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Ports North

CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

Chapter B5:Marine Water Quality

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B5.1 Introduction

The Cairns Shipping Development Project (the CSDP or project) is a capital dredging project in Trinity Inlet and Trinity Bay to increase the capacity of the Port of Cairns for tourism and shipping. Up to 1 M m^3 of material is proposed to be dredged.

The project has the potential to influence water quality within Trinity Inlet and Trinity Bay during both the construction phase and operational phases. Impacts on water quality could result from capital dredging of the existing shipping channel into Cairns port, the channel bend, swing basins and inner port. Additionally, the placement of dredge material at the onshore dredge material placement area (DMPA) could also have water quality impacts due to tailwater releases. These influences are both short term (i.e. construction) and continuing (i.e. maintenance dredging and operation).

Terms of Reference (ToR) for the project have been set by the Queensland Government (2012) with provisions to address marine water quality, potential impacts, mitigation and monitoring in Section 5.3.2 of the TOR. Additionally, the Environmental Impact Statement (EIS) guidelines for the project have been set by the Australian Government (2012) with provisions to address the existing environment, potential impacts, mitigation and monitoring in Section 5.9 through 5.14 of the EIS guidelines.

This chapter addresses environmental issues and impacts to marine water quality associated with the construction and operation of the project. This chapter describes the following:

- the baseline water quality of the existing marine environment in the study area
- assessment of potential impacts on marine water quality
- options for managing and mitigating identified impacts.

It is noted that potential water quality impacts on the marine environment associated with stormwater runoff or spills from the land-based components of the project (including groundwater) are addressed in Chapter B6, Water Resources**.**

B5.2 Existing Situation

This section provides a summary of the general water quality conditions and available water quality data in the study area. The study area for marine water quality includes Trinity Inlet and the coastal waters of Trinity Bay extending east to Cape Grafton and north to Double Island (refer to **Figure B5-1**). Previous studies, monitoring campaigns and literature were used to characterise the existing water quality and determine baseline levels for impact assessment. In this sense (and where possible), the water quality components within this baseline assessment were aimed at identifying the plausible linkages (i.e. tides, currents, rainfall, etc.) of the existing water quality regime, based on present knowledge.

This baseline assessment has provided water quality results and information on heavy metals, turbidity, suspended sediment, dissolved oxygen, nutrients and oil in water. Where appropriate the assessment has compared baseline results with applicable guideline values.

B5.2.1 Methodology

B5.2.1.a Data Sources (1995 – 2014)

The key existing studies identified as most applicable in characterising baseline water quality are discussed below. The locations of these monitoring sites per each study are presented on **Figure B5-1**.

- Cairns Shipping Development (CSD) Project EIS, BMT WBM Coastal Data Collection (February 2013-February 2014)
  - This data set comprises a significant portion of the main body of information from which baseline conditions, particularly suspended sediment and turbidity, have been established. Overall, this data set consists of 12 months collection at some locations, with some sites discontinued after six months. For February 2013 through August 2013, these data were collected at three sites along the channel

and two in the region of the DMPA. For September 2013 through February 2014, data were collected at one location within the shipping channel and one at the DMPA (**Figure B5-1**). These data include:

- Static seabed water level, current, wave, turbidity, temperature and conductivity measurements
- Water quality grab samples for Total Suspended Sediments (TSS) (at various depths), metals (surface and bottom) and nutrients (surface and bottom). These samples were collected in both wet and dry seasons, and during spring and neap tides
- Current, water level, turbidity temperature and conductivity transects.

- Further information in regard to the Coastal Data Collection program is provided in BMT WBM (2013).
- CSD Project EIS, BMT WBM Water Quality Monitoring Program (July 2013 to July 2014) – This additional water quality data was collected in support of the project, and intended to provide information to the EIS at six additional sites not covered in the Coastal Data Collection (**Figure B5-1**). This data set consists of 12 months of continuous turbidity and some physico-chemical measurements, along with grab samples of total and dissolved metals, nutrients and TSS taken during both wet and dry seasons and during spring and neap tides. The monitoring sites were chosen in consultation with State and Federal Government agencies, and were chosen because:
  - They are located at sensitive receptors where potential impacts (above background) could occur from dredging and placement
  - They allow for development of site specific water quality trigger values as part of the Dredge Management Plan (e.g. locally derived values for determining acceptable impacts from turbidity on water quality)
  - They are appropriately located for compliance monitoring during capital dredging
- Additionally, routine profiling of four deep water sites located between the DMPA and the offshore reef areas was undertaken during equipment servicing trips. Further information in regard to the Water Quality Monitoring Program is provided in BMT WBM (2013).
- Ports North (Formerly the Cairns Port Authority, CPA; 1995–2007 then Ports North 2007-2013) data – Water quality monitoring program extending back to 1995 for some constituents, represents more than 17 years of data. These data were primarily collected within Trinity Inlet; however, there were some older data that characterise water quality within the shipping channel to its current extents (**Figure B5-1**). These data do not represent continuous monitoring (as do some of the coastal data collection and water quality monitoring data), however, the period of records for this data is extensive so as to capture seasonal and more long-term climatic influences.
- James Cook University (JCU; 2013-2014) – Monitoring of photosynthetically active radiation (PAR) since February 2013 (ongoing) by James Cook University at four intertidal sensitive receptor (seagrass) locations within Trinity Bay. Additionally, two sub-tidal locations have been monitored, one at the DMPA between February 2013 and February 2014, and one at water quality monitoring site 3 adjacent to the channel (Trinity Bay) between October 2013 and July 2014 (**Figure B5-1**).
- Rainforest and Reef Research Centre (RRRC; 1995-2012) – Data which include marine water quality measurements collected from 1995 to present; however, there were some significant periods during which it was not collected. It is noted these data were not undertaken in a comprehensive seasonal monitoring program; rather they are representative of opportunistic monitoring of plume water quality in association with large catchment inflows from cyclones. Additionally, these data have been synthesised into regions of flood plume types which define regions of frequency and level of pollutant exposure.

It should be noted that monitoring data collected during times of dredging (including maintenance dredging undertaken between 21 July 2013 and 17 August 2013) were quarantined from the data sets because they represent conditions monitored during dredging operations and would not represent background conditions. This quarantined data represents approximately eight percent of the data set.

B5.2.1.b Additional Data Collection and Collation (2009 - 2017)

The revised CSD EIS now includes land placement of all channel dredge material in a land-based dredge material placement area (DMPA) at the Northern Sands void (soft material), with a small proportion of stiff clays (up to 100 000 m^3) to be placed on Ports North land at Tingira Street.

As tailwater discharges will occur from the Northern Sands DMPA, further water quality data was collected between July 2016 and March 2017 in areas potentially impacted by tailwater discharges. These areas, which were not previously studied as part of the original draft EIS, include:

- Barron River, where tailwater discharges for the placed dredge material are proposed.
- Thomatis / Richters Creek, where tailwater discharges could become mobilised.

This water quality data collection campaign will continue such that 12 + months of data is available at these locations prior to a decision on the project.

Additional marine water quality data was also collected in areas of key sensitive ecological receptors, in similar locations to where data was collected as part of the original EIS. The purpose of this was to supplement the existing dataset for these important areas, and include:

- Trinity Inlet – where seagrass meadows are located.
- Palm Cove (Double Island) – where coral reefs at Double Island are located.

The above locations are shown on **Figure B5-2**.

Data from the water quality monitoring program (July 2016 to March 2017) was supplemented by data from other sources, including:

- Data collected by BMT WBM (and made available to the Project) for the AQUIS project in the Barron River (July 2014 to September 2014) and Thomatis/Richters Creek (Dec 2013 to Feb 2015).
- Data collected by the Landline Consulting (on behalf of the operator) in the Northern Sands void (2010 to 2016).
- Data collected by Cairns Regional Council in the Barron River (2009 to 2016).

The findings from this additional data collection / collation are detailed in Appendix AI (Additional Water Quality Baseline Studies), with the key findings summarised in **Section B5.2.17**.

B5.2.1.c Water Quality Data Divisions

The water quality monitoring locations for the previously listed programs and studies are presented on **Figure B5-1**. The data were collated and consolidated by sampling location. Sampling locations were grouped into six principal areas (**Figure B5-1**) with a few sub-regions delineated by both geographical features and the pertinent waterway types and applicable water quality objectives. The delineated areas include:

- Region 1 – Trinity Inlet:
  - Middle estuary
  - Lower estuary.
- Region 2 – Inner Cairns Harbour:
  - Enclosed coastal
  - Open ocean.
- Region 3 – Open ocean, outer Cairns harbour, including False Cape
- Region 4 – Open ocean, DMPA
- Region 5 – Northern Beaches
- Region 6 – Far eastern harbour, which includes a conservation park zone and the Cape Grafton WQ monitoring location.

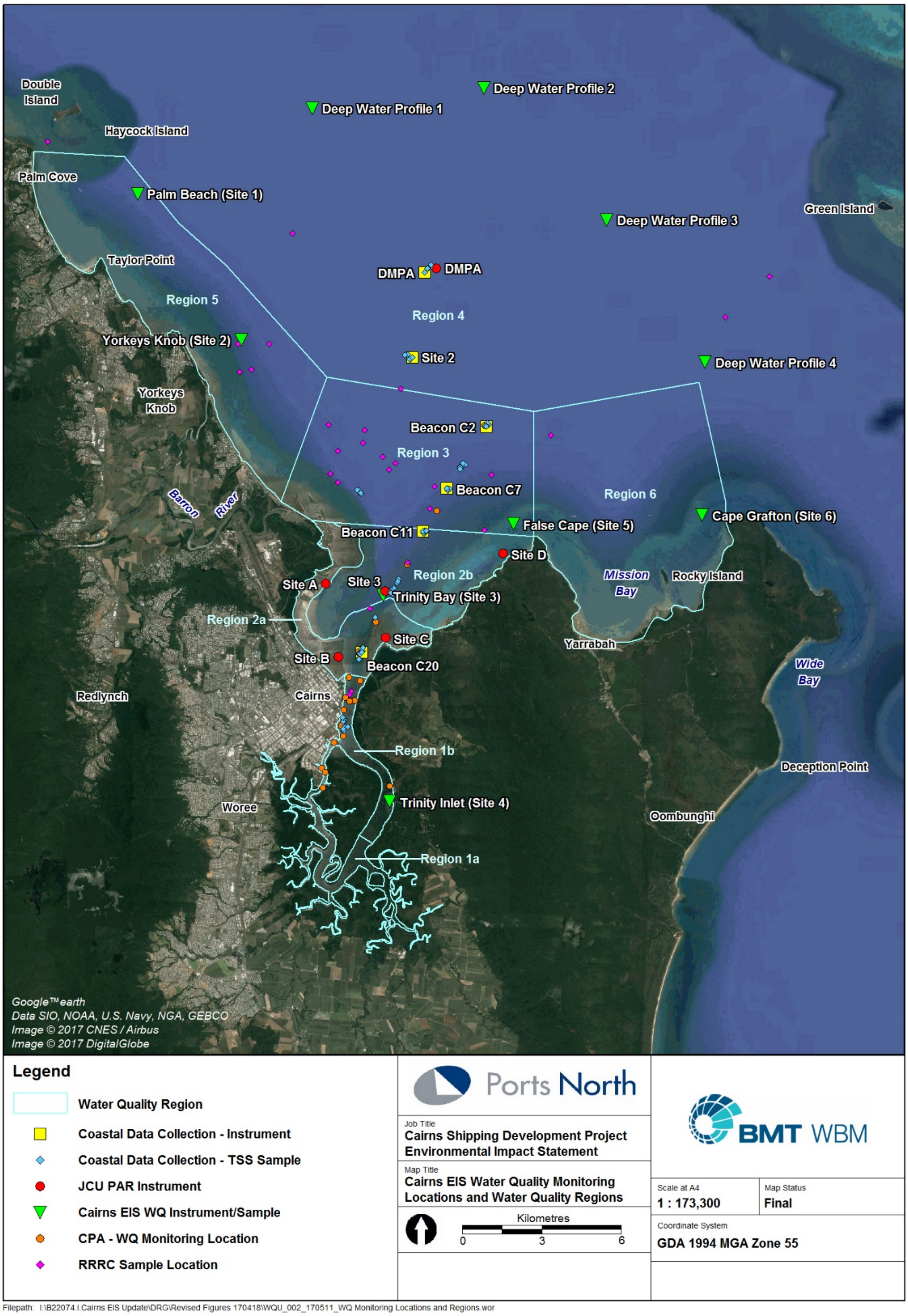

Figure B5-1 Cairns Shipping Development Project EIS water quality monitoring locations and water quality regions.

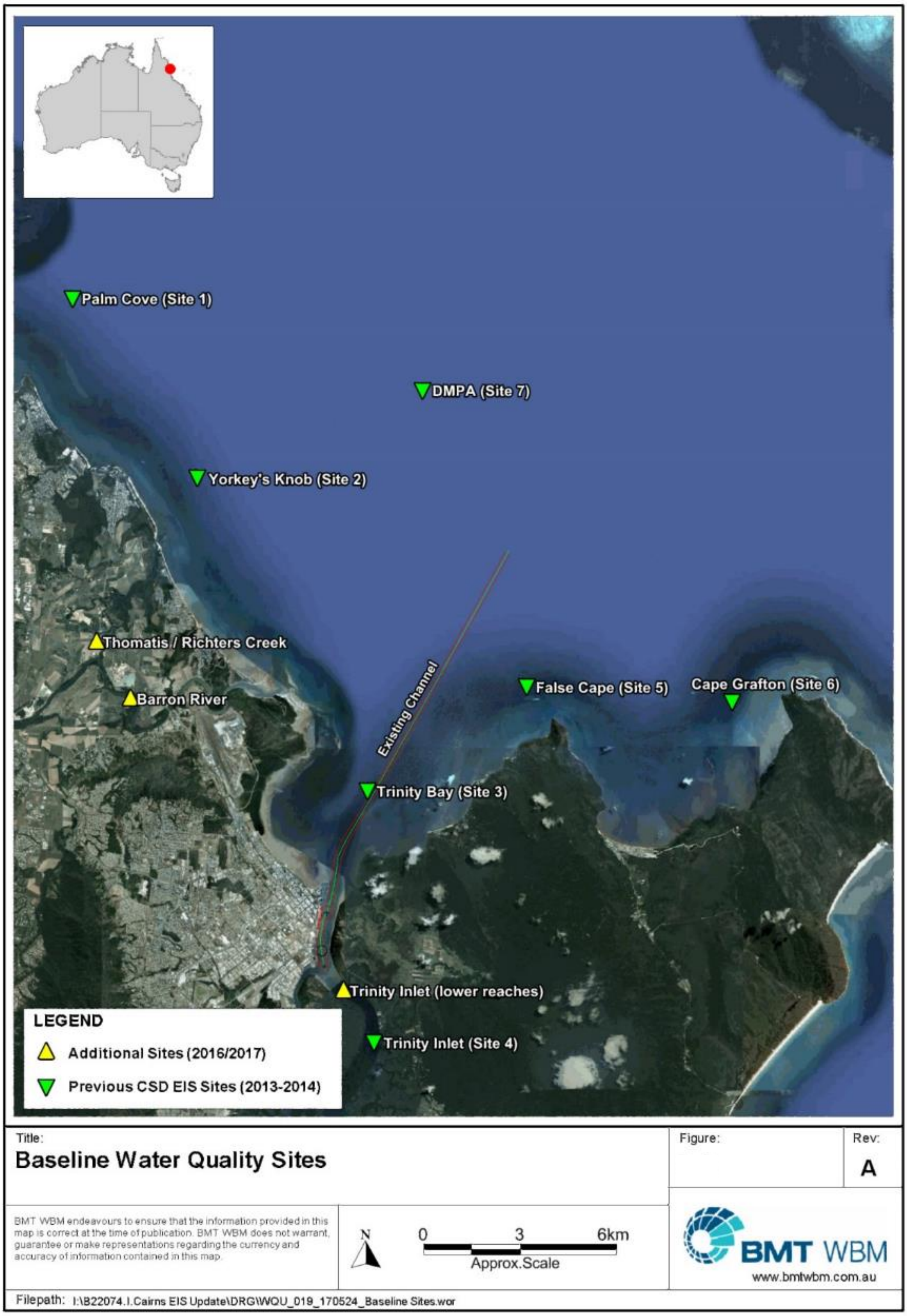

Figure B5-2 Additional water quality monitoring sites (2016-2017) and previous sites (2013-2014).

It is noted that some regions (1 and 2) are divided strictly along the lines where applicable water quality objectives and geographical features distinguish one from another (i.e. Trinity Inlet and inner Trinity Bay). Beyond those regions, however, these features are less strictly applied and are based on the locations of the monitoring regions and general geographic features. These regions were adopted to characterise baseline conditions specifically where needed. They are general so as to provide a sufficient amount of spatial resolution to the data without being overly specific.

Water quality data were divided into six general groups of parameters:

- Physico-chemical.
- TSS and turbidity
- Photosynthetically Active Radiation (PAR)
- Metals
- Nutrients
- Oil and grease.

Due to the spatial, seasonal and temporal coverage of the previously listed data sets, not all sites and regions could be represented for each parameter. Table B5-1 presents the primary data source(s) used to characterise background for each parameter ground and for each region.

TABLE B5-1 WATER QUALITY DATA PRIMARY SOURCE MATRIX

Region	Physico-Chemical	Turbidity-TSS	PAR	Metals	Nutrients	Oil and Grease
1a	3	3	no data	3	3	3
1b	3	1, 2 & 3	no data	3	3	3
2a	1	1, 2 & 3	4	no data	3	no data
2b	1	1, 2 & 3	4	2	3	no data
3	1	1, 2 & 3	no data	2	3	no data
4	1	1	4	no data	no data	no data
5	2	2	no data	2	2	no data
6	2	2	no data	2	2	no data

1 - CSD Project EIS, Coastal Data Collection (wet and dry season)

2 - CSD Project EIS, WQ Monitoring (wet and dry season)

3 – Ports North WQ data (1995-2013)

4 - James Cook University (2014) - PAR data

B5.2.1.d Suitability of Baseline Data

Under the Queensland TOR, water quality data requirements must account for seasonal (i.e. wet and dry seasons) and tidal variation. The EIS Guidelines also outline the need for collection of water quality data at sensitive receptor sites (such as seagrass and coral communities) that could be affected by the dredging and placement.

The baseline data sets are sufficient to meet the TOR and EIS Guidelines because:

- The Coastal Data Collection provides an uninterrupted 12-month coastal and water quality data set for model calibration purposes and assists to capture any storm events and/or freshwater flows during the 2013/14 wet season.
- The Water Quality Monitoring Program provides greater than 12 months (July 2013 to July 2014, and July 2016 to March 2017) of continuous turbidity measurements at sensitive receptors to use as part of baseline characterisation, impact assessment, and the development of trigger values.
- The other (secondary) data sets are used for constituents which are not included in the primary data sets (e.g. oil and grease), or to provide historical, seasonal, and climatic context to the primary data sets.

It should be noted the Queensland and Federal Governments were consulted in the development of the baseline monitoring program for the project.

To address regulator concerns about the 12-month period of turbidity monitoring for the Draft EIS (July 2013 – July 2014) being representative of typical conditions, historic water quality conditions were assessed using satellite imagery. This assessment found that the monitoring period of July 2013 – July 2014 was fairly typical of conditions over the 10-year period between 2006 and 2016. If anything, the range of turbidity values is narrower compared to other years, meaning that the turbidity values used to represent background conditions in the impact assessment are conservative. The methodology and findings of this assessment are fully detailed in Section 3.6 of **Appendix AI** (Additional Water Quality Baseline Studies).

B5.2.2 Water Quality Guidelines

The indicators and water quality objectives and guidelines for assessing the impact of water quality upon the environmental values (EVs) are determined (described in order of precedence) from the following legislation, policies and guidelines.

B5.2.2.a Environmental Protection Act 1994 and Environmental Protection (Water) Policy 2009

The *Queensland Environmental Protection Act 1994* is the principal legislative basis for environmental protection within the context of ecologically sustainable development in Queensland. To achieve this aim with regards to water quality, the Act provides the *Environmental Protection (Water) Policy 2009* (EPP Water) and the EPP Water is the principal legislative basis for water quality management in Queensland. The EPP Water includes a process for:

- Identifying environmental values (EVs) of waterways, including both aquatic ecosystems values and human use values
- Establishing corresponding water quality objectives (WQOs) to protect identified EVs.

The EVs and WQOs for Trinity Inlet and Trinity Bay (Basin No. 111) were set by the Department of Environment and Heritage Protection (DEHP; formerly DERM) July 2010. The plan, shown on **Figure B5-3**, covers lowland freshwater streams and the marine and estuarine environments from the tidal limits of Trinity Inlet (e.g. Simmonds and Smith's Creek) to the waters of Trinity Bay (i.e. from the entrance of the Barron River to False Cape).

The EPP Water WQOs provide benchmarks for water quality through annual median values. That is annual median from monitoring data should be compared to these values.

B5.2.2.b Queensland Water Quality Guidelines (2009)

The Queensland Water Quality Guidelines 2009 (QWQG) (DERM, 2009) are intended to address the need for local guidelines as identified in the ANZECC/ARMCANZ (2000) guidelines by:

- providing guideline values (numbers) that are tailored to Queensland regions and water types
- providing a process/framework for deriving and applying local guidelines for waters in Queensland.

The QWQG provide a mechanism for recognising and protecting local Queensland waters and are not mandatory legislative standards or WQO's. WQOs are generally reserved for the waters' schedule in the EPP Water.

The QWQG values applicable to the Trinity Inlet and Trinity Bay locality are that of the Wet Tropics region for a 'slightly to moderately' disturbed water for those constituents and waterway types the EPP Water does not address.

B5.2.2.c Water Quality Guidelines for the Great Barrier Reef Marine Park

The Water Quality Guidelines for the Great Barrier Reef Marine Park (WQGGBRMP) specifically describe the concentrations and trigger values for sediment, nutrients and pesticides that have been established as necessary for the protection and maintenance of marine species and ecosystem health of the Great Barrier Reef. The guidelines address the ANZECC/ARMCANZ (2000) processes of defining environmental values and defining water quality objectives and support the following initiatives listed below:

- the Australian Government's Reef Rescue Plan, targeting improved farm management practices and supporting water quality monitoring programs
- the Australian Government's Reef Water Quality Protection Plan
- the Australian Government's Coastal Catchment Initiative (CCI)
- the Australian Government's National Water Quality Management Strategy (NWQMS).

Given the initiatives above, the guidelines ultimately provide environmentally-based values for water quality contaminants, based upon a compilation of currently-available scientific information, which, if breached, will trigger management actions, and are not for use as single point compliance triggers as part of a dredging project.

The trigger values for sediments and nutrients provided within WQGGBRMP for an enclosed coastal water body (i.e. that of Trinity Inlet and Trinity Bay) are adapted from the QWQG to facilitate a complementary system between Queensland and Australian Government water quality guidelines in the GBRMP. As the WQGGBRMP are comparable to the QWQG, reference to water quality guidelines is based on the QWQG where appropriate.

B5.2.2.d ANZECC/ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000) guidelines can be used where regional guidelines (QWQG) are not adequate or available, for example, when assessing toxicants such as metals and metalloids.

The main objective of the recent ANZECC/ARMCANZ (2000) water quality guidelines is to provide an authoritative guide for setting water quality objectives required to sustain current, or likely future, environmental values for natural and semi-natural water resources in Australia and New Zealand. The guidelines are intended to provide Government, industry, consultants and community groups with a sound set of tools for assessing and managing ambient water quality, according to designated environmental values. The guidelines similar to the QWQG were not intended to be applied as mandatory standards but do provide guidelines for recognising and protecting water quality.

With respect to toxicants (heavy metals and pesticides) in marine waters, the ANZECC/ARMCANZ (2000) guidelines provide four levels of protection for different ecosystems (80 percent, 90 percent, 95 percent and 99 percent). For Trinity Inlet and Trinity Bay which is considered to be 'slightly to moderately disturbed' the 95 percent protection is commonly applied, and as recommended by ANZECC/ARMCANZ (2000), the 99 percent level is applied for certain toxicants (e.g., cadmium) to protect vulnerable biota or to mitigate bioaccumulation.

B5.2.3 Description of Environmental Values, Water Quality Objectives and Guidelines

Provided in Table B5-2 is a summary of the relevant environmental values (EVs) as presented in the EPP Water Schedule 1 of Trinity Inlet and Trinity Bay. The WQOs and guidelines defined by the documents in Section 1.1 are in turn provided in Table B5-2. Waterway types, as per the EPP Water, are presented on **Figure B5-3**. The EVs and water quality objectives and guidelines presented are used to assist in the evaluation of existing (baseline) water quality conditions of Trinity Inlet and Trinity Bay and as an indication of the potential impact from the project.

With reference to the WQOs and guidelines summarised in **Table B5-3** and as noted in **Section B5.2.2.b**, the EPP Water objectives provide the quantitative measure of performance for the EVs where applicable followed by the WQGGBRMP (2010) and the ANZECC/ARMCANZ (2000) in order of precedence. Compliance with the most generally stringent aquatic ecosystem values will ensure achievement of all EV outcomes for Trinity Inlet and Trinity Bay.

In contrast to the EPP Water WQOs, the ANZECC/ARMCANZ (2000) toxicant trigger values (TTV) for metals/metalloids are for instantaneous comparison of data. Metals/metalloids are assessed in terms of their dissolved concentrations rather than total concentrations.

TABLE B5-2 TRINITY INLET AND TRINITY BAY ENVIRONMENTAL VALUES

Environmental values	Trinity Inlet and Trinity Bay – Marine & Estuarine
Educational and Scientific Use	✓
Aquatic Ecosystems	✓
Seagrass[a]	✓
Aquaculture	✓
Human Consumer	✓
Oystering[b]	✓
Primary Recreation	✓
Secondary Recreation	✓
Visual Recreation	✓
Cultural and Spiritual Values	✓

[a] Seagrass is a component of the aquatic ecosystem EV.

[b] Oystering is a component of the human consumer EV.

TABLE B5-3 TRINITY INLET AND TRINITY BAY WATER QUALITY OBJECTIVES AND GUIDELINES

Parameter	Units	Waterway Type: Open Coastal	Waterway Type: Enclosed Coastal	Waterway Type: Mid Estuary	Applicable Guideline
Ammonia N	µg/L	2	15	15	EPP Water (2009) - Annual median values
Chlorophyll a	µg/L	0.45	2	3	
Dissolved oxygen	% of sat	95-105	No more than 10% decrease in minimal diurnal concentration		
Filterable reactive phosphorus (FRP)	µg/L	4	7	7	
Organic N	µg/L	135	200	200	
Oxidised N	µg/L	2	20	30	
Particulate N	µg/L	20	--	--	
Particulate phosphorous	µg/L	2.8	--	--	
pH	pH units	8.15 - 8.40	7.1 - 8.2	6.5 - 8.4	
Secchi depth	m	10	> 1.2m (20th percentile)		
Temperature		--	< +2 °C Increase		
Total nitrogen	µg/L	140	250	250	
Total phosphorus	µg/L	20	20	20	
Total suspended solids	mg/L	2	Where background is < 15mg/L, no increase > 10mg/L for extended periods. Where background is > 15mg/L, no increase > 25mg/L for extended periods.		
Turbidity	NTU	1	10[a]	10[a]	
Sedimentation		Daily Average = 3 mg/cm2/day Daily Maximum = 15mg/cm2/day			WQGGBRMP (2010)
Faecal Coliform	CFU/100mL	Median count no greater than 150 CFU/100mL in bathing season 80% of samples less than 600CFU/100mL; min 5 samples			ANZECC/ARMCANZ (2000) Recreational WQ Guidelines
Aluminium	µg/L	0.5[b]			ANZECC/ARMCANZ (2000) Toxicant Trigger Values
Arsenic	µg/L	50.0[c]			
Cadmium	µg/L	0.7[d]			
Chromium	µg/L	4.4			
Cobalt	µg/L	1.0			
Copper	µg/L	1.3			
Iron	µg/L	300[b]			

Parameter	Units	Waterway Type			Applicable Guideline
		Open Coastal	Enclosed Coastal	Mid Estuary	
Lead	µg/L	4.4			
Manganese	µg/L	80.0[b]			
Mercury (inorganic)	µg/L	0.1[d]			
Nickel	µg/L	7.0[d]			
Selenium	µg/L	3.0[b]			
Silver	µg/L	1.4			
Tributyltin (TBT) - expressed as Sn	µg/L	0.006			
Zinc	µg/L	15.0			
Ammonia	µg/L	460[e]			
Nitrate	µg/L	700[b]			
Cyanide	µg/L	4			
Diuron	µg/L	0.9			WQGGBRMP (2010)[d]
Simazine	µg/L	0.2			
Atrazine	µg/L	0.6			
Hexazinone	µg/L	1.2[b]			
Ametryn	µg/L	0.5			
Chlorpyrifos	µg/L	0.0005			
Endosulfan	µg/L	0.005			
DDE	µg/L	0.0005[b]			
Tebuthiuron	µg/L	0.02[b]			

[a] Queensland Water Quality Guidelines (2009). Department of Environment and Resource Management, Queensland Government.

[b] Marine TTV of low reliability; indicative guideline only

[c] Based on more stringent recreational guideline value

[d] Based on the 99% protection level to protect against chronic toxicity to related species and bioaccumulation

[e] New ammonia TTV based on Batley and Simpson (2009)

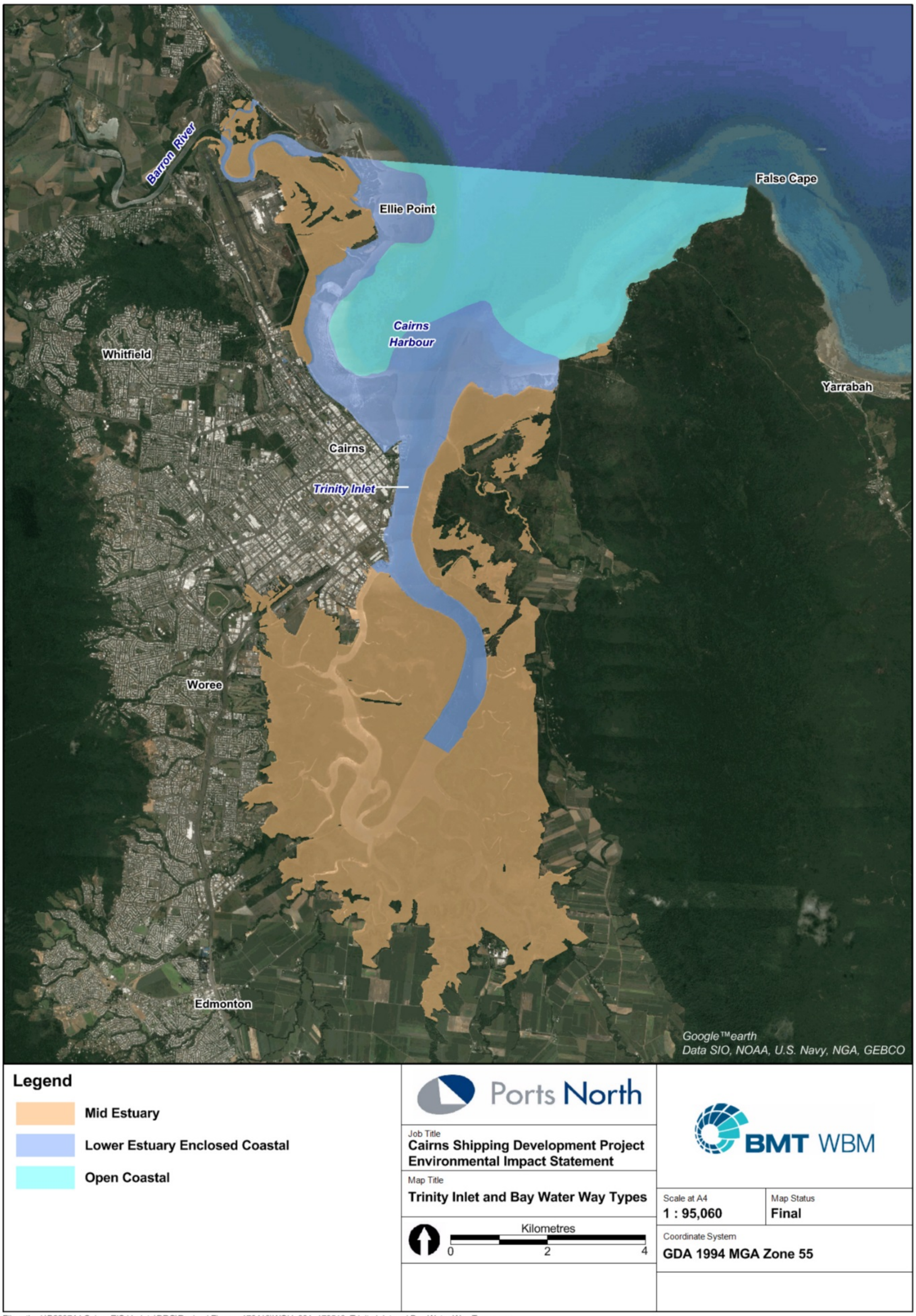

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Figure B5-3 Trinity Inlet and Trinity Bay waterway types (as per Schedule 1 of EPP Water).

B5.2.4 Overview

The Port of Cairns and the shipping channel are located in Trinity Inlet and Trinity Bay. The Great Barrier Reef is approximately 25-30 km offshore to the northeast. There are some freshwater inflows that drain into Cairns harbour, and Trinity Inlet is fed by numerous freshwater creeks which drain small catchments, including Smith's Creek, Skeleton Creek, Redbank Creek, and also Chinaman's Creek and Fearnley St Drain, which contribute urban and industrial inputs. The Barron River feeds into the north-western region of Trinity Bay.

The Barron River catchment is 2150km^2, (Barron and Haynes 2009) approximately the size of the Calliope River in Gladstone and the Ross River in Townsville (Milliman and Farnsworth 2011). The catchments draining directly to Trinity Inlet are approximately 340 km^2 in total area (Barron and Haynes 2009). While the combined catchments are 46 percent natural forest, 29 percent of the land is used for grazing and 13 percent for crops including sugarcane, and seven percent urban. Sugarcane crops comprise approximately 26 percent of the Trinity Inlet catchment land use.

Trinity Inlet and Trinity Bay are naturally turbid environments (**Photo B5-1**), especially following periods of high rainfall and sustained winds and currents which resuspend seabed sediments. As a result, naturally occurring turbid plumes are a regular feature of the marine environment. An example of a turbid plume is shown in **Photo B5-1**, which shows a turbid plume in Trinity Inlet resulting from freshwater discharge from Hills Creek (East Trinity).

Water quality is an important environmental asset in the study area and surrounds due to the presence of a number of ecological receptors that are sensitive to water quality conditions (**Chapter B7** (Marine Ecology)). These sensitive receptors include seagrass meadows that are located throughout Trinity Inlet and Trinity Bay, as well as fringing coral communities near Cape Grafton (east), Double Island (northwest) and offshore reefs (northeast). The historical and current conditions of these ecological assets are discussed in **Chapter B7** (Marine Ecology).

Photo B5-1 Naturally turbid marine environment of Trinity Inlet and Trinity Bay.

Source: Ports North.

Photo B5-2 Naturally occurring turbid plumes in Trinity Inlet resulting from freshwater discharge from Hills Creek, East Trinity.

Source: Ports North.

B5.2.5 Sediment and Pollutant Sources

Sediment and nutrient fluxes into Trinity Inlet and Trinity Bay continuously occur due to tidal flushing and riverine discharge of catchment related runoff associated with (sometimes cyclonic) rainfall events between November and May (Barron and Haynes 2009). The plumes can extend into the Great Barrier Reef lagoon varying according to size and dynamics of the flood event (GBRMPA 2001). Catchment inflows and urban stormwater runoff also introduce metals and organic pollutants, such as pesticides, into the surrounding waterways (Mitchell *et al.* 2006).

Hateley *et al.* (2009) estimated through modelling that the Barron River delivers approximately 44,000 tonnes of sediment per year (t/yr) to Trinity Bay, while Trinity Inlet catchments deliver 19,000 t/yr. However as indicated in **Chapter B3** (Coastal Processes) (refer table B3-8), modelled results appear to be a significant under-estimate of the actual Barron River annual sediment loads which have been recorded through physical measurements of between 163 000 t/yr and 396 000t/yr for the period of 2007-2011. Of total nitrogen and phosphorus, Hateley *et al.* (2009) predicted loads of 1400 and 230 t/yr, respectively, are delivered to Trinity Inlet and Trinity Bay from the Barron and Trinity catchments.

A photo of the Barron River discharging into Trinity Bay is shown in **Photo B5-3**.

Anthropogenic sources of sediment and turbidity include urban runoff and dredging activities. The key water quality issue related to dredging activities is the generation of turbid plumes. Additional sources of pollutants within Trinity Inlet and Trinity Bay and surrounds include:

- Two sewage treatment plants, the Southern STP (19.4 ML/day) and the Edmonton STP (6.7 ML/day) discharge to Trinity Inlet and provide a constant source of nitrogen and phosphorus to that waterway (Cairns Regional Council [CRC] 2013)

- If not appropriately managed, boating and shipyard activities have potential to release petroleum-based pollutants, anti-fouling leachates, litter and some organic waste (Mitchell et al 2006)
- Urban stormwater flows that discharge into the port area via constructed drains that may contribute gross pollutants, along with dissolved and particulate contaminants.

Photo B5-3 Barron River discharging into Trinity Bay.

Source: Ports North.

B5.2.6 Seasonality

Sediment transport within Trinity Bay is primarily affected by seasonal wind regimes, diurnal currents, and tropical cyclones (Carter *et al.* 2002). Southeast trade winds in the winter and north and northeast winds during the summer are also accompanied by a daily easterly coastal breeze. These processes and movements cause bed re-suspension of mud and result in high background turbidity (Carter *et al.* 2002). These forces are also strong enough to create currents (>0.20 cm/s) that can mobilise sediment particles as coarse as sand at the seabed.

During typical weather conditions, under which south-easterly winds prevail, sediments generated from the Barron River settle out uniformly coarse-to-fine sediments relative to the distance from the entrance. Variable summer winds from the north and northeast are seen to result in counter clockwise circulation of sediment transport to the east and south with fine and some coarse sediments depositing within Trinity Inlet and as far east as False Cape and Cape Grafton (Carter *et al.* 2002).

Because of these divisions of seasonal wind and rain regimes, the data used for this baseline characterisation were divided into two distinct seasons, where practical. Based on the seasonal occurrences of the wind regimes and rainfall data, the seasonal division will be as follows:

- Wet season will consist of the months of November to April. Monsoonal troughs, cyclones and a majority of the median annual rainfall (87 percent) occurs during these months (Cairns Airport; BoM 2013; Carter *et al.* 2002; Devlin *et al.* 2012)

- Dry season will consist of the months of May through October. Subtropical ridge formation with southeast trade winds are predominant through these months (BoM 2013).

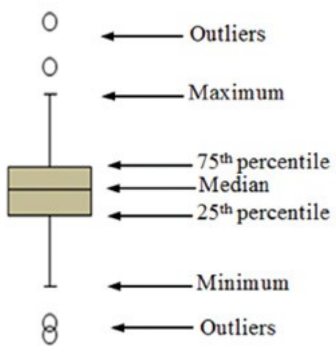
These ocean/coastal and sediment transport processes are more thoroughly described in Chapter B3, Coastal Processes**.**

B5.2.7 General Physico-Chemical Characteristics

Physico-chemical parameters that comprise the baseline characterisation for water quality within Trinity Inlet and Trinity Bay and surrounds are:

- Salinity
- Temperature
- pH
- Dissolved oxygen (DO) expressed as a percentage of saturated DO.

The figures in the subsections below present box and whisker plots for each of these parameters. These box and whisker plots present a convenient way of graphically depicting groups of numerical data through their five-number summaries: the smallest observation (sample minimum), lower quartile (Q1 or 25th percentile), median (Q2 or 50th percentile), upper quartile (Q3 or 75th percentile), and largest observation (sample maximum). A boxplot may also indicate which observations, if any, might be considered outliers. Boxplots display differences between populations without making any assumptions of the underlying statistical distribution: they are non-parametric. The spacing between the different parts of the box helps indicate the degree of dispersion (spread) and skewness in the data, and identify outliers.



B5.2.7.a Salinity

Seasonal salinity is typically lower during the wet season closer to Trinity Inlet, likely because of the influence of freshwater inflows. For the wet season, salinity increases farther from Trinity Inlet. Region 1 is represented by the Ports North data, Regions 2 through 4 by the Coastal Data Collection and Regions 5 and 6 by the Water Quality Monitoring Program.

Salinity in the Barron River and Thomatis / Richters Creek is discussed in **Section B5.2.17**.

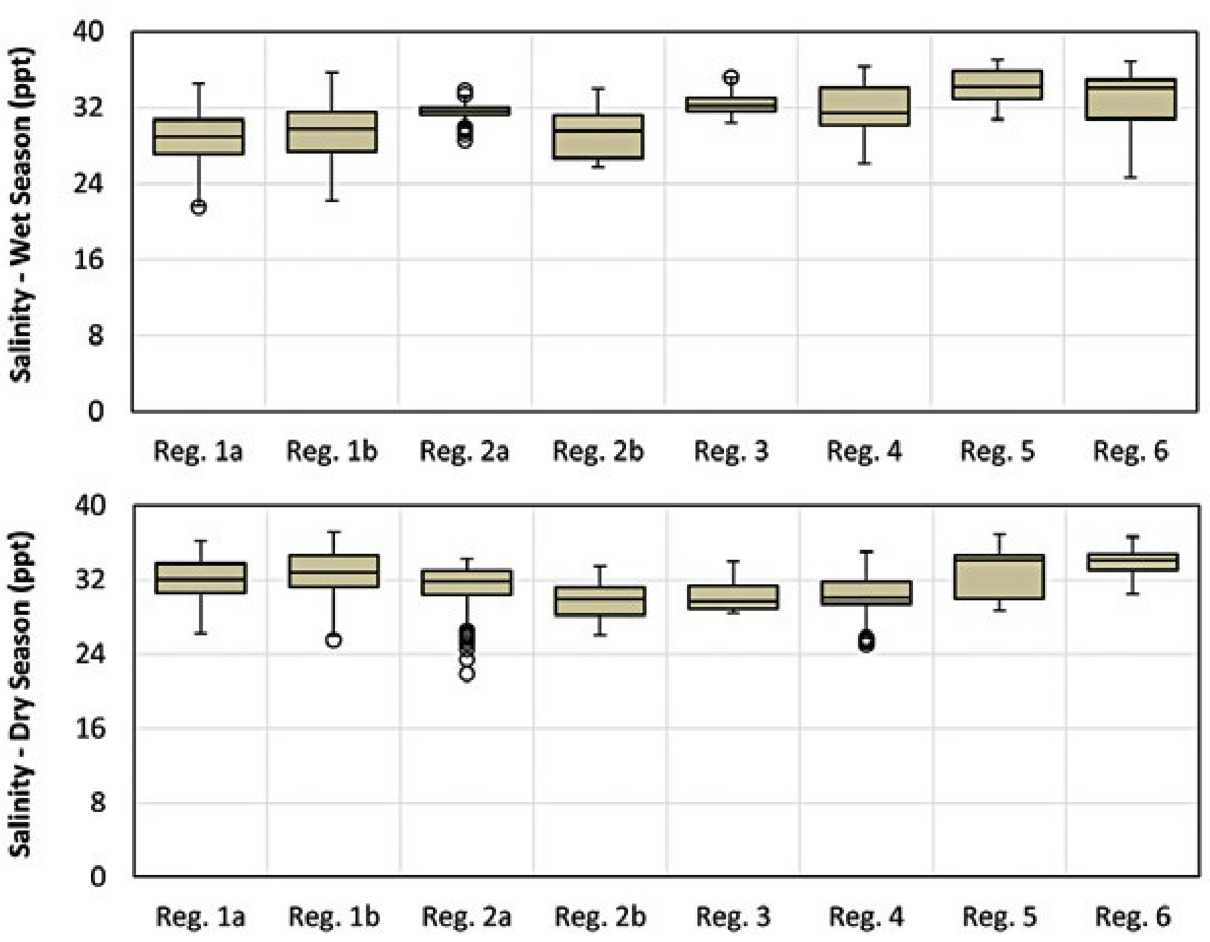


Figure B5-4 Seasonal salinity box and whisker plots.

B5.2.7.b Temperature

Water temperature remained relatively constant throughout the area, slightly decreasing toward the open ocean, especially during the dry season. Dry season temperatures were approximately 4-5°C less from site to site.

Temperature in the Barron River and Thomatis / Richters Creek is discussed in **Section B5.2.17**.

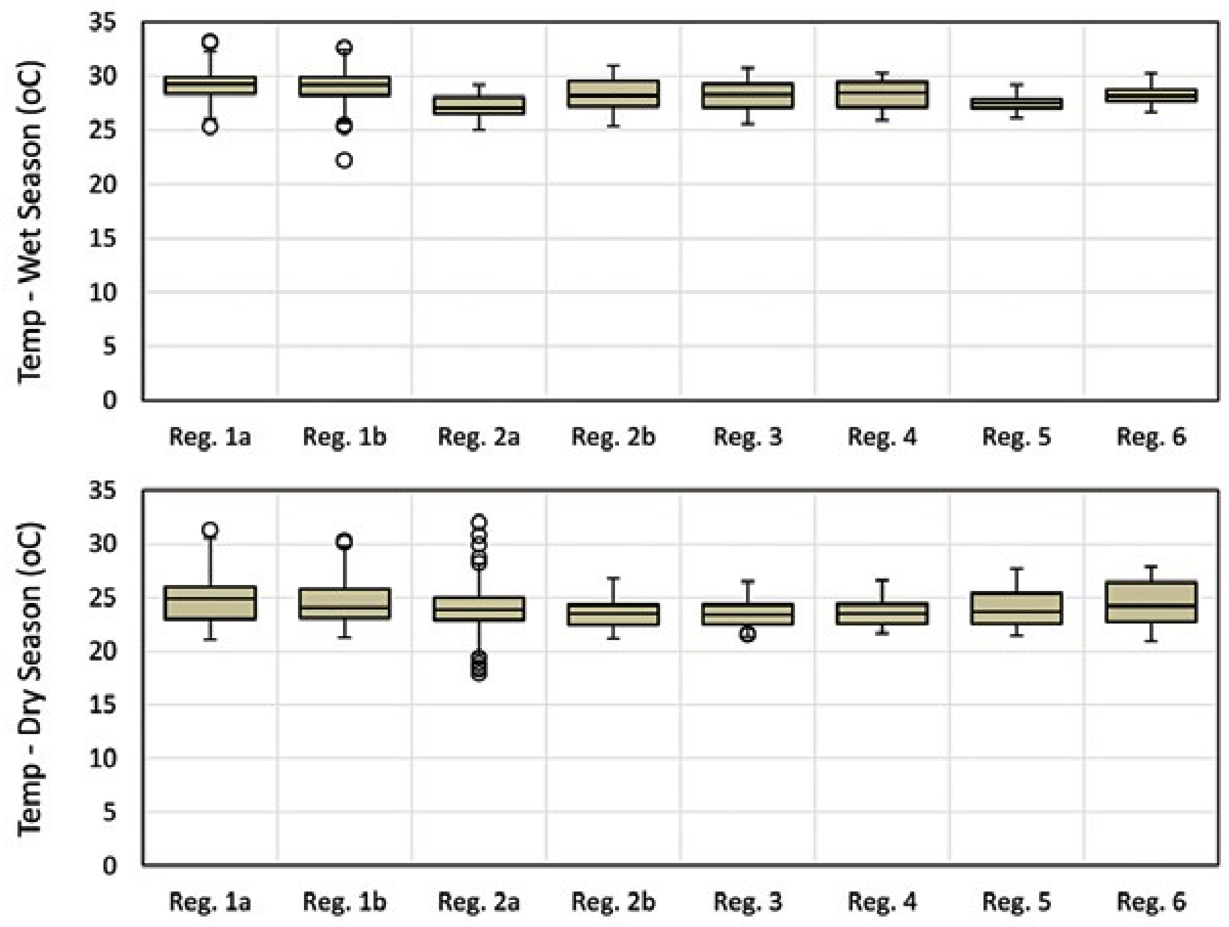


Figure B5-5 Seasonal temperature box and whisker plots.

B5.2.7.c pH

Trinity Inlet and Trinity Bay pH levels increased with increased connection with the open ocean. This is likely due to the influence of more acidic conditions of catchment flows and acid sulphate soils (Mitchell *et al.* 2006) and because of the basic nature of oceanic water. Of particular interest with these data is the wide variability of pH within region 1b. These data are indicative of both inlet and open ocean, however, there are values observed at the sites of that location that are likely due to anthropogenic causes, including the influence of acid sulfate soils (ASS), as this behaviour is not replicated within any of the other regions. Nevertheless pH was generally compliant with the WQO with the exception of region 2a during the dry season, where the median pH value is slightly elevated above the WQO. Analysis of the spatial and temporal trends of the data did not reveal an obvious pattern or cause for this.

It should be noted the WQO for pH are different for some regions because they are within different waterway types (e.g., enclosed coastal versus mid estuary).

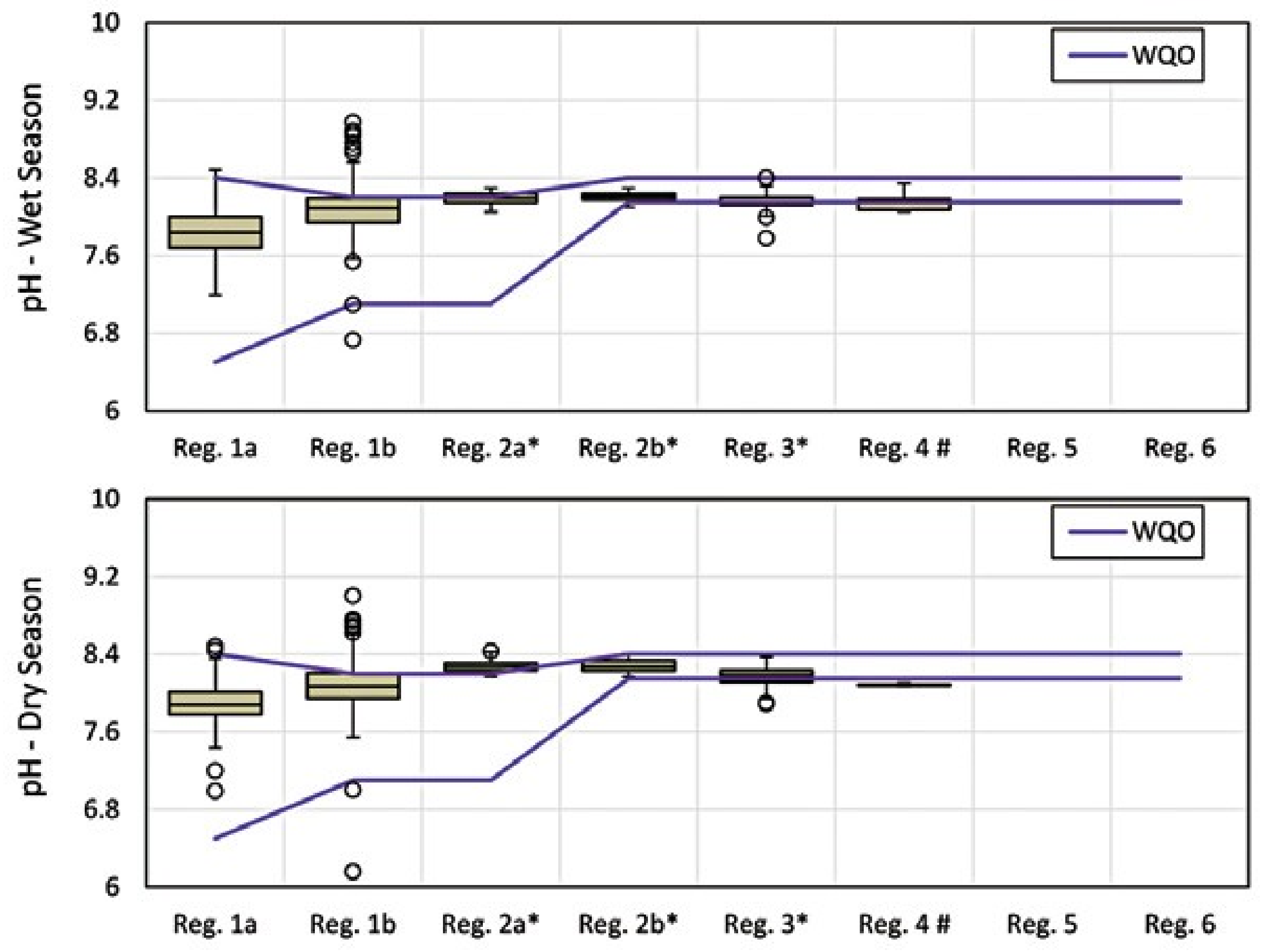
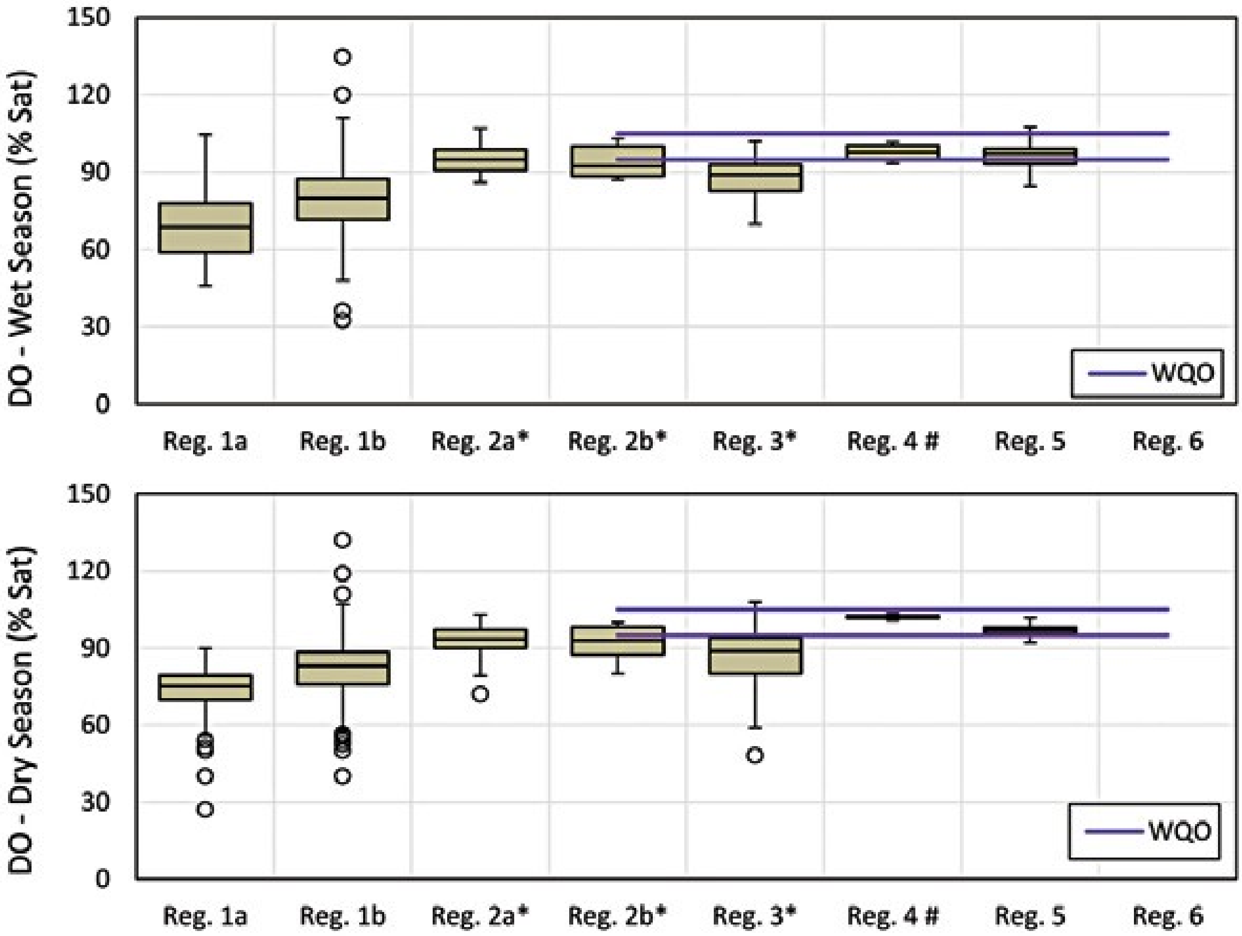


Figure B5-6 Seasonal pH box and whisker plots.

B5.2.7.d Dissolved Oxygen

Dissolved oxygen (DO) typically increased with improved connection to the open ocean. Even with increased DO in Trinity Bay (Regions 2b and 3), DO concentrations were less than the minimum DO WQO. Low DO in Trinity Inlet (Regions 1a and 1b) was likely due to chemical oxygen demand associated with metals mobilisation from acid sulphate soils (Mitchell *et al.* 2006), organic nutrient loading (Worley Parsons 2010) and limited tidal flushing. In a manner similar to pH, DO variability in region 1b was greater than that observed within the other regions. Analysis of the spatial and temporal trends of the data did not reveal an obvious pattern or cause for this.

It should be noted the WQOs for these figures do not extend across all regions because there is no applicable numeric WQO for those regions (see **Table B5-3**). For DO within the enclosed coastal and mid-estuary regions, the WQO is assessed in terms of the change in DO levels.



* pH data from PortsNorth (1995-2013) data used. Limited Coastal Data Collection or EIS pH data available

\# Deep Water Profiling data used for Region 4

Figure B5-7 Seasonal dissolved oxygen box and whisker plots.

B5.2.8 Turbidity and Total Suspended Sediment (TSS)

TSS and turbidity have been studied extensively in Trinity Inlet and Trinity Bay. TSS and turbidity is of particular relevance to the project due to capital dredging and on-going maintenance dredging required in the development area and the potential impact upon sensitive ecological habitats (outlined in further detail in Chapter B7, Marine Ecology).

B5.2.8.a Historical Background and Seasonal Effects on Turbidity

There is anecdotal evidence that turbidity and TSS within Trinity Inlet and Trinity Bay has changed over the last few decades. Over the past 100 years, much of the forest, coastal vegetation and wetlands in this region have been modified to allow urban, industrial and agricultural development. Coastal rivers now increasingly bring eroded sediment to settle as mud in the estuaries, coastal shallows and on inshore reefs (Mitchel *et al.* 2006).

Trinity Inlet and Trinity Bay frequently experience naturally high suspended sediment concentrations (20-200mg/L) driven primarily by south-east trade winds during the dry season, north and north-east winds (15-25 knots) and tropical cyclones during the wet season (Carter *et al.* 2002). During the dry season, the wind, current and wave climates drive seabed mud re-suspension. Some currents are sufficient (greater than 0.2 m/s) to move sediment as coarse as sand (Carter *et al.* 2002).

During the wet season, sediments from the Barron River are deposited at various locations within the bay depending on the sediment particle size. In particular, coarse sediment grain sizes tend to settle out near the

Barron River entrance, shoreline channels or along the beaches. Finer sediment particles settle out within mangroves or within the centre of Trinity Bay (Carter *et al.* 2002).

Figure B5-8 shows the effects of currents and wind on sediments in the vicinity of Trinity Bay. Wind and current measurements taken at Green Island (north-east of Cairns) were plotted against TSS concentrations at three locations along the northern beaches from Double Island to south of Yorkeys Knob. In particular, TSS appears to be strongly correlated to currents along with wind speed and direction. In these instances (22 and 29 August) sustained south-east winds and associated south-easterly currents resulted in TSS concentrations greater than 1000 mg/L at Site 1 south of Yorkeys Knob (Wolanski and Spagnol 2000).

Figure B5-9 also shows the effects that wind speed and direction can have on turbidity in Trinity Bay, especially in areas exposed to these winds. In this figure, a portion of the turbidity data from Palm Cove Beach (Site 1) has been plotted against wind speed and wind direction data. This shows that during periods of stronger south-east winds, there was generally an associated spike in turbidity at Palm Cove Beach. In areas more sheltered from these winds, such as Trinity Inlet, turbidity is less susceptible to wind direction and more influenced by stronger currents during spring tides. This is illustrated on **Figure B5-9** which shows turbidity spikes in Trinity Inlet which are generally associated with spring tide phases.

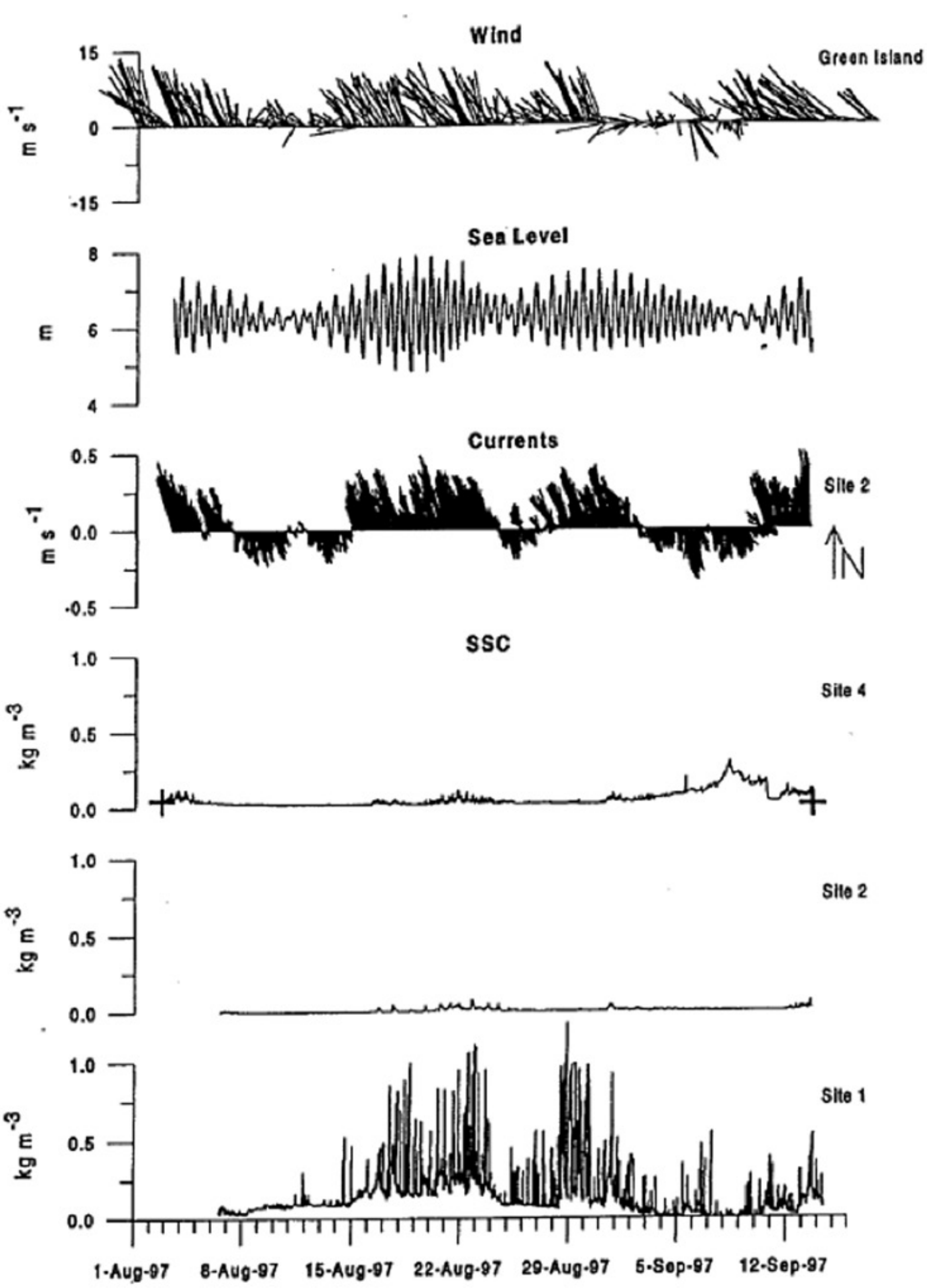


Figure B5-8 Wind, current and turbidity measurements near Northern Beaches.

Source: Wolanski and Spagnol (2000).

Palm Cove Beach (Site 1) **Trinity Inlet (Site 4)**

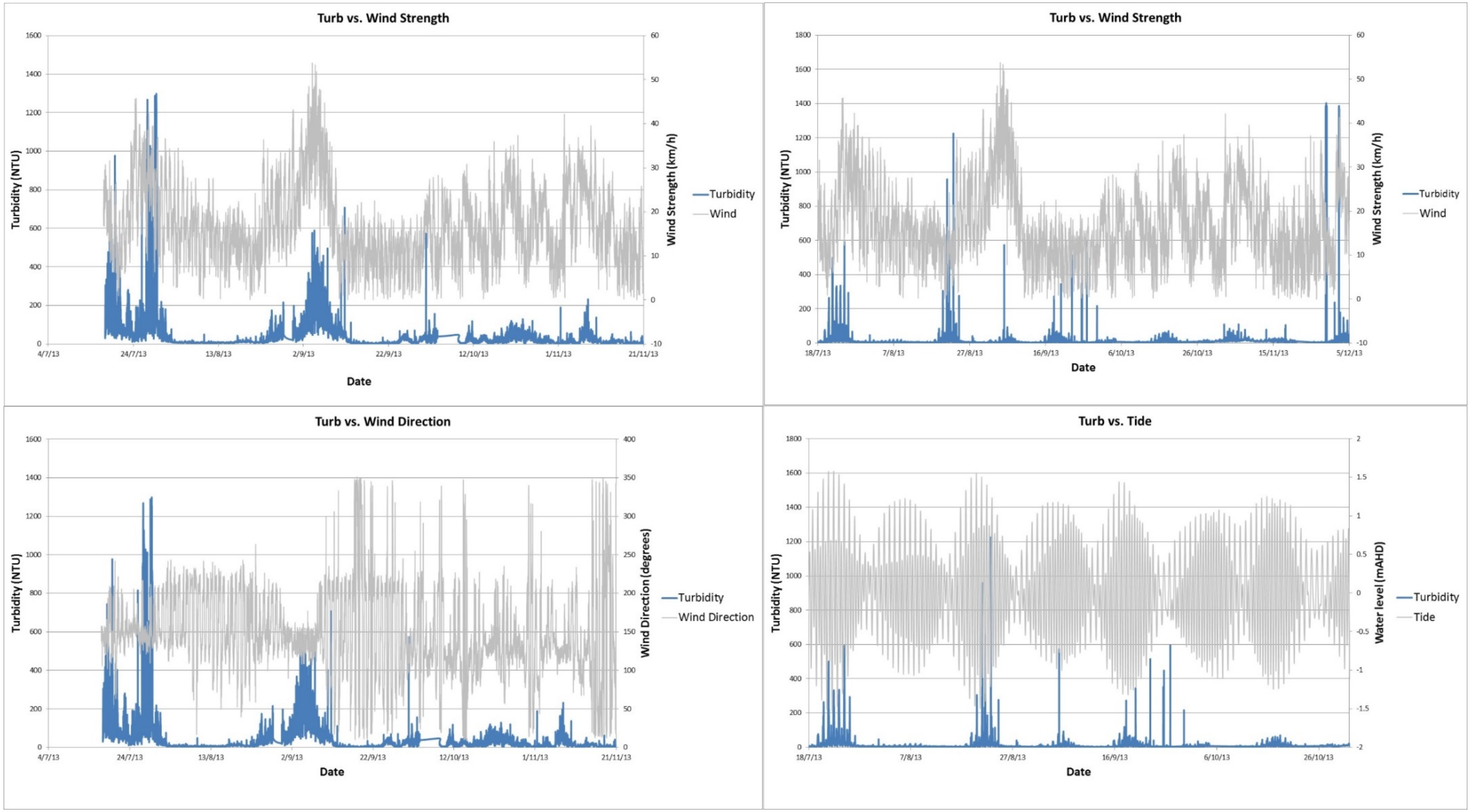


Figure B5-9 Turbidity at Northern Beaches (left column) and Trinity Inlet (right column) from Cairns EIS Water Quality Monitoring Program – correlated with wind and tidal data.

B5.2.8.b Previous Studies

Barron and Haynes (2009) have estimated background TSS concentrations at 4.09 mg/L within 6 km of the shore and 1.43 mg/L from 6-24 km.

Davis *et al. (*1998) conducted wet season (November 1994 to December 1994) sampling at three locations near the entrance of Trinity Inlet and one at the DMPA. Their findings demonstrated high TSS concentrations at:

- Marlin Jetty (Trinity Inlet) – 35 mg/L with spikes of up to 1,200 mg/L associated with tidal currents (spring). Neaps tide currents generated lower increase of approximately 50mg/L.
- Mud flats adjacent to the entrance of Trinity Inlet – very high TSS concentrations throughout the monitoring period from 800 mg/L to greater than 2,500 mg/L.
- Shipping channel at the entrance – generally very high background concentrations (350-400 mg/L). It is suspected that these measurements reflect a mobilised mud layer near the sea bed at this location.
- Offshore maintenance dredging DMPA – high background TSS at approximately 400 mg/L. The peak TSS concentrations usually coincided with periods occurring after the fastest current (at the DMPA) were observed rather than at the same time.

Connell Wagner (1991) concluded that north-easterly winds (summer) tended to produce the highest turbidity within Trinity Inlet, with concentrations of 70 NTU. East and south-easterly winds were observed to generate lower turbidity of 30 to 40 NTU (Connell Wagner 1991). GHD (2000) found that turbidity within Trinity Inlet was influenced by catchment and urban stormwater, but also from re-suspension of material in Trinity Bay and transported during flood tides.

More regional studies have indicated lower inshore ambient TSS concentrations at 1.2 to 1.7 mg/L (Furnas *et al.* 2011). These concentrations were not associated with cyclonic riverine floods which were typically significantly higher (Furnas *et al.* 2011).

B5.2.8.c Turbidity

The primary sources of turbidity data used in the characterisation of baseline conditions are from the Project specific Coastal Data Collection and the Water Quality Monitoring Program. Turbidity data for both sources of data are summarised in **Figure B5-10**. **Figure B5-11** presents turbidity data collected as part of the Ports North monitoring program. These data were collected from 2001 to 2013 at locations within Trinity Inlet only. **Table B5-4** shows the regional statistical information for turbidity divided into seasons for the Coastal Data Collection and Water Quality Monitoring Program. **Table B5-5** shows the same statistical measures for the Ports North monitoring program.

The baseline turbidity data collected as part of the 12-month Coastal Data Collection and Water Quality Monitoring Program was used to develop threshold values for impact assessment (as well as trigger values for the Dredge Management Plan). Further information on how this data was analysed and used for impact assessment is included in Appendix AJ (Marine Water Quality Impact Assessment).

General analysis of the data indicates the following observations:

- The Coastal Data Collection and Water Quality Monitoring programs showed there was no significant difference between wet season and dry season turbidity values. Some areas, such as Trinity Inlet, False Cape and Cape Grafton had higher turbidity during the wet season. This is likely due to these areas being more sheltered from predominant south-east winds and therefore more influenced by freshwater flows. Other areas, such as Yorkeys Knob and Palm Cove Beach (Region 5), had higher turbidity during the dry season as these areas are more exposed to sustained south-easterly winds during the winter.
- During the wet and dry seasons, turbidity levels generally increased from the Trinity Inlet out to near shore areas (False Cape, Cape Grafton and Northern Beaches). Turbidity was relatively low (<10 NTU) at offshore areas (region 4) during both seasons. The highest median turbidity was at False Cape during the wet season.
- All monitoring locations demonstrated median turbidity levels in excess of the WQO for both seasons,

with the exception of Trinity Inlet (Region 1b) during the dry season

- The Ports North turbidity data show similar turbidity levels to those observed in the Coastal Data Collection and Water Quality Monitoring programs.

Turbidity in the Barron River and Thomatis / Richters Creek is discussed in **Section B5.2.17**.

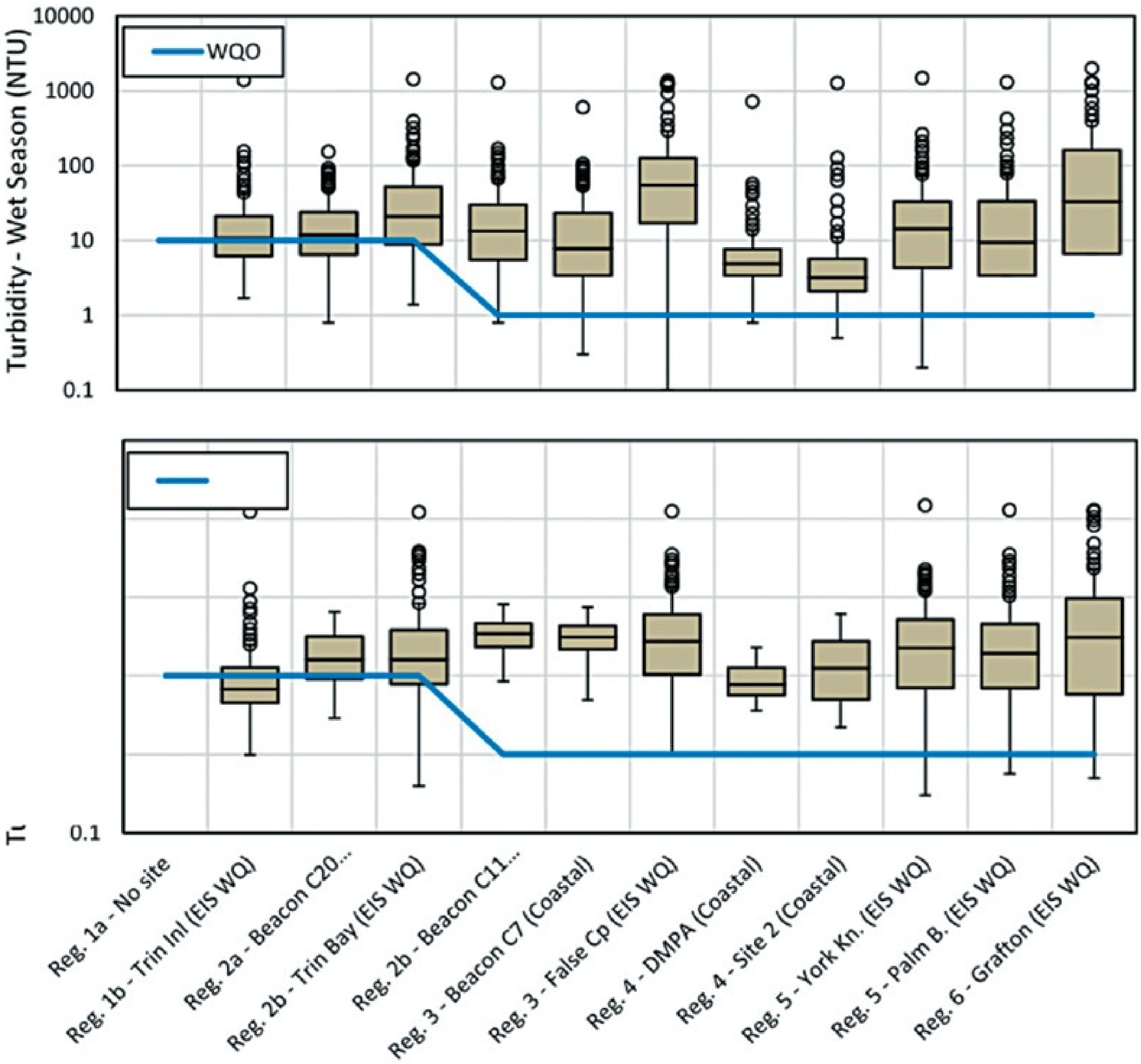


Figure B5-10 Coastal Data Collection WQ Data (2013-2014) and WQ Monitoring Program (2013-2014) turbidity box and whiskers, wet season (top) and dry season (bottom).

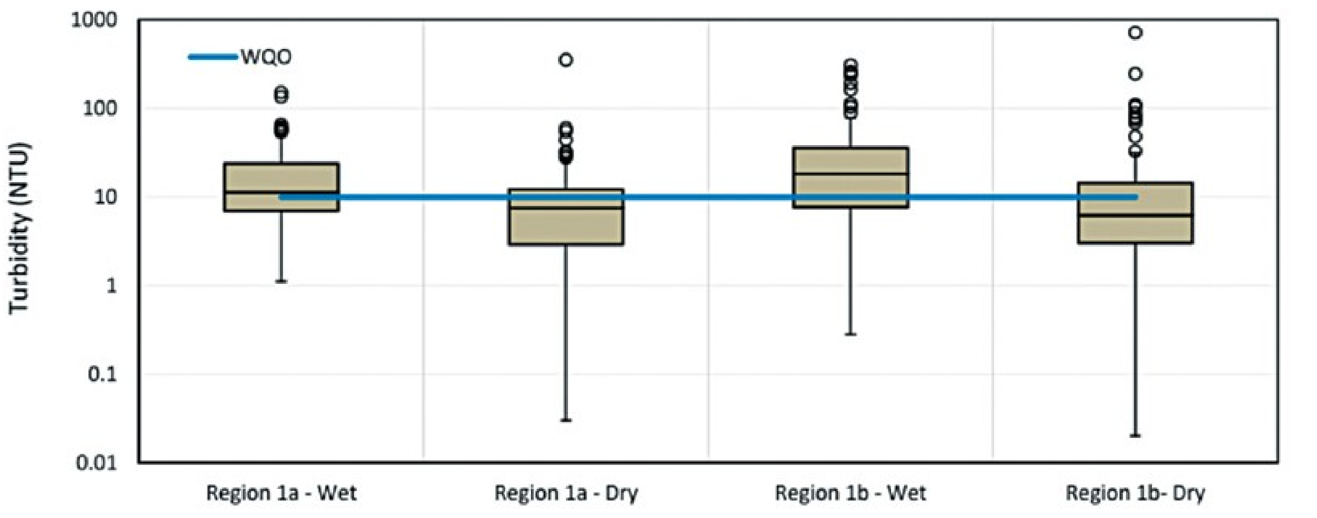


Figure B5-11 Cairns Port Authority WQ Data (2001-2013) turbidity box and whisker.

TABLE B5-4 COASTAL DATA COLLECTION WQ DATA (2013-2014) AND WQ MONITORING PROGRAM (2013-2014) TURBIDITY (NTU) STATISTICS

Season	Region	*n*	Mean	Min	Percentile 20th	50th	80th	95th	Max
Wet	***WQO***					***10***			
	1a	--	--	--	--	--	--	--	--
	1b	23300	23	2	6	*11*	27	74	1387
	2a	5115	19	1	6	*12*	30	59	153
	WQO					***1***			
	2b	33476	41	1	7	*21*	60	124	1423
	3	21296	144	0	11	*55*	161	815	1355
	4	35770	9	1	2	*3*	7	31	1264
	5	33471	31	0	3	*9*	40	96	1305
	6	33478	189	0	4	*33*	277	1212	1984
Dry	***WQO***					***10***			
	1a	--	--	--	--	--	--	--	--
	1b	21804	15	1	4	7	15	50	1284
	2a	27041	26	0	6	*12*	32	93	298
	WQO					***1***			
	2b	36281	42	0	7	*16*	48	199	1390
	3	32840	56	1	8	*28*	72	173	1332
	4	52488	14	1	3	*6*	19	45	1286
	5	19848	40	1	6	*19*	54	138	1282
	6	19848	100	0	4	*31*	123	390	1971

Italicized values highlighted in red represent exceedances of the WQO; applied to the median only.

TABLE B5-5 PORTS NORTH (2001-2013) TURBIDITY (NTU) STATISTICS

Season	Region	*n*	Mean	Min	Percentile				Max
					20th	50th	80th	95th	
Wet	***WQO***					***10***			
	1a	96	19	1	6	*11*	30	57	150
	1b	806	31	0	6	*18*	41	88	306
Dry	***WQO***					***10***			
	1a	86	14	0	2	7	13	32	350
	1b	684	16	0	3	6	17	75	712

Italicized values highlighted in red represent exceedances of the WQO; applied to the median, only.

B5.2.8.d Total Suspended Sediments (TSS)

TSS was monitored during the Coastal Data Collection events, for both wet and dry seasons. This data formed the primary basis of characterisation for TSS where applicable[1].

Gaps in these data include region 1a (mid-estuary in Trinity Inlet) and regions 5 and 6. To supplement these data, the CPA monitoring program sampled for TSS between 1995 and 1997 within Trinity Inlet and Trinity Bay to the end of the channel. Additionally, the Water Quality Monitoring Program included TSS sampling which has also been summarised here.

Figure B5-12 presents the Coastal Data Collection TSS concentrations for each region, and **Figure B5-13** presents the CPA TSS concentrations. Statistical summaries of each data source are provided in **Table B5-6** for the Coastal Data Collection and **Table B5-6** for the CPA data. Again it is noted that the WQOs in these figures does not extend to all regions because the WQO is not a static numerical value for those regions.

Table B5-7 presents the RRRC data for the regions for which data were sampled in the wet seasonal. Data coverage for TSS data extends from 1996 to 1999 only. Finally, **Table B5-8** presents the Water Quality Monitoring Program TSS grab samples.

On a regional level, Devlin *et al.* (2012) have mapped flood plume area within the GBR region based on load contributions and frequency of flooding using physical measurements and satellite imagery. This mapping and analysis are based on 10 years of flooding data. This analysis produced three types of areas of plumes:

- Primary plume waters – characterised by high TSS concentrations
- Secondary plume waters – characterised by high phytoplankton production
- Tertiary plume waters – characterised by elevated dissolved and detrital matter.

The spatial distribution of these areas relative to the frequency of these plume water types has been assessed by Devlin *et al.* (2012) for Trinity Inlet and Trinity Bay. These plumes are shown in **Figure B5-14**. Note the high frequency of primary plume waters within inner Trinity Inlet dissipates to low frequency approximately at the end of the shipping channel, prior to the DMPA.

Within the Wet Tropics, the estimated mean TSS concentration was 23.3 mg/L for primary areas, 15.0 mg/L in secondary areas, and 8.3 mg/L in tertiary areas (Devlin *et al.* 2012).

General analysis of the data indicates the following observations:

- The wet and dry season data for the Coastal Data Collection demonstrated a similar pattern of high median TSS concentrations in Trinity Inlet and decreasing with increasing distance from the entrance of Trinity Inlet. TSS concentrations for each region demonstrated similar ranges between wet and dry seasons.
- Region 4 (offshore area) was the only area that demonstrated compliance with the TSS WQO from the Coastal Data Collection (the WQO for Trinity Inlet and Inner Trinity Bay is not shown as it is specified in

[1] TSS samples were collected for both wet and dry conditions over two or three days during each monitoring

terms of increases in TSS over background levels).

- Similar to the Coastal Data Collection, the CPA data demonstrated high TSS in Trinity Inlet in the wet season (25- 35 mg/L), however, median dry season TSS concentrations were less than 10 mg/L. Within Trinity Bay, median TSS values increased farther away from the Trinity Inlet entrance. In contrast to the trend demonstrated by the Coastal Data Collection, typical CPA TSS concentrations were higher in the outer bay for both seasons.
- The CPA TSS samples extended three full years, and likely demonstrated typical seasonal variation in TSS geographically, inclusive of catchment and wind influences.
- Median CPA TSS concentrations within the Bay are typically greater than the WQO for open coastal waters, though only slightly so for some regions.
- Median RRRC TSS concentrations are within the ranges similar to the other studies.

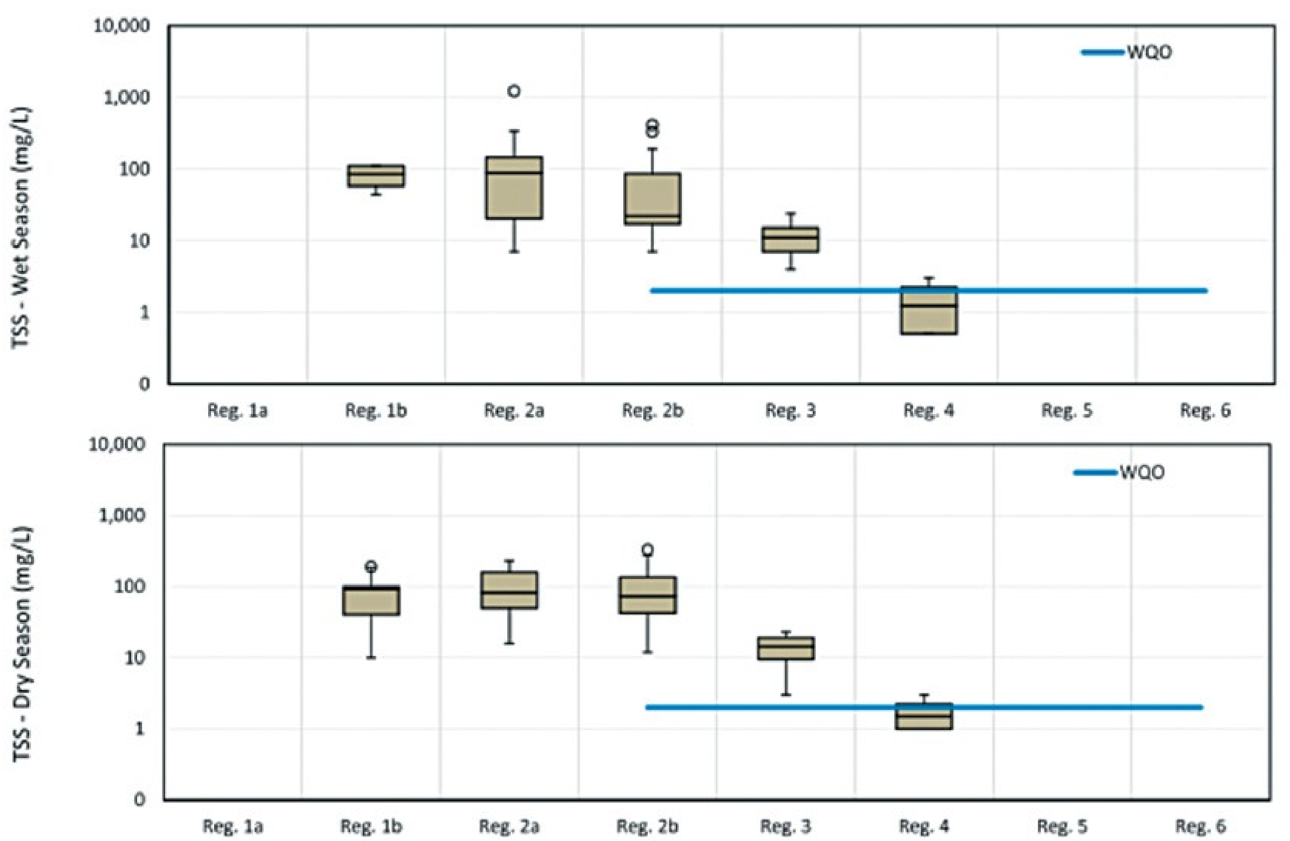


Figure B5-12 Coastal Data Collection WQ Data (2013) TSS box and whiskers, wet season (top) and dry season (bottom).

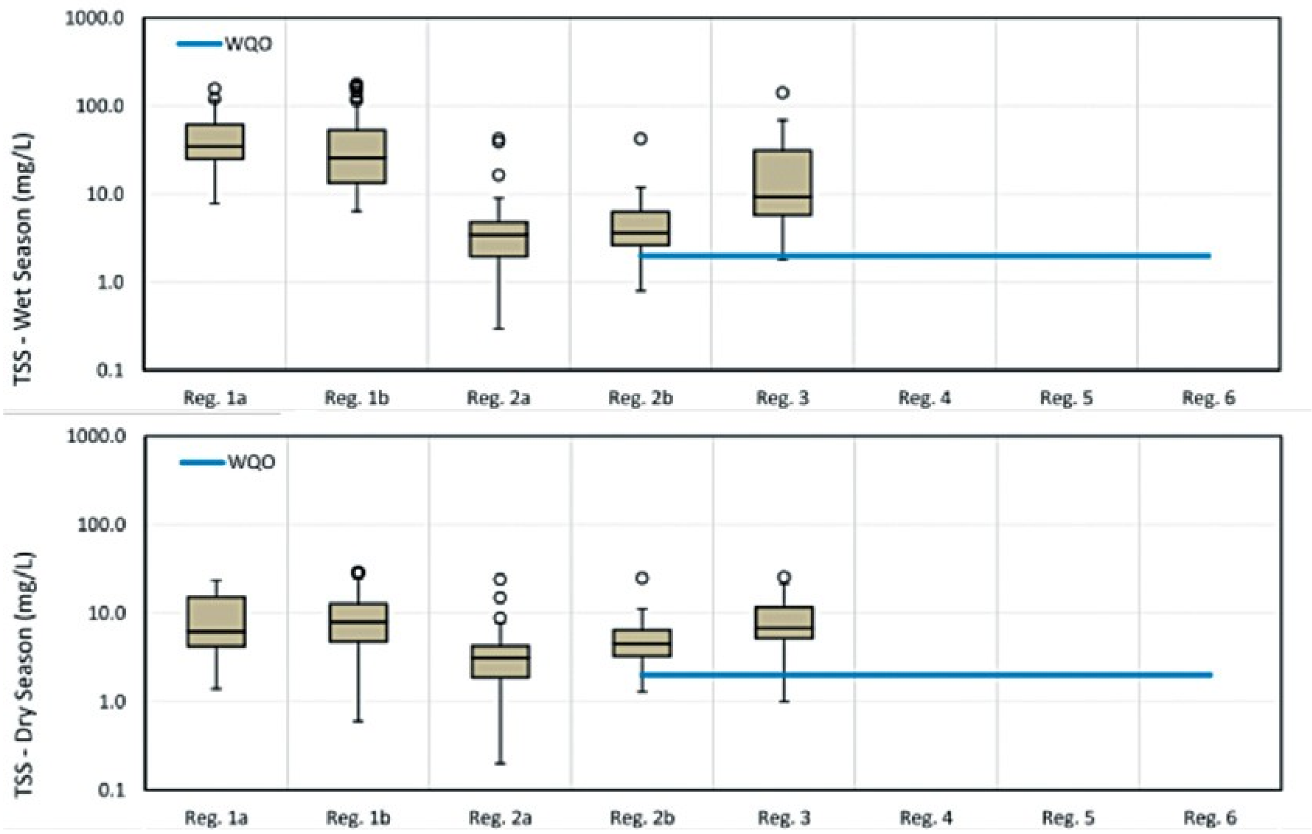


Figure B5-13 Cairns Port Authority WQ Data (1995-1997) TSS box and whiskers.

TABLE B5-6 COASTAL DATA COLLECTION WQ DATA (2013) TSS (MG/L) STATISTICS

Season	Region	*n*	Mean	Min	Percentile 20th	Percentile 50th	Percentile 80th	Percentile 95th	Max
Wet	***WQO***					***na***			
	1a	--	--	--	--	--	--	--	--
	1b	8	82	44	54	86	110	110	110
	2a	10	192	7	12	89	160	747	1220
	WQO					***2***			
	2b	18	707	7	16	*24*	112	2058	11400
	3	7	12	4	6	*11*	17	22	24
	4	4	2	1	1	1	2	3	3
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
Dry	***WQO***					***na***			
	1a	--	--	--	--	--	--	--	--
	1b	10	83	10	24	94	102	154	190
	2a	7	107	16	33	83	190	224	230
	WQO					***2***			
	2b	15	94	12	36	*74*	140	197	330
	3	10	14	3	8	*15*	19	22	23
	4	4	2	1	1	2	2	3	3
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

Italicized values highlighted in red represent exceedances of the WQO; applied to the median, only.

TABLE B5-7 COASTAL DATA COLLECTION WQ DATA (2013) TSS (MG/L) STATISTICS

Season	Region	*n*	Mean	Min	Percentile 20th	50th	80th	95th	Max
Wet	***WQO***					***na***			
	1a	25	51	8	22	35	73	118	158
	1b	91	41	6	11	26	65	135	178
	2a	20	7	0	2	3	5	39	42
	WQO					***2***			
	2b	10	8	1	2	*4*	7	26	42
	3	30	22	2	6	*9*	36	58	141
	4	--	--	--	--	--	--	--	--
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--
Dry	***WQO***					*na*			
	1a	39	9	1	4	6	16	19	23
	1b	103	9	1	4	8	13	19	29
	2a	24	4	0	2	3	5	14	24
	WQO					***2***			
	2b	12	6	1	3	*5*	7	15	25
	3	36	9	1	4	*7*	13	19	26
	4	--	--	--	--	--	--	--	--
	5	--	--	--	--	--	--	--	--
	6	--	--	--	--	--	--	--	--

Italicized values highlighted in red represent exceedances of the WQO; applied to the median, only.

TABLE B5-8 RRRC DATA (1995-2013) TSS (MG/L) STATISTICS

Season	Region	Count	Mean	Min	Percentile 20th	50th	80th	95th	Max
WET	***WQO***					***na***			
	1a	--	--	--	--	--	--	--	--
	1b	3	34	20	--	30	--	--	53
	2a	1	31	--	--	--	--	--	--
	WQO					***2***			
	2b	1	24	--	--	--	--	--	--
	3	21	15	2	9	*13*	16	43	46
	4	10	4	1	2	*3*	6	9	11
	5	6	11	2	2	*11*	13	22	25
	6	1	10	--	--	--	--	--	--

Italicized values highlighted in red represent exceedances of the WQO; applied to the median, only.

TABLE B5-9 WATER QUALITY MONITORING PROGRAM (2013) TSS (MG/L) STATISTICS

Season	Region	TSS Upper	TSS Lower
	WQO	***na***	
Dry	1a	--	--
	1b	<2	2
	2a	--	--
	WQO	***2***	
	2b	*4*	*4*
	3	*26*	*40*
	4	--	--
	5 (Palm Beach)	<2	*4*
	5 (Yorkeys Knob)	*6*	*31*
	6	*14*	*35*

Italicized values highlighted in red represent exceedances of the WQO.

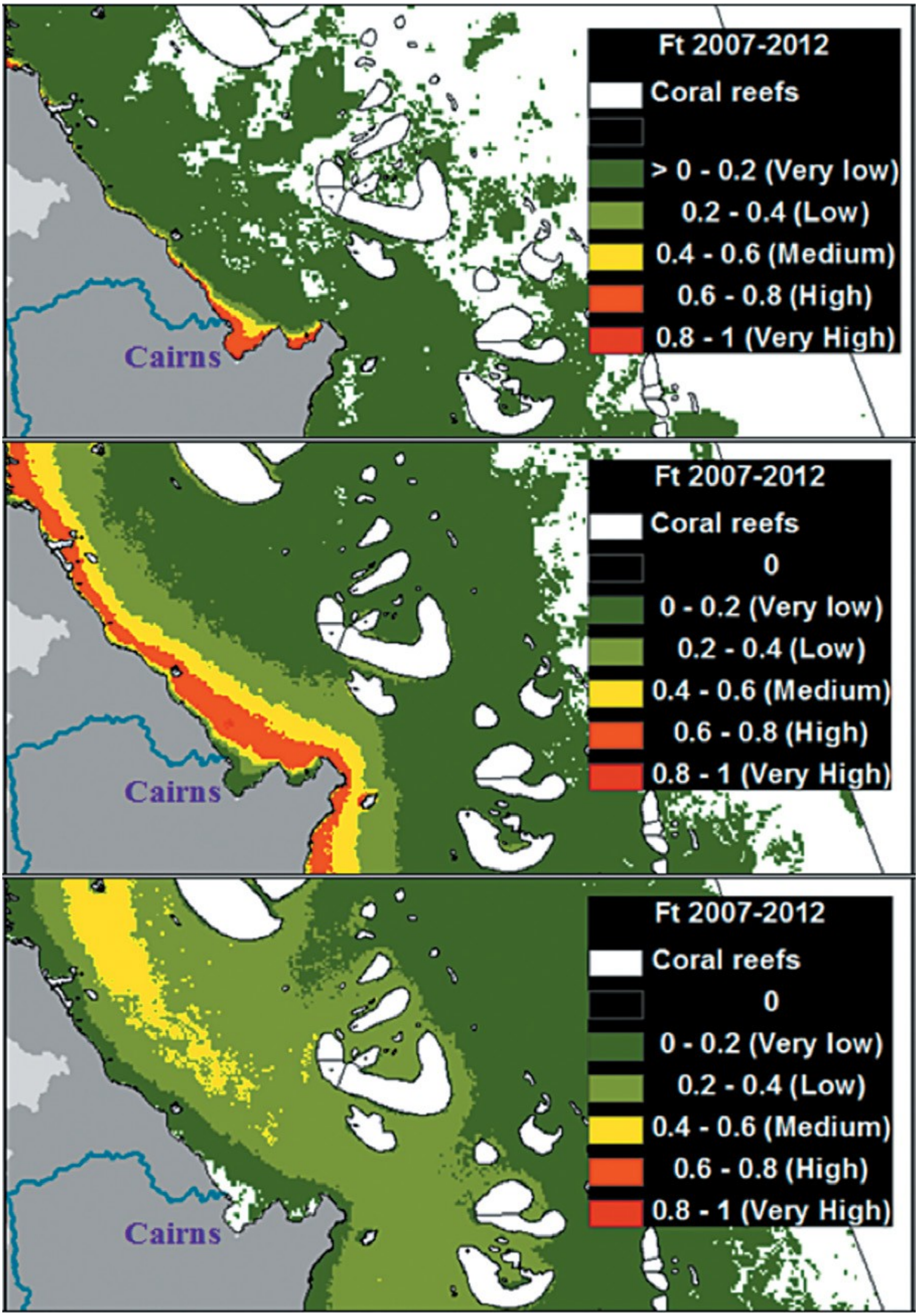


Figure B5-14 Flood plume type and frequency: primary (top), secondary (middle) and tertiary (bottom).

Source: Devlin *et al.* (2012).

B5.2.8.e Turbidity TSS Correlation

TSS is an important parameter of concern with regard to water quality as it is what is typically measured and monitored to determine compliance with water quality objectives.

Turbidity, however, is the general parameter often used as a surrogate for TSS because it is easier and more cost-efficient to monitor. Therefore, there is the need to establish a relationship between turbidity and TSS such that the conversion of turbidity data to TSS concentrations can be made without the need to monitor for TSS.

Previously, Connell Wagner (1991) had undertaken this task for Trinity Inlet and Trinity Bay and surrounds in their Dredge and Dump Monitoring Report (Connell Wagner 1991). That study determined a relationship of 1.5 mg/L of TSS per 1 NTU of turbidity.

The Coastal Data Collection TSS data collection was conducted in concert with the collection of transect data for currents, waves, conductivity, temperature and turbidity. TSS samples were collected at the same time, location and depth as the turbidity measurements, allowing for the correlation between TSS and turbidity for nearly identical parcels water. **Figure B5-15** shows the linear correlation between TSS and turbidity for the study area. This relationship is based on the analysis of TSS in 84 water samples collected with synchronised turbidity (NTU) measurements over numerous campaigns in 2011 and 2013 (including both dredging and non-dredging periods). The relationship established using this method is 1.71 mg/L of TSS per 1 NTU of turbidity. The derivation of this relationship is further described in **Chapter B3** (Coastal Processes).

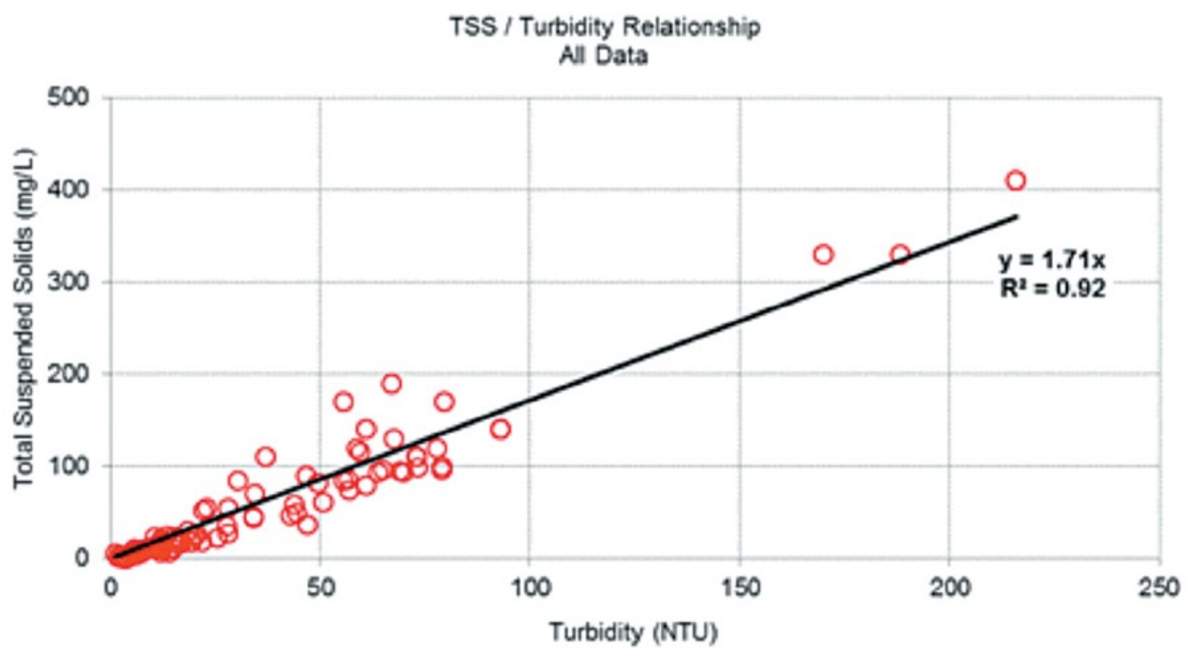


Figure B5-15 TSS – Turbidity correlation.

B5.2.9 Deep Water Profiling

Deep water profiling was undertaken during each servicing trip throughout the 12-month Water Quality Monitoring Program. These profiling sites, generally located between the DMPA and offshore reef areas, are shown on **Figure B5-1.** The aim of including these deep water profiling sites was to provide further information in terms of the baseline offshore water quality.

The deep water profiling involved using a water quality instrument to log readings of turbidity, pH and dissolved oxygen (DO) through the water column from surface to seabed. A summary of this data is presented in **Table B5-10**.

TABLE B5-10 SUMMARY OF DEEP WATER (OFFSHORE) PROFILING DATA

Deep Water Profiling Site	Water Depth	Average Turbidity (NTU)	Average pH	Average DO (% sat)
Deep 1	Surface (0.3m)	0.3	8.2	100.0
	Middle (~10m)	0.3	8.2	99.1
	Bottom (~18m)	0.9	8.2	98.5
Deep 2	Surface (0.3m)	1.6	8.2	99.5
	Middle (~10m)	1.0	8.2	99.3
	Bottom (~24m)	0.4	8.2	98.5
Deep 3	Surface (0.3m)	0.6	8.2	98.8
	Middle (~10m)	0.2	8.2	99.3
	Bottom (~25m)	0.7	8.2	97.9
Deep 4	Surface (0.3m)	0.5	8.2	99.1
	Middle (~10m)	0.3	8.2	99.0
	Bottom (~25m)	1.1	8.2	97.0
Average		**0.7**	**8.2**	**98.8**

B5.2.10 Photosynthetically Active Radiation (PAR)

Photosynthetically active radiation (PAR) is a measure of the amount of light available for photosynthetic processes of the benthic marine community (e.g. seagrasses). PAR reaching the sea floor is impacted by the water depth and the amount of suspended material in the water column that leads to light attenuation. Previous studies of light within Trinity Inlet determined that light attenuation increased farther up in the estuary, and hence a decrease in PAR (Dennison and O'Donohue 1994). The greatest attenuation of light (decrease of PAR) occurred within the smaller tributaries within the estuary. This typically corresponded to higher chlorophyll-a concentrations and productivity rates (Dennison and O'Donohue 1994). The amount of PAR that reaches the sea floor is also directly affected by water depth as the total amount of light that arrives at the water surface is attenuated as it passes through the water column.

James Cook University (JCU) conducted 12 months of benthic PAR monitoring (2013-2014) (Jarvis et al. 2014) at selected locations to form a baseline of light regime in areas of current or previous seagrass areas. This is the first time that JCU has collected PAR data in the Cairns area, and the use of this baseline data to derive local seagrass tolerance limits is still under development.

The JCU PAR locations are shown on **Figure B5-1**, and include three intertidal PAR monitoring sites and three subtidal monitoring sites.

B5.2.10.a PAR and Turbidity

Two of the JCU subtidal PAR monitoring sites also had turbidity loggers recording measurements at the same locations. These two sites, and associated monitoring period, are as follows:

- Existing offshore DMPA – monitoring period February 2013 to January 2014
- Next to outer channel in Trinity Bay (Site 3) – monitoring period October 2013 to June 2014.

It should be noted that during the monitoring period, no seagrass was evident at either of the above subtidal monitoring sites (Jarvis *et al.* 2014). The main purpose of the two subtidal sites measuring PAR and turbidity was to investigate whether a relationship between PAR and turbidity could be observed from the data obtained.

The data from these two subtidal PAR monitoring sites was analysed to determine the total daily benthic PAR (mol/m^2/ day). At these sites, turbidity and depth was recorded as part of the Coastal Data Collection (existing offshore DMPA) and the Water Quality Monitoring Program (Site 3). Using this data, a preliminary light attenuation coefficient (Kd) was able to be calculated. This coefficient takes into account water depth and surface irradiance to provide an indication of attenuation of light per metre of water. This can then be correlated with turbidity data without these other variables (i.e. water depth and surface irradiance) affecting the relationship. Light attenuation (Kd) was calculated using the following formula derived from Anthony *et al.* (2004):

$$Kd = \ln\left(\frac{E(s)}{E(z)}\right)/z$$

In this equation, E(s) is the PAR at the water surface and E(z) is the PAR at a depth of z.

For this preliminary calculation, surface irradiance (PAR) data was sourced from the nearest Australian Institute of Marine Science (AIMS) marine weather monitoring station at Agincourt Reef approximately 100km north of Cairns. It is noted that this location is not ideal, and further PAR monitoring (benthic and surface) would need to be undertaken prior to commencement of dredging to further refine the light attenuation relationship.

Daily fluctuation in benthic PAR at the two subtidal sites was assessed by plotting the time series of total daily benthic PAR and the two-week running average for both sites. A two-week running average was chosen as recent studies in Gladstone for the key intertidal seagrass *Zostera muelleri* (capricorni) found that a two-week average of daily light was a critical time window to support seagrass growth (Chartrand *et al.* 2012). This data is presented on **Figure B5-16** and **Figure B5-17**, which also includes average daily benthic PAR for each site. These figures illustrate that while the average daily benthic PAR levels are low at both sites, benthic PAR fluctuates widely and at times seagrass at these sites could receive significantly greater light levels, especially during the growing season (July – December).

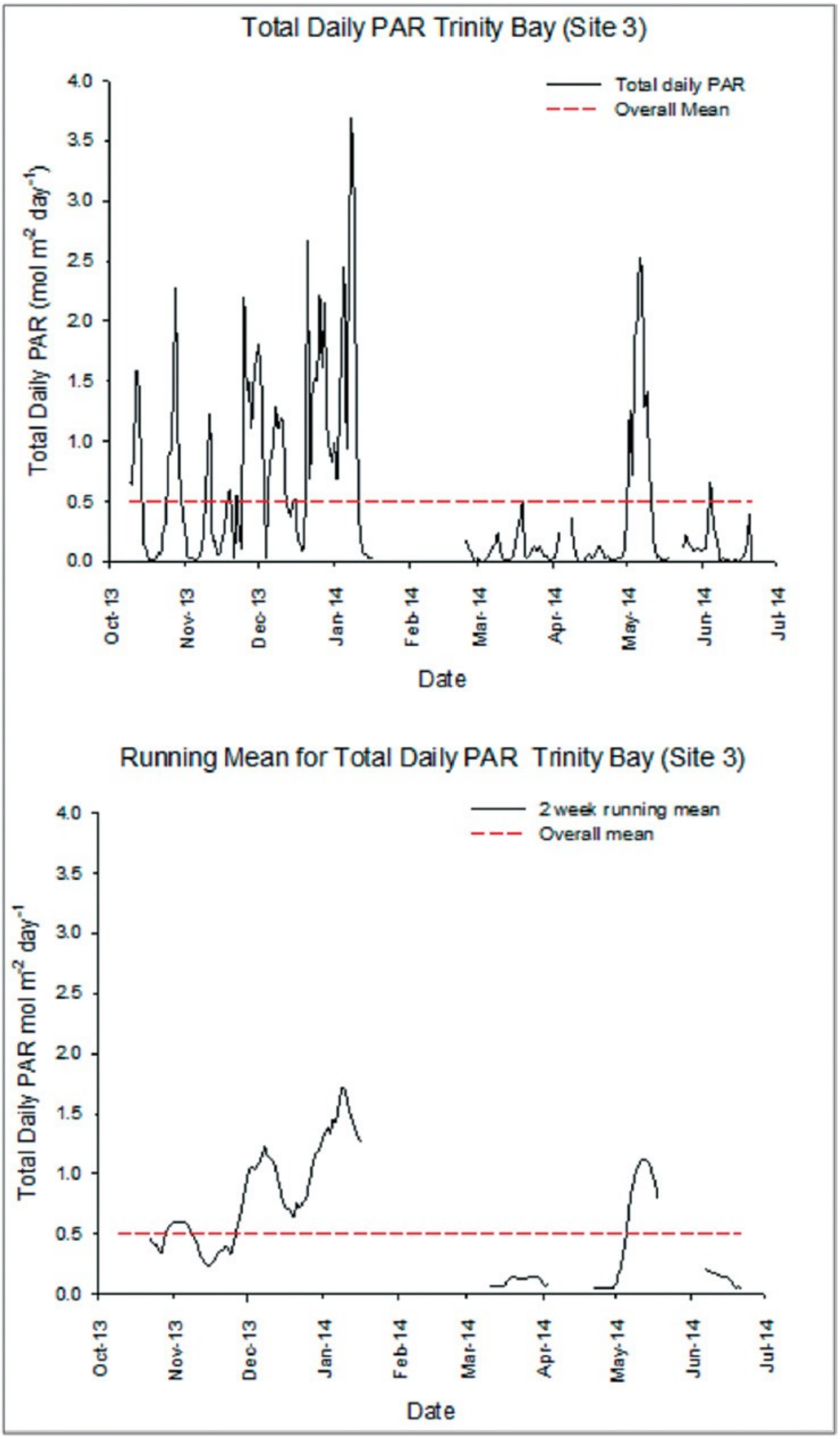


Figure B5-16 Total Daily PAR (top) and two week running mean of total daily PAR (bottom) for Site 3.

Source: Jarvis *et al.* (2014).

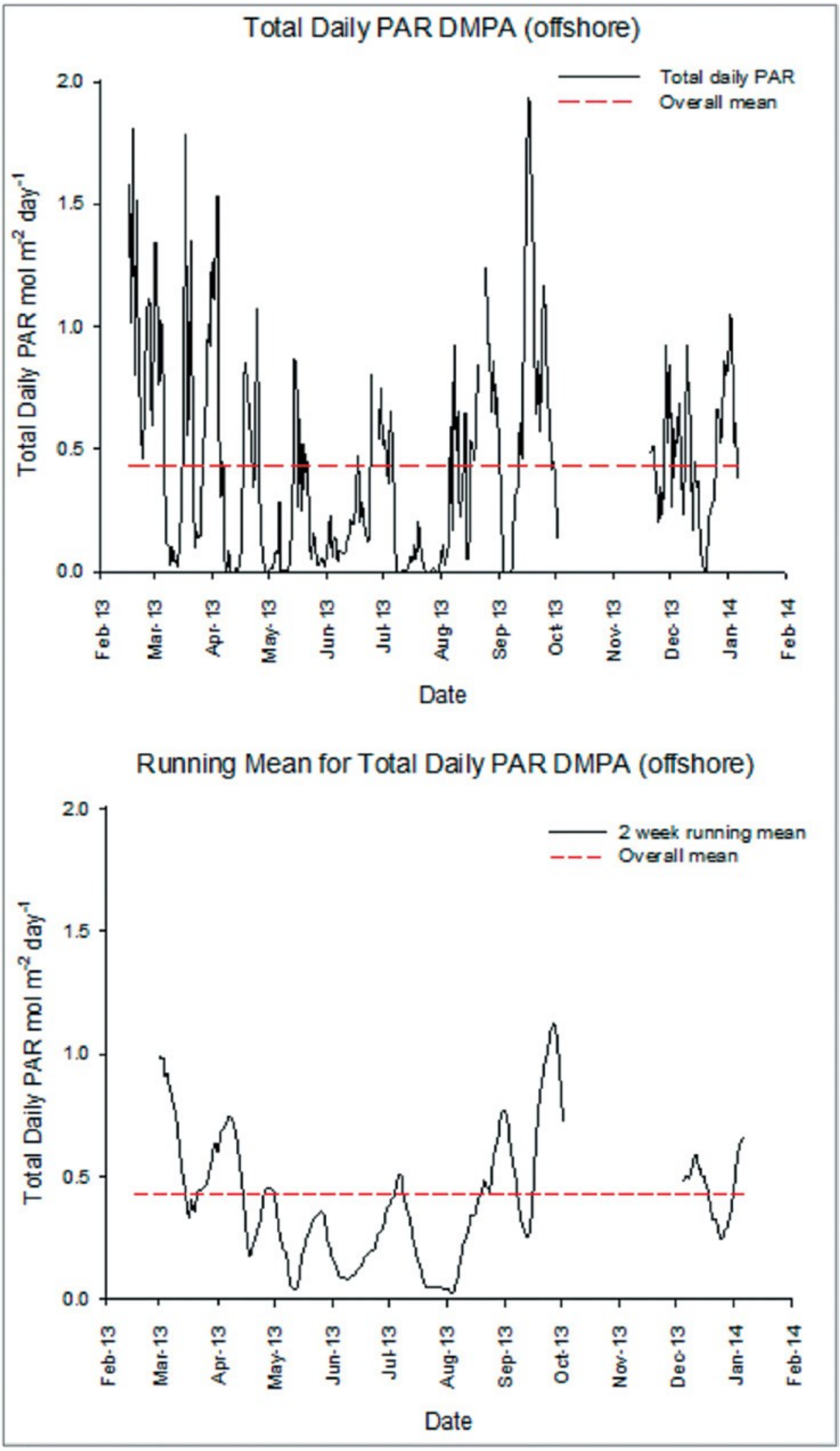


Figure B5-17 Total daily PAR (top) and two-week running mean of total daily PAR (bottom) for DMPA site.

Source: Jarvis *et al.* (2014).

The data indicates that average total daily PAR reaching the sea bed at the Trinity Bay site was 0.43 mol/m^2/day and the DMPA site was 0.50 mol/m2/day. **Figure B5-16** and **Figure B5-17** indicate that PAR levels ranged from 0.00 – 1.94 mol/m^2/day at the near shore site (Site 3) and from 0.00 – 3.69 mol/m2/day for the offshore site (DMPA). This is within the range of benthic PAR previously measured at Abbot Point in subtidal seagrass meadows dominated by *Halophila* (0.28 – 4.5 mol/m^2/day) (Jarvis *et al.* 2014). Jarvis *et al.* (2014) noted that this range of benthic PAR is well below the likely light requirements for *Zostera* (at least 4.5 mol/m^2/day) and *Halodule* (5.2 mol/m^2/day). **Figure B5-16** and **Figure B5-17** indicate that the two week rolling average of benthic PAR during the seagrass growing season (July- December) fluctuate greatly and may still be capable of maintaining *Halophila* meadows at certain times of the year which can survive in light with less than six percent surface irradiance (Udy and Levy 2002).

The average daily turbidity data was plotted against the total daily benthic PAR for each subtidal monitoring site (Figure B5-18). This figure shows that benthic PAR values peaked at about 4 mol/m^2/day at Trinity Bay (~4m water depth) and about 2.5 mol/m^2/day at the existing DMPA (~14m water depth). Figure B5-18 also shows that benthic PAR was generally extinguished when turbidity was approximately 100 NTU at Trinity Bay, and approximately 20 NTU at the existing DMPA. The difference in turbidity when light extinguishment occurs is related to the water depth at each site.

It is important to note that Figure B5-18 shows a relatively poor relationship between benthic PAR and turbidity data, with a low level of correlation (R2 of 0.2). Further turbidity and PAR monitoring prior to commencement of dredging could be used in an attempt to strengthen this relationship.

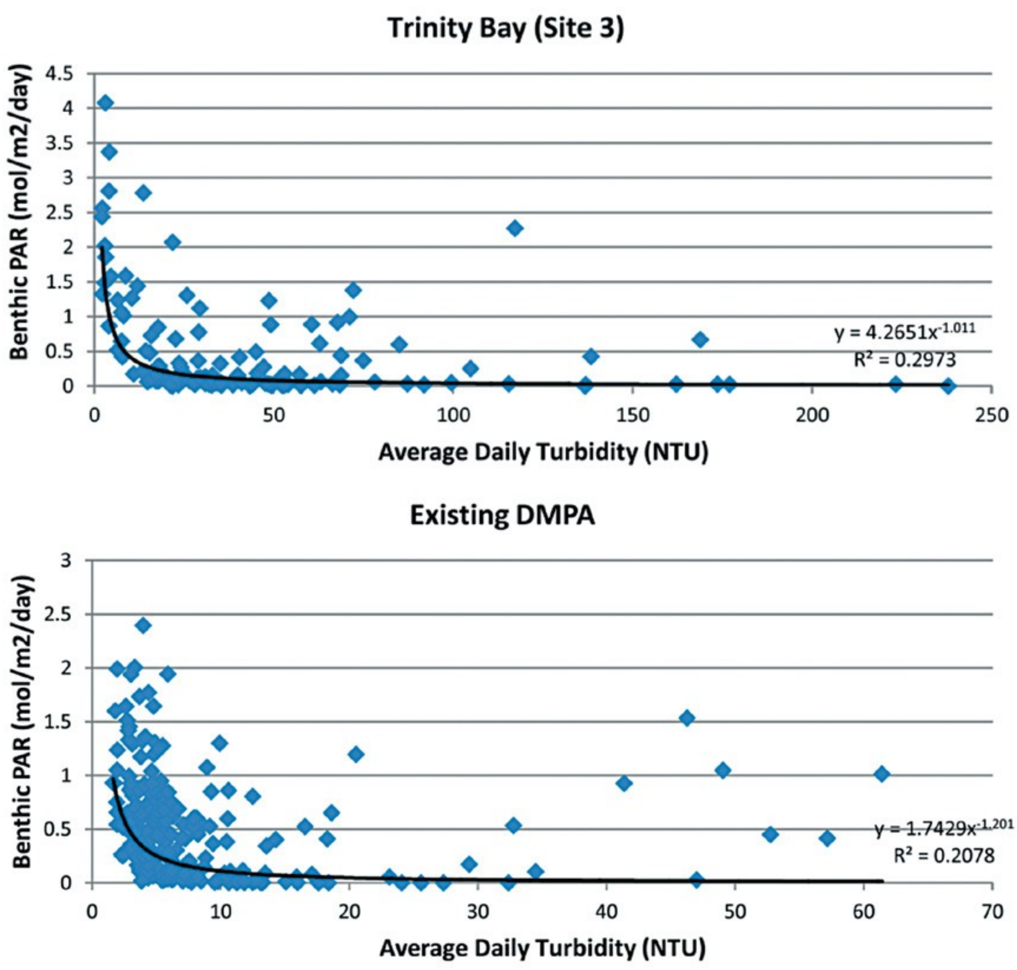


Figure B5-18 Benthic PAR (mol/m^2/day) and average daily turbidity (NTU) for Trinity Bay (top) and existing DMPA (bottom).

To further understand the relationship between turbidity and PAR, and to aid in a preliminary conversion of turbidity to PAR in any depth of water, light attenuation data (per metre of water) for each monitoring site were plotted against average daily turbidity (**Figure B5-19**). As shown on **Figure B5-19**, both sites show a general trend of increasing light attenuation with increasing turbidity. As mentioned previously, the correlation of light attenuation to turbidity data is relatively poor (R2 of 0.1 and 0.4), and could not be reliably used without further PAR monitoring and analysis. Nevertheless, this relatively poor correlation is used to undertake a preliminary conversion of turbidity to PAR to test impact assessment thresholds in Appendix AJ (Marine Water Quality Impact Assessment).

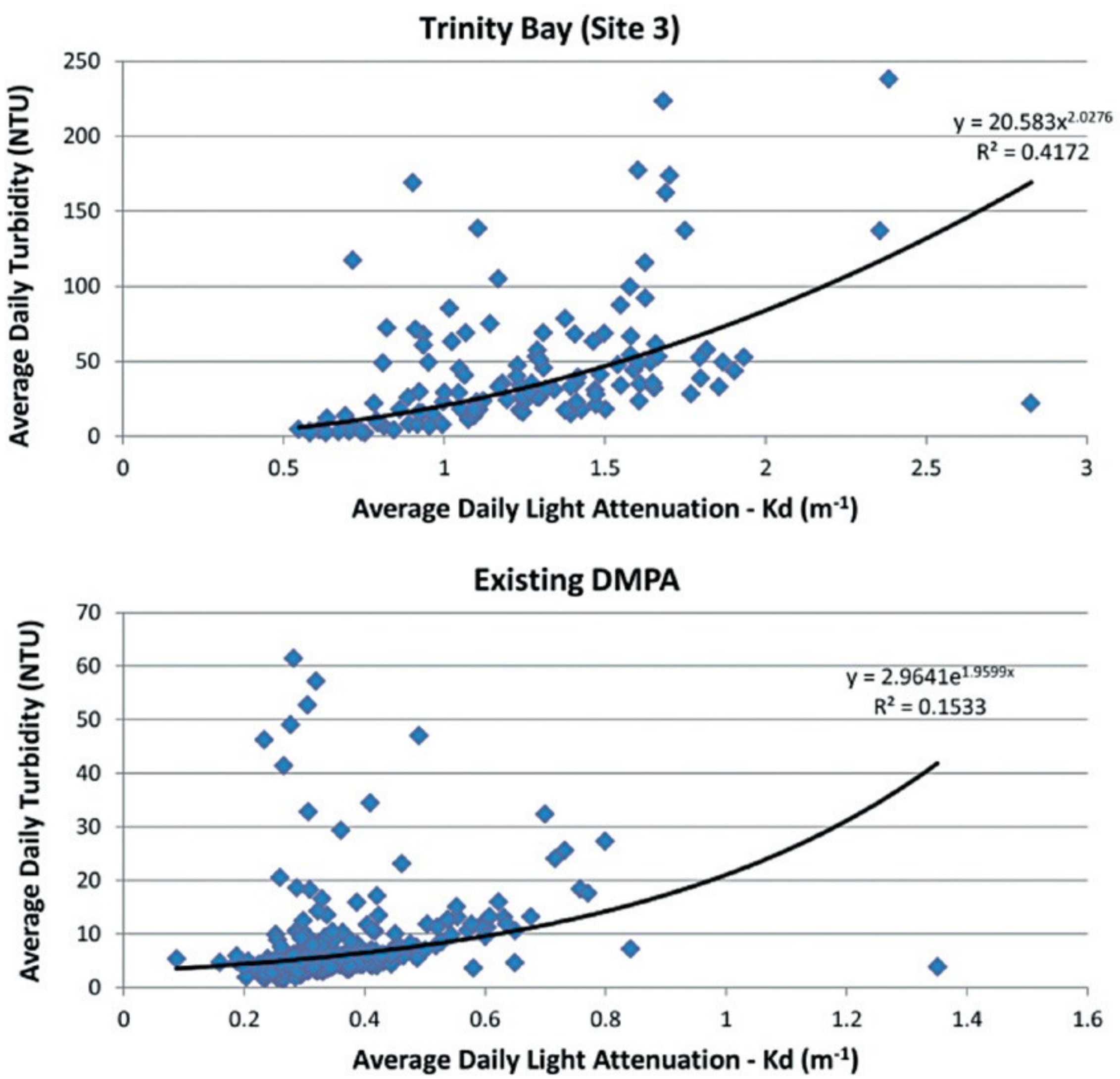


Figure B5-19 Turbidity and light attenuation (Kd) relationship at Trinity Bay (top) and existing DMPA (bottom).

B5.2.10.b Other PAR Monitoring Sites

JCU also monitored PAR at three intertidal sites (Sites A, B and C) and one other subtidal site (Site D) between April 2013 and December 2013 (refer to **Figure B5-1** for locations of these sites). The data collected from these four sites, sourced from Jarvis *et al.* (2014), is presented on Figure B5-20.

In regard to this PAR data, Jarvis *et al.* (2014) noted that light levels (mol/m^2/day) were consistently greater at site B on the intertidal bank at the southern end of the Esplanade and lowest for the subtidal site D at False Cape. Light levels were similar between the other two intertidal sites A and C. Light showed a limited seasonal effect with light decreasing slightly in the wet season (December-May) compared to the dry season (June-November) seasons. Site D near False Cape is a completely subtidal site so lower light levels are to be expected.

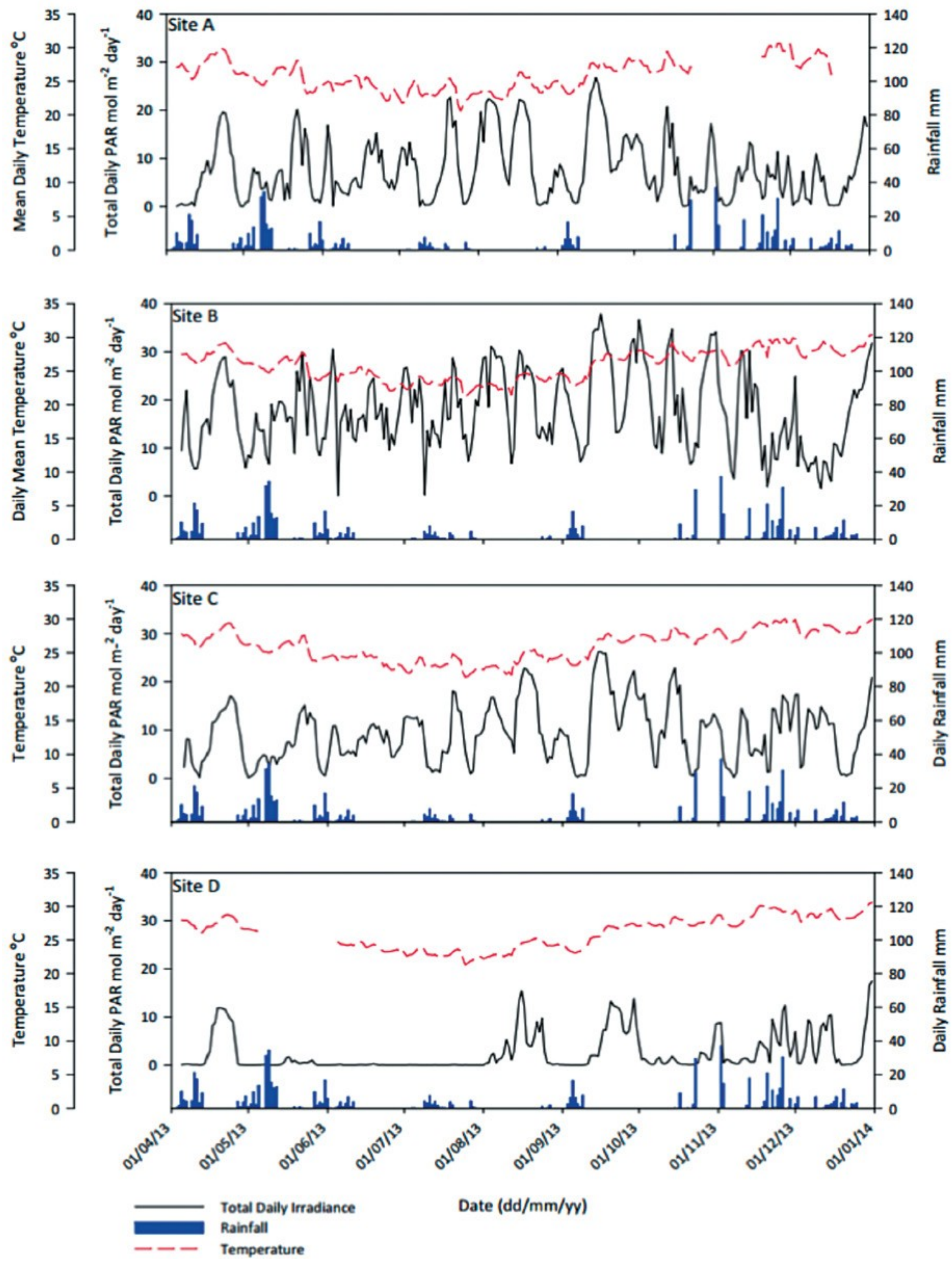


Figure B5-20 Total daily PAR (mol/m^2/day), mean daily temperature (° C), and total daily rainfall (mm) for JCU monitoring sites (April to December 2013).

Source: Jarvis *et al.* (2014).

B5.2.11 Metals/Metalloids

Monitoring of total metals/metalloids in the surface water, primarily within Trinity Inlet, is undertaken by Ports North as part of their routine monitoring campaign. The available monitoring data in Trinity Inlet (region 1) are summarised in Table B5-11 below, with the ANZECC/ARMCANZ (2000) Toxicity Trigger Value (TTV) provided for comparison purposes. It should be noted that the TTV is relevant to the dissolved fraction of metals, however, the Ports North data only includes total metals.

Grab samples of metals were collected during the Water Quality Monitoring campaign as part of opportunistic water quality monitoring at the locations where instruments were deployed. These metals samples included both dissolved and total concentrations. The samples were collected within the upper and lower portion of the water column.

The ANZECC/ARMCANZ (2000) guidelines state that for toxicants in water (such as metals/metalloids), the 95th percentile of monitoring data should be compared to the TTV. As such, **Table B5-12** and **Table B5-13** present the 95th percentile dissolved and total metals concentrations, respectively, at the monitoring locations.

The Ports North data indicate the 95th percentile cadmium, copper, chromium, zinc and tributyltin exceed the TTVs (as well as the 80th percentile values), however, it is noted these metals concentrations are given in total concentrations rather than the dissolved fractions.

Assessment of data from the Water Quality Monitoring Program indicates that 95th percentile aluminium, and copper concentrations exceeded the TTV for all monitoring locations. Two sites also had slight exceedances of zinc. Concentrations of metals/metalloids were relatively similar throughout the water column (i.e. upper and low samples were similar), indicating the water column is generally well mixed in the study area.

TABLE B5-11 PORTS NORTH (2001-2013) TOTAL METALS (µG/L) DATA STATISTICS

Region	Statistic	As	Cd	Cu	Cr	Pb	Zn	TBT [a]
		ANZECC TTV						
		50	0.7	1.3	4.4	4.4	15	6
Region 1a	Count	13	7	27	9	7	47	7
	LOR > TTV [b]	3	6	5	2	6	0	0
	No. > TTV [c]	0	2	13	4	0	7	0
	80th %-ile	10.6	*1.6*	*3.0*	*12.2*	1.0	4.8	2.5
	95th %-ile	15.2	*2.0*	*16.3*	*14.6*	1.0	*30.8*	2.5
Region 1b	Count	81	50	243	62	50	317	83
	LOR > TTV [b]	18	25	18	6	26	0	0
	No. > TTV [c]	3	16	125	22	0	32	19
	80th %-ile	17.0	*2.0*	*3.0*	*20.0*	1.0	4.0	*8.0*
	95th %-ile	20.0	*2.0*	*10.0*	*21.0*	1.0	*25.0*	*26.3*

Italicized values highlighted in red represent exceedances of the TTV

a Tributyltin, measured as nanograms of tin per millilitre of water

b Number of samples not detected above the LOR, with an LOR greater than the TTV. These values were omitted

c Number of samples detected above the TTV

TABLE B5-12 WATER QUALITY MONITORING PROGRAM (2013) – 95TH PERCENTILE DISSOLVED METALS (µG/L)

Region	Site	Depth	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Ag	Zn	Hg
			Limit of Reporting (LOR)											
			20	5	0.7	2	1	20	1	5	3	1	5	0.1
			ANZECC TTV											
			0.5	50	0.7	4.4	1.3	300	4.4	80	7	1.4	15	0.1
1b	Trinity Inlet	Upper	*27.35*	2.26	0.31	1.43	*3.93*	11.70	0.47	55.65	1.40	0.46	*16.55*	0.0003
		Lower	*15.40*	2.34	0.32	1.00	*3.20*	9.66	0.46	22.80	1.43	0.48	12.27	0.0005
2b	Trinity Bay	Upper	*33.15*	2.32	0.31	1.43	*3.33*	10.00	0.43	4.97	1.37	0.46	13.61	0.0001
		Lower	*33.60*	2.32	0.31	1.43	*2.99*	10.85	0.46	4.71	1.37	0.46	9.13	0.0001
3	False Cape	Upper	*36.45*	2.40	0.31	1.43	*2.81*	10.00	0.43	2.93	1.38	0.46	14.10	0.0001
		Lower	*34.05*	2.38	0.31	1.43	*6.05*	32.95	0.43	3.35	1.42	0.46	11.50	0.0001
5	Palm Beach	Upper	*32.95*	2.32	0.31	1.43	*2.55*	54.20	0.44	2.84	1.39	0.46	12.64	0.0001
		Lower	*30.85*	2.38	0.31	1.43	*2.30*	10.85	0.44	3.01	1.37	0.46	*18.30*	0.0001
5	Yorkey's Knob	Upper	*31.75*	2.32	0.31	1.43	*3.01*	10.00	0.43	3.65	1.37	0.46	10.31	0.0001
		Lower	*33.85*	2.32	0.31	1.43	*2.30*	10.00	0.45	2.76	1.37	0.46	13.55	0.0001
6	Cape Grafton	Upper	*37.55*	2.40	0.33	1.43	*3.07*	10.00	0.44	4.03	1.43	0.46	14.25	0.0001
		Lower	*36.40*	2.38	0.31	1.43	*1.84*	10.00	0.43	3.86	1.42	0.46	2.50	0.0001

Italicized values highlighted in red represent exceedances of the Toxicity Trigger Value (TTV).
Limit of Reporting (LOR) is the lowest level able to be detected by the laboratory.
Note: To analyse the data, values below the LOR were assumed to be half the LOR value as per ANZECC/ARMCANZ (2000). For some samples, the LOR was raised due to matrix interference, while for others the LOR was lowered on request to lab.

TABLE B5-13 WATER QUALITY MONITORING PROGRAM – 95TH PERCENTILE TOTAL METALS (µG/L)

Region	Site	Depth	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Ag	Zn	Hg
			Limit of Reporting (LOR)											
			20	5	0.7	2	1	20	1	5	3	1	5	0.1
1b	Trinity Inlet	Upper	773	2.29	0.31	1.43	9.94	632	0.72	62.15	1.44	0.46	17.55	0.0001
		Lower	149	2.38	0.32	1.00	10.14	135	1.64	25.80	1.47	0.48	16.85	0.0001
2b	Trinity Bay	Upper	211	2.44	0.31	1.43	3.68	235	0.53	37.65	1.46	0.46	15.98	0.0001
		Lower	299	2.59	0.31	1.43	4.02	320	0.49	31.15	1.46	0.46	17.80	0.0001
3	False Cape	Upper	177	2.47	0.31	1.43	3.01	156	0.46	11.25	1.42	0.46	34.93	0.0001
		Lower	833	2.47	0.31	2.61	4.26	685	1.52	37.80	1.49	0.46	19.50	0.0001
5	Palm Beach	Upper	150	2.43	0.31	1.43	3.98	146	0.50	7.30	1.41	0.46	15.40	0.0001
		Lower	176	2.44	0.31	1.43	3.39	165	2.64	8.13	1.42	0.46	15.25	0.0008
5	Yorkeys Knob	Upper	158	2.43	0.31	1.43	9.71	110	0.53	12.25	1.46	0.46	12.70	0.0001
		Lower	626	2.44	0.31	2.95	4.22	535	2.75	38.50	1.49	0.46	15.25	0.0001
6	Cape Grafton	Upper	955	2.43	0.31	3.29	6.01	788	1.20	52.65	1.43	0.46	15.07	0.0001
		Lower	386	2.44	0.31	3.12	2.43	365	1.48	18.80	1.44	0.46	16.44	0.0001

B5.2.12 Nutrients and Chlorophyll

Ports North routinely monitors Trinity Inlet for total nitrogen and phosphorus, ammonia and chlorophyll a. **Table B5-14** summarises the Ports North nutrient and chlorophyll statistical concentrations in the region for which data were collected (Region 1). Ammonia has both a scheduled water quality objective under the EPP (Water) 2009 and a Toxicity Trigger Value (TTV) under ANZECC/ARMCANZ (2000) guidelines. In **Table B5-14**, the ammonia TTV (0.46 mg/L) was not included, as even the maximum ammonia concentrations for the region did not exceed this value.

Grab samples of nutrients were collected during the Water Quality Monitoring campaign as part of opportunistic water quality monitoring at the locations where instruments were deployed. These samples included ammonia, nitrate and nitrite, and phosphates, as well as total nutrient concentrations. The samples were collected within the upper and lower portion of the water column, during both wet and dry seasons over spring and neap tides. **Table B5-15** presents the median nutrient concentrations for the sampled locations.

Nutrient data from Dennison and O'Donohue (1994) showed median ammonia concentrations (0.05mg/L) similar to the median ammonia concentrations of Ports North data (0.06 and 0.08 mg/L for both subregions in Region 1).

Median ammonia concentrations from the Water Quality Monitoring data were a lot lower than previously recorded, with median concentrations of 0.0015 mg/L. As a value of half the LOR was used in the analysis of this data, this median concentration represents a value of half the LOR (0.003 mg/L). All other nutrient data from the Water Quality Monitoring campaign were either at or below the WQOs.

Overall, the Ports North data show that Trinity Inlet has experienced high levels of phosphorus and ammonia in the past. Both nutrients demonstrate exceedances of the WQO. Higher nutrient concentrations are thought to be the result of intensive agricultural land use in the upstream catchments (Environment North 2005) and from sewage treatment plant discharge within the estuary (Worley Parsons 2010).

On a regional level, Devlin *et al.* (2012) estimate that 90 percent of the nutrients entering the GBR lagoon are from terrestrial sources associated with catchment runoff. Within the Wet Tropics these nutrients are generally from fertilised agriculture (Devlin *et al.* 2012).

TABLE B5-14 PORTS NORTH (2001-2013) NUTRIENT AND CHLOROPHYLL A DATA STATISTICS

Parameter	Region	*n*	Mean	Min	Percentile 20th	Percentile 50th	Percentile 80th	Percentile 95th	Max
Total Nitrogen (mg/L)	***WQO***					***0.25***			
	1a	47	0.25	0.05	0.13	0.19	0.27	0.49	1.50
	WQO					***0.25***			
	1b	95	0.24	0.05	0.10	0.16	0.25	0.50	4.60
Total Phosphorus (mg/L)	***WQO***					***0.02***			
	1a	32	0.06	0.01	0.03	*0.05*	0.07	0.13	0.18
	WQO					***0.02***			
	1b	54	0.19	0.01	0.02	*0.045*	0.08	0.20	7.2
Ammonia (mg/L)	***WQO***					***0.015***			
	1a	11	0.09	0.05	0.05	*0.06*	0.12	0.165	0.19
	WQO					***0.015***			
	1b	11	0.11	0.05	0.05	*0.08*	0.14	0.23	0.31
Chlorophyll *a* (µg/L)	***WQO***					***3***			
	1a	34	4.8	1	2	3	6	13.8	21
	WQO					***2***			
	1b	236	3.1	1	2	*3*	4	6	28

Italicized values highlighted in red represent exceedances of the WQO.

TABLE B5-15 WATER QUALITY MONITORING PROGRAM (2013) – MEDIAN (50%ILE) NUTRIENT (MG/L) CONCENTRATIONS

Region	Site	Depth	Ammonia	NOx	Total N	Ortho-P	Total P
			Limit of Reporting (LOR)				
			0.003	0.002	0.05	0.002	0.005
1b	Trinity Inlet	**WQO (*TTV*)**	**0.015 (*0.46*)**	**0.02[a] (*0.7*)**	**0.25**	**0.007**	**0.02**
		Upper	0.0015	0.001	0.15	0.001	0.016
		Lower	0.0015	0.002	0.14	0.002	0.016
2b	Trinity Bay	**WQO (*TTV*)**	**0.002 (*0.46*)**	**0.002[a] (*0.7*)**	**0.14**	**0.004**	**0.02**
		Upper	0.0015	0.002	0.10	0.001	0.011
		Lower	0.0015	0.001	0.14	0.001	0.016
3	False Cape	Upper	0.0015	0.001	0.09	0.001	0.011
		Lower	0.0015	0.001	0.11	0.001	0.015
4	Palm Beach	Upper	0.0015	0.001	0.09	0.001	0.010
		Lower	0.0015	0.001	0.08	0.001	0.010
5	Yorkey's Knob	Upper	0.0015	0.001	0.08	0.002	0.011
		Lower	0.0015	0.001	0.09	0.002	0.010
6	Cape Grafton	Upper	0.0015	0.001	0.09	0.001	0.010
		Lower	0.0015	0.001	0.08	0.002	0.011

Italicized values highlighted in red represent exceedances of the WQO
Limit of Reporting (LOR) is the lowest level able to be detected by the laboratory.
Note: To analyse the data, values below the LOR were assumed to be half the LOR value as per ANZECC/ARMCANZ (2000).

a WQO is for combined nitrate and nitrite (oxidised nitrogen)
b LOR is greater than the WQO

B5.2.13 Oil and Hydrocarbons

The only oil and grease data available for this baseline characterisation is the Ports North monitoring data for Trinity Inlet. These data were collected from 1995 to 1997. Table B5-16 presents the statistical measures of the oil and grease data from this dataset.

For Ports North oil and grease monitoring data, many samples were not detected at concentrations greater than the LORs and therefore reported as 0. The actual LOR at the time of the analysis was not ascertained for this baseline characterisation. Therefore, the statistical values of the data have been summarised based only on the detected samples and the number of samples not detected for oil and grease are reported in **Table B5-16** as ND (not detected).

Overall, the levels of oil and grease detected in Trinity Inlet are likely due to boating activities, coupled with the limited flushing capacity of the estuary.

Total petroleum hydrocarbons (TPH) were monitored during the same time period as oil and grease in the Ports North program, however, none were detected in the two-year monitoring period.

TABLE B5-16 PORTS NORTH (1995-1997) OIL AND GREASE (MG/L) DATA STATISTICS

Region	*n* (ND[a])	Mean	Min	Percentile 20th	50th	80th	95th	Max
WQO					--[b]			
1a	32 (18)	0.86	0.1	0.2	0.4	1.62	2.28	2.6
1b	47 (24)	0.93	0.1	0.2	0.5	1.88	2.37	3.7

a ND - not detected at a concentration greater than the level or reporting, which is unknown

b Narrative oil and grease WQO: Oil and petrochemical should not be noticeable as a visible film on the water

B5.2.14 Pesticides

Pesticides are typically generated from agriculturally intensive land use, including forestry and orchards. Agriculture comprises approximately 13 percent of the Barron River and Trinity Inlet catchments (Mitchell *et al.* 2006). Pesticide measurements within Trinity Inlet and Trinity Bay are limited. Kapernick *et al.* (2006) monitored for range of pesticides including diuron, atrazine, simazine, and hexazinone at the Barron River entrance and Fitzroy Island (east of Cape Grafton) for both wet and dry seasons. **Table B5-17** presents the pesticide measurements at these two sites.

For diuron, simazine, atrazine, hexazinone, amtryn, and tebethiuron a total of nine samples at Fitzroy Island were collected over both wet and dry seasons, however, specific numbers per season were not provided. For the same constituents, one sample was collected at the Barron River entrance during the wet season. For chlorpyrifos, endosulfan and DDE, seven samples were collected over wet and dry seasons at Fitzroy Island and two samples were collected at the Barron River entrance over the wet season.

None of the samples were measured in excess of the Draft WQGGRBMPA (2010) trigger values.

TABLE B5-17 KAPERNICK ET AL (2006) PESTICIDE (MG/L) DATA STATISTICS

Season	Pesticide	ANZECC TTV[a]	Fitzroy Island			Barron River Entrance		
			Mean	Min	Max	Mean	Min	Max
Dry	Diuron	0.9	0.0025	0.0004	0.004		--	
	Simazine	0.2	0.00009	< 0.001	0.0005		--	
	Atrazine	0.6	< 0.001	< 0.001	< 0.001		--	
	Hexazinone	1.2	< 0.001	< 0.001	< 0.001		--	
	Ametryn	0.5	< 0.001	< 0.001	< 0.001		--	
	Tebuthiuron	0.02		--			--	
	Chlorpyrifos	0.0005	< 0.00003	< 0.00003	< 0.00003		--	
	Endosulfan	0.005	< 0.0006	< 0.0006	< 0.0006		--	
	DDE	0.0005	< 0.00005	< 0.00005	< 0.00005		--	
Wet	Diuron	0.9	0.0028	0.0009	0.0058		0.0019[b]	
	Simazine	0.2	< 0.001	< 0.001	< 0.001		0.008[b]	
	Atrazine	0.6	0.00061	< 0.001	0.0016		0.0032[b]	
	Hexazinone	1.2	0.00062	< 0.001	0.0016		0.001[b]	
	Ametryn	0.5	< 0.001	< 0.001	< 0.001		< 0.001[b]	
	Tebuthiuron			--			< 0.001[b]	
	Chlorpyrifos	0.0005	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003
	Endosulfan	0.005	< 0.0006	< 0.0006	< 0.0006	< 0.001	< 0.001	< 0.001
	DDE	0.0005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005

a For slightly to moderately disturbed waters

b Based on one measurement

B5.2.15 Bacteria

Bacteria (faecal coliform) was measured routinely within Trinity Inlet by Ports North from 2001 to 2013. **Table B5-18** presents the statistical measure of faecal coliform data from this dataset.

The median organism counts for wet and dry seasons of both regions were less than the ANZECC/ARMCANZ (2000) recreational water quality guideline for the bathing season.

TABLE B5-18 PORTS NORTH (2001-2013) FAECAL COLIFORM (CFU/100ML) DATA STATISTICS

Season	Region	*n*	Mean	Min	Percentile				Max
					20th	50th	80th	95th	
	WQO					***150***			
Wet	1a	25	176	< 1	14	39	160	363	2600
	1b	181	150	< 1	5	19	110	411	5900
Dry	1a	25	126	2	38	59	184	458	560
	1b	171	85	< 1	6	18	59	300	5200

B5.2.16 Perfluorinated Compounds (PFCs)

Perfluorinated compounds (PFCs) are chemical compounds often used as a component of aqueous film-forming foams (AFFFs) used for firefighting. These compounds are characterised as persistent in the environment with the potential to bio-accumulate or biomagnify. A spill of AFFFs (Tridol S3) occurred in January 2013 at a commercial premises on Draper Street in Cairns. The spill consisted of approximately 1000 L of Tridol S3 concentrate and 60,000 L of water that was discharged to the onsite stormwater system draining to Trinity Inlet close to Wharf 11/Navy Base. Approximately 21 000 L of the total volume was pumped and disposed via a trade waste contractor, resulting in an estimated 40 000 L of diluted foam being potentially discharged to Trinity Inlet.

Monitoring was undertaken by DEHP, and PFCs were detected at the discharge site just after the event. Subsequent modelling and validation sampling in April 2013 recorded PFCs at low levels, although it was noted that some of the PFCs could have originated from other sources (southern sewage treatment plant, based on chemical fingerprinting). Based on this monitoring, it was concluded that PFCs occurred at levels that represented a low risk to human health and recreational fishing, but had the potential for low level bioaccumulation and biomagnification.

Further sediment quality testing was subsequently undertaken by Ports North in April and July 2013 to verify possible extent of PFCs in sediments proposed for maintenance dredging, however, results indicated an absence of broad scale contamination and that the spill presented a low risk (also refer to **Chapter B4** (Sediment Quality)).

B5.2.17 Additional Data (2009 – 2017)

The Revised Draft EIS now includes land placement of all dredge material. With the change in design, additional water quality studies were undertaken to supplement the existing baseline data discussed in previous sections. The findings from these studies are detailed in **Appendix AI** (Additional Water Quality Baseline Studies), with key findings summarised in the following sections.

B5.2.17.a Northern Sands

Water quality grab samples and depth profiling was undertaken at the existing Northern Sands void on 26 July 2016. Historical monitoring data for the void (2010 to 2016) was also provided by Northern Sands (Landline Consulting).

The void water is typically fresh (electrical conductivity between 200 and 1,000 µs/cm), with electrical conductivity and salinity (around 0.4 ppt) consistent through the water column. During profiling on 26/7/16, turbidity was 25 NTU at the surface and increased to approximately 70 NTU near the bottom. Dissolved oxygen (DO) levels have historically fluctuated significantly, with levels between 0 mg/L and 9 mg/L. On 26/7/16, DO was approximately 100 % saturation at the surface and decreased to approximately 40-60 % saturation near the bottom.

Historically pH has been relatively neutral, with levels maintained between 6.5 and 8.0. On 26/7/16, pH generally decreased with depth, and was between 7 and 8. Concentrations of metals/metalloids and hydrocarbons were low, however nutrients were elevated, in particular NOx (nitrite and nitrate) which were significantly elevated above guideline values.

B5.2.17.b Barron River

Water quality depth profiling was undertaken in the Barron River on two separate occasions, once during the dry season (July 2016) and again in the wet season (March 2017). Further to this, a water quality instrument was deployed in the Barron River from July 2016 to March 2017 (and will remain deployed until July 2017), and previously for two months during the dry season (July 2014 to September 2014).

Salinity in the Barron River typically ranged between about 5 ppt and 30 ppt, and appeared to fluctuate in response to tidal cycles and rainfall events. Higher salinities (~30 ppt) were generally coincident with spring tides, while lower salinities (~5 ppt) were generally coincident with neap tides when freshwater flows appeared to dominate the salinity regime in the Barron River. Salinity in the Barron River can become very fresh (about 0.1 ppt) for short periods of time after rainfall events, however in general, the Barron River is brackish with salinity typically around 20 ppt for most of the time.

Water quality profiling data indicated that there is a salt water wedge in effect in the Barron River, with saline water up to 30 ppt (seawater is typically ~35 ppt) near the bottom, and brackish water (5 to 20 ppt) in surface water layers (top 2 m of water).

Turbidity in the Barron River was variable, with turbidity ranging from 6 NTU during dry conditions up to 500 NTU during rainfall events. In general, turbidity was typically around 20 NTU as indicated by the median value of monitoring data (Table B5-19).

Water quality profiling data indicated that pH was fairly consistent through the water column, with a slight increase in pH with increasing water depth. Values were similar between the dry season and wet season surveys, with pH ranging between 7 and 8. Water temperature in the Barron River was relatively consistent, with temperature between 25°C and 30°C during the summer, and 20°C to 25°C during the winter.

A summary of the combined data sets for the Barron River is presented in **Table B5-19**.

TABLE B5-19 SUMMARY OF COMBINED BARRON RIVER DATA

Summary Statistic	Salinity	Turbidity	Temperature
	ppt	NTU	°C
Minimum	0.1	2.6	21.0
20th Percentile	12.7	5.9	23.9
Median	19.0	18.2	28.1
80th Percentile	25.4	74.4	29.8
95th Percentile	29.4	114.9	30.8
Maximum	32.2	508.9	32.2

B5.2.17.c Thomatis / Richters Creek

A water quality instrument was deployed in Thomatis/Richters Creek from September 2016 to February 2017, and also previously for 14 months between December 2013 and February 2015.

Salinity in Thomatis/Richters Creek was mostly around 30 ppt, with minimal fluctuation evident due to tidal cycles. Salinity only decreased during large rainfall events when freshwater flows in the Barron River were large enough to push into Thomatis/Richters Creek. During these periods, salinity would decrease to about 0.1 ppt for short periods of time.

Similar to the Barron River, turbidity in Thomatis/Richters Creek was variable with turbidity ranging from about 10 NTU during dry conditions up to 350 NTU during rainfall events. In general, turbidity was typically around 20 NTU as indicated by the median value of monitoring data (**Table B5-20**). Water temperature in Thomatis/Richters Creek was relatively consistent, with temperature between 25°C and 30°C during the summer, and 20°C to 25°C during the winter.

A summary of the combined data sets for Thomatis/Richters Creek is presented in **Table B5-20**.

TABLE B5-20 SUMMARY OF COMBINED THOMATIS / RICHTERS CREEK DATA

Summary Statistic	Salinity	Turbidity	Temperature
	ppt	NTU	°C
Minimum	0.1	0.4	21.0
20th Percentile	24.6	14.0	24.9
Median	28.7	19.2	28.2
80th Percentile	31.7	29.8	29.8
95th Percentile	33.6	89.6	30.7
Maximum	35.2	346.2	31.5

B5.2.17.d Palm Cove (Double Island)

A water quality instrument was deployed near Palm Cove beach (and Double Island) for three months from August 2016 to November 2016. The purpose of this deployment was to supplement the previous 12 months of turbidity data collected between July 2013 and July 2014.

This data indicates that turbidity during the most recent deployment was around 50 NTU for most of the time, with some larger spikes in turbidity around 100 – 200 NTU. While turbidity during the 2013/2014 deployment period was slightly lower in general, there were some larger turbid spikes up to around 400 - 700 NTU during this period.

Turbidity was higher during the latest three-month deployment (2016), with median turbidity of 40 NTU, compared to a median turbidity of 17 NTU during the 12-month 2013/2014 deployment.

A summary of the combined data sets for Palm Cove (Double Island) is presented in **Table B5-21**.

TABLE B5-21 SUMMARY OF COMBINED PALM ISLAND (DOUBLE ISLAND) DATA

Summary Statistic	Turbidity
	NTU
Minimum	0.8
20th Percentile	5.9
Median	21.5
80th Percentile	57.9
95th Percentile	110.9
Maximum	687.7

B5.2.17.e Trinity Inlet

A water quality instrument was previously deployed in the upper reaches of Trinity Inlet and collected 12 months of data (July 2013 to July 2014). To collect water quality data closer to the Port and proposed Inner Harbour dredging works, a water quality instrument was deployed in the mid to lower reaches of Trinity Inlet between July 2016 and March 2017. Additionally, water quality depth profiling was undertaken at the same location in Trinity Inlet during the dry season (July 2016).

Salinity in Trinity Inlet was relatively consistent temporally and spatially, with salinity maintained between 30 and 35 ppt throughout the deployment period and through the water column during water quality profiling.

Turbidity fluctuated with tidal cycles and rainfall events. There were some larger spikes in turbidity up to about 100 NTU coincident with spring tides and/or significant rainfall, however median turbidity during the instrument deployment was approximately 16 NTU (**Table B5-22**). During profiling, turbidity was lower at the surface (~2 NTU) and increased with water depth up to about 5 NTU near the bottom.

Temperature were relatively consistent throughout the deployment period, with temperature between 20°C and 30°C, while pH was consistent through the water column at around 7.5 to 7.7.

A summary of the Trinity Inlet deployed instrument data is presented in **Table B5-22**.

TABLE B5-22 SUMMARY OF TRINITY INLET DATA

Summary Statistic	Salinity	Turbidity	Temperature
	ppt	NTU	°C
Minimum	27.1	3.4	22.5
20th Percentile	30.1	6.9	24.8
Median	33.1	15.9	28.9
80th Percentile	34.6	36.9	30.1
95th Percentile	35.3	75.8	30.7
Maximum	35.6	150.4	31.3

B5.2.18 Key Findings

In summarising the previous sections, the key findings in regard to baseline water quality conditions are as follows:

- Dissolved oxygen levels were lower than the acceptable range for regions with a specific WQO (open coastal regions). In the remaining regions (without a specific WQO), which are defined by acceptable changes to the background DO concentrations, DO was typically low - likely from oxygen demand from other pollutants (e.g. sewage effluent) within Trinity Inlet.
- Median TSS concentrations collected during the Coastal Data Collection in Trinity Inlet and Trinity Bay were elevated (80-95 mg/L in Trinity Inlet and 10-75 mg/L in Trinity Bay). In contrast, median TSS concentrations from the Ports North data (collected over a longer period) showed lower TSS levels in Trinity Inlet and Trinity Bay.
- Median turbidity levels typically exceeded the WQOs, with median turbidity levels ranging from approximately five to 50 NTU for all regions and seasons. Peak turbidity levels range from 150 to 1,900 NTU. Ports North data for Trinity Inlet demonstrated similar turbidity values to those of the Coastal Data Collection and Water Quality Monitoring Program data for those regions.
- Turbidity in Barron River and Thomatis/Richters Creek was variable, with turbidity ranging from 6-10 NTU during dry conditions up to 350-500 NTU during rainfall events. In general, turbidity in these waterways was typically around 20 NTU.
- Seasonal assessments of TSS and turbidity for the study area as a whole do not reveal any significant variation between wet and dry season. However, there appears to be some correlation between exposure to south-easterly winds and increased turbidity for some sites (e.g. Northern Beaches). Turbidity in other more protected areas (e.g. Trinity Inlet, False Cape) appears to be more likely influenced by freshwater inflows during the wet season.
- Salinity in the Barron River typically ranged between about 5 ppt and 30 ppt, and appeared to fluctuate in response to tidal cycles and rainfall events. Higher salinities (~30 ppt) were generally coincident with spring tides, while lower salinities (~5 ppt) were generally coincident with neap tides when freshwater flows appeared to dominate the salinity regime in the Barron River. Salinity in the Barron River can become very fresh (about 0.1 ppt) for short periods of time after rainfall events, however in general, the Barron River is brackish with salinity typically around 20 ppt for most of the time.
- Salinity in Thomatis/Richters Creek was mostly around 30 ppt, with minimal fluctuation evident due to tidal cycles. Salinity only decreased during large rainfall events when freshwater flows in the Barron River were large enough to push into Thomatis/Richters Creek. During these periods, salinity would decrease to about 0.1 ppt for short periods of time.
- Ports North data indicated that some total metals/metalloids, including tributyltin, cadmium, copper, chromium and zinc exceeded the TTV for the 95th percentile value in Region 1. The Water Quality Monitoring Program indicated some exceedances of dissolved aluminium, copper, and zinc.
- Ports North data indicated elevated nutrient levels in Region 1 relative to the EPP Water WQOs for total phosphorus and ammonia, the likely source of which is STPs. In contrast, the Water Quality Monitoring Program indicated low levels of nitrogen and phosphorus.

Overall, while there are some exceedances of water quality guideline values in the study area, this is not unexpected of a marine environment located adjacent to an urban/industrialised area. The range of anthropogenic sources that influence inshore marine areas such as Trinity Inlet are common along the Queensland coast.

In regard to turbidity, the near shore areas of Trinity Bay are naturally turbid environments, especially following periods of high rainfall and sustained winds and currents. However, this is to be expected in near shore areas such as Trinity Bay with shallow water depths and muddy benthic sediments which are susceptible to re-suspension. In deeper waters further offshore, the turbidity is relatively low due to less re-suspension of bottom sediments.

B5.3 Assessment of Potential Impacts

The project has the potential to influence water quality within Trinity Inlet and Trinity Bay during both the construction phase and operational phases. Impacts on water quality could result from capital dredging of the existing shipping channel into Cairns port, the channel bend, swing basins and inner port. Additionally, land placement of dredge material at the Northern Sands DMPA could also have water quality impacts in the Barron River due to the proposed hydraulic placement of the material and associated tailwater releases from this DMPA. These influences are potentially both short term (i.e. construction) and continuing in the longer term (i.e. maintenance dredging and operation).

This report presents the findings of the assessment of potential impacts to marine water quality associated with the construction and operation of the Revised Draft EIS, with particular focus on the following:

- Construction related – primarily capital dredging and placement activities, and also construction of wharf infrastructure.
- Operation of the port facilities, focusing on accommodating an increased number of larger cruise vessels at Trinity Inlet wharves, maintenance dredging of the entrance channel, and placement of maintenance dredge material at the approved marine DMPA.
- Options for managing and mitigating identified impacts.

B5.3.1 Assessment Approach

A risk-based approach has been used to assess water quality impacts, and is based on the consideration of the following:

- Consequence of Impact – made up of assessment of the intensity, scale (geographic extent), duration of water quality impacts and sensitivity of environmental receptors to the impact (as prescribed in the EPP Water). **Table B5-23** is a summary of the categories used to define impact significance
- Duration of Impact - the duration of identified impacts is classified as per **Table B5-24**.
- Likelihood of Impact – which assesses the probability of the impact occurring. **Table B5-25** is a summary of the categories used to define impact likelihood
- Risk rating – which assesses the level of risk for key impacting processes. The risk table (**Table B5-26**) adopted is generated from the Consequence and Likelihood scores, based on the overall matrix presented in Part A of the EIS.

TABLE B5-23 CATEGORIES USED TO DEFINE CONSEQUENCE OF IMPACT (WATER QUALITY)

IMPACT CONSEQUENCE	DESCRIPTION FOR WATER QUALITY (INCLUDES MAGNITUDE, DURATION, AND SENSITIVITY OF RECEIVING VALUES)
Very High	Permanent change in the Ecosystem for Trinity Inlet and Trinity Bay and surrounds resulting from changes to water quality due to direct impacts of the construction or operational phases of the Cairns Shipping Development project and associated activities. Generally corresponds to the 'Zone of High Impact' in terms of dredge-related turbidity as per **Section B5.3.2** below.
High	Water quality in Trinity Inlet and Trinity Bay and surrounds is permanently altered due to direct impacts of the construction or operational phases of the Cairns Shipping Development project and associated activities such that the scheduled Environmental Values and Water Quality Objectives are no longer achievable if currently being achieved, or are prevented from being achieved in the future if currently not being achieved. Generally corresponds to the 'Zone of High Impact' in terms of dredge-related turbidity as per **Section B5.3.2** below.
Moderate	Water quality in Trinity Inlet and Trinity Bay and surrounds is temporarily altered due to direct and indirect impacts of the construction phase of the Cairns Shipping Development project and associated activities such that the scheduled Environmental Values and Water Quality Guidelines are no longer achievable if currently being achieved, or are prevented from being achieved in the future if currently not being achieved. Generally corresponds to the 'Zone of Low to Moderate Impact' in terms of dredge-related turbidity as per **Section B5.3.2** below.
Minor	Water quality in Trinity Inlet and Trinity Bay and surrounds is temporarily impacted such that mitigation measures prevent changes to water quality over an annual period, though short term exceedances may occur during construction activities. Generally corresponds to the 'Zone of Low to Moderate' Impact in terms of dredge-related turbidity as per **Section B5.3.2** below.
Negligible	No detectable impacts on the water quality in Trinity Inlet and Trinity Bay and surrounds through the use of effective mitigation measures during the construction and operational phases and no perceptible change to long term water quality through altered flow regimes or other hydrologic changes resulting from the Project. Generally corresponds to the 'Zone of Influence' in terms of dredge-related turbidity as per **Section B5.3.2** below.
Beneficial	Existing water quality is improved in Trinity Inlet and Trinity Bay and surrounds.

TABLE B5-24 CLASSIFICATIONS OF THE DURATION OF IDENTIFIED IMPACTS

RELATIVE DURATION OF IMPACTS	
Temporary	Days to months
Short Term	Up to one year
Medium Term	From one to five years
Long Term	From five to 50 years
Permanent / Irreversible	In excess of 50 years

TABLE B5-25 CATEGORIES USED TO DEFINE LIKELIHOOD OF IMPACT (WATER QUALITY)

LIKELIHOOD	CATEGORIES
Highly Unlikely/Rare	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction/life of the project but probability well below 50%; unlikely but not negligible
Possible	Less likely than not but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability greater than 50%
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impacting period

TABLE B5-26 RISK MATRIX FOR WATER QUALITY

LIKELIHOOD	IMPACT CONSEQUENCE				
	Negligible	Minor	Moderate	High	Very High
Highly Unlikely/ Rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

TABLE B5-27 RISK RATING LEGEND

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact to marine water quality
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact to marine water quality
Medium Risk	An issue requiring project specific controls and procedures to manage
Low Risk	Manageable by standard mitigation and similar operating procedures
Negligible Risk	No additional management required

B5.3.2 Methodology

The typical approach to assessing the predicted impacts from construction and operations works is to assess compliance against water quality guideline values (such as the EPP Water). This method allows a direct comparison of the likely compliance with established guidelines to ensure protection and/or enhancement of environmental values for the waters of concern.

As the actual capital dredging works are anticipated to occur only over a span of approximately 12 weeks (depending on the dredge plant used and not including mobilisation and demobilisation), impacts over this short duration are problematic to compare for compliance against annual median water quality guidelines. Specifically, calculation of an annual median from only 12 weeks of impact would result in underestimation of potential impacts.

Given this, three levels of assessment were undertaken to support assessment of the potential impacts from the proposed dredging and placement works.

Firstly, median concentrations for the dredging campaign were assessed against water quality guideline values. Although it is acknowledged (as above) that this approach is not strictly precise, it does provide a high level 'screening' type assessment tool to allow rapid identification of potential impacts, worthy of subsequent rigorous assessment. This approach is also a minimum requirement of the State Terms of Reference (ToR).

Secondly, percentile exceedance plots of dredging related turbidity are presented. These percentile plots are direct outputs from the modelling, and provide an indication of excess turbidity from dredging activities (these plots are discussed further in **Section B5.3.3**). Additionally, time series plots of modelled turbidity at particular locations are presented. These plots are separated out into ambient turbidity natural re-suspension and dredge-related turbidity for the modelling period. This was undertaken to aid in the assessment of impacts at particular locations by identifying the proportion of turbidity originating naturally and from dredging and placement works.

Thirdly, project-specific threshold values were developed to assess potential impacts to marine water quality and ecologically sensitive areas. These impact predictions are presented as 'zones of impact' as recommended by the Commonwealth EIS Guidelines and GBRMPA Modelling Guidelines, and are derived using the percentile exceedance plots described above. The zones of impact approach is now recognised as 'best practice' in dredging environmental assessments, building on the methodologies set out in the dredging environmental assessment guidelines produced by the WA EPA (2016).

The zones adopted for the current assessment, include the following:

- Zone of High Impact = water quality impacts resulting in predicted mortality of ecological receptors with recovery time greater than 24 months.
- Zone of Low to Moderate Impact = water quality impacts resulting in predicted sub-lethal impacts to ecological receptors and/or mortality with recovery between 6 months (lower end of range) to 24 months (upper end of range).
- Zone of Influence = extent of detectable[2] plume, but no predicted ecological impacts.

The zones of impact, and the threshold values used to develop the zones of impact, are detailed in Appendix AJ (Marine Water Quality Impact Assessment).

B5.3.3 Modelling Outputs

To assist with the impact assessment, dredge plume modelling results from the Appendix AG (Numerical Modelling Report) were used. These modelling results consist of time series results and percentile contour plots.

Similar to the analysis of baseline monitoring data (Appendix AJ - Marine Water Quality Impact Assessment), the percentile contour plots were developed using a 30-day moving window. The percentile impacts correspond to the maximum increase due to dredging of the 30-day moving window derived percentile statistics during the entire simulation. Different locations within the model will have experienced their worst period at different times during the simulation and the different percentile statistics may also have occurred during different 30-day windows. Key features of the 30-day moving window percentile analysis include:

- Consideration of a range of impact durations from acute to chronic.
- Can be applied to a long-term program and capture periods of high intensity versus low intensity impacts.
- A similar analysis applied to the baseline data can quantify the ambient conditions including natural variability across different periods. This can be used to derive meaningful thresholds for the impacts.

When interpreting percentile contour plots presented throughout this report, it is important to note that these are not snap-shots in time and therefore do not represent the spatial extent of the dredge plume at any given time. Instead, these plots indicate the areas where turbidity was elevated at some point during the dredge campaign. The type of percentile plot (e.g. 50th percentile or 95th percentile) indicates the amount of time that the turbidity was exceeded at a particular location.

[2] 'Detectable' plume in terms of detectable above background conditions by instrumentation deployed in the water column

Percentile contour plots included in this report represent depth averaged turbidity (i.e. turbidity averaged vertically in the water column from surface to sea bed). Percentile plots also showing near-bed turbidity are presented in the **Appendix AG** (Numerical Modelling Report).

Further details on modelling outputs and assumptions are provided in the **Appendix AG** (Numerical Modelling Report).

B5.3.4 Construction Phase Impacts

B5.3.4.a Turbid Plumes from Capital Dredging

A key concern regarding water quality for the project is from the release of sediment particles to the water body during the capital dredging program. Turbid plumes may occur to some extent as a result of dredging activities.

The proposed capital dredging using a mechanical backhoe dredge (BHD) and a trailer suction hopper dredge (TSHD) will generate turbid plumes. The turbid plumes have the potential to migrate and impact upon nearby sensitive ecological receptors. The extent of the plume will depend on a range of factors including season, wind strength and direction, currents, tide status, type of sediment, location and type of dredge, as well as working methods and productivity.

The total duration of the capital dredging campaign is expected to be approximately 12 weeks for the TSHD, with the BHD dredging component expected to take approximately 5-6 weeks within this dredging period. Modelling was undertaken using the following two dredging scenarios, representing the lower and upper bounds of likely dredging works:

- **Scenario 1** – lower end of the expected total dredge material volume (710 000 m^3 of soft material from the channel and 100 000 m^3 of stiff clay material from the inner channel and harbour) and limited overflow from the TSHD (maximum 10 minutes of overflow).
- **Scenario 2** – upper end of the expected total dredge material volume (900 000 m^3 of soft material from the channel and 100 000 m^3 is stiff clay material from the inner channel and harbour) and less-restricted overflow from the TSHD (30 minutes of overflow per cycle).

Modelling of both dredging scenarios was undertaken over three different weather periods (representing a range of wind and wave conditions), with the best and worst of the modelling outputs representing the 'likely best case' and 'likely worst case' scenarios presented in this report. These scenarios provide lower and upper bounds to expected water quality impacts.

It should be noted that extreme climatic events are not included as part of the worst-case scenarios as dredging would be unlikely to be occurring during these periods as dredging is proposed to be undertaken during the dry season. Furthermore, the dredge would not likely operate during extreme conditions for safety reasons.

Screening Assessment against Water Quality Guidelines and Baseline Data

An initial high level screening assessment of the potential impacts to median water quality concentrations based on the modelling data was undertaken for the sensitive ecological receptor sites where baseline monitoring was undertaken (refer to **Figure B5-2** for locations).

Results for this approach are presented in **Table B5-28**, which shows potential increases to median concentrations at the water quality monitoring locations.

TABLE B5-28 PREDICTED IMPACTS TO MEDIAN TURBIDITY

Location	Water Quality Conditions	Median Turbidity (NTU)	
		Likely Best Case	Likely Worst Case
Palm Cove Beach	Increase above ambient	0.1	0.5
	Ambient condition	22	22
	% Increase	0.5%	2.3%
Yorkeys Knob	Increase above ambient	0.5	1.3
	Ambient condition	19	19
	% Increase	2.6%	6.8%
Trinity Bay	Increase above ambient	2.4	7.2
	Ambient condition	16	16
	% Increase	15.0%	45.0%
Trinity Inlet - Upper	Increase above ambient	0.5	2.1
	Ambient condition	12	12
	% Increase	4.2%	17.5%
Trinity Inlet - Lower	Increase above ambient	2.0	3.8
	Ambient condition	16	16
	% Increase	12.5%	23.8%
False Cape	Increase above ambient	0.4	1.2
	Ambient condition	28	28
	% Increase	1.4%	4.3%
Cape Grafton	Increase above ambient	0.03	0.1
	Ambient condition	31	31
	% Increase	0.1%	0.3%
Existing DMPA	Increase above ambient	0.00	0.01
	Ambient condition	6	6
	% Increase	0.0%	0.2%
QWQG (annual)		**10**	

Note: Shaded cells indicate exceedance of the QWQG guideline value

The results in **Table B5-28** indicate that capital dredging will only minimally increase median turbidity values (less than 7 percent increase) at most locations compared to ambient conditions. Areas where ambient median turbidity is expected to increase more substantially include Trinity Bay (up to 45% during worst case – however this is located next to the channel dredging), and Trinity Inlet, where increases of up to 18% (Trinity Upper) and 24% (Trinity Lower) are expected during the worst case. Notwithstanding that ambient turbidity in these areas is already elevated above the water quality guideline value (10 NTU), further assessment was undertaken and discussed in the following sections.

Percentile Plots

The following percentile contour plots (**Figure B5-22** and **Figure B5-23**) show depth averaged dredging-related turbidity above background levels. Note that these plots include capital dredging by the TSHD and the BHD. Also note that the scales used on the plots differ between the 50^{th} and 95^{th} percentiles to reflect ambient turbidity during these varying conditions. Plots shown are based on the following percentile values:

- 50^{th} percentile plot (**Figure B5-22**) - typical (median) turbidity levels, which occur 50 percent of the time.
- 95^{th} percentile plot (**Figure B5-23**) - infrequent periods (occurring five percent of the time) of high turbidity.

For context, percentile contour plots showing modelled ambient turbidity (without dredging) during 50^{th} and 95^{th} percentile conditions are provided on **Figure B5-21**.

Figure B5-22 indicates that as a result of capital dredging, median (50th percentile) turbidity is predicted to increase slightly (up to 2 NTU for the best case and up to 6 NTU for the worst case) along the northern coastline up to Double Island. Turbid plumes are also predicted to mobilise up Trinity Inlet due to dredging in the inner port, with median turbidity predicted to increase by approximately 2-4 NTU in Trinity Inlet. The greatest increase to median turbidity is predicted to be in and adjacent to the outer channel dredging area, which is predicted to increase by approximately 10-20 NTU.

Figure B5-23 indicates that under 95th percentile conditions, turbidity is predicted to increase by approximately 10-30 NTU above background conditions (approximately 100-150 NTU) in close proximity to the outer channel dredging area, and up to 10 NTU above background conditions (approximately 75 NTU) in Trinity Inlet.

Due to the predominant south-easterly wind and wave direction in the area, turbid dredge plumes are less likely to mobilise in an easterly direction towards False Cape and Cape Grafton.

The impact significance of these results is interpreted using time series plots and zones of impact in the following section.

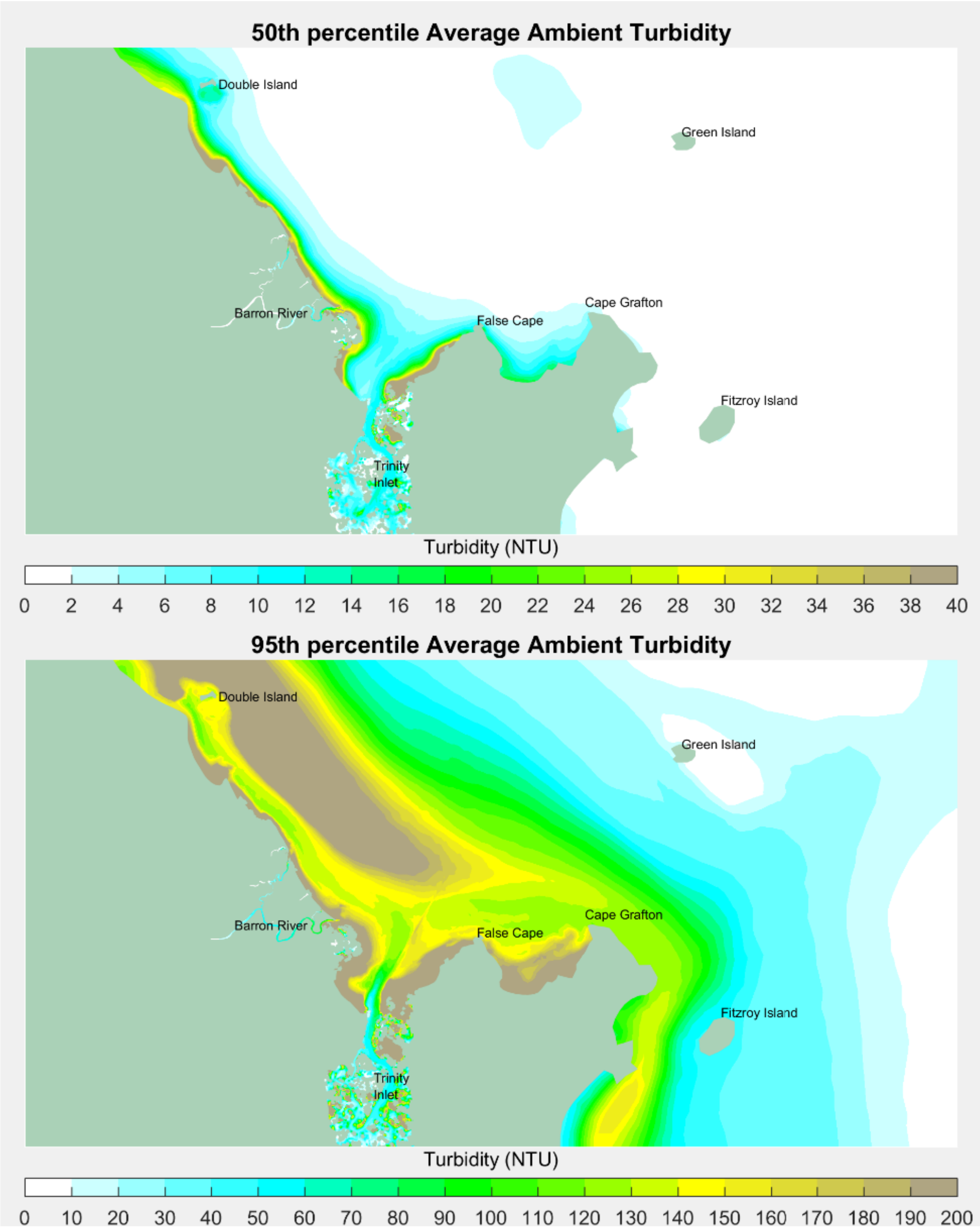


Figure B5-21 Modelled ambient turbidity (without dredging) – 50th percentile (top) and 95th percentile (bottom).

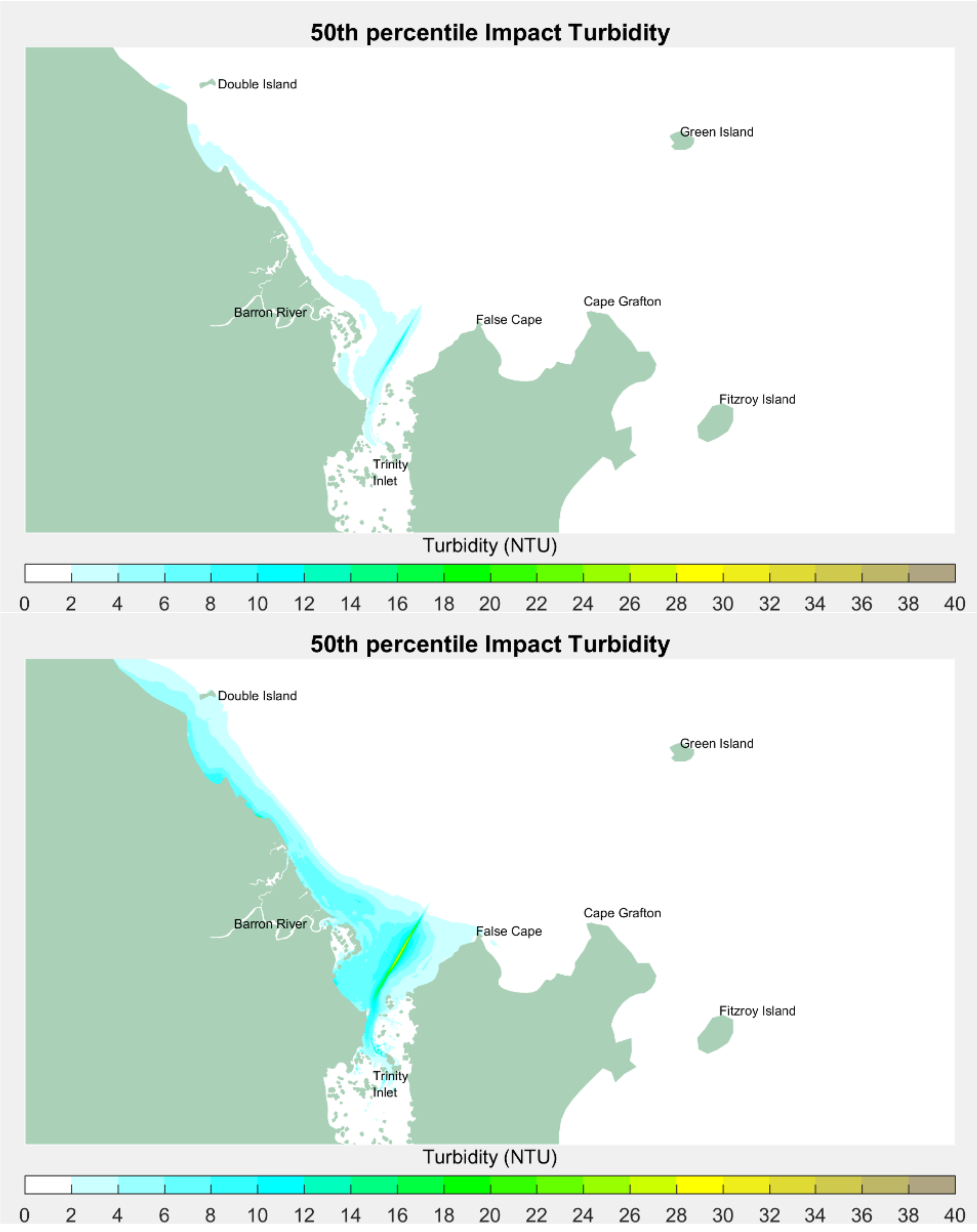


Figure B5-22 Impact of dredging on 50th percentile turbidity – likely best case (top) and likely worst case (bottom). Scale: 2 to 40 NTU.

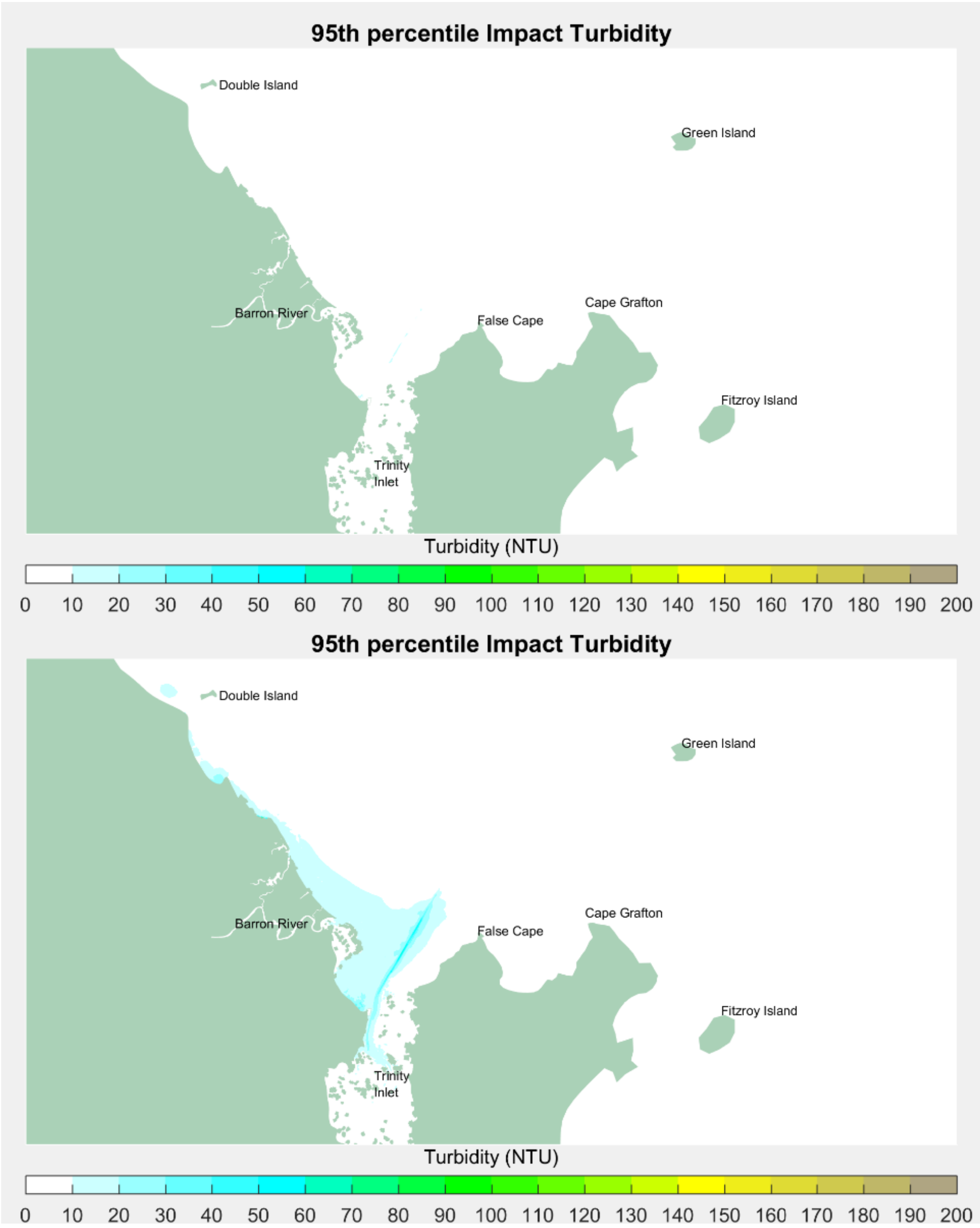


Figure B5-23 Impact of dredging on 95th percentile turbidity – likely best case (top) and likely worst case (bottom). Scale: 10 to 200 NTU.

Time Series Plots

The above sections presented the turbid plumes predicted by modelling of the capital dredging campaign. These predicted turbid plumes would consist of suspended sediment from the dredge plume and subsequent re- suspension of dredge material during wind and wave events over the modelling period. However, in addition to the suspended sediment from dredge material, there would also be a proportion of naturally occurring suspended sediment in the water column from natural re-suspension during windy conditions.

Therefore, to put the magnitude of modelled turbid plumes into some context at locations of sensitive receptors, ambient turbidity from natural re-suspension was modelled for the duration of the dredging campaign. This enables a comparison of ambient turbidity to dredge-related turbidity at sensitive receptors.

The time series data was extracted from the model at six of the baseline water quality monitoring locations, representing sensitive receptors (**Figure B5-2**).

Figure B5-24 and **Figure B5-25** present time series plots of ambient turbidity versus dredge-related turbidity, with ambient turbidity shown as green lines and dredge-related turbidity shown as blue lines (note the different turbidity scales on the y axis for each location). These plots indicate that sediment from natural re-suspension is the dominant source of turbidity at all sites. The only plots where dredge-related turbidity is noticeable is at Trinity Bay which is close to the outer channel dredging area, and at Trinity Inlet which is relatively close to the inner harbour dredging area. Ambient turbidity is much lower in Trinity Inlet than other sites and therefore dredge-related turbidity is more noticeable. Nevertheless, spikes in dredge-related turbidity at these two sites also correspond to spikes in ambient turbidity when climatic conditions lead to wave and wind conditions that re-suspend sediment and/or during spring tides in Trinity Inlet.

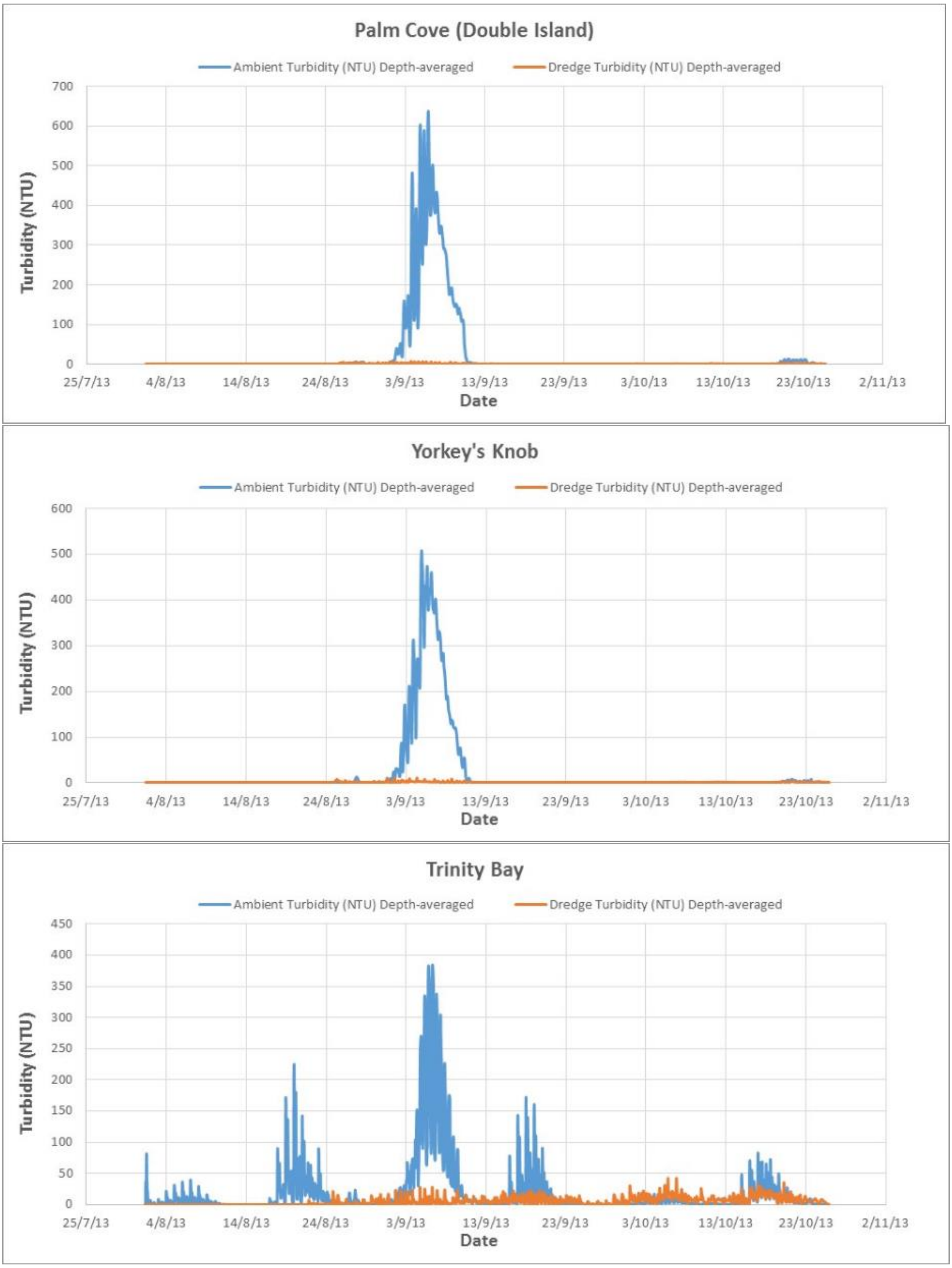


Figure B5-24 Natural re-suspension (ambient sediments) vs. dredge sediments – Palm Cove (top), Yorkeys Knob (middle) and Trinity Bay (bottom).

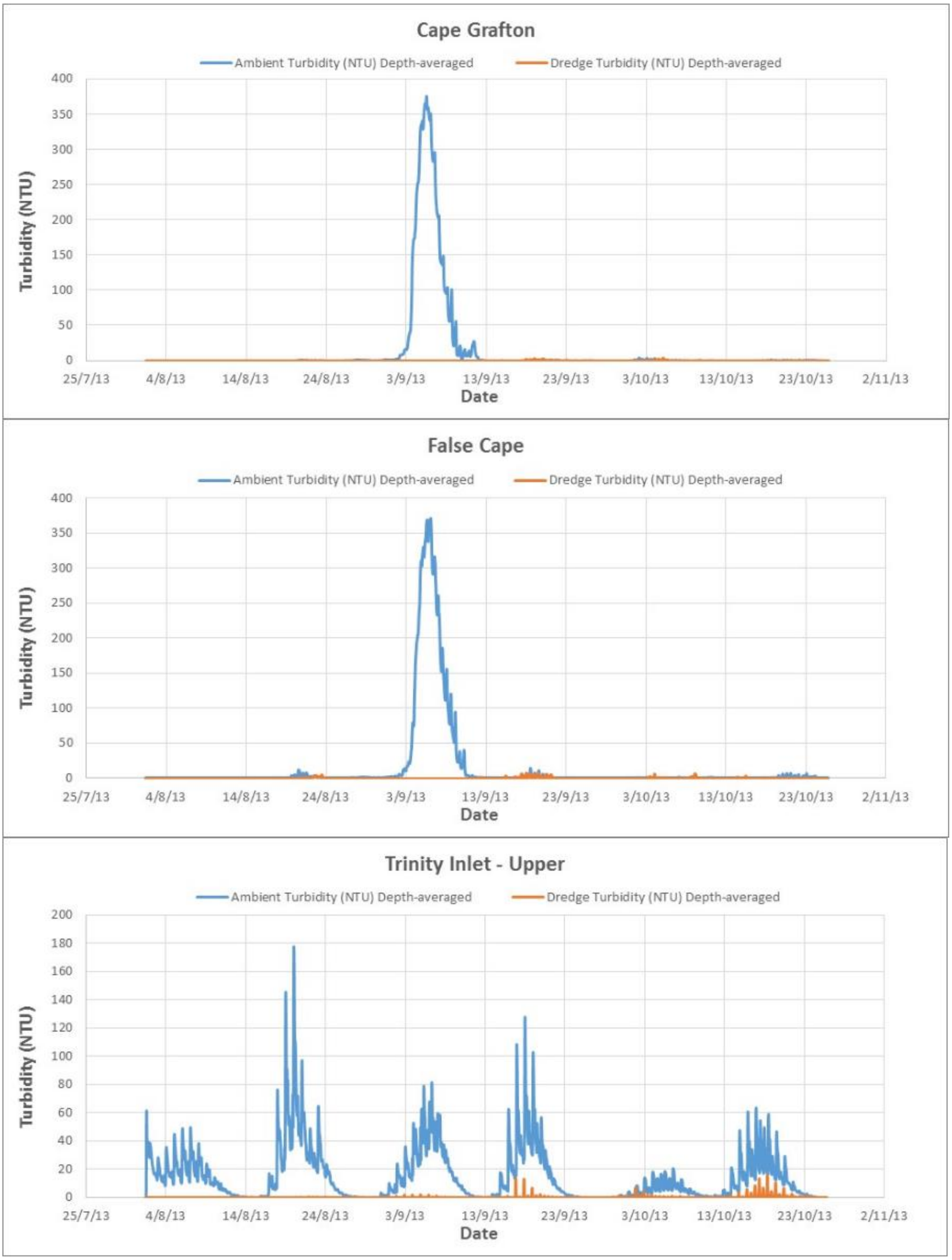


Figure B5-25 Natural re-suspension (ambient sediments) vs. dredge sediments – Cape Grafton (top), False Cape (middle) and Trinity Inlet (bottom).

Zones of Impact

In accordance with the methodology presented in **Appendix AJ** (Marine Water Quality Impact Assessment), spatial zones of predicted impact were developed using site-specific impact threshold values from the baseline monitoring data. These impact zone maps indicate areas where modelled turbidity is higher than the relevant impact threshold value. The impact zone map is shown on **Figure B5-26** and **Figure B5-27**, with the likely best case and likely worst case shown to provide an indication of the lower and upper bounds of impact predictions for capital dredging. The impact zones are described as follows:

- Zone of Influence - extent of detectable plume, but no predicted ecological impacts.
- Zone of Low to Moderate Impact – water quality may be pushed beyond natural variation potentially resulting in sub-lethal impacts to ecological receptors and/or mortality with recovery between six months (lower end of range) to 24 months (upper end of range).
- Zone of High Impact – water quality would most likely be pushed beyond natural variation (excluding extreme weather events) potentially resulting in mortality of ecological receptors with recovery greater than 24 months.

Also shown on the zone of impact figures are seagrass extents (from annual monitoring undertaken by JCU). These seagrass extents are shown as the historical maximum seagrass extent (from monitoring data collected between 1984 and 2015) and the most recently available seagrass extent from 2015. Note that 2016 seagrass data was not available at the time of writing, but preliminary indications are that the extent is similar to 2015.

Figure B5-26 indicates that the zone of influence (i.e. extent of detectable plumes but no predicted ecological impact) extends from the outer channel dredging area northwards along the coastline to approximately 10 km past Double Island for the likely best case, and approximately 30 km past Double Island for the likely worst case. Under a likely worst case scenario, the zone of influence is also predicted to extend in an easterly direction to Cape Grafton.

From the inner port dredging area, the zone of influence extends up Trinity Inlet along the eastern extent of Admiralty Island, with the zone of influence extending up to the seagrass areas under a likely worst case scenario (**Figure B5-27**).

For the likely best case, the zones of impact (not including the zone of influence) are limited to the dredging footprint (high impact zone). For the likely worst case, a zone of low to moderate impact zone is predicted to extend southwards along Trinity Inlet for approximately 2 km, and northwards for approximately 2 km adjacent to the channel out to the channel bend. The zones of impact are not predicted to occur within historic seagrass meadows (**Figure B5-27**).

It should be noted that the zones of impact on **Figure B5-26** and **Figure B5-27** only relate to potential impacts from increased turbidity in the water column. Other impacting processes which may affect sensitive ecological receptors (such as sediment deposition and benthic habitat disturbance) are discussed in **Chapter B7** (Marine Ecology).

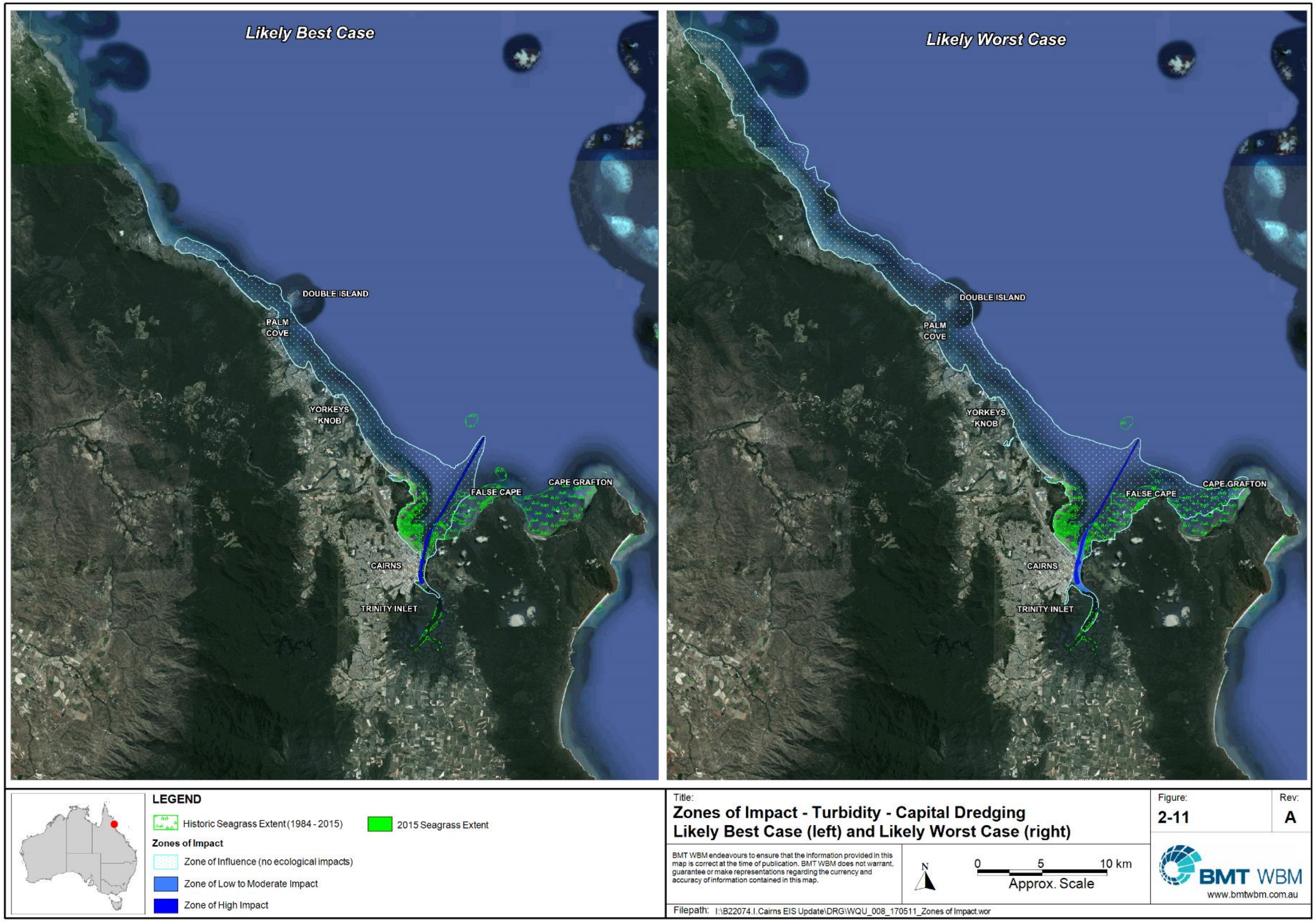


Figure B5-26 Zones of impact – turbidity - capital dredging.

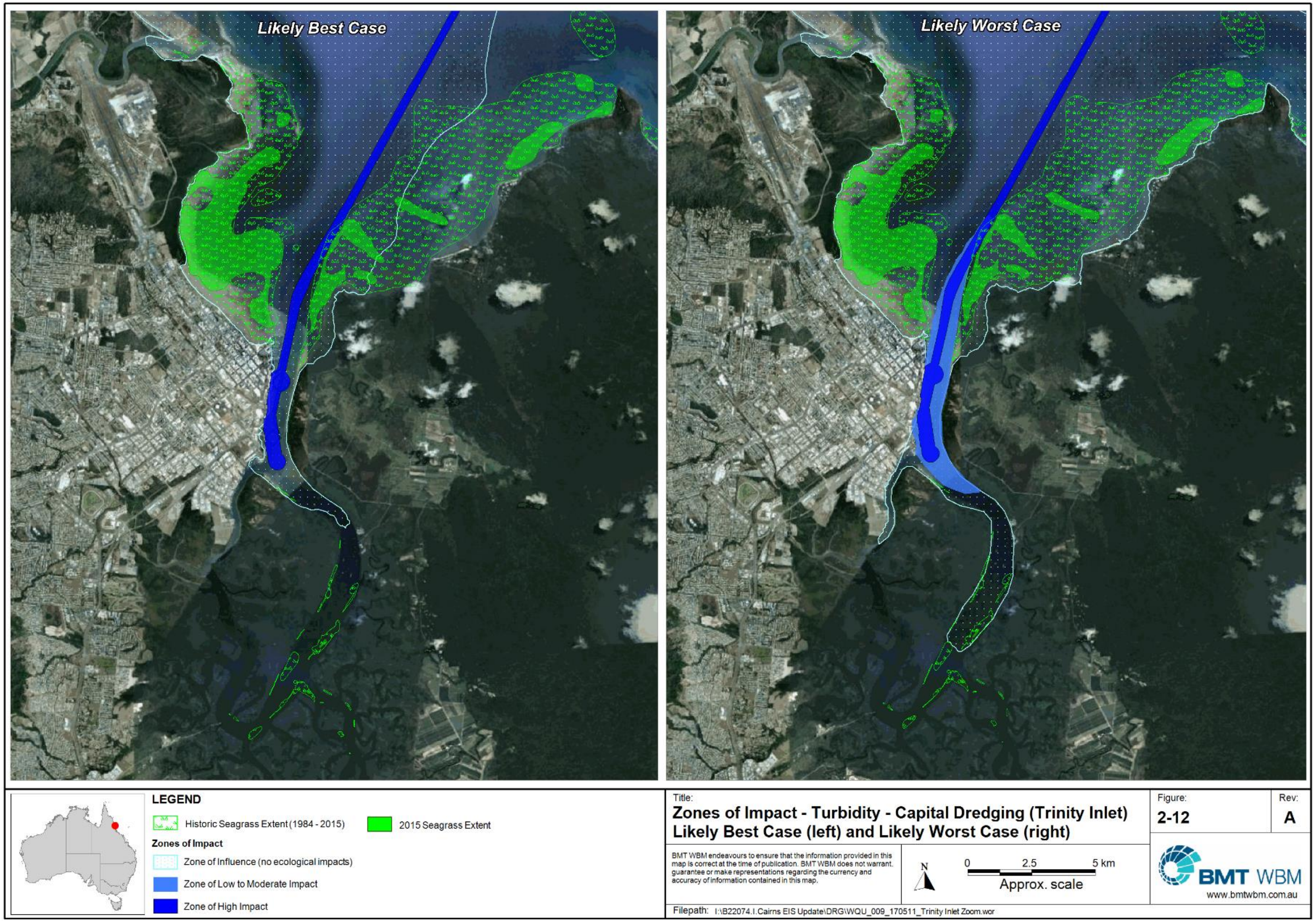


Figure B5-27 Zones of impact – Turbidity - Capital Dredging – Trinity Inlet and Cairns Harbour.

Prop Wash

The TSHD will be steaming between the channel dredging area and the dredge pump-out mooring location during each dredge cycle to pump the dredge material onshore. While there will be no propeller (e.g. prop) wash while the dredge is moored and pumping, there may be some prop wash while the dredge steams across the shallower nearshore areas. This prop wash has the potential to disturb bed sediments resulting in turbid plumes.

A sensitivity case was modelled which simulated this prop wash as a sediment source in the nearshore areas during each dredge cycle. The results are presented in the Appendix AG (Numerical Modelling Report), and indicate that turbid plumes from the prop wash are predicted to be negligible.

In terms of BHD dredging, there may be minor and infrequent prop wash during will be BHD positioning. Also, there may be minor prop wash from barge and tug movements along Smiths Creek to the Tingira Street DMPA. It is likely that the effect of such activities would be of a similar scale to what currently occurs from existing tug and barge operations to that area, with small and localised short term events, primarily around the shallow areas of the proposed unloading area. Therefore, any that turbid plumes from the BHD dredging (and associated activities) prop wash are predicted to be negligible.

Summary of Key Findings – Capital Dredging Turbid Plumes

The predicted impacts for each scenario have been determined based on the impact significance criteria defined in **Section B5.3.1** and can be summarised as follows.

Dredging of Inner Port

Based upon the high-level assessment against the QWQG, median turbidity levels are predicted to increase by up to 4% (Trinity Upper) and 13% (Trinity Lower) during the best case, and up to 18% (Trinity Upper) and 24% (Trinity Lower) during the worst case for a short-term duration of up to 12 weeks.

Assessment of ambient turbidity from natural re-suspension versus dredge-related turbidity indicated that Trinity Inlet is predicted to have some noticeable spikes in dredge-related turbidity (note that ambient turbidity is much lower at this site and therefore dredge-related turbidity is more noticeable). However, spikes in dredge-related turbidity at this site are predicted to correspond to spikes in ambient turbidity during spring tides (conditions which typically resuspend sediment within Trinity Inlet).

The percentile contour plots indicated that median turbidity is predicted to increase slightly (up to 4 NTU) within Trinity Inlet. 95th percentile turbidity is predicted to increase up to 10 NTU above background 95th percentile conditions in Trinity Inlet for a period of 12 weeks.

Using the zone of impact methodology, a zone of influence (i.e. extent of detectable plumes but no predicted ecological impacts) is predicted to extend from the inner port southwards along Trinity Inlet to areas of historical seagrass. A zone of low to moderate impact is predicted to extend approximately 2 km southwards along Trinity Inlet and approximately 2 km northwards adjacent to the channel (but not within historic seagrass meadows) only under a likely worst case scenario.

Therefore, based on these assessments overall, short- term minor impacts (**Table B5-23**) are expected from turbid plumes generated from capital dredging in the inner port.

Dredging of Outer Channel

Based upon the high-level assessment against the QWQG, median turbidity levels are expected to increase by up to 15% in Trinity Bay during the likely best case scenario, and up to 45% in Trinity Bay during the likely worst case scenario. However, the Trinity Bay site is located approximately 150 m away from the channel dredging area.

Assessment of ambient turbidity from natural re-suspension versus dredge-related turbidity predicted that sensitive ecological receptor sites would receive a much larger proportion of natural sediment re-suspension compared to dredged sediment.

The percentile contour plots indicated that median turbidity is predicted to increase slightly (up to 6 NTU) due to dredging of the outer channel. 95^{th} percentile turbidity is predicted to increase by approximately 10-30 NTU above background 95^{th} percentile conditions.

Using the zone of impact methodology, a relatively small zone of low to moderate impact is predicted to occur near the bend in the channel close to the inner port area. A zone of influence is predicted to occur for the remaining areas in the vicinity of the outer channel dredging.

The model outputs suggest that under the likely worst case scenario, turbid dredge plumes are predicted to be slightly increased in the near shore environment along the coastline to the north of the dredging area and to the east towards Cape Grafton (these plumes would be detectable with instrumentation but may not be visible to the naked eye). However, marine water quality is not predicted to change significantly.

Therefore, based on these assessments overall, short- term minor impacts (**Table B5-23**) are expected from turbid plumes generated from the capital dredging in the outer channel.

B5.3.4.b Sediment Deposition from Capital Dredging

While the previous section assessed impacts to water quality from suspended sediments in the water column as a result of turbid dredge plumes, this section assesses the potential impacts in terms of sediment deposition from the settlement of these suspended sediments.

Details on the predicted sediment deposition impacts throughout the study area are provided in the Appendix AG (Numerical Modelling Report). In brief, the change in sedimentation rates resulting from the deposition of suspended solids from dredging plumes are predicted to occur as shown on **Figure B5-28** and **Figure B5-29** for the likely best and likely worst cases for capital dredging.

The zones of impact for corals are shown on **Figure B5-30**, which indicates that while there is predicted to be zones of impact within and adjacent to the channel, the zones of impact do not coincide with areas containing coral reefs within the study area (including Double Island and Rocky Island). While a zone of influence is predicted to extend near to Rocky Island reef during the likely worst case scenario, there are no ecological impacts predicted within this zone of influence. Potential impacts to coral reefs from sediment deposition are assessed further in **Chapter B7** (Marine Ecology).

While the zones of impact are likely to extend over some historical seagrass areas, seagrasses are typically less sensitive to sediment deposition. However, as the thresholds are less certain (refer to **Appendix AJ** - Marine Water Quality Impact Assessment), zones of impact as they relate to seagrass are not presented in this report, but potential impacts to seagrass from sediment deposition are discussed in **Chapter B7** (Marine Ecology).

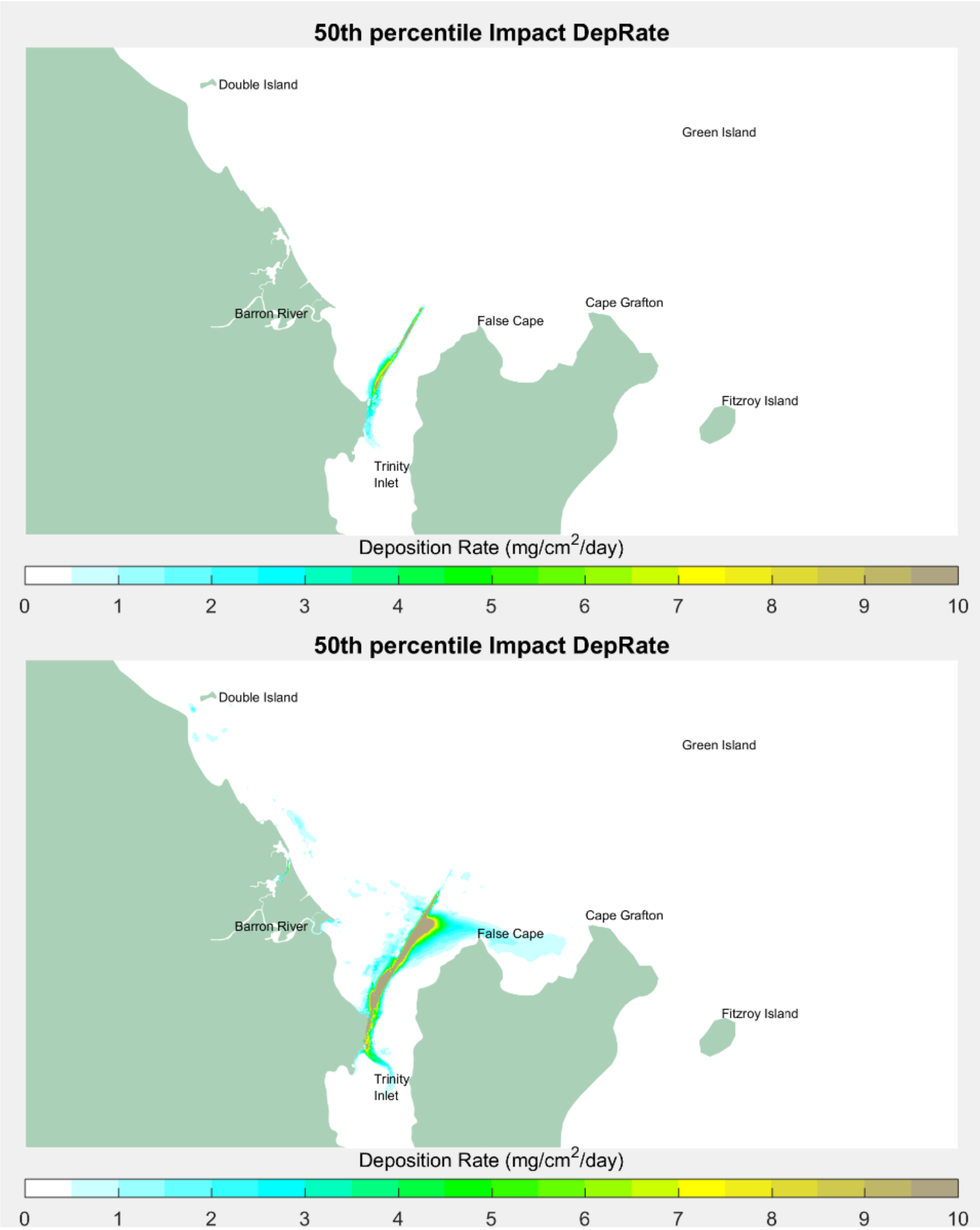


Figure B5-28 Impact of dredging on 50th percentile sediment deposition – likely best case (top) and likely worst case (bottom).

Scale: 0.5 to 10 mg/cm2/day.

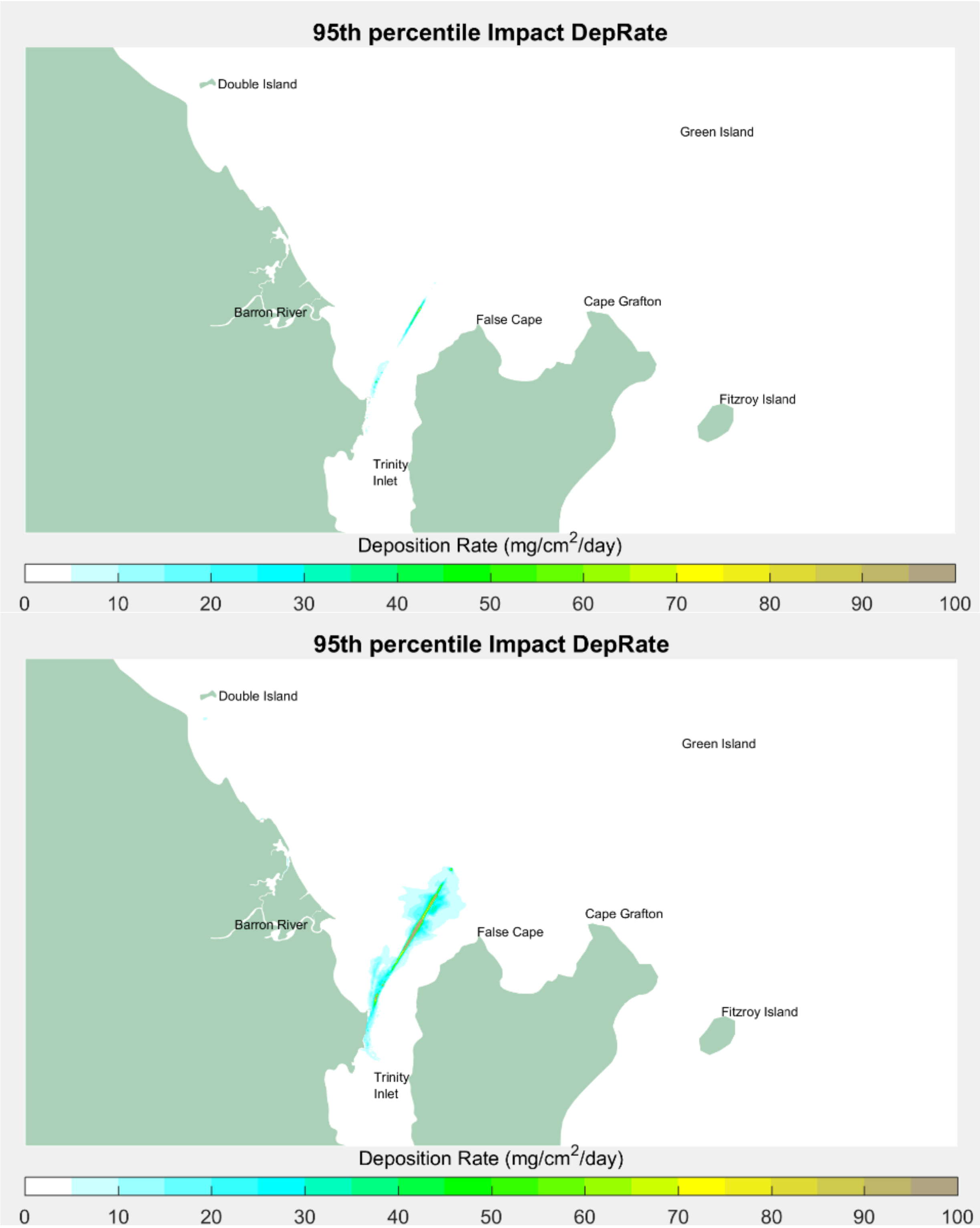


Figure B5-29 Impact of dredging on 95th percentile sediment deposition – likely best case (top) and likely worst case (bottom).

Scale: 5 to 100 mg/cm2/day.

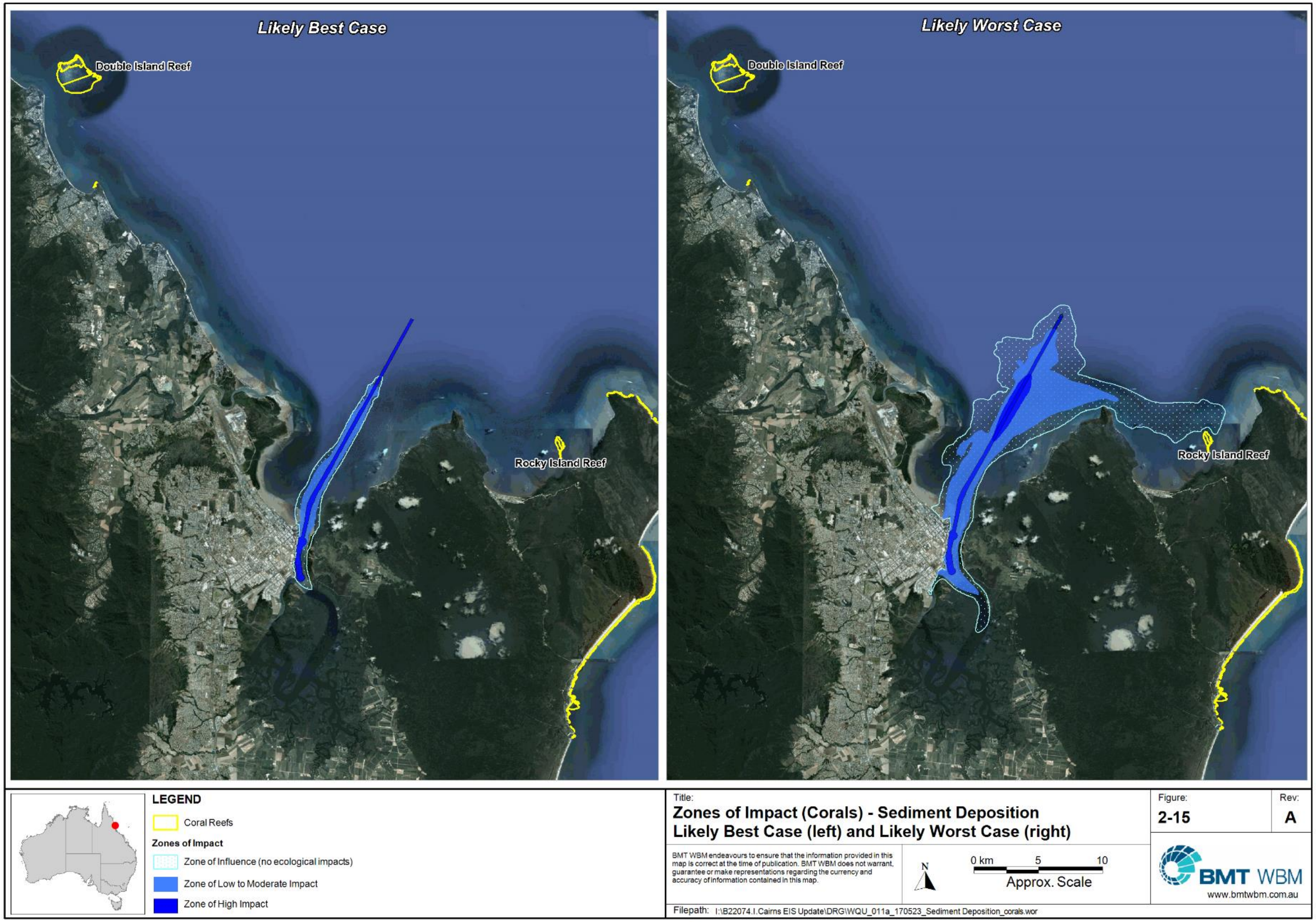


Figure B5-30 Zones of impact (corals) – sediment deposition.

B5.3.4.c Tailwater Impacts – Northern Sands DMPA

Dredge material placement is proposed to be placed at the Northern Sands dredge material placement area (DMPA). Dredge material will be pumped to shore via an enclosed pipeline from the dredge mooring and pump-out area to the Northern Sands DMPA located in the Barron River delta.

It is proposed that tailwater from the DMPA will be discharged into the Barron River via either of two discharge locations – Discharge Point A (adjacent to the DMPA) and Discharge Point B (near the Captain Cook highway bridge located approximately 2.5 km downstream of the DMPA).

For the tailwater modelling, it was assumed that tailwater would be discharged at a constant rate of 1 m^3/s, with a salinity of 35 ppt (or 35 PSU) and total suspended solids (TSS) of 100 mg/L (approximately equivalent to a turbidity of 60 NTU). Conservatively, only the likely worst case tailwater discharge scenario was modelled, which assumes the upper range of tailwater discharge volume based on the upper range of expected dredge material volumes.

To assess potential impacts to the Barron River and Thomatis / Richters Creek from tailwater discharges, model outputs were provided for turbidity and salinity, and are discussed in the following sections.

Turbidity

Contour Plots

Contour plots showing the changes to 50th percentile turbidity are presented on **Figure B5-31**. These contour plots represent changes to median turbidity (50th percentile) due to the tailwater discharges from both discharge options.

The 50th percentile contour plots indicate that the tailwater discharges are predicted to increase median turbidity by up to 4 NTU in a localised area within approximately 100 m of the discharge locations. Turbidity increases up to 3 NTU above median ambient turbidity are predicted to extend approximately 500 m upstream and downstream of Discharge Point A and approximately 200 m upstream and downstream of Discharge Point B.

Turbidity increases up to 1 NTU are predicted to extend up to the confluence with Thomatis / Richters Creek for Discharge Point A, and up to adjacent to the DMPA for Discharge Point B. While turbidity increases extend further downstream for Discharge Point B, median turbidity is not expected to increase at the mouth of the Barron River.

Zones of Influence

The significance of the tailwater discharges in terms of turbidity impacts is interpreted using zones of impact. These zones of impact are described in Appendix AJ (Marine Water Quality Impact Assessment), and are shown on **Figure B5-32** for both options for tailwater discharge. The zones of impact indicate that only a zone of influence is predicted in the Barron River for both discharge options. There are no zones of low to moderate impact, or zones of high impact, predicted in the receiving waters.

As shown on **Figure B5-32**, for Discharge Point A (adjacent to DMPA) the zone of influence extends up to the confluence with Thomatis / Richters Creek, but plumes do not extend into Thomatis / Richters Creek. For Discharge Point B (Captain Cook Highway bridge), the zone of influence extends up to the DMPA and down to near the mouth of the Barron River.

Overall, the difference between the two discharge options is minimal, with negligible impacts predicted for both options. With median ambient turbidity in the Barron River of approximately 20 NTU, a tailwater discharge of approximately 60 NTU, and the volume of discharge (1 m^3/s) compared to typical dry season Barron River flows (~ 5 m^3/s), these negligible impacts are not unexpected.

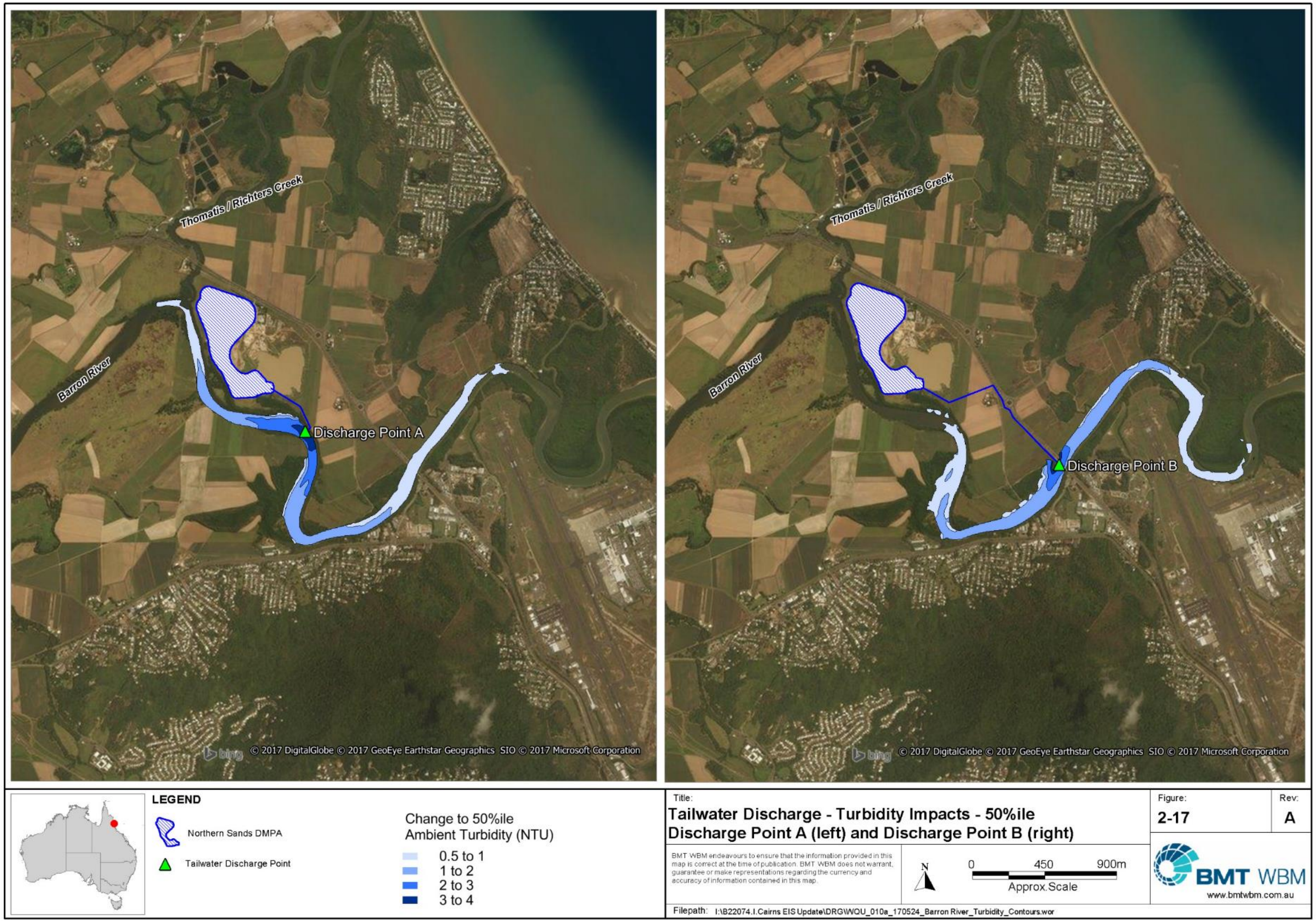


Figure B5-31 Tailwater impacts to 50th percentile turbidity – Discharge Point A (left) and Discharge Point B (right).

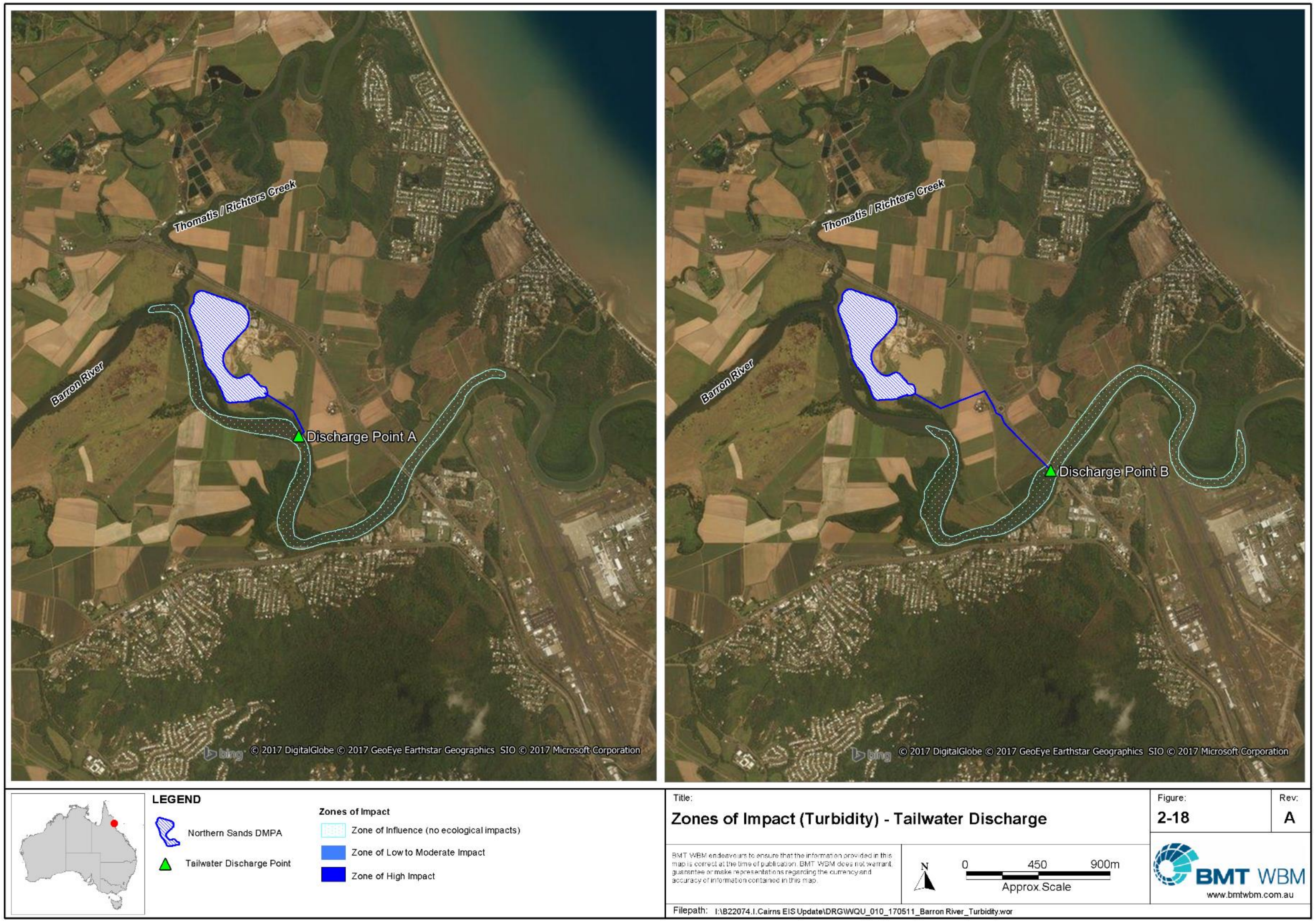


Figure B5-32 Zones of impact – turbidity – tailwater discharge.

Salinity

The significance of the tailwater discharges in terms of salinity impacts is interpreted using contour plots (showing the change to salinity due to tailwater discharges) and time series graphs.

Contour Plots

Contour plots showing the changes to 50th percentile salinity are presented on **Figure B5-33**, while contour pots showing the change to 99th percentile salinity are presented on **Figure B5-34**. These contour plots represent changes to 'typical' salinity (50th percentile) and changes to acute short-term maximum salinity (99th percentile) due to the tailwater discharges from both discharge options.

The 50th percentile contour plots (**Figure B5-33**) indicate that the spatial extent of predicted salinity changes would be similar between the two discharge options, with slight salinity changes up to the tidal limit in the Barron River (near Lake Placid Road), down past the Captain Cook Highway bridge, and down Thomatis / Richters Creek to the mouth.

For Discharge Point B, the change in 50th percentile salinity is expected to remain below 1 ppt for most areas, with an area (~2 km reach) near the discharge point where salinity is expected to be increase up to 2 ppt (**Figure B5-33**). For Discharge Point A, the change in 50th percentile salinity is expected to be up to 3 ppt in river reaches within approximately 1 km of the discharge point. Changes up to 2 ppt are expected approximately 2 km further upstream and downstream of the discharge point and down Thomatis / Richters Creek. The change in 50th percentile salinity is expected to remain below 1 ppt for remaining areas.

Discharge of tailwater from Discharge Point A is expected to change 99th percentile salinity by up to 3 ppt near the confluence with Thomatis / Richters Creek, up to 2 ppt in other areas upstream of the discharge point (approximately 3 km upstream), and less than 1 ppt in all other areas. Tailwater discharge from Discharge Point B is expected to change 99th percentile salinity by up to 2 ppt in areas upstream of the discharge point to the confluence with Thomatis / Richters Creek, and less than 1 ppt in all other areas.

The changes to salinity are less pronounced further downstream as the ambient salinity is higher in the lower reaches of the Barron River.

The significance of salinity changes requires an understanding of ambient salinity. That is, changes of 1-2 ppt for freshwater would be more significant than for brackish to saline waters. This is explored further using the time series graphs in the following section.

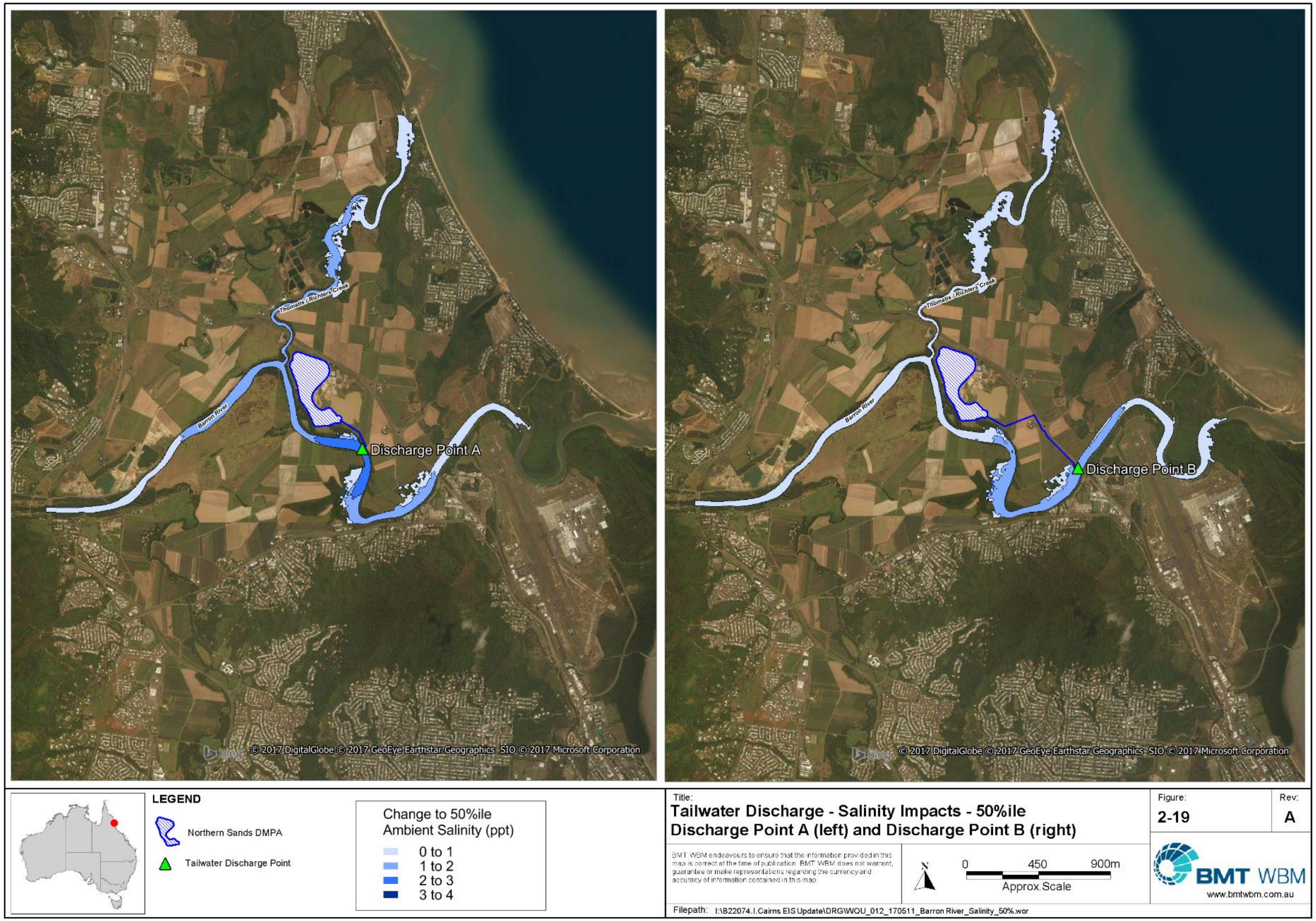


Figure B5-33 Tailwater impacts to 50th percentile salinity – Discharge Point A (left) and Discharge Point B (right).

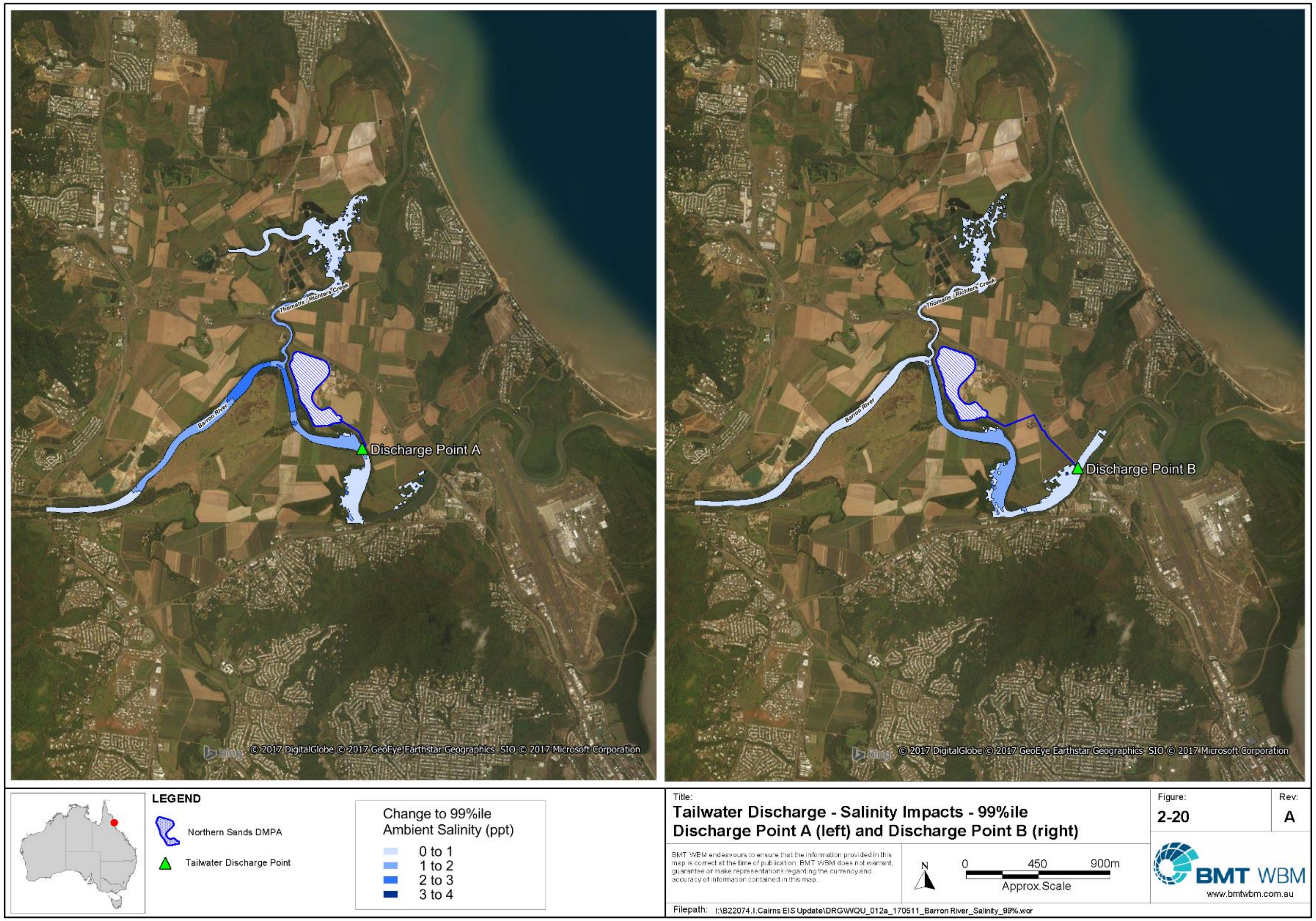


Figure B5-34 Tailwater impacts to 99th percentile salinity – Discharge Point A (left) and Discharge Point B (right)

Time Series Graphs

Time series graphs provide context to the predicted changes shown in the contour plots, as they show ambient salinity and tailwater discharge salinity at various points along the Barron River.

Time series data of ambient and tailwater salinity was extracted from the model at a number of locations in the Barron River and Thomatis / Richters Creek. This data was used to produce time series graphs showing surface salinity (top metre) and bottom salinity (bottom metre) from model simulation start to finish.

Time series graphs from all locations are included in Appendix AJ (Marine Water Quality Impact Assessment). These graphs indicate the following:

- In the upper Barron River, ambient salinity during the modelling period is up to around 8 ppt. Tailwater discharges are predicted to increase this salinity by less than 1 ppt for Discharge Point B and up to 2 ppt for Discharge Point A, representing an increase of approximately 13 % and 25% respectively.
- In the Barron River near Discharge Point A, ambient salinity is up to around 20 ppt. With tailwater discharges predicted to increase salinity by up to 2-3 ppt, this represents an increase of approximately 10-15%.
- In the Barron River near Discharge Point B, ambient salinity is up to around 30 ppt. With tailwater discharges predicted to increase this salinity by up to 2 ppt, this represents an increase of approximately 7%. Figure 2 24 illustrates these relatively minor increases in salinity at this location.
- In the lower reaches of the Barron River, where ambient salinity is typically around 30-35 ppt, increases in salinity due to tailwater discharges are almost imperceptible (less than 1 ppt), as illustrated in Figure 2 25.
- In the upper reaches of Thomatis / Richters Creek, ambient salinity is up to around 14 ppt. Tailwater discharges are predicted to increase this salinity by less than 1 ppt for Discharge Point B and up to 2 ppt for Discharge Point A, representing an increase of approximately 7 % and 14% respectively.

The time series graphs demonstrate that predicted salinity increases are relatively minor in the upper reaches of the Barron River and Thomatis / Richters Creek (increases of approximately 7% - 25%), and almost imperceptible in the lower reaches of the Barron River. Salinity changes further downstream are less pronounced as the ambient salinity is higher in the lower reaches of the Barron River. Conversely, salinity changes further upstream are more pronounced (although still relatively minor) as ambient salinity is lower in the upper reaches of the Barron River. For this reason, the discharge location further downstream (i.e. Discharge Point B) would pose the least risk to the salinity regime in the upper reaches of the Barron River and Thomatis / Richters Creek.

As can be seen in the time series graphs, the Barron River and Thomatis / Richters Creek are typically subjected to fluctuating salinity levels due to a strong tidal influence. Therefore, the relatively minor salinity increases from tailwater discharges pose minimal risk to the salinity regime of these waterways, particularly considering the short-term duration of tailwater discharge (~10 weeks). Furthermore, as dredging and tailwater discharges are proposed to occur during the dry season when there are less freshwater flows, ambient salinity would be expected to be higher. Tailwater salinity would therefore be likely to have less impact during this period.

Summary of Key Findings – Northern Sands DMPA Tailwater

In terms of turbidity impacts, the discharge of tailwater is expected to result in only a zone of influence in the Barron River for both discharge options. There are no zones of low to moderate impact, or zones of high impact, predicted in the receiving waters. The difference between the two discharge options is minimal, with negligible impacts predicted for both options.

In terms of salinity, the spatial extent of predicted salinity changes would be similar between the two discharge options. While tailwater discharge is predicted to increase salinity by about 1-3 ppt, this magnitude of increase is relatively minor in the upper reaches of the Barron River and Thomatis / Richters Creek (increases of approximately 7% - 25%), and almost imperceptible in the lower reaches of the Barron River.

Salinity changes further downstream are less pronounced as the ambient salinity is higher in the lower reaches of the Barron River, while salinity changes further upstream are more pronounced (although still relatively minor) as ambient salinity is lower in the upper reaches of the Barron River. For this reason, the discharge location further downstream (i.e. Discharge Point B) would pose the least risk to the salinity regime in the upper reaches of the Barron River and Thomatis / Richters Creek.

In summary, Discharge Point A poses the least risk in terms of turbidity impacts (due to the greater distance to the Barron River mouth) but greater risk in terms of upstream salinity impacts, while Discharge Point B poses a slightly higher risk in terms of turbidity but with a lower risk in terms of salinity.

In this context, it should be recognised that the Barron River and Thomatis / Richters Creek are typically subjected to fluctuating salinity levels due to a strong tidal influence and the relatively minor salinity increases from tailwater discharges (from both discharge options) pose minimal risk to the salinity regime of these waterways, particularly considering the short-term duration of tailwater discharge (~10 weeks).

Therefore, based on this assessment, the potential impacts to marine water quality from tailwater discharges from either of the discharge points (A or B) at the Northern Sands DMPA are expected to be short-term and **minor**.

B5.3.4.d Tailwater Impacts – Tingira Street DMPA

Stiff clays dredged using a backhoe dredge will be taken to the Tingira Street DMPA and mechanically placed without the need for tailwater discharges. Potential impacts from stormwater runoff from the Tingira Street DMPA site both during and following placement will be managed onsite through implementation of a stormwater management and erosion and sediment control plan. Assuming the implementation of this plan, the potential impacts to marine water quality within the Smiths Creek area from the use of the Tingira Street DMPA are expected to be short-term and **negligible**.

B5.3.4.e Dredge Mooring Point Impacts

Potential generation of turbid plumes at the dredge mooring point is discussed previously in **Section B5.3.4.a**.

There is potential for additional turbidity to be generated in the event of a dredge material spill at the mooring point, or a pipeline failure. It is expected that standard dredge operational measures (in the Dredge Management Plan) will minimise the likelihood of this occurring, and if it does, measures will be implemented to contain any spills. Therefore, the potential impacts are expected to be short-term and negligible.

B5.3.4.f Pipeline Crossing – Richters Creek

The onshore pipeline from the dredge pump-out to the Northern Sand DMPA is required to cross Richters Creek as shown on **Figure B5-35**.

It is proposed that the pipeline crossing would involve laying a submerged pipe on the bed of the creek. Installation would involve earthworks on each bank to create a ramp down to water level (to reduce any sharp/rapid bends in pipe). The pipe would be constructed on one side and then pulled (or floated and sunk depending on the length) across the creek and sunk onto the creek bed. The ramp will be approximately 10 m wide (plus batters) to allow for the pipe and access for earthmoving equipment.

During earthworks and installation of the pipeline, there is potential for increased turbidity due to disturbance of bed and bank sediments, and runoff from exposed soils during earthworks. For works such as these, standard practice is to install erosion and sediment controls. As such, the potential impact of increased turbidity in Richters Creek during these works should be short-term and negligible.

Due to the need for construction plant and equipment to install the pipeline across Richters Creek, there is potential that fuel/oil spills and other contaminants may pollute marine waters if not appropriately managed.

Dredge operators and construction contractors must, by law, comply with established fuel/oil storage and handling standards and protocols to reduce the risk of incidents. Appropriate operational procedures are included in the Dredge Management Plan (Chapter C2, Dredge Management Plan) which sets out management measures to reduce that the risk of fuel/oil spills and contaminants, and if they occur, how they are managed to minimise impact. The potential for fuel/oil spills presents a short-term negligible impact.

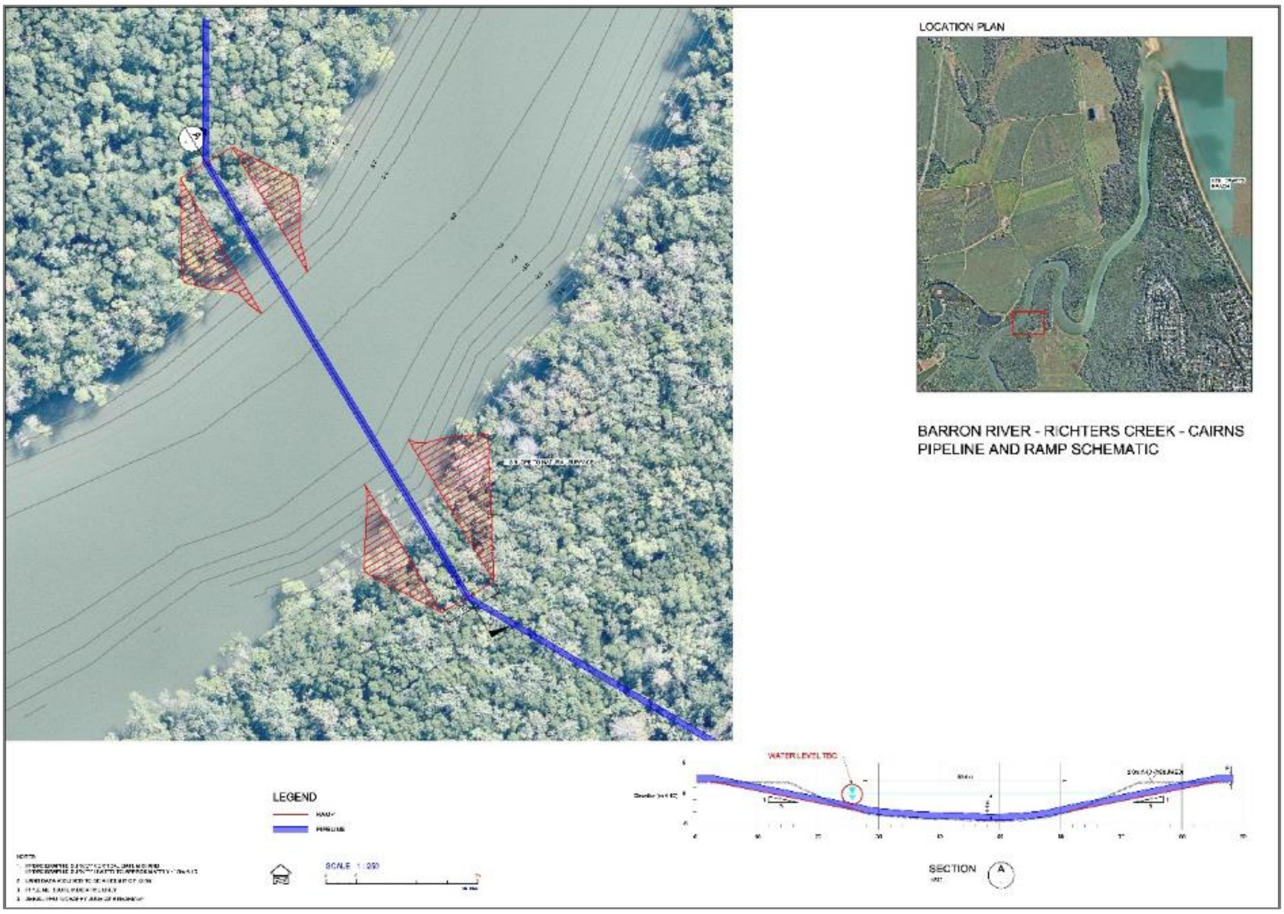


Figure B5-35 Sketch of prospective Richters Creek pipeline crossing.

B5.3.4.g Mobilisation of Contaminants from Capital Dredging

Mobilisation of contaminants such as nutrients and metals/metalloids is a potential impact which could result from disturbance or dredging of marine sediments. While sediment quality is discussed further in Chapter B4: Marine Sediment Quality, the mobilisation of contaminants into the water column from dredging is assessed in this report using pore water and elutriate testing results of sediments.

Pore water and elutriate concentrations of nutrients and metals/metalloids were analysed in additional sediment samples collected for the CSD Draft EIS (October 2013). These sites were located in the inner port dredge area, and include PWA (near Wharf 10), PWB (near Wharf 1) and PWC (Smith's Creek Swing Basin).

Pore water results

As an initial assessment, concentrations of contaminants in pore water were analysed. As stated in the National Assessment Guidelines for Dredging 2009 (NAGD), pore water is assumed to represent the major route of exposure to sediment contaminants by benthic organisms. Where pore water concentrations lie below the ANZECC/ARMCANZ (2000) marine water quality trigger values, it is considered unlikely that there would be adverse effects on such organisms.

In the case of nutrients, the key species of interest are ammonia and nitrogen oxides (NOx), which have associated toxicity trigger values. The toxicity trigger value for nitrate, which forms the main form of oxidised nitrogen, is 13 mg/L (assuming 95% protection of species). For ammonia, the toxicity trigger value currently specified in ANZECC/ARMCANZ (2000) is 0.9 mg/L. However, the trigger value for ammonia in estuarine and marine waters has been revised by Batley and Simpson (2009) with the addition of new data. A new trigger value of 0.46 mg/L was derived for slightly to moderately disturbed systems (95% protection).

The pore water results for nutrients (Appendix AJ - Marine Water Quality Impact Assessment) indicate that NOx pore water concentrations were below the trigger level and therefore pose a negligible risk. Ammonia pore water concentrations were elevated above the Batley and Simpson (2009) water quality trigger level of 0.46 mg/L at two out of three sample sites. However, for sediment pore water, Batley and Simpson (2009) recommended a trigger value of 3.9 mg/L, which was derived from the 80th percentile of background data from Sydney Harbour. As the pore water ammonia concentrations are well below 3.9 mg/L, ammonia is considered to pose short-term negligible impacts, especially considering elutriate testing results discussed in the following section.

The pore water results for metals/metalloids (Appendix AJ - Marine Water Quality Impact Assessment) indicates there were no dissolved metal/metalloid concentrations elevated above trigger levels in pore water in any of the sediment samples. These results indicate that metal/metalloids in pore water pose short-term negligible impacts.

Notwithstanding the negligible risk from contaminants in pore water as discussed above, this risk is further reduced due to the expectation that these pore water concentrations would become rapidly diluted during the dredging process. This dilution effect is assessed further with elutriate testing results discussed in the following section.

Elutriate results

The elutriate test investigates desorption of contaminants from sediment particulates to waters, and is designed to simulate release of contaminants from sediment typically during marine placement. However, as land placement is proposed for the project, elutriate test results are analysed in this section for release of contaminants from sediments during the dredging process.

Elutriate tests assess whether contaminant concentrations in the water column are likely to exceed relevant ANZECC/ARMCANZ (2000) water quality trigger values. NAGD (2009) states that the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values should not be exceeded after allowing for initial dilution, defined as ‘that mixing which occurs within four hours of dumping’. Initial dilution will depend on a number of factors, such as depth, layering in the water column, and current velocities and directions.

The elutriate results for nutrients and metals/metalloids (**Appendix AJ** - Marine Water Quality Impact Assessment) are well below the relevant water quality trigger levels. Therefore, the mobilisation of contaminants poses short-term negligible impacts to marine water quality.

B5.3.4.h Potential Acid Sulfate Soil Impacts from Capital Dredging

Disturbance and exposure of potential acid sulfate soils (PASS) in the dredge material can lead to water quality impacts from changes in pH if the material is allowed to oxidise. As discussed in Chapter B4: Marine Sediment Quality, potential ASS is expected to be present in the very soft to soft clay and silt materials below a sediment depth of approximately one metre (the top one metre had shell or other neutralising material). The PASS volume represents approximately ~250,000 to 320,000 m^3 of the proposed dredge volume, with the remaining material (~460,000 to 580,000 m^3) expected to be self-neutralising material.

PASS material (that is not self-neutralising) will potentially release acidity if exposed to air for extended periods. Under normal operating conditions of the TSHD, the dredge material remains waterlogged in the hopper for a matter of hours, therefore the risk of oxidation is negligible. At the TSHD dredge pump-out location, the dredge material will be pumped via enclosed pipeline into a void filled with water, ensuring the dredge material is waterlogged at all times.

PASS will be managed in the Northern Sands DMPA such that tailwater discharges into the Barron River are at a neutral pH with short-term negligible impacts. Further details on how the PASS will be managed in the Northern Sands DMPA are discussed in **Chapter B1** (Land).

B5.3.4.i Dredging and Construction Plant and Equipment

Upgrade to the wharf infrastructure will involve installation of independent dolphins requiring steel piles. These piles will be driven by a piling rig with crane and hammer from a barge. It is proposed there will be 21 independent dolphins, each requiring four piles. Therefore, 84 piles need to be installed during construction.

Due to the need for construction plant and equipment to upgrade the wharf infrastructure, and the use of dredging plant and equipment for the dredging works, there is potential that fuel/oil spills and other contaminants may pollute marine waters if not appropriately managed.

Dredge operators and construction contractors must, by law, comply with established fuel/oil storage and handling standards and protocols to reduce the risk of incidents. Appropriate operational procedures are included in the Construction Management Plan (**Chapter C1** (Construction Environmental Management Plan)) and the Dredge Management Plan (**Chapter C2** (Dredge Management Plan)) which sets out management measures to reduce that the risk of fuel/oil spills and contaminants, and if they occur, how they are managed to minimise impact. The potential for fuel/oil spills as part of the construction phase of the project presents a short-term negligible impact.

B5.3.5 Operational Phase Impacts

Potential impacts on the marine environment associated with the upgraded wharf will be addressed and mitigated with the implementation of the port's Environmental Management System for port operational activities. Further details are provided in the following sections for shipping operations and maintenance dredging, as these operations are considered to be two key areas with the potential to impact marine waters during the operational phase of the project.

B5.3.5.a Increased Shipping

Once operational, the most optimistic (best case) forecasts as part of the Demand Study Update for the project (**Appendix H**) is that cruise shipping activity will increase from 64 current cruise ship visits in 2016 to 150 cruise ship visits by 2031 even without the channel improvements and fuel provision afforded by the CSDP.

If the CSDP is approved and constructed, the channel and fuel provision upgrades will lead to a predicted 183 ship visits per year by 2031 (approximately 33 additional ships). However, it should be noted that a much larger number of these overall ships (183) will be able to access Trinity Wharves compared to the current situation where many of these vessels are only able to moor offshore from Yorkey's Knob.

The increase in shipping and refuelling activity may increase the potential for shipping-related contaminants to enter the marine environment. Current and increased shipping operations may introduce contaminants from:

- hydrocarbons, from refuelling or vessel sourced discharges
- ballast water
- antifouling systems
- black water and grey water release
- other wastewater
- airborne contaminants from exposed materials entering the water column
- solid waste such as packaging materials.

Ballast water, antifouling, waste and wastewater are regulated by the following conventions and legislation which vessels operating in Australia need to comply with:

- International Obligations:
  - *Convention for the Prevention of Pollution from Ships 1973*
  - *Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (London Convention) 1972*
  - *Convention on the Control of Harmful Antifouling Systems on Ships (IMO-AFS Convention) 2001*
  - *Convention for the Control and Management of Ship's Ballast Water and Sediments 2004.*

- Commonwealth Legislation:
  - *Biosecurity Act 2016 for management of introduced pests in ballast water, managed by the Department of Agriculture*
  - *Environment Protection (Sea Dumping) Act 1981.*
- State Legislation:
  - *Environmental Protection (Waste Management) Regulation 2000, and Environmental Protection (Water) Policy 2009*
  - *Transport Operations (Marine Pollution) Act 1995 and Transport Operations (Marine Pollution) Regulation 2008*
  - *Maritime Safety Queensland Act 2002.*

On 1 July 2001, Australia introduced mandatory ballast water management requirements to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ballast water from international vessels. These requirements are enforceable under the *Quarantine Act 1908*. The requirements are consistent with the International Maritime Organisation (IMO) Ballast Water Convention 2004 that aims to minimise the translocation of harmful aquatic species in ships' ballast water and ballast tank sediments.

The discharge of high-risk ballast water in Australian ports or waters is prohibited. All internationally plying vessels intending to discharge ballast water anywhere inside the Australian territorial sea must manage their ballast water in accordance with Australia's mandatory ballast water management requirements. This would apply to all international cruise ships visiting the Port of Cairns.

In Queensland's jurisdiction, the international conventions are given force through the *Transport Operations (Marine Pollution) Act 1995* and *Regulation 2008*, which aim to protect Queensland's marine and coastal environment from the adverse effects of ship-sourced pollution. Section 93A(2) of the Act appoints the General Manager, MSQ, as the Marine Pollution Controller to direct the marine pollution response in Queensland coastal waters. Other relevant Queensland legislation is the *Maritime Safety Queensland Act 2002* which establishes MSQ and empowers it to 'deal with the discharge of ship sourced pollutants into Queensland Coastal Waters'.

Fuel handling and storage procedures are currently part of the port's existing port operational activities. These procedures will be reviewed and revised as necessary to accommodate the change in shipping and Intermediate Fuel Oil (IFO) refuelling activity resulting from the project as well as the additional volume of ships that will be potentially using the port for fuel bunkering.

Modelling of potential oil spills associated with operational shipping activities was undertaken by APASA (2014). This study indicated that oil spills from operational shipping activities pose a very low to insignificant risk.

Assuming these procedures are effectively updated and implemented, the potential for introduced contaminants from increased shipping presents a long-term **minor** impact from the current situation. Mitigation of these potential impacts will be addressed by compliance with the above legislation administered by the above authorities, and implementation of the port's operational procedures.

B5.3.5.b Future Maintenance Dredging

Future maintenance dredging will be needed to ensure the shipping channel and inner port remains at the required depths for safe navigation of ships. As outlined in the Chapter B3 Coastal Processes, the widening and deepening of the outer channel will result in an increase in annual maintenance dredging volume in the order of 2-6%. The existing annual maintenance dredging volume or the inner port is not likely to change significantly as a result of the project as this area does not accumulate sediment as rapidly as the outer channel.

Channel maintenance dredging campaigns typically occur during the months of July and August and generally take about four weeks. On average, approximately 350 000 m^3 of *in-situ* material is dredged annually from the outer channel by a trailer suction hopper dredge (TSHD), while approximately 40 000 m^3 of *in-situ* material is dredged annually from the inner port using a grab bucket dredge. The additional volume associated with the expanded channel will likely extend these campaigns by a period of 1 to 3 days.

Modelling Assessment

To assess impacts from future maintenance dredging requirements, maintenance dredging and material placement simulations were performed for a maintenance dredging campaign with an increased volume of 6% above the average maintenance volume. Modelling was also performed with a subsequent 12-month re-suspension period following dredging. The results are presented in **Appendix AJ** (Marine Water Quality Impact Assessment) as zones of impact maps for dredging and placement at the existing DMPA and the 12-month resuspension period following placement at the existing DMPA. The zones of impact figures indicate the following:

- Increases in turbidity as a result of maintenance dredging and placement at the existing DMPA are not predicted to result in any 'zones of low to moderate impact', or 'zones of high impact'. In other words, turbidity is expected to remain within natural variability (i.e. maintaining 20^{th}, 50^{th} and 80^{th} percentiles of natural turbidity).
- There is a 'zone of influence' extending out from the channel dredging area to the north-west up past Double Island and Palm Cove to Wangetti, and east out to Cape Grafton. While this zone indicates the predicted extent of detectable plumes, the turbidity in this zone is predicted to remain within natural variability and therefore ecological impacts are not predicted to occur.
- For dredge material placement at the existing DMPA, a 'zone of influence' is predicted to extend approximately 5 km north-west and 2 km south-east of the existing DMPA.
- 12 months following dredging, re-suspension from the existing DMPA is predicted to result in a 'Zone of Influence' extending approximately 15 km the north-west and 5 km to the south-east. Note that most placed material remains at the DMPA.

Compared to capital dredging, smaller volumes of material are involved in maintenance dredging and the timeframes over which dredging will occur will be shorter. Impacts from maintenance dredging are considered to be localised and relatively short term, with limited increases in turbidity adjacent to sensitive environments. Previously, impacts on sensitive receptors from maintenance dredging have been assessed as being acceptable to regulatory agencies (as outlined in the Ports North 10-year maintenance dredging permit and LTMP).

While there is ample capacity at the existing approved DMPA for the maintenance dredging requirements associated with the project, a future alternative marine DMPA in deeper waters adjacent to the existing site has also been investigated as part of the revised draft EIS. As outlined in Chapter B3 Coastal Processes, this alternative site in deeper waters could be used once the existing site has reached capacity. As outlined in Chapter B3, the alternative DMPA site has very high (99.9%) retention rates of placed material as a result of its depth, further limiting the resuspension of the placed material in the long term.

Review of Monitored Data

To further assess potential impacts from maintenance dredging, water quality monitoring data was reviewed. Water quality monitoring for the Draft EIS was undertaken between July 2013 and July 2014 at a number of locations (BMT WBM 2014). During this monitoring period, annual maintenance dredging was undertaken (between 21 July 2013 and 17 August 2013). The monitoring data was assessed to determine if any discernible impacts due to maintenance dredging could be observed. The time series turbidity data, along with the maintenance dredging period, is presented in Appendix AJ (Marine Water Quality Impact Assessment).

The monitoring data indicates that all monitoring sites had a similar spike in turbidity which coincided with the commencement of maintenance dredging. However, during this period there were high winds and a spring tide. Once these high winds and spring tides abated, turbidity at all sites was greatly reduced, even while maintenance dredging continued. This indicates that turbidity measured at the six sensitive receptor locations is likely to have been driven primarily by weather events as opposed to any detectable effect of maintenance dredging plumes. This confirms the above-mentioned conclusion that turbid plumes from maintenance dredging are localised and short-term, and were not observable in the monitoring data at sensitive receptor locations.

Based on the above modelling and monitoring assessments, turbid plumes from future maintenance dredging are considered to pose a long-term minor impact to marine water quality.

In terms of potential mobilisation of contaminants from sediment during future maintenance dredging, it is expected that a sediment sampling and analysis plan (SAP) will be developed and implemented to determine the suitability of future maintenance dredge material for marine placement, as is the present process. Any contaminated material detected in future testing will need to be investigated and managed under the NAGD and sea dumping permit process. As such, mobilisation of contaminants from future maintenance dredging is expected to pose a long-term negligible impact to marine water quality.

B5.3.6 Cumulative Dredging Assessment

Due to capacity limitations of the Northern Sands DMPA, it is preferred that any overlying maintenance dredge material that is present in the channel prior to the capital dredge campaign is not placed into the Northern Sands DMPA. Therefore, it is likely that a maintenance dredging campaign will be undertaken immediately prior to the capital dredging campaign to remove this overlying material.

As such, a cumulative dredging assessment was undertaken whereby model outputs from a typical maintenance dredging campaign were assessed together with model outputs from the capital dredging campaign. This was undertaken using zones of impact for water quality, with the zones from maintenance dredging and the zones from capital dredging displayed on the one impact zone map (**Figure B5-36**). The rationale being that if there are any impact zones due to maintenance dredging, these zones may be present once capital dredging commences and have a cumulative impact on water quality.

As discussed in **Section B5.3.5.b**, maintenance dredging is not expected to result in any zones of impact beyond the zone of influence, which indicates the predicted extent of detectable plumes but the turbidity in this zone is predicted to remain within natural variability. The zone of influence for maintenance dredging in the nearshore environment is similar to the capital dredging, extending out from the channel dredging area to the north-west up past Double Island and Palm Cove to Wangetti, and east out to Cape Grafton. The only significant difference between capital and maintenance dredging in terms of the zone of influence is due to dredge material placement at the existing DMPA during maintenance dredging. This results in a zone of influence extending approximately 10 km north-west and 2 km south-east of the existing DMPA (**Figure B5-36**).

As the turbid plumes generated from maintenance dredging are only expected to result in a zone of influence, it is expected that any residual turbidity still in the system once capital dredging commences is relatively insignificant. Therefore, the potential impacts from the cumulative dredging scenario are expected to be similar to that for the capital dredging scenario discussed in previous sections, with the addition of a zone of influence in the offshore environment due to placement at the existing DMPA during maintenance dredging. However, the plumes from placement of maintenance dredge material at the existing DMPA are likely to be short-term and will have dissipated prior to commencement of capital dredging.

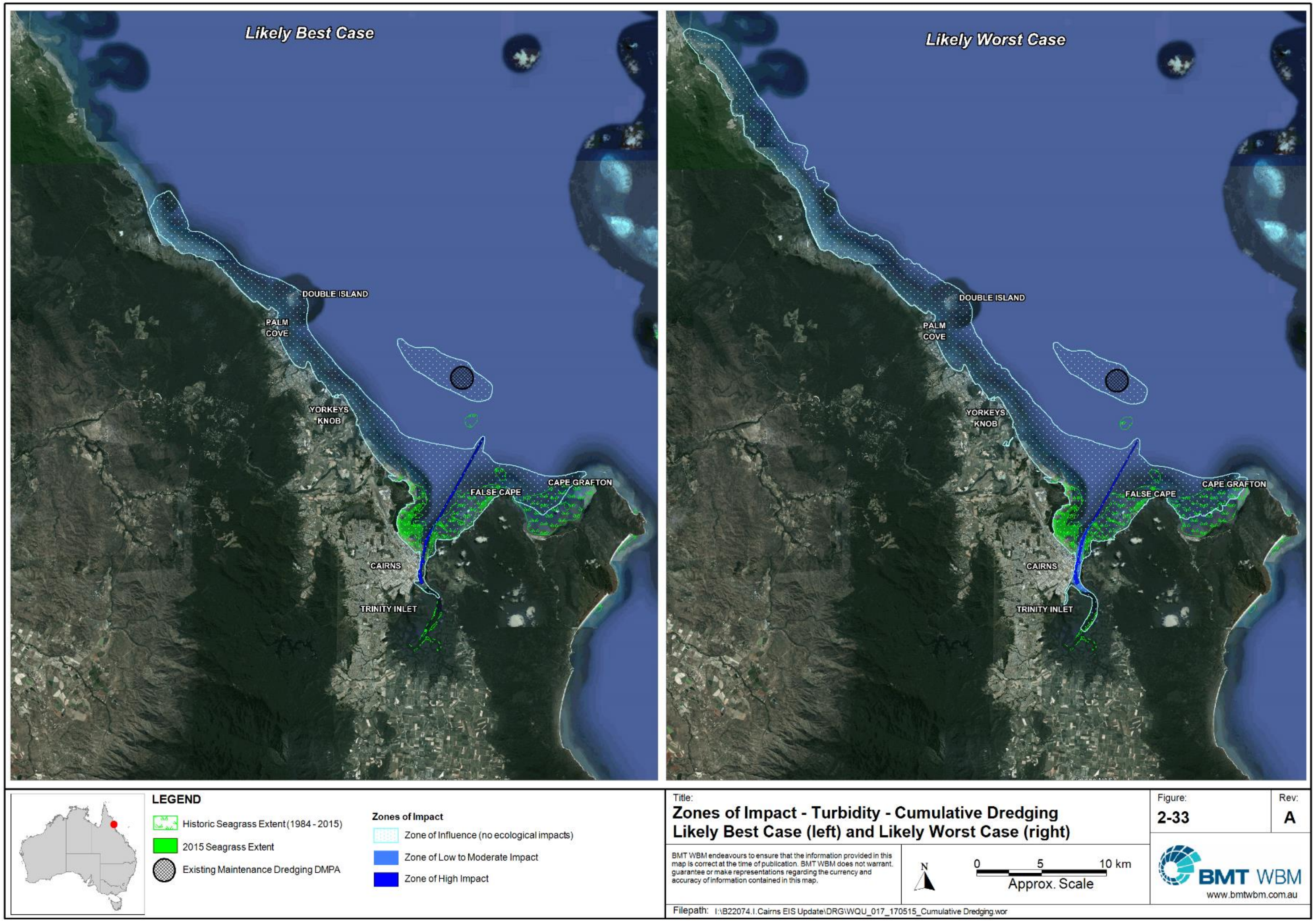


Figure B5-36 Zones of impact – turbidity – cumulative dredging.

B5.4 Recommended Mitigation Measures

The mitigation measures listed in this section are also included in **Chapter C2** (Dredge Management Plan).

B5.4.1 Mitigation Measures – Construction Phase

B5.4.1.a Capital Dredging

In this impact assessment, it has been assumed that a number of standard mitigation or best practice measures will be employed to minimise potential turbidity impacts generated by capital dredging works. These standard mitigation measures are as follows:

- Ensure the dredge operates within the approved dredge footprint at all times.
- Overflow dredging (dredging after a full hopper load has been achieved) by the TSHD is undertaken in accordance with the overflow regime detailed in Chapter C2, Dredge Management Plan.
- Dredge hopper compartment is to be kept water tight during all dredging activities.
- Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle (dredging area to pump-out location).
- The dredge is to be fitted with a 'green valve' in order to minimise the areal extent of turbidity plumes generated by dredge operation. The 'green valve' ensures that overflow from the dredge vessel is released under the keel of the vessel rather than at the water surface and with minimal energy.
- Washing the hopper compartment and pumping out of the hopper must not take place outside the pump-out location.
- Further to the above standard mitigation measures, a reactive water quality monitoring program will be implemented to reduce the potential impacts further. The reactive water quality monitoring program will involve the following:
    - The monitoring program will be implemented during the dredge campaign to monitor water quality at locations of sensitive receptors (including similar monitoring locations to those used in the impact assessment section).
    - Monitoring data will be collected and downloaded regularly and the data assessed against threshold triggers, with appropriate management actions implemented if threshold triggers are exceeded.
    - The monitoring program will be used in real time to guide the dredging campaign and to monitor the effectiveness of the above mitigation measures. If trigger levels are exceeded, the dredge contractor will be responsible for taking actions, in consultation with Ports North, to ensure impacts are avoided at sensitive receptors.
    - The reactive water quality monitoring program is detailed further in **Chapter C2** (Dredge Management Plan).

As demonstrated in the 'Potential Impacts' section, potential impacts from other parameters (e.g. nutrients and metals) in sediment are negligible and no mitigation measures are required.

B5.4.1.b Tailwater Discharges from Northern Sands DMPA

It is assumed that appropriate management controls will be implemented within the DMPA such that tailwater discharges do not exceed specified water quality criteria, as follows:

- 48-hour rolling average TSS does not exceed 100 mg/L.
- 14 day rolling average TSS does not exceed 50 mg/L.

To further mitigate potential turbidity and salinity impacts in the Barron River, monitoring of sites within the Barron River will be undertaken as part of the reactive water quality monitoring program discussed in the previous section and detailed in **Chapter C2** (Dredge Management Plan).

B5.4.1.c Pipeline Crossing at Richters Creek

Standard mitigation measures are to be implemented to reduce the risk of increased turbidity and other contaminants entering the marine waters, including:

- Appropriate erosion and sediment controls installed around earthworks associated with the pipeline crossing works.
- To reduce the risk of fuel/oil spills from construction plant and equipment, standard procedures are included in **Chapter C2** (Dredge Management Plan).

B5.4.1.d Potential Acid Sulfate Soil (PASS) Impacts from Dredging

It is assumed that the following standard mitigation measure will be employed to minimise potential impacts from oxidisation of PASS dredge material:

- Dredge material should ideally remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidisation.

B5.4.1.e Dredging and Construction Plant and Equipment

Standard operational mitigation measures are to be implemented to reduce the risk of fuel/oil spills and other contaminants entering the marine waters, including:

- Development and Implementation of a Dredge Management Plan (in accordance with **Chapter C2** (Dredge Management Plan)) which includes management measures to be followed by dredge staff. This document is to be kept as on-board dredge equipment and readily accessible to dredge staff
- A hydrocarbon spill kit is to be located on the dredge and transport barges. This spill kit is to contain such items as absorbent material for spills on deck and also floating booms to contain hydrocarbon slicks if spills manage to enter the water. This spill kit is to be maintained regularly to ensure contents are fully stocked and in good condition
- Consistent with present practice, first strike spill response equipment and appropriately trained staff for the port are accessible and able to respond to events, and have access to more spill response resources if the event escalates
- All fuel and chemical supplies on the dredge and transport barges are to be stored in bunded areas as per the requirements of AS1940:2004 - The storage and handling of flammable and combustible liquids 2004, and applicable WHS Act requirements.

B5.4.2 Mitigation Measures – Operational Phase

B5.4.2.a Future Maintenance Dredging

It is assumed that the following standard mitigation measures will be employed to minimise potential impacts from future maintenance dredging:

- Preparation and implementation of a sediment sampling and analysis plan (SAP) to determine suitability of future maintenance dredge material for marine placement consistent with GBRMPA requirements (noting maintenance material at Port of Cairns has always been suitable for at sea placement).
- Any contaminated material detected in future testing will be assessed and investigated to determine suitability and management options under the NAGD and sea dumping permit process.
- Existing maintenance dredging operations occur in accordance with Sea Dumping and Marine Park permit conditions including the approved Long Term Dredge Spoil Disposal Management Plan (LTDSDMP) which contains management measures to reduce impacts on water quality from dredging and placement. This plan will be reviewed and updated in consultation with the established TACC for approval by the Determining Authority. This process will likely occur in parallel with a process to resolve a new Sea Dumping and Marine Park Permit.

Further to the above standard mitigation measures, the following additional mitigation measures are proposed to reduce the potential impacts further:

- Update the Sea Dumping and Marine Parks Permits and associated LTDSDMP to address the additional volumes and duration of maintenance dredging required by the wider channel.

B5.4.2.b Increased Shipping

It is assumed that compliance with relevant legislation in regard to shipping will be employed as part of standard mitigation measures. To further reduce the potential future risk to marine water quality from refuelling activities associated with the provision of IFO at the port, additional mitigation proposed includes revision of fuel handling and spill response procedures in the port's operational procedures.

B5.4.3 Monitoring

Water quality monitoring during the construction phase of the project will be undertaken in accordance with the reactive monitoring programs described above and detailed in **Chapter C2** (Dredge Management Plan). This will also include several validation monitoring programmes to ensure that predicted impacts modelled in the Revised Draft EIS can be demonstrated to be an accurate prediction of actual impacts during operation.

B5.5 Residual Impacts and Assessment Summary

Table B5-29 summarises the marine water quality issues identified by the impact assessment in the previous sections. This assessment table also includes the significance of each of the identified impacting processes, the likelihood of the impact occurring, and the resulting risk rating.

The standard and additional mitigation measures discussed in previous sections are also summarised in **Table B5-29**, with a risk rating indicated for the residual impacts after mitigation. As indicated in this assessment table, all residual impacts are rated as either a low or negligible risk.

Construction phase residual impacts would be short-term (up to one year) in duration, while operational phase residual impacts would be long-term in duration extending over the life of the project.

TABLE B5-29 RISK ASSESSMENT SUMMARY – MARINE WATER QUALITY

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Primary impacting processes	**Statutory mitigation measures required**	**Consequence of impact**	**Likelihood of impact**	**Risk rating**	**Additional mitigation measures proposed**	**Consequence of impact**	**Likelihood of impact**	**Residual Risk rating**
Construction Phase								
Generation of turbid plumes and sediment deposition from capital dredging	• Ensure TSHD dredge operates within the approved dredge footprint at all times. • Overflow dredging by the TSHD is undertaken in accordance with the overflow regime in the Dredge Management Plan. • Dredge hopper compartment is to be kept water tight during all dredging activities, except emptying and washing of hopper at the pump-out location. • Ensure the top of overflow valves are not lowered during the transport component of the dredging cycle • No high pressure jets to be used on drag heads outside of the dredge footprint • Dredge to be fitted with a 'green valve'	Minor	Possible	Low	• Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C) • Implementation of validation water quality monitoring programmes to demonstrate accuracy of impact predictions and modelling	Minor	Unlikely	Low
Cumulative dredging - maintenance dredging followed by capital dredging	• Same as above	Minor	Possible	Low	• Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C)	Minor	Unlikely	Low

(Continued over)

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
Generation of turbid plumes and increased salinity from tailwater discharges from the Northern Sands DMPA	• Tailwater discharges from the Northern Sands DMPA do not exceed specified water quality criteria.	Minor	Possible	Low	• Implementation of a reactive water quality monitoring program, with management/corrective actions implemented if trigger levels are exceeded (as outlined in the Dredge Management Plan in Part C)	Minor	Unlikely	Low
Pipeline crossing of Richters Creek	• Installation of erosion and sediment controls on land	Negligible	Possible	Negligible	Nil	Negligible	Possible	Negligible
Mobilisation of contaminants into water column	• Dredge material has been assessed as being uncontaminated (as described in Chapter B4)	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Oxidisation of potential acid sulphate soil material	• Risks of oxidation are negligible assuming placement of the dredged material in waterlogged void • Dredge material should ideally remain waterlogged and not be left within TSHD hopper or dump barges for periods longer than 24 hours to minimise the risk of PASS oxidisation in the hopper.	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Dredging and construction plant and equipment	• Development and implementation of a Dredge Management Plan by the Contractor (in accordance with the DMP contained in Part C). • Hydrocarbon spill kit is to be located on the dredge and transport barges. • First strike spill response equipment and staff are accessible and able to respond to events, and have access to more spill response resources if the event escalates.	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible

Marine Water Quality	Initial assessment with standard mitigation (e.g. statutory compliance) in place				Residual assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment)			
	• All fuel and chemical supplies to be stored appropriately.							
Operational Phase								
Increased shipping	Compliance with relevant legislation	Minor	Possible	Low	• Revise fuel handling and spill response procedures in the Port's operational procedures	Minor	Unlikely	Low
Future maintenance dredging – mobilisation of contaminants into water column	• Preparation and implementation of a sediment sampling and analysis plan (SAP) to determine suitability of future maintenance dredge material for marine placement (noting maintenance material at Port of Cairns has always been suitable for at sea placement) • Any contaminated material detected in future testing will be assessed and investigated to determine suitability and management options under the NAGD and sea dumping permit process	Negligible	Unlikely	Negligible	Nil	Negligible	Unlikely	Negligible
Future maintenance dredging – water quality from dredge plumes	• Existing maintenance dredging operations occur in accordance with an approved LTDSDMP which contains management measures to reduce impacts on water quality from dredging and placement	Minor	Possible	Low	• Update the LTDSDMP to address the additional volumes and duration of maintenance dredging required by the wider channel	Minor	Possible	Low

B5.6 References

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