Port of Gladstone Maintenance Dredging Environmental Monitoring Procedure

Brief description

The monitoring and management of maintenance dredging activities at the Port of Gladstone is essential to ensure that the potential environmental impacts of this activity are controlled through the identification of sensitive environmental receptors, understanding environmental risks and employing measures and safeguards to mitigate potential environmental issues

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If you require any further information, please contact the Custodian.

The current version of this Procedure is available on GPC's Intranet.

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1 Terms and definitions

In this Procedure:

''Administering authority'' means the Department of Environment and Science and any successor administering the Environmental Protection Act 1994

"ANZECC" means Australian and New Zealand Environment and Conservation Council.

"ARMCANZ" means Agriculture and Resource Management Council of Australia and New Zealand.

"AWAC" means Acoustic Wave and Current profiler.

"BPAR" means Benthic Photosynthetically Active Radiation.

"DAF" means Department of Agriculture and Fisheries.

"DAWE" means Department of Agriculture, Water and the Environment.

"DES" means Department of Environment and Science.

"DO" means dissolved oxygen.

"EA" means Environmental Authority.

"EBSDS" means East Banks Sea Disposal Site.

"EC" means electrical conductivity.

"EIS" means Environmental Impact Statement.

"EM" means environmental monitoring.

"EMP" means Environmental Management Plan.

"EMS" means Environmental Management System.

"Environmental Nuisance" means unreasonable interference or likely interference with an environmental value caused by:

(a) Noise, dust, odour or light;

(b) An unhealthy, offensive or unsightly condition because of contamination; or

(c) Another way prescribed by Regulation.

"EWMA" means Exponentially Weighted Moving Average.

"Exceedance" means when a contaminant has been released to the receiving environment at a level beyond what is allowed or stipulated by a set limit.

"GGCDP" means Gatcombe Golding Channel Duplication Project.

"GHHP" means Gladstone Healthy Harbour Partnership.

"GPC" means Gladstone Ports Corporation Limited.

"IMO" means International Maritime Organisation.

"LMDMP" means Long Term Maintenance Dredging Management Plan.

"Monitoring" means:

(a) Observe and check the progress or quality of (something) over a period of time; keep under systematic review;

(b) Maintain regular surveillance over listen to and report on.

"MP" means Monitoring Procedure.

"NADG" means National Assessment Guidelines for Dredging.

"NTU" means Nephelometric Turbidity Units.

"PCIMP" means Port Curtis Integrated Monitoring Program.

"PoG" means Port of Gladstone.

"SAP" means sediment analysis plan.

"Sensitive Receptor" means a fixed location of significance with the potential for impact.

"TDP" means Total Daily Par.

"TBT" means Tributyltin.

"Water Quality" means a quantitative measure of the physical, chemical and biological characteristics of water, relative to the requirements of a stated environmental value.

"WBDDP" means Western Basin Dredging and Disposal Project.

"WQ" means water quality.

"WQOs" means Water Quality Objectives.

Terms that are capitalised and not otherwise defined in this Procedure are defined in the GPC Corporate Glossary Instruction (as listed in Appendix 1 – Related documents).

2 Introduction

2.1 Purpose

This Monitoring Procedure (**"MP"**) has been developed to:

(a) Describe the GPC systems for monitoring and managing potential environmental risks and impacts associated with maintenance dredging activities in the Port of Gladstone (**"PoG"**);

(b) Describe the measures and safeguards to be implemented during maintenance dredging; and

(c) Address compliance requirements.

2.2 Scope

The MP covers all aspects of the environmental monitoring (**"EM"**) undertaken around the PoG annual maintenance dredging for the period of 01 December 2018 to 01 December 2019 by GPC and engaged Contractors. The latter, herein referred to as Activity Based EM, will be

conducted starting two (2) weeks prior maintenance dredging operations commencement, it will continue throughout dredging operations and it will conclude two (2) weeks post dredging operations completion.

The present MP implements, supports and should be read in conjunction with:

(a) The Port of Gladstone Maintenance Dredging Environmental Management Plan (EMP) (#879363);

(b) The Port of Gladstone Long Term Maintenance Dredging Management Plan (LMDMP) (#1385321); and

(c) The Deed of Agreement Implementation Strategy (#1192974).

Details on the abovementioned documents can be found in the EMP, Section 1.

This MP also introduces and describes aspects of the LMDMP and associated long term monitoring schedule. Whilst part of the same framework, the yearly Activity Based EM conducted around maintenance dredging is undertaken and assessed for compliance purposes to prevent and manage and potential environmental harm. Instead, monitoring elements part of the long term schedule are commitments in place to help to determine and define long terms impacts of maintenance dredging on the receiving environment and sensitive receptors.

2.3 Objectives

This MP aims to maintain compliance with the relevant permits and approvals detailed in the EMP by implementing the required and appropriate EM program. Adaptive management actions based on monitoring results are in place to ensure no environmental harm occurs to the receiving environment and sensitive ecological receptors from maintenance dredging related plumes. This procedure addresses:

(a) Addresses environmental values and risks;

(b) Incorporation of a risk based framework in the monitoring programs;

(c) Monitoring of the effects of dredging activities and inform adaptive management. This can be subdivided into three (3) aspects:

    (i) Ambient monitoring;

    (ii) Impact detection; and

    (iii) Adaptive management.

(d) Implementation of the Long Term Monitoring Schedule.

The performance of this MP will be measured through post dredging audit (EMP Section 3.11). Permit non compliances or other environmental incidents during maintenance dredging operations will be used as a measurement of this procedure effectiveness and will also trigger review of its contents.

3 Procedure

3.1 Roles and Responsibilities

GPC Employees and Contractors are responsible for the environmental performance of their activities and for complying with the general environmental duty as set out in Section 319 (1) of the *Environmental Protection Act 1994* (Qld) which states:

'A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to minimise the harm'.

Roles and responsibilities in relation to this monitoring procedure are detailed in Section 3.6 of the EMP.

3.2 Environmental Monitoring Framework

GPC's Risk Management Framework provides the processes to ensure the Environmental Management System (**"EMS"**) suitably manages all aspects under the control or influence of GPC.

The PoG maintenance dredging risk assessment is documented in GPC's Aspects and Impacts Register (#764185). Monitoring based risk controls and actions are documented and detailed in this MP and are derived from the LMDMP and Deed of Agreement Implementation Strategy which set the long term monitoring programs for maintenance dredging activities.

As mentioned in Section 2.2, as well as the Activity Based EM undertaken yearly during maintenance dredging campaigns this MP details also the Long term Monitoring Schedule which includes a range of monitoring programmes (LMDMP Table 15). These incorporate plume monitoring, seagrass, reef and benthic monitoring as well as hydrographic surveys; some of these are undertaken at irregular intervals.

The implementation and effectiveness of the MP is monitored through processes such as periodical risk reviews, audits, inspections, incident and complaint investigations and reporting.

Monitoring outputs inform GPC's adaptive management of maintenance dredging and the continual improvement processes described in the LMDMP. To establish the Activity Based and some of the components of the Long Term MP, GPC applies a risk assessment framework and considers the following aspects and impacts:

(a) Identification of sensitive receptors and environmental values through hydrodynamic modelling and impact assessment (LMDMP Section 3). These include water quality (**"WQ"**), flora and fauna, and Matters of State and National Environmental Significance;

(b) Predicted impacts, through the abovementioned modelling and impact assessment, of maintenance dredging on identified sensitive receptors and environmental values;

(c) State-wide maintenance dredging considerations to optimise operational efficiency and minimise environmental impacts;

(d) Activity Based environmental monitoring and adaptive management to mitigate predicted impacts; and

(e) Environmental information and observations for evaluation purposes.

3.3 Activity based WQ monitoring

As mentioned in Section 3.2, the Activity Based EM was devised upon hydrodynamic and plume modelling as well as impact assessment and long term data sets. Modelling outputs were used to determine possible zones of impact and influence associated with maintenance dredging activities.

It is important to notice that the current Activity Based monitoring detailed in this MP is geared towards modelling outputs of a 340,000 m^3 maintenance dredging campaign in the PoG main channels with spoil placement at the East Banks Sea Disposal Site (**"EBSDS"**). Therefore the MP is adequate for smaller dredging campaigns as showed by the different modelling outputs which were also validated through a range of field studies as well as with data collected during

Activity Based monitoring. Detailed information on maintenance dredging impact assessment, modelling and zones of impact can be found in Section 3 of the LMDMP.

Using the abovementioned modelling outputs, areas influenced by dredging operations were highlighted and thus used to identify appropriate monitoring locations. The latter will therefore be appropriate and used to protect the receiving environment and sensitive receptors through monitoring and adaptive management (Section 4.3.1).

Monitoring will comprise telemetry WQ and light (Benthic photosynthetically Active Radiation (**"BPAR"**)) and will be undertaken to:

(a) Measure WQ, specifically turbidity, and BPAR levels adjacent and at sensitive receptors sites within the PoG (Appendix 3). The data and observations collected will inform adaptive management; and

(b) Implement adaptive management and mitigation measures to avoid and minimise any potential impact of maintenance dredging activities on sensitive receptors within the PoG.

Additional to WQ and light, monitoring aspects such due diligence in situ WQ grabs form part of the overall Activity Based EM detailed in this MP as well as monitoring components of the Long term Monitoring Schedule and thus LMDMP which are implemented as per approved timelines detailed in Table 15 of the LMDMP.

As mentioned in Section 2.2, the Activity Based monitoring will be conducted starting two (2) weeks prior to dredging commencement, it will continue throughout dredging operations and it will conclude two (2) weeks post dredging operations completion. Monitoring components of the Long term Monitoring Schedule and thus LMDMP will also be implemented whenever applicable and appropriate. All monitoring will be undertaken by suitably qualified personnel and following relevant and appropriate guidelines.

(c) WQ Monitoring

Two (2) WQ sites, one (1) for compliance and one (1) for reference purposes (**Table 1**), were selected as per methods mentioned in Section 3.2 and 3.3; both sites were also utilised during the Western Basin Dredging and Disposal Project (**"WBDDP"**) (**Table 1**) therefore long term data sets and information have been gathered. At these sites the full suite of physical-chemical parameters will be collected in real time (telemetry) by purpose built buoys equipped with dual multiparameter sondes. At the compliance site turbidity readings as an Exponentially Weighted Moving Average (**"EWMA"**) will be screened and assessed against trigger values (Section 4.3.2) for compliance purposes.

The support site as well as the rest of the physical-chemical parameters (temperature, electrical conductivity (**"EC"**), pH and dissolved oxygen (**"DO"**)) collected at WQ sites will not be assessed against triggers, but will aid in the data interpretation and isolate potential impacts of maintenance dredging on WQ. The telemetered WQ monitoring sites will log readings every 15 minutes, all equipment will be appropriately serviced and maintained.

The WQ monitoring site locations and naming is consistent with the Port Curtis Integrated Monitoring Program (**"PCIMP"**) which is a long term ambient WQ program.

Table 1: *Maintenance dredging telemetered WQ monitoring sites.*

Site	Status	Site description and water area	WQ zone of impact
WB50	Compliance	Part of the Gatcombe Golding Channel Duplication Project (GGCDP) Environmental Impact Statement (EIS) baseline strategy monitoring and also a former compliance site for the WBDDP. WB50 is located adjacent to the dredging effort and in close proximity to a	Zone of influence

Site	Status	Site description and water area	WQ zone of impact
		major sensitive receptor (i.e. the Wiggins Island Seagrass meadow) which was identified as being within the zone of influence by impact hypothesis modelling. As a former WBDDP compliance site, trigger limits can be applied to WB50 for NTU to monitor and manage the campaign in the same manner as the previous campaigns.	
MH10	Support	Part of the GGCDP EIS baseline monitoring (as P5) and former WBDDP support site, meaning that no trigger limits have been established for this site. MH10 will be utilised as a support site to monitor NTU near significant seagrass beds (Pelican Banks and Facing Island seagrass beds) between Curtis and Facing Islands which are predicted to be outside of the zone of influence.	Outside of zone of influence

Due diligence grab samples for metals and Tributyltin (**"TBT"**) at five (5) locations (**Table 2** and Appendix 2) will also be undertaken once per each monitoring phase and thus before, during and after maintenance dredging. Samples will be analysed for a range of metals and TBT (**Table 3**) by a National Association of Testing Authorities (**"NATA"**) accredited laboratory holding the accreditation for the analyses required.

Table 2: *WQ grabs sampling sites.*

Site	GPS coordinates
NW70	S23°44.351' E151°10.703'
WB50	S23°48.304' E151°12.555'
IH15	S23°47.733' E151°14.307'
MH40	S23°50.779' E151°20.481'
MH50	S23°52.887' E151°22.648'

WQ grab samples for metals and TBT will test the following impact hypothesis:

- *Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area.*

Results will be used to examine if any changes are observed during the monitoring program and will aid in the long term management of PoG maintenance dredging activities. Despite this monitoring component being due diligence, GPC will screen the results against Water Quality Objectives (**"WQOs"**) for Gladstone Harbour Zones. Please note that for metals the WQOs for Gladstone Harbour Zones adopt the Australian and New Zealand Environment and Conservation Council (**"ANZECC"**) and Agriculture and Resource Management Council of Australia and New Zealand (**"ARMCANZ"**) guidelines. Thus results will be screened against ANZECC/ARMCANZ thresholds for 95% marine species protection. Whilst this part of the monitoring program is not associated with specific permit conditions, in case of elevation GPC will do everything reasonable and practicable to investigate and determine the reason of such elevations. If these are deemed to be caused by dredging activities appropriate corrective actions will be implemented to prevent any potential harm to the environment; for more information refer to Section 5.14 of the EMP.

Table 3: *Analytes tested once pre, during and post maintenance dredging operations for due diligence as part of the Activity Based monitoring program.*

Analyte	Unit
Aluminium (filtered)	µg/L
Cadmium (filtered)	µg/L
Chromium (filtered)	µg/L
Copper (filtered)	µg/L
Lead (filtered)	µg/L
Mercury (filtered)	µg/L
Nickel (filtered)	µg/L
Silver (filtered)	µg/L
Zinc (filtered)	µg/L
Tributyltin (TBT)	ngSn/L

(i) Turbidity and management trigger values

Turbidity monitoring will test the following impact hypothesis:

- *Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area.*

Turbidity is a measurement of water clarity and is influenced by suspended matter (organic and inorganic) as well as dissolved matter. Turbidity is an expression of the optical property of light to be scattered and absorbed with a greater amount of matter within the water column leading to a higher amount of light scattering and thus higher turbidity. Dredging activities have the capacity to increase background turbidity levels potentially resulting in environmental harm. Therefore turbidity is an important parameter to measure during dredge operations.

During maintenance dredging operations, turbidity (as an Exponentially Weighted Moving Average (**"EWMA"**)) will be screened against turbidity triggers developed for the WQ compliance site WB50 (**Table 4**) as per methods mentioned in Section 3.2 and 3.3. Both percentiles and turbidity triggers were initially developed and employed for the WBDDP, these are:

- 80th percentile: internal alert when values exceed trigger > 36 hrs; and
- 95th percentile: external notification when values exceed trigger > 24 hrs.

The internal alert and external notification trigger levels will be implemented based on the application of a 6 hourly EWMA to the raw turbidity data. The data collected via telemetry will undergo appropriate preliminary QA/QC procedures. The de-confounding process includes automatic algorithm and manual based validation processes. The EWMA is a smoothing technique developed by statistical experts that takes into consideration background levels so that readings increase and decrease gradually avoiding false readings and alarms (both on and off). Therefore when values exceed triggers or go below triggers they will not be expected to invert their trends suddenly. The 6 Hour EWMA is calculated by using a 60:40 weighting system, where the current EWMA (Z_i) is computed by adding 60% of the mean turbidity readings during the preceding (just recorded) 6 hours (X_i) to 40% of the preceding 6 hour EWMA value (Z_{i-1}). Mathematically, 6-hourly values of the EWMA statistic are computed using the following equation:

$$Z_i = 0.6\ X_i + 0.4Z_{i-1}$$

Where i is the mean of the data for the ith period (in this case, the current 6-hour period).

Table 4: *Turbidity triggers summary at all compliance WQ monitoring stations.*

Site name	Status	Zone	Compliance parameter	Wet season triggers (01 Oct – 31 Mar)	Dry season triggers (01 Apr – 31 Sep)	Data requirements
WB50	Compliance	Western Basin	Turbidity (NTU)	30 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	17 NTU (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Data logged every 15 mins. Real time (telemetry) feed. WQ automatically de-confounded data + 6 hourly EWMA plot feed for turbidity
				48 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	27 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
MH10	Support	Mid-harbour	Turbidity (NTU)	N/A	N/A	Data logged every 15 mins. Real time (telemetry) feed. WQ automatically de-confounded data + 6 hourly EWMA plot feed for turbidity

Table notes: For the compliance site WB50, internal alert is reached when 80th %tile trigger is exceeded > 36 hrs, whilst the external trigger is reached when 95th %tile trigger is exceeded >24 hrs

(ii) Turbidity Adaptive Management

Adaptive management steps have been developed to ensure appropriate procedures and actions are undertaken when turbidity at the WQ compliance site reaches the abovementioned percentiles (**Figure 1** and **Figure 2**). When the turbidity, as 6 hour EWMA, at WB50 remains below the Internal Alert Levels (Alert Level 1 (internal)) for less than 36 hours, no investigation into the cause of turbidity changes, if any are occurring, and dredging operational management will be undertaken.

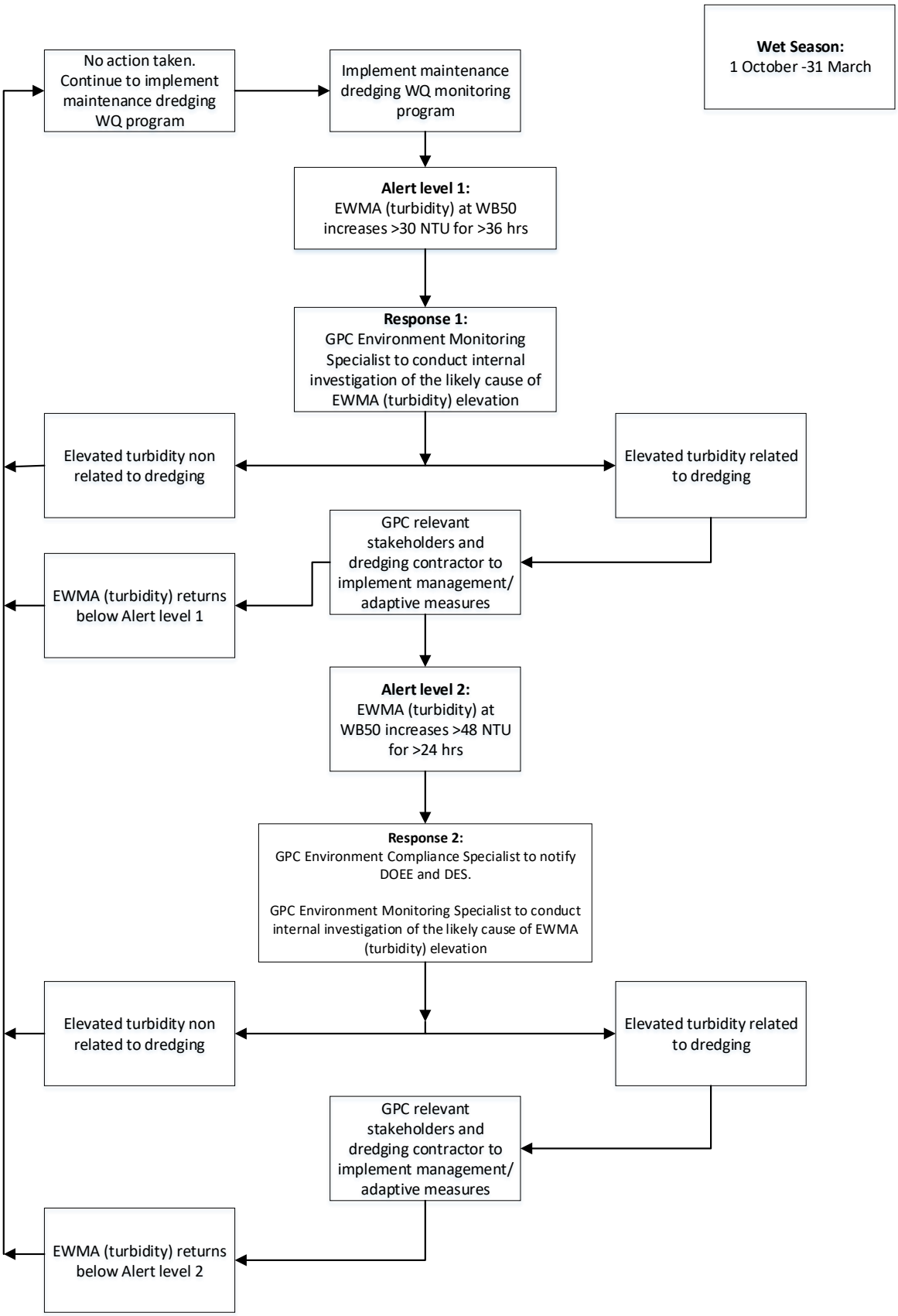


Figure 1: *Sensitive Receptor WQ Trigger Flowchart (Wet Season).*

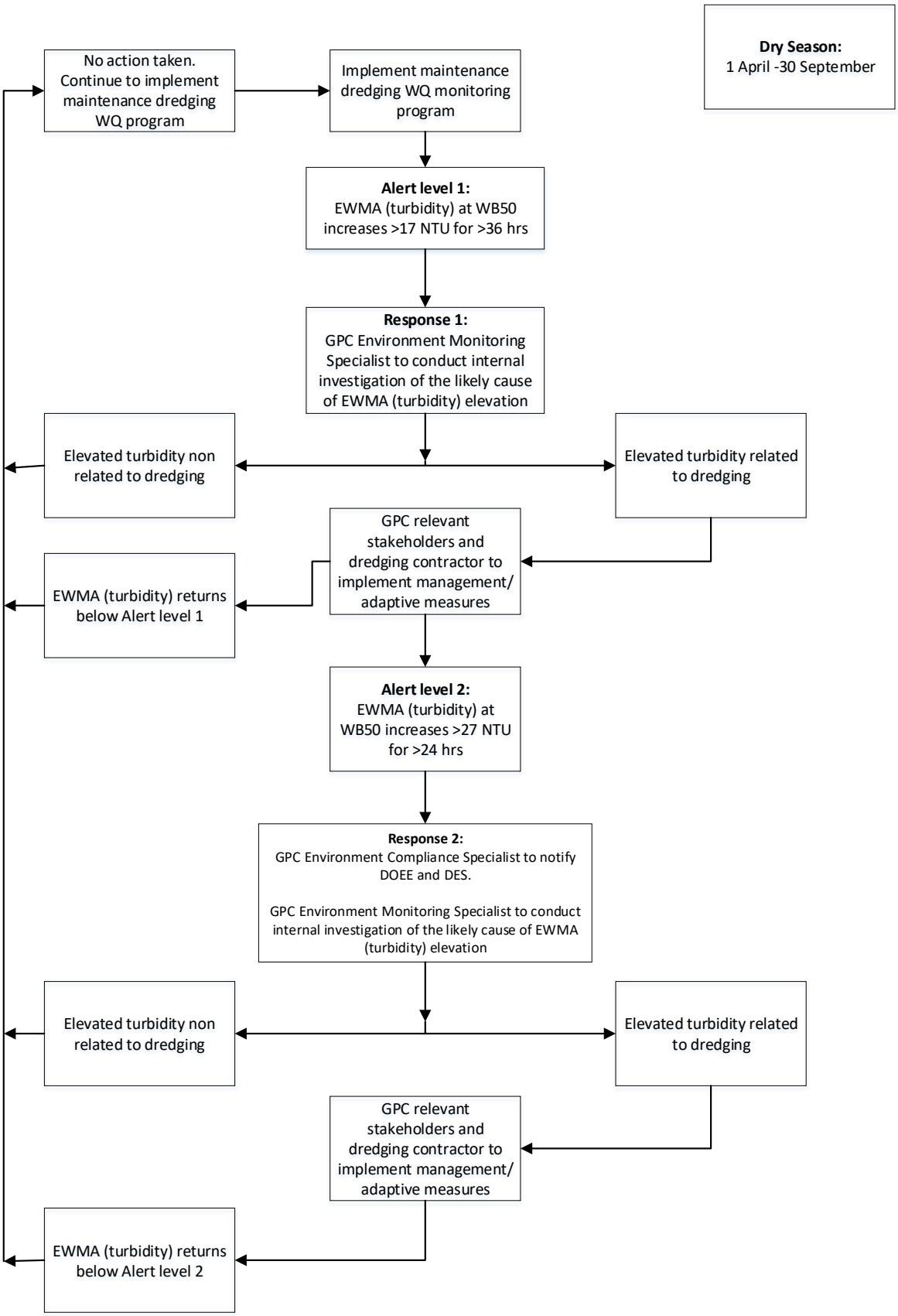


Figure 2: *Sensitive Receptor WQ Trigger Flowchart (Dry Season).*

(d) BPAR Monitoring

Seagrass meadows are an important primary producer in Port Curtis and have high economic and ecological value. In fact, seagrass beds play a key role in providing food resources and habitat for species of turtle and dugong as well as fish at both juvenile and adult life stages. Due to their sensitivity to reduced light conditions, seagrass meadows are often chosen as a sensitive receiver for detecting dredging related plume impacts.

Measurement of the light reaching seagrass (**"BPAR"**) is the key monitoring parameter to assess and determine whether sufficient light is reaching seagrass meeting its growth and health requirements. Levels of light making it to the benthos and thus to the seagrass canopy can be impacted directly by turbidity, but also by a range of other environmental factors such as cloud cover.

Therefore BPAR monitoring will be undertaken to:

- Measure light levels at sensitive receptors that can be affected by maintenance dredging operations to avoid and manage any potential impacts of maintenance dredging on Port Curtis seagrass meadows and sensitive receptors (Appendix 3); and

- Determine the need and implement mitigation measures to prevent environmental harm to seagrass beds and other sensitive receptors.

The results of this monitoring will test the following impact hypothesis:

- *Maintenance dredging activities do not result in impact to sensitive receptors*

(i) Seagrass Monitoring Background

As mentioned in Section 3.3(d) BPAR measurement is the key monitoring parameter to assess and determine whether sufficient light is reaching seagrass meeting its growth and health requirements. GPC and the James Cook University (JCU) seagrass ecology team (formerly within Department of Agriculture and Fisheries (DAF)) developed light requirements values specific to Port Curtis seagrass meadows. This was the result of laboratory and field studies undertaken for a number of years prior and during the WBDDP (Chartrand *et al.* 2012; 2016).

Such studies were initially undertaken for *Zostera muelleri* as it is the seagrass species with the highest light requirement occurring within the PoG. The studies demonstrated that *Z. muelleri* requires 6 mol/m^2/day on a fourteen (14) day rolling average of PAR (as Total Daily Par (**"TDP"**)) and management actions need to be considered after seven (7) days rolling average of low light availability (i.e. <6 mol/m^2/day) (**Table 7**). This light requirement value, which will be adopted in this MP and related Activity Based EM, is therefore the most conservative one. In fact, further studies have confirmed that other seagrass species light requirements are lower; for example for *Halodule uninervis* the recommended value is 5 mol/m^2/day on a 14 day rolling average.

Seagrass has two seasons, the Growing Season (July to December) and the Senescent Season (January – June), whilst the trigger is designed for the growing season only, GPC have adopted a conservative approach of applying the trigger across the full year. Adaptive Management for BPAR is applied using the BPAR trigger flowchart (Figure 3). The flowchart has been developed to outline the steps to be undertaken for routine maintenance dredging in the event of BPAR result fall under the recommended 6 mol/m^2/day on a 14 day rolling average.

(ii) BPAR Monitoring Sites

The BPAR monitoring site for maintenance dredging operation was identified as per methods outlined in Section 3.2 and 3.3. In fact, the Passage Island seagrass meadows (WB25) (**Table 5** and Appendix 2) have been identified as the only significant receptor within the potential Zone of Influence during a simulated maintenance dredging campaign of 340,000 m^3. Therefore, at the BPAR monitoring site WB25, light (PAR) sensors mounted on benthic frames will be installed, commissioned and maintained. In order to minimise data loss the frames will be equipped with dual PAR sensors. Moreover the light sensors will be set up within the boundaries of the meadows and mounted in line with the seagrass canopy to ensure BPAR measurement collected represent the actual amount of light received by the plants.

A control site (CT) will also be set up on land in an appropriate elevated location to record daily ambient changes in total available PAR. Such inclusion will allow for variations in daily ambient PAR due to factors such as cloud cover, assisting in the analysis and interpretation of BPAR levels at the compliance monitoring site. TDP and a 14 days rolling average will be calculated from the raw BPAR data collected via telemetry. As per Collier *et al*. (2016) management triggers and related actions will be applied on a fourteen (14) day rolling average of PAR (TDP); during maintenance dredging operations management actions will be considered after seven (7) days of 14 day rolling average <6 mol/m^2/day.

Table 5: *Maintenance dredging BPAR monitoring sites.*

Site	Status	Site description and water area	WQ zone of impact
CT	Control	Control site. PAR collected above at a land based station.	N/A
WB25	Compliance	Adjacent to the dredging effort and at major sensitive receptor (i.e. the Passage Island seagrass meadows) which was identified as being within the zone of influence by impact hypothesis modelling.	Zone of influence

Table 6: *Adaptive management for BPAR to be implemented during maintenance dredging operations.*

Season	Rule	Condition	Activity
Growing (July – January**)	1 Go	BPAR 14 day rolling average >6mol m^{-2} d^{-1}	None required
	2 Internal alert	BPAR 14 day rolling average <6 mol m^{-2} d^{-1}	GPC Environment Monitoring Specialist increases surveillance (e.g. data accuracy, equipment status, dredge operations check, environmental conditions check).
		BPAR 14 day rolling average <6 mol m^{-2} d^{-1} >3 but <5 continuous days	GPC Environment Monitoring Specialist reviews data for potential causal factors (e.g. equipment status, rainfall, wind, dredging activity etc.). Notify internal stakeholders.
	3 Investigate	BPAR 14 day rolling average <6 mol m^{-2} d^{-1} >5 continuous days	GPC Environment Monitoring Specialist reviews and investigate causal factors and document findings.

Season	Rule	Condition	Activity
	If significant weather event has been identified as causal factor, hold at 3 and continue monitoring light/seagrass*		
	4 Action	BPAR 14 day rolling average <6 mol m^{-2} d^{-1} For 7 continuous days	Trigger meeting of internal stakeholders and dredging contractor to review findings of the investigation and determine potential actions for dredge management and seagrass protection.
		BPAR 14 day rolling average <6 mol m^{-2} d^{-1} For 10 continuous days	Implement agreed actions for dredge management and seagrass protection.
		BPAR 14 day rolling average <6 mol m^{-2} d^{-1} For 14 continuous days	GPC Environment Compliance Specialist to notify external regulator(s).

** GPC to provide notification to the regulator(s) on the 14th consecutive day of 14 day rolling average PAR <6 mol m^{-2} d^{-1}. Notification will provide clarification that the low light conditions are a result of the significant weather event.*
*** Growing season based on Chartrand et al. (2012), Rasheed et al. (2017).*

Table note: Integration time for the rolling average is 14 days and will commence at the start of the monitoring program. Adaptive management actions will be implemented during dredging operations only.

3.4 Dredger Data

All GPS coordinates recorded by the dredger must be to three decimal places. Key data collected by the dredger during the activity and reported to the Department of Environment and Science (**"DES"**) include:

(a) Areas being dredged;

(b) Volumes dumped at the spoil ground (in situ m^3);

(c) Dump run tracks, showing the spoil disposal track over the EBSDS; and

(d) Any incidents in line with the requirements of the Environmental Authority (EA)

Additional data to maintain compliance with approvals includes:

(a) Times and Dates of each dump run;

(b) Marine megafauna observations log of each dump run i.e. date, time, direction, distance, species, presentation (single or group) and spotter details;

(c) Weekly plotting sheet or certified ship extract: and

(d) Vessel Log including responsible vessel person (Master).

3.5 Activity Based Reporting Requirements

Turbidity and associated EWMA, BPAR, metals monitoring and key dredger data described in Section 3.4 will form the content of GPC's compliance report compiled for DES following maintenance dredging campaigns (**Table 7**).

The Condition of EA requires a report to be submitted to DES within 40 business days of completion of all dredging related monitoring.

Table 7: *Reporting requirements summary table.*

Data	Locations
Dredged areas	All
Volumes (in situ m^3)	All
Dump Run Tracks	All
Incidents	All
Turbidity	WB50 & MH10
BPAR	WB25
Metals	NW70, WB50, IH15, MH40 & MH50

The volume of material disposed at sea is reported annually to DAWE under the International Maritime Organisation (**"IMO"**) agreement, refer to Section 13 of the EMP.

3.6 Impact Hypothesis Monitoring Programs

The LMDMP considers impact hypothesis to test the long term impact of maintenance dredging on Port of Gladstone environment and surrounding habitats. The LMDMP also seeks to understand baseline conditions through ambient monitoring programs. These impact hypothesis and ambient monitoring commitments are outlined in Table 15 of the LMDMP and described in detail in the Sections below.

(a) Sediment and Analysis Plan

The National Assessment Guidelines for Dredging (**"NADG"**) set out the framework for the environmental impact assessment and defining feasibility of dredge material to ocean disposal. A five (5) yearly Sediment Analysis Plan (SAP) (#1427539) is undertaken in compliance with the NADG to provide a set of results that will allow a statistically valid evaluation of the physical and chemical properties of the sediment in the proposed dredge area against appropriate thresholds to inform dredging and disposal decisions. From this assessment it can then be determined if the dredge material is suitable for sea disposal.

The impact hypotheses to be tested by this monitoring is:

- *Disposal of dredged material will not result in contaminant related impacts to the marine environment*

Learnings and recommendations for monitoring and management are included in monitoring and management plans for implementation and continuous improvement. Monitoring is required every five (5) years and was last conducted in 2017.

(b) Sediment Monitors

The impact hypothesis to be tested by this monitoring is:

- *Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area.*

To complement WQ monitoring adjacent to the EBSDS, GPC has purchased specialised sediment dynamic monitors to enable targeted investigations into sediment movement at EBSDS and in the inner harbour as required. These were deployed in several occasion during and outside maintenance dredging operations in the past years to collect all necessary data. These will provide a better understanding of sediment movement and assess against the above impact hypothesis. The reports interpreting the data considered that:

- It is unlikely that maintenance dredging operations in the PoG will result in significant, widespread detectable adverse environmental impacts on the sensitive receptors (corals and seagrasses) in the region around the port and EBSDS; and

- It is also very unlikely that the placement of sediment from maintenance dredging at EBSDS and its subsequent resuspension would result in ecological impacts in the GBRWHA (excluding the EBSDS itself).

No monitoring is scheduled during the 2019 maintenance dredging campaign.

(c) Bioavailability Studies

Bioavailability studies at the EBSDS were to:

- Assess pollutant concentrations at the disposal site to ensure these do not reach levels where toxic effects could occur.

The impact hypothesis tested was:

- Pollutant concentrations *within dredge plumes at the loading and disposal sites do not reach levels where toxic effects or algal blooms could occur*.

The outcome of the 2018 plume monitoring confirmed that pollutant concentrations at the disposal site did not reach levels where toxic effects or algal blooms could occur. The study showed that the plumes were short lived and were not expected to cause adverse environmental effects. The plume monitoring results will complement the results of sediment studies and the previous studies into monitoring of dredge and disposal plumes.

GPC will propose to the TACC that no additional bioavailability studies are required at this time (awaiting TACC feedback), and will use the NADG to guide further investigations.

(d) Water Quality (Plume Validation)

The plume validation monitoring is conducted to assist to:

- Determine the impact on sensitive receptors in relation to size of dredging campaign. This includes determining what is the zone of impact; zone of influence and what areas are outside the zone of influence.

The hypothesis to be tested by this monitoring is:

- *Sediments generated during dredging and disposal do not subsequently reach sensitive areas in amounts that would be harmful to the ecological value and amenity of the area*

And/or:

- *Pollutant concentrations within dredge plumes at the loading and disposal sites do not reach levels where toxic effects or algae blooms could occur.*

Validation of current modelling is complete and focused on a maximum of 340,000 m^3 dredging campaign, where WQ measurements and samples were conducted inside the plume. Further plume sampling will be scheduled in the event that the dredging activity or sediment characteristics changed and/or new information for impact modelling is required.

(e) Reef Survey

Reef condition monitoring will continue will assist to:

- Determine if there is an environmental impact caused by maintenance dredging on closest reef communities.

The hypothesis to be tested by this monitoring is:

- *Maintenance dredging activities do not result in impacts to sensitive receptors.*

Reef habitats occur outside the zone of influence within the Gladstone Harbour and on the eastern side of Facing Island, adjacent to the EBSDS. The reef survey is conducted on a five (5) year frequency to determine if maintenance dredging activity is causing an environmental impact. The last survey was conducted in 2018.

(f) Benthic Habitats

Benthic fauna and flora sampling is designed to examine the spoil ground and determine if any long term changes are occurring outside the EBSDS. This is achieved by conducting sampling every five (5) years and looking at the zone of impact, zone of influence and outside the zone of influence. In line with the LMDMP commitment:

- *The deposited spoil does not result in long term changes to benthic communities outside EBSDS.*

Monitoring is required every five years and was last conducted in 2016.

(g) Hydrographic Survey

Hydrographic surveys are carried out post dredging campaign and undertaken within one (1) month of the campaign completion. The post survey from a previous campaign is utilised as initial for the new campaign (as a pre dredging survey).

Hydrographic surveys will continue in order to:

- Assess dredged material deposition patterns within the zone of placement impact and; and

- Identify potential navigation hazards, and the capacity of the EBSDS for future disposal events.

The impact hypothesis to be tested in future surveys is as follows:

- *The deposited spoil does result in navigation hazards within and adjacent to the EBSBDS*.

GPC carries out the hydrographic surveys of the EBSDS generally once annually following maintenance dredging campaigns. Any high spots that could form navigation hazards should be identified and communicated to the Regional Harbour Master. GPC submits Hydrographic surveys to DAWE and the Hydrographic survey office at the beginning and end of the sea dumping approval in compliance with the Sea Dumping Permit. Refer to Section 13 of the EMP.

(h) Marine Pests

Marine pest surveys will assist to:

- Determine if translocation of maintenance dredging equipment has resulted in new marine pests being introduced within the PoG. The survey will identify the location and status (pest-free) of marine pest within the port.

The hypothesis to be tested by this monitoring is:

- *Maintenance dredging does not result in the introduction of marine pests into new environments within the port area*

GPC undertakes a marine pest survey every five (5) years and was last conducted in 2015.

3.7 Ambient Monitoring Programs

(a) PCIMP

GPC's participation in PCIMP will continue during the permit period. The broad objective of this program is to assess the ambient mid to far-field WQ and adjacent ecosystems in the Port Curtis region to determine trends over time. The program is designed to identify any potential areas for concern without assigning direct causality. The key objectives of the program are to:

(i) Quantify concentrations of various indicators within the Port Curtis region to establish a baseline, and continually monitor the condition of the region;

(ii) Engage and involve stakeholders to adopt adaptive management practices, if required; and

(iii) Collect and collate high-quality data from sites within the Port Curtis region for PCIMP members and the Gladstone Healthy Harbour Partnership (**"GHHP"**) Report Card.

PCIMP consists of representatives from Gladstone industry, local government, research institutions and other stakeholders. GPC is a founding member of PCIMP which was first established in 2001. Currently GPC contributes financially to the program.

This information was historically reported every three (3) years in an ecosystem health report card. Trends on WQ, bioaccumulation and sediment quality for period 2006 – 2015 are available on the PCIMP website http://www.pcimp.com.au. PCIMP information is now collated for the public in GHHP report cards, discussed below. This program is used as baseline data for water and sediment quality results.

(b) GHHP

The GHHP is a forum bringing together several parties (including community, industry, science, government, statutory bodies and management) to maintain and where necessary improve the health of Port Curtis.

GHHP undertakes annual reporting of the health of the Gladstone Harbour advising on management recommendations and action based on rigorous science and strong stakeholder engagement to ensure the ongoing and continuous improvement in the health of Port Curtis.

GPC is a member of the GHHP management committee. The program is currently reviewing existing monitoring programs and investigating opportunities for further monitoring.

The 2019 GHHP report card for the health of the Port Curtis is provided at - http://ghhp.org.au/report-cards/2019.

(c) Seagrass surveys

Seagrass monitoring will continue during the monitoring period which will assist to:

(i) Assess broad-scale changes in seagrass meadow extent over time; and

(ii) Develop a long-term record of seagrass condition in the PoG.

Seagrass habitats occur adjacent to the dredged area and are predicted to receive turbid plumes from maintenance dredging. Turbid plumes in these areas are predicted to be short lived. Seagrass habitats are generally considered beyond the zone of potential plume effects and monitoring of maintenance dredging activities has supported this to date.

Seagrass monitoring sites are shown Appendix 2.

(i) Coastal Seagrass - Port Curtis and Rodds Bay seagrass monitoring program (broad scale survey)

Components of this program have been carried out on at different frequencies (quarterly or annually) since 2002, allowing broad-scale changes in seagrass meadow extent to be assessed over time. GPC and DAF and more recently JCU have collaborated to carry out this monitoring. Permanent transect monitoring of seagrasses in Port Curtis and Rodds Bay was established in November 2009. Monitoring was initially conducted quarterly at seven locations in Port Curtis and Rodds Bay, this was increased to monthly during the WBDDP and then decreased to quarterly at the completion of dredging activities. The last annual survey was conducted in 2018.

It has been determined through TACC agreement in 2018 that this broad scale seagrass surveys will continue on a yearly basis. This will align with obligations in the Deed of Agreement.

(ii) Deep Water Seagrass

It has been determined through TACC agreement in 2018 that Deepwater Seagrass Surveys will occur on a 5 yearly basis starting in 2019. The last Deepwater Seagrass Survey was conducted in 2014, which focused on the ephemeral deepwater seagrass adjacent to the EBSDS.

(iii) Wharf Analysers

GPC have installed three telemetered WQ analysers at three (3) wharf locations in the PoG measuring the full suite of standard physico-chemical parameters (temperature, EC, pH, DO and turbidity):

- Fisherman's Landing;
- RGTCT Clinton Wharf; and
- Boyne Wharf.

These analysers will provide a continuous and long term dataset for the PoG ambient water.

3.8 Data Management

Data shall be managed in accordance with the Environmental and Resource Use Data Management Procedure (#1101368). This procedure outlines GPC processes for recording and managing environmental and resource use data. The purpose of this Procedure is to document the processes used by GPC to:

(a) Collect, store and report on environmental and resource use data;

(b) Report trends and exceedances to internal and external parties for compliance and due diligence purposes or to help identify efficiency opportunities;

(c) Ensure processes are in place to monitor the quality and accuracy of data; and

(d) Describe how GPC meets the requirements of AS/NZS ISO 14001:2015.

3.9 Validation

Environmental data validation in line with LMDMP is achieved by the following processes:

(a) Quality Control / Quality Accreditation

Quality control of laboratory analysis is controlled through the use of laboratories that hold current NATA Accreditation, where possible.

GPC conducts audits on external providers that undertake environmental monitoring on a periodic basis to:

(i) Assess the level of conformance of the external providers with the requirements of AS/NZS ISO 14001:2015, relevant Australian standards for sampling and standard test methods;

(ii) Assess the Contractor's level of conformance with GPC contract requirements, which includes qualifications, technical experience and previous direct experience with the scope of works requirements; and

(iii) Provide GPC with feedback regarding the operation and compliance of monitoring and reporting activities undertaken by external parties.

(b) Peer review of reports

All reports are peer reviewed to ensure that the report:

(i) Aligns with scope of works and delivers required objectives; and

(ii) Contains no technical or referencing errors and is to the required standard.

3.10 Access to Reports and Data

GPC publishes the current approved version of the LMDMP and Environmental Monitoring Procedure on the GPC website for public access.

In accordance with Principal 16 of the Maintenance Dredging Strategy, GPC also provides a WQ and adaptive management report prepared in accordance with statutory approval requirements for the most recent dredging campaign on GPC's website along with a copy of the most recent SAP.

From January 2019 all monitoring reports related to the PoG LMDMP is published on GPC's website.

GPC keep a register of documents and reports (current and archived) including access to reports and data on the GPC website; the process is outlined in Section 3.16.3 of the EMP.

4 Monitoring and review

This procedure will be reviewed prior to each dredging campaign as required/appropriate or as a result of:

(a) Findings of internal and external inspections and/or audits;

(b) Changes in legislation or approvals;

(c) Incident and/or complaint investigations; and

(d) The review of monitoring results.

The review process is necessary to ensure currency, relevance and accuracy. Revisions are kept as a new version in GPC's document management system eDocs and must be communicated to all relevant GPC Employees.

For protocols on document management and review for this procedure refer to Section 3.17 of the EMP.

5 References

BMT WBM Pty Ltd (2014e) Modelling and Assessment of the Port of Gladstone Maintenance Dredging and Sea Disposal to Inform Sea Dumping Permit Applications, August 2014. BMT WBM Pty Ltd, Brisbane.

Chartrand, K.M. and Ralph, P.J. and Petrou, K. and Rasheed, M.A., 2012. Development of a light-based seagrass management approach for the Gladstone Western basin dredging program. Fisheries Queensland, Department of Agriculture Fisheries and Forestry, Cairns, pp. 126.

Chartrand K.M., Bryant C.V., Carter A.B., Ralph P.J. and Rasheed M.A., 2016. Light Thresholds to Prevent Dredging Impacts on the Great Barrier Reef Seagrass, *Zostera muelleri* ssp*. capricorni*. Front. Mar. Sci. 3:106. doi: 10.3389/fmars.2016.00106

Collier, C.J., Chartrand, K., Honchin, C., Fletcher, A. Rasheed, M., 2016. Light thresholds for seagrasses of the GBR: a synthesis and guiding document. Including knowledge gaps and future priorities. Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns (41pp.).

Rasheed, M., Wells, J. and Carter, A., 2017. Seagrasses in Port Curtis and Rodds Bay 2016: Annual long-term monitoring. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 17/02, James Cook University, Cairns.

6 Appendices

6.1 Appendix 1 – Related documents

(a) Guiding Principles

The following guiding principles relate to this Procedure:

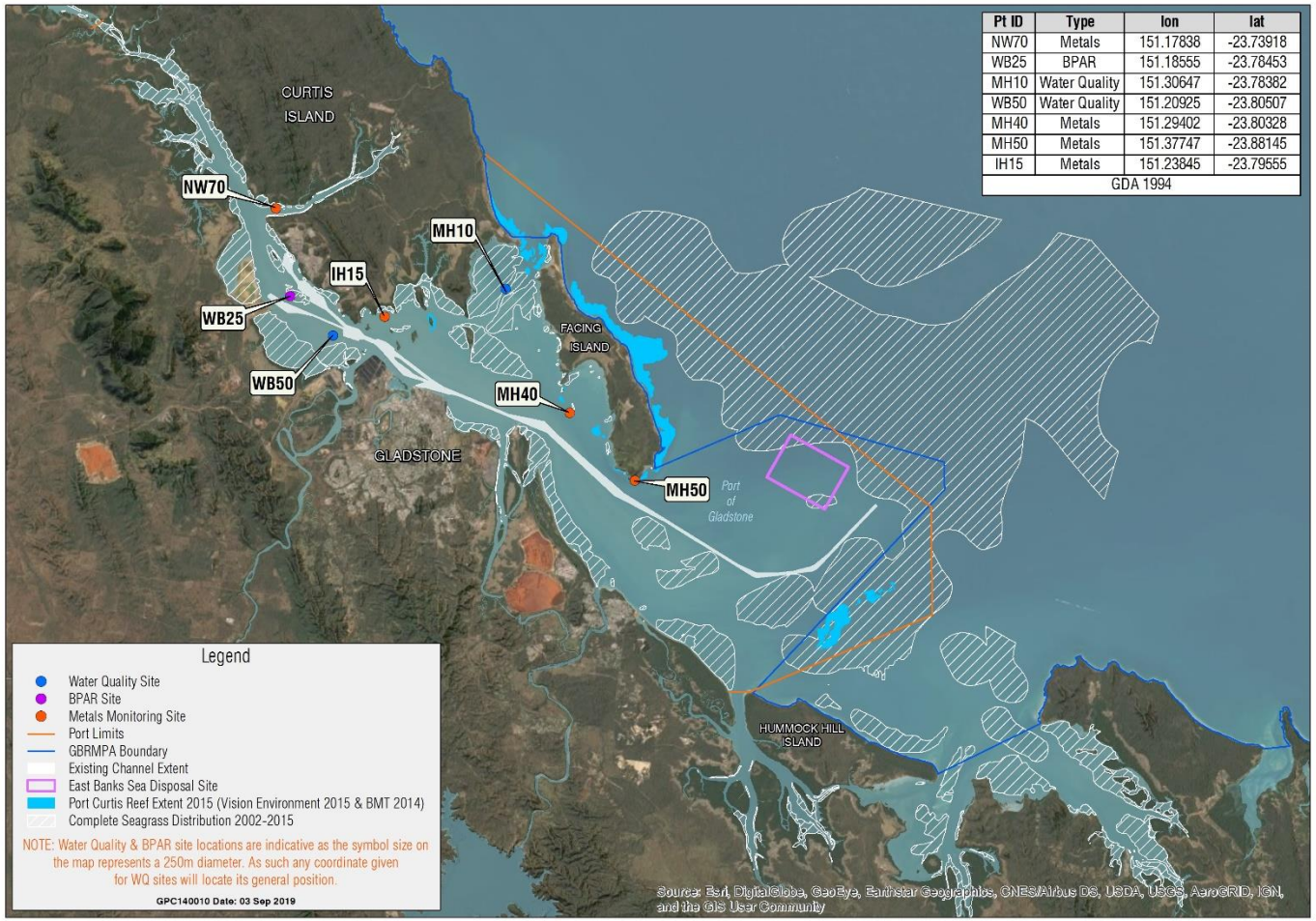
Type	What
GOC Principles	**Principle 7** – Recognise and manage risk
GPC Principles	**Sustainability** – We preserve the inherent worth of Port assets for future generations. We protect the health and safety of our people, the environment and our community. We engage with and contribute to the communities in which we operate. **Teamwork** – We are one company, one team. We work together to achieve our objectives.

(b) Gladstone Ports Corporation documents

The following documents relate to this Procedure:

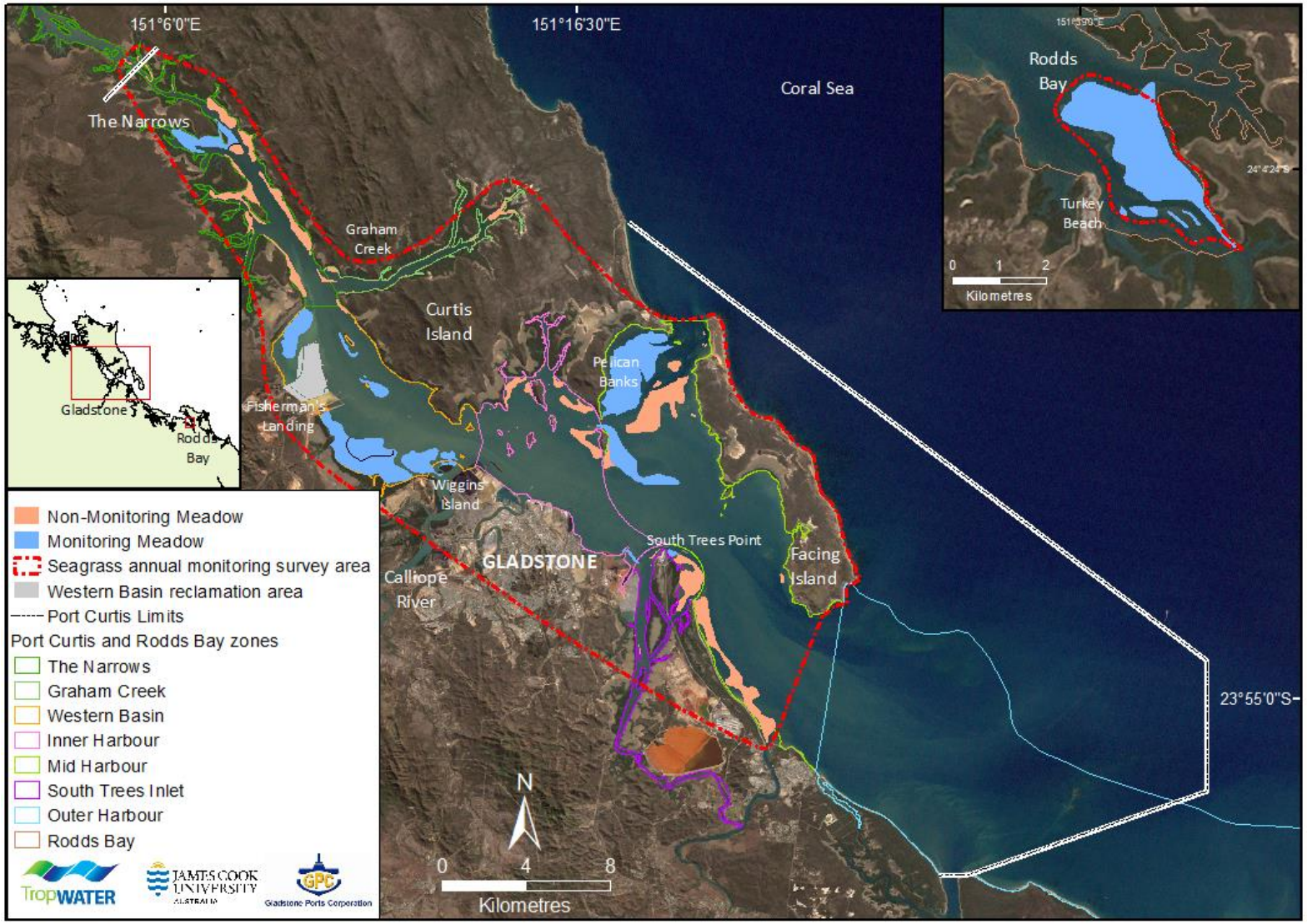
Type	Document number and title
Tier 1: Policy	#366016 Environment Policy
Tier 2: Standard/Strategy	#809151 Environmental Management Standard
Tier 3: Specification/ Procedure/Plan	#146256 Environmental Management System Plan #1385321 Port of Gladstone Long Term Maintenance Dredging Management Plan – V6 #879363 Port of Gladstone Maintenance Dredging Environmental Management Plan – V13A #1192974 Implementation Strategy for the Section 19 Deed of Agreement for Maintenance Dredging Activities
Tier 4: Instruction/Form/ Template/Checklist	#1621179 GPC Corporate Glossary Instruction
Other	N/A

6.2 Appendix 2 – Monitoring figures



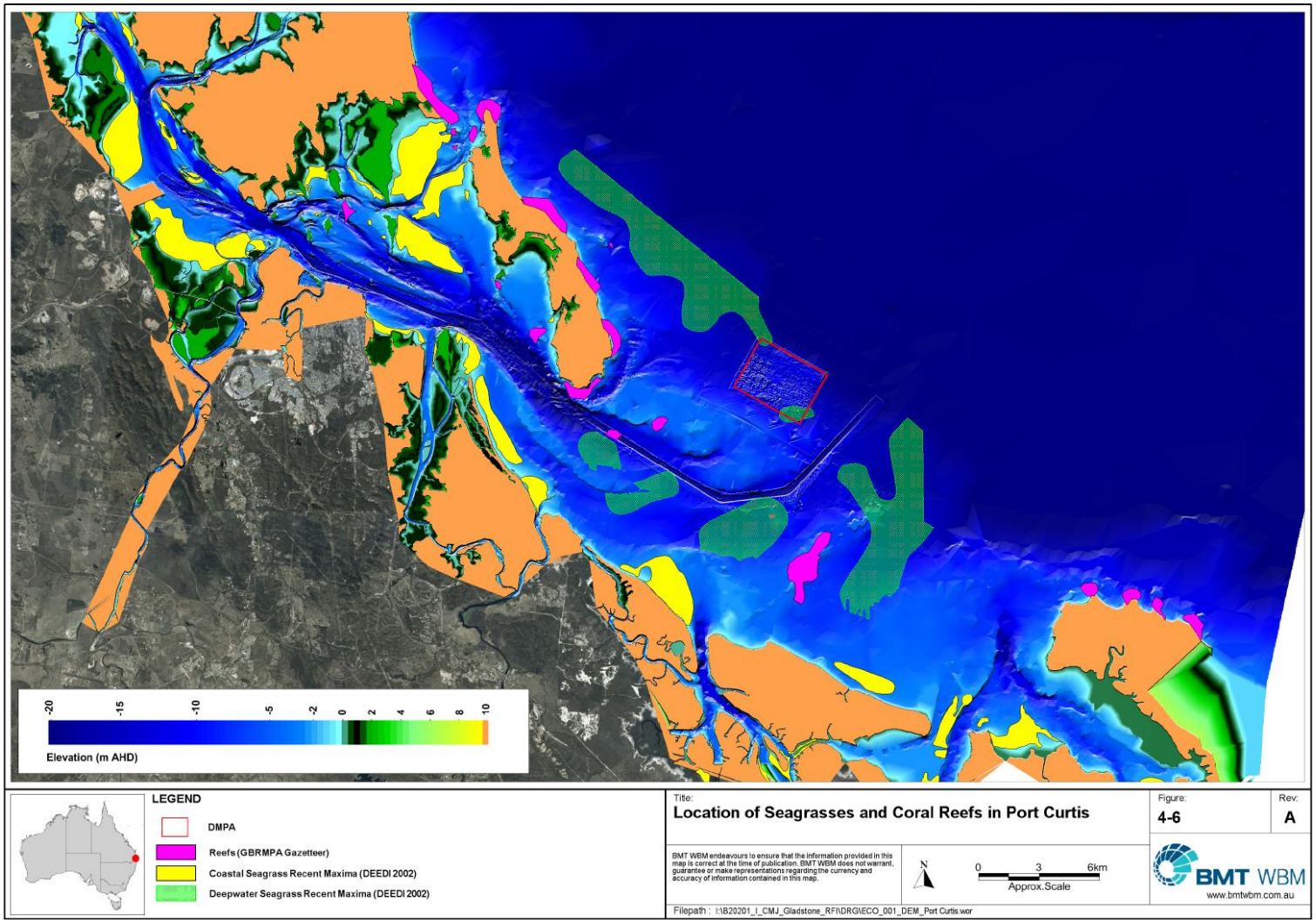
Pt ID	Type	lon	lat
NW70	Metals	151.17838	-23.73918
WB25	BPAR	151.18555	-23.78453
MH10	Water Quality	151.30647	-23.78382
WB50	Water Quality	151.20925	-23.80507
MH40	Metals	151.29402	-23.80328
MH50	Metals	151.37747	-23.88145
IH15	Metals	151.23845	-23.79555
GDA 1994			

Telemetered (BPAR and Turbidity) monitoring locations and metals sampling sites

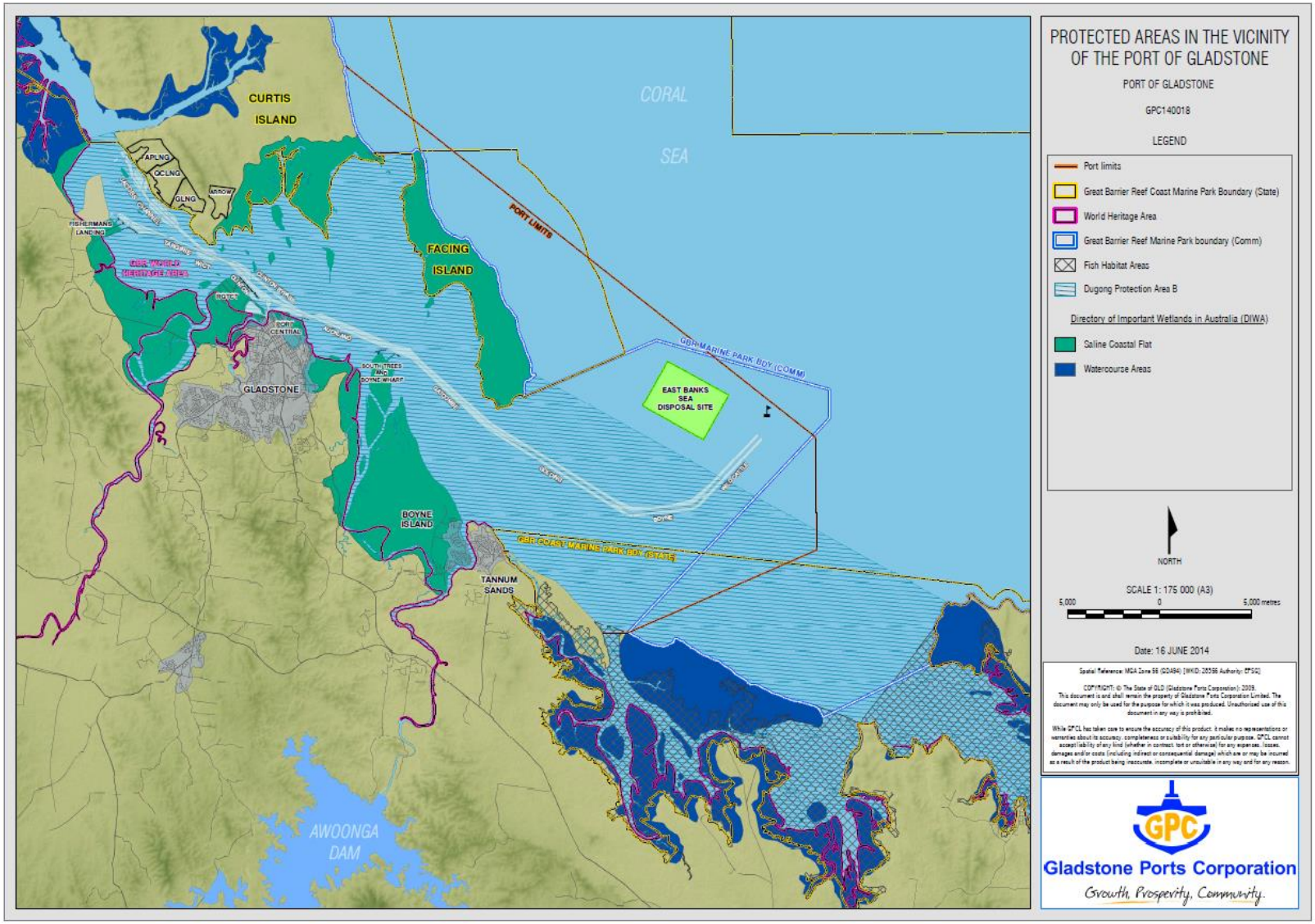


Seagrass distribution in 2018 and monitoring meadows within Port Curtis and Rodds Bay

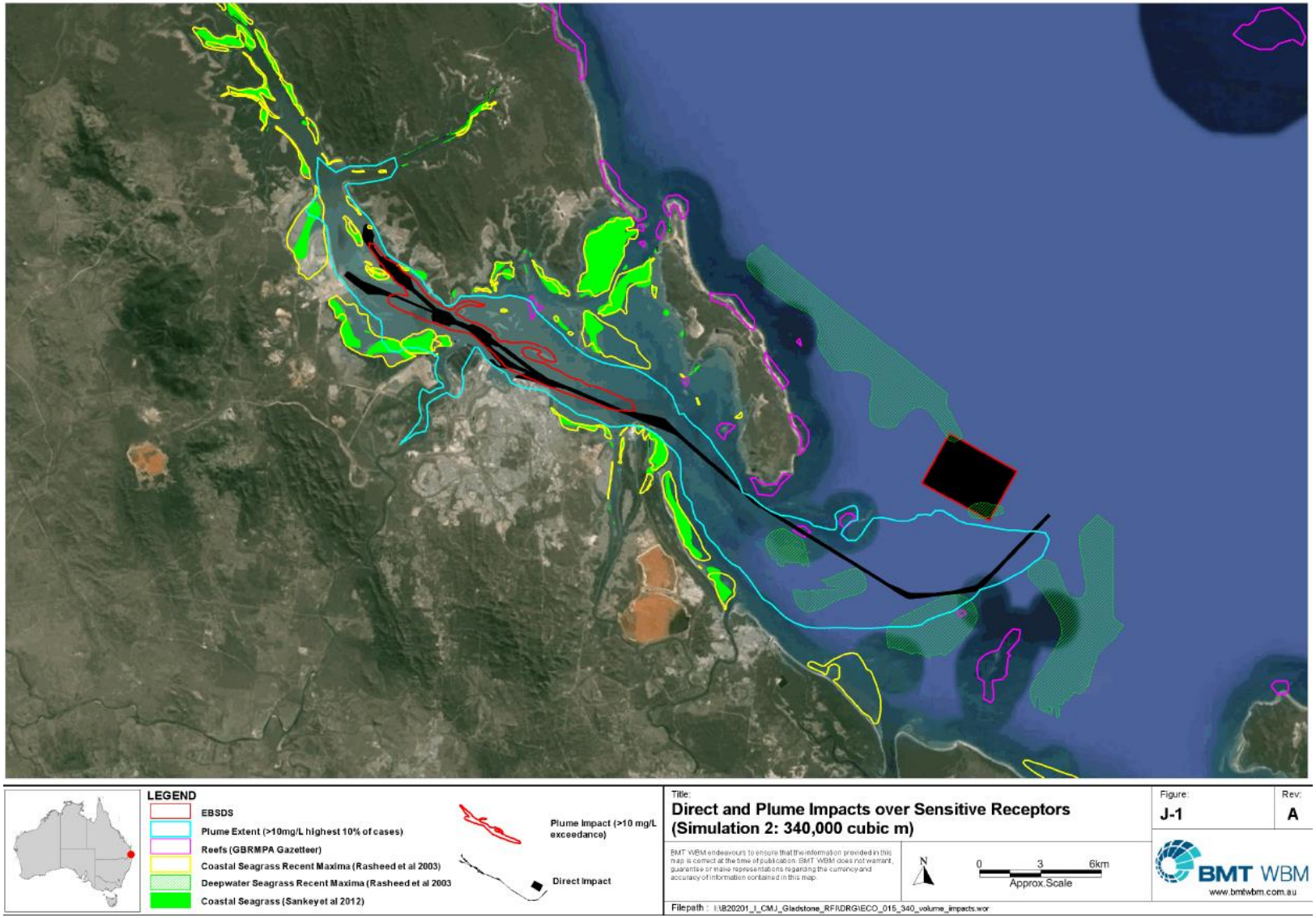
6.3 Appendix 3 – Sensitive Receptors



Seagrass and Reef habitats in the Port of Gladstone (BMT WBM 2014)



Marine protected Areas in the vicinity of the Port of Gladstone



Direct and plume impacts over sensitive receptors (Simulation2: 340,000 m^3) (BMT WBM 2014e)

6.4 Appendix 4 – Revision history

Revision date	Revision description	Author	Endorsed by	Approved by
16/12/13	v1 Procedure development	T.Tobin		
06/10/14	v2 Addition of due diligence monitoring	P.Rose		
08/01/14	v3 Addition of compliance site BG10 and edits from EHP review.	T.Tobin		
10/01/14	v4 Addition of further edits following EHP review and dry season triggers and flowchart	A.Bennett, P.Rose		
16/06/14	v5 Change to EIS monitoring regime for July dredging campaign	T.Tobin, A.Bennett		
16/08/14	v6 Update of document for December 2014 – December 2015 dredging period.	A.Bennett		
16/03/15	v7 Update of document for December 2015 – December 2016 dredging period.	A.Bennett		
17/08/16	v8 Removal of expired EIS monitoring regime and general administration review and formatting.	T. Tobin		
09/03/2018	v9-17 Review for 2018 dredging campaign and Addition of Deed of Agreement Implementation Strategy commitments / links and LMDMP requirements.	T. Tobin		
23/11/2018	v17a Administrative (not requiring re-authorisation). Added BPAR adaptive management flowchart.	F. Pastorelli		
31/05/2019	v17b Administrative (not requiring re-authorisation). Update in alignment with LMDMP, the 2019 conditions register review and the annual administration document review.	F. Pastorelli, T Tobin	K. Lockwood	
09/09/2020	V19 Administrative (not requiring re-authorisation). Procedure update and streamlining.	F. Pastorelli	K. Lockwood	
22/07/2020	V20 Administrative (not requiring re-authorisation). HSF review.	F. Pastorelli	K. Lockwood	