APPENDIX 5

ARROW LNG PLANT

Marine Water Quality
- Part A: Marine Water Quality Report

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Arrow LNG Plant Supplementary Report to the EIS

Part A: Marine Water Quality Report

Scott Wilson, Amie Anastasi, Mackenzie Hansler, Bronson Stoneham, Morgan Payne and Dylan Charlesworth

December 2012

Please note: This report is broken into two sections.

Part A: Marine Water Quality

Part B: Marine and Estuarine Ecology

This section contains Part A only

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Arrow LNG Plant Supplementary Report to the EIS

Part A: Marine Water Quality Report

Prepared for Coffey Environments (Pty) Ltd on behalf of Arrow CSG (Australia) Pty Ltd (Arrow Energy)

December 2012

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Executive Summary

A marine water quality data review and consequent water sampling programme was undertaken to update the baseline water quality data for the Calliope River and relevant sites in Port Curtis as reported in the Arrow LNG Plant Environmental Impact Statement (EIS). The findings will inform the Supplementary Report to the EIS (SREIS) being prepared for the project. Sampling was focused around the proposed LNG jetty site, Boatshed Point swing basin, access channel and material offloading facility (MOF) sites, launch site 1 and associated dredging areas (including the Calliope River), immediately offshore from the mainland tunnel launch site, and the outfall site at Boatshed Point. The data review highlighted that despite recent reports, the need for more fine scale spatial and temporal water quality data was required particularly relating to tidal and lunar phase patterns.

A water quality sampling programme was conducted in line with the previous water quality monitoring undertaken for the Arrow LNG Plant EIS and included total metals, nutrients and physico-chemical parameters. Samples were collected and sent for chemical analysis or measured *in situ*, where possible. The programme involved sampling over a low, mid and high tide sequence at consecutive neap and spring lunar phases in August 2012. Metals and nutrients were measured at top and bottom of the water column while physico-chemical parameters were measured every 0.5m in depth profiles.

Findings indicate that there were few metals elevated above project water quality guideline values. Copper was the exception, exceeding the guidelines in approximately a quarter of all samples. Metals were found to be in greater concentration during the spring tide sampling than at the neap tide and more prevalent at sites around Hamilton Point and Boatshed Point than at the tunnel launch site sites which were in turn greater than those in the Calliope River.

Nutrients were generally below levels of reporting and there were no observable trends between tides or between neap and spring sampling periods. The upper Calliope River recorded the highest levels for most nutrients and the greatest number of guideline exceedances. There was little difference in nutrients across the lower Calliope River, tunnel launch site and Hamilton Point and Boatshed Point areas.

For the physico-chemical measures pH, turbidity and chlorophyll-*a* were the main parameters that exceeded guideline levels. There were greater exceedances in the harbour sites than in the Calliope River sites but few trends between tidal patterns could be discerned. The upper Calliope River sites indicated lower levels of salinity,

pH and dissolved oxygen in line with reduced tidal range and flushing. Depth profiling across all sites revealed little change with depth indicating a well-mixed system at the time of sampling.

The data collected during this water sampling programme both spatially and temporally overall adds to the current baseline of information for the areas relevant to the Arrow LNG Plant activities. The findings indicate differences in spring and neap tide results that should be considered in future sampling programmes. Likewise, future monitoring should include tidal height and top/bottom differences in water quality which were found in this study to be present for some parameters and locations however for the most part the findings are indicative of a well-mixed system at the time of year the sampling was conducted.

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Introduction

Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) plant on Curtis Island off the Central Queensland coast, near Gladstone. The project, known as the Arrow LNG Plant, is a component of the larger Arrow LNG Project which incorporates the upstream coal seam gas field developments and transmission gas pipelines.

An environmental impact statement (EIS) has been prepared for the project under Part 4 of the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act) and s. 133 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act). Coffey Environments Australia Pty Ltd (Coffey Environments), a subsidiary of Coffey International Pty Ltd, was commissioned to assist Arrow Energy in the preparation of the Arrow LNG Plant EIS. The EIS will inform a decision on whether the project should proceed and, if so, under what conditions. The EIS went on public exhibition on 16 April 2012, with submissions closing on 28 May 2012. Arrow Energy is required to prepare a supplementary report to the EIS to respond to comments raised in submissions on the EIS.

Coffey Environments has been engaged to prepare the supplementary report to the EIS. The supplementary report will describe any changes made to the project description since the EIS was finalised and assess the implications of the changes on the impacts of the project identified and assessed in the EIS. It will also address any additional data requirements identified in the EIS and respond to comments made in submission to the EIS.

The following report is a response to the brief provided by Coffey Environments that described the relevant works completed to date and the changes in the design, layout and dredging requirements for the MOF, mainland launch site, LNG jetty and mainland tunnel launch site. Broadly the report addresses the need for further marine water quality monitoring in the project area to update the water quality baseline and to identify any characteristics that may have changed since the submission of the EIS.

Objectives

The objective of the study was to update the estuarine and marine water quality baseline data in the Arrow LNG Plant project area since the submission of the EIS. The specific objectives are as follows:

(a) To undertake a data review and analysis of marine water quality reports and data since the submission of the Arrow LNG Plant EIS;

(b) To design and conduct a water quality sampling program to meet identified data needs; and

(c) To interpret collected water quality data and update baseline.

Project Marine Water Quality Criteria

Project marine water quality criteria were developed for the Arrow LNG Plant EIS and based upon:

- Queensland Water Quality Guidelines 2009.
- ANZECC/ARMCANZ Australian and New Zealand guidelines for fresh and marine water quality 2000.
- Queensland Environmental Protection (Water) Policy 2009.

The resulting project marine water quality criteria, based on guidelines and policies, and against which water quality in this report is compared, is shown in Table 1. A full description of how these criteria were developed is provided in Chapter 16 of the Arrow LNG Plant EIS.

The application of project marine water quality guidelines for this assessment does not indicate that these guidelines will be applicable through the life of the project. Specific criteria may be applied through conditioning associated with other statutory vehicles such as dredge management plans or environmental authorities.

Table 1: Marine project water quality criteria

Parameter	Target			Source
	Unit	**Port Curtis (Enclosed Coastal Waters)**	**Calliope River (Mid-estuarine Waters)**	
Physicochemical and Nutrients				
Ammonia nitrogen	µg/L	8	10	Queensland Water Quality Guidelines
Oxidised nitrogen	µg/L	3	10	
Organic nitrogen	µg/L	180	260	
Total nitrogen	µg/L	200	300	
Filterable reactive phosphorous	µg/L	6	8	
Total phosphorous	µg/L	20	25	
Chlorophyll *a*	µg/L	2	4	
Dissolved oxygen	% saturation - lower limit	90	85	Queensland Water Quality Guidelines
	% saturation - upper limit	100	100	
Turbidity	NTU	6	8	
Light penetration	Secchi depth in metres	1.5	1	
Suspended solids	mg/L	15	20	
pH	Lower limit	8	7	
	Upper limit	8.4	8.4	
Metals				
Mercury	µg/L	0.1	0.1	ANZECC/ARMCANZ (2000) Water Quality Guidelines*
Silver	µg/L	1.4	1.4	
Cadmium	µg/L	0.7	0.7	
Chromium	µg/L	4.4	4.4	
Copper	µg/L	1.3	1.3	
Nickel	µg/L	7.0	7.0	
Lead	µg/L	4.4	4.4	
Zinc	µg/L	15	15	
Cobalt	µg/L	1	1	
Vanadium	µg/L	100	100	

*Slightly to moderately disturbed marine waters

Data Review

A review of completed works and available data was conducted to ascertain whether any additional work scope items were required to fulfil the terms of reference or if there was any additional data that had been made publicly available since the marine water quality component in EIS had been compiled (October 2011). The analysis concentrated on the areas of the LNG jetty site, Boatshed Point swing basin, access channel and MOF sites, launch site 1 and associated dredging areas (including the Calliope River), immediately offshore the mainland tunnel launch site, and the outfall site at Boatshed Point.

The Connell Hatch (2006) Wiggins Island Coal Terminal EIS was quoted in the Arrow LNG Plant EIS Appendix 8 Marine Water Quality Report. However, the details were considered important to document here in lieu of sampling in the Calliope River. The report documents nine sites downstream of Devil's Elbow in the Calliope River. The study found most sites in the Calliope River exceeded the guidelines for nutrients. This was attributed by Connell Hatch (2006) to sediment loads and runoff. Turbidity exceeded the guidelines at most sites and times. Both chlorophyll-*a* and pH were also outside set limits on most occasions. Metals were generally low across all sections with the exception of elevated aluminium and manganese in the lower sections.

The Western Basin Dredging and Disposal Project water quality report (GHD 2009) reports monthly sampling between April and August 2009 and continuous data logging for light and turbidity during this time. One water quality grab monitoring site was located close to each of Hamilton Point, Boatshed Point and the tunnel launch site. Physico-chemistry was recorded monthly at three depths. The majority of the metals, herbicides and pesticides analysed were either below their relevant ANZECC water quality trigger values (95% species protection level for slightly to moderately disturbed systems) or detection limits. Cadmium exceeded trigger values (>0.7 µg/L) on two occasions. Chlorpyrifos and metolachlor were the only pesticides to be above the level of reporting (0.005 µg/L). This occurred on six and seven samples respectively. All nitrogenous nutrients exceeded guidelines on at least one occasion (Total Oxidised Nitrogen 0.003 mg/L, Total Kjeldahl Nitrogen 0.18 mg/L, Total Nitrogen 0.2 mg/L) . Tidal conditions were shown to be a major influencing factor on turbidity and light with spring tidal conditions more of a factor than neap.

A CSIRO (Angel et al. 2012) report on *Metals in the waters and sediments of Port Curtis, Queensland*, sampled twenty one sites from the Narrows to Rodd's Bay. Two sites were in the vicinity of Hamilton Point and one near to the Tunnel launch site. No samples were collected in the Calliope River. All metals were below ANZECC water quality trigger values (95% species protection level for slightly to moderately disturbed systems) and no areas of concern were evident. Physico-chemical depth profiling indicated a well-mixed system.

Whole of harbour water quality monitoring has been conducted by The Queensland Department of Environment and Heritage Protection on a monthly basis since September 2011 (EHP 2012). An expanded program was developed in February 2012 and now includes 52 sites. In the current program 10 sites were located in the Calliope River and two sites around Hamilton and Boatshed Points. Physico-chemistry and chlorophyll-*a* was taken at most of these sites but for metals only two sites in the Calliope and the two Curtis Island sites were sampled. For nutrients four sites in the Calliope River and the two Curtis Island sites were sampled. Subsurface samples were collected for all laboratory analysed parameters. None of the dissolved or total metals measured were of concern at any sites with the exception of exceedences found around South Trees Inlet for aluminium and molybdenum (low reliability 95% species protection level for slightly to moderately disturbed systems of 0.5 and 23µg/L, respectively) and one site in the marina for copper (high reliability 95% species protection level for slightly to moderately disturbed systems of 1.3 µg/L). Nutrients were generally low and below guideline values (95% species protection level for slightly to moderately disturbed systems). In the latest report (August 2012) there were no differing trends from that previously reported.

Methods

Marine Water Quality Assessment

A review of recent water quality data and analysis was undertaken for project sites, encompassing the waters of Port Curtis and the Calliope River (see Figure 1). Gaps identified in this review were used to inform the design of the water quality monitoring program.

The data analysis was undertaken by reviewing all relevant water quality reports and literature available for the project area and surrounding waters. Water quality data from these reports was collated and used in conjunction with the existing dataset to identify requirements for additional data on spatial and temporal water quality information. These requirements were then used to inform the design of the sampling program.

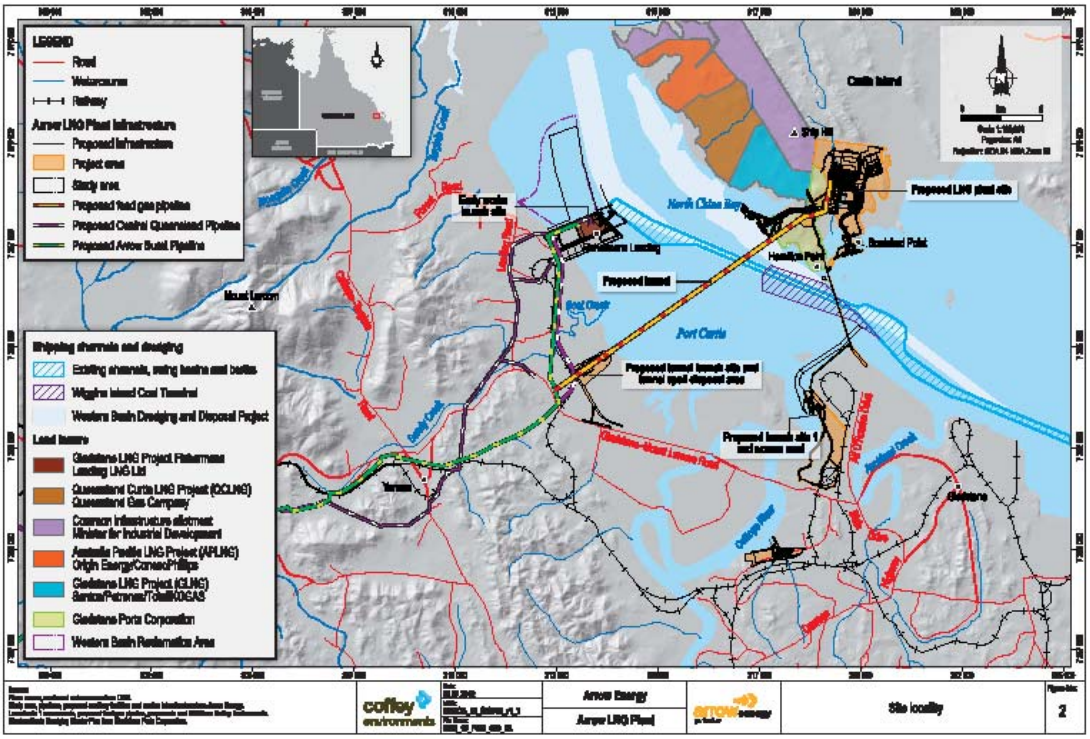

Figure 1: Arrow LNG Plant areas of marine influence

Synopsis

Despite the wealth of water quality data available for Port Curtis there are still gaps in the knowledge. The Calliope River has at least monthly information for physico-chemistry across a range of sites along the estuarine reach. The data set for metals and nutrients however are less spatially extensive. The areas around Hamilton and Boatshed Points and the tunnel launch site have only one or two sites that a regularly monitored (monthly). Only one previous study, the sampling for the Arrow LNG Plant EIS (BMT WBM 2011), have accounted for differences in water quality with tidal patterns (high, mid, low tide) although

this was only around Hamilton and Boatshed Points. No studies have accounted for lunar phase (Neap and spring tide) when evaluating water quality in Port Curtis. The sampling performed within this project addressed additional data requirements identified during the data analysis. It was concluded that the proposed marine water sampling programme take both tidal patterns and lunar phase into account when developing a more informative programme relevant to Arrow LNG Plant activities in the Port Curtis.

The current study therefore measured the following parameters to maintain consistency with previous and existing programmes:

- Physico-chemistry in depth profile;
- Suite of metal and nutrients at top and bottom of the profile; and
- Other measures (Chlorophyll-*a*, TOC, TSS).

An intensive sampling programme was conducted to cover spatially the varying habitats around the locations of interest:

- 10 sites in the Calliope River (from the mouth to Devil's Elbow);
- 5 sites around the tunnel launch site location;
- 5 sites around Hamilton Point; and
- 10 sites around Boatshed Point and Tide Island.

Site Locations & Sampling Information

Water quality parameters were sampled at 30 sites (See Figure 2) between 22 August 2012 and 31 August 2012 over both neap and spring tidal conditions. Table 2 contains GPS coordinates for each of the sites.

Single water grab samples were collected at the surface (-0.5m) and bottom (+0.5m) at each identified sampling site at high, mid and low tide on the spring and neap tides to account for spatial, short term temporal and tidal patterns. At sites where water depth was equal to or less than 1m, only surface (-0.5m) samples were taken. At 20% of sites a blind duplicate sample was collected and sent for analysis as a confirmatory sample. These sample locations were randomised, but tidal samples over that day were kept at the same site. Top water samples (-0.5m) were taken using a sample collection pole and bottom samples (+0.5m) were collected the using a Van Dorn sampler. All water samples were collected in accordance with the Queensland Water Quality Sampling Manual (DERM, 2010). The sample bottle type, sample bottle preparation, sample collection, sample storage and sample holding times, followed Australian Standard AS/NZS 5667.1:1998. Samples were either processed in the field or on return to the laboratory then sent with the required chain of custody to a National Association of Testing Authorities (NATA) accredited commercial analytical laboratory.

The following techniques were used for sample analysis:

- Total metals (Ultra-trace) - Inductively Coupled Plasma – Mass Spectrometry (APHA 3125)
- Total recoverable mercury – Cold Vapour - Flow Injection Mercury System (APHA 3112)
- Nutrients – (APHA 4500)
- Total Suspended Solids – (APHA 2540)
- Total organic carbon (APHA 5310)

Reference standards and appropriate quality assurance and quality control measures in the analytical procedure were undertaken. Levels of reporting were at least equal to the project water quality criteria, which are based upon relevant ANZECC and Queensland Water Quality Guidelines levels (as describe in Chapter 16 of the Arrow LNG Plant EIS). Table 1 shows the relevant marine water quality criteria.

Analytes measured in water samples were selected based upon the previous sampling requirements (Arrow LNG Plant EIS Appendix 8 and Western Basin Dredging and Disposal Project EIS). Metals such as antimony, barium and beryllium were not sampled in the

original Arrow LNG Plant EIS, do not all have water quality guideline values and are not usually analysed or considered to be of concern locally (Angel et al. 2012, EHP 2012). The following categories of analytes were measured:

- Total metals (unfiltered) measured in µg/L - mercury, iron, silver, aluminium, arsenic, cadmium, chromium, cobalt copper, manganese, nickel, lead, zinc and vanadium.
- Nutrients (unfiltered) measured in µg/L - total nitrogen and total phosphorus.
- Nutrients (filtered) measured in µg/L - ammonia nitrogen, filtered reactive phosphorus (orthophosphate), oxidised nitrogen.
- Total suspended solids and total organic carbon.

The following *in-situ* physico-chemical parameters were recorded:

- Temperature (^{o}C),
- pH,
- Conductivity (mS/cm),
- Salinity (ppt),
- Dissolved oxygen (both in mg/L and %),
- Turbidity (NTU),
- Chlorophyll *a* (µg/L), and
- Light penetration (secchi depth in metres)

These were recorded at successive 0.5m depths from surface to bottom (to a maximum depth of 7.5m where possible due to cable length) at each identified site with a YSI multiprobe sonde (Model no. 6920 V2). Instruments were calibrated with standard solutions prior to each days use. All field instruments were calibrated daily.

Table 2: Site GPS Coordinates

Site Number	Location	Latitude	Longitude
Site 1	Calliope River	-23.48870167	151.13800333
Site 2	Calliope River	-23.49237667	151.13323000
Site 3	Calliope River	-23.49778667	151.13138000
Site 4	Calliope River	-23.50277667	151.13179833
Site 5	Calliope River	-23.50505833	151.12637000
Site 6	Calliope River	-23.51498000	151.12338667
Site 7	Calliope River	-23.51993167	151.11310333
Site 8	Calliope River	-23.52858833	151.11650167
Site 9	Calliope River	-23.53809667	151.11305667
Site 10	Calliope River	-23.54821000	151.10975667
Site 11	Tunnel Launch Site	-23.48729333	151.11221000
Site 12	Tunnel Launch Site	-23.48635167	151.10943167
Site 13	Tunnel Launch Site	-23.48531333	151.10702833
Site 14	Tunnel Launch Site	-23.48449333	151.11030000
Site 15	Tunnel Launch Site	-23.48512000	151.11250000
Site 16	Hamilton Point	-23.47071667	151.12276500
Site 17	Hamilton Point	-23.47375833	151.12574500
Site 18	Hamilton Point	-23.47724167	151.12831500
Site 19	Hamilton Point	-23.47929667	151.13170500
Site 20	Hamilton Point	-23.47956833	151.13549833
Site 21	Boatshed Point	-23.47809500	151.13642000
Site 22	Boatshed Point	-23.47731500	151.13761833
Site 23	Boatshed Point	-23.47635500	151.13803500
Site 24	Boatshed Point	-23.47722500	151.13884167
Site 25	Boatshed Point	-23.47687000	151.14058167
Site 26	Boatshed Point	-23.47729667	151.14379500
Site 27	Boatshed Point	-23.47844500	151.14056667
Site 28	Boatshed Point	-23.47898167	151.13812500
Site 29	Boatshed Point	-23.48034000	151.13656500
Site 30	Boatshed Point	-23.48184167	151.13517333

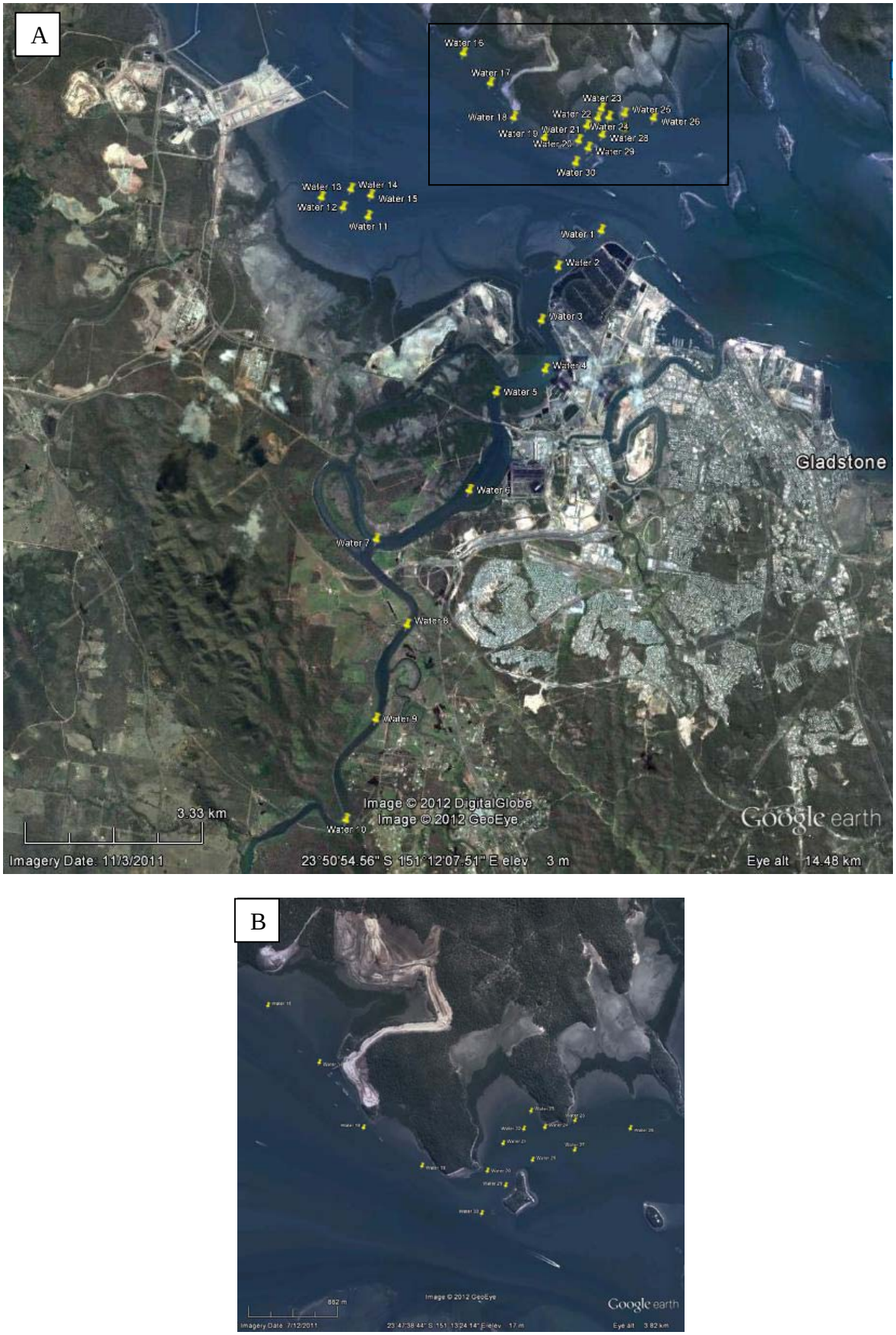

Figure 2: Map of site locations (Map A – all sites, Map B – Close up of sites 16-30)

Results & Discussion

Total Metals

Tables 1-1 through 1-24 (Appendix 1) show metals results, provided as total recoverable metals, irrespective of soluble partition. These tables represent analytical results from the top of the water column and the bottom of the water column respectively, for all 30 sites. Total metals results for the neap tide (Tables 1-1 through 1-12) and spring tide (Tables 1-13 through 1-24) sampling periods are both shown. Metal concentrations exceeding project water quality criteria are shown in bold type.

All results for mercury and silver were below their respective detection limits; however for mercury the detection limit is equal to the water quality target (i.e., 0.1µg/L). The detection limit for silver is well below the water quality objective of 1.4µg/L. These findings for mercury and silver are similar to those found in the previous study undertaken by BMT WBM (Arrow LNG Plant EIS Appendix 8). In this previous study, mercury and silver were both found to be below detection limits, however for both metals the detection limit for these metals was in excess of the water quality objective.

During neap tide sampling, the only metal with results that were detectably higher than the project water quality criteria was copper. The total metals concentration for copper had values ranging from below the limit of detection up to a one off result of 5µg/L analysed from site 23 Boatshed Point at high tide in the sample from the bottom of the water column. There were a total of 6 instances where copper concentration were detectably higher than the ANZECC WQG, these were at sites 11, 13, 15 at launch site 1, site 18 (low tide, top of water column), site 17 at LNG jetty (low tide, bottom of water column) and at site 23 Boatshed Point (high tide, bottom of water column).

During spring tide sampling, copper and zinc were the only metals with results that were detectably higher than project water quality criteria. Zinc concentration was only higher than project water quality criteria at one site in one instance over this sampling period. This was at site 30, SE of Hamilton Point, high tide, bottom of the water column. Copper concentrations were higher overall during the spring tide sampling period with a total of 41 instances of the 180 grab samples taken where the concentration of copper was found to be in excess of project water quality criteria.

Copper concentrations during the spring tide sampling period ranged from below detection limits to a maximum concentration of 8µg/L at site 19 Hamilton Point (low tide, top of the water column). During the last sampling campaign undertaken by BMT WBM for the Arrow LNG Plant EIS, copper concentrations were found to be below detection limits at all sites. The current study shows an overall increase in baseline copper concentrations within the sampled areas in comparison with the previous study. The CSIRO study (Angel et al. 2012) showed similar copper concentrations as the current study. A possible reason for the differences in copper concentrations observed between spring and neap tides is the increase in suspended solids associated with spring tides. Metals are often bound in complexes within

the suspended material in the water column. This is true of all metals however, not just copper.

While no high reliability guidelines exist for aluminium, iron, arsenic or manganese, all samples taken from all locations at each sampling period were above the limit of detection for these metals. There are several potential sources of aluminium in the harbour including tidal and/or dredge related resuspension of sediments containing aluminosilicates along with nearby aluminium industries (Angel et al. 2012, EHP 2012). Iron concentrations are seen to be higher downstream in the Calliope River and within Port Curtis than those concentrations observed upstream. Iron oxyhydroxide reduction is prevalent in Keppel Bay (Radke et al. 2005) and is likely to be responsible for the iron trends observed in the more saline reaches of the Calliope and in Port Curtis. Previous studies conducted by CSIRO in the area have shown high and variable levels of aluminium in the area for some time (Angel et al. 2010). Iron, arsenic and manganese sources have all been indicated as natural, with geological formations in the area (Angel et al. 2012, Apte et al. 2005).

Within the Port Curtis catchment region, there are several mineral resources which have been explored in the past, with some ongoing and new explorations beginning. The main resources previously described include deposits of magnesite, limestone, salt, oil shale, nickel and cobalt, chrysophase, quarry rock, construction sand, gold and manganese (Holmes 1984). Numerous small deposits of chromite have also been worked in the area (Kirkegaard et al. 1970). As well as these geological sources, several anthropogenic sources of metals within the Port Curtis area have been documented. Arsenic has also been reported in strong association with historical gold workings in the area (Pope 1994) as well as other reported potential point sources of arsenic including ex-cattle dips (Vicente-Beckett et al. 2006). Due to the strong spatial separations in maximum concentrations of copper, manganese, nickel and zinc found by Angel et al. (2010), it is indicated that there is no one particular source responsible for elevated metal concentrations. The study (Angel et al. 2010) concluded that copper and zinc concentrations within the area are likely to originate from anthropogenic sources, whereas nickel and manganese are likely to be released by natural processes, such as reduction of manganese (hydr) oxides, leaching by the lower sediments and water pH.

Cobalt has a project water quality criteria guideline of 1µg/L. Concentrations of cobalt ranged from below the limit of detection to 1.6µg/L (site 18, low tide, bottom of the water column). Cobalt exceeded project water quality guidelines on 25 separate occasions, only during the spring tide sampling and almost exclusively at mid and/or low tide, but never within the Calliope River or near the tunnel launch site. All mid and/or low tide cobalt exceedences were observed at and around Hamilton Point and Boatshed Point. There was only one exceedence at high tide, this was the sample taken at site 29, Boatshed Point, at the top of the water column. Similar concentrations for these metals have been shown in other studies (Angel et al. 2012, EHP 2012). However, the previous study by BMT WBM showed overall lower concentrations for these metals, with the exception of cobalt, which was not previously tested.

From the results, it appears that overall, total metals concentrations may be slightly lower overall for the neap tide sampling as opposed to the spring tide sampling period. This is evident through a higher proportion of samples being below detection limits for more metals. In particular, the results for copper concentrations show this trend. Some variations are also apparent within sites between the top and bottom of the water column and between tidal periods (low, mid and high tide). There were generally greater exceedances and higher concentrations of metals at sites around Hamilton Point and Boatshed Point than at the tunnel launch site sites which were in turn greater than those in the Calliope River. A potential cause for the higher metals concentrations observed during spring as opposed to neap tide metal concentrations is the increase in suspended solids associated with spring tides. Metals are often bound in complexes within the suspended material in the water column.

Nutrients

Results for analysed nutrients in relation to the relevant water quality guidelines are recorded in Tables 2-1 through 2-12 (Appendix 2). Results for the neap tide sampling period are shown in Tables 2-1 through 2-6 with results from the spring tide sampling period shown in Tables 2-7 through 2-12. Values exceeding the project water quality criteria for mid-estuarine (Sites 1 – 10) and for enclosed coastal (Sites 11 – 30) waters in Central Queensland are highlighted in bold. The values presented in the tables are measured values for each sample.

Ammonia nitrogen and nitrogen oxides were below the limits of detection for all samples at all sites over both the neap and spring tide sampling periods for both top and bottom of the water column. When analysing marine samples for these and other nutrients, the samples have to be diluted in order for the instrumentation to read them. That multiplies the detection limits by the dilution factor and for these nutrients meant that the limits of detection were higher than project water quality criteria. The detection limits were still within the similar ranges (10-20 mg/L) and recent findings by DEHP (2012) indicated levels of ammonia nitrogen and nitrogen oxides recorded at a similar time to our sampling in similar locations were well below the guidelines. Supporting this is that nutrients and total organic carbon are generally considered to be low in Port Curtis (WBM 1999).

Filtered reactive phosphorus (FRP), total nitrogen and total phosphorus all had values which were in excess of project water quality criteria. The FRP were close to double that of the guidelines at the upper Calliope River sites only which indicates an upper catchment source usually associated with sediment runoff (Radke et al. 2005). These were irrespective of time or tide reflecting a constant supply at this time and were similarly reported in August by DEHP (2012). Total nitrogen exceeded the guideline by 100 times at Site 1 on only one sampling occasion. This was over ten times greater than reported in the baseline (BMT WBM 2011). Total phosphorus showed no clear trends with tide or site but was only found to be elevated at Port Curtis sites. These levels were similar to that previously reported (BMT WBM 2011) up to five times greater than guidelines.

While there is no project water quality criteria for total organic carbon, results ranged from below the limit of detection to 10,000µg/L (as C) at site 1 (low tide, top of the water column,

spring tide sampling period). The sites which recorded TOC above detection limits were only found in the Calliope River with those in the upper Calliope more regularly above the limits, correlating with the elevated nutrients described above. This suggests that there are similar upper riverine sources likely from terrestrial origins (Radke et al. 2005).

Overall there are no observable within site trends in results between tides, top or bottom of the water column or between neap and spring sampling periods. This is consistent with a well-mixed system. Across sites the upper Calliope River recorded the highest levels for most nutrients and the greatest number of project water quality criteria exceedances. There was little difference in nutrients across the lower Calliope River, tunnel launch site and Hamilton and Boatshed Point areas.

Physicochemical Parameters

Median values of the YSI measured physicochemical parameters at all 30 sites are shown in Tables 3-1 to 3-12 (Appendix 3). Results for the neap tide sampling period are shown in Tables 3-1 through 3-6. Results for the spring tide sampling period are shown in Tables 3-7 through 3-12. Values exceeding the project water quality criteria for mid-estuarine (Sites 1 – 10) and for enclosed coastal (Sites 11 – 30) waters of Central Queensland are highlighted in bold.

pH, turbidity, chlorophyll-*a* and dissolved oxygen all had values which exceed project water quality criteria. Sites 1 – 10 have a higher incidence of exceedence during the neap tide sampling period as compared to the spring tide sampling period. During neap tide sampling, high (in excess of project water quality criteria) turbidity readings were seen for most samples at sites 1 – 5 and high chlorophyll-*a* and percentage dissolved oxygen for some samples at sites 6 – 10. However, at the same sites during the spring sampling period, the incidence of exceedence was considerably lower. This could be due to increased flushing during spring tides.

Sites 11 – 30 have similarly high exceedence rates during both the neap and spring tide sampling with most, and in some cases, all samples exceeding project water quality criteria for pH, turbidity, chlorophyll-*a* and to a lesser extent percentage dissolved oxygen. There are no project water quality criteria for temperature, conductivity or salinity.

Figure 1-1 and 1-2 show the YSI deployment times with respect to the tidal state for neap tide and spring tide sampling periods respectively.

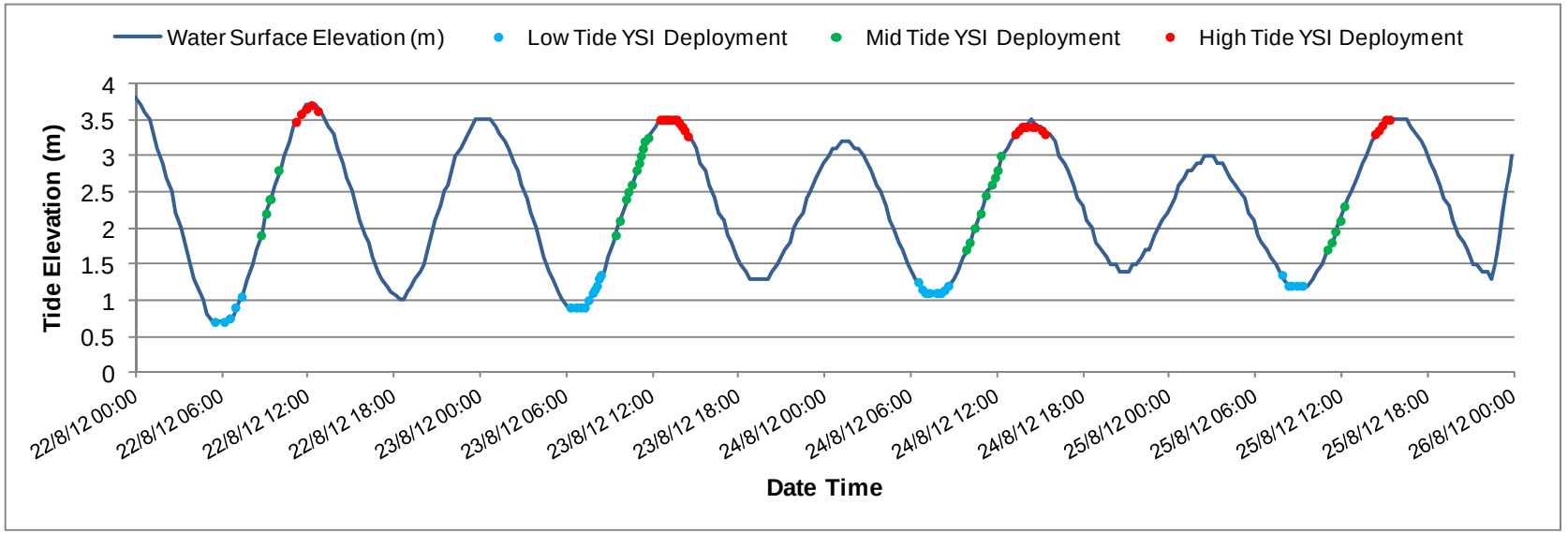

Figure 1-1 Neap Tide YSI Deployment Times

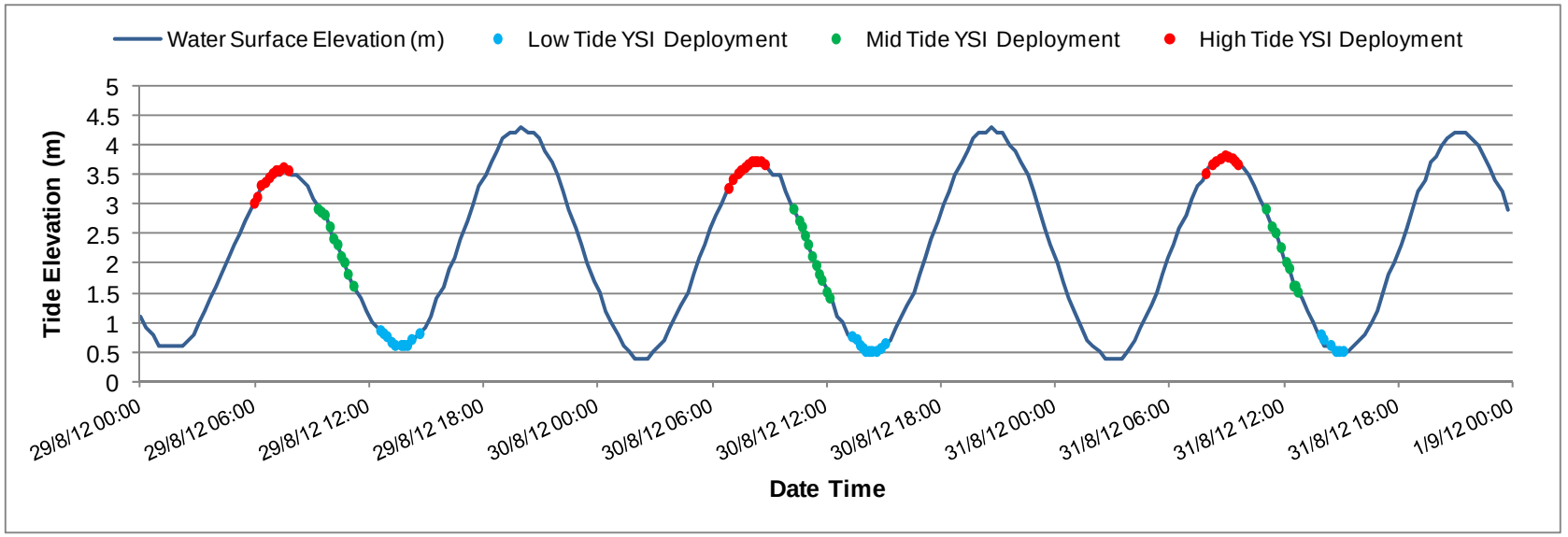

Figure 1-2 Spring Tide YSI Deployment Times

Physicochemical Depth Profiles

Temperature

Figures 2-1 through 2-12 show the temperature profiles of each site for each tidal event. Results for the neap tide sampling period are shown in Figures 2-1 through 2-6 with spring tide sampling period results shown in Figures 2-7 through 2-12. The YSI data demonstrate that temperature varied little with depth for all sites with less than two degrees of change over depth. This was true for both the spring and neap tide sampling periods. This suggests minimal thermal stratification at the sites sampled and is consistent with a well-mixed environment. Amongst sites however, there is more variation dependant on location, with temperatures ranging from slightly above 19°C to almost 25°C at the surface.

Possible reasons for temperature variation between sites include water depth and proximity to discharge of warm water from the cooling pipes from the Gladstone Power Station in the Calliope River. Temperatures were observed to be slightly higher in the upper Calliope River sites, potentially due to reduced oceanic flushing at these reaches. DERM (2011) reports a long term average temperature for the Calliope River of 16.8-36.4°C, the temperatures observed during this study fall within this long-term range.

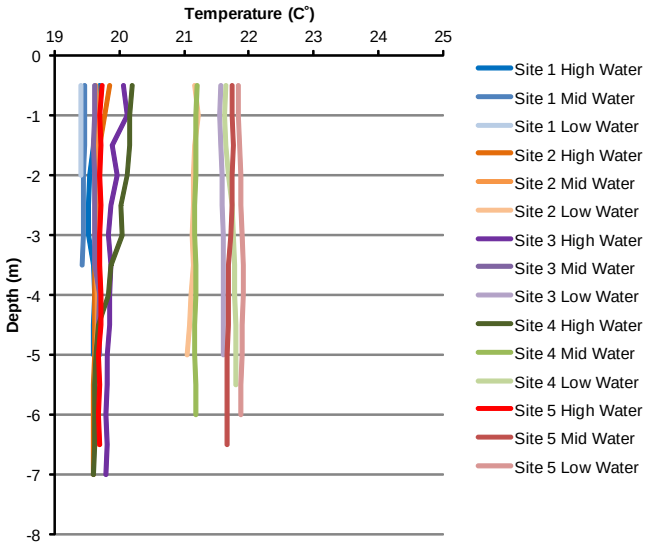

Figure 2-1 Neap Tide YSI Temperature Depth Profiles for Sites 1-5

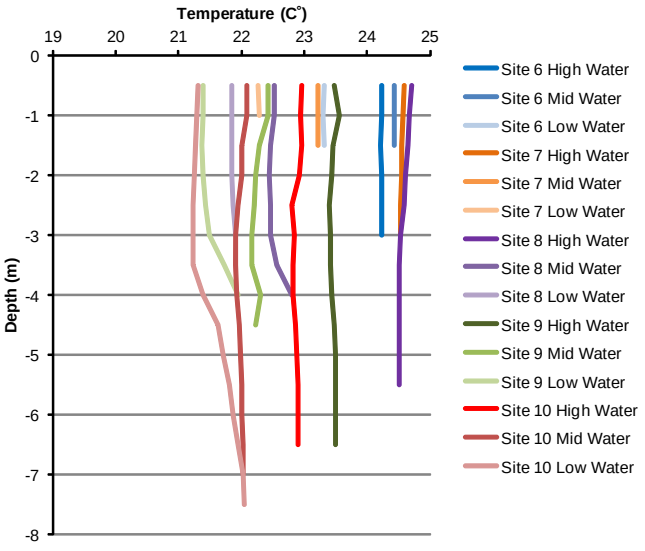

Figure 2-2 Neap Tide YSI Temperature Depth Profiles for Sites 6-10

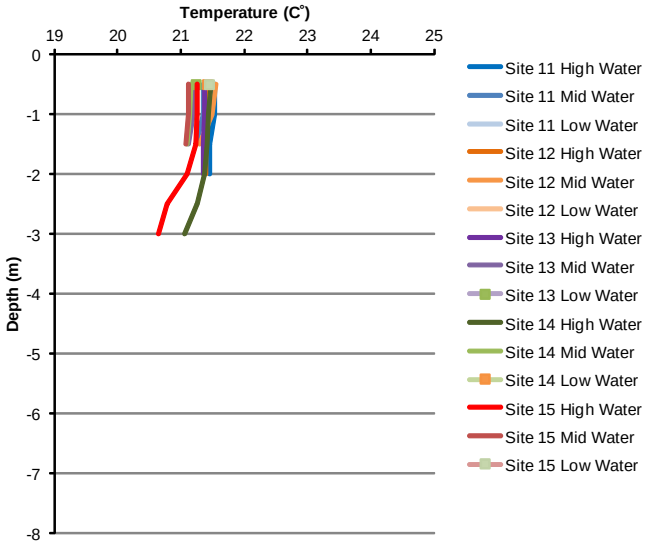

Figure 2-3 Neap Tide YSI Temperature Depth Profiles for Sites 11-15

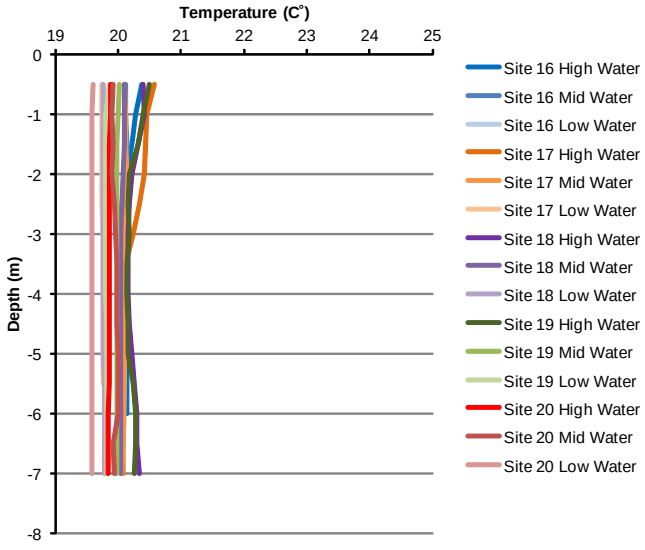

Figure 2-4 Neap Tide YSI Temperature Depth Profiles for Sites 16-20

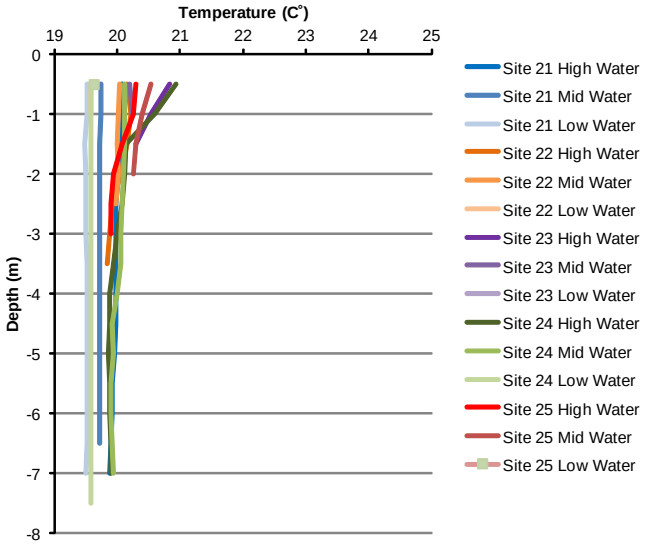

Figure 2-5 Neap Tide YSI Temperature Depth Profiles for Sites 21-25

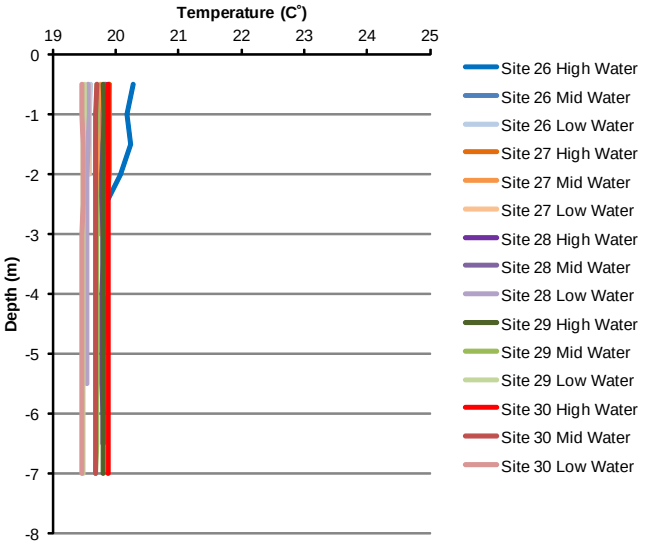

Figure 2-6 Neap Tide YSI Temperature Depth Profiles for Sites 26-30

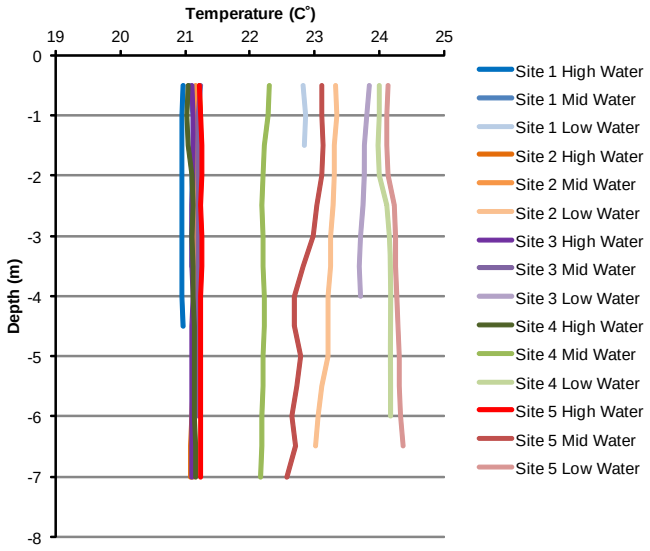

Figure 2-7 Spring Tide YSI Temperature Depth Profiles for Sites 1-5

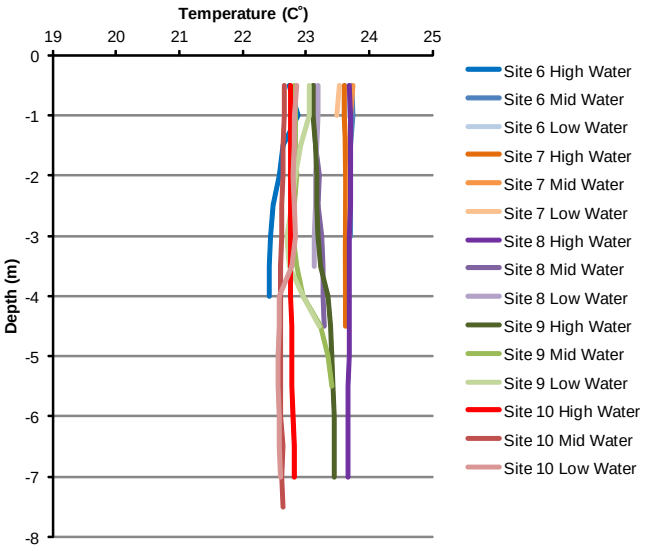

Figure 2-8 Spring Tide YSI Temperature Depth Profiles for Sites 6-10

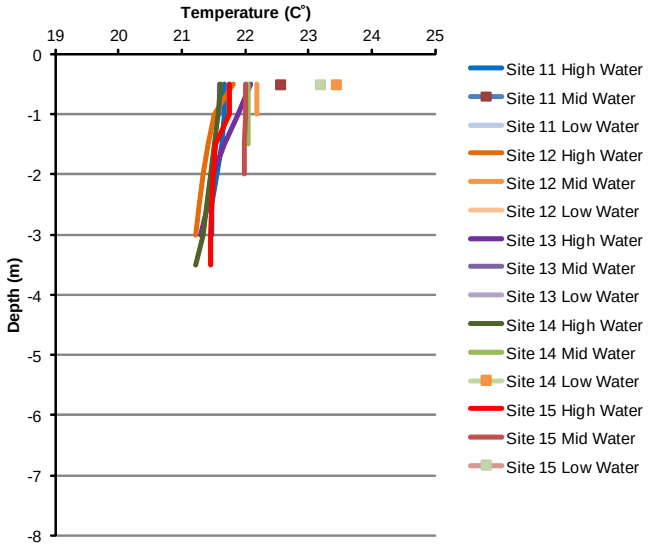

Figure 2-9 Spring Tide YSI Temperature Depth Profiles for Sites 11-15

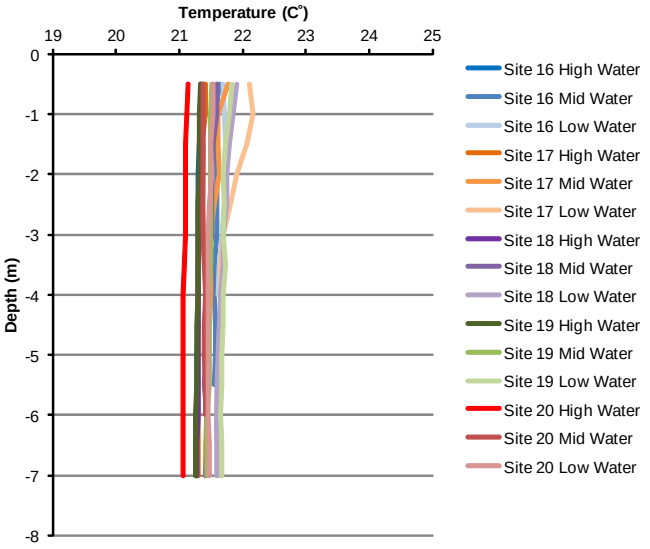

Figure 2-10 Spring Tide YSI Temperature Depth Profiles for Sites 16-20

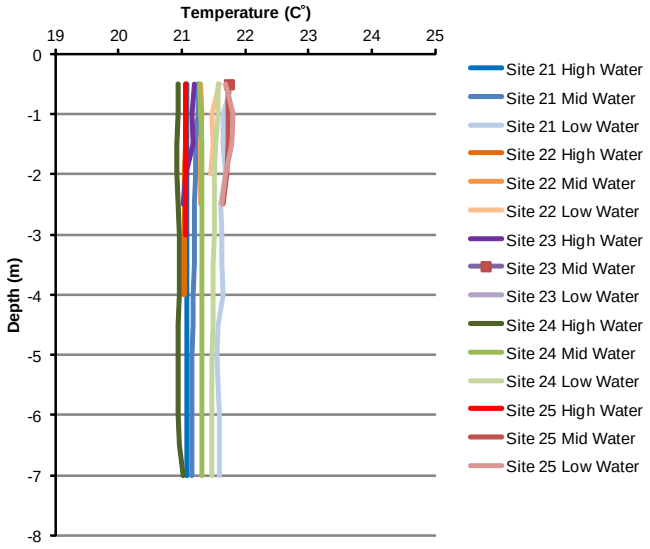

Figure 2-11 Spring Tide YSI Temperature Depth Profiles for Sites 21-25

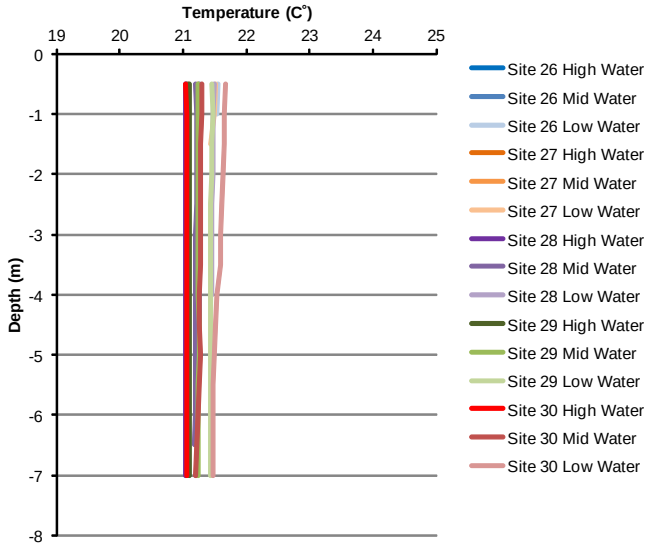

Figure 2-12 Spring Tide YSI Temperature Depth Profiles for Sites 26-30

Chlorophyll-*a*

Figures 3-1 through to 3-12 show the chlorophyll-*a* profiles of each site for each tidal event. Results from the neap tide sampling period are shown in Figures 3-1 to 3-6 and spring tide sampling period results are shown in Figures 3-7 to 3-12. Most median values for chlorophyll-*a* were equal to or exceeded the relevant project water quality criteria, though concentrations with depth were quite varied. Chlorophyll-*a* concentrations ranged dependant on site and depth from less than 1µg/L to a maximum of almost 25µg/L. Overall, the majority of chlorophyll-*a* concentrations ranged between 2 µg/L and 4 µg/L for all sites at all tides and tidal periods for all depths. Sites 6 – 10 within the Calliope River had generally higher chlorophyll-*a* concentrations. During spring tide sampling, sites 26 to 30, at Boatshed Point had high chlorophyll-*a* concentrations at the surface. Relevant guideline values are represented on each figure by a solid black line. Figures 9-1 through 9-30 show chlorophyll-*a* concentrations by site for each sampling period.

Chlorophyll-*a* is a measure of algal abundance within a waterway. Some species of algae can grow very quickly and form an algal bloom, the decomposition of a bloom can quickly deplete waterways of dissolved oxygen. Previous studies have shown that the concentrations of chlorophyll-*a* within Port Curtis is often extremely variable (EHP 2012). The long term average for the Calliope River (EHP 2012) is 0.1-37.4µg/L. All concentrations measured during this study fall within this long-term average. Chlorophyll-*a* concentrations less than 4µg/L for mid-estuarine waters of Central Queensland and less than 2µg/L for enclosed coastal waters of Central Queensland comply with project water quality criteria. Most concentrations measured during this study exceed the project water quality criteria. The reason for elevated chlorophyll-*a* concentrations within Port Curtis during the current sampling event is unclear and could be due to several compounding factors including temperature and nutrient load.

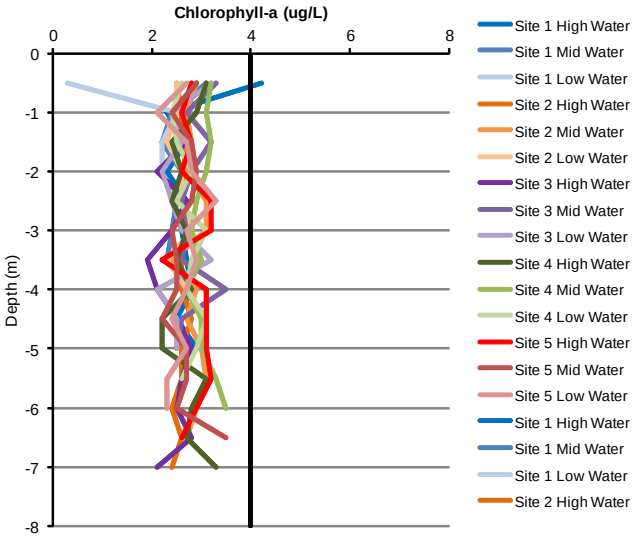

Figure 3-1 Neap Tide YSI Chlorophyll-a Depth Profiles for Sites 1-5

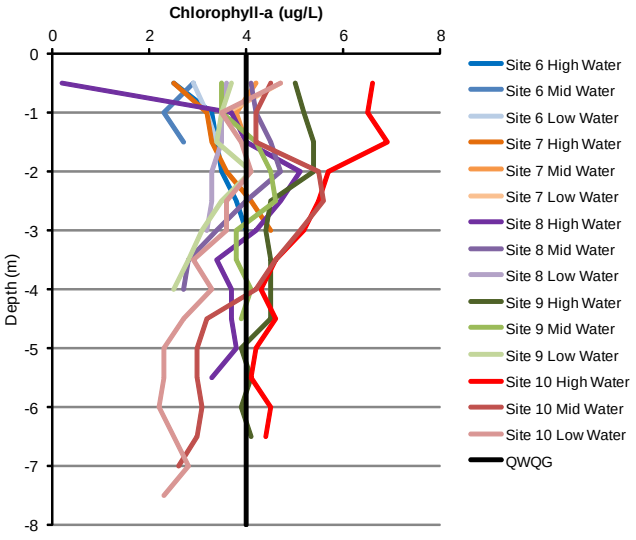

Figure 3-2 Neap Tide YSI Chlorophyll-a Depth Profiles for Sites 6-10

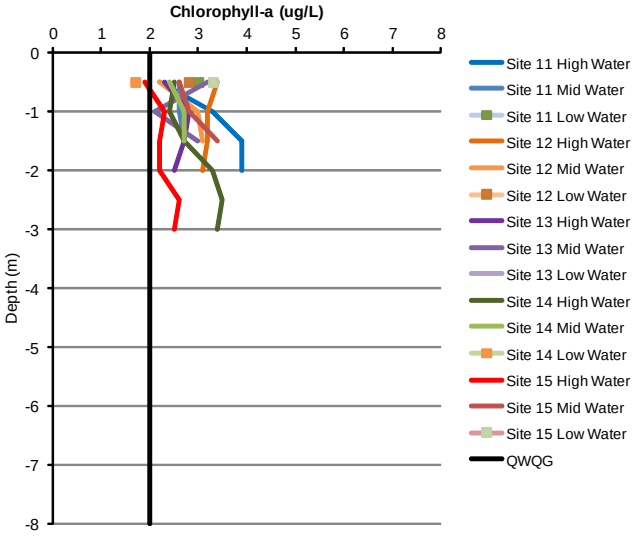

Figure 3-3 Neap Tide YSI Chlorophyll-a Depth Profiles for Sites 11-15

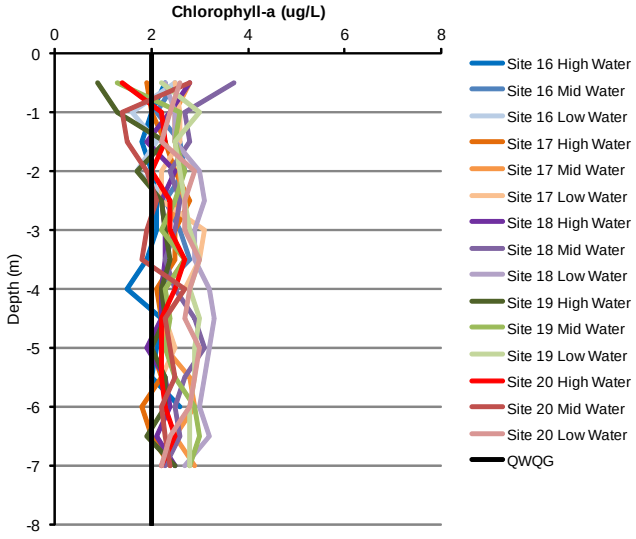

Figure 3-4 Neap Tide YSI Chlorophyll-a Depth Profiles for Sites 16-20

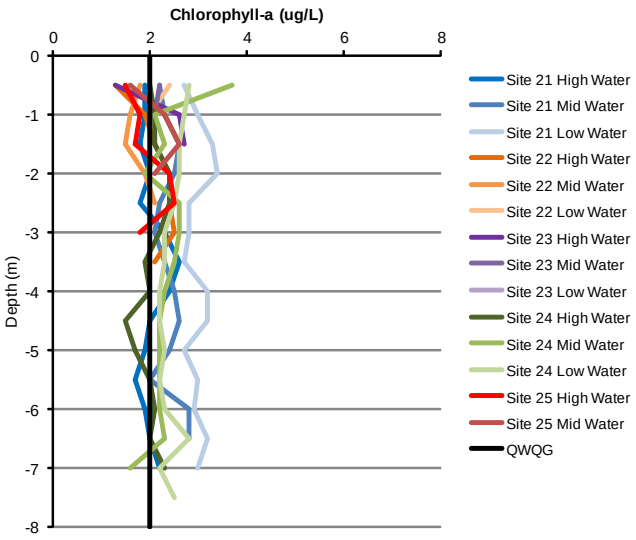

Figure 3-5 Neap Tide YSI Chlorophyll-a Depth Profiles for Sites 21-25

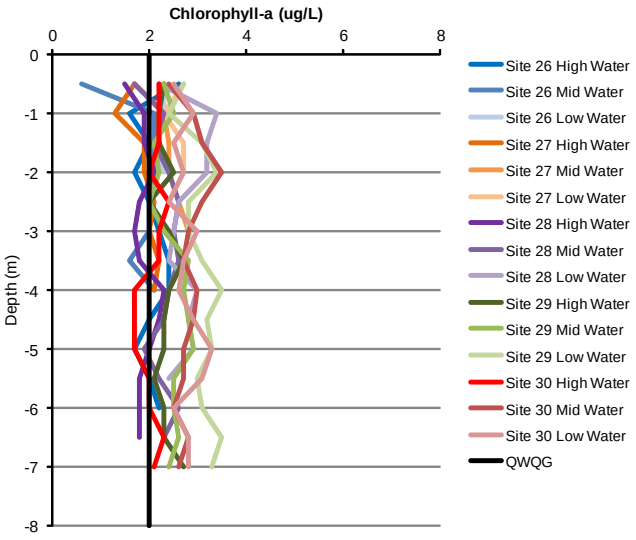

Figure 3-6 Neap Tide YSI Chlorophyll-a Depth Profiles for Sites 26-30

Black line: QWQGs (2009) for mid-estuarine and enclosed coastal waters of central Queensland for Sites 1-10 and Sites 11-30, respectively.

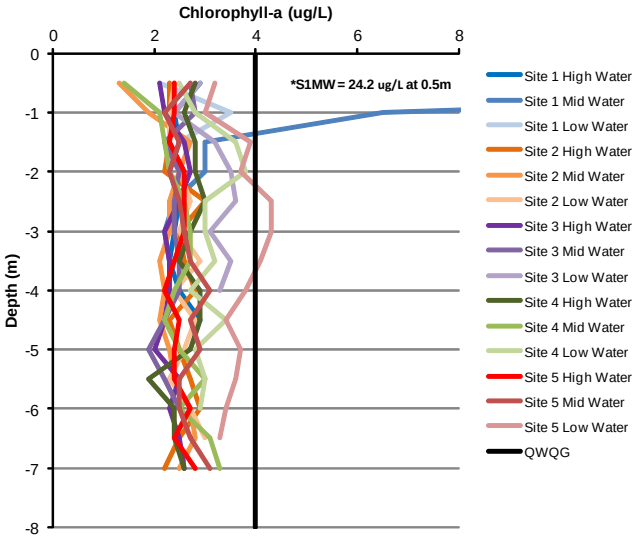

Figure 3-7 Spring Tide YSI Chlorophyll-a Depth Profiles for Sites 1-5

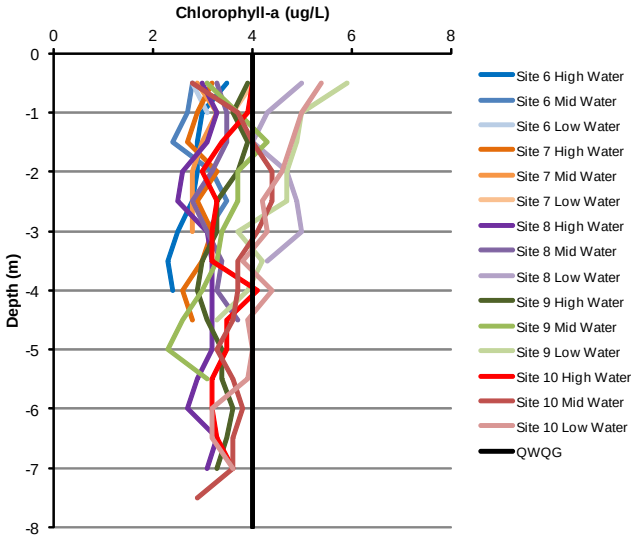

Figure 3-8 Spring Tide YSI Chlorophyll-a Depth Profiles for Sites 6-10

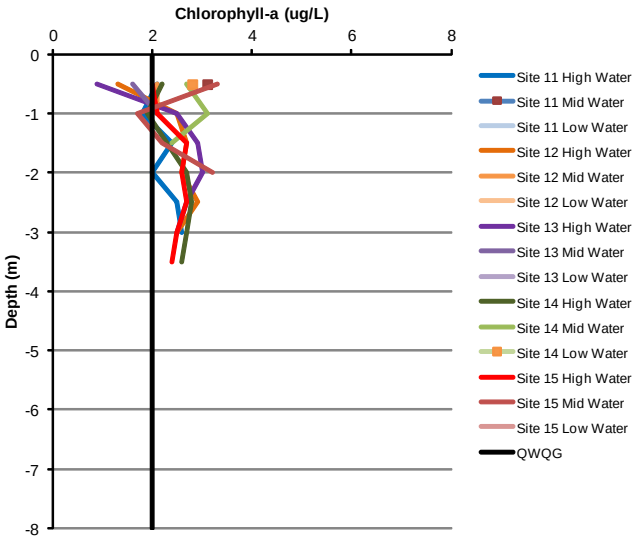

Figure 3-9 Spring Tide YSI Chlorophyll-a Depth Profiles for Sites 11-15

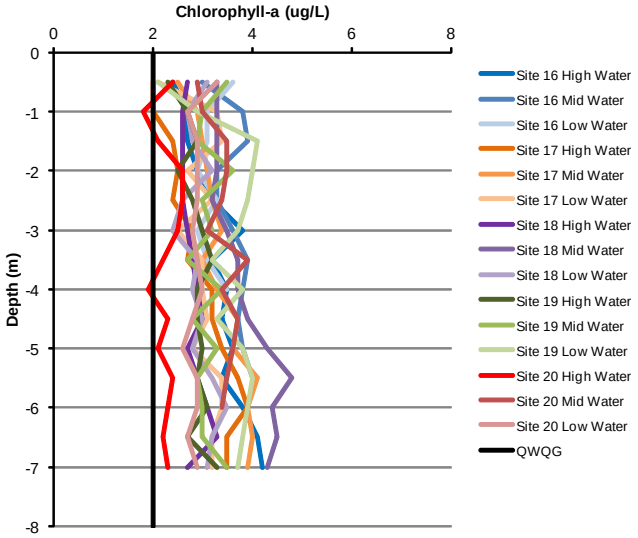

Figure 3-10 Spring Tide YSI Chlorophyll-a Depth Profiles for Sites 16-20

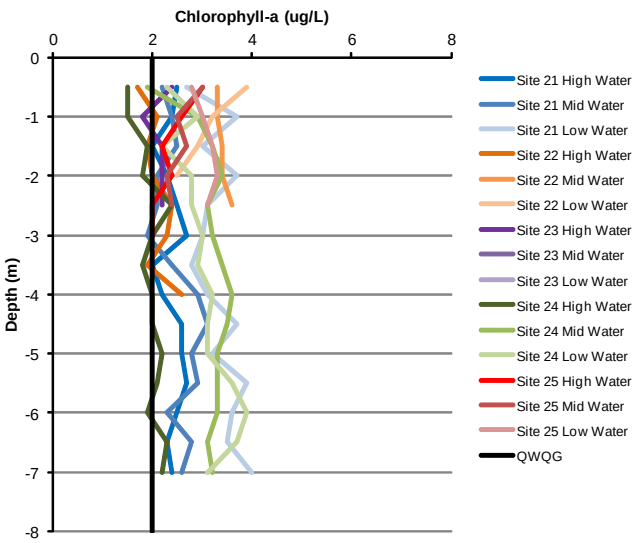

Figure 3-11 Spring Tide YSI Chlorophyll-a Depth Profiles for Sites 21-25

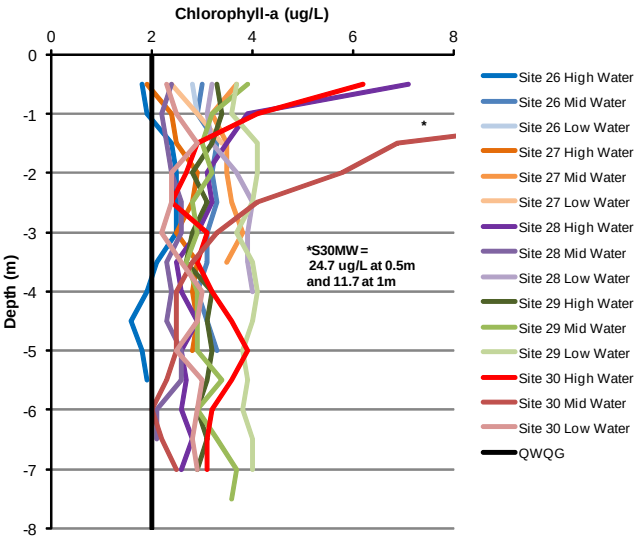

Figure 3-12 Spring Tide YSI Chlorophyll-a Depth Profiles for Sites 26-30

Black line: QWQGs (2009) for mid-estuarine and enclosed coastal waters of central Queensland for Sites 1-10 and Sites 11-30, respectively.

Conductivity and Salinity

Figures 4-1 through 4-12 show the conductivity profiles of each site for each tidal event. Results for the neap tide sampling period are shown in Figures 4-1 to 4-6 and spring tide sampling period results are shown in Figures 4-7 through 4-12.

Figures 5-1 to 5-12 show the conductivity profiles of each site for each tidal event. Results for the neap tide sampling period are shown in Figures 5-1 through 5-6, spring tide sampling period results are shown in Figures 5-7 through 5-12.

Salinity and conductivity varied with tidal events as well as spatially between sites. Some minimal stratification was observed at some sites around Boatshed Point and within the Calliope River, however most sites showed little to no stratification. Conductivity ranged from just above 20mS/cm in the Calliope River to a maximum of around 53mS/cm near the tunnel launch site. Salinity was found to range from 15ppt in the upper Calliope River sites to a maximum of just below 37ppt at some of the Boatshed Point sites.

Salinity and conductivity variation arises from varying inflows of fresh water into tidal estuaries. This can show the impact of rainfall and flooding events in the greater catchment area (EHP 2011). High salinities (>35ppt) are usually likely to occur due to high evaporation levels and during periods of low freshwater inflows (EHP 2011). Salinity and conductivity can have a variable effect on fish species, though estuarine species are generally more tolerant to salinity and conductivity changes with fish being able to move into more suitable saline environments (EHP 2011).

In comparison to the BMT WBM study previously conducted, this study found more variation in conductivity and salinity across all sites. The previous study had a range of just 47mS/cm to 51mS/cm. This variation could be due to changes in freshwater inflow at the time of sampling or due to the fact that this study was much more intensive than the previous study covering a greater number of sites over a greater area.

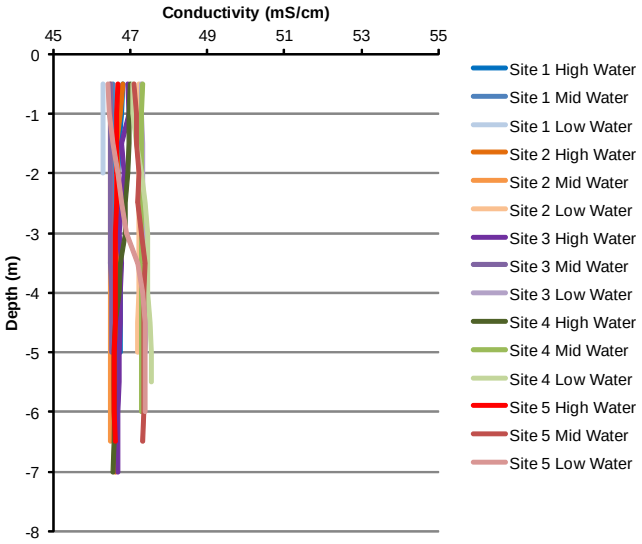

Figure 4-1 Neap Tide YSI Conductivity Depth Profiles for Sites 1-5

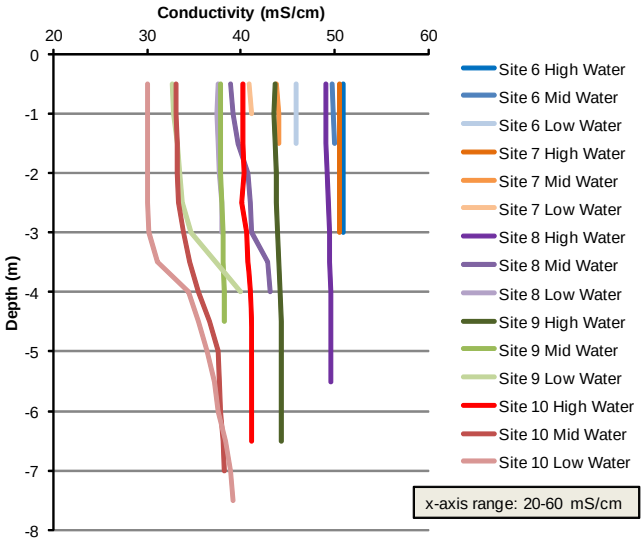

Figure 4-2 Neap Tide YSI Conductivity Depth Profiles for Sites 6-10

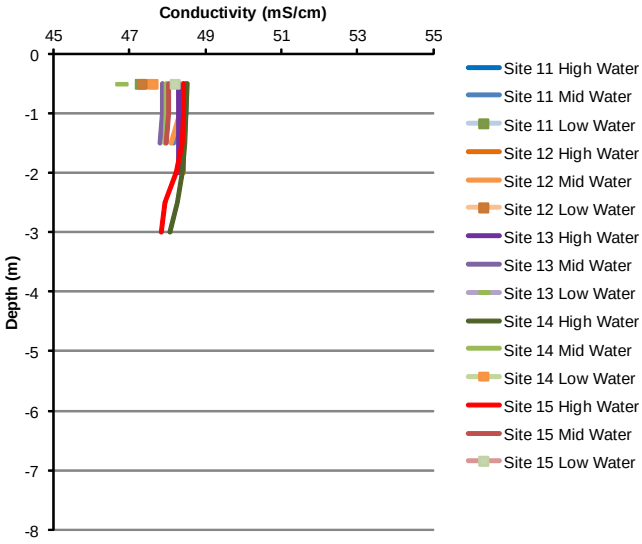

Figure 4-3 Neap Tide YSI Conductivity Depth Profiles for Sites 11-15

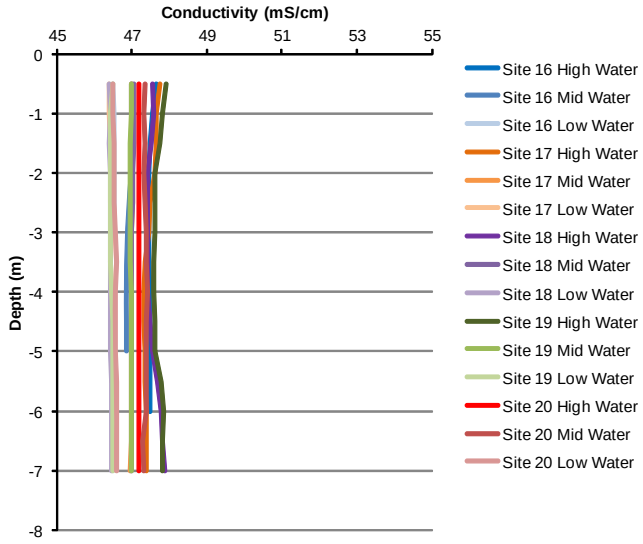

Figure 4-4 Neap Tide YSI Conductivity Depth Profiles for Sites 16-20

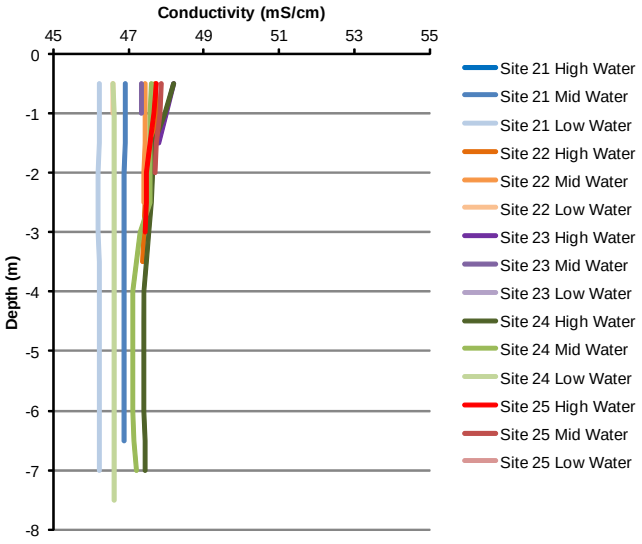

Figure 4-5 Neap Tide YSI Conductivity Depth Profiles for Sites 21-25

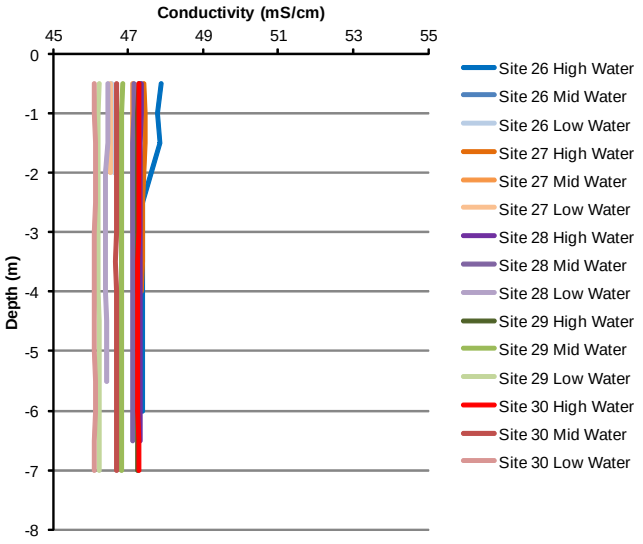

Figure 4-6 Neap Tide YSI Conductivity Depth Profiles for Sites 26-30

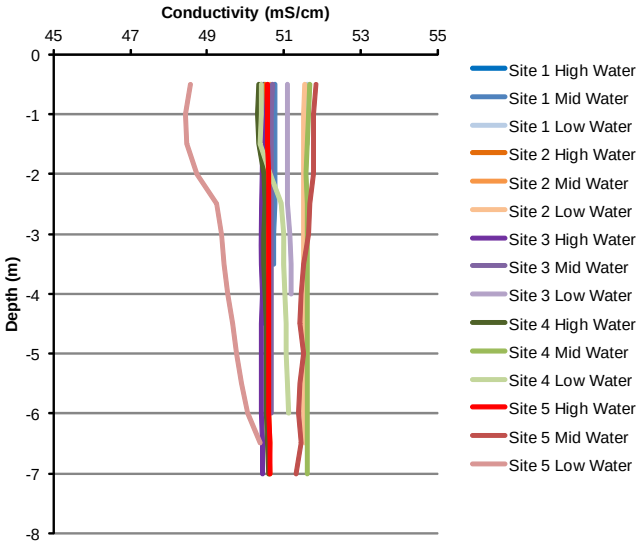

Figure 4-7 Spring Tide YSI Conductivity Depth Profiles for Sites 1-5

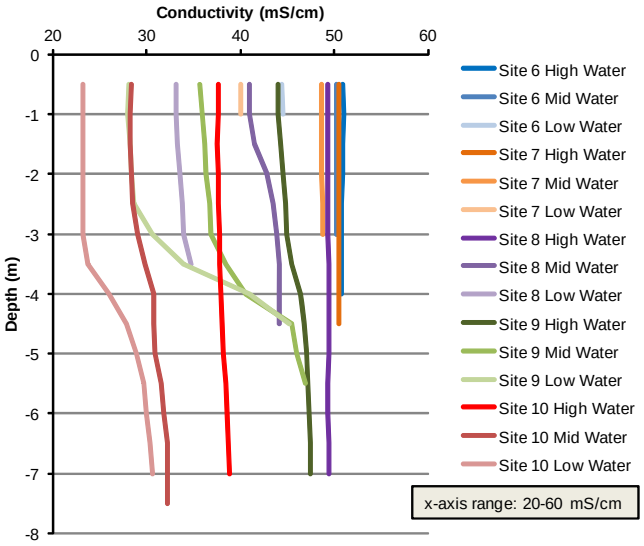

Figure 4-8 Spring Tide YSI Conductivity Depth Profiles for Sites 6-10

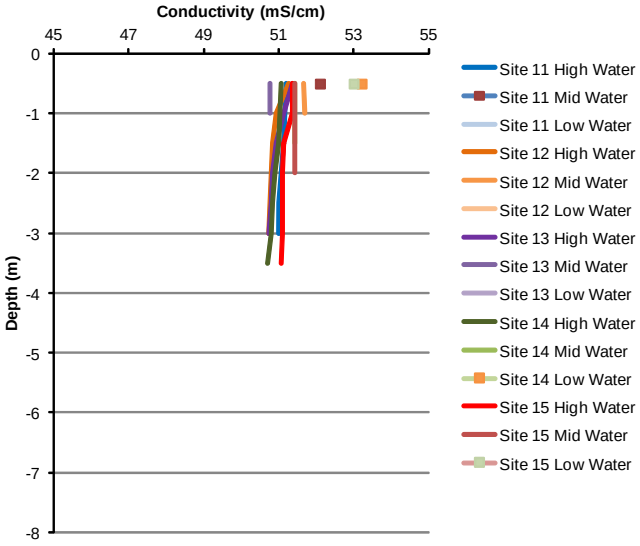

Figure 4-9 Spring Tide YSI Conductivity Depth Profiles for Sites 11-15

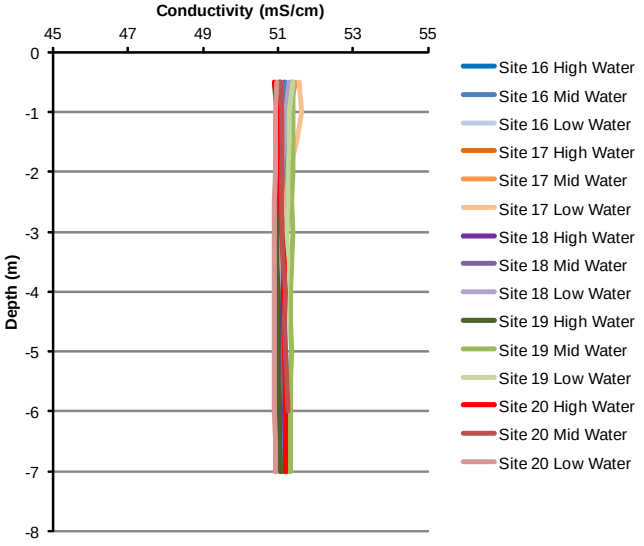

Figure 4-10 Spring Tide YSI Conductivity Depth Profiles for Sites 16-20

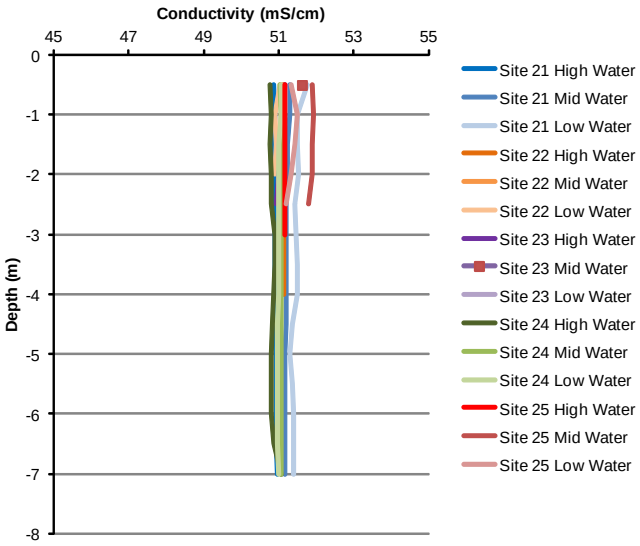

Figure 4-11 Spring Tide YSI Conductivity Depth Profiles for Sites 21-25

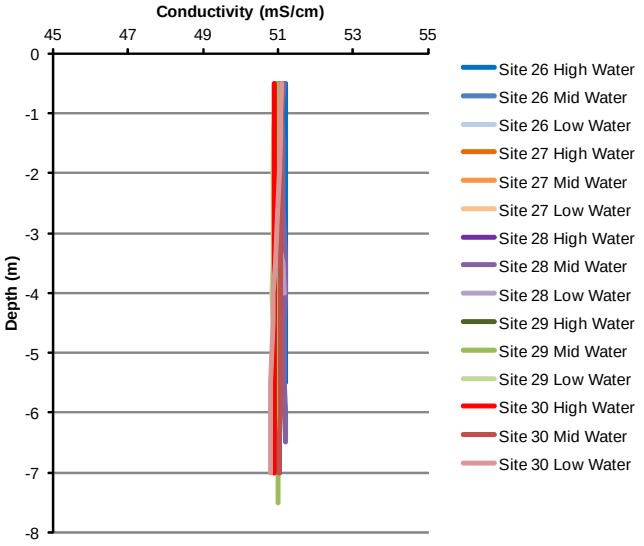

Figure 4-12 Spring Tide YSI Conductivity Depth Profiles for Sites 26-30

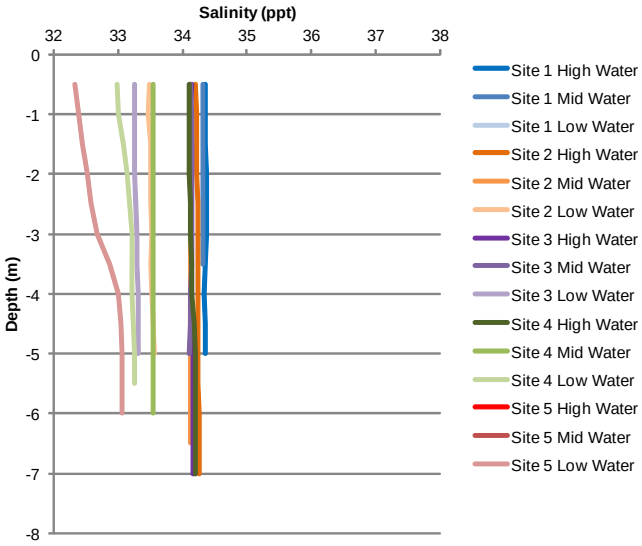

Figure 5-1 Neap Tide YSI Salinity Depth Profiles for Sites 1-5

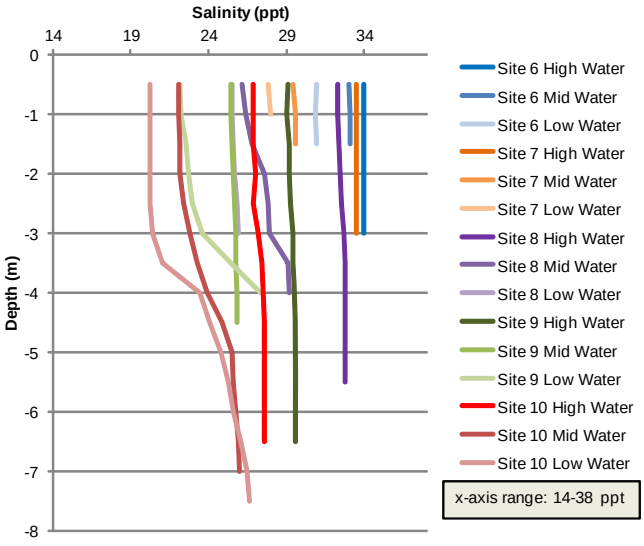

Figure 5-2 Neap Tide YSI Salinity Depth Profiles for Sites 6-10

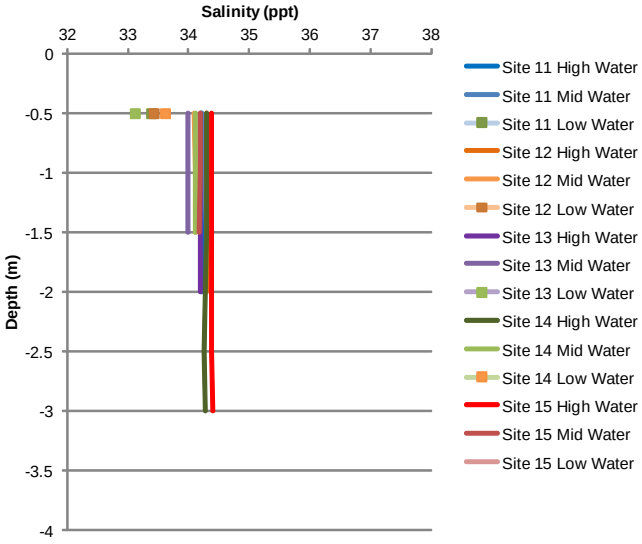

Figure 5-3 Neap Tide YSI Salinity Depth Profiles for Sites 11-15

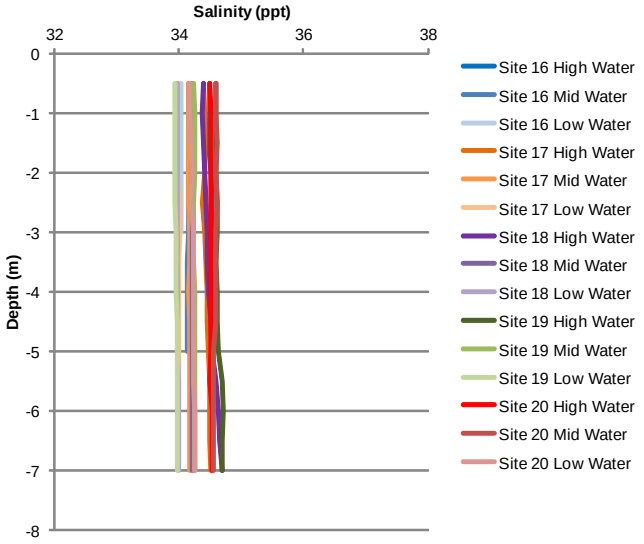

Figure 5-4 Neap Tide YSI Salinity Depth Profiles for Sites 16-20

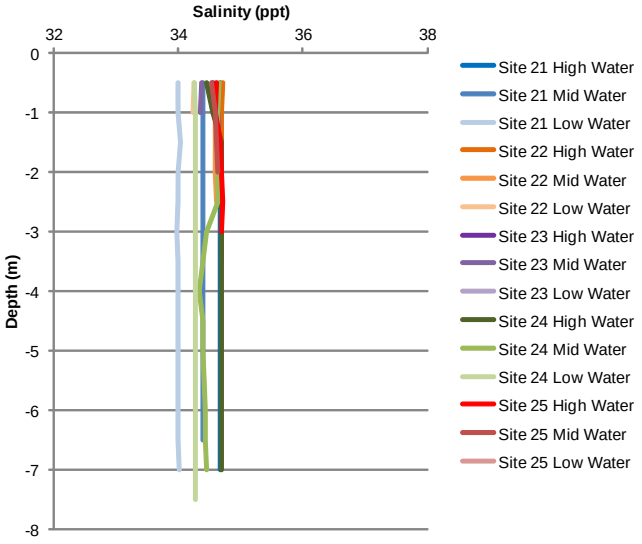

Figure 5-5 Neap Tide YSI Salinity Depth Profiles for Sites 21-25

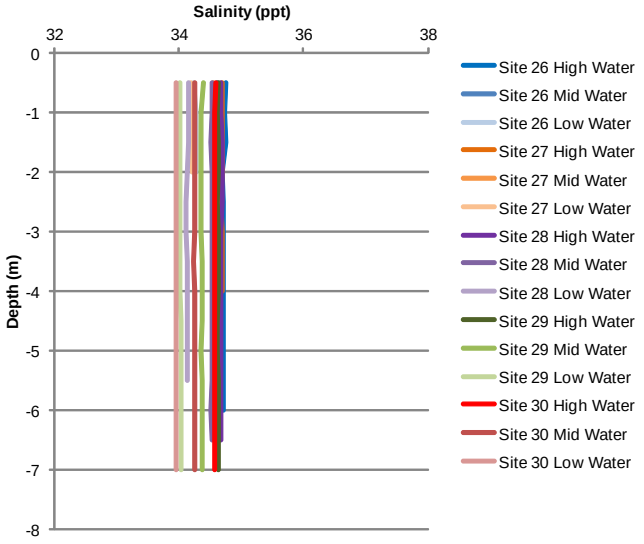

Figure 5-6 Neap Tide YSI Salinity Depth Profiles for Sites 26-30

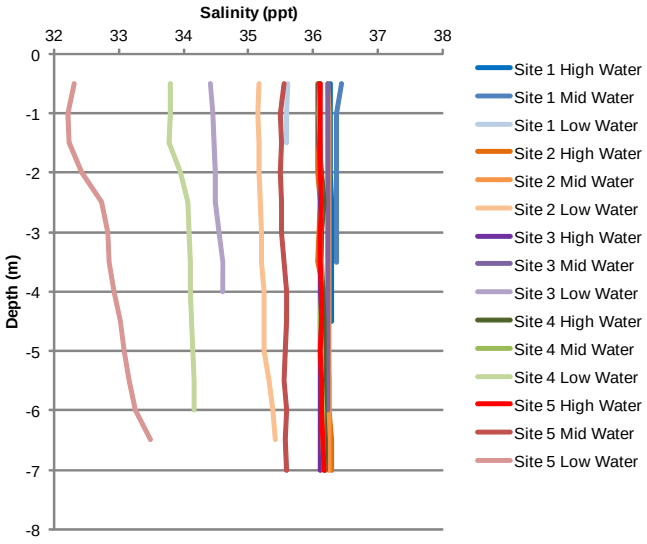

Figure 5-7 Spring Tide YSI Salinity Depth Profiles for Sites 1-5

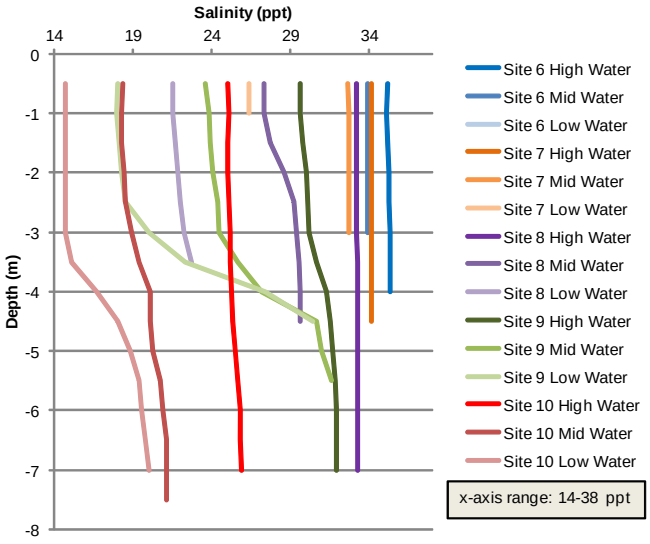

Figure 5-8 Spring Tide YSI Salinity Depth Profiles for Sites 6-10

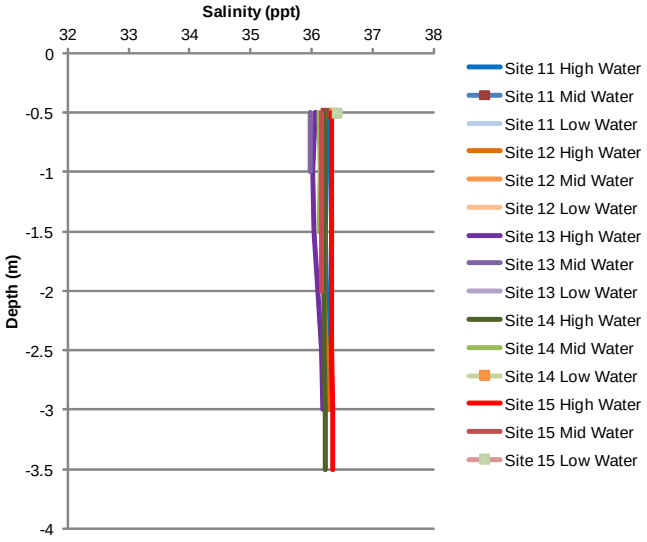

Figure 5-9 Spring Tide YSI Salinity Depth Profiles for Sites 11-15

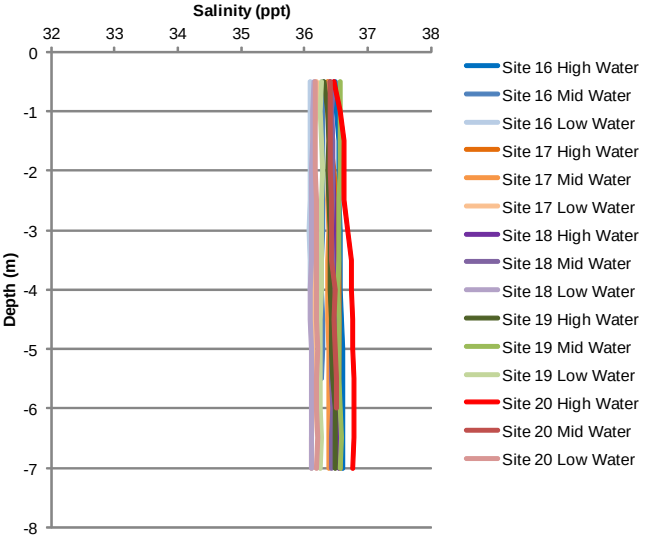

Figure 5-10 Spring Tide YSI Salinity Depth Profiles for Sites 16-20

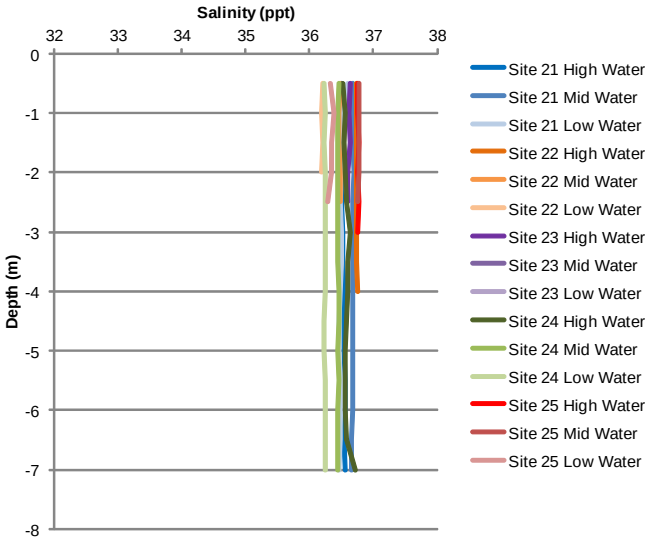

Figure 5-11 Spring Tide YSI Salinity Depth Profiles for Sites 21-25

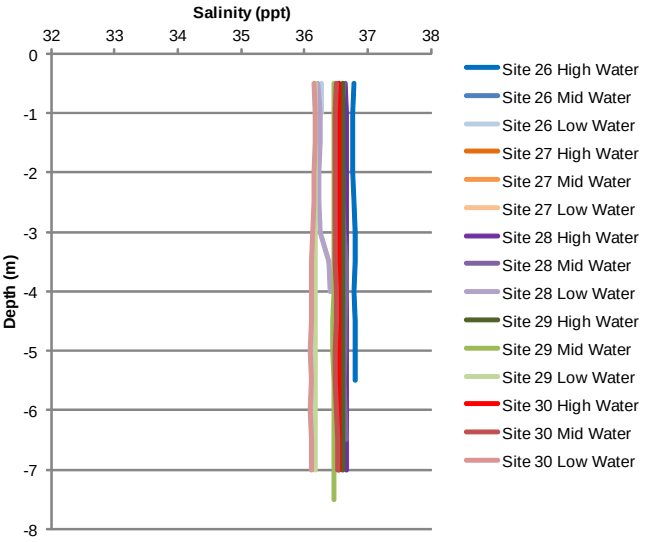

Figure 5-12 Spring Tide YSI Salinity Depth Profiles for Sites 26-30

pH

Figures 6-1 through 6-12 show the pH depth profiles of each site for each tidal event. Results for the neap tide sampling period are shown in Figures 6-1 through 6-6 and spring tide sampling period results are shown in Figures 6-7 through 6-12.

pH stratification was minimal though spatial differences were apparent. project water quality criteria exceedences were common at several sites regardless of tidal variation. pH range was variable dependant on site location ranging from 7.3 to a maximum of slightly below 8. Calliope River was observed to have overall lower pH values than the tunnel launch site area, which was in turn lower than the Hamilton Point sites and finally Boatshed Point sites. This pH variation between sampling areas was more distinct during neap tide sampling. Variation was less prominent during spring tide sampling, possibly due to greater flushing rates on the bigger tides, making the sampling sites more similar in pH levels.

In comparison to the BMT WBM study previously conducted, this study found more variation in pH across all sites. The previous study had a range of just above 8 to slightly higher than 8.2. EHP (2012) reports a long term pH average within the Calliope River of 7.1-8.7 and within the greater Gladstone waterways of 7.7-8.2. All measurements taken during the current sampling period fall within the long-term ranges previously reported, though not always within project water quality criteria. The tunnel launch sites, Hamilton Point and Boatshed Point sites had most exceedences of the project water quality criteria with all pH readings being outside guideline values. Calliope River of the other hand had no project water quality criteria exceedences during this sampling campaign.

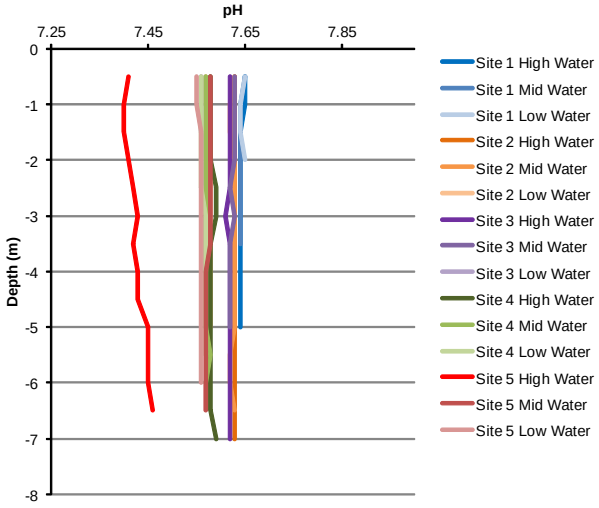

Figure 6-1 Neap Tide YSI pH Depth Profiles for Sites 1-5

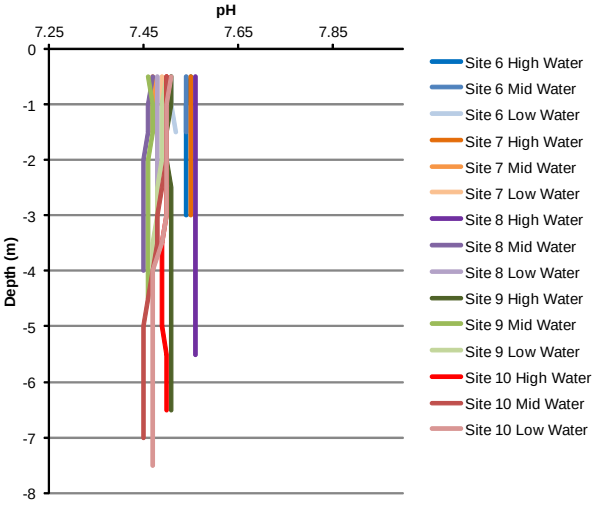

Figure 6-2 Neap Tide YSI pH Depth Profiles for Sites 6-10

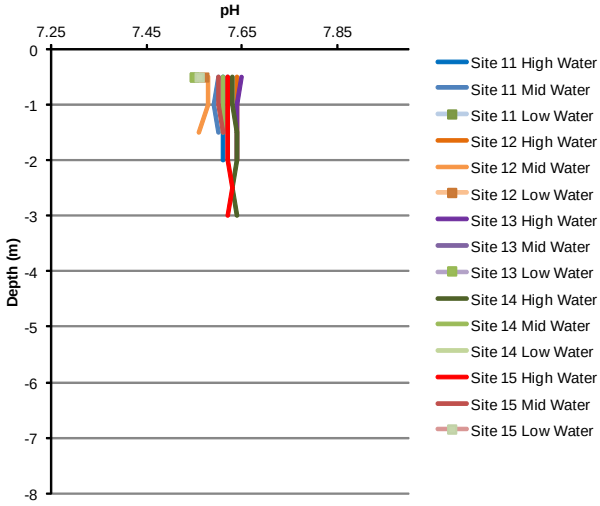

Figure 6-3 Neap Tide YSI pH Depth Profiles for Sites 11-15

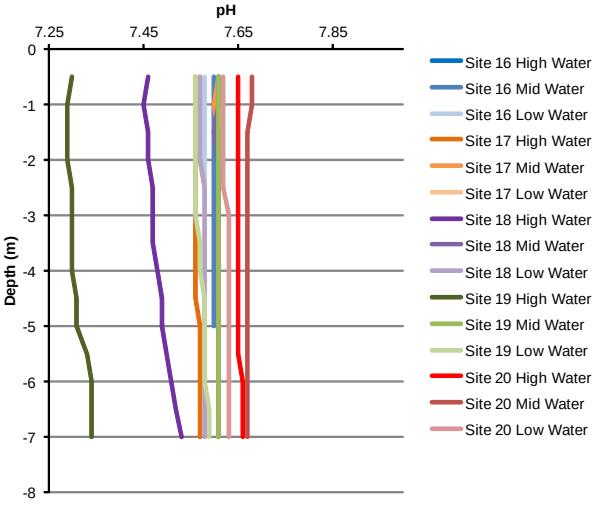

Figure 6-4 Neap Tide YSI pH Depth Profiles for Sites 16-20

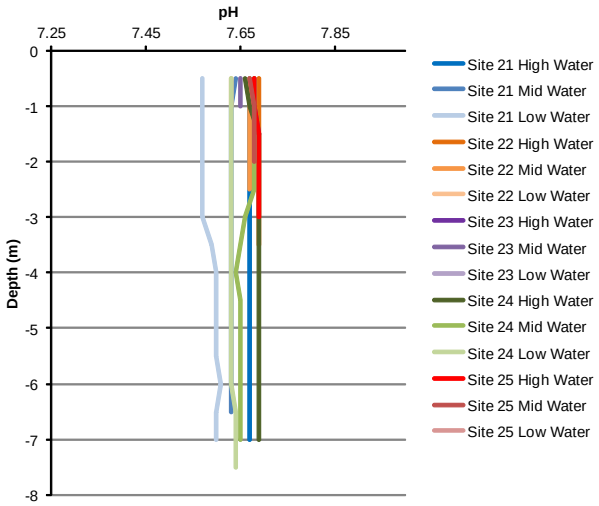

Figure 6-5 Neap Tide YSI pH Depth Profiles for Sites 21-25

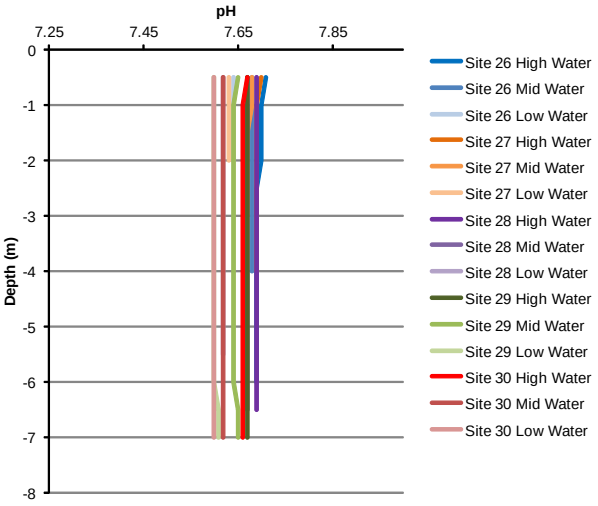

Figure 6-6 Neap Tide YSI pH Depth Profiles for Sites 26-30

QWQGs (2009) recommend a pH range of 7.0-8.4 for mid-estuarine waters (Sites 1-10; top two) and 8.0-8.4 for enclosed coastal waters (Sites 11-30; bottom four) of central Queensland.

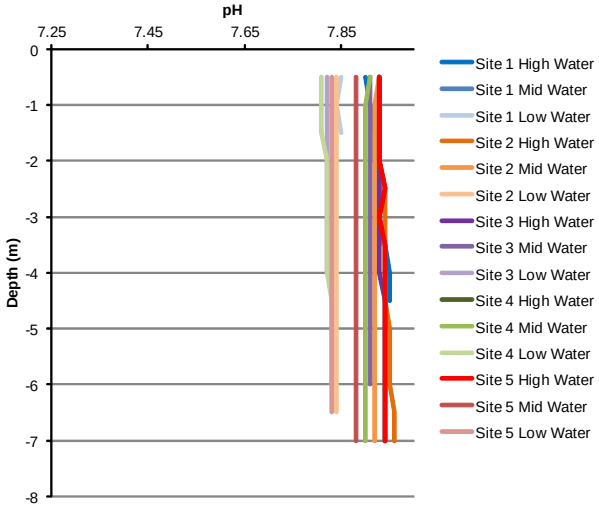

Figure 6-7 Spring Tide YSI pH Depth Profiles for Sites 1-5

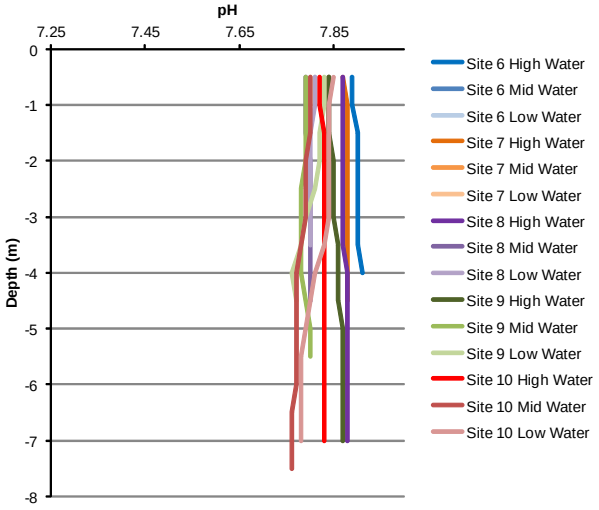

Figure 6-8 Spring Tide YSI pH Depth Profiles for Sites 6-10

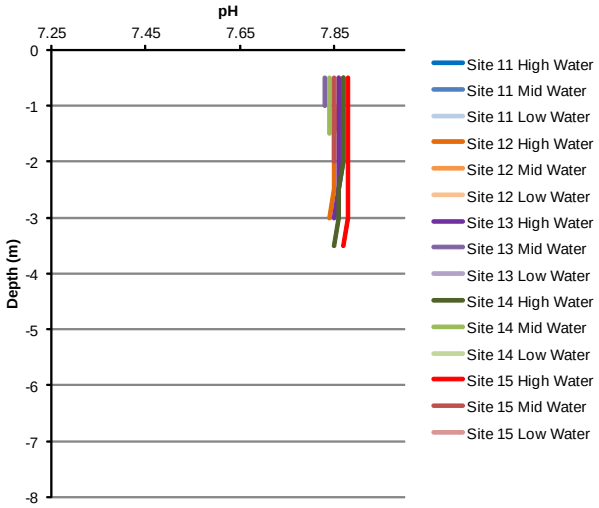

Figure 6-9 Spring Tide YSI pH Depth Profiles for Sites 11-15

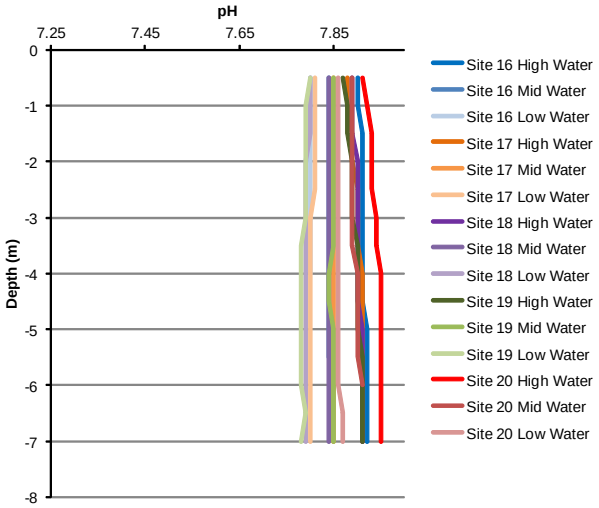

Figure 6-10 Spring Tide YSI pH Depth Profiles for Sites 16-20

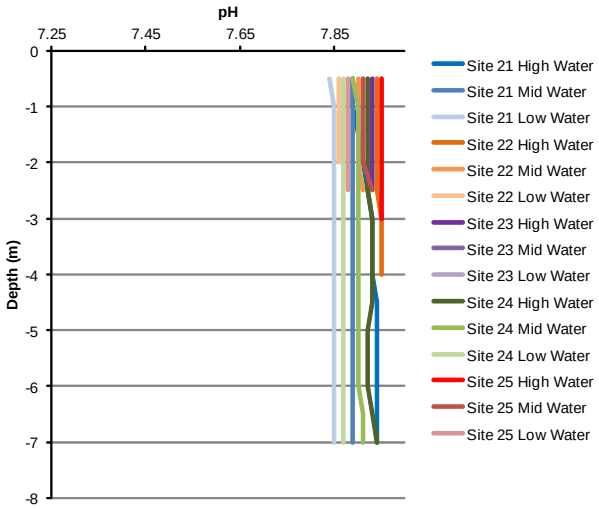

Figure 6-11 Spring Tide YSI pH Depth Profiles for Sites 21-25

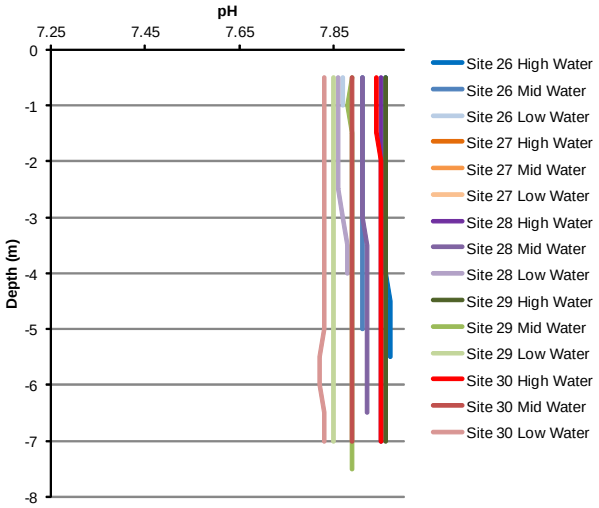

Figure 6-12 Spring Tide YSI pH Depth Profiles for Sites 26-30

QWQGs (2009) recommend a pH range of 7.0-8.4 for mid-estuarine waters (Sites 1-10; top two) and 8.0-8.4 for enclosed coastal waters (Sites 11-30; bottom four) of central Queensland.

Dissolved Oxygen

Figures 7-1 through 7-11 show the dissolved oxygen saturation percentage profiles of each site for each tidal event. Neap tide sampling period results are shown in Figures 7-1 through 7-5 and spring tide sampling period results are shown in Figures 7-6 through 7-11. Note that due to equipment failure, there were no dissolved oxygen results for sites 1 – 5 during neap tide sampling. The project water quality criteria are represented on the figures as a solid black line.

It can be seen in the figures that dissolved oxygen stratification was minimal at all sites for both the neap and spring tide sampling periods. Differences between sites and also between tidal states are apparent. Exceedences of project water quality criteria were apparent, particularly during the neap tide sampling period. Dissolved oxygen percentage saturation was dependant on site and tidal state, ranging from a minimum of between 85-90% to a maximum of between 105-110%.

Dissolved oxygen values in water are often over 100% air saturation levels. 100% air saturation refers to the amount of dissolved oxygen that would be in water if it was completely saturated with air. However photosynthesis of plants (including algae) contributes pure oxygen into the water and may do so at a rate faster than which the oxygen can diffuse from the water into the air. This will result in dissolved oxygen levels that are in excess of 100% and is often indicative of an algal bloom.

Sites around the tunnel launch site and Boatshed Point had the greatest number of project water quality criteria exceedences for dissolved oxygen, with few around Hamilton Point and within the Calliope River. EHP (2012) confirms that dissolved oxygen levels in Port Curtis are highly variable, with most long-term records between 85% and 105% saturation within the harbour area and between 55% and 132% within the Calliope River. project water quality criteria indicate that at dissolved oxygen concentration greater than 50% saturation, significant effects on marine and estuarine life are unlikely.

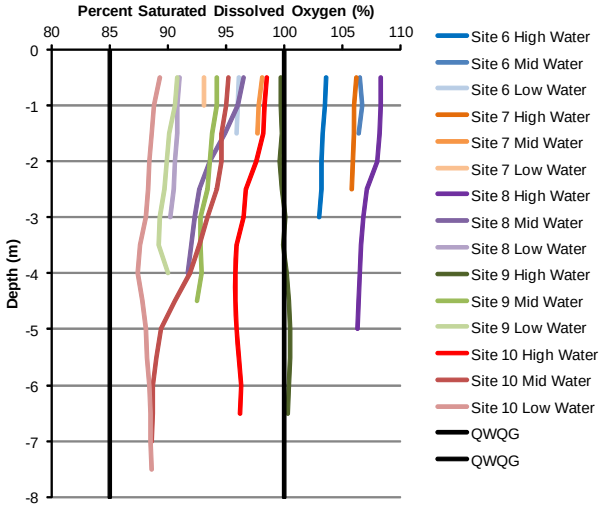

Figure 7-1 Neap Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 6-10

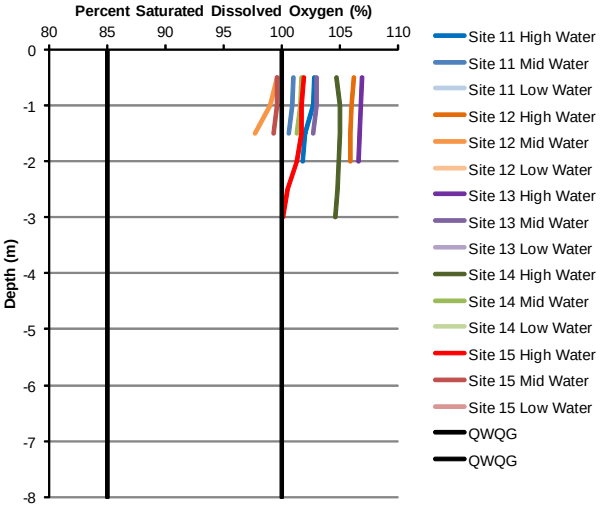

Figure 7-2 Neap Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 11-15

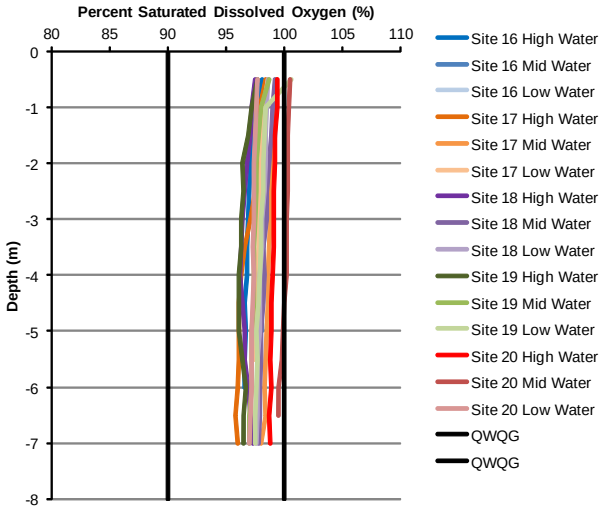

Figure 7-3 Neap Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 16-20

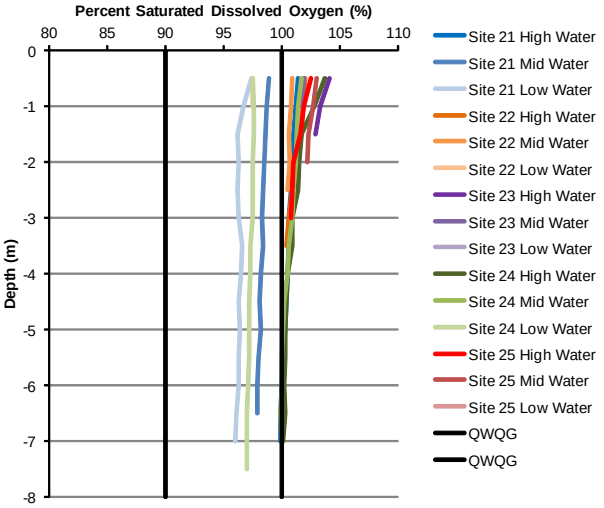

Figure 7-4 Neap Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 21-25

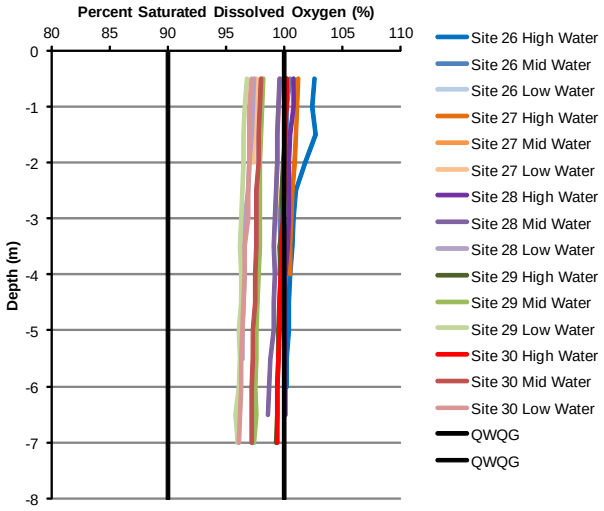

Figure 7-5 Neap Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 26-30

Black line: QWQGs (2009) for mid-estuarine and enclosed coastal waters of central Queensland for Sites 1-10 and Sites 11-30, respectively.

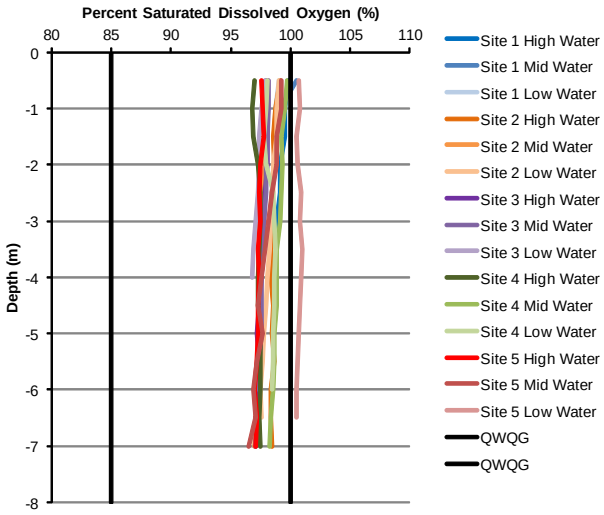

Figure 7-6 Spring Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 1-5

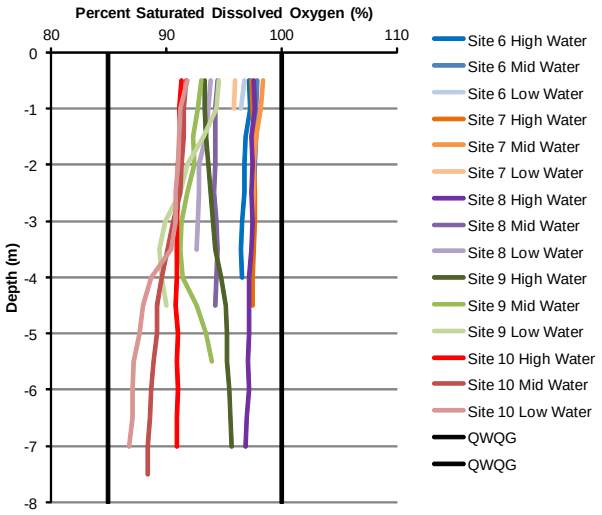

Figure 7-7 Spring Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 6-10

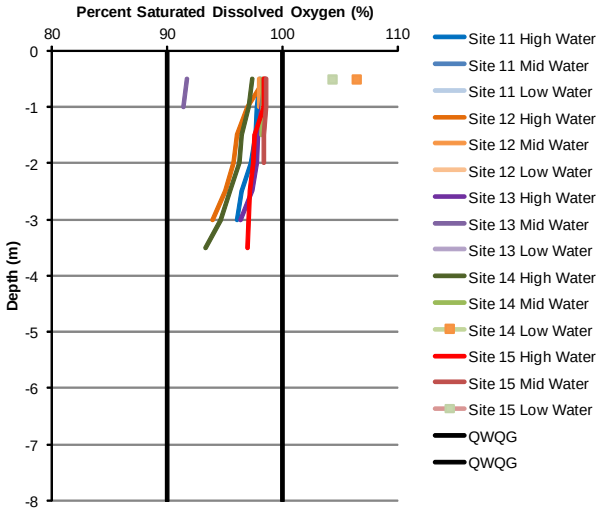

Figure 7-8 Spring Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 11-15

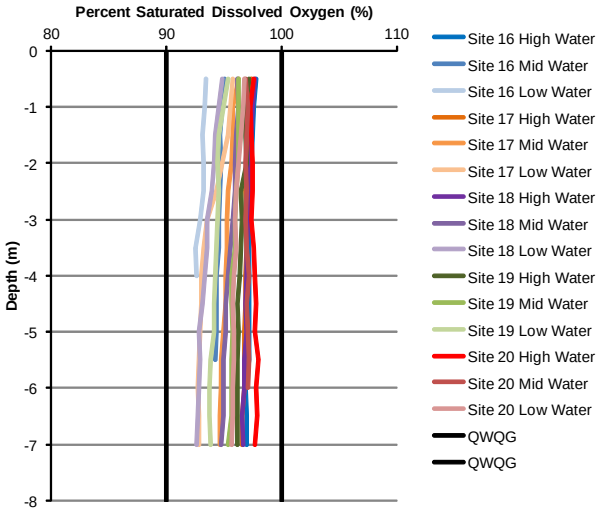

Figure 7-9 Spring Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 16-20

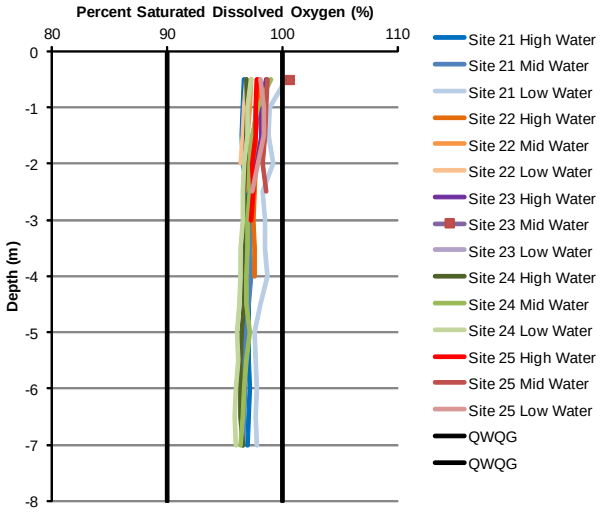

Figure 7-10 Spring Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 21-25

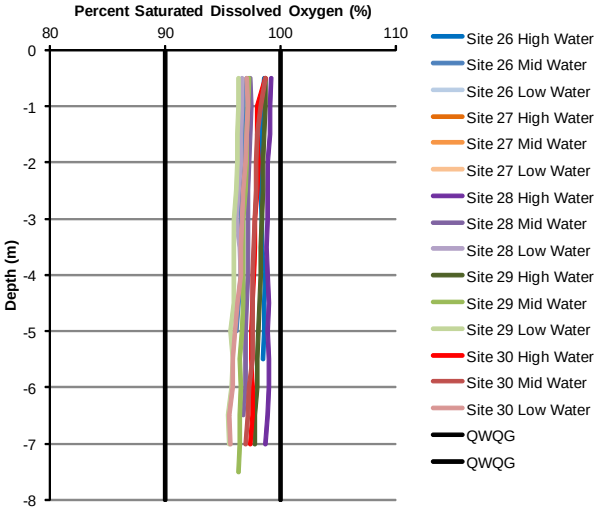

Figure 7-11 Spring Tide YSI Percent Saturated Dissolved Oxygen Depth Profiles for Sites 26-30

Black line: QWQGs (2009) for mid-estuarine and enclosed coastal waters of central Queensland for Sites 1-10 and Sites 11-30, respectively.

Turbidity

Figures 8-1 through 8-12 show the turbidity profiles of each site for each tidal event. Results from the neap tide sampling period are shown in Figures 8-1 through 8-6 and spring tide sampling period in Figures 8-7 through 8-12. Relevant guideline values are represented on the figures as a solid black line.

The figures show minimal to no stratification of turbidity through depth for most sites with the exception of site 30 SE of Hamilton Point measured mid tide during the neap tide sampling period. At this site turbidity dropped with depth. Some variation with tidal state is observed. Spatial variation is distinct as is the variation of results between neap and spring tide sampling periods with the spring tide sampling period being overall more turbid. Turbidity results varied greatly dependant on site, tide and sampling period. A minimum turbidity of less than 2NTU was recorded at several sites, including within the Calliope River (Sites 6 – 1-), near the tunnel launch site (Sites 11 – 15) and around Boatshed Point (Site 26), with maximum values of up to 80NTU being recorded during the spring tide sampling period at one of the Hamilton Point sites (Site 17).

Sites in the Calliope River had the fewest guideline value exceedences. There were no exceedences during the neap tide sampling at sites 6 – 10 in the upper Calliope. During spring tide sampling however, turbidity levels were much higher and so exceedences more common. Sites within the Calliope River (sites 1 – 10) and near the tunnel launch site (sites 11-15) had fewer exceedences than sites around Hamilton Point and Boatshed Point where exceedences were common during the spring tide sampling period with very few values below the project water quality guideline.

Currents produced by spring tides are known to be major natural contributing factors to high turbidity levels in the area. It is possible that ongoing dredging operations could have contributed to the higher turbidity levels observed at sites near the dredging activities in the Hamilton Point area and to a lesser extent the Boatshed Point area. However, during this study, a full depth profile could not be obtained and therefore turbidity at the particularly deep sites could not be fully assessed and compared with the previous sampling study performed by BMT WBM. In the previous study, BMT WBM had six sites around Hamilton Point and Boatshed Point that were sampled during a spring tide. When results from the current study are compared to the previous study, only to the depth available, it would appear that results from the spring tidal sampling period are similar to those found previously.

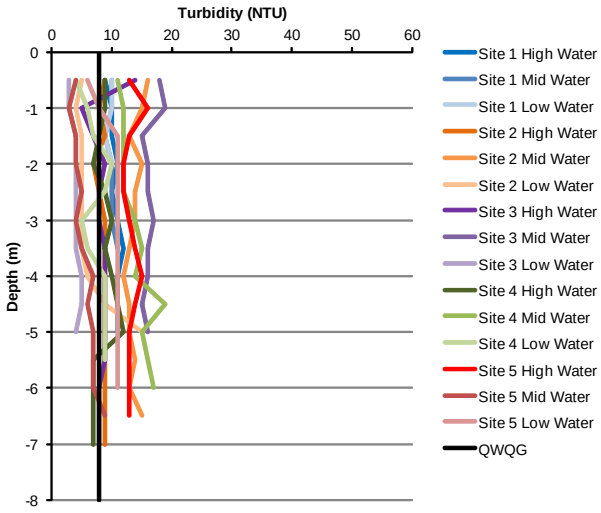

Figure 8-1 Neap Tide YSI Turbidity Depth Profiles for Sites 1-5

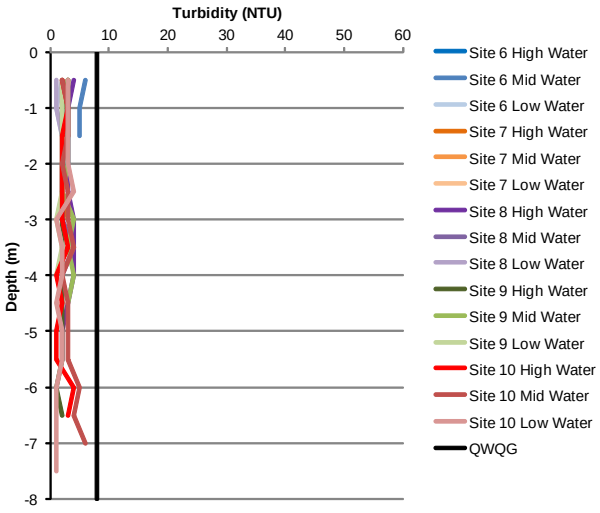

Figure 8-2 Neap Tide YSI Turbidity Depth Profiles for Sites 6-10

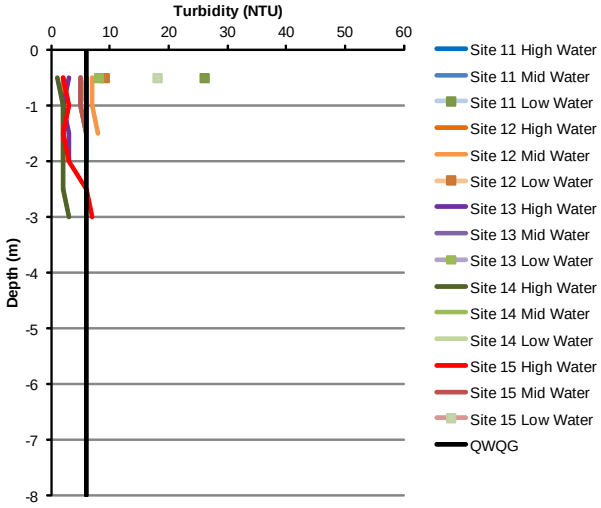

Figure 8-3 Neap Tide YSI Turbidity Depth Profiles for Sites 11-15

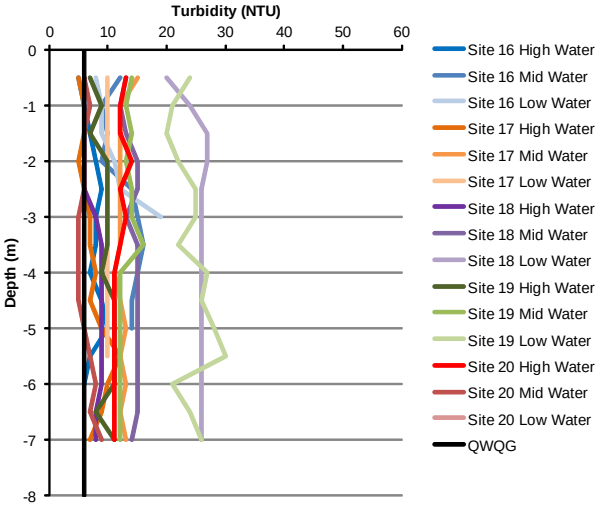

Figure 8-4 Neap Tide YSI Turbidity Depth Profiles for Sites 16-20

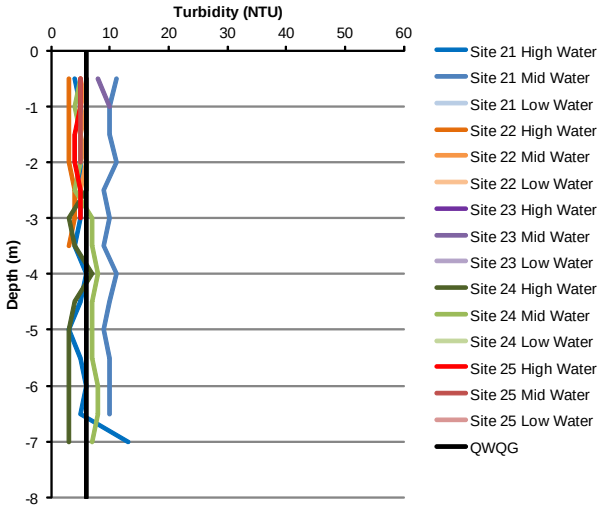

Figure 8-5 Neap Tide YSI Turbidity Depth Profiles for Sites 21-25

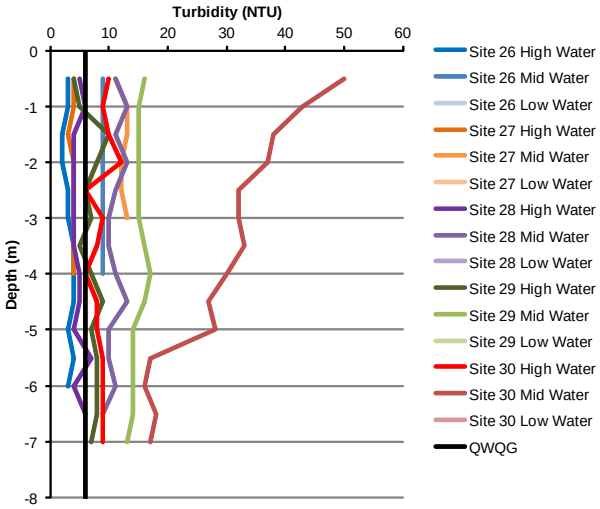

Figure 8-6 Neap Tide YSI Turbidity Depth Profiles for Sites 26-30

Black line: QWQGs (2009) for mid-estuarine and enclosed coastal waters of central Queensland for Sites 1-10 and Sites 11-30, respectively.

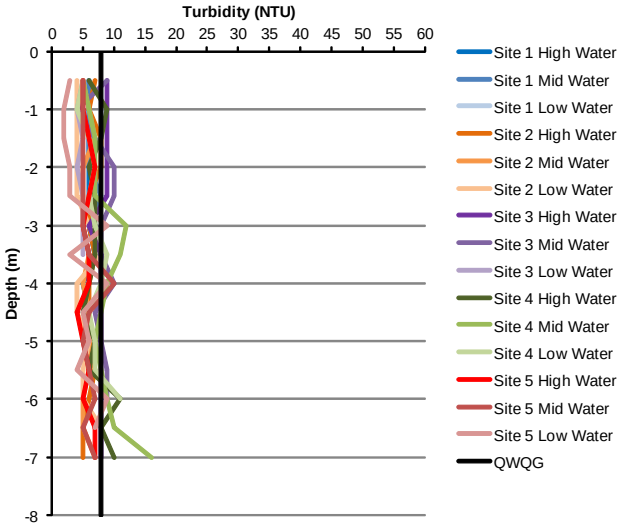

Figure 8-7 Spring Tide YSI Turbidity Depth Profiles for Sites 1-5

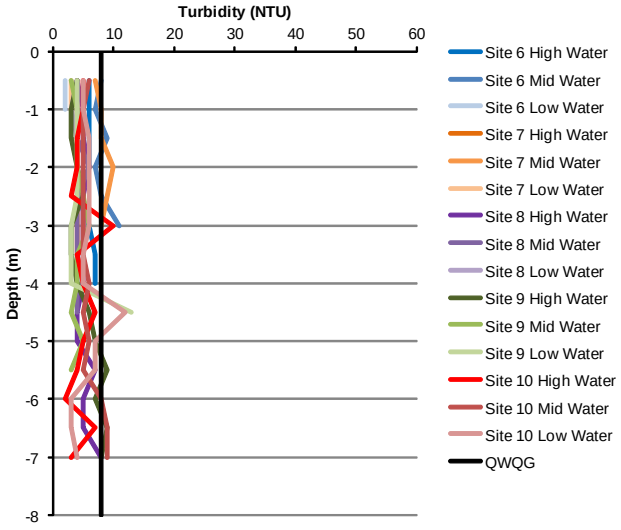

Figure 8-8 Spring Tide YSI Turbidity Depth Profiles for Sites 6-10

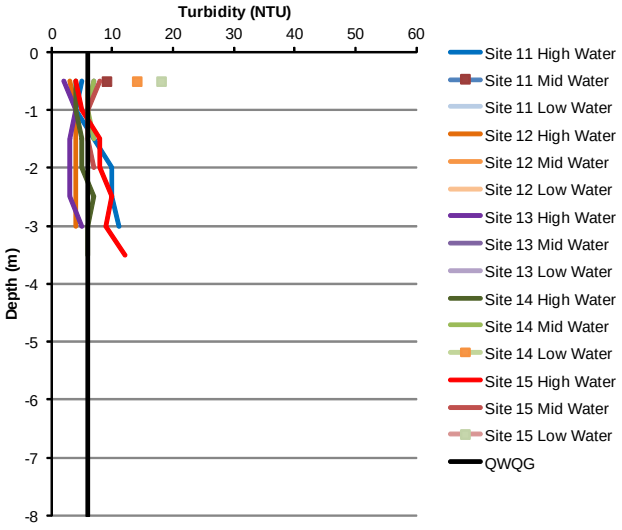

Figure 8-9 Spring Tide YSI Turbidity Depth Profiles for Sites 11-15

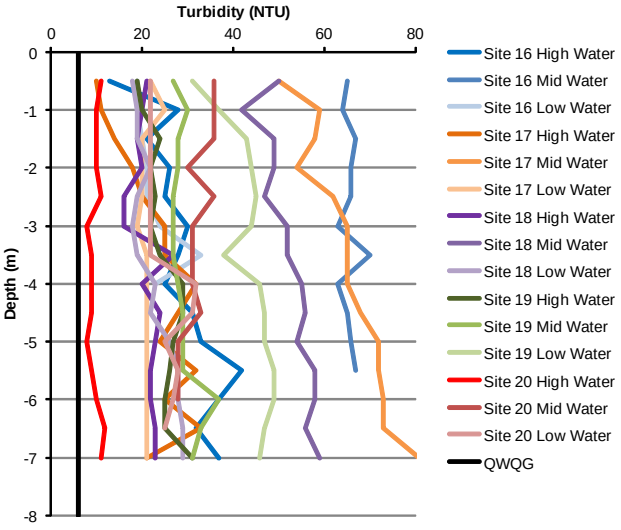

Figure 8-10 Spring Tide YSI Turbidity Depth Profiles for Sites 16-20

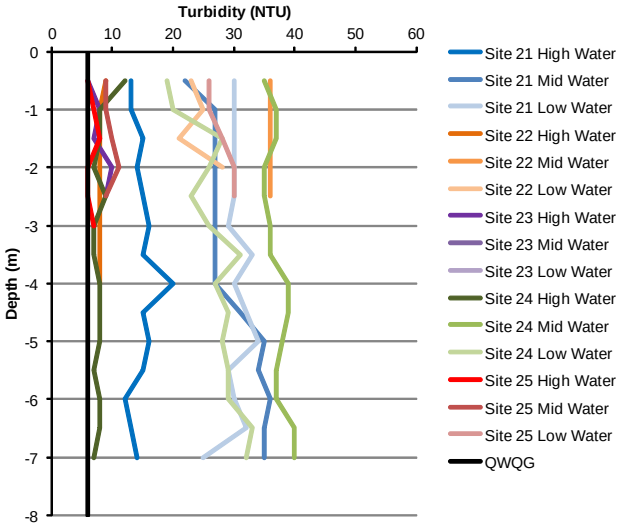

Figure 8-11 Spring Tide YSI Turbidity Depth Profiles for Sites 21-25

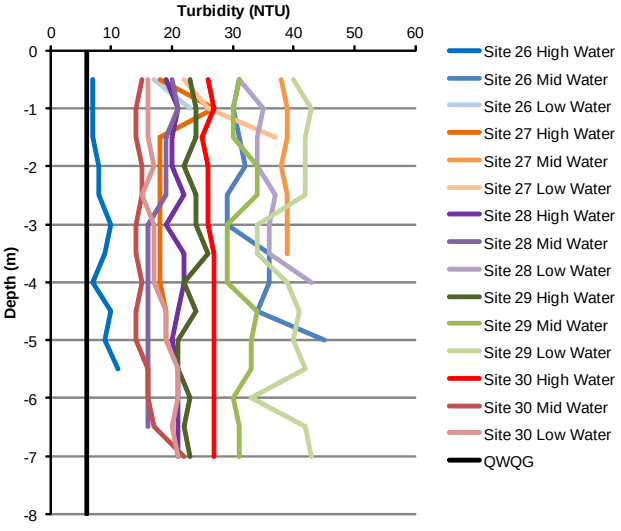

Figure 8-12 Spring Tide YSI Turbidity Depth Profiles for Sites 26-30

Black line: QWQGs (2009) for mid-estuarine and enclosed coastal waters of central Queensland for Sites 1-10 and Sites 11-30, respectively.

Additional Water Quality Values

Results for non-metered physico-chemical water quality values are presented in Tables 4-1 through 4-12 (Appendix 4). Results for the neap tide sampling period are shown in Tables 4-1 through 4-6 with results for the spring tide sampling period shown in Tables 4-7 through 4-12. Values exceeding project water quality criteria for mid-estuarine (Sites 1 – 10) and for enclosed coastal (Sites 11 – 30) waters of Central Queensland are highlighted in bold. This data represents those parameters (total suspended solids, light penetration/ water clarity) that required other means apart from the use of a YSI multi-probe meter for measuring physico-chemical water quality (See Methods for more details).

Total suspended solids (TSS) exceeded project water quality criteria at sites 1 – 5 and 16 – 30 for most samples either at the top or bottom of the water column, if not both, for both neap and spring tide sampling periods. Secchi depth was also in exceedence at most of these sites. This corresponds to the previous finding of WBM (1999) where water clarity was considered poor at less than 2m. Sites 6 – 10 in the upper Calliope River had a much lower incidence of exceedence, particularly for TSS with no exceedence at these sites during the neap tide sampling period. Secchi depth was also more frequently within project water quality criteria during the neap tide sampling period at these sites. This is expected in these upper Calliope River sites which are less affected by tidal influence and river flows at the time of year the samples were taken. Dekker and Phinn (2005) also found that tidal stage and stream flow were major influencing factors in Port Curtis on TSS and secchi depth.

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Conclusions

For each parameter measured, the appropriate project water quality criteria has been included as a reference. Project water quality criteria are based on Australia New Zealand Environment and Conservation Council (ANZECC) and provide high reliability water quality guidelines for water quality management; however these guidelines become supplemental when state or regional guidelines or objectives are available. The ANZECC or Queensland Water Quality Guidelines were used as a basis for the project water quality criteria wherever each is appropriate according to the Arrow LNG Plant EIS (values shown in Table 1).

Within the results, variations are seen for total metals, turbidity, chlorophyll-*a*, salinity and conductivity between the top of the water column and the bottom of the water column. For all of these parameters, this variation may be due to resuspension of sediments or detritus through tidal flow, from intrusion of land based fresh water, or due to stratification via another method. In addition, it was generally found that spring tide conditions had more of an effect, being the possible cause for higher metals concentrations, higher turbidity and other related physicochemical parameter reading and higher nutrient concentrations. on sampling results that did the neap tide conditions. This is potentially due to higher rates of water flow and higher currents during spring tides, which increases flushing times and also increases the overall resuspension of sediments.

There are some project water quality criteria exceedences or deviations outside the established guideline values demonstrated within this study. Parameters which exceeded or deviated from the relevant established guideline values (see Table 1) include: total metals (copper and zinc); nutrients (FRP, total phosphorus and total nitrogen); physicochemical parameters (turbidity, chlorophyll-*a*, dissolved oxygen and pH); TSS; and secchi depth.

Any deviation or exceedence of a guideline (or trigger) value does not necessarily indicate that the aquatic ecosystems is harmful, rather it indicates that further investigation or action is required. The project water quality criteria referred to within this document are concentrations below which aquatic ecosystems should not be significantly impacted. Within this and the previous study, total metals were measured; however total metals (unfiltered) metals includes both dissolved and suspended particulate metals. The bioavailable fraction of this total metals concentration may be quite small and within project water quality criteria. Using total metals concentrations as a baseline value can be conservative and in the case where total metals exceed guidelines, samples can under certain circumstances be reanalysed for dissolved metals only, this is not possible for the current study. However in areas found by this study where high total metals concentrations are prevalent, in future studies dissolved metals only may be sampled and analysed to provide further context to the dissolved and potentially bioavailable fraction of the metals found.

It should be noted however that the values represented here are representative only of the specific conditions for the specific sampling events and may not be representative of long term sampling results. Seasonal fluctuation, catchment inflows, high current velocities and rainfall, amongst other inputs may all have some role in causing elevated values. These, along with

anthropogenic activities within the Gladstone Harbour region could all be contributing factors to elevated values.

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Appendix 1: Figures 9-1 through 9-30 – Chlorophyll-a site results

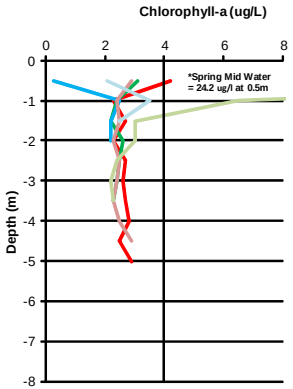


Figure 9-1 Chlorophyll-a YSI Depth Profiles for Site 1

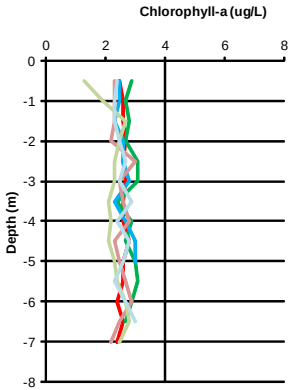


Figure 9-2 Chlorophyll-a YSI Depth Profiles for Site 2

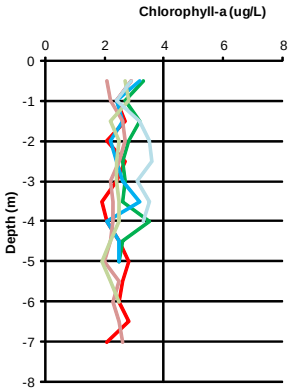


Figure 9-3 Chlorophyll-a YSI Depth Profiles for Site 3

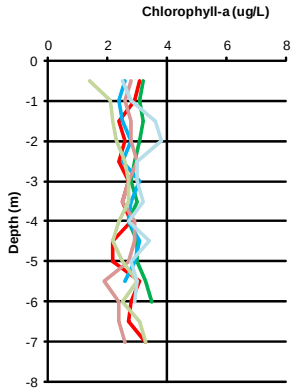


Figure 9-4 Chlorophyll-a YSI Depth Profiles for Site 4

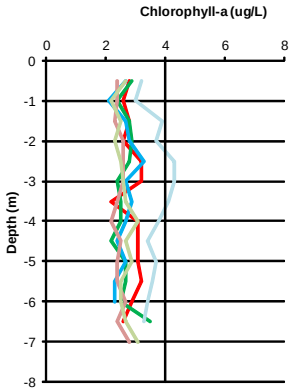


Figure 9-5 Chlorophyll-a YSI Depth Profiles for Site 5

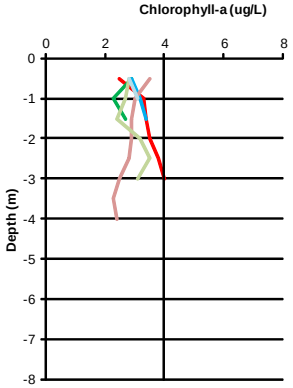


Figure 9-6 Chlorophyll-a YSI Depth Profiles for Site 6

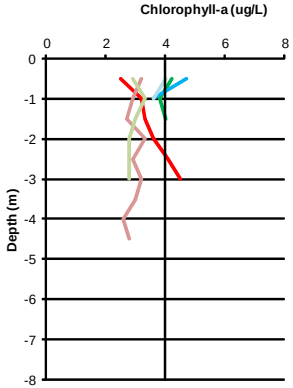


Figure 9-7 Chlorophyll-a YSI Depth Profiles for Site 7

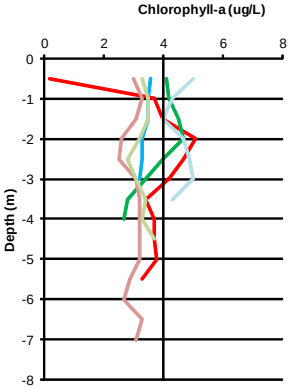


Figure 9-8 Chlorophyll-a YSI Depth Profiles for Site 8

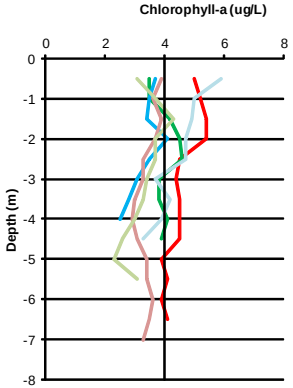


Figure 9-9 Chlorophyll-a YSI Depth Profiles for Site 9

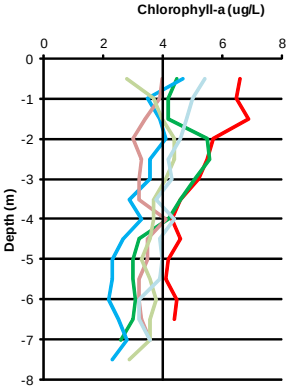


Figure 9-10 Chlorophyll-a YSI Depth Profiles for Site 10

Neap High Water | Neap Mid Water | Neap Low Water | Spring High Water | Spring Mid Water | Spring Low Water | QWQG*

*QWQG (2009) for mid-estuarine waters of central Queensland.

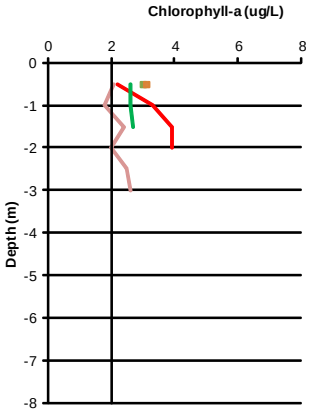


Figure 9-11 Chlorophyll-a YSI Depth Profiles for Site 11

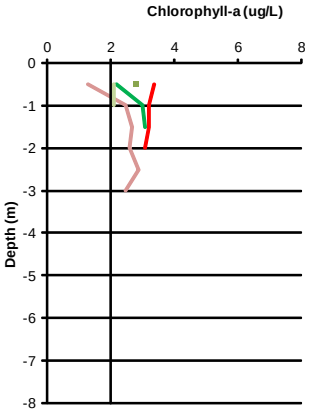


Figure 9-12 Chlorophyll-a YSI Depth Profiles for Site 12

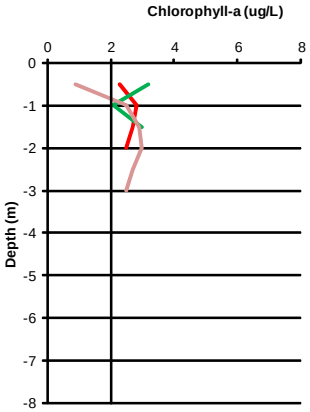


Figure 9-13 Chlorophyll-a YSI Depth Profiles for Site 13

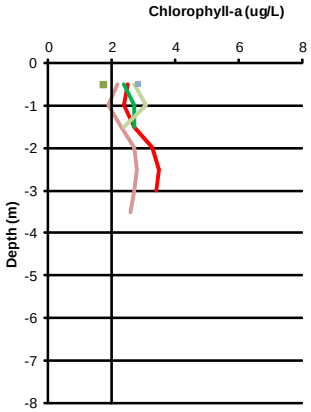
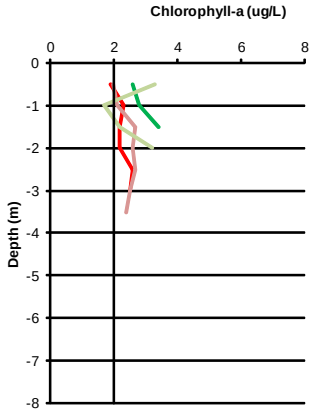


Figure 9-14 Chlorophyll-a YSI Depth Profiles for Site 14



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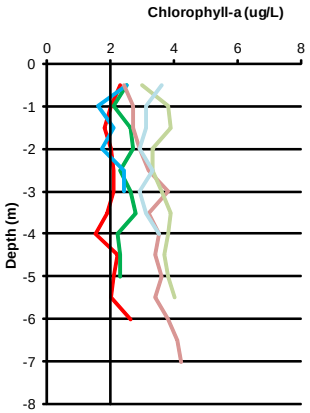

Figure 9-16 Chlorophyll-a YSI Depth Profiles for Site 16

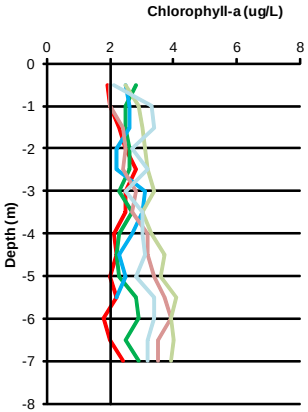

Figure 9-17 Chlorophyll-a YSI Depth Profiles for Site 17

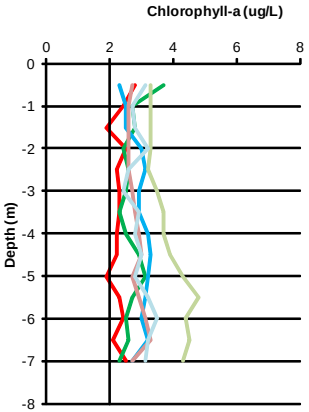

Figure 9-18 Chlorophyll-a YSI Depth Profiles for Site 18

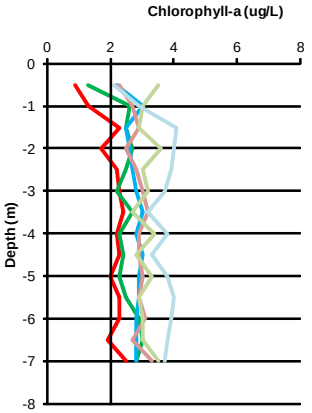

Figure 9-19 Chlorophyll-a YSI Depth Profiles for Site 19

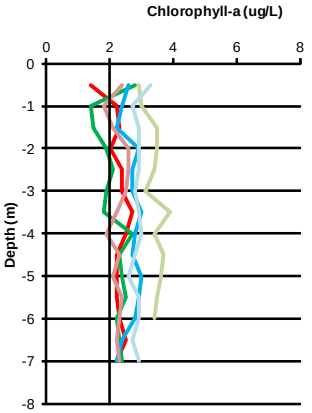

Figure 9-20 Chlorophyll-a YSI Depth Profiles for Site 20

Neap High Water | Neap Mid Water | Neap Low Water | Spring High Water | Spring Mid Water | Spring Low Water | QWQG*

*QWQG (2009) for enclosed coastal waters of central Queensland.

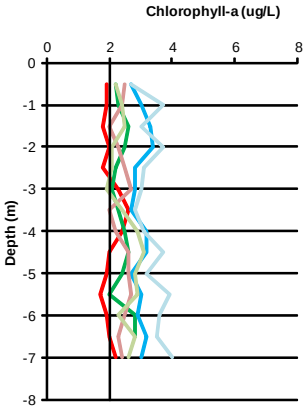

Figure 9-21 Chlorophyll-a YSI Depth Profiles for Site 21

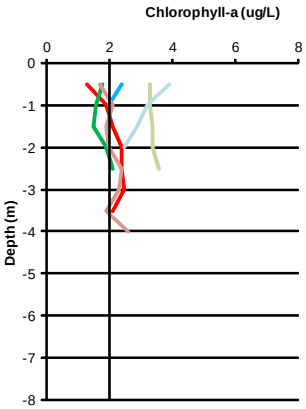

Figure 9-22 Chlorophyll-a YSI Depth Profiles for Site 22

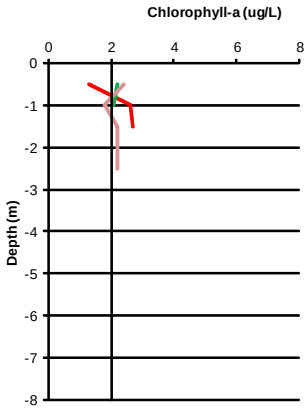

Figure 9-23 Chlorophyll-a YSI Depth Profiles for Site 23

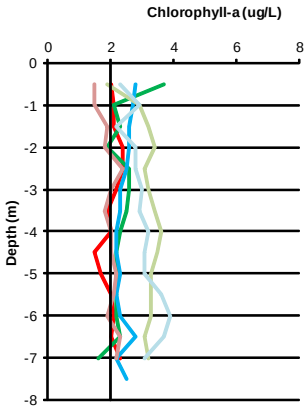

Figure 9-24 Chlorophyll-a YSI Depth Profiles for Site 24

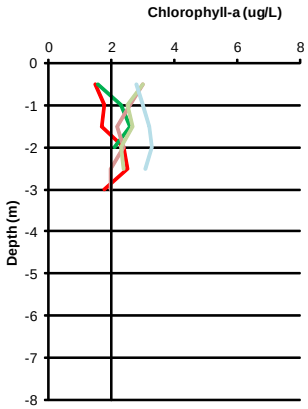

Figure 9-25 Chlorophyll-a YSI Depth Profiles for Site 25

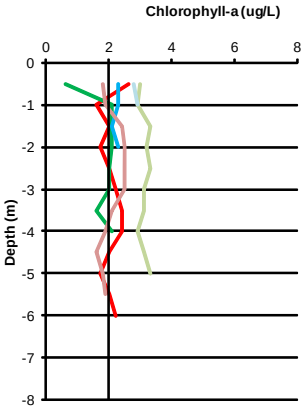

Figure 9-26 Chlorophyll-a YSI Depth Profiles for Site 26

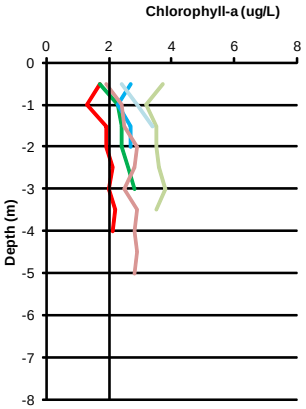

Figure 9-27 Chlorophyll-a YSI Depth Profiles for Site 27

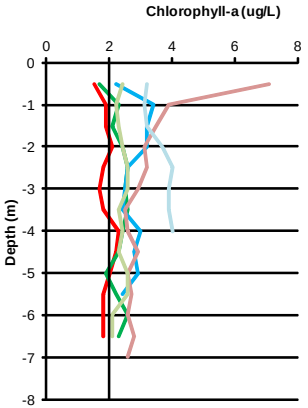

Figure 9-28 Chlorophyll-a YSI Depth Profiles for Site 28

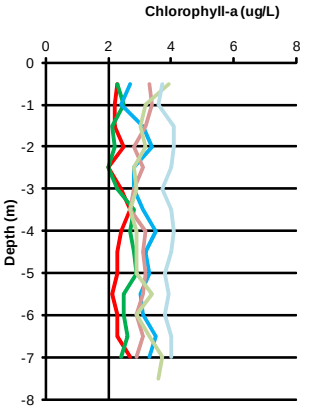

Figure 9-29 Chlorophyll-a YSI Depth Profiles for Site 29

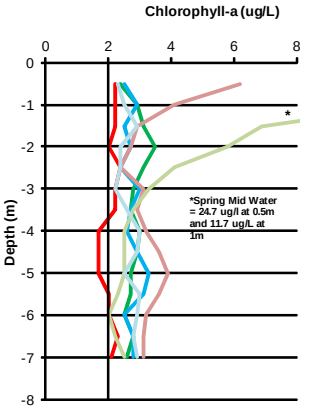

Figure 9-30 Chlorophyll-a YSI Depth Profiles for Site 30

Neap High Water | Neap Mid Water | Neap Low Water | Spring High Water | Spring Mid Water | Spring Low Water | QWQG*

*QWQG (2009) for enclosed coastal waters of central Queensland.

Appendix 2: Tables 1-1 through 1-24 – Total Metals Laboratory Results

Table 1-1. Neap Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site														WQG*
	1			2†			3			4			5		
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	547	743	676	404.5 ± 34.5	843.5 ± 236.5	370.5 ± 29.5	393	1180	357	503	593	314	603	101	536	NG
Iron	587	825	750	410 ± 30	937 ± 273	414 ± 30	435	1320	369	514	681	332	643	106	576	NG
Arsenic	1.5	2	1.8	1.6	2 ± 0.1	1.6	1.6	1.8	1.6	1.7	1.6	1.6	1.8	1.4	1.6	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	0.5	0.9	0.7	LD	LD	LD	LD	1.3	LD	0.6	1.1	LD	0.6	LD	LD	4.4
Cobalt	0.3	0.4	0.4	0.2	0.5 ± 0.1	0.3	0.2	0.6	0.3	0.3	0.4	0.3	0.3	LD	0.3	1
Copper	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.3
Lead	LD	LD	LD	LD	0.3 ± 0.1	LD	LD	0.4	LD	0.2	LD	LD	LD	LD	LD	4.4
Manganese	14	18.9	19	11.1 ± 0.3	24.3 ± 4.5	21 ± 0.4	11.3	29.3	22.4	16.9	26.4	22.9	16.6	18.6	27.4	NG
Nickel	0.8	1.1	0.9	0.9 ± 0.2	1.1 ± 0.	0.8 ± 0.2	0.7	1	LD	0.8	1.2	LD	0.6	0.5	0.9	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	3.4	3.8	3.6	2.8	4.3 ± 0.1	3.1 ± 0.5	3.1 ± 0.2	5.4	2.3	2.6	2.9	2.3	3.2	1.8	3	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-2. Neap Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	1			2†			3			4			5			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	710	565	675	719 ± 133	986 ± 54	1164.5 ± 605.5	326	1060	352	966	1450	581	842	558	737	NG
Iron	688	614	742	800 ± 136	1085 ± 55	1397.5 ± 772.5	330	1100	375	1060	1560	646	951	611	827	NG
Arsenic	1.7	1.7	1.8	1.9 ± 0.1	2.1 ± 0.1	2.2 ± 0.5	1.6	1.8	1.5	1.9	2.2	1.7	1.9	1.7	1.7	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	0.6	LD	1.5	0.7 ± 0.1	1	LD	LD	1.1	LD	1.7	1.5	1	0.9	0.6	0.7	4.4
Cobalt	0.3	0.3	0.4	0.4 ± 0.1	0.5	0.7 ± 0.3	0.2	0.5	0.3	0.5	0.7	0.4	0.4	0.4	0.4	1
Copper	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1	LD	LD	LD	LD	1.3
Lead	LD	LD	LD	0.2	0.3	0.7	LD	0.5	LD	0.3	0.5	LD	0.3	LD	0.2	4.4
Manganese	17	15.2	18.1	20 ± 3.8	25.8 ± 1	46.6 ± 20.3	10	24.2	22.3	24.6	44.7	30.5	23.4	30.9	37	NG
Nickel	0.9	0.9	1.8	0.9 ± 0.1	1.1 ± 0.1	1.3 ± 0.4	0.6	1.1	0.6	1.4	1.2	0.6	1.1	1	1	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	3.3	3.1	3.6	3.8 ± 0.5	4.5 ± 0.2	5.2 ± 1.9	3.1	3.8	2.4	3.7	5.4	3	3.7	3.1	3.7	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-3. Neap Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	6			7			8†			9			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	200	261	147	186	229	179	226.5 ± 30.5	151.5 ± 0.5	149.5 ± 16.5	228	373	131	178	146	189	NG
Iron	203	306	160	210	288	205	248.5 ± 37.5	172 ± 4	163.5 ± 19.5	255	428	147	202	166	211	NG
Arsenic	1.6	1.6	1.3	1.6	1.4	1.3	1.7 ± 0.1	1.5	1.3	1.6	1.6	1.2	1.6	1.5	1.2	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.2	0.7
Chromium	LD	LD	LD	0.5	LD	LD	LD	1.2	LD	LD	LD	LD	LD	LD	LD	4.4
Cobalt	LD	0.3	LD	0.2	0.2	0.2	LD	LD	LD	0.2	0.3	LD	0.2	LD	0.2	1
Copper	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.3
Lead	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	4.4
Manganese	21.2	25.2	31.4	25.8	37.2	40	31.8 ± 1.1	35.5 ± 0.5	37.3 ± 0.7	35.9	48.6	38.4	37.8	40	41.6	NG
Nickel	LD	0.5	LD	0.7	LD	LD	LD	0.9 ± 0.2	LD	LD	LD	LD	0.7	LD	LD	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2	2.7	2.3	1.6	2.8	2.7	2.1 ± 0.1	1.2 ± 0.1	2.9 ± 0.1	2.2	2.7	2.9	2.4	2.2	3.3	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-4. Neap Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	6			7			8†			9			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	136	138	172	140	172	127	155 ± 21	104.5 ± 1.5	310 ± 85	152	185	129	175	184	103	NG
Iron	134	160	191	156	190	140	175.5 ± 21.5	113 ± 4	370.5 ± 95.5	169	208	147	221	202	112	NG
Arsenic	1.6	1.4	1.3	1.6	1.4	1.3	1.7 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	1.6	1.5	1.3	1.3	1.6	1.3	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	LD	LD	LD	LD	LD	LD	LD	0.7	LD	LD	LD	LD	LD	LD	4.4
Cobalt	LD	LD	LD	LD	LD	LD	LD	LD	0.3 ± 0.1	LD	0.2	LD	0.2	LD	LD	1
Copper	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.3
Lead	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	4.4
Manganese	18.9	24.8	30.9	25.4	31.8	31.4	26.2 ± 0.1	27.9 ± 0.3	44 ± 3.4	32.5	40.5	35.4	40.9	36.2	31	NG
Nickel	LD	0.8	LD	LD	0.9	LD	LD	LD	0.8 ± 0.3	LD	LD	LD	LD	LD	LD	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	1.7	2.2	2.3	1.7	2.8	2.5	1.9 ± 0.1	1.8	3.2 ± 0.4	2.1	2.3	2.6	2.2	2.2	2.5	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-5. Neap Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	11†			12			13			14			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	368.5 ± 32.5	308.5 ± 82.5	1530 ± 160	98	350	542	190	256	545	143	193	418	160	190	1140	NG
Iron	408.5 ± 32.5	320 ± 58	1735 ± 135	110	393	689	217	313	673	156	219	488	177	243	1430	NG
Arsenic	1.6	1.5	2.35 ± 0.15	1.4	1.6	2	1.5	1.3	1.8	1.4	1.5	1.7	1.5	1.5	2.3	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	LD	2.1 ± 0.2	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1	1.3	4.4
Cobalt	0.3 ± 0.1	0.3 ± 0.1	0.9 ± 0.1	LD	0.3	0.4	LD	0.2	0.5	LD	0.2	0.4	LD	0.3	0.8	1
Copper	LD	LD	**2**	LD	LD	1	LD	LD	**3**	LD	LD	LD	LD	LD	**2**	1.3
Lead	LD	LD	0.5	LD	LD	LD	LD	LD	0.2	LD	LD	LD	LD	LD	0.5	4.4
Manganese	24 ± 0.4	18 ± 0.7	67.8 ± 2.2	14	26.7	56.8	20	25.3	72.4	13.9	21.8	50.2	8.4	18.3	61.7	NG
Nickel	LD	0.7	1.70 ± .1	LD	0.7	1	LD	0.7	0.9	0.6	LD	0.8	0.6	1.4	1.3	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.5	2.1 ± 0.1	6 ± 0.4	1.8	2.1	2.5	2.3	2	2.3	1.7	2	2	2	2	4.4	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-6. Neap Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	11†			12			13			14			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	0.1
Aluminium	1215 ± 85	363 ± 29	-	123	435	-	203	322	-	134	274	-	275	212	-	NG
Iron	1425 ± 85	455.5 ± 29.5	-	133	522	-	240	403	-	147	344	-	312	263	-	NG
Arsenic	2 ± 0.1	1.6	-	1.4	1.6	-	1.5	1.4	-	1.4	1.6	-	1.5	1.6	-	NG
Cadmium	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	0.7
Chromium	1.6 ± 0.2	LD	-	LD	LD	-	0.6	LD	-	LD	0.9	-	LD	0.6	-	4.4
Cobalt	0.7 ± 0.1	0.3	-	LD	0.3	-	LD	0.3	-	LD	0.2	-	0.2	0.3	-	1
Copper	1	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	1.3
Lead	0.5 ± 0.1	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	4.4
Manganese	44.2 ± 2.2	22.3 ± 0.3	-	14	30.6	-	19.2	28.1	-	13.5	24.4	-	12.7	19.6	-	NG
Nickel	1	0.7 ± 0.2	-	LD	0.8	-	LD	0.7	-	0.5	1.1	-	0.6	1	-	7
Silver	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	1.4
Vanadium	4.9 ± 0.2	2.4 ± 0.2	-	2	2.6	-	2.2	2.1	-	1.6	2.3	-	2.2	2.1	-	100
Zinc	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-7. Neap Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	16†			17			18			19			20†			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	293 ± 6	621.5 ± 57.5	380 ± 42	228	699	609	324	575	1080	271	824	544	298.5 ± 40.5	347.5 ± 8.5	837.5 ± 27.5	NG
Iron	358.5 ± 5.5	768 ± 69	462.5 ± 49.5	270	895	720	341	735	1340	301	1030	706	364.5 ± 53.5	395 ± 3	1011.5 ± 48.5	NG
Arsenic	1.6 ± 0.1	1.8 ± 0.1	1.8	1.5	1.8	2	1.5	1.8	2.4	1.5	1.8	2	2.1 ± 0.1	1.5	1.8 ± 0.1	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	0.7 ± 0.1	LD	LD	0.8	0.5	0.9	0.6	1.2	LD	2.5	0.6	LD	0.8	1	4.4
Cobalt	0.3 ± 0.1	0.5 ± 0.1	0.4 ± 0.1	0.2	0.5	0.4	0.2	0.4	0.8	0.2	0.6	0.6	0.4 ± 0.1	0.2	0.6	1
Copper	LD	LD	LD	LD	LD	1	LD	LD	**2**	LD	LD	LD	LD	LD	LD	1.3
Lead	LD	0.3 ± 0.1	0.3 ± 0.1	LD	0.3	0.4	LD	0.2	0.8	LD	0.5	0.5	0.3	LD	0.5 ± 0.1	4.4
Manganese	8.8 ± 0.1	16.1 ± 1.8	11.7 ± 0.8	7.1	17.3	14	7.8	16.4	24.4	7.6	17	19.2	14.7 ± 1.4	8.4 ± 0.4	16.6 ± 0.1	NG
Nickel	LD	1 ± 0.1	0.9	LD	0.8	0.9	1	0.8	1.4	0.5	1.7	1.1	0.5	0.9 ± 0.2	1 ± 0.5	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.2 ± 0.1	3.2 ± 0.2	2.3 ± 0.1	2.1	3.5	3.1	2.8	3.2	4.6	2.4	3.6	3.2	2.3 ± 0.2	2.6	3.9 ± 0.4	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-8. Neap Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	16†			17			18			19			20†			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	337 ± 4	528.5 ± 81.5	523 ± 27	211	520	956	380	735	818	329	550	706	202.5 ± 15.5	393.5 ± 104.5	530 ± 144	NG
Iron	381.5 ± 13.5	649 ± 117	633.5 ± 58.5	231	673	1100	423	915	983	372	685	850	239.5 ± 19.5	447.5 ± 128.5	673 ± 163	NG
Arsenic	1.7 ± 0.1	1.7 ± 0.1	1.9 ± 0.1	1.2	1.7	2.2	1.5	1.6	2.1	1.5	1.8	1.6	2 ± 0.1	1.6 ± 0.1	1.8 ± 0.1	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	0.6	LD	0.7	1.9	0.9	LD	0.7	0.7	1.1	LD	0.6	LD	0.5	0.7	4.4
Cobalt	0.3 ± 0.1	0.4	0.4	LD	0.5	0.6	0.2	0.5	0.6	0.2	0.4	0.5	0.3 ± 0.1	0.3 ± 0.1	0.5	1
Copper	LD	LD	LD	LD	LD	**2**	LD	LD	1	LD	LD	LD	LD	LD	LD	1.3
Lead	LD	0.3 ± 0.1	0.3	LD	0.3	0.6	0.2	0.4	0.4	LD	0.3	0.4	LD	LD	0.4	4.4
Manganese	9 ± 0.2	15.2 ± 0.8	14.2 ± 0.3	6.4	18.7	23	9.9	17.3	19.4	9.1	13.7	16.4	10.8 ± 0.5	9.4 ± 1.7	19.4 ± 3	NG
Nickel	LD	0.9 ± 0.1	1 ± 0.1	1	1.7	1.2	0.5	0.9	1.1	1.1	LD	1.2	LD	0.6 ± 0.1	LD	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.2	2.9 ± 0.1	2.8 ± 0.2	2.4	3.1	4.1	2.7	4.4	3.5	2.7	2.9	4.3	2	2.8 ± 0.3	3 ± 0.3	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-9. Neap Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	21			22			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	0.1
Aluminium	96	517	1260	64	342	805	111	261	-	114	423	673	96	247	326	NG
Iron	118	590	1590	71	372	978	130	290	-	158	469	832	130	269	380	NG
Arsenic	1.9	1.6	2.2	1.9	1.5	1.9	1.8	1.4	-	1.4	1.4	1.8	1.4	1.4	1.6	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	0.7	1.6	LD	LD	0.9	LD	0.5	-	LD	LD	0.8	LD	LD	LD	4.4
Cobalt	LD	0.3	0.9	LD	0.2	0.5	LD	0.2	-	0.2	0.3	0.5	LD	0.2	0.3	1
Copper	LD	LD	1	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	1.3
Lead	LD	LD	0.7	LD	LD	0.3	LD	LD	-	LD	LD	0.3	LD	LD	LD	4.4
Manganese	7.3	10.2	29	5.6	8.7	15.9	8.3	6.7	-	11.4	10.7	15.3	7.7	8.3	9.2	NG
Nickel	LD	0.8	1.2	LD	0.5	LD	LD	0.7	-	0.5	LD	LD	LD	LD	LD	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	1.4
Vanadium	1.3	3.1	4.8	1.3	2.7	3.4	1.6	2.6	-	2.6	2.6	3.3	2.1	2.4	2.6	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

- = Site inaccessible at tide. No sample taken.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-10. Neap Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	21			22			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	0.1
Aluminium	136	298	1040	88	349	-	101	-	-	112	207	614	235	306	-	NG
Iron	156	326	1290	101	392	-	131	-	-	154	225	774	278	339	-	NG
Arsenic	1.9	1.5	1.9	2	1.5	-	1.8	-	-	1.5	1.4	1.7	2	1.5	-	NG
Cadmium	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	0.7
Chromium	LD	LD	1.2	LD	LD	-	LD	-	-	LD	LD	1.3	LD	LD	-	4.4
Cobalt	LD	0.2	0.9	LD	0.2	-	LD	-	-	LD	LD	0.4	LD	0.2	-	1
Copper	LD	LD	LD	LD	LD	-	**5**	-	-	LD	LD	LD	LD	LD	-	1.3
Lead	LD	LD	0.8	LD	LD	-	LD	-	-	LD	LD	0.3	LD	LD	-	4.4
Manganese	8	8.5	33.4	6.2	9.2	-	9.1	-	-	8.1	6.9	14.6	8.6	8.9	-	NG
Nickel	LD	LD	LD	LD	LD	-	0.7	-	-	LD	LD	LD	0.5	LD	-	7
Silver	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	1.4
Vanadium	1.5	2.6	4.4	1.6	2.7	-	1.7	-	-	2.2	2.1	3.1	1.8	2.6	-	100
Zinc	LD	LD	LD	8	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-11. Neap Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	26			27†			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	136	348	797	194.5 ± 7.5	739 ± 159	819 ± 114	205	269	548	402	338	619	458	266	809	NG
Iron	150	400	1020	242.5 ± 11.5	912 ± 198	1012 ± 148	256	327	636	503	425	793	608	341	921	NG
Arsenic	2.1	1.6	1.9	2	1.85 ± 0.05	1.8 ± 0.1	2.1	2.1	1.6	2	2.1	1.6	2.3	2	1.3	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	LD	1	LD	0.9	1 ± 0.2	1	LD	0.6	LD	LD	0.6	LD	LD	0.6	4.4
Cobalt	LD	0.2	0.5	LD	0.5 ± 0.1	0.6	LD	0.3	0.4	0.3	0.5	0.5	0.3	0.4	0.4	1
Copper	1	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1	1	1	1.3
Lead	LD	LD	0.4	LD	0.3 ± 0.1	0.4	LD	0.2	0.2	LD	0.4	0.3	0.2	0.3	0.3	4.4
Manganese	7	8.7	16.8	7.8 ± 0.9	16 ± 1.7	19.8 ± 0.2	7.4	14.9	10.8	12.1	19.7	14.6	15	17.4	14.3	NG
Nickel	LD	LD	LD	0.6	0.7 ± 0.2	LD	1.2	LD	LD	0.7	LD	LD	0.7	0.5	0.9	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	1.7	2.7	3.4	1.9 ± 0.1	3.9 ± 0.4	3.8 ± 0.3	2.1	1.9	3.2	2.5	2.6	3.2	3	2.4	3.2	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-12. Neap Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	26			27†			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	167	288	424	169 ± 15	346 ± 152	794.5 ± 2.5	211	206	969	180	154	1040	314	312	978	NG
Iron	186	322	538	210 ± 28	399.5 ± 174.5	958 ± 2.9	246	258	1140	219	188	1310	438	382	1130	NG
Arsenic	2	1.5	1.6	2.1 ± 0.1	1.7 ± 0.1	1.8	2	2.1	2	2	1.9	2	2.1	2	1.7	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	0.7	LD	LD	LD	LD	0.9	LD	LD	1.1	LD	LD	1.4	0.7	LD	0.8	4.4
Cobalt	LD	LD	0.4	LD	0.3 ± 0.1	0.6 ± 0.1	LD	0.3	0.6	0.2	0.2	0.7	0.3	0.4	0.6	1
Copper	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1	LD	LD	1.3
Lead	LD	LD	0.2	LD	LD	0.4	LD	LD	0.4	LD	LD	0.6	0.2	0.3	0.4	4.4
Manganese	5.8	7.1	12	6.1 ± 0.7	10.3 ± 0.3	16.6 ± 2	6.6	12.8	17.8	8.2	10.1	22	11.9	16.1	16.9	NG
Nickel	0.8	LD	LD	0.6 ± 0.1	LD	LD	0.6	LD	LD	LD	LD	LD	1.9	0.6	1.1	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	1.5	2.6	2.7	2 ± 0.2	3.1 ± 0.1	3.8 ± 0.2	2.1	1.8	4.2	2.1	1.8	4.5	2.5	2.4	4	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-13. Spring Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	1			2			3			4			5			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	464	403	600	512	415	398	622	484	208	553	536	280	378	420	230	NG
Iron	643	474	699	748	499	451	880	554	225	816	634	324	517	492	242	NG
Arsenic	1.5	1.6	1.7	1.6	1.6	1.7	1.4	1.7	1.6	1.4	1.7	1.7	1.3	1.6	1.6	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	1.5	1.3	LD	0.7	LD	LD	0.8	LD	LD	1.4	LD	LD	0.5	LD	LD	4.4
Cobalt	0.3	0.3	0.4	0.4	0.3	0.3	0.5	0.3	0.2	0.4	0.3	0.3	0.3	0.3	0.2	1
Copper	**4**	LD	LD	1	LD	LD	1	LD	LD	1	LD	LD	1	LD	LD	1.3
Lead	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	4.4
Manganese	17.4	14	27.4	19.5	16.7	24.2	23.6	17.4	23.1	23.9	20.8	32.9	16.3	22.6	24.7	NG
Nickel	1.2	1.2	0.9	0.7	LD	0.8	0.8	LD	0.6	1.2	LD	0.7	0.6	LD	0.5	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	3.2	3	2.8	3.4	3.3	2.9	3.6	3.4	2.4	3.5	3.9	3	3	2.9	2.7	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-14. Spring Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	1			2			3†			4			5			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	359	297	500	363	314	337	528 ± 5	442.5 ± 60.5	248 ± 28	495	974	337	365	311	367	NG
Iron	466	340	526	480	332	376	706.5 ± 13.5	512.5 ± 82.5	255 ± 20	700	1210	382	492	345	399	NG
Arsenic	1.4	1.6	1.6	1.4	1.5	1.7	1.4	1.65 ± 0.05	1.6	1.5	2	1.7	1.3	1.6	1.7	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	LD	LD	0.5	LD	LD	0.8 ± 0.1	LD	LD	0.8	0.9	LD	LD	LD	LD	4.4
Cobalt	0.3	0.2	0.3	0.3	0.2	0.3	0.4	0.3	0.2	0.4	0.6	0.3	0.3	0.3	0.3	1
Copper	1	LD	LD	1	LD	LD	1	LD	LD	**2**	LD	LD	1	LD	LD	1.3
Lead	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.3	LD	LD	LD	LD	4.4
Manganese	13.6	11.4	22.3	14.2	12.3	21.3	21.3 ± 0.5	16.2 ± 1.9	23 ± 0.8	19.8	39.3	27.9	15.6	17.8	31.3	NG
Nickel	0.6	LD	0.9	0.6	LD	0.8	0.8	LD	0.6 ± 0.1	0.9	LD	0.6	0.6	LD	0.6	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.8	2.6	2.9	2.9	2.7	2.6	3.4 ± 0.5	3.3 ± 0.1	2.5	3.3	4.4	2.9	2.8	2.1	2.2	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-15. Spring Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	6			7			8			9			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	465	602	203	439	533	238	390	288	294	276	270	302	540	300	459	NG
Iron	615	745	236	502	663	261	535	358	342	348	316	355	701	406	506	NG
Arsenic	1.6	1.6	1.5	1.5	1.6	1.4	1.4	1.5	1.5	1.3	1.1	1.3	1.5	1.2	1	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	0.8	LD	LD	LD	LD	LD	0.6	0.8	LD	LD	LD	LD	LD	LD	LD	4.4
Cobalt	0.4	0.4	0.2	0.4	0.4	0.2	0.4	0.3	0.3	0.3	0.2	0.2	0.4	0.3	0.3	1
Copper	1	LD	LD	LD	LD	LD	LD	LD	LD	LD	1	LD	1	1	LD	1.3
Lead	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	4.4
Manganese	31.5	41.8	24.3	34.6	38.9	29.3	35.6	32.2	34.4	30.4	29.7	34.2	52.7	35.6	39.4	NG
Nickel	0.9	LD	0.5	LD	LD	0.6	0.8	LD	LD	LD	LD	LD	LD	LD	LD	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	3.8	3.2	1.7	3	3.1	2	3.2	2.6	2.3	3.2	3.2	2.2	4.4	4	3.9	100
Zinc	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-16. Spring Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site														WQG*
	6			7			8			9†			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	293	328	-	388	313	-	490	231	243	568 ± 2	252.5 ± 26.5	197 ± 1	458	495	280	NG
Iron	394	400	-	504	364	-	623	263	281	731.5 ± 0.5	326.5 ± 43.5	217 ± 5	600	720	286	NG
Arsenic	1.1	1.5	-	1.3	1.6	-	1.4	1.5	1.4	1.5 ± 0.1	1.1	1.6 ± 0.1	1.4	1.3	1.2	NG
Cadmium	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	1.1	LD	-	1.7	LD	-	LD	LD	LD	0.6	1.3	LD	LD	0.6	LD	4.4
Cobalt	0.3	0.3	-	0.4	0.3	-	0.4	0.2	0.3	0.4	0.3	0.2	0.4	0.4	0.3	1
Copper	LD	LD	-	LD	LD	-	LD	LD	LD	1	1	LD	LD	**2**	LD	1.3
Lead	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	4.4
Manganese	20	31.4	-	34.1	27.2	-	39	27.7	30.5	41.4 ± 0.2	26.6 ± 2.1	26.2 ± 0.3	44	55	35.5	NG
Nickel	1.1	LD	-	1.2	LD	-	LD	LD	LD	0.7 ± 0.2	LD	0.7 ± 0.1	LD	0.8	LD	7
Silver	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.6	2.6	-	3	2.6	-	3.4	2.3	2.1	3.7 ± 0.1	2.8 ± 0.1	2.1 ± 0.1	3.8	4.8	2.8	100
Zinc	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-17. Spring Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site														WQG*
	11			12			13			14			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	0.1
Aluminium	331	369	-	165	198	-	139	234	-	257	141	552	251	319	802	NG
Iron	392	451	-	210	227	-	159	280	-	312	158	662	294	387	1020	NG
Arsenic	1.9	1.5	-	2.1	1.4	-	2	1.4	-	1.9	1.4	1.5	1.8	1.7	1.9	NG
Cadmium	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	LD	-	LD	LD	-	0.6	LD	-	LD	LD	1	LD	LD	0.8	4.4
Cobalt	0.2	0.4	-	LD	0.3	-	LD	0.4	-	0.2	0.2	0.5	0.2	0.3	0.7	1
Copper	LD	1	-	LD	1	-	LD	1	-	LD	1	**2**	LD	LD	**2**	1.3
Lead	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	0.3	4.4
Manganese	10.6	32.3	-	7.8	26.8	-	6	57.5	-	8.9	15.4	38.7	10.1	13.9	53.8	NG
Nickel	2.1	0.5	-	LD	LD	-	0.7	LD	-	LD	LD	1.1	LD	1.7	1	7
Silver	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.4	3.3	-	2.5	2.7	-	2.3	2.9	-	2.6	2.8	3.8	1.9	2.9	4.9	100
Zinc	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-18. Spring Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site														WQG*
	11			12			13			14†			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	0.1
Aluminium	354	-	-	216	-	-	245	-	-	420.5 ± 2.5	199.5 ± 13.5	-	510	286	-	NG
Iron	447	-	-	256	-	-	310	-	-	492 ± 1	235.5 ± 11.5	-	678	327	-	NG
Arsenic	2.1	-	-	2.1	-	-	2	-	-	1.7 ± 0.1	1.4 ± 0.1	-	2	2	-	NG
Cadmium	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	0.7
Chromium	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	4.4
Cobalt	0.3	-	-	0.2	-	-	0.2	-	-	0.3	0.2	-	0.4	0.2	-	1
Copper	LD	-	-	LD	-	-	LD	-	-	LD	1	-	LD	LD	-	1.3
Lead	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	0.2	LD	-	4.4
Manganese	15.2	-	-	9.1	-	-	16.8	-	-	16.1 ± 0.3	14.6 ± 0.2	-	19.6	13.2	-	NG
Nickel	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	7
Silver	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	1.4
Vanadium	2.7	-	-	2.4	-	-	2.7	-	-	3.4 ± 1.2	2.9 ± 0.1	-	3.1	2	-	100
Zinc	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-19. Spring Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	16			17			18			19			20			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	638	1570	736	466	803	1020	466	2190	730	687	874	959	579	505	803	NG
Iron	972	2140	1010	632	1090	1330	652	3110	993	953	1230	1310	801	751	1140	NG
Arsenic	2.2	3.3	1.6	2	2.6	1.8	2.1	3.7	1.7	2.3	2.6	2.1	1.6	1.6	2.1	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	0.7	1.8	1.4	LD	0.6	1	LD	2.5	0.6	LD	0.8	2.1	LD	LD	LD	4.4
Cobalt	0.6	**1.3**	0.8	0.4	0.7	1	0.5	**1.7**	0.7	0.5	0.7	1	0.4	0.7	0.6	1
Copper	LD	1	**2**	LD	LD	**2**	LD	**3**	**2**	**2**	LD	**8**	LD	LD	**2**	1.3
Lead	0.4	1	0.3	0.3	0.5	0.5	0.5	1.1	0.3	0.4	0.5	0.5	0.3	0.8	0.4	4.4
Manganese	23.1	44.3	26.8	15.7	24.1	38.6	18.9	51.8	26.2	20.5	24.1	37.9	18.7	33.6	25	NG
Nickel	0.9	1.4	1.5	LD	0.6	1.2	LD	2	1	LD	0.7	1.8	LD	LD	0.7	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	3.2	6.6	4.9	2.9	4.3	5.7	3.2	9.6	4.8	3.6	4.5	5.7	3.3	3.2	3.7	100
Zinc	LD	6	LD	LD	LD	LD	LD	10	LD	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-20. Spring Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	16			17			18			19†			20			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	890	1780	1390	715	1800	1090	505	1700	1580	545 ± 63	1420 ± 140	1285 ± 55	440	645	1260	NG
Iron	1280	2480	1910	1000	2520	1510	689	2350	2180	752 ± 96	1990 ± 180	1770 ± 80	517	982	1780	NG
Arsenic	2.3	3.5	2.2	2.3	3.5	2	2.2	3.4	2.3	2.2 ± 0.1	3.2	2.3 ± 0.1	1.6	1.7	2.4	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	1.1	2	2.7	LD	2.1	1.2	LD	1.9	2	1	1.7 ± 0.4	1.7 ± 0.1	LD	LD	2.4	4.4
Cobalt	0.8	**1.3**	**1.5**	0.6	**1.4**	1	0.4	**1.4**	**1.6**	0.5	**1.2 ± 0.1**	**1.4 ± 0.1**	0.3	0.6	1	1
Copper	LD	**2**	**3**	**2**	**2**	**3**	LD	**2**	**3**	LD	1.5 ± 0.1	**3**	LD	LD	**2**	1.3
Lead	0.6	1	0.7	0.5	1.1	0.5	0.4	1	0.8	0.4	0.9 ± 0.2	0.8 ± 0.1	LD	0.5	0.8	4.4
Manganese	32.5	44.4	50.3	25.8	51.4	41	21.8	47.1	57	21.3 ± 2.4	37.4 ± 4.2	53.2 ± 3	14	23.7	37.2	NG
Nickel	0.9	1.6	2	0.5	1.7	1.3	LD	1.6	1.7	0.9	1.2 ± 0.3	1.3 ± 0.1	LD	LD	1.6	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	3.8	7.2	7.5	3.3	7.5	6.1	3.1	7.8	7.9	2.7± 0.4	6.2 ± 0.3	7.4 ± 0.1	2.8	3.2	5	100
Zinc	LD	8	LD	LD	8	LD	LD	8	LD	LD	5.5 ± 0.5	LD	LD	LD	5	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-21. Spring Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site														WQG*
	21			22			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	0.1
Aluminium	304	400	979	218	984	328	185	764	-	234	1270	747	184	470	984	NG
Iron	434	543	1420	278	1530	447	259	1060	-	302	1900	1010	228	623	1290	NG
Arsenic	1.6	1.6	2.4	1.6	2.2	1.9	1.5	1.9	-	1.5	2.4	1.6	1.5	1.5	1.7	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	LD	0.8	LD	1.2	LD	LD	0.7	-	LD	1.7	LD	LD	1.4	0.7	4.4
Cobalt	0.4	0.4	0.8	0.2	**1.1**	0.5	0.2	0.7	-	0.3	**1.2**	0.6	0.2	0.4	0.7	1
Copper	LD	LD	**2**	LD	**2**	1	LD	**2**	-	LD	**3**	LD	LD	LD	1	1.3
Lead	0.2	0.3	0.7	LD	1	0.2	LD	0.7	-	LD	1.2	0.5	LD	0.2	0.6	4.4
Manganese	17.5	19.9	33	12.3	41.4	21.7	10.4	30.4	-	13.1	47.2	26.6	10.8	19.1	31	NG
Nickel	LD	LD	0.8	LD	0.8	LD	LD	0.8	-	LD	1.4	0.6	LD	1.5	0.6	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.7	2.8	4	2.5	4.5	2.5	2.3	4	-	2.5	5.4	3.2	2.3	2.9	3.7	100
Zinc	LD	LD	LD	LD	5	LD	LD	LD	-	LD	7	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-22. Spring Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	21			22†			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	0.1
Aluminium	280	563	1190	339 ± 57	1665 ± 235	948.5 ± 23.5	226	-	-	296	1120	1070	283	331	998	NG
Iron	382	779	1760	446.5 ± 85.5	2355 ± 435	1240 ± 40	305	-	-	372	1730	1460	353	455	1330	NG
Arsenic	1.7	1.6	2.6	1.8 ± 0.1	2.7 ± 0.2	1.7	1.8	-	-	1.6	2.2	1.9	1.6	1.4	1.8	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	LD	1.2	LD	3.4 ± 0.4	0.7 ± 0.1	LD	-	-	LD	2.2	1.9	LD	LD	0.8	4.4
Cobalt	0.3	0.5	1	0.3 ± 0.1	**1.4 ± 0.3**	0.7 ± 0.1	0.3	-	-	0.3	1	0.8	0.3	0.3	0.8	1
Copper	LD	LD	**2**	LD	**3**	LD	LD	-	-	LD	**2**	1	LD	LD	1	1.3
Lead	0.2	0.4	0.8	LD	1.3 ± 0.2	0.5 ± 0.1	LD	-	-	LD	1	0.6	LD	0.2	0.6	4.4
Manganese	15.7	22.6	41.4	15.4 ± 2.9	48.6 ± 8.4	25.9 ± 1.1	15.9	-	-	11.8	39.1	32.9	14.4	14.5	29.5	NG
Nickel	LD	LD	0.9	LD	2.7 ± 0.1	LD	0.8	-	-	LD	1.8	1.7	LD	LD	0.7	7
Silver	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.6	2.6	4.9	2.9 ± 0.2	6.1 ± 0.5	4.5 ± 0.9	2.6	-	-	2.7	4.8	4.2	2.6	2.7	3.8	100
Zinc	LD	LD	5	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-23. Spring Tide Total Metals Laboratory Results for Top of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	26			27			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	210	779	886	817	1460	887	1040	785	1580	1320	516	1080	934	367	820	NG
Iron	268	1170	1220	1060	2190	1120	1190	1090	2140	1790	804	1450	1190	509	1060	NG
Arsenic	1.6	1.8	1.6	2.1	2.6	2.2	2.2	1.9	2	2.5	1.8	1.9	2.1	1.6	1.5	NG
Cadmium	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	0.7	2.1	1	2.2	2.1	0.7	0.6	1.6	1.2	1.3	0.8	0.6	LD	0.6	4.4
Cobalt	0.2	0.8	0.6	0.5	**1.2**	0.8	0.6	0.6	**1.3**	**1.1**	0.6	1	0.7	0.4	0.6	1
Copper	LD	**2**	1	1	**3**	**2**	**2**	**2**	1	**2**	**2**	LD	**2**	1	LD	1.3
Lead	LD	0.7	0.5	0.4	1.4	0.6	0.5	0.5	0.9	1	0.6	0.8	0.7	0.4	0.4	4.4
Manganese	11.7	37.5	23.9	28.3	49.8	32.3	28.8	26.8	45.7	42.6	31.2	46.9	28.6	21.1	22.8	NG
Nickel	LD	0.8	1.5	1.2	1.9	2.4	1	0.8	1.2	1.5	1.6	0.8	0.9	LD	0.6	7
Silver	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	2.4	4	3.5	4.3	5.5	5	4.4	4	5.6	5.4	3.5	5.2	4.3	3.2	3.7	100
Zinc	LD	LD	LD	LD	7	LD	LD	LD	6	7	LD	LD	LD	7	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters. NG = No guideline exists.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Table 1-24. Spring Tide Total Metals Laboratory Results for Bottom of Water Column

(all values expressed in µg/L)

Parameter	Site															WQG*
	26†			27			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Mercury	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.1
Aluminium	511.5 ± 160.5	1285.5 ± 384.5	-	545	332	-	919	244	1640	1000	1050	1100	1220	445	770	NG
Iron	669.5 ± 217.5	1820 ± 550	-	736	513	-	1160	327	2200	1310	1470	1530	1610	599	1010	NG
Arsenic	1.8 ± 0.2	2.3 ± 0.4	-	1.9	1.6	-	2.1	1.6	2	2.2	2	1.8	2.3	1.6	1.6	NG
Cadmium	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	0.7
Chromium	LD	1.5 ± 0.7	-	LD	LD	-	0.7	LD	3.1	0.8	1.2	1.8	1.1	LD	LD	4.4
Cobalt	0.35 ± 0.05	**1 ± 0.3**	-	0.5	0.6	-	0.6	0.3	**1.1**	0.8	0.8	1	0.9	0.5	0.7	1
Copper	LD	**2.5 ± 0.5**	-	LD	1	-	1	LD	**2**	**2**	**2**	LD	**2**	1	LD	1.3
Lead	LD	1.2 ± 0.5	-	0.3	0.6	-	0.5	LD	0.8	0.7	0.8	0.8	0.8	0.4	0.4	4.4
Manganese	17.4 ± 4.4	42.8 ± 12.2	-	22.4	29.1	-	28	15.8	41.2	32.5	33.9	43.3	38.5	23	33.7	NG
Nickel	LD	1.4 ± 0.3	-	LD	0.6	-	1.1	LD	2.3	1.1	0.9	1.5	1	LD	LD	7
Silver	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	1.4
Vanadium	3.3 ± 0.5	5.2 ± 1	-	3.4	3.4	-	4.2	2.8	6	4.5	4.4	5	5.2	3.2	3.8	100
Zinc	LD	LD	-	LD	LD	-	LD	LD	5	LD	LD	LD	**22**	LD	LD	15

* ANZECC (2000) WQGs for slightly to moderately disturbed marine waters.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

LD = Less than detection limit. Relevant detection limits are as follows:

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

Mercury:	0.1 µg/L	Chromium:	0.5 µg/L	Nickel:	0.5 µg/L
Aluminium:	10 µg/L	Cobalt:	0.2 µg/L	Silver:	0.1 µg/L
Iron:	5 µg/L	Copper:	1 µg/L	Vanadium:	0.5 µg/L
Arsenic:	0.5 µg/L	Lead:	0.2 µg/L	Zinc:	5 µg/L
Cadmium:	0.2 µg/L	Manganese:	0.5 µg/L		

Appendix 3: Tables 2-1 through 2-12 – Nutrient Laboratory Results

Table 2-1. Neap Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		1			2†			3			4			5			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	25
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	25

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-2. Neap Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		6			7			8†			9			10			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	**12**	**12**	LD	**13.5 ± 0.5**	**15.5 ± 0.5**	LD	**14**	**19**	**12**	**18**	**15**	8
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	1,000	LD	LD	1,000	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	25
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	**10**	LD	**11.5 ± 0.5**	**15.5 ± 0.5**	LD	**20**	**10**	**10**	**20**	**10**	8
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	1500 ± 500	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	25

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-3. Neap Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		11†			12			13			14			15			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	**30**	LD	LD	LD	LD	LD	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	6
Nitrogen Oxides	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	NG
Total Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	-	200
Total Phosphorus	µg/L as P	LD	LD	-	LD	LD	-	20	LD	-	LD	LD	-	**50**	LD	-	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-4. Neap Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		16†			17			18			19			20†			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	1000	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	**30**	LD	LD	LD	LD	LD	**110**	LD	LD	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-5. Neap Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		21			22			23			24			25			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	200
Total Phosphorus	µg/L as P	20	LD	LD	LD	LD	-	LD	-	-	LD	LD	LD	LD	LD	-	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-6. Neap Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		26			27†			28			29			30			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-7. Spring Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		1			2			3†			4			5			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	10,000	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	**1,000**	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	25
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	25

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-8. Spring Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		6			7			8			9†			10			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	**12**	LD	**12**	**18**	**11**	**12**	**20**	**16**	**21**	**26**	8
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	10	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	1,000	LD	LD	1,000	1,000	1,000	1,000	1,000	1,000	1,000	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	25
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	10
Filtered Reactive Phosphorus	µg/L as P	LD	LD	-	LD	LD	-	LD	**12**	**16**	LD	LD	**12.5 ± 0.5**	**13**	**20**	**21**	8
Nitrogen Oxides	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	10[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	-	LD	LD	-	LD	LD	1,000	LD	LD	LD	1,000	1,000	1,000	NG
Total Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	300
Total Phosphorus	µg/L as P	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	25

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-9. Spring Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		11			12			13			14†			15			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	-	LD	LD	-	LD	LD	-	LD	LD	**30**	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	8
Filtered Reactive Phosphorus	µg/L as P	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	6
Nitrogen Oxides	µg/L as N	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	3[b]
Total Organic Carbon[c]	µg/L as C	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	NG
Total Nitrogen	µg/L as N	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	200
Total Phosphorus	µg/L as P	LD	-	-	LD	-	-	LD	-	-	LD	LD	-	LD	LD	-	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-10. Spring Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		16			17			18			19†			20			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-11. Spring Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		21			22†			23			24			25			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	-	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	20	LD	LD	-	LD	LD	LD	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	-	-	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	**50**	LD	LD	-	-	LD	LD	LD	LD	LD	LD	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Table 2-12. Spring Tide Nutrient Laboratory Results

Parameter	Units	Site															WQG[a]
		26†			27			28			29			30			
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Top of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	LD	LD	LD	LD	**30**	LD	LD	LD	LD	LD	LD	LD	LD	20
Bottom of the Water Column																	
Ammonia Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	8
Filtered Reactive Phosphorus	µg/L as P	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	6
Nitrogen Oxides	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	3[b]
Total Organic Carbon[c]	µg/L as C	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	NG
Total Nitrogen	µg/L as N	LD	LD	-	LD	LD	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	200
Total Phosphorus	µg/L as P	LD	LD	-	LD	**30**	-	LD	LD	LD	LD	LD	LD	LD	LD	LD	20

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Combined value for NO_2 and NO_3.

[c] as Nitrogenous and phosphoric organic carbonaceous species.

† Site with duplicates. Results are shown as mean ± SE.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

LD = Less than detection limit. Relevant detection limits are as follows:

Ammonia Nitrogen:	20 µg/L	Total Organic Carbon:	1000 µg/L
Filt. Reac. Phosphorus:	10 µg/L	Total Nitrogen:	200 µg/L
Nitrogen Oxides:	20 µg/L	Total Phosphorus:	20 µg/L

Appendix 4: Tables 3-1 through 3-12 – Physicochemical Water Quality Values

Table 3-1. Neap Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	1			2			3			4			5			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	5	3.7	2.5	9.2	7	5.5	8.5	5.4	5.7	7.8	6.7	5.9	8.3	6.9	6	NG
Temperature (˚C)	19.60	19.45	19.40	19.63	19.64	21.14	19.86	19.63	21.59	19.86	21.18	21.77	19.70	21.68	21.88	NG[b]
Conductivity (mS/cm)	46.73	46.52	46.30	46.63	46.48	47.22	46.74	46.49	47.37	46.73	47.28	47.45	46.61	47.32	47.04	NG
Salinity (ppt)	34.35	34.31	34.16	34.25	34.12	33.51	34.15	34.14	33.29	34.15	33.54	33.21	NR	NR	32.78	NG
pH	7.64	7.64	7.65	7.63	7.63	7.58	7.62	7.63	7.57	7.58	7.57	7.57	7.43	7.58	7.56	7.0-8.4
Turbidity (NTU)	**11**	**10**	**10**	**9**	**14**	5	**8.5**	**16**	4	**9**	**14**	**9**	**13**	5	**11**	8
Chlorophyll-*a* (µg/L)	2.7	2.4	2.2	2.6	2.9	2.6	2.5	2.7	2.5	2.7	3.05	2.7	2.9	2.7	2.7	4
Dissolved Oxygen (%)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	85-100
Dissolved Oxygen (mg/L)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NG

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Varies based on location and conditions - none are currently established at this location.

NG = No guideline exists.

NR = No reading due to equipment malfunction

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-2. Neap Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	6			7			8			9			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	3.1	1.8	1.6	2.7	1.5	1.1	5.7	4	3.4	6.6	5.1	4.4	11.3	9.7	9.2	NG
Temperature (˚C)	24.23	24.44	23.31	24.56	23.21	22.28	24.53	22.50	21.85	23.47	22.23	21.41	22.90	22.00	21.39	NG[b]
Conductivity (mS/cm)	50.92	49.94	45.90	50.56	44.03	41.03	49.54	40.92	37.65	44.07	37.97	33.60	40.80	35.00	34.42	NG
Salinity (ppt)	33.99	33.10	30.90	33.47	29.56	27.92	32.73	27.72	25.63	29.45	25.64	22.81	27.39	23.59	23.44	NG
pH	7.54	7.54	7.51	7.55	7.47	7.49	7.56	7.45	7.48	7.51	7.46	7.49	7.50	7.48	7.47	7.0-8.4
Turbidity (NTU)	3	5	2	3	2	2.5	3	2	2	2	3	2	2	3	2	8
Chlorophyll-*a* (µg/L)	3.45	2.7	3.2	3.45	**4**	**4.15**	3.7	**4.05**	3.4	4.5	3.9	3.45	**4.6**	**4.2**	2.9	4
Dissolved Oxygen (%)	**103.25**	**106.50**	96.00	**105.95**	97.80	93.10	**106.80**	93.15	90.70	**100.10**	93.40	89.95	96.30	92.30	88.40	85-100
Dissolved Oxygen (mg/L)	7.13	7.37	6.85	7.30	7.05	6.89	7.39	6.88	6.85	7.19	7.01	6.96	7.05	7.05	6.75	NG

[a] QWQGs (2009) for mid-estuarine waters of central Queensland. NG = No guideline exists.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-3. Neap Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	11			12			13			14			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	2	1.6	0.4	2.4	1.7	0.4	2.5	1.7	0.4	3	1.9	0.5	3	1.8	0.6	NG
Temperature (˚C)	21.50	21.35	21.38	21.39	21.50	21.38	21.37	21.19	21.23	21.40	21.14	21.41	21.16	21.11	21.44	NG[b]
Conductivity (mS/cm)	48.45	48.31	47.27	48.44	48.34	47.33	48.30	47.87	46.79	48.44	47.97	47.61	48.32	48.05	48.19	NG
Salinity (ppt)	34.22	34.22	33.38	34.29	34.11	33.42	34.20	33.99	33.11	34.29	34.12	33.61	34.39	34.20	34.06	NG
pH	**7.61**	**7.60**	**7.55**	**7.64**	**7.58**	**7.57**	**7.64**	**7.62**	**7.55**	**7.64**	**7.61**	**7.58**	**7.62**	**7.60**	**7.56**	8.0-8.4
Turbidity (NTU)	6	5	**26**	2	**7**	**9**	3	6	**8**	2	6	6	3	5	**18**	6
Chlorophyll-*a* (µg/L)	**3.6**	**2.6**	**3**	**3.2**	3	**2.8**	**2.6**	**3**	2	**3**	**2.7**	1.7	**2.25**	**2.8**	**3.3**	2
Dissolved Oxygen (%)	**102.35**	**100.90**	93.20	**105.95**	99.00	94.40	**106.75**	**103.00**	93.10	**104.85**	**101.60**	94.90	**101.50**	99.60	92.90	90-100
Dissolved Oxygen (mg/L)	7.40	7.32	6.79	7.68	7.17	6.87	7.74	7.50	6.81	7.60	7.40	6.90	7.38	7.25	6.73	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland. NG = No guideline exists.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-4. Neap Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	16			17			18			19			20			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	6.3	5	3.4	11.3	9.6	8.8	14.1	13.3	12	15.5	16.2	14.2	9.1	9.8	8.6	NG
Temperature (˚C)	20.13	20.04	19.76	20.10	20.10	19.75	20.24	20.04	19.76	20.21	19.98	19.81	19.85	19.95	19.59	NG[b]
Conductivity (mS/cm)	47.47	46.92	46.51	47.39	46.99	46.44	47.53	47.00	46.42	47.69	46.98	46.47	47.17	47.37	46.57	NG
Salinity (ppt)	34.53	34.15	34.04	34.45	34.17	33.99	34.47	34.22	33.97	34.61	34.25	33.96	34.52	34.60	34.24	NG
pH	**7.61**	**7.60**	**7.58**	**7.56**	**7.61**	**7.58**	**7.48**	**7.61**	**7.58**	**7.30**	**7.61**	**7.57**	**7.65**	**7.67**	**7.63**	8.0-8.4
Turbidity (NTU)	**7.5**	**14**	**10**	**7**	**12**	**10**	**8**	**15**	**26**	**10**	**12.5**	**24.5**	**11.5**	6	NR	6
Chlorophyll-*a* (µg/L)	**2.05**	**2.4**	**2.25**	**2.2**	**2.55**	**2.5**	**2.3**	**2.6**	**3**	**2.25**	**2.5**	**2.8**	**2.25**	**2.25**	**2.7**	2
Dissolved Oxygen (%)	96.85	98.55	98.20	96.45	98.65	97.80	96.70	98.25	98.00	96.45	97.40	97.95	99.05	**100.20**	97.35	90-100
Dissolved Oxygen (mg/L)	7.17	7.32	7.34	7.15	7.32	7.31	7.15	7.30	7.33	7.12	7.24	7.32	7.37	7.43	7.29	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Varies based on location and conditions - none are currently established at this location.

NG = No guideline exists.

NR = No reading due to equipment malfunction.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-5. Neap Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	21			22			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	11.3	8.9	8	3.6	3.1	1	1.8	1.2	-	13.4	10.1	8.3	3.8	2.2	0.7	NG
Temperature (˚C)	20.00	19.72	19.51	20.05	20.01	19.59	20.53	20.22	-	20.09	20.09	19.59	20.01	20.35	-	NG[b]
Conductivity (mS/cm)	47.52	46.89	46.21	47.59	47.43	46.58	48.00	47.35	-	47.63	47.57	46.62	47.54	47.79	-	NG
Salinity (ppt)	34.68	34.40	33.99	34.69	34.59	34.25	34.64	34.36	-	34.69	34.64	34.28	34.69	34.61	-	NG
pH	**7.67**	**7.63**	**7.57**	**7.69**	**7.67**	**7.63**	**7.68**	**7.65**	-	**7.69**	**7.68**	**7.63**	**7.69**	**7.68**	**-**	8.0-8.4
Turbidity (NTU)	5	**10**	NR	3	5	NR	6	**9**	-	6	5	NR	5	5	-	6
Chlorophyll-*a* (µg/L)	1.95	**2.3**	**2.9**	**2.1**	1.8	**2.2**	**2.6**	**2.15**	-	**2.1**	**2.4**	**2.55**	1.8	**2.2**	**-**	2
Dissolved Oxygen (%)	**100.90**	98.45	96.40	**101.20**	**100.70**	97.50	**103.30**	**101.80**	-	**101.45**	**101.10**	97.50	**101.30**	**102.50**	-	90-100
Dissolved Oxygen (mg/L)	7.48	7.35	7.24	7.50	7.46	7.30	7.59	7.53	-	7.51	7.49	7.30	7.51	7.56	-	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

NR = No reading due to equipment malfunction.

- = Site inaccessible at tide. No sample taken.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-6. Neap Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	26			27			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	10.8	4	2.1	4.2	3.1	1.8	7.2	6.7	5.5	17.6	18.4	17.8	15.1	13.3	11	NG
Temperature (˚C)	19.82	19.82	19.59	19.87	19.75	19.57	19.79	19.80	19.55	19.79	19.69	19.49	19.87	19.68	19.47	NG[b]
Conductivity (mS/cm)	47.40	47.26	46.60	47.41	47.12	46.52	47.31	47.13	46.41	47.25	46.83	46.22	47.27	46.68	46.11	NG
Salinity (ppt)	34.72	34.62	34.27	34.69	34.55	34.21	34.68	34.53	34.13	34.63	34.37	34.02	34.57	34.25	33.95	NG
pH	**7.69**	**7.68**	**7.64**	**7.69**	**7.67**	**7.63**	**7.69**	**7.67**	**7.62**	**7.67**	**7.64**	**7.60**	**7.66**	**7.62**	**7.60**	8.0-8.4
Turbidity (NTU)	3	**9**	NR	4	**12.5**	NR	4	**11**	NR	**7**	**15**	NR	**9**	**31**	NR	6
Chlorophyll-*a* (µg/L)	**2**	**2.05**	**2.3**	1.95	**2.4**	**2.7**	1.8	**2.3**	**2.8**	**2.3**	**2.5**	**3.1**	**2.15**	**2.8**	**2.75**	2
Dissolved Oxygen (%)	**100.75**	99.90	97.80	**100.80**	99.40	97.50	**100.30**	99.20	96.60	99.65	97.85	96.30	99.75	97.55	96.60	90-100
Dissolved Oxygen (mg/L)	7.49	7.43	7.32	7.49	7.41	7.31	7.47	7.39	7.24	7.42	7.31	7.23	7.42	7.29	7.26	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Varies based on location and conditions - none are currently established at this location.

NG = No guideline exists.

NR = No reading due to equipment malfunction.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-7. Spring Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	1			2			3			4			5			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	4.7	3.9	1.8	8.2	7.9	6.2	7.8	6.4	4	7.9	7.2	5.5	8.5	7.6	6.1	NG
Temperature (˚C)	20.96	21.11	22.85	21.20	21.14	23.24	21.11	21.20	23.75	21.13	22.21	24.16	21.25	22.80	24.25	NG[b]
Conductivity (mS/cm)	50.48	50.75	51.60	50.56	50.62	51.52	50.42	50.66	51.10	50.51	51.62	50.99	50.59	51.51	49.43	NG
Salinity (ppt)	36.28	36.37	35.59	36.15	36.24	35.21	36.11	36.22	34.50	36.16	36.13	34.10	36.13	35.56	32.86	NG
pH	7.93	7.93	7.85	7.94	7.92	7.84	7.93	7.91	7.82	7.94	7.9	7.82	7.94	7.88	7.83	7.0-8.4
Turbidity (NTU)	6	6	8	6	5.5	4	8	**8.5**	5	7	8	7	6	5	4	8
Chlorophyll-*a* (µg/L)	2.5	3	2.5	2.5	2.3	2.5	2.3	2.45	3.25	2.7	2.5	3	2.4	2.65	3.7	4
Dissolved Oxygen (%)	99.10	98.70	98.80	98.55	97.60	98.30	97.65	97.75	97.35	97.40	98.90	98.60	97.35	97.80	**100.70**	85-100
Dissolved Oxygen (mg/L)	7.15	7.10	6.92	7.09	7.02	6.85	7.04	7.03	6.76	7.01	6.98	6.81	6.99	6.86	7.00	NG

[a] QWQGs (2009) for mid-estuarine waters of central Queensland. NG = No guideline exists.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-8. Spring Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	6			7			8			9			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	3.7	2.5	1	3.7	2.4	0.9	5.7	4.2	2.8	6.7	5.5	3.9	11.3	9.7	9	NG
Temperature (˚C)	22.53	23.71	23.64	23.62	23.70	23.51	23.68	23.21	23.16	23.29	22.85	22.92	22.76	22.62	22.68	NG[b]
Conductivity (mS/cm)	50.84	50.26	44.52	50.54	48.71	40.03	49.39	43.54	33.55	45.96	36.84	28.60	37.87	30.73	24.86	NG
Salinity (ppt)	35.26	33.89	29.64	34.17	32.74	26.41	33.26	29.20	21.89	30.95	24.47	18.52	25.26	20.12	15.92	NG
pH	7.90	7.84	7.81	7.88	7.84	7.80	7.88	7.80	7.80	7.86	7.79	7.81	7.83	7.77	7.82	7.0-8.4
Turbidity (NTU)	6	8	2	4	8	3	5	4	4	4.5	4	4	4.5	5	5.5	8
Chlorophyll-*a* (µg/L)	2.85	2.95	3.1	2.9	2.85	3.8	3.1	3.3	**4.7**	3.4	3.3	**4.7**	3.35	3.7	**4.1**	4
Dissolved Oxygen (%)	96.80	97.75	96.80	97.60	97.70	95.95	97.30	94.30	92.80	94.55	92.40	91.20	90.95	89.60	89.55	85-100
Dissolved Oxygen (mg/L)	6.83	6.81	6.92	6.80	6.86	7.01	6.82	6.81	7.00	6.76	6.82	7.06	6.77	6.89	7.06	NG

[a] QWQGs (2009) for mid-estuarine waters of central Queensland. NG = No guideline exists.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-9. Spring Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	11			12			13			14			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	2.7	0.6	-	2.9	0.8	-	3	1	-	3.3	1.5	0.4	3.3	1.7	0.4	NG
Temperature (˚C)	21.59	22.55	-	21.375	22.185	-	21.59	21.595	-	21.46	22.04	23.43	21.5	21.995	23.18	NG[b]
Conductivity (mS/cm)	51.095	52.1	-	50.82	51.68	-	50.895	50.765	-	50.91	51.44	53.21	51.11	51.425	53	NG
Salinity (ppt)	36.245	36.23	-	36.205	36.21	-	36.085	35.975	-	36.21	36.13	36.37	36.33	36.16	36.41	NG
pH	**7.87**	**7.87**	-	**7.85**	**7.86**	-	**7.86**	**7.83**	-	**7.87**	**7.84**	**7.88**	**7.88**	**7.85**	**7.87**	8.0-8.4
Turbidity (NTU)	**8.5**	**9**	-	4	6	-	3	**6.5**	-	5	**7**	**14**	**8**	**6.5**	**18**	6
Chlorophyll-*a* (µg/L)	**2.25**	**3.1**	-	**2.55**	**2.1**	-	**2.6**	1.85	-	**2.6**	**2.7**	**2.8**	**2.5**	**2.7**	**2.7**	2
Dissolved Oxygen (%)	97.5	98.5	-	95.95	98	-	97.85	91.55	-	96.3	98.3	**106.4**	97.5	98.5	**104.3**	90-100
Dissolved Oxygen (mg/L)	6.96	6.91	-	6.875	6.92	-	6.98	6.54	-	6.89	6.96	7.35	6.96	6.985	7.23	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

NG = No guideline exists.

NR = No reading due to equipment malfunction.

- = Site inaccessible at tide. No sample taken.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-10. Spring Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	16			17			18			19			20			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	7.2	5.4	3.8	11.3	10.2	8.3	14.6	14.4	12.4	16	16	13.7	10	8.8	6.8	NG
Temperature (˚C)	21.29	21.57	21.71	21.30	21.49	21.66	21.30	21.46	21.68	21.29	21.49	21.69	21.07	21.39	21.47	NG[b]
Conductivity (mS/cm)	51.19	51.15	51.04	51.16	51.15	51.03	51.07	51.21	51.02	50.99	51.38	51.25	51.17	51.12	50.91	NG
Salinity (ppt)	36.57	36.29	36.10	36.54	36.38	36.13	36.47	36.44	36.12	36.41	36.56	36.27	36.75	36.43	36.20	NG
pH	**7.91**	**7.84**	**7.80**	**7.91**	**7.85**	**7.80**	**7.90**	**7.84**	**7.79**	**7.90**	**7.85**	**7.79**	**7.95**	**7.89**	**7.86**	8.0-8.4
Turbidity (NTU)	**29**	**66**	**21**	**24.5**	**65**	**21**	**21.5**	**53**	**22**	**24.5**	**28.5**	**45.5**	**10**	**31**	**22**	6
Chlorophyll-*a* (µg/L)	**3.4**	**3.8**	**3.1**	**3**	**3.35**	**3.15**	**2.7**	**3.7**	**2.95**	**2.9**	**3**	**3.8**	**2.3**	**3.45**	**2.9**	2
Dissolved Oxygen (%)	97.20	94.60	93.15	96.90	95.25	93.10	97.00	95.50	93.50	96.45	95.90	94.35	97.65	97.00	95.95	90-100
Dissolved Oxygen (mg/L)	6.96	6.75	6.64	6.94	6.80	6.64	6.95	6.82	6.67	6.91	6.84	6.72	7.01	6.94	6.87	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland. NG = No guideline exists.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-11. Spring Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	21			22			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	11	11.1	9.7	3	1.7	2.8	2.3	0.6	-	10.4	9.4	8.5	3	1.7	2.6	NG
Temperature (˚C)	21.08	21.19	21.63	21.04	21.30	21.49	21.15	21.74	-	20.94	21.31	21.50	21.05	21.72	21.70	NG[b]
Conductivity (mS/cm)	50.92	51.22	51.45	51.14	51.08	50.94	51.11	51.62	-	50.82	51.07	50.99	51.18	51.91	51.35	NG
Salinity (ppt)	36.54	36.68	36.49	36.74	36.48	36.20	36.63	36.54	-	36.58	36.45	36.24	36.76	36.78	36.35	NG
pH	**7.93**	**7.89**	**7.85**	**7.94**	**7.90**	**7.86**	**7.93**	**7.92**	-	**7.92**	**7.90**	**7.87**	**7.95**	**7.91**	**7.88**	8.0-8.4
Turbidity (NTU)	**15**	**27**	**30**	**8**	**36**	**24**	**8**	**19**	-	**8**	**37**	**28**	**6.5**	**9**	**28**	6
Chlorophyll-*a* (µg/L)	**2.45**	**2.45**	**3.35**	**2.05**	**3.4**	**3.05**	**2.2**	**2.4**	-	2	**3.25**	**3.05**	**2.3**	**2.5**	**3.1**	2
Dissolved Oxygen (%)	97.00	97.25	98.40	97.65	97.10	96.65	98.10	**100.60**	-	96.70	97.00	96.40	97.60	98.60	98.10	90-100
Dissolved Oxygen (mg/L)	6.97	6.98	7.01	7.02	6.95	6.92	7.04	7.15	-	6.97	6.95	6.89	7.01	7.00	6.98	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Varies based on location and conditions - none are currently established at this location.

NG = No guideline exists.

- = Site inaccessible at tide. No sample taken.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Table 3-12. Spring Tide Median Physiochemical Water Quality Values

Parameter	Site															WQG[a]
	26			27			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
Depth of Water at Time of Sampling (m)	5.1	2.5	1.2	4.6	3	1.3	7.3	6.4	3	18.1	18.9	16.1	14	16.4	12.8	NG
Temperature (˚C)	21.05	21.25	21.55	21.07	21.25	21.50	21.04	21.20	21.47	21.09	21.24	21.44	21.05	21.27	21.56	NG[b]
Conductivity (mS/cm)	51.22	51.10	51.10	51.18	51.00	50.95	51.04	51.17	50.98	51.02	51.01	50.86	50.91	51.07	50.91	NG
Salinity (ppt)	36.79	36.53	36.28	36.75	36.45	36.20	36.66	36.63	36.25	36.60	36.47	36.18	36.55	36.49	36.12	NG
pH	**7.96**	**7.91**	**7.87**	**7.97**	**7.90**	**7.86**	**7.95**	**7.92**	**7.86**	**7.96**	**7.89**	**7.85**	**7.95**	**7.89**	**7.83**	8.0-8.4
Turbidity (NTU)	**8**	**31.5**	**20**	**18**	**39**	**26**	**21**	**16**	**35.5**	**23**	**31**	**41.5**	**27**	**15**	**17**	6
Chlorophyll-*a* (µg/L)	1.9	**3.1**	**2.85**	**2.8**	**3.5**	**2.9**	**2.85**	**2.4**	**3.8**	**3.1**	**3**	**4**	**3.15**	**2.65**	**2.7**	2
Dissolved Oxygen (%)	98.40	96.65	97.25	98.80	96.80	96.70	98.90	97.20	96.60	98.30	96.80	96.00	97.75	97.65	96.60	90-100
Dissolved Oxygen (mg/L)	7.07	6.93	6.94	7.09	6.94	6.91	7.11	6.97	6.91	7.06	6.94	6.87	7.03	7.00	6.90	NG

[a] QWQGs (2009) for enclosed coastal waters of central Queensland. NG = No guideline exists.

[b] Varies based on location and conditions - none are currently established at this location.

L = Low tide, M = Mid tide, H = High tide.

Dissolved oxygen guidelines are set for percent of saturated value due to temperature dependence of dissolved oxygen in the water column.

Bolded values represent exceedences of QWQG, or in the case of dissolved oxygen and pH, values outside the guidelines range.

Appendix 5: Tables 4-1 through 4-12 – Additional Water Quality Values

Table 4-1. Neap Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	1			2			3			4			5			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	16	20	**32**	16	**38**	**21**	**23**	**44**	16	**23**	**22**	19	**30**	13	13	20
BWC Total Suspended Solids (mg/L)	18	**30**	**34**	**34**	**26**	**29**	**25**	**40**	**25**	**40**	**49**	**38**	**35**	18	**34**	20
Total Dissolved Solids[b] (g/L)	33.86	33.82	33.70	33.77	33.66	33.13	33.69	33.68	32.94	33.69	33.16	32.87	33.71	32.85	32.49	NG
Oxidation-Reduction Potential[b] (mV)	415.5	405	419	417	418	421	424.5	419	423.5	431	421.5	426	444	424	442	NG
Secchi Depth (m)	1.03	**0.68**	**0.69**	**0.88**	**0.63**	**0.85**	**0.88**	**0.54**	**0.91**	**0.94**	**0.84**	**0.84**	**0.75**	1.02	**0.81**	<1

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

Table 4-2. Neap Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	6			7			8			9			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	12	10	4	8	12	12	12	10	11	18	18	6	8	8	8	20
BWC Total Suspended Solids (mg/L)	8	9	4	11	10	6	12	8	10	12	9	7	12	9	4	20
Total Dissolved Solids[b] (g/L)	33.59	32.81	30.83	33.14	29.64	28.135	32.49	27.96	26.045	29.54	26.07	23.45	27.67	24.17	24.03	NG
Oxidation-Reduction Potential[b] (mV)	342.5	387	404	333.5	379	398.5	350	378	405	359	393	401.5	370	392.5	403	NG
Secchi Depth (m)	1.10	**0.81**	**0.06**	1.11	1.08	1.00	**0.99**	1.01	1.37	1.10	1.10	1.25	1.10	**0.90**	1.25	<1

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

Table 4-3. Neap Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	11			12			13			14			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	**17**	8	**42**	**16**	**18**	**25**	13	15	**21**	8	**20**	**19**	13	13	**38**	15
BWC Total Suspended Solids (mg/L)	**34**	**19**	-	9	**23**	-	7	**16**	-	8	14	-	15	**17**	-	15
Total Dissolved Solids[b] (g/L)	33.75	33.75	33.01	33.82	33.66	33.05	33.74	33.56	32.78	33.82	33.66	33.22	33.90	33.74	33.61	NG
Oxidation-Reduction Potential[b] (mV)	390	404	401	391	405	405	388.5	405	406	377.5	406	405	387.5	406	405	NG
Secchi Depth (m)	**0.57**	**0.68**	**0.35**	**1.04**	**0.55**	**0.49**	**0.91**	**0.61**	**0.38**	**1.03**	**0.66**	**0.51**	**1.07**	**0.68**	**0.44**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

- = Site inaccessible at tide. No sample taken.

Table 4-4. Neap Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	16			17			18			19			20			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	9	**25**	**28**	15	**20**	**25**	10	**24**	**42**	**18**	**20**	**34**	**23**	**21**	**25**	15
BWC Total Suspended Solids (mg/L)	**16**	**33**	**30**	10	**43**	**36**	**16**	**36**	**44**	**19**	**23**	**28**	**16**	**20**	**35**	15
Total Dissolved Solids[b] (g/L)	34.02	33.68	33.59	33.95	33.70	33.55	33.97	33.74	33.53	34.10	33.77	33.52	34.01	34.08	33.77	NG
Oxidation-Reduction Potential[b] (mV)	387.5	413	406	389.5	415	404	394	410.5	399.5	404.5	416.5	397	422.5	424	424.5	NG
Secchi Depth (m)	**0.62**	**0.46**	**0.59**	**0.73**	**0.47**	**0.51**	**0.63**	**0.55**	**0.79**	**0.65**	**0.45**	**0.68**	**0.77**	**0.79**	**0.57**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

Table 4-5. Neap Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	21			22			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	**22**	**17**	**49**	10	14	**26**	14	11	-	8	**25**	**29**	**23**	10	**27**	15
BWC Total Suspended Solids (mg/L)	14	**20**	**63**	**20**	**18**	-	14	-	-	**18**	**18**	**32**	**18**	6	-	15
Total Dissolved Solids[b] (g/L)	34.15	33.90	33.55	34.16	34.07	33.77	34.11	33.87	-	34.17	33.95	33.80	34.16	34.09	7.62	NG
Oxidation-Reduction Potential[b] (mV)	412.5	416	440	421	422	420.5	417	418.5	-	422.5	422	420	419.5	418.5	46.54	NG
Secchi Depth (m)	**1.09**	**0.70**	**0.37**	1.06	**0.85**	**0.48**	**0.74**	**0.80**	-	**0.81**	**0.89**	**0.50**	**0.85**	**0.92**	**0.66**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

- = Site inaccessible at tide. No sample taken.

Table 4-6. Neap Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	26			27			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	15	**19**	**27**	**20**	**19**	**39**	**17**	**28**	**25**	**30**	**29**	**30**	**23**	**24**	**56**	15
BWC Total Suspended Solids (mg/L)	**22**	**24**	**28**	**30**	**28**	**30**	**16**	**19**	**37**	11	**20**	**40**	**20**	**31**	**24**	15
Total Dissolved Solids[b] (g/L)	34.19	34.10	33.79	34.16	34.04	33.74	34.15	34.02	33.67	34.11	33.88	33.57	34.06	33.78	33.51	NG
Oxidation-Reduction Potential[b] (mV)	421	415.5	408.5	423.5	413.5	416.5	429	434	426	423.5	443	423.5	416.5	417.5	426	NG
Secchi Depth (m)	**1.27**	**0.88**	**0.67**	**0.88**	**0.67**	**0.52**	**0.96**	**0.63**	**0.47**	**0.83**	**0.46**	**0.56**	**0.72**	**0.50**	**0.64**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

Table 4-7. Spring Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	1			2			3			4			5			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	**23**	**37**	10	16	**46**	15	**44**	**88**	12	18	**67**	13	**26**	15	12	20
BWC Total Suspended Solids (mg/L)	**24**	15	**22**	**23**	**72**	14	**21**	**26**	18	**26**	**38**	**22**	19	**29**	18	20
Total Dissolved Solids[b] (g/L)	35.55	35.63	34.97	35.44	35.52	34.64	35.41	35.50	34.03	35.45	35.43	33.68	35.42	34.95	32.60	NG
Oxidation-Reduction Potential[b] (mV)	397	375	353	398	378	356	401	381.5	354.5	397.5	383.5	359	400	386.5	359	NG
Secchi Depth (m)	**0.75**	**0.70**	**0.71**	**0.63**	**0.86**	**0.84**	**0.70**	**0.75**	**0.98**	**0.65**	**0.77**	**0.72**	**0.75**	**0.84**	1.04	<1

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

Table 4-8. Spring Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	6			7			8			9			10			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	**21**	15	8	12	16	12	12	18	14	8	6	12	11	10	15	20
BWC Total Suspended Solids (mg/L)	**28**	**24**	-	12	20	-	15	15	14	**22**	**21**	9	16	17	13	20
Total Dissolved Solids[b] (g/L)	34.68	33.49	29.71	33.74	32.47	26.78	32.94	29.31	22.61	30.88	25.00	19.42	25.72	20.94	16.91	NG
Oxidation-Reduction Potential[b] (mV)	400.5	389.5	359	399	362.5	356.5	397.5	360	335	396.5	354	345	393.5	353	342	NG
Secchi Depth (m)	**0.71**	**0.74**	1.18	**0.82**	**0.75**	**0.91**	**0.67**	**0.96**	**0.90**	1.02	**0.86**	**0.86**	**0.80**	**0.77**	**0.77**	<1

[a] QWQGs (2009) for mid-estuarine waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

Table 4-9. Spring Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	11			12			13			14			15			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	8	**31**	-	5	**22**	-	10	12	-	8	**16**	**51**	8	15	**36**	15
BWC Total Suspended Solids (mg/L)	12	-	-	5	-	-	8	-	-	11	11	-	**25**	11	-	15
Total Dissolved Solids[b] (g/L)	35.53	35.52	-	35.49	35.50	-	35.39	35.29	-	35.50	35.44	35.66	35.60	35.46	35.69	NG
Oxidation-Reduction Potential[b] (mV)	342	334	-	344	334	-	345	334.5	-	350	338	324	348	336.5	329	NG
Secchi Depth (m)	**0.72**	**0.55**	-	**0.80**	**0.89**	-	**0.92**	**0.79**	-	**0.72**	**0.71**	**0.40**	**0.83**	**0.77**	**0.37**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

- = Site inaccessible at tide. No sample taken.

Table 4-10. Spring Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	16			17			18			19			20			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	**27**	**57**	**40**	19	**40**	**48**	**29**	**86**	**49**	**26**	**55**	**54**	**22**	**57**	**47**	15
BWC Total Suspended Solids (mg/L)	**58**	**62**	**79**	**57**	**103**	**77**	**43**	**122**	**83**	**48**	**57**	**88**	**39**	**57**	**68**	15
Total Dissolved Solids[b] (g/L)	35.81	35.57	35.40	35.79	35.65	35.43	35.72	35.70	35.42	35.67	35.80	35.55	35.97	35.69	35.49	NG
Oxidation-Reduction Potential[b] (mV)	346	338	337.5	346	339	345	346	338.5	332	348	352.5	338	365.5	364	358	NG
Secchi Depth (m)	**0.55**	**0.25**	**0.40**	**0.49**	**0.36**	**0.34**	**0.37**	**0.20**	**0.37**	**0.37**	**0.38**	**0.26**	**0.58**	**0.29**	**0.40**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

Table 4-11. Spring Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	21			22			23			24			25			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	**42**	**42**	**50**	**17**	**68**	**41**	10	**60**	-	**16**	**70**	**44**	14	**32**	**46**	15
BWC Total Suspended Solids (mg/L)	**38**	**47**	**61**	**22**	**81**	**51**	**22**	-	-	**18**	**86**	**61**	**19**	**28**	**54**	15
Total Dissolved Solids[b] (g/L)	35.78	35.90	35.75	35.96	35.73	35.49	35.86	35.79	-	35.82	35.71	35.52	35.98	36.00	35.62	NG
Oxidation-Reduction Potential[b] (mV)	357	342.5	381	365	362	359	364	361	-	365	362	359.5	363	360	362	NG
Secchi Depth (m)	**0.47**	**0.41**	**0.30**	**0.62**	**0.21**	**0.32**	**0.66**	**0.25**	-	**0.56**	**0.25**	**0.39**	**0.64**	**0.59**	**0.28**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

- = Site inaccessible at tide. No sample taken.

Table 4-12. Spring Tide Additional Water Quality Values

Parameter	Site															WQG[a]
	26			27			28			29			30			
	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	
TWC Total Suspended Solids (mg/L)	**34**	**65**	**36**	**45**	**67**	**50**	**41**	**59**	**60**	**49**	**64**	**77**	**53**	**44**	**35**	15
BWC Total Suspended Solids (mg/L)	**40**	**59**	-	**53**	**52**	-	**51**	**31**	**70**	**57**	**60**	**83**	**86**	**66**	**62**	15
Total Dissolved Solids[b] (g/L)	36.00	35.77	35.56	51.18	51.00	50.95	35.89	35.87	35.53	35.84	35.72	35.47	35.79	35.75	35.42	NG
Oxidation-Reduction Potential[b] (mV)	363	362	361	7.97	7.9	7.86	362	355	363.5	361	356	364	358	359	372	NG
Secchi Depth (m)	**0.62**	**0.30**	**0.33**	**0.44**	**0.23**	**0.32**	**0.38**	**0.29**	**0.23**	**0.32**	**0.25**	**0.27**	**0.33**	**0.53**	**0.36**	<1.5

[a] QWQGs (2009) for enclosed coastal waters of central Queensland.

[b] Total dissolved solids and oxidation-reduction potential results are shown as median YSI values.

L = Low tide, M = Mid tide, H = High tide.

Bolded values represent exceedences of QWQG.

NG = No guideline exists.

TWC = Top of water column sample.

BWC = Bottom of water column sample.

- = Site inaccessible at tide. No sample taken.