Procedure

Gatcombe and Golding Cutting Channel Duplication Project Environmental Monitoring

Endorsed: TBC

Brief description

The environmental monitoring and management of Gatcombe and Golding Cutting Channel Duplication Project at the Port of Gladstone is essential to ensure that the potential environmental impacts of this activity are managed through the identification of sensitive environmental receptors, understanding environmental risks and employing measures and safeguards to mitigate potential environmental impacts. Specifically, this Procedure applies to the establishment of the Western Basin Expansion reclamation area and dredging activities.

Document information

Current version	5
First released	11 May 2018
Last updated	24 September 2019
Effective by	To be confirmed
Review frequency	Refer Section 7
Review before	To be confirmed
Audience	Commonwealth and State Government agencies, community, industry and other stakeholders as part of the Channel Duplication EIS process

Document accountability

Role	Position
Owner	Port Strategy and Development General Manager
Custodians	Environmental Specialist – Compliance Environmental Specialist – Monitoring and Measurement

Table of contents

Figures

Abbreviations

Term	Definition
ANZECC	Australian and New Zealand Environment and Conservation Council
BPAR	benthic photosynthetically active radiation
BUF	barge unloading facility
CSD	cutter suction dredger
Cth	Commonwealth
DES	Department of Environment and Science
DO	dissolved oxygen
DoEE	Department of Environment and Energy
DTRP	Dredge Technical Reference Panel
EHP	Department of Environment and Heritage Protection (now known as DES)
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPP (Water)	*Environmental Protection Policy (Water) 2009*
ERA	Environmentally Relevant Activity
ESMM	Environmental Specialist Monitoring and Measurement
EVs	environmental values
EWMA	exponentially weighted moving average
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GHHP	Gladstone Healthy Harbour Partnership
GPC	Gladstone Ports Corporation Limited
HD	highly disturbed
HEV	high ecological value
JCU	James Cook University
m	metres
m^3	cubic metre
MCU	material change of use
MD	moderately disturbed
mg/L	milligrams per litre
NTU	nephelometric turbidity units
PAR	photosynthetically active radiation

Term	Definition
PCIMP	Port Curtis Integrated Monitoring Program
Procedure	Environmental Monitoring Procedure
Project	Gatcombe and Golding Cutting Channel Duplication Project
QWQG	Queensland Water Quality Guideline
SD	slightly disturbed
TBT	Tributyltin
TSHD	trailing suction hopper dredger
TSS	total suspended solids
WB	Western Basin
WBDDP	Western Basin Dredging and Disposal Project
WBE	Western Basin Expansion
WICT	Wiggins Island Coal Terminal
WQ	water quality
WQOs	water quality objectives

1 Procedure statement

This Procedure has been developed to:

- Describe the Gladstone Ports Corporation Limited (GPC) system for monitoring and managing potential environmental impacts and risks associated with the dredging component and the establishment of the Western Basin Expansion (WBE) reclamation area and barge unloading facilities (BUF) (Project activities) of the Gatcombe and Golding Cutting Channel Duplication Project (the Project) in the Port of Gladstone
- Describe the measures and safeguards to be implemented during Project activities
- Address compliance requirements within the following Project environmental approvals:
  - Coordinator-General Report
  - *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) controlled action conditions
  - Environmentally Relevant Activity (ERA) 16 Development Permit of material change of use (MCU) for ERA 16 conditions.

2 Project and procedure scope

The Project scope addressed by this Procedure includes:

- Construction of the WBE reclamation area bund walls and a BUF prior to dredging commencing
- Initial dredging works, of approximately 0.25 million cubic metres (Mm^3) of seabed material (including dredging tolerance) to establish an access channel to -7m lowest astronomical tide to allow barges to transport dredged material from the Gatcombe and Golding Cutting shipping channels to the BUF
- Dredging approximately 12.6Mm of seabed material (including dredging tolerance) to permanently duplicate the already existing Gatcombe and Golding Cutting bypass shipping channels. The preferred dredging methodology involves utilising a trailing suction hopper dredger (TSHD) which loads the dredged material from the Gatcombe and Golding Cutting shipping channels into barges (four barges will be working in cycles for the entire dredging operation) which will transport the material to the BUF adjacent to the existing Western Basin (WB) reclamation area to be unloaded using large excavators into trucks for placement within the existing WB and WBE reclamation areas
- Dredged material placement for beneficial reuse within the WB and WBE reclamation areas
- Removal, relocation and installation of new navigational aids
- Demobilisation of dredging operations
- Dewatering of dredged material within the WB and WBE reclamation areas and the licenced discharge of tailwater into Port Curtis.

This Procedure covers the environmental monitoring during Project dredging within the Port of Gladstone by the GPC and engaged contractors.

This Procedure supports and should be read in conjunction with the:

- Dredging Environmental Management Plan (Dredging EMP)
- Relevant GPC Environmental Management System (EMS) procedures as referenced in the EMP and Procedure.

This Procedure will be reviewed every three months during Project activities, and updated as required.

3 Procedure objective

The objective of this Procedure is to maintain compliance with the EPBC Act controlled action conditions and ERA 16 conditions by implementing the required environmental monitoring programs for Project activities in the Port of Gladstone. This Procedure ensures compliance by enabling the application of adaptive management actions based on monitoring results to ensure no long term harm to sensitive ecological receptors from dredging related plumes. Additionally, the programs identified in this Procedure progressively build a better understanding of Project dredging activities in the Port of Gladstone and assist in managing and quantifying potential environmental risks.

The performance of this Procedure will be measured through internal and external audits as part of GPC's EMS. Permit non-compliances or other environmental incidents during Project activities will be used as a measurement of the success of this Procedure and will also trigger review of its contents.

4 Roles and responsibilities

GPC staff 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* 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.*

Table 1 provides a summary of the responsibilities and accountabilities associated with implementation of this Procedure.

Table 1: Environmental roles and responsibilities

Position	Responsibility	Reporting to
Onsite		
Port Infrastructure Planning Manager	Responsible for overall management of Project dredging activities, approval and implementation of this document and associated management plans.	Port Strategy and Development General Manager
Civil/Structural Supervisor	Coordination and oversight of Project dredging activities in the Port.	Port Infrastructure Planning Manager
Offsite		
Environmental Manager	Ensure environmental management, monitoring, reporting and auditing responsibilities are met.	People, Community and Sustainability General Manager
Environmental Specialist–Monitoring and Measurement (ESMM)	Responsible for environmental monitoring and measurement.	Environmental Manager
Environmental Specialist – Compliance	Provide assistance to the Port Infrastructure Planning Manager to ensure compliance with Project Dredging EMP, this document and regulatory obligations, including reporting.	Environmental Manager

4.1 Dredge Technical Reference Panel

A Dredge Technical Reference Panel (DTRP) will be established for the duration of the Project to provide recommendations and scientific advice for water quality (WQ) management in the initial stage and to oversee the development and implementation of the environmental monitoring program. The DTRP will comprise scientific experts in WQ, seagrass and benthic habitat as well as management, regulators and dredging technical advisors.

The DTRP membership and terms of reference will be established by the Environmental Manager in consultation with the Department of Environment and Energy (DoEE) and the Department of Environment and Science (DES) prior to commencing WBE reclamation area bund wall works.

5 Background

5.1 Monitoring objectives

The monitoring program described in Section 5 of the Procedure has been developed based upon the findings of the Project hydrodynamic and plume modelling, and impact assessment (BMT WBM 2019). The WQ monitoring will be undertaken to:

- Measure WQ and light impacts at sensitive receptor sites within Port Curtis
- Implement management and mitigation measures to minimise the WQ impacts on sensitive receptor sites within Port Curtis.

The results of this monitoring will test the impact hypotheses as follows:

> *Sediments generated during dredging activities do not cause significant impact to sensitive receptor areas causing harm and loss of habitat.*

5.2 Port Curtis water quality objectives

Water quality objectives (WQOs) are numeric measures to protect environmental values (EVs), such as aquatic ecosystems and human uses. WQOs are set out for the Port of Gladstone in *Environmental Protection Policy (Water) 2009* (EPP (Water)). These WQOs are based on national and state WQ guidelines and objectives (i.e. ANZECC/ARMCANZ 2000; DERM 2009; Department of Environment and Heritage Protection (EHP) 2014).

The Curtis Island, Calliope River and Boyne River Basins Environmental Values and Water Quality Objectives (EHP 2014) has been prepared pursuant to the provisions of the EPP (Water), which is subordinate legislation under the *Environmental Protection Act 1994*. The EPP (Water) provides a framework for:

- Identifying EVs for Queensland waters, and deciding the WQOs to protect or enhance those EVs (WQOs are long term goals for receiving waters, not individual point source emission objectives)
- Including the identified EVs and WQOs under Schedule 1 of the EPP (Water).

The document contains EVs and WQOs for waters in the Curtis Island, Calliope River and Boyne River basins, Gladstone Harbour, The Narrows and adjacent coastal waters, and is listed under Schedule 1 of the EPP (Water).

The purpose of the document is to identify locally relevant EVs and WQOs for the region, based on local historical data and in close consultation with the local community. These WQOs are used as an input into setting development conditions, influence local government planning schemes and underpin report card grades for ecosystem health monitoring programs like the Gladstone Healthy Harbour Partnership (GHHP) and other similar programs. These WQOs have been refined from national and state WQ guidelines and present a truer picture of the values and WQ of local waterways. This ensures the values the community holds for its waterways can be maintained and improved into the future, without imposing unrealistic standards from national guidelines that may be inappropriate for local conditions.

EVs identified within the EPP (Water) for the Port of Gladstone adjacent coastal waters and nearby estuaries include:

- Aquatic ecosystems – biodiversity, ecological interaction, plants, animals, key species (e.g. turtles, seagrass, dugongs, etc.) and their habitat, food and drinking water
- Human consumption – humans consuming aquatic food from this area, including fish, crustaceans and shellfish
- Primary recreation – activities with full body contact with water, including swimming, windsurfing, diving and water skiing
- Secondary recreation – indirect contact and low probability of water being swallowed, including wading, boating, rowing and fishing
- Visual recreation – amenity of waterways for recreation which does not involve contact with water such as walking or picnicking
- Drinking water (waters in which desalination for drinking water may apply) – suitability of a raw drinking supply assuming minimal treatment required
- Industrial use – suitability of water supply for industrial use. Industries usually treat water supply for their individual needs.
- Cultural and spiritual values
- Aquaculture – health of aquaculture species and human consuming aquatic food from commercial ventures in this area.

WQOs are long term goals for WQ management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. WQOs are not individual point source emission objectives, but the receiving WQOs.

The EPP (Water) also contains the management intent for Queensland waters, and the decision to release wastewater or contaminant to waters must ensure the following:

- For high ecological value (HEV) waters: the measures for the indicators are maintained
- For slightly disturbed (SD) waters: the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the WQOs for high ecological value water
- For moderately disturbed (MD) waters:
  - If the measures for indicators of the EVs achieve the WQOs for the water: the measures for the indicators are maintained at levels that achieve the WQOs for the water, or
  - If the measures for indicators of the EVs do not achieve the WQOs for the water: the measures for indicators of the EVs are improved to achieve the WQOs for the water
- For highly disturbed (HD) waters: the measures for the indicators of all EVs are progressively improved to achieve the WQOs for the water.

Following stakeholder consultation and analysis of WQ data, WQOs were derived for both baseflow and event WQOs in Gladstone Harbour and other waterways where data was available. Section 3.1 of the EPP (Water) outlines WQOs to protect the identified EV. The relevant WQOs tables in the document for the protection of aquatic ecosystems include:

- Table 2A: Gladstone Harbour, The Narrows, adjacent coastal waters and estuaries – baseflow WQOs
- Table 2B: Gladstone Harbour and The Narrows: time/flow thresholds for applying baseflow WQOs
- Table 2D: Gladstone Harbour and Boat Creek: event WQOs.

Figure 1 shows the EPP (Water) Port Curtis marine estuarine water types, and Table 2 details the EPP (Water) WQO for the protection of aquatic ecosystems for the ten WQ monitoring sites.

Table 2: Port Curtis and The Narrows EPP (Water) WQOs to protect aquatic ecosystem environmental value under baseflow conditions (peak discharge < 100m^3/sec)

Site (refer Figure 1)	EPP (Water) area/type	Parameter	Wet season (1 October to 31 March)			Dry season (1 April to 31 September)		
			20th %ile	50th %ile	80th %ile	20th %ile	50th %ile	80th %ile
WB50 and C3	MD2421 Western Basin	Turbidity (NTU)	7	13	29	4	8	17
MH10 and MH60	MD2423 Mid Harbour	Turbidity (NTU)	4	9	16	2	4	7
CD1, CD2, CD4 and CD5	MD2424 Outer Harbour	Turbidity (NTU)	2	7	13	1	3	6
NW50	SD2441 The Narrows	Turbidity (NTU)	8	15	30	4	7	12
RB1	Rodds Bay	Turbidity (NTU)	2	5	12	3	4	7

Source: EHP (2014)

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

The Narrows
Graham's Creek
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Curtis Island
North Entrance
Facing Island
Coral Sea
Port Limits
Marine Park Line
Gladstone
Calliope River
Gatcombe Channel
South Trees Island
East Banks DMPA
Golding Cutting Channel
Boyne Island
Tannum Sands
Boyne River
Colosseum Inlet
Rodds Bay

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks DMPA
- Built Up Areas

EPP (water) zones

- Auckland Inlet
- Boat Creek
- Colosseum Inlet
- Graham's Creek (Lower)
- Graham's Creek (Upper)
- Inner Harbour
- Lower Boyne Estuary
- Lower Calliope Estuary
- Mid Boyne Estuary
- Mid Calliope Estuary
- Mid Harbour
- Outer Harbour
- Rodds Bay
- South Trees Inlet (Lower)
- South Trees Inlet (Upper)
- The Narrows
- Western Basin
- Open coastal waters
- Marinas / boat harbours / constructed estuaries
- Excluded water type

Source:
Aerial: GPC (2014); DigitalGlobe Web Map Service (2013) and ESRI Data Sources.

Map by: NKM
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_233.mxd 11/02/2019 16:14

0 2,200 4,400 Metres

Date: 11/02/2019 Version: 2 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 1: EPP (water) zones for Port Curtis, The Narrows and adjacent coastal waters

5.3 Baseline water quality monitoring

Within the EPP (Water) and QWQG guidelines percentile values can be estimated, which can be used to further derive WQ objectives for an area. Under this approach, an expected 18 samples at each site over a minimum of 12 months may allow for the creation of an appropriate value (trending towards the blanket ANZECC 2000 guideline of 24 data values for an appropriate population estimate). Noting this, percentiles based on a smaller number of samples will typically derive percentiles estimates within actual percentile estimates, giving more stringent estimates (EHP 2009).

Ten Project WQ monitoring sites, spanning from The Narrows to open coastal waters east and south of Facing Island, were selected in 2014 as part of the Gatcombe and Golding Cutting Channel Duplication Project EIS baseline data collection strategy in consultation with Commonwealth and State regulatory agencies (i.e. Department of the Environment, Great Barrier Reef Marine Park Authority, EHP and Department of Science, Information Technology, Innovation and the Arts). All monitoring locations were selected to provide data to characterise the current baseline WQ of Port Curtis, with the potential for these ten Project sites to transition into compliance and reference monitoring sites during dredging works.

Continuous turbidity data (and other WQ parameters) were logged every 15 minutes over a 13 month period (June 2014 to July 2015). During a short period of the monitoring program, annual maintenance dredging occurred within Port Curtis. With acknowledgment of the potential for maintenance dredging to bias ambient baseline data, the scale and occurrence of maintenance dredging was not considered to impact baseline water quality (principally as maintenance dredging reports indicated no detectable impact of turbidity on monitored seagrass meadows throughout the entire water quality baseline monitoring period).

The 13 month monitoring dataset underwent a quality control process whereby data points that were obviously not valid (e.g. due to fouling, instrument malfunctions) were removed from the dataset. One of the key objectives of collecting the 13 months of turbidity data for the Port was to utilise this data to develop Port specific WQOs and compliance WQ triggers to be adopted during dredging activities. For further detail on these ten Project WQ monitoring sites refer to Section 6.1.2.

The Project EIS baseline WQ monitoring data set has been used to develop the Project WQ zones of impact (refer Section 5.4) and Project turbidity trigger levels (refer Section 6.6.1). Due to data deficiency for a selection of new Project monitoring sites, the Project water quality turbidity trigger values will be calculated as part of the pre-Project WQ monitoring program (refer Section 6.3).

5.4 Project water quality zones of impact

Spatial zones of predicted impact were developed using site-specific impact assessment threshold values, based on the 13 month baseline WQ (turbidity) data from 1 June 2014 to 5 July 2015. The baseline WQ (turbidity) data was analysed over 14 day windows, which were moved by 5 day increments over the entire dataset. A range of percentiles were calculated for each of these different periods, to represent water conditions (i.e. 20th percentile is calm conditions with low wind and waves/neap tides, 50th percentile is average conditions and 80th percentile is rough conditions with high wind and waves/spring tides). Threshold values were derived for each of these percentiles, to consider the natural variability of turbidity in the Port and to consider both short term and sustained impacts.

Threshold values were developed for the three zones of impact and the zone of influence as shown in Table 3.

Table 3 Description of impact assessment threshold values

Zone of impact	Definition	Methodology
Zone of high impact	Excess turbidity from dredging activities most likely to cause WQ to deteriorate beyond natural variation	Excess turbidity greater than three standard deviations from the natural background mean at each percentile (i.e. 20th, 50th and 80th percentiles)
Zone of medium impact	Excess turbidity from dredging activities likely to cause WQ to deteriorate beyond natural variation	Excess turbidity greater than two standard deviations from the natural background mean at each percentile (i.e. 20th, 50th and 80th percentiles)

Zone of impact	Definition	Methodology
Zone of low impact	Excess turbidity from dredging activities may cause WQ to deteriorate beyond natural variation	Excess turbidity greater than one standard deviation from the natural background mean at each percentile (i.e. 20th, 50th and 80th percentiles)
Zone of influence	Extent of detectable plume (as measured by instrumentation) but no predicted ecological impacts	Turbidity related to dredging activities exceeds: ■ 1 NTU above 50th percentile conditions ■ 2 NTU above 80th percentile conditions ■ 5 NTU above 95th percentile conditions ■ 10 NTU above 99th percentile conditions

To determine the zones of impact the site-specific threshold values from the Project EIS baseline WQ monitoring were interpolated spatially across the study area producing 3-dimensional threshold grids. These threshold grids were then analysed against the 3-dimensional model output grids using GIS mapping software. This produced impact zone maps which illustrate predicted areas where modelled turbidity (ambient and dredging activity) is higher than the relevant turbidity threshold value for a specific zone of impact.

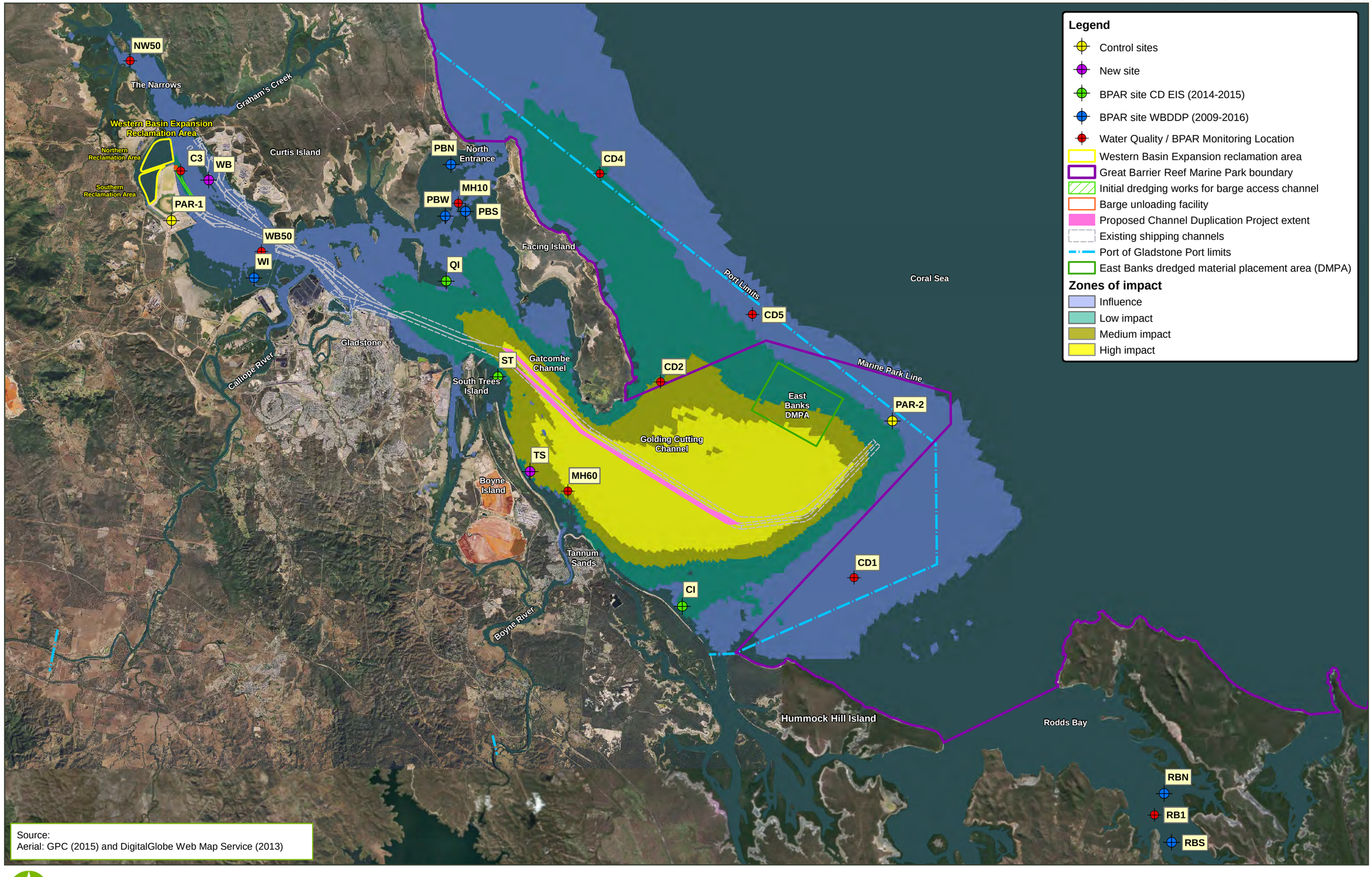
The initial WQ zones of impact have been tested utilising biological tolerances for Port Curtis seagrass meadows and coral reefs. For each of the baseline WQ monitoring sites located on or in close proximity to seagrass meadows, and for a number of sites located in sensitive seagrass and coral reef locations through Port Curtis and nearby islands, the site-specific turbidity and benthic photosynthetically active radiation (BPAR) thresholds as well as sedimentation for the zone of influence and the three WQ zones of impact were tested. The biological testing at each location confirms that the modelling was appropriate for each zone of impact.

The hydrodynamic modelling time series plots for points on or near sensitive coral communities and along transect over each Port Curtis seagrass meadows have been used in the impact assessment and as an input into the development of this Procedure and associated adaptive mitigation strategies to be implemented during the establishment of the WBE reclamation area and BUF, and dredging.

Figure 2 shows the WQ zones of impact that have been predicted from the model.

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_303.mxd 25/07/2019 14:31

0 2,250 4,500 Metres

Date: 25/07/2019 Version: 3 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 2: Water quality zones of impact (Stages 1 and 2 dredging)

6 Project monitoring program

The sections below detail the monitoring that will be undertaken prior, during and after dredging activities, including the parameters, locations and frequency of the monitoring.

6.1 Water quality

6.1.1 Background

Turbidity is a measurement of water clarity, and is influenced by suspended matter (organic and inorganic) and dissolved organic matter. Turbidity is an expression of the optical property of light to be scattered and absorbed rather than transmitted through the water sample, with a greater amount of matter within the water column leading to a higher amount of light scattering, and thus higher turbidity. Project activities have the potential to result in elevated turbidity levels within the Port. Therefore, turbidity is an important parameter to monitor during Project activities.

6.1.2 Water quality monitoring sites

Several WQ sites have been selected to monitor turbidity levels prior to, during and post dredging activities. Site selection has been based on existing WQ data collection programs (e.g. Gatcombe and Golding Cutting Channel Duplication EIS WQ data collection program), previous Port dredging projects, and the findings of the Project impact assessment (i.e. BMT WBM 2019).

Several sites were established for data collection grouped into offshore (CD1, CD2, MH60, CD4, and CD5) and inshore (MH10, WB50, NW50 and C3). Offshore sites were at a depth of >15m and are highly influenced by wind and wave action. Inshore sites were shallow (approximately 5m depth) and highly tidally influenced. Each WQ monitoring site is described below and summarised in Table 4. The WQ monitoring sites are generally consistent with the Port Curtis Integrated Monitoring Program (PCIMP).

CD1 and CD2 – CD1 and CD2 are located within the Great Barrier Reef Marine Park (GBRMP), and adjacent to sensitive habitats, including seagrass meadows and reef communities and located in the zone of influence (CD1) and the zone of medium impact (CD2). These sites will act as sentinel management sites during Project dredging works. The Project EIS hydrodynamic modelling predicts increased turbidity impacts within the GBRMP at the 50th percentile. Both CD1 and CD2 are considered near-field for the channel duplication area to be dredged.

MH60 – MH60 is located southwest of the channel duplication area to be dredged adjacent to intertidal and subtidal seagrass habitats. It is located within the zone of medium impact. The site also provides an indication of flood event flows from the Boyne River. It serves as a near-field site for the channel duplication area to be dredged. This site is located within the vicinity of PCIMP WQ monitoring site MH60 which has been monitored for a range of parameters from 2006. While site MH60 was grouped among the offshore sites for the purposes of this monitoring program, it was noted that the location of MH60 exhibits both inshore and offshore characteristics (MH60) lies within the Mid Harbour zone, close to the Outer Harbour zone boundary). Scientists from Vision Environment consider that this site exhibited characteristics closer to the offshore environment, when compared to the characteristics and influences of sites further inshore of the estuary (e.g. WB50 and MH10).

CD4 – CD4 is located within the GBRMP boundary and outside Port limits. CD4 is positioned to be within the zone of low impact. CD4 is located adjacent to comparable sensitive seagrass and coral habitats at similar depths to those at potentially impacted sites. CD4 is also located near previous WQ monitoring site SGM2 used during the Western Basin Dredging and Disposal Project (WBDDP) WQ monitoring and is within a deep water seagrass meadow. CD4 provides a far-field monitoring site and a reference location for WQ in the Outer Harbour and open coastal waters.

CD5 – CD5 is located approximately 6.5km east of Facing Island. It acts as a far-field site for the Project and is within the zone of influence. CD5 is located within a deep water seagrass meadow within the GBRMP boundary and outside Port limits.

WB50 – WB50 is located in the Western Basin area of Port Curtis, adjacent to the mouth of the Calliope River and the Wiggins Island Coal Terminal (WICT) and Wiggins Island seagrass meadows. Monitoring at WB50 is designed to capture impacts from natural flow events from the Calliope River. It is a well studied monitoring site with WQ dating back to 2009. WB50 is located within the zone of moderate impact.

MH10 – MH10 is located adjacent to the Pelican Banks seagrass meadows. MH10 is within the zone of influence.

NW50 – NW50 is located adjacent to Worthington Island and is in The Narrows. It is located in a zone of influence.

RB1 – RB1is located outside of the Project impact areas within Rodds Bay, south of the Port and will be used as reference sites

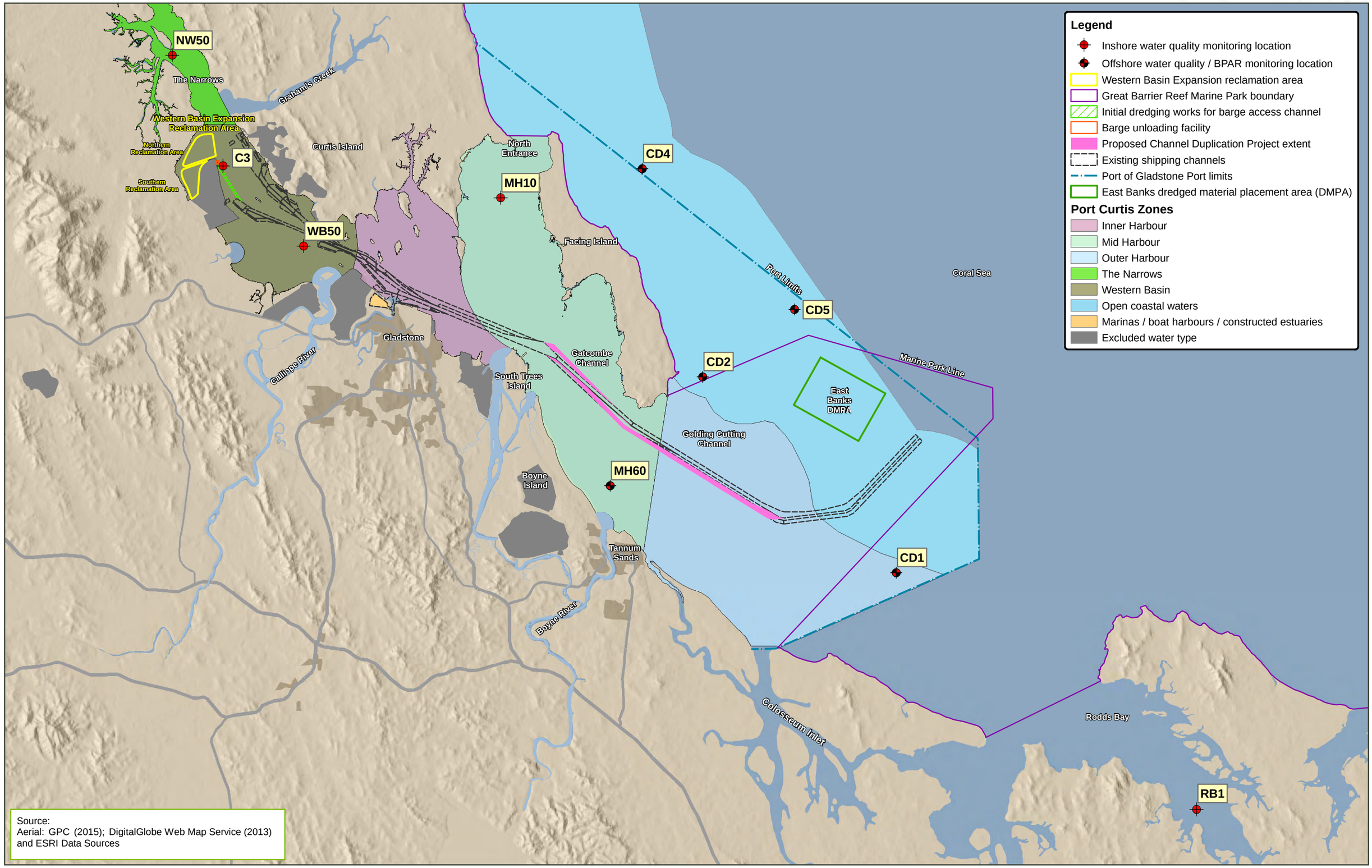
C3 – C3 is located adjacent to the existing Western Basin reclamation area, and it is within the zone of influence. C3 did not exist during the Project EIS baseline monitoring and has been included in close proximity to the Western Basin reclamation area to monitor any potential WQ impacts from the establishment of the Western Basin reclamation area and during the tailwater discharges to the neighbouring aquatic area.

Table 4: Project water quality monitoring sites

Site	Location	Description and water area	EPP (Water) management intent/ level of protection	Project water quality zone of impact
CD1	Offshore	Adjacent to Seal Rocks. Outer harbour (MD2423)	Moderately disturbed	Zone of influence
CD2	Offshore	Off East Point off Facing Island. Coastal waters outside Gladstone Harbour east and south of Facing Island	Slightly to moderately disturbed	Medium impact
MH60	Offshore	Located outside the mouth of the Boyne River. Mid Harbour (MD2423)	Moderately disturbed	Medium impact
CD4	Offshore	Off the eastern side of Facing Island, adjacent to Pearl Ledge. Coastal waters outside Gladstone Harbour east and south of Facing Island	Slightly to moderately disturbed	Low impact
CD5	Offshore	Off the eastern side of Facing Island, 3km northwest of East Banks dredged material placement area. Coastal waters outside Gladstone Harbour east and south of Facing Island	Slightly to moderately disturbed	Zone of influence
C3	Inshore	Adjacent to Western Basin reclamation area. Western Basin (MD2421)	Moderately disturbed	Zone of influence
WB50	Inshore	Outside the mouth of the Calliope River. Western Basin (MD2421)	Moderately disturbed	Zone of influence
MH10	Inshore	Adjacent to Pelican banks seagrass meadows. Mid Harbour (MD2423)	Moderately disturbed	Zone of influence
NW50	Inshore	Adjacent to Worthington island in The Narrows (SD2442)	Slightly disturbed	Zone of influence
RB1	Inshore	Within Rodds Bay. To be used as reference site away from Project impact areas.	Slightly disturbed	Outside zone of influence

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon



Source:
Aerial: GPC (2015); DigitalGlobe Web Map Service (2013) and ESRI Data Sources

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_220.mxd 16/07/2019 16:33

0 2,250 4,500 Metres

Date: 16/07/2019 Version: 4 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 3: Baseline water quality monitoring locations

GPC will also conduct a due diligence water sampling program (refer Table 10) during the three phases of the Project dredging program (i.e. pre, during, and post dredging) for other WQ parameters (refer Table 5 and Table 6) at all the Project WQ monitoring sites (refer Figure 3).

This data will be used to examine if any changes are observed since the baseline monitoring. Table 5 details the methods and frequency for WQ monitoring.

Table 5: Summary of water quality, light and sedimentation monitoring at all sites

Data type	Parameter	Monitoring objective	Method	Frequency
WQ	Turbidity Temperature pH Conductivity Dissolved oxygen (DO)	Compliance	WQ telemetry and remote loggers utilising surface WQ sondes	Logged every 15 minutes with real time feed
	Turbidity Temperature pH Conductivity DO	Due diligence	In situ depth profiling - WQ sonde	Monthly
	Total suspended solids (TSS)	Due diligence	Water sampling (mid water column)	Monthly
	Metals/metalloids Nutrients Chlorophyll *a*	Due diligence	Water sampling - Perspex pole sampler	Monthly
	Organic contaminants	Due diligence	Water sampling - Perspex pole sampler	Quarterly
Light	BPAR	Compliance	BPAR telemetry and remote loggers	Logged every 15 minutes (data transferred every 30 minutes in real time) during dredging

Table 6 lists all the physiochemical parameters to be tested and their unit of measurement. National Association of Testing Authorities (NATA) approved laboratories are to be used for laboratory analysis of non *in-situ* parameters. Due diligence water quality sampling is to be compared to relevant ANZECC/ARMCANZ guidelines and water quality objectives as per Schedule 1 of the EPP (Water) *Curtis Island, Calliope River and Boyne River Basins Environmental Values and Water Quality Objectives* (DEHP 2014).

Table 6: Details of parameters to be tested

Water quality parameter [a,b]	Unit	Relevant ANZECC/ARMCANZ guidelines for 95% protection of aquatic ecosystems in moderately disturbed waters	Relevant ANZECC/ARMCANZ guidelines for 99% protection of aquatic ecosystems in slightly disturbed waters
pH	pH	-	-
Temperature	°C	-	-
Conductivity	mS/cm	-	-
DO	% sat and mg/L	-	-
TSS	mg/L	-	-
Total Nitrogen	mg/L	-	-

Water quality parameter [a,b]	Unit	Relevant ANZECC/ARMCANZ guidelines for 95% protection of aquatic ecosystems in moderately disturbed waters	Relevant ANZECC/ARMCANZ guidelines for 99% protection of aquatic ecosystems in slightly disturbed waters
Total Phosphorous	mg/L	-	-
Chlorophyll *a*	µg/L	-	-
Ammonia (nitrogen)	µg/L	-	-
Aluminium (total)[c]	µg/L	0.5	0.5
Arsenic (III) (total and dissolved)	µg/L	2.3	2.3
Arsenic (V) (total and dissolved)	µg/L	13[d]	13[d]
Cadmium (total and dissolved)	µg/L	5.5	0.7
Chromium (VI) (total and dissolved)	µg/L	4.4	0.14
Copper (total and dissolved)	µg/L	1.3	0.3
Lead (total and dissolved)	µg/L	4.4	2.2
Mercury (total and dissolved)	µg/L	0.4	0.1
Nickel (total and dissolved)[c]	µg/L	7.0	7.0
Silver (total and dissolved)	µg/L	1.4	0.8
Zinc (total and dissolved)	µg/L	15	7.0
Tributyltin (TBT)	µg Sn/kg	0.006[d]	0.006[d]
TPH	mg/L	-	-

Table notes:

a Reliability of modelled protection levels ranges from low to very high
b Modelled protection levels are based on freshwater and marine water medium; marine water thresholds were selected where available
c 99% protection level is recommended for slightly to moderately disturbed marine systems
d Considered sufficiently protective for slightly-moderately disturbed ecosystems (ANZECC/ARMCANZ 2018)

Source: ANZECC/ARMCANZ (2000/2018)

6.2 Benthic photosynthetically active radiation

6.2.1 Background

BPAR monitoring will be undertaken in accordance with the DES Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2018[1] to:

- Measure WQ and light impacts at or adjacent to sensitive receptor sites within the Port of Gladstone
- Determine the need or otherwise for the implementation of mitigation measures.

The results of this monitoring will test the impact hypotheses as follows:

> *Sediments generated during dredging and dredged material placement do not have a significant impact on sensitive receptor areas causing harm and loss of habitat.*

[1] Source: *Environmental Protection (Water) Policy 2009 - Monitoring and Sampling Manual; Biological assessment (Version: February 2018); "Guidance on using Photosynthetically Active Radiation (PAR) as a method to measure light availability for aquatic photosynthetic organisms facing acute impacts". Guideline was available at the following web address (on 24-July-2019): https://environment.des.qld.gov.au/water/pdf/deriving-local-water-quality-guidelines.pdf*

Monitoring is likely to be conducted using flat 2π sensors for use in BPAR monitoring; however, for Project compliance monitoring, calibration (using computational methods and total daily estimation) and QA/QC processes are required to remain at a high standard (as per DES 2018).

Seagrass meadows are an important benthic primary producer in Port Curtis and have high economic and ecological value. These habitats play a key role in providing food resources and habitat for vulnerable species of turtle and dugong as well as fish juveniles. Due to their sensitivity to reduced light (i.e. decreased water clarity) seagrass meadows are often chosen as a sensitive receiver for detecting dredging related plume impacts. In Port Curtis, seagrasses are the sensitive habitat most commonly found adjacent to port facilities and shipping channels that are regularly dredged, including the Project activities (refer Figure 4).

6.2.2 Seagrass light monitoring sites

BPAR sites have been selected to cover the range of seagrass meadow types (different species and depths) potentially interacting with the Project related sediment plumes within the zone of influence. Sites occur across a gradient of potential impact from Project activities that influence WQ and include sites in the major coastal meadows adjacent to the Gatcombe and Golding Cutting Channels. With the exception of the surface control station all BPAR instruments will be deployed within the boundaries of the known seagrass meadows just above the seagrass canopy to ensure BPAR measurements reflect the actual amount of light received by seagrasses. BPAR is strongly influenced by water depth so it is critical that these instruments are deployed within the seagrass meadows for relevance and interpretation of seagrass light thresholds. Where practical sites with an existing history of BPAR measurement have been utilised to allow for incorporation of longer history into the understanding of natural ranges of BPAR into the Project monitoring program. These sites are also paired with the seagrass surveys outlined in Tables 8 and 9.

Control surface PAR1 and PAR2 – These sites are established above the water in air to determine light levels reaching the surface (coastal and offshore). These provide control levels of PAR critical for inference assessment as PAR can be affected by a range of atmospheric issues such a cloud cover as well as those in the water column that are targeted for management.

Rodds Bay North (RBN) and Rodds Bay South (RBS) – These sites are located within Rodds Bay, south of Port Curtis and well outside the Project zone of influence. These two sites are considered reference sites and will be not be impacted by the proposed Project activities. These sites will be used to compare any variation in data to determine if changes to WQ are natural variations in conditions.

Pelican Banks North (PBN) – This site is in the northern section of the largest shallow seagrass meadow in Port Curtis. The meadow is dominated by *Z. muelleri* subsp. *capricorni* and this northern most location is in an area where disturbance from the Project is expected to be slight and may be suitable as a reference site. There is a long history of BPAR monitoring at this site with continuous data collected from January 2013 until December 2018.

Pelican Banks South (PBS) – This site is in the southern section of the Pelican Banks seagrass meadow and is dominated by *Z. muelleri.* The site is closer to the Project activity than PBN and is expected to experience no ecological impact from the Project dredging activities. There is a long history of BPAR monitoring at this site with continuous data collected from January 2013 until December 2018.

Pelican Banks West (PBW) – This site is in the western section of the Pelican Banks seagrass meadow and is dominated by *Z. muelleri. This site is expected to experience no ecological impact from Project dredging activities.* There is a long history of BPAR monitoring at this site with continuous data collected from January 2013 until December 2018.

Quoin Island (QI) – This site is in a largely sub-tidal *Halodule uninervis* dominated meadow on the bank between Quoin Island and the shipping channel. It is close to the Project channel dredging activities and is expected to experience a low level of impact. Being a deeper meadow, it may be more susceptible to light loss through turbidity than other nearby intertidal meadows. BPAR data has been collected at this site for 12 months (May 2014 to May 2015) as part of the Project EIS.

Black Swan (BS) – Intertidal *Z. muelleri* meadow in The Narrows. Located in an area of The Narrows with a relatively constant seagrass presence. Impacts from the Project are expected to be slight at this location and this site is a suitable reference site or a gradient of impact for comparison with sites with a higher level of influence from the Project activity.

Wiggins Island (WI) – This site is in a *Z. muelleri* dominated meadow nearest the barge access channel dredging adjacent to the WICT and is expected to see no ecological impact from the Project dredging activities. BPAR data has been collected at this site from 2009 to 2018.

South Trees (ST) – This site is in intertidal *Z. muelleri* meadow adjacent to Gatcombe Channel where extensive dugong and turtle feeding has been recorded. It is expected to receive a low level of impact and BPAR has been collected previously at this site between May 2014 and June 2015.

Tannum Sands (TS) – Located in subtidal meadow dominated by *Halodule uninervis* along the coast between South Trees and Tannum Sands inshore of the Gatcombe Channel. BPAR has not previously been monitored at this site.

Colosseum Inlet (CI) – This site is located in the sub tidal *Halodule uninervis* dominated meadow near the mouth of Colosseum Inlet inshore of the southern end of Gatcombe Channel. BPAR was previously collected as part of the Project EIS investigations at this site between May 2014 and June 2015.

CD1/2/4/5 – These four sites are all located in the deeper water areas where transitory *Halophila decipiens* can occur. BPAR has been monitored at these sites from between June 2014 and July 2015.

WB – This site is in a *Z. muelleri/Halophila ovalis* dominated meadow nearest the proposed WBE reclamation area and is expected to experience no ecological impact from the Project dredging activities. BPAR has not previously been monitored at this site.

Table 7: Monitoring location for BPAR for seagrass protection

Seagrass site number and name	Dominant seagrass species	Management intent	Established/ site history
PAR-1	Surface PAR collected above the water at the land based station near Fisherman's Landing	Surface PAR reference for inshore	2009 to 2018
PAR-2	Surface PAR collected above the water at the channel marker near the outer channel	Surface PAR reference for offshore	New
PBN	Coastal Intertidal *Z. muelleri* seagrass meadow between Curtis Island and Facing Island	Slightly Disturbed	2009 to 2018 (WB)[2]
PBS	Coastal Intertidal *Z. muelleri* seagrass meadow between Curtis and Facing Island	Moderately Disturbed	2011 to 2018 (WB)[2]
PBW	Coastal Intertidal *Z. muelleri* seagrass meadow between Curtis and Facing Island	Moderately Disturbed	2011 to 2018 (WB)[2]
QI	Coastal shallow sub-tidal to intertidal meadow dominated by *Halodule uninervis*	Moderately Disturbed	2014 to 2015 (CD)[1]
BS	Intertidal *Z. muelleri* meadow in The Narrows region	Slightly Disturbed	2012 to 2018 (WB)[2]
WI	Intertidal meadow adjacent to Wiggins Island dominated by *Z. muelleri*	Moderately Disturbed	2009 to 2018 (WB)[2]
ST	Intertidal meadow between the shore and Gatcombe Channel near South Trees Inlet dominated by *Z. muelleri*	Moderately Disturbed	2014 to 2015 (CD)[1]
TS	Largely sub-tidal meadow along the coast between South Trees and Tanum Sands dominated by *Halodule uninervis*	Slightly-Moderately Disturbed	New

Seagrass site number and name	Dominant seagrass species	Management intent	Established/ site history
CI	Sub-tidal meadow dominated by *Halodule uninervis* along the coast of Wild Cattle Island inshore of the Golding Cutting Channel	Slightly Disturbed	2014 to 2015 (CD)[1]
CD1, CD2, CD4 and CD5	Deep water seagrasses, dominated by *H. decipiens*	Slightly-moderately disturbed	2014 to 2015
WB	Intertidal meadow adjacent to Wiggins Island dominated by *Z. muelleri*	Moderately Disturbed	New
RBN	Intertidal meadow *Z. muelleri* with *Halophila ovalis*	All levels of protection	2009 to 2018
RBS	Intertidal meadow *Z. muelleri* with *Halophila ovalis*	All levels of protection	2009 to 2018

Table notes:

1 Gatcombe and Golding Cutting Channel Duplication Project

2 Western Basin Dredging and Disposal Project

6.3 Monitoring program (prior to Project activities)

In alignment with the monitoring procedure objective, the Project environmental monitoring program was designed to ensure sensitive receptor areas will not receive significant impacts from sediments generated during the Project activities. The initial phase of the Project environmental monitoring program commences before any Project related activities and impacts commence. The monitoring program includes both compliance and due diligence monitoring and will be carried out within zones of low and medium impacts, zone of influence, and outside the zone of influence. Table 8 provides a summary of the environmental monitoring program to be undertaken prior to Project activities commencing.

Once the pre-Project WQ monitoring data has been collected and analysed, it will be used, in conjunction with data from existing Port health monitoring programs (refer Appendix 3), to review and update this Procedure prior to Project activities commencing. This will be done to ensure that the most appropriate WQ and light triggers levels have been adopted for the Project that minimise WQ impacts and protect and minimise impacts on the ecological values of Port Curtis.

6.4 Monitoring program (during WBE reclamation area bund wall and BUF construction)

The environmental monitoring program to be implemented during WBE reclamation area bund wall construction will utilise the same WQ, seagrass and light monitoring sites used as part of the Project EIS and the prior to dredging monitoring program (refer Section 6.3). In addition to the design and construction improvements based on the findings of the independent review of the bund wall failure from the WBDDP, WQ monitoring will occur during bund wall construction activities. The program objective is to ensure sensitive receptors will not receive significant impacts from sediments generated during the WBE reclamation area bund wall and BUF construction. As the timeframes for the Project construction of the bund wall and dredging activities are likely to be greater than the WBDDP, any identified changes to turbidity will be identified early and corrective action can occur prior to dredging occurring.

Table 9 provides a summary of the environmental monitoring program to be undertaken during the bund wall construction activities.

Table 8: Environmental monitoring program (prior to Project activities)

Monitoring component	Compliance objective	Description	Monitoring period	Monitoring location/Sites	Monitoring frequencies	Reporting requirements
Water quality	Compliance	Continuous in-situ WQ monitoring for physicochemical parameters (i.e. Turbidity, Temperature. pH, Conductivity and DO)	6 months	CD1 MH60 RB1 CD2 WB50 C3 CD4 MH10 CD5 NW50	Continuous (logged every 15 min)	- Raw data every 15 min; - EWMA every 6 hours; - Rolling average every hour.
	Due diligence	Periodic WQ sampling and testing for physicochemical parameters (i.e. Turbidity, Temperature. pH, Conductivity, DO, TSS, Metals/metalloids, Nutrients, Chlorophyll a and Organic contaminants)	6 months	CD1 MH60 RB1 CD2 WB50 C3 CD4 MH10 CD5 NW50	- Quarterly for organic contaminants - Monthly for the rest of parameters	Monthly
Light	Compliance	Continuous BPAR monitoring	12 months;	PBN PAR-1 WB PBS PAR-2 WI PBW CD1 ST RBN CD2 TS RBS CD4 CI QI BS CD5	Continuous (logged every 15 min; data transfer every 30 min)	Every 30 min
Benthic habitat and communities	Due diligence	Coastal seagrass meadow mapping and biomass assessments using the long term seagrass monitoring methodology	October/ November	Throughout the Project zone of influence, The Narrows, Graham's Creek and Curtis Island seagrass meadows	One survey event	As soon as practical after survey completed
		Deep water seagrass survey	October/ November	The Project zone of influence	One survey event	As soon as practical after survey completed
		Macroalgae survey	October/ November	The Project zone of influence	One survey event	As soon as practical after survey completed
		Periodic assessments of the shallow seagrass meadows linked to BPAR monitoring sites	12 months	PBN PAR-1 QI PBS PAR-2 CI PBW WB ST RBN WI TS RBS BS	Quarterly	As soon as practical after survey

Monitoring component	Compliance objective	Description	Monitoring period	Monitoring location/Sites	Monitoring frequencies	Reporting requirements
	Due diligence	Reef condition survey at the coral reef locations	6 months	locations shown on Figure 5	Two surveys (over 6-month period)	As soon as practical after survey completed

Table 9: Environmental monitoring program (during WBE reclamation area bund wall and BUF construction)

Monitoring component	Compliance Objective	Description	Monitoring period	Monitoring location/Sites	Monitoring Frequencies	Reporting requirements
Water quality	Compliance	Visual inspection of the area will occur to identify any sediment plumes located near the WBE reclamation area bund wall and BUF construction	During construction	Western Basin reclamation area and BUF	Daily	Daily
	Compliance	Continuous in-situ WQ monitoring for physicochemical parameters (i.e. Turbidity, Temperature pH, Conductivity and DO)	During construction + 3 months post reclamation (unless Project dredging commences earlier)	NW50 WB50 MH10 C3 RB1	Continuous (logged every 15 min)	- Raw data every 15 min; - EWMA every 6 hours; - Rolling average every hour.
	Due diligence	Periodic WQ sampling and testing for physicochemical parameters (i.e. Turbidity, Temperature pH, Conductivity, DO, TSS, Metals/metalloids, Nutrients, Chlorophyll a and Organic contaminants)	During construction + 3 months post reclamation (unless Project dredging commences earlier)	NW50 WB50 MH10 C3 RB1	- Quarterly for organic contaminants - Monthly for the rest of parameters	Monthly
Light	Compliance	Continuous BPAR monitoring	During construction + 3 months post reclamation (unless Project dredging commences earlier)	PB ST QI TS WI RBN WB BS RBS	Continuous (logged every 15 min; data transfer every 30 min)	Every 30 min

Monitoring component	Compliance Objective	Description	Monitoring period	Monitoring location/Sites	Monitoring Frequencies	Reporting requirements
Benthic habitat and communities	Due diligence	Coastal seagrass meadow mapping and biomass assessments using the long term seagrass monitoring methodology	Oct./Nov. during construction	Throughout the Port and Rodds Bay	- One survey each Oct./Nov. during construction - One survey post reclamation	As soon as practical after survey completed
	Due diligence	Periodic assessments of the shallow seagrass meadows linked to BPAR monitoring sites	During construction	PB ST QI TS WI WB BS	- Quarterly during construction - Two additional quarterly surveys post reclamation	As soon as practical after survey completed

6.5 Monitoring program (during Project dredging activities and post dredging)

The environmental monitoring program to be implemented during Project dredging activities will utilise the same WQ, seagrass and light monitoring sites used as part of the Project EIS and the prior to dredging monitoring program (refer Section 6.3). The program objective is to ensure sensitive receptors will not receive significant impacts from sediments generated during and post Project dredging activities. The monitoring program includes both compliance and due diligence monitoring and will be carried out within zones of low and medium impacts, zone of influence, and outside the zone of influence. Table 10 provides a summary of the environmental monitoring program to be undertaken during and post the Project dredging activities. It should be noted that Table 10 does not include the Project tailwater discharge monitoring, and it is separately elaborated in Section 6.8.

Table 10: Environmental monitoring program (during Project dredging activities and post dredging)

Monitoring component	Compliance Objective	Description	Monitoring period	Monitoring location/Sites	Monitoring Frequencies	Reporting requirements
Water quality	Compliance	Continuous in-situ WQ monitoring for physicochemical parameters (i.e. Turbidity, Temperature pH, Conductivity and DO)	During dredging + Three months post dredging	CD1 MH10 RB1 CD2 MH60 C3 CD4 WB50 CD5 NW50	Continuous (logged every 15 min)	- Raw data every 15 min; - EWMA every 6 hours; - Rolling average every hour.
	Due diligence	Periodic WQ sampling and testing for physicochemical parameters (i.e. Turbidity, Temperature pH, Conductivity, DO, TSS, Metals/metalloids[a], Nutrients, Chlorophyll a and Organic contaminants)	During dredging + Three months post dredging	CD1 MH10 RB1 CD2 MH60 C3 CD4 WB50 CD5 NW50	- Quarterly for organic contaminants - Monthly for the rest of parameters	Monthly
Light	Compliance	Continuous BPAR monitoring	During dredging + Three months post dredging	PBN PAR-1 WB PBS PAR-2 WI PBW CD1 ST RBN CD2 TS RBS CD4 CI BS CD5 QI	Continuous (logged every 15 min; data transfer every 30 min)	Every 30 min

Monitoring component	Compliance Objective	Description	Monitoring period	Monitoring location/Sites	Monitoring Frequencies	Reporting requirements
Benthic habitat and communities	Due diligence	Coastal seagrass meadow mapping and biomass assessments using the long term seagrass monitoring methodology	- Oct./Nov. during dredging - One Oct./Nov. post dredging	Throughout the Port and Rodds Bay	- One survey each October/November - One survey post dredging	As soon as practical after survey completed
		Deep water seagrass survey	- Oct./Nov. during dredging - One Oct./Nov. post dredging	The Project zone of influence	- One survey each October/November - One survey post dredging	As soon as practical after survey completed
		Macroalgae survey	- Oct./Nov. during dredging - One Oct./Nov. post dredging	The Project zone of influence	- One survey each October/November - One survey post dredging	As soon as practical after survey completed
		Periodic assessments of the shallow seagrass meadows linked to BPAR monitoring sites	- During Dredging - Two quarters post dredging	PBN PAR-1 QI PBS PAR-2 CI PBW WB ST RBN WI TS RBS BS	- Quarterly during dredging - Two quarterly post dredging	As soon as practical after survey
	Due diligence	Reef condition survey at the coral reef locations	- During Dredging - One season post dredging	Locations shown on Figure 5	- Two surveys (wet and dry season) during dredging - One survey event post dredging	As soon as practical after survey completed

Table note:

a Refer Table 15 for the metals/metalloids that would be included as per the 'due diligence' analytical suite.

6.6 Adaptive management trigger values

6.6.1 Turbidity management trigger values

Turbidity trigger levels for the Project were developed using the Project EIS WQ baseline monitoring data collection program (refer Section 5.3 and the Project EIS Water Quality Technical Report), including the percentiles of data ranges (e.g. 80th percentile = internal alert and 95th percentile = external exceedance notification). The internal alert and external reporting trigger levels are set based on the application of a 6 hourly exponentially weighted moving average (EWMA) to the raw background turbidity data. 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 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:

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

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

The resulting background turbidity data set was examined to determine the intensity, duration and frequency of turbidity fluctuations which occurred through natural background variation. By applying a probabilistic framework and examining the natural variations from a statistical and performance based standpoint, the 80th and 95th percentile of EWMA background data over 36 and 24 hours, respectively, were chosen as the basis for establishing practical moderately disturbed WQ management trigger values.

The majority of the WQ monitoring sites are moderately disturbed except for NW50 and RB1, which are slightly disturbed (refer Table 4). In accordance with the EPP (Water) guideline[2], the internal trigger levels are set at the 80th %ile for the moderately disturbed areas and will be established for monitoring sites NW50 and C3 (slightly disturbed areas) during detailed design based on the 6 months of pre-Project monitoring (refer Table 8). The external trigger values were adopted at 95th %tiles for moderately disturbed areas. Given the variation that occurs between sites within Port Curtis, each monitoring site will have a site specific internal and external reporting trigger level for the wet and dry season. Sites that show similar variation patterns and percentiles have been grouped together.

Table 11 details the WQ trigger levels calculated from the Project EIS baseline WQ monitoring data using the EWMA methodology. Sites NW50, C3 and RB1 do not have an appropriate level of current historic data and their WQ monitoring triggers will be developed using data obtained during six months of pre-Project WQ monitoring (refer Table 8 and Section 6.3) and processed by application of EWMA methodology. Likewise, all trigger values given in Table 11 will be reviewed and updated after completion of pre-Project monitoring program.

Table 11: Management trigger summary

Site	Status	Zone	Parameter	Wet season triggers (01 Oct – 31 Mar)	Dry season triggers (01 Apr – 31 Sep)	Data requirements
WB50	Compliance	Western Basin	Turbidity (NTU) / Telemetry	**Internal alert** **16 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**Internal alert** **19 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.

[2] Source: *Guideline (draft) on Deciding Aquatic Ecosystem Indicators and Local Water Quality Guideline available at the following web address (on 24-July-2019): https://environment.des.qld.gov.au/water/pdf/deriving-local-water-quality-guidelines.pdf*

Site	Status	Zone	Parameter	Wet season triggers (01 Oct – 31 Mar)	Dry season triggers (01 Apr – 31 Sep)	Data requirements
				External exceedance notification **30 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**External exceedance notification** **35 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
MH10	Compliance	Mid Harbour	Turbidity (NTU) / Telemetry	**11 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**9 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				20 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**17 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
MH60	Compliance	Mid Harbour	Turbidity (NTU) / Telemetry	**9 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**7 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				20 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**14 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
NW50[a]	Compliance	The Narrows	Turbidity (NTU) / Telemetry	**TBD** (70th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**TBD** (70th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				TBD (95th %ile of the 6 hr EWMA applied to background turbidity data – external alert trigger)	**TBD** (95th %ile of the 6 hr EWMA applied to background turbidity data – external alert trigger)	
CD1	Compliance	Outer Harbour	Turbidity (NTU) / Telemetry	**6 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**4 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				11 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**10 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	

Site	Status	Zone	Parameter	Wet season triggers (01 Oct – 31 Mar)	Dry season triggers (01 Apr – 31 Sep)	Data requirements
CD2	Compliance	Outer Harbour	Turbidity (NTU) / Telemetry	**6 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**4 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				11 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**10 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
CD4	Compliance	Outer Harbour	Turbidity (NTU) / Telemetry	**6 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**4 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				11 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**10 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
CD5	Compliance	Outer Harbour	Turbidity (NTU) / Telemetry	**6 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**4 NTU** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				11 NTU (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**10 NTU** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	
C3[a]	Compliance	Western Basin	Turbidity (NTU) / Telemetry	**TBD** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	**TBD** (80th %ile of the 6 hr EWMA applied to background turbidity data – internal alert trigger)	Real time data feed to GPC. De-confounded data + 6 hourly EWMA plot.
				TBD (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	**TBD** (95th %ile of the 6 hr EWMA applied to background turbidity data – external notification trigger)	

Table note:

a Denotes specific turbidity monitoring sites that lack historic data, and their WQ monitoring triggers will be developed from 6 months of pre-Project monitoring (refer Table 8) and using EWMA methodology. Water quality triggers for NW50 and C3 will be determined upon provision of the 6 month water quality data (during detailed design).

To manage WQ a sensitive receptor WQ trigger flowchart (refer Figure 7 in Section 6.11.1) has been developed to outline the management steps to be undertaken during the Project activities.

The WQ trigger flowchart process is designed to reduce the Project WQ impacts and risks to the environment, including minimising Project impacts on biodiversity, marine turtles, marine megafauna and the aesthetic values of the Port of Gladstone.

6.6.2 Seagrass management trigger values

Measurement of the light, or BPAR, reaching the seagrass is a key parameter of interest in order to determine whether sufficient light has reached the seagrass to meet their growth requirements and maintain seagrass health. While turbidity is the dredging related vector it is actually how that translates to light reaching the bottom that seagrasses actually respond to. In Port Curtis, a number of field and laboratory studies by the James Cook University (JCU) seagrass ecology team developed locally relevant values for the light requirements for the likely highest light requiring species, *Zostera muelleri* (Chartrand et al. 2012; 2016). The JCU team has also reviewed and examined thresholds appropriate for other seagrass species that occur in Port Curtis and the Great Barrier Reef (Collier et al. 2016). There are three major meadow types potentially influenced by the Project and the light thresholds for each are summarised in Table 12 and the sections below.

Coastal seagrass – *Zostera muelleri* subsp. *capricorni* dominated meadows

An extensive range of studies have been undertaken in Port Curtis to derive a light threshold appropriate for managing *Z. muelleri* during acute impacts associated with dredging. These have included several field based light manipulation experiments, laboratory trials as well as examination of light history and biomass trends at coastal sites in Port Curtis over a number of years (see Chartrand et al. 2012; 2016; Petrou et al. 2012; Collier et al. 2016). These studies as well as others for the same species in other locations (Collier et al 2016) support a light threshold of a Rolling average of 6 mol photons m^{-2} day^{-1} over 14 days with a recorded time to impact of 28 days when this threshold is not achieved. Local studies of *Z. muelleri* in Port Curtis have suggested that this is an appropriate threshold to apply during the seagrass growing season (approximately July-December) but is also likely to be a valid threshold at other times of year based on other studies for the species (Collier et al. 2016).

The light data collected at *Z. muelleri* dominated Pelican Banks North and South Trees Inlet sites indicates that these meadows are not growing in a light-limited environment. Mean total daily irradiance during growing seasons in 2013 and 2014 was maintained well above the suggested light threshold of 6 mol photons m^{-2} day^{-1} over a 14 day period, with the exception of a few days in early July 2014 (Chartrand et al. 2012). The 6 mol photons m^{-2} day^{-1} over a 14 day period threshold was implemented successfully as part of a dual WQ dredging management approach (with turbidity) in the later stages of WBDDP (Chartrand et al. 2016). The management plan incorporated a multi-staged approach where alerts and actions could be implemented within a timeframe that allowed action to occur before actual seagrass declines were likely. The studies showed the earliest declines in seagrass were recorded from light deprivation after 28 days. The management action plan had:

- Initial Level 1 measures at 14 days below threshold to investigate data and possible causes
- Level 2 measures, including:
  - After 16 days meeting of technical management group
  - Additional actions at 18 days and 20 days
- Final mitigation action (stop or modify dredging activity implemented at 21 days below the threshold).

This resulted in action to be implemented 7 days before the first declines were recorded during the experimental light shading studies (Chartrand et al. 2016).

Coastal seagrass – *Halodule uninervis* dominated meadows

There have been several studies examining the light requirements for *Halodule uninervis* in the Great Barrier Reef region and while none have specifically been carried out in Port Curtis, a recent synthesis of these studies has recommended a threshold of 5 mol photons m^{-2} day^{-1} integrated over a 14 day Rolling average period with declines expected after 40 days of this requirement not being met (Collier et al. 2016). Examination of light history and biomass trends at the Facing Island meadow dominated by *Halodule uninervis* in Port Curtis found that during the growing season in 2013 and 2014, BPAR was maintained well above the suggested light threshold of 5 mol photons m^{-2} day^{-1}, and seagrass abundance, though very low, was maintained for the entirety of the study. This suggests that the threshold derived from other Queensland locations is likely to be appropriate for application in Port Curtis. However further refinement or testing of this value in the local meadows prior to Project activities commencing will occur.

Deep water seagrass – *Halophila* spp. dominated meadows

Deep water *Halophila* ssp. seagrass meadows are highly transitory both between years and seasonally (York et al. 2015). In Port Curtis, their presence in waters deeper than 10m is highly variable between the years when they have previously been mapped (2002; 2009; 2013; 2014; see Carter et al. 2015). A major part of their seasonality and high level of spatial variability from year to year is due to this species living at the margins of their light requirements (Chartrand et al. 2018; 2017) and in Port Curtis it is likely that for much of the year they naturally receive light below the requirements for growth, explaining their variable presence. Recent work on light requirements for these deep water *Halophila* species in the Great Barrier Reef, and in particular for *Halophila decipiens*, the dominant Port Curtis deep water species, suggest that they have a light requirement of between 1.5 and 2 mol m^{-2} day^{-1} during the growing periods (between July and December; Chartrand et al. 2017; 2018).

Halophila spp. are physically very small and are not as structurally replete below-ground compared with other large and longer-lived species, which are able to rely on these below-ground stores to temporarily alleviate stresses incurred by reductions in light and WQ (Ralph et al. 2007). For this reason the Rolling average period for the light trigger is reduced to 7 days rather than the longer 14 days used for the larger growing species and the expected time to impact if the threshold is not maintained is only 14 days (Collier et al. 2016; Chartrand et al. 2017). In addition, these deep water seagrasses are likely to be annual in Port Curtis with recent research showing that in the Great Barrier Reef they are generally absent between January and June (York et al. 2015) and for *H. decipiens* it appears that there is a programmed die off of the plants each year regardless of how much light they receive (Chartrand et al. 2018). Therefore the light threshold for deep water *Halophila* is only applied during the July to December growing period when the plants are potentially present.

Implementing a light threshold for deep water seagrasses in Port Curtis during the Project is more complex than for the coastal meadows due to the fact that, for much of the time, it is expected the threshold will not be achieved under natural conditions, combined with the transient nature of these meadows. Having appropriate reference locations at similar depths will assist as part of inference assessments to ascertain the potential impacts of dredger related plumes as opposed to natural periods of low light.

Table 12 summarises the management light thresholds for the Port Curtis seagrass meadows. Collier et al. (2016) recommended light values for the protection of seagrasses. These are detailed in the table below with additional triggers included for earlier detection and therefore management and mitigation can be implemented earlier so that the impact level identified by Collier et al. (2016) are not reached.

Table 12: Management light thresholds (adapted from Collier et al. 2016)

Species	Meadow type	Monitoring site/ meadow	Management threshold (mol photons m^{-2} d^{-1})	Integration time (days)[a] (mol photons m^{-2} d^{-1})	Internal notification time (days Rolling average below threshold)	External notification time (days)[b] (mol photons m^{-2} d^{-1})	Modify activities (days)[c] (mol photons m^{-2} d^{-1})	Time to impact (days)[d] (mol photons m^{-2} d^{-1})
*Halophila species**	Deep water transitory	CD1 CD2 CD4 CD5	**1.5 to 2 (July to Dec only)**	**7***	1 (7)*	3 (10)*	5(12)*	7 **(14)***
Zostera muelleri	Coastal enduring	PBN PBS WI BS ST WB	**6**	**14**	1 (14)	7 (21)	10 (24)	14 **(28)**
Halodule uninervis	Coastal enduring	QI ST TS CI	**5**	**14**	1 (14)	14 (21)	18 (28)	26 **(40)**

Table notes:

Value in brackets represent the total number of days of light below the threshold incorporating the days of integration for the Rolling average (7 for *Halophila*, 14 for other species)

Values in bold font in table are the values identified in Collier et al. (2016)

a: Averaging time to describe light history and as first signal to trigger adaptive management plan – Internal Alert Level (Level 1 trigger)

b: This is the number of days light can remain below threshold levels before external notification is required. At this stage an inference assessment would begin to compare with reference sites and to determine if BPAR levels are due to dredging or other (natural) cause

c: If inference assessment determines BPAR levels are being influenced by Project activities, modification of Project activities would occur by this time

d: Time to impact expected – External notification and additional management measures should be implemented before this time

* For transitory deep water *Halophila* sites management actions are suggested only during July and December when these species and meadows are likely to be present as part of annual growth cycles.

6.7 Seagrass surveys and monitoring

Seagrasses are the principal marine habitat most likely to directly interact with Project activities. They occur adjacent to the areas to be dredged, WBE reclamation area, BUF and the licenced discharge point (refer Figure 4). They are also, predicted to receive turbid plumes from the Project dredging activities although these are predicted to be short lived with the expectation that management of BPAR within acceptable thresholds for seagrass growth will lead to their protection.

Seagrass monitoring will be conducted to complement management and monitoring of the BPAR seagrass thresholds. The seagrass monitoring program will assist to:

- Assess broad-scale changes in seagrass meadow extent and condition over time
- Ensure management actions to maintain WQ and BPAR within acceptable limits for seagrass are having their desired effect
- Assess any potential impacts of the Project to seagrass meadows by providing information on seagrass condition before, during and post Project activities
- Provide a regular (quarterly) update on condition of seagrass meadows during dredging activities to inform operational management.

The hypothesis to be tested by this monitoring is:

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

The Project seagrass monitoring will build on established ambient seagrass monitoring conducted by JCU for GPC since 2002 (refer Section 6.2.2) but will also include additional monitoring sites and timings to meet specific Project requirements.

Two temporal scales of seagrass monitoring will be conducted (refer Figure 4), including:

1. Annual surveys at the time of peak seagrass abundance (October to December), including:
    - For all coastal seagrasses in the Port limits and in the out of Port reference area in Rodds Bay
    - For the offshore deep water seagrasses within the Project WQ zone of influence.
2. Quarterly assessments of the nine coastal seagrass meadows associated with coastal BPAR assessments.

The monitoring of the transitory deep water *Halophila* meadows associated with BPAR assessments will be undertaken as part of the annual rather than quarterly program. This is principally due to these meadows being annual and not present between January and June each year, with little value in more frequent than annual monitoring. Timing of the seagrass monitoring will occur to ensure both scales of monitoring are conducted for at least 12 months prior to the commencement of the Project. This will ensure that:

- An update of the complete seagrass distribution in the area is available prior to the Project commencing (last conducted in 2014)
- At least 12 months of data is collected on seagrass change and associated BPAR at the nine quarterly monitoring meadow locations to provide a good seasonal understanding of seagrass change and BPAR at these key monitoring and management sites prior to the Project commencing.

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

BS
The Narrows
Grahams Creek
Northern Reclamation Area
Southern Reclamation Area
WB
PAR-1
Curtis Island
PBN
North Entrance
PBW
PBS
CD4
Facing Island
QI
WI
Coral Sea
Port Limits
CD5
Clinton Ash Ponds
Gladstone
Calliope River
ST
Gatcombe Channel
South Trees Island
CD2
Marine Park Line
East Banks DMPA
PAR-2
Golding Cutting Channel
TS
Boyne Island
Tannum Sands
CD1
CI
Wild Cattle Island
Boyne River
Rodds Peninsula
Hummock Hill Island
Colosseum Inlet
Rodds Bay
RBN
RBS

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- November 2014 seagrass mapping extent
- Complete seagrass distribution (2002-2018)
- Quarterly monitoring meadows
- Control sites
- New site
- Annual monitoring meadows
- BPAR site CD EIS (2014-2015)
- BPAR site WBDDP (2009-2016)
- Deepwater survey boundary 2013
- Deepwater survey boundary 2014

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Historic seagrass mapping: McCormack et al. (2013), Rasheed et al. (2003), Bryant & Rasheed (2013), Davies et al. (2015), Rasheed et al. (2017), Chartrand et al (2018), Chartrand et al. (2019)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_218.mxd 25/07/2019 12:26

0 2,500 5,000 Metres

Date: 25/07/2019 Version: 7 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 4: Seagrass and BPAR monitoring locations

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

The Narrows
Graham's Creek
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Curtis Island
North Entrance
Sable Chief Rocks
Facing Island
Gatcombe Heads
Oyster Rock
Coral Sea
Port Limits
Gladstone
Calliope River
Gatcombe Channel
South Trees Island
Marine Park Line
East Banks DMPA
Golding Cutting Channel
Boyne Island
Tannum Sands
Jenny Lind Banks
Seal Rocks
Boyne River
Wild Cattle Island
Rodds Peninsula
Colosseum Inlet
Hummock Hill Island
Rodds Bay

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port Limits
- East Banks dredged material placement area (DMPA)

Coastal fringing reef extents

- Dominant sediment sparse algae
- Dominant sediment sparse mix
- Mixed substrates
- Moderate hard coral, mixed other

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Coastal fringing reef extents: Vision Environment (2015)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_234.mxd 11/02/2019 16:15

0 1,900 3,800 Metres

Date: 11/02/2019 Version: 2 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 5: Coral reef monitoring locations

Monitoring methods will follow those established as part of the long term seagrass monitoring for Port Curtis to allow direct comparisons with meadow scale assessments of seagrass change that have been conducted since 2002 (Rasheed et al. 2017; Carter et al. 2014) and will measure seagrass meadow changes in area, biomass and species composition. Work conducted on seagrasses during the Project EIS development, as part of the WBDDP and the long term ambient seagrass monitoring program have shown that the biomass of seagrasses can vary substantially within the boundaries of meadows between surveys and that monitoring of seagrass change is best conducted at a scale that can capture this variability as well as measure change in area of seagrass meadows.

Quarterly monitoring of the nine coastal seagrass meadows will continue during the Project activities and for a period of 12 months post dredging. Annual monitoring of the larger seagrass extent will continue three years post dredging to assess longer term condition of seagrasses which is especially critical for assessing post Project condition of the highly transitory deep water seagrasses that can vary substantially in the presence from year to year. These meadows will require a longer post dredging assessment window for assessment (refer Table 13).

Table 13: Seagrass monitoring summary

Monitoring scale	Captures	Pre-Project timing	During Project	Post Project
Annual seagrass monitoring	All coastal seagrass meadows within the Port limits Offshore deep water transitory seagrasses within the zone of influence	At least one annual survey conducted October to December (seagrass peak)	Annual	Annual for 3 years
Quarterly assessments	All of the nine coastal seagrass monitoring meadows that form part of detailed BPAR threshold assessment	Quarterly for at least 12 months prior to project start	Quarterly	Quarterly for 12 months

6.8 Tailwater discharge monitoring

Once the outer reclamation and internal bund walls are complete, and the geotextile material is restrained and stabilised, Project dredged material will be transported into the WB and WBE reclamation areas. Dredged material and water mix will be spread into several locations within the WB and WBE reclamation areas to ensure the decant waters flow and facilitate discrete settling of suspended particles. Dredged material placement within the WB and WBE reclamation areas will be mounded to the final profile as much as possible from direct placement from the trucks.

It is estimated that the tailwater flows may vary from 5,000m^3 to 30,000m^3 per day. This tailwater flow rate is indicative only and will be finalised with the selected dredging contractor.

During the placement of dredged material within the reclamation areas, a series of decant ponds will be constructed internal to the outer bund wall to allow for the fine material to settle from the tailwaters. The internal ponds will be designed to store the soil-water mix for a sufficient time, as to allow the suspended sediments in the discharge water to reduce to acceptable levels (i.e. less than or equal to 100mg/L).

Variable height weir boxes will be installed between the cells, allowing the rate of discharge and movement of waters between cells to be controlled. The cells will be designed and maintained so that a freeboard of not less than 0.5m is maintained at all times during the dredging operation.

Three potential decant discharge locations are provided in Figure 6 and summarised in Table 14. The tailwater flow path and discharge location(s) will be confirmed along with, the dredging methodology prior to the commencement of Project works. A conventional drop inlet structure fabricated from pre-cast reinforced concrete items will be installed and connected to an outlet culvert through the bund wall.

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_362.mxd 12/02/2019 09:18

0 255 510 Metres

Date: 12/02/2019 Version: 0 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 6: Project tailwater discharge locations

Table 14: Potential decant water discharge locations

Discharge location	Coordinates (MGA56 GDA94)
1	312432.3, 7370476.7
2	312494.2, 7370473.1
3	312335.5, 7370369.7

WQ monitoring parameters to be measured within the dewatering pond prior to licenced discharge are detailed in Table 15, including proposed release limits. These release limits will be reviewed and updated prior to the commencement of reclamation dewatering activities to address any changes to the dredging methodology proposed by the dredging contractor.

Table 15: Water quality monitoring parameters for tailwater discharge

Parameter	Release limit		Monitoring frequency
	minimum	maximum	
TSS		100 mg/L	Monthly or weekly during discharge events
NTU		62.5*	Logged every 15 minutes
pH	6.5	9.0	Hourly[1]
DO		100% sat[2]	Monthly or weekly during discharge events
Total Nitrogen		210 µg/L[2]	Monthly or weekly during discharge events
Oxidised Nitrogen (NO*x* as Nitrate and Nitrite)		16 µg/L[2]	Monthly or weekly during discharge events
Total Phosphorus		29 µg/L[2]	Monthly or weekly during discharge events
Ammonia (nitrogen) (at a pH of 8)		8 µg/L[2]	Monthly or daily if pH is outside release limits
Aluminium		0.5 µg/L[3]	Monthly or daily if pH is outside release limits
Arsenic (III) (filtered)		2.3 µg/L[3]	Monthly or daily if pH is outside release limits
Arsenic (V) (filtered)		4.5 µg/L[3]	Monthly or daily if pH is outside release limits
Cadmium (filtered)		0.7 µg/L[5]	Monthly or daily if pH is outside release limits
Chromium (VI) (filtered)		4.4 µg/L[4]	Monthly or daily if pH is outside release limits
Copper (filtered)		1.3 µg/L[4]	Monthly or daily if pH is outside release limits
Lead (filtered)		4.4 µg/L[4]	Monthly or daily if pH is outside release limits
Mercury (filtered)		0.1 µg/L[5]	Monthly or daily if pH is outside release limits
Nickel (filtered)		7.0 µg/L[5]	Monthly or daily if pH is outside release limits
Silver (filtered)		1.4 µg/L[4]	Monthly or daily if pH is outside release limits
Zinc (filtered)		15 µg/L[4]	Monthly or daily if pH is outside release limits
TPH		10 mg/L	Monthly

Table notes:

1 While pH is to be sampled hourly, limits apply to pH as a 6 hour Rolling average
2 Source: Table 2A MD2421 Western Basin, 80th percentile (EHP 2014)
3 Source: Low reliability trigger value, Section 8.3.7 (ANZECC 2000 V2)
4 Source: ANZECC trigger values for marine waters 95th percentile (ANZECC 2000 V2)
5 Source: ANZECC trigger values for marine waters 99th percentile (ANZECC 2000 V2)
6 Refer to Table 8.3.7 of the ANZECC guidelines if pH differs from 8
* The NTU release limit is based on the TSS and NTU relationship established within the Port of Gladstone during the Western Basin Dredging and Disposal Project (i.e. TSS = 1.6 x NTU). This TSS and NTU relationship will be recalculated and potentially amended if required (refer paragraph below).

TSS and NTU levels will be monitored within the WB and/or WBE reclamation areas during the initial two weeks of Project dewatering. Eight samples of TSS and NTU will be collected daily over the two week period and sent to the laboratory to determine the TSS level. The Project specific TSS and NTU relationship within the reclamation areas will be reassessed based on the outcome of monitoring and laboratory assessment to determine if this relationship is required to be amended. Should a different derivation of the TSS and NTU relationship be calculated then consultation will occur with DES to amend the NTU release limit in Table 15 and the approved Environmental Authority for the Project.

6.9 Other monitoring and reporting

6.9.1 Dredger data

Key data to be collected by the dredger operator during the Project dredging activity and reported to DoEE and DES includes:

- Areas being dredged, including dates when dredgers were operational
- Volumes placed within the WB and WBE reclamation areas (in situ m^3)
- Any dredger incidents in line with the requirements of the Environmental Authority and EPBC Act controlled action conditions.

Additional data to be recorded to maintain compliance with approvals includes:

- Marine megafauna species observations log from the dredger operations (i.e. date, time, direction, distance, species, presentation (single or group) and marine fauna spotter details)
- Vessel log, including responsible vessel person (Master).

6.9.2 Hydrographic survey

Hydrographic surveys will be undertaken post dredging in order to confirm the duplicated Gatcombe and Golding Cutting Channels and barge access channel have achieved the design depths.

GPC will submit the hydrographic surveys of the duplicated Gatcombe and Golding Cutting Channels to the DoEE, DES and the hydrographic survey office at the beginning and end of the Project dredging in compliance with the Project environmental approval conditions.

6.10 Reporting requirements

The turbidity, BPAR, seagrass, metals monitoring and key dredger data described in Section 6 will form the content of GPC's compliance report compiled for submission to DoEE and DES following the Project dredging campaigns.

6.11 Environmental management procedures during Project dredging activities

6.11.1 Summary of adaptive management procedures

Figures 7 to 9 summarise the management processes and procedures if turbidity/BPAR levels exceed the internal alert and/or external reporting trigger levels for the durations specified.

To protect seagrass condition during Project activities a BPAR trigger flowchart (refer Figure 8) has been developed to outline the steps to be undertaken during the Project dredging.

The BPAR trigger flowchart is designed to reduce the WQ impacts and risks to the seagrass habitats within the Port of Gladstone.

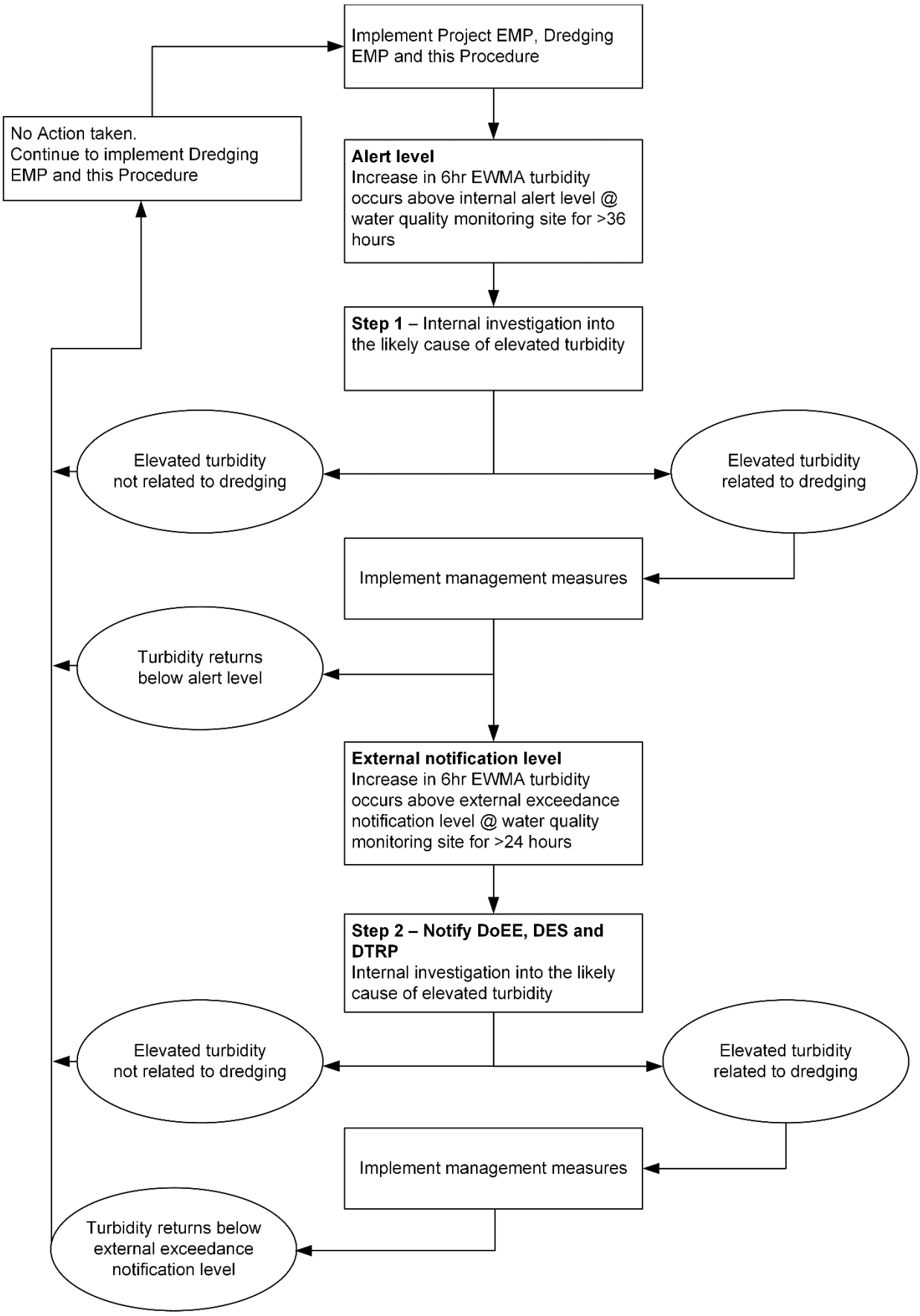


Figure 7: Sensitive receptor water quality trigger flowchart

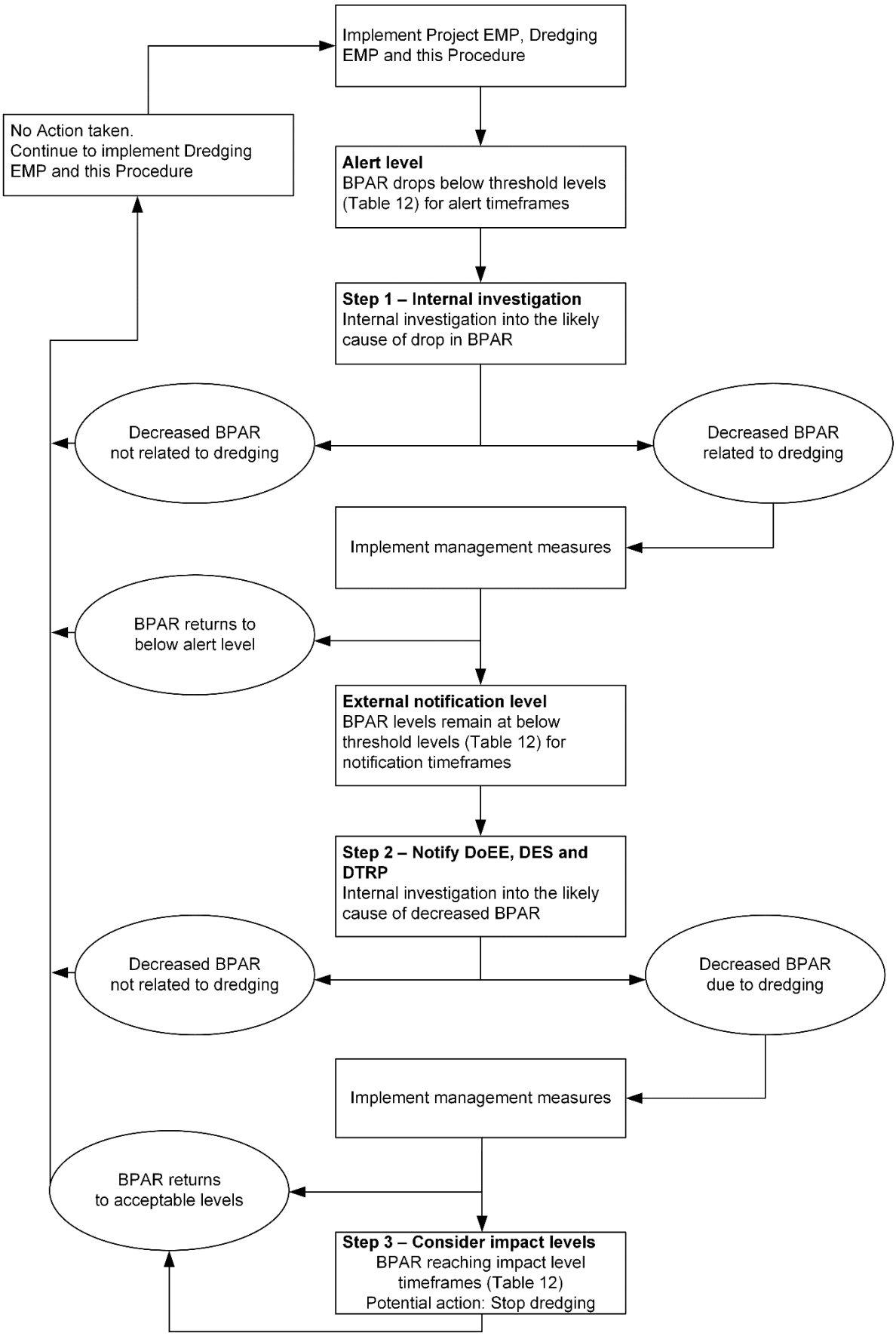


Figure 8: Sensitive receptor BPAR trigger flowchart

Figure 9 is a summary of the integration of the turbidity and BPAR monitoring and trigger values to ensure adaptive management of the establishment of the WBE reclamation area and BUF, and dredging operation occurs and the ecological values of Port Curtis are protected and managed during the Project operations.

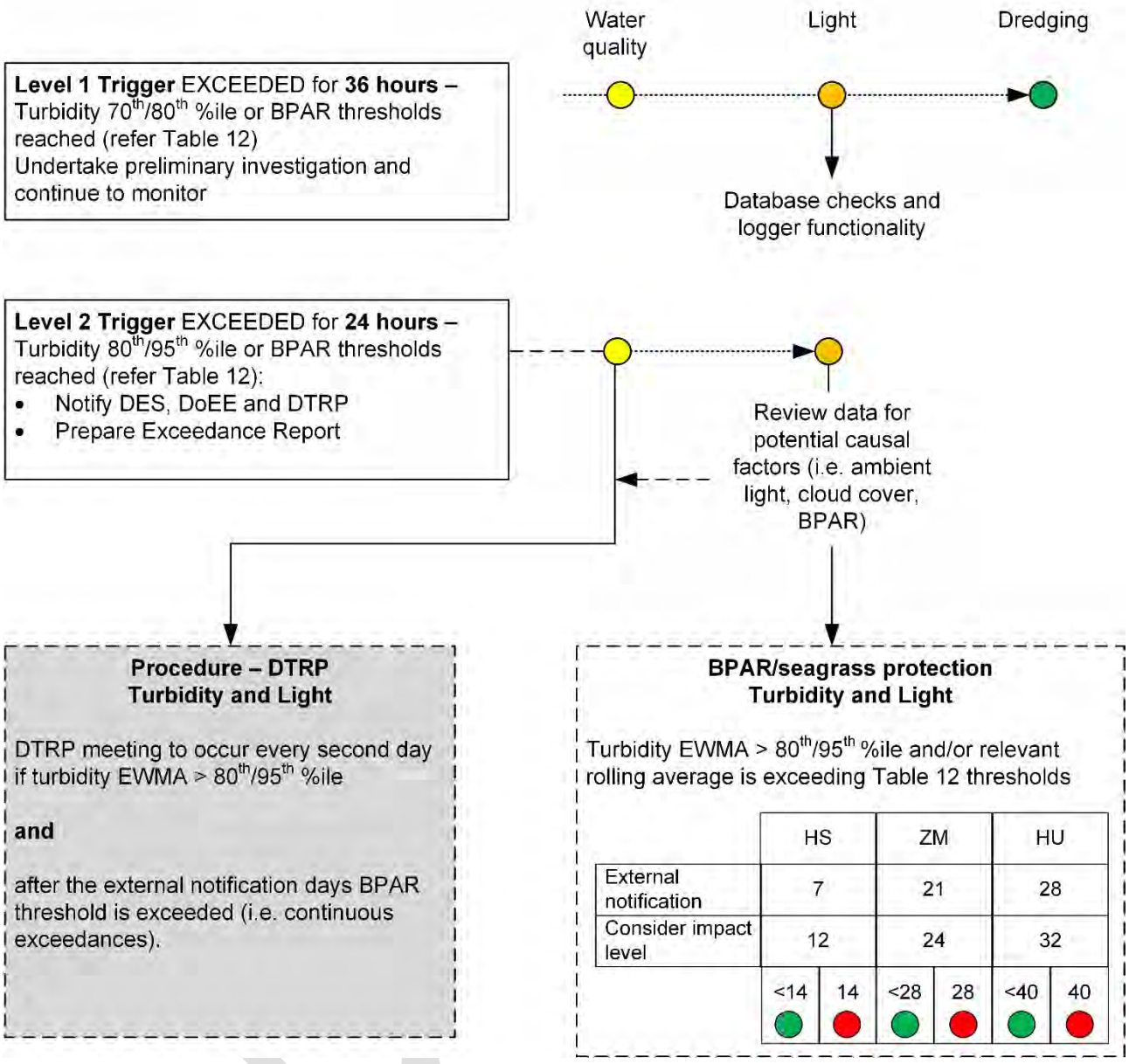


Figure 9: Dual water quality management flowchart for Project to ensure seagrass protection

6.11.2 Step process of adaptive management procedures

6.11.2.1 Standard monitoring procedure

WQ (in NTU values) and BPAR levels will be monitored and data managed according to the monitoring plan detailed in Sections 6.4 and 6.5.

While the 6 hourly EWMA for each WQ monitoring site remains below the specified Internal Alert Levels (level 1 trigger) for less than 36 hours, no investigation into the cause of turbidity changes (if any) and no dredging operational management intervention is required.

While BPAR levels remain below the integration time levels (Internal Alert Levels) detailed in Table 12, no investigation into the cause of BPAR changes (if any) and no Project operational management intervention is required.

6.11.2.2 Step 1 – Internal investigation

When the Internal Alert Level at a designated monitoring site for NTU is exceeded continuously for a 36 hour period (i.e. 6 x 6 hourly EWMA readings), or the BPAR and seagrass integration time levels exceed the acceptable limits, the ESMM or delegate will initiate an investigation, within 24 hours, which will consider the following:

- Examination of the monitoring equipment to determine if any interference has occurred (e.g. extreme low tide; particles lodged on the probe such as debris) to validate the exceedance
- Analysis and comparison with background turbidity levels and predicted dredge plume modelling in order to place elevated turbidity levels in local and dredging influenced context, including:
    - Recent weather conditions and/or unusual events surrounding the area to be dredged, in Port Curtis and the Calliope River system that may have impacted upon turbidity
    - Turbidity levels at the reference sites and other WQ monitoring sites (current and previous 48 hours)
    - Predicted background turbidity ranges for the monitoring site based on background WQ and tidal data (i.e. 6 hourly EWMA, including the 99th percentile)
    - Spot monitoring of turbidity at upstream locations and investigation to determine any unusual events upstream of site that may have impacted on turbidity
    - Consideration of the turbidity in relation to the predictive modelling of the dredge plume at specific locations
- Check anthropogenic influences (outside the direct Project activities) occurring within Port Curtis
- The spatial distribution of exceedances in relation to unaffected sites and the position of the dredger and associated equipment, including the consideration of aerial surveys
- Consideration of likely elevated natural turbidity from predicted rainfall events in the upstream river and creek systems over the next 2 to 3 days
- Determine the position of dredging equipment in relation to the exceedance location
- Determine the production rate and type of material currently being dredged, including any changes over the previous 48 hours
- Determine production rate and type of material to be dredged over the next 2 to 5 days.

An Internal Alert Level report will be prepared detailing all the above information. This report will be provided to management for their review and discussion with DTRP when required.

If the ESMM deems the breach of the Internal Alert Level to be predominantly due to dredging and/or placement activities, in consultation with the dredging contractor, will consider the need for implementation of management measures to decrease dredging related turbidity levels.

Within the internal investigation, a specific investigation procedure is to be utilised (refer below) by the GPC monitoring specialist for the process after identification of an EWMA exceedance or BPAR various consecutive days (<6 mol/m^2/day) or any other relevant environmental incident, including anomalies in the due diligence monthly WQ grabs and profiling.

- Review data from telemetry or daily report from WQ contractor to ascertain there has actually been an elevation-exceedance (i.e. set up automated emails and alarms so that elevated data records are not missed and data is checked)
- Inform relevant stakeholders (Compliance Specialist, Planning and Development manager, etc.)
- Contact WQ contractor to ascertain there are no issues with equipment
- Analyse data against environmental conditions (e.g. tides, rainfall, wind)

- Check dredger position and activity
- Contact dredging contractor to get any relevant information or feedback
- Pass on information to WQ contractor who conduct final analysis and will generate a briefing on the likely causes of elevation-exceedance
- Inform relevant stakeholders (Compliance Specialist, Planning and Development manager, etc.) so that corrective measures can be actioned if needed/appropriate/applicable
- Save briefing on GPC eDOCs
- Fill in exceedances and elevations table in CVIP monitoring register with all details, flow of action, GPC eDOC no of briefing, etc.
- Use information to log in an incident in GPC Cintillate (Compliance Specialist).

6.11.2.3 Implement management measures

Management measures will be implemented and remain in place until WQ and/or BPAR no longer triggers Internal Alert Level values. The measures may include, but not limited to the following:

- The average rate of dredging, transfer and/or placement will decrease. This will reduce the amount of turbidity released into the water column.
- The material being dredged will be assessed and where practical the dredger will be relocated or sequenced to dredge coarser material to allow finer sediments to settle out of the dredge plume
- Barges will reduce the overflow rate or stop working in over flow mode for a period
- The dredging contractor will implement alternate methodologies to reduce turbidity in the sensitive areas, and/or
- Dredging equipment will be relocated to alternative areas of the channel duplication area to be dredged footprint to allow respite for sensitive receptors in specific locations, including:
    - Dredging the western parts of the channel if the tide is about to go out
    - Dredging the eastern parts of the channel if the tide to about to come in.

If the WQ and BPAR remains at acceptable limits for a period of greater than 24 hours, no further management measures will be taken. WQ and BPAR monitoring will continue.

6.11.2.4 Step 2 – Notify DES and DoEE and implement management measures

If the External Notification Trigger Level at a designated monitoring site in the low or moderate impact zones is exceeded continuously for a 24 hour period (4 x 6 hourly EWMA readings) for turbidity, or threshold levels and timeframes for External Notification Reporting are reach for BPAR, the ESMM will notify DES, DoEE and DTRP within one business day. The ESMM will provide a written external notification to DES, DoEE and DTRP (within an additional 24 hours) on the likely cause of the elevated turbidity levels or decreased BPAR levels (i.e. due to background conditions or predominately due Project activities). This information will be provided within an exceedance report and will summarise the following:

- Examination of the monitoring equipment to determine if any interference has occurred (e.g. extreme low tide; particles lodged on the probe such as debris) to validate the exceedance
- Analysis and comparison with background turbidity levels and predicted dredge plume modelling in order to place elevated turbidity levels in local and dredge influenced context, including:
    - Recent weather conditions and/or unusual events surrounding the area to be dredged, in Port Curtis and the Calliope River system that may have impacted upon turbidity
    - Turbidity levels at the reference sites and other WQ monitoring sites (current and previous 48 hours)

- Predicted background turbidity ranges for the monitoring site based on background WQ and tidal data (i.e. 6 hourly EWMA, including the 99th percentile)
- Spot monitoring of turbidity at upstream locations and investigation to determine any unusual events upstream of site that may have impacted on turbidity
- Consideration of the turbidity in relation to the predictive modelling of the dredge plume at specific locations

- Check anthropogenic influences (outside the direct Project activities) occurring within Port Curtis
- The spatial distribution of exceedances in relation to unaffected sites and the position of the dredger and associated equipment, including the consideration of aerial surveys
- Consideration of likely elevated natural turbidity from predicted rainfall events in the upstream river and creek systems over the next 2 to 3 days
- Determine the position of dredging equipment in relation to the exceedance location
- Determine the production rate and type of material currently being dredged, including any changes over the previous 48 hours
- Determine production rate and type of material to be dredged over the next 2 to 5 days.

If the changes are determined to be Project related and are above the predicted dredge plume modelling, the ESMM, in consultation with the dredging contractor, will advise of the management measures to be implemented to decrease the turbidity levels at the exceedance location.

6.11.2.5 Implement management measures

If the External Notification Reporting Trigger Level is exceeded continuously for a period of 48 hours (8 x 6 hourly EWMA readings) or for longer than threshold limits for BPAR, and is found to be predominately due to Project activities, an environmental investigation will be undertaken by the relevant DTRP members. The outcomes of the investigation and the management measures implemented will be tabled at a meeting of the DTRP. The DTRP will agree on additional management measure(s) to be implemented and a timeframe for their implementation.

The DTRP will also consider whether additional seagrass health assessments and/or other methods of seagrass health assessment should be undertaken on the seagrass communities at nominated receptor sites to determine whether the increased turbidity has caused a decrease in seagrass productivity and health.

The DTRP will reconvene after a predetermined period to review the success of the implementation of the management measures. If WQ returns to acceptable levels, no further management measures will be taken. The WQ and BPAR monitoring program will continue.

If the turbidity level continues to remain above the External Notification Trigger Level or BPAR is reaching impact levels, the DTRP will consider the implementation of further management measures to reduce turbidity.

6.11.2.6 Step 3 – DTRP meeting

If the implementation of further management measures is determined not to be effective in reducing turbidity levels and increasing BPAR levels at seagrass meadows, another meeting with the DTRP will be convened and the severity of the exceedance and its potential impacts on the environment will be assessed. The DTRP may then propose additional measures to assist in the management of WQ.

The DTRP will consider the outcomes of any seagrass health assessments and may draw on additional resources, including further scientific opinion, in developing a further set of recommendations for implementation. Stopping dredging altogether until BPAR light levels are acceptable is the final step in managing WQ from Project activities.

The DTRP may recommend changes to this Procedure and/or the Dredging EMP to improve the effective management of WQ in the future. All changes to the Procedure and/or Dredging EMP will be made in consultation with GPC, DES and DoEE.

6.11.2.7 *Step 4 – Stop dredging*

If the implementation of management measures does not improve the BPAR levels being received at seagrass monitoring sites, and the time to impact levels are reached and continue to be exceeded, the Project activity will stop until the BPAR level returns to acceptable levels.

6.11.2.8 *Reporting*

Once WQ and BPAR levels are within acceptable limits, a report will be provided to DES and DoEE within one month, detailing the outcomes of the External Notification Level exceedance, the management measures implemented and any proposed amendments to the Dredging EMP and this Procedure.

7 Procedure monitoring and review

This Procedure, its operation and implementation will be reviewed every three months during the Project activities or as a result of:

- Findings of internal and external inspections and/or audits
- Changes in legislation or approvals
- Incident and/or complaint investigations
- 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 Hummingbird and will be communicated to all relevant Project and GPC staff.

Any changes to the monitoring program that potentially increase the risk of environmental harm or are inconsistent with the Project EIS commitments and/or environmental approval conditions will be approved by DoEE and DES prior to implementation. Changes of a minor nature will not require resubmission of the Procedure to administering authorities.

8 More information

This Procedure will be available to all employees, contractors and consultants to which it applies. This document is uncontrolled when printed.

If you require any further information contact the Port Infrastructure Planning Manager.

9 Terms and definitions

The key terms and definitions below apply to this Procedure.

Term	Definition	Source
Custodian	Under the GPC governance structure, the Custodian is accountable for monitoring the application of the system and advising the Owner of the monitoring outcomes, and is also accountable for proposing system design or redesign and facilitation of conformance.	

Term	Definition	Source
Environmental harm/ nuisance	Unreasonable interference or likely interference with an environmental value caused by: • Noise, dust, odour or light; • An unhealthy, offensive or unsightly condition because of contamination; or Another way prescribed by Regulation.	*Environment Protection Act 1994*
Monitoring	• Observe and check the progress or quality of (something) over a period of time; keep under systematic review • Maintain regular surveillance over • Listen to and report on	Oxford Dictionary (2013)
Owner	Under the GPC governance structure, the Owner is accountable for approval and has the authorised discretion to implement or significantly change the system.	
Sensitive receptor	A fixed location of significance with the potential for impact.	GPC (2013)
Water quality	A quantitative measure of the physical, chemical and biological characteristics of water, relative to the requirements of a stated environmental value.	GPC (2013) adapted from the EPP (Water)
Exceedance	When a contaminant has been released to the receiving environment at a level beyond what is allowed or stipulated by a set limit.	GPC (2013)

10 Document version control

Version	Date	Author	Change description
1	10/05/18	S Cole	Draft for GPC review
2	31/05/18	S Cole	Version included in the Channel Duplication Project EIS
3	20/02/19	S Cole	Revised version included in the Channel Duplication Project EIS
4	6/08/19	S Cole	Revised version included in the Channel Duplication Project AEIS dated 9 August 2019
5	24/09/19	S Cole	Revised version included in the Channel Duplication Project AEIS dated 24 September 2019

11 References

Australian and New Zealand Environment Conservation Council/Agriculture and Resources Management Council of Australia and New Zealand 2000, *National Water Quality Management Strategy, Paper No. 4,* Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines (Chapters 1-7) pp. 3.1: 1-3, 4.4: 10-11.

BMT WBM 2019, 'Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project – Coastal Processes and Hydrodynamics Technical Report', July 2019.

Carter, A.B., Davies, J.D., Bryant, C.V., Jarvis, J.C., McKenna, S.A. and Rasheed, M.A. 2015. 'Seagrasses in Port Curtis and Rodds Bay 2014: Annual long-term monitoring, biannual Western Basin, and updated baseline survey', Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 15/06, James Cook University, Cairns, 75 pp.

Chartrand K.M., Bryant C.V., Sozou A., Ralph P.J. and Rasheed M.A. 2017, 'Final Report: Deep-water seagrass dynamics - Light requirements, seasonal change and mechanisms of recruitment', Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication, James Cook University, Report No 17/16. Cairns, 67 pp.

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

Chartrand, K. M., Szabó, M., Sinutok, S., Rasheed, M. A., & Ralph, P. J. 2018. Living at the margins–The response of deep-water seagrasses to light and temperature renders them susceptible to acute impacts. Marine environmental research (in press)

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.

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.).

Department of Environment and Heritage Protection 2009, Queensland Water Quality Guidelines, version 3, ISBN 978-0-9806986-2-2.

Department of Environment and Heritage Protection 2014, 'The Curtis Island, Calliope River and Boyne River Basins Environmental Values and Water Quality Objectives'.

Department of Environment and Science (DES) 2018, Monitoring and Sampling Manual: Environmental Protection (Water) Policy, Brisbane: Department of Environment and Science Government.

Petrou, K. and Jimenez-Denness, I. and Chartrand, K. and McCormack, C. and Rasheed, M. and Ralph, P.J., 2013. Seasonal heterogeneity in the photophysiological response to air exposure in two tropical intertidal seagrass species. Marine Ecology Progress Series 482, 93-106.

York, P.H., Carter, A.B., Chartrand, K. Sankey, T., Wells, L. and Rasheed, M.A., 2015. Dynamics of a deep-water seagrass population on the Great Barrier Reef: annual occurrence and response to a major dredging program. Scientific Reports 5, 13167.

12 Appendices

12.1 Appendix 1 – Related documents

12.1.1 Legislation and regulation

Key relevant legislation and regulation, as amended from time to time, includes but is not limited to:

Type	Name
Commonwealth legislation and guideline	*Environment Protection and Biodiversity Conservation Act 1999* *Great Barrier Reef Marine Park Act 1975* *ANZECC Water Quality Guidelines for Fresh and Marine Water 2000*
State legislation	*Environmental Protection Act 1994* *Environmental Protection Regulation 1998* *Environmental Protection (Water) Policy 2009* *Coastal Protection and Management Act 1995* *Planning Act 2016* *Aboriginal Cultural Heritage Act 2003* *Fisheries Act 1994* *Marine Parks Act 2004* *Transport Operations (Marine Safety) Act 1994* *Transport Operations (Marine Pollution) Act 1995*
Other	ISO AS/NZS 14001:2004 Environmental Management Systems

12.1.2 Guiding principles

The guiding principles below relate to this Procedure:

Type	Details
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.

12.1.3 Gladstone Ports Corporation documents

The documents below relate to this Procedure.

Type	Document number and title
Policy	Environment Policy (#366016)
Standard	Environmental Standards (#809151)
Specification/Procedure	Environmental Management System Manual (#146256)

12.2 Appendix 2 – Regulatory reporting requirements

Approval reporting conditions – Dredging campaign (DoEE and DES)	Locations
Area to be dredged	ALL
Volumes (in situ m^3)	ALL
Barge movements to the BUF	ALL
Incidents	ALL
Turbidity	WB50, MH10, NW50, MH60, CD1, CD2, CD4 CD5, and licenced discharge points
BPAR	WB50, MH10, NW50, MH60, CD1, CD2, CD4, CD5, Rodds Bay North, Rodds Bay South, Pelican Banks North, Pelican Banks South, Pelican Banks West, Quoin Island, Wiggins Island, Black Swan, South Trees, Tannum Sands, Colosseum Inlet, and Western Basin
Metals	WB50, MH10, NW50, MH60, CD1, CD2, CD4 CD5, and licenced discharge points
Total suspended solids	Licenced discharge points
pH	WB50, MH10, NW50, MH60, CD1, CD2, CD4 CD5, and licenced discharge points
Dissolved oxygen	WB50, MH10, NW50, MH60, CD1, CD2, CD4 CD5, and licenced discharge points
Ammonia N	WB50, MH10, NW50, MH60, CD1, CD2, CD4 CD5, and licenced discharge points

Dredged material volume
Volume of dredged material placed in the WB and WBE reclamation areas (in situ m^3)

Bathymetric survey report at prior and post Project dredging campaign – To DoEE, DES and Australian Hydrographic Office
Survey of seafloor, including areas dredged (i.e. duplicated Gatcombe and Golding Cutting Channels and barge access channel

12.3 Appendix 3 – Existing health monitoring programs

12.3.1 Wharf analysers

GPC has installed three real time, telemetered WQ analysers at three wharf locations in the Port of Gladstone including:

- Fisherman's Landing
- RG Tanna Coal Terminal Clinton wharf
- Boyne wharf

The parameters to be measured include:

- Turbidity
- Temperature
- pH
- Conductivity
- Dissolved oxygen.

These analysers will provide a continuous and long term dataset for Port activities.

12.3.2 Port Curtis Integrated Monitoring Program

GPC's participation in the PCIMP is likely to continue prior to and during the Project dredging. 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:

- Quantify concentrations of various indicators within the Port Curtis region to establish a baseline, and continually monitor the condition of the region
- Engage and involve stakeholders to adopt adaptive management practices, if required
- 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.

PCIMP currently monitors under two main themes (WQ and sediments). The comprehensive monitoring program conducted quarterly includes WQ parameters including nutrients and key pollutants like metalloids.

Monitoring is conducted at 54 water sites, which for ease of reporting are split across various zones across the Port of Gladstone. The zones extend from The Narrows in the north to Rodds Bay in the south and include zones of higher impact in the inner harbour, as well as more pristine areas in the outer harbour and reference locations.

This information was historically reported every three years in an ecosystem health report card. Trends on WQ, bioaccumulation and sediment quality are available on the PCIMP website www.pcimp.aims.gov.au.

PCIMP information is now collated for the public in GHHP report cards, discussed below. This program is used as baseline data for WQ and bioaccumulation results.

12.3.3 Gladstone Healthy Harbour Partnership

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

The guiding principles of the Partnership are open, honest and accountable management, annual reporting of the health of the Gladstone Harbour and management recommendations and action based on rigorous science and strong stakeholder engagement to ensure the ongoing and continuous improvement in the health of Gladstone Harbour. GHHP aims to bring opportunities to partners such as:

- Efficient, cost effective, coordinated and targeted monitoring and research activities focused on GHHP needs and priorities, and management recommendations and action that removes any monitoring and research duplication
- Including existing industry and research effort to maximise and optimise value of investment (both time and money) while improving the quality of the data generated from monitoring and research programs (i.e. pooling resources to look at the big picture)
- Contributing to the development of the Port (and/or appropriate sub-components thereof) specific environmental values, WQOs and trigger values
- Facilitating cooperation between industry, research, community and government to pool the best possible expertise to understand and manage Gladstone Harbour health
- Improving community engagement, communication and confidence in the health and management of the harbour by providing synthesised information in easy to understand language, but without loss of scientific rigor
- Coordinating science and science communication products
- Informing decision-making for users of the Gladstone Harbour
- Assisting to secure the region's tourism and marine recreation industries.

GPC is a member of the GHHP management committee. The program is currently reviewing existing monitoring programs and investigating opportunities for further monitoring. GHHP will be notified of dredging activities as it may influence data collected during this time and therefore have a bearing on report card results.

GHHP released its latest report card for the health of the Gladstone Harbour in 2017 (http://rc.ghhp.org.au/report-cards).

12.3.4 Ecosystem Research and Monitoring Program

GPC continues to progress the Ecosystem Research and Monitoring Program. This program is required to be implemented for a minimum of 10 years and is anticipated to run until late 2021. The information collated is used to monitor, manage and improve the marine environment and to offset any impacts on listed threatened and migratory species and the values of the Great Barrier Reef World Heritage Area such as turtles, dugongs, dolphins, shorebirds, seagrass, wetlands and mangroves.

12.3.5 Biodiversity Offset Strategy

The Biodiversity Offset Strategy has been developed by GPC to provide tangible initiatives aimed at avoiding potential impacts to the values of the Great Barrier Reef World Heritage Area, National Heritage Place and EPBC Act listed threatened migratory species. The objective of the strategy is to provide for long-term conservation of threatened and migratory species, including their habitats. Projects performed / planned under the strategy relate to listed threatened and migratory species protection, habitat enhancement and restoration actions in the region or the wider bioregion such as 'seagrass friendly' mooring systems, wetland rehabilitation projects and WQ improvement programs.

12.3.6 Sediment monitors

GPC has purchased two specialised sediment dynamic monitors to enable targeted investigations into sediment movement within the Port as required.

The initial focus of this monitoring will be:

- To gather high resolution data on the particle size distribution of suspended solids and how they vary in time and space
- To gain a better understanding of the movement patterns of suspended sediment that may be sourced from the Port and offshore areas, and more accurate information about settlement rates
- To improve the ability of hydrodynamic modellers to accurately undertake simulations of plumes from resuspension of sediment
- To gain information on current velocity and directions across the water column and Project suspended solid concentrations.

The impact hypotheses to be tested by this monitoring is:

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

Each of the monitors will consist of the following equipment mounted onto a specialised frame:

- 2 x LISST (particle size distribution and settlement)
- 1 x WETLab NTU sensor
- 1 x WETLab ECO PAR sensor.

Additionally, an AWAC sensor that measures wave height, current direction and speed will be installed at a static location within Port limits to assist the above-mentioned objectives.

The sediment monitors will be easily transferable to different locations within the Port and at offshore sites, and will therefore allow for flexible investigations of sediment transport in Port Curtis as required.

As per the monitoring schedule, in this period GPC aim to commission develop and implement a program for use of the sediment monitors to undertake targeted investigations into sediment movement in the Port of Gladstone.