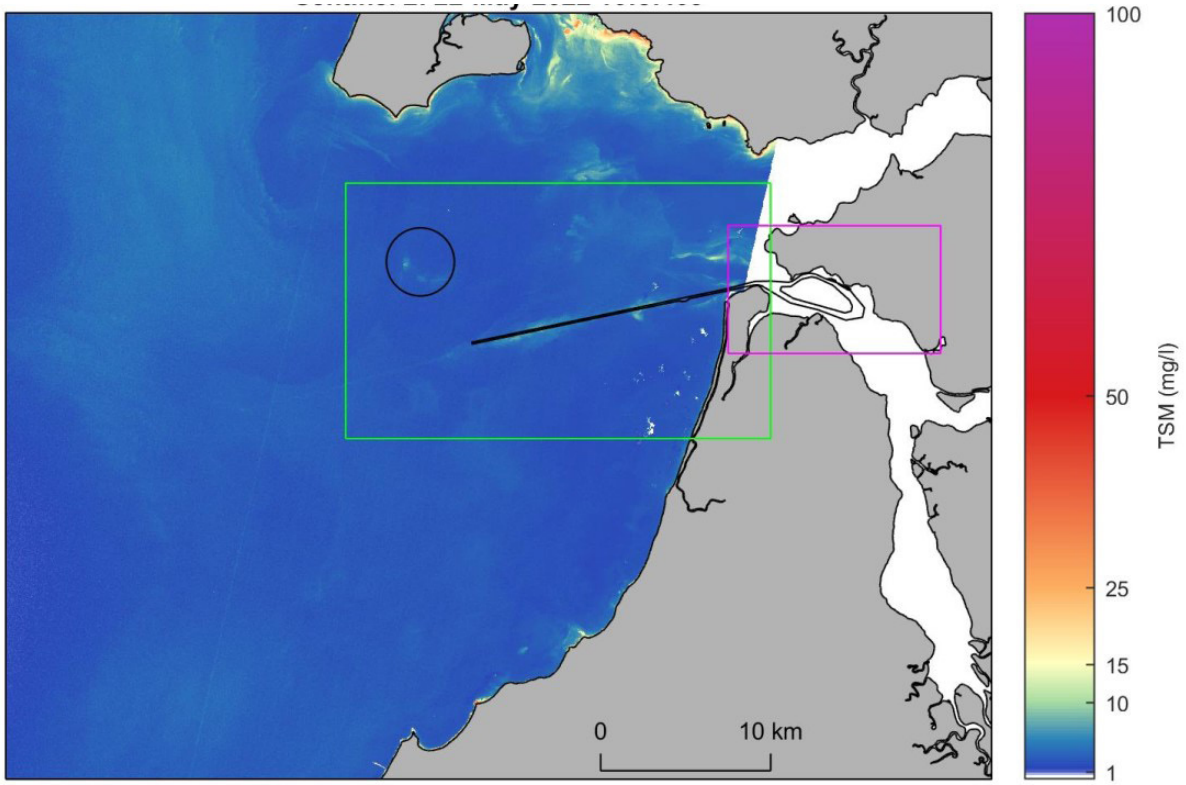

FIGURE 6.1 – SATELLITE-DERIVED TURBIDITY FROM THE SENTINEL-2 SENSOR FOR ALBATROSS BAY (EXAMPLE ON 22/05/2022 AT 10:57 AEST (DURING 2022 MAINTENANCE DREDGING PROGRAM).

Daily satellite image capture will commence seven (7) days prior the planned annual maintenance program and continue until 7 days following departure of the dredger.

An analysis of daily satellite derived data along with daily metocean and meteorological conditions and dredge vessel logs will be complied following the completion of each annual maintenance program, to determine the level of impact, if any, from dredging and placement activities.

This report will inform each years Marine Environmental Monitoring Program and promote continuous improvement.

6.1.1 Current state – satellite imagery

The 2023 maintenance dredging program was undertaken by the TSHD Brisbane and involved the relocation of approximately 781,300m³ of sediment from the dredged areas of the Port to the relocated Albatross Bay DMPA.

- Natural variations in turbidity driven by the natural conditions (wave and tidal) over the monitoring period were significantly larger than the variations in turbidity due to the maintenance dredging.
- The Port of Weipa 2023 maintenance dredging program did not influence the regional turbidity in the area.
- Plumes were observed close to the dredger when dredging, adjacent to the South Channel and within the Albatross Bay DMPA. The size and concentration of the plumes varied. The largest plume was up to 7.5km in length and 1.5km in width of approximately 10mg/L, occurring adjacent to the South Channel towards the end of the dredge program when both the dredging and bed levelling were occurring in the South Channel.
- All of the plumes resulting from maintenance dredging (including those from both dredging and placement) were found to remain close to where they were created. This shows that little net residual transport occurs in the region.

6.2 Seagrass and Benthic Habitat – Pre and Post

Impact monitoring for seagrass and benthic habitat will only occur when annual sedimentation at the Port is determined to be greater than 1,000,000m³. In this event, the ambient seagrass and benthic habitat program described in section 5.3 Seagrass and Benthic Habitat, will be deployed both:

- prior to the commencement of maintenance dredging (ideally within 4 weeks of program commencement), and
- following completion of maintenance dredging and placement activities (ideally within 4 weeks of completion).

A technical note summarising the state of seagrass and benthic habitat will be compiled prior to commencement of maintenance dredging. The technical note should also provide commentary on the resilience of seagrass compared with normal years of lesser sedimentation.

An impact report after the maintenance program will inform the following year's Marine Environmental Monitoring Program and promote continuous improvement.

7.0 Adaptive management program

Adaptive monitoring occurs in addition to the ongoing ambient marine monitoring program and impact monitoring program, and typically occurs in real-time during maintenance dredging and placement activities. Adaptive monitoring occurs using:

- Marine Water Quality – Satellite imagery
- Marine megafauna monitoring
- Marine Water Quality – Real-time instruments.

The most sensitive receptor in and around the Port of Weipa is seagrass. There are also some coral species present in the Weipa region, although based on dredge plume modelling, they are expected to be beyond the area where increased turbidity occurs as a result of maintenance dredging programs at the Port of Weipa.

7.1 Adaptive marine water quality – Satellite imagery

Published information on thresholds for seagrasses are typically defined in terms of benthic PAR rather than turbidity. The measured data were used to determine relationships between benthic PAR and turbidity at the monitoring sites and based on these approximately equivalent thresholds in terms of turbidity intensity were derived.

Based on the seagrass species present around the Port of Weipa and the benthic PAR thresholds noted in the literature, the analysis suggests that a turbidity threshold in the order of 15-20 NTUe (equivalent to approximately 30 mg/l) is representative of the lower threshold for light availability at the monitoring sites during the dry season (i.e. when the turbidity is above this there is insufficient benthic light).

Satellite derived turbidity data is provided in mg/l sea surface TSM. As water quality estimates derived satellite imagery are sea surface measurements, additional analysis has been undertaken to convert benthic intensity to equivalent surface intensity.

7.1.1 Threshold concentration and management status

A conservative threshold of 20 mg/l sea surface TSM will be adopted for satellite derived adaptive water quality management at the Port of Weipa at all three water quality monitoring sites. This aligns with the thresholds analysis for short duration (20 days), which ranged between 25 to 47 mg/l across the 3 monitoring sites.

Trigger areas (monitoring sites) and management status based on satellite derived TSM concentrations are set out in Table 7.1 below.

7.1.2 Management Actions

TSM concentration (mg/l)	Management status
0-20	No action
20-30	Investigate
30+	Respond
30+ 3 consecutive days	Stop

TABLE 7.1 – TRIGGER CONCENTRATIONS AND DURATION FOR ADAPTIVE MANAGEMENT RESPONSE

Based on the Management Status, the following response actions set out in Table 7.2 will apply.

7.2 Adaptive marine megafauna monitoring

Management status	Management action
No action	No response action required. Apply standard measures to dredging program.
Investigate	Investigate to determine whether turbidity at trigger area/s is potentially dredging and/or disposal related. Examine: • Dredging and disposal activities of the dredger for the preceding 24-hour period • Meteorological (rainfall) and sea state conditions (wave, wind and tides) • Determine if flow from Embley or Pine River is contributing to turbidity levels. • Where possible examine trigger site to ensure no natural processes or human activity (e.g. fishing) are contributing to turbidity levels • Broader regional MODIS imagery If it is determined that dredging activities have contributed to the higher than background turbidity levels, the dredging operation should be placed in a warning status.
Respond	Investigate to determine whether turbidity at trigger area/s is potentially dredging and/or disposal related. Examine: • Dredging and disposal activities of the dredger for the preceding 24-hour period • Meteorological (rainfall) and sea state conditions (wave, wind and tides) • Determine if flow from Embley or Pine River is contributing to turbidity levels. • Where possible examine trigger site to ensure no natural processes or human activity (e.g. fishing) are contributing to turbidity levels • Broader regional MODIS imagery If it is determined that dredging activities have contributed to the higher than background turbidity levels, the dredging operation should be placed in a warning status.
Stop	If it is determined that dredging activities have contributed to the persistent higher than background turbidity levels, disposal activities should cease until: • Turbidity falls below trigger levels Weather or tidal predictions stabilise to a point where continued raised turbidity from a dredge related plume is unlikely.

TABLE 7.2 – ADAPTIVE MANAGEMENT ACTIONS FOR EACH MANAGEMENT ZONE.

Adaptive monitoring of marine megafauna during dredging campaigns will be undertaken according to the protocol provided in Table 7.3.

7.3 Adaptive marine water quality – real time instruments

Protocol	Details
Parameters	Presence of marine megafauna in monitoring zone: • Megafauna includes whales, dolphin, dugong, turtles • Monitoring zone is within 300 m of dredging activity
Method	Observations using binoculars from bridge of dredger by crew
Timing and frequency	Throughout dredging campaign Observations to commence prior to any activities commencing and will continue until all activities cease
Sites	Wherever dredge is operating
Data analysis	Record observations in Masters' log and reported daily to the environment manager

TABLE 7.3 – MARINE MEGAFAUNA MONITORING PROTOCOL.

Real time instruments will only be deployed for adaptive management purposes when estimated maintenance program volume is greater than 1,000,000m³.

To inform the real time adaptive marine water quality program an assessment into ambient water quality conditions and environmental thresholds at the Port of Weipa was initially undertaken in 2020. The original report is available on the NQBP website: Weipa Dredging Permits Reports and Research. Established environmental thresholds will be reviewed every three (3) years to ensure they are reflective of ambient conditions.

Statistical analysis of measured water quality and deposition data was undertaken using an intensity, duration and frequency (IDF) approach to understand the natural variability in the environment in terms of turbidity, benthic light availability (benthic PAR) and sediment deposition. The analysis was undertaken on the data from the ambient monitoring program supplied by James Cook University (JCU). The results have focused on the conditions during the dry season as any future maintenance dredging is likely to occur during dry season conditions.

The IDF results indicate that turbidity data is the most appropriate parameter for monitoring during dredging operations when real-time monitoring is required to inform adaptive management. Based on the results of the percentile analysis and published benthic PAR thresholds, the 90th percentile turbidity was adopted as a turbidity intensity threshold. As the proposed 90th percentile turbidity/SSC threshold is on average only naturally exceeded for 10% of the time, it can be considered to be representative of a threshold for short duration acute impacts due to high turbidity/SSC, as opposed to longer duration chronic impacts due to prolonged periods of lower SSC.

Intensity thresholds developed using the ambient monitoring program data supplied by JCU, have been calculated using benthic logger data. As water quality estimates derived satellite imagery are sea surface measurements, additional analysis has been undertaken to convert benthic intensity to equivalent surface intensity.

For longer duration maintenance programs (greater than 1,000,000m³) natural conditions are defined in terms of intensity and duration in Table 7.4.

Site	Benthic intensity (NTUe)	Surface intensity (NTU)	Average duration (hrs)	90th percentile duration (hrs)	Maximum duration (hrs)
WQ1	25	13	96	153	346
WQ2	19	10	96	216	483
WQ4	95	34	96	339	514

TABLE 7.4 – BENTHIC SSC/NTU INTENSITY THRESHOLDS AT WATER QUALITY MONITORING LOCATIONS.

Management zones are to be applied to specified durations of time that the intensity thresholds are exceeded at trigger sites (Table 7.5). Management levels extend from Management Zone A, which is normal operations, through two higher levels to Management Zone D, when dredge operations would cease. Management zones B and C involved various levels of investigation to determine if the intensity exceedances were naturally derived (weather related) or due to dredge operations, in addition to the instigation of mitigation and management actions.

Site	Surface intensity (NTU)	Management Zone A Duration (hrs)	Management Zone B Duration (hrs)	Management Zone C Duration (hrs)	Management Zone D Duration (hrs)
WQ1	10	<96	96-153	153-346	>346
WQ2	12	<96	96-216	216-483	>483
WQ4	14	<96	96-339	339-514	>514

TABLE 7.5 – SURFACE INTENSITY THRESHOLDS AND ALLOWABLE DURATION (HRS) FOR RESPECTIVE MANAGEMENT ZONES.

An example plot showing how the various duration thresholds could fit into different adaptive management zones is provided in Figure 7.1.

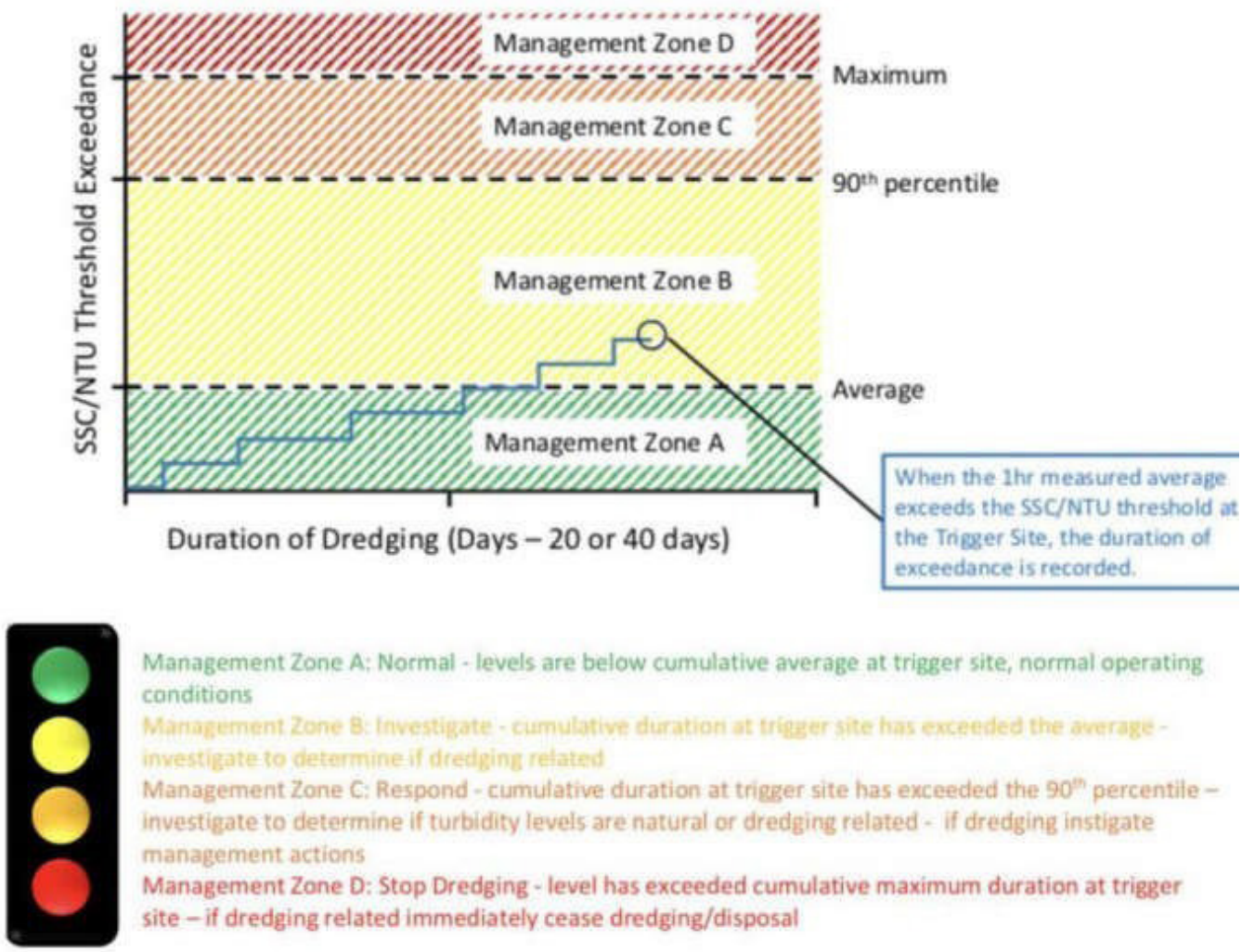

FIGURE 7.1 – HYPOTHETICAL EXAMPLE OF PLOT SHOWING DURATION TRIGGER LIMITS AND MANAGEMENT ZONES.

8.0 Data analysis and reporting

8.1 Ambient monitoring

Data analysis and reporting will be undertaken annually for ambient water quality and seagrass surveys.

Data analysis will focus on reporting on each parameter investigated and will include analysis of the most recent year's data (i.e. new data) and the long-term dataset (historical trends). Individual reports will be prepared for water quality and seagrass results.

Summary reports of ambient monitoring will be placed on NQBPs website.

8.2 Impact monitoring

Data analysis and reporting will be completed within three (3) months of the completion of each dredge campaign.

Data analysis will focus on comparing the before, during and after results to determine any potential impacts from dredging. Data from ambient monitoring will be used to provide regional and long-term context. Individual reports will be prepared for water quality results.

The report will also comment on the most recent plume modelling with respect to observed suspended solids concentrations.

8.3 Adaptive monitoring

Data analysis for the adaptive water quality monitoring will occur for the entirety of the dredge campaign. The NQBP project team will be provided daily updates and the TACC weekly updates on dredge progress, incidents and an overview of the adaptive monitoring from the previous week.

8.4 Summary report – environment and compliance

A summary report will be completed within 6 months of the completion of each dredge campaign detailing both impact and adaptive monitoring results, permit condition compliance and dredging execution parameters (in situ volume removed, post dredge bathymetry, operational timing and shutdowns). Outcomes of this report will be discussed with the TACC members.

Summary Monitoring Plan - Less than 1,000,000m³		
Ambient monitoring	Ongoing ambient marine water quality – Data loggers	No change to standard ambient program
	Ongoing annual seagrass surveys	
	Ongoing invasive marine pest monitoring program	
	Sediment characterisation (every 5 years)	Prior to 2028 maintenance program
	Benthic Infauna assessment (DMPA)	Prior to 2024 maintenance program
Impact monitoring	Marine water quality – Satellite imagery (daily) • Regional area • Port area	Commencing 1 week prior to maintenance program Continuing to 1 week post maintenance program
Adaptive monitoring	Marine water quality – Satellite imagery (daily) • Regional area • Port area	Commencing 1 week prior to maintenance program Continuing to 1 week post maintenance program Daily technical note and condition-response analysis
	Marine megafauna	Ongoing observations from TSHD bridge Records kept

Reporting

During annual maintenance program	• Daily technical note of satellite imagery capture and turbidity • Daily reporting to project team, including adaptive management requirements • Daily reporting from TSHD marine megafauna observations • Weekly updates to TACC
Following completion of annual maintenance program	• Water quality impact assessment derived from - Ambient marine water quality – data loggers - Marine water quality – satellite imagery • Closeout report – environmental monitoring and compliance

Summary Monitoring Plan - Greater than 1,000,000m³		
Ambient monitoring	Ongoing ambient marine water quality – Data loggers	No change to standard ambient program
	Ongoing annual seagrass surveys	
	Ongoing invasive marine pest monitoring program	
	Sediment characterisation (every 5 years)	Prior to 2028 maintenance program
	Benthic Infauna assessment (DMPA)	Prior to 2024 maintenance program
Impact monitoring	Marine water quality – Satellite imagery (daily) • Regional area • Port area	Commencing 1 week prior to maintenance program Continuing to 1 week post maintenance program
	Seagrass surveys	Within 4 weeks prior to maintenance program Within 4 week post maintenance program
Adaptive monitoring	Marine water quality – Satellite imagery (daily) • Regional area • Port area	Commencing 1 week prior to maintenance program Continuing to 1 week post maintenance program Daily technical note and condition-response analysis
	Marine megafauna	Ongoing observations from TSHD bridge Records kept
	Marine water quality – Real time instruments	Commencing 1 week prior to maintenance program Continuing to 1 week post maintenance program

Reporting

During annual maintenance program	• Technical note / summary of seagrass condition and resilience
During annual maintenance dredging program	• Daily technical note of satellite imagery capture and turbidity • Daily reporting to project team, including adaptive management requirements • Daily reporting from TSHD marine megafauna observations • Weekly updates to TACC
Following completion of annual maintenance program	• Water quality impact assessment derived from - Ambient marine water quality – data loggers - Marine water quality – satellite imagery • Closeout report – environmental monitoring and compliance

NORTH QUEENSLAND BULK PORTS CORPORATION

Mackay Office
Level 1, Waterfront Place,
Mulherin Drive
Mackay Harbour, QLD 4740
PO Box 3340,
North Mackay, QLD 4740
Phone: 07 4969 0700

Brisbane Office
Level 1, 324 Queen Street
Brisbane, QLD 4000
GPO Box 409, Brisbane, QLD 4001
Phone: 07 3011 7900

Phone: 1300 129 255
Email: info@nqbp.com.au
Website: nqbp.com.au