Water Quality Management Plan - Aura Development

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1 Introduction

This Water Quality Management Plan (WQMP) addresses the management and monitoring of surface water and groundwater on and adjacent to the Aura site in accordance with Condition 4 of the Department of Agriculture, Water and the Environment (DAWE) Final Approval Decision conditions (EPBC Ref 2011/5987 dated 6/6/2013) under the *Environment Protection and Conservation Act 1999* (EPBC Act). Condition 4 of the approval details the following requirements:

Prior to the commencement of the action, the person undertaking the action must submit to the Minister for approval a Water Quality Management Plan. The Water Quality Management Plan must address the management of both groundwater and surface water .

Table 1-1 outlines the information required under Condition 4 and the corresponding report section where the information has been provided.

Table 1-1 DAWE Condition 4 Requirements

Item	WQMP Section
(a) Outline baseline water quality data.	Appendix A
(b) Set out water quality performance objectives and parameters.	Section 3
(c) Set monitoring and reporting periods.	Section 6
(d) Set out scientifically robust methods for sampling and data collection.	Section 2
(e) Include a risk assessment of any modelling, assumptions and predictions used.	Appendix C
(f) Identify readily measurable performance indicators and goals and identify performance indicators at which point corrective actions will be taken.	Section 3
(g) Corrective actions, and/or mechanisms for developing corrective actions, and the parties responsible for implementing corrective actions.	Section 4
(h) Include a scientifically robust method for detecting a 10% change in water quality parameters in Bells Creek and 5% change in water quality in Pumicestone Passage unless an alternate is approved by the Minister.	Section 3 and Appendix B
(i) Demonstrate adaptive management mechanisms reflecting contemporary industry best practice are being implemented throughout the period of approval.	Section 5

Note that for Condition 4(h), an alternate method to detect changes in water quality in Bells Creek and Pumicestone Passage was endorsed by SEWPAC in 2014 (WQMP version R.B20318.001.003). This method is outlined in Section 3 and detailed in Appendix B.

1.1 Abbreviations and Definitions

The following key abbreviations and definitions are used in this document:

- DAWE – Department of Agriculture, Water and the Environment, the federal government department that administers the *Environment Protection and Conservation Act 1999* (EPBC Act). This department was previously referred to as the Department of Energy and Environment (DoEE) and prior to that the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC).
- EHMP – Estuarine Health Monitoring Program, which is a multi-agency funded (led by the Queensland Government) regional environmental monitoring program. Monitoring is undertaken by Healthy Land and Water and includes collection of water quality data at monthly intervals at a number of sites throughout Southeast Queensland, including sites in Bells Creek estuary and Pumicestone Passage.
- Ambient monitoring – routine water quality monitoring over set intervals (e.g. monthly) to characterise long-term trends in water quality.
- Event based monitoring – collection of water quality samples during periods of increased waterway discharge following rainfall events, with a primary objective of estimating loads of contaminants (e.g. sediments and nutrients) that are transported during events.
- Real-time continuous monitoring – continuous monitoring (i.e. measurements logged every 10 minutes) of *in-situ* water quality using sensors deployed in waterways. Data is transmitted in near real-time via telemetry to servers where the data is stored, analysed and displayed on web platforms.
- Development works – refers to construction activities including vegetation clearing, site establishment, drainage works and bulk earthworks. Also includes completion of stabilisation works including landscape construction works and removal of sediment basins or conversion of basins to operational stormwater treatment devices (e.g. bioretention ponds).
- Civil construction – refers to works following development works, including construction of residential housing and/or commercial premises.
- Catchment – in hydrological terms, a catchment is an area where precipitation collects and drains off into a common outlet. There are three catchments within the Aura site as follows:
    - Lamerough Creek.
    - Bells Creek North.
    - Bells Creek South.
- Precinct/s – areas defined by the Caloundra South Urban Development Area Master Plan (Precincts 1 to 19) and included in Annexure A of the EPBC approval.

2 Methods for Sampling and Data Collection

This section describes the scientifically robust methods for sampling and data collection as per Condition 4(d) of the approval. Further detail on the statistical analysis of the data collected is provided in Appendix B.

2.1 Surface Water Quality

2.1.1 Scope of Monitoring

The primary surface water quality issues to address through the monitoring program include:

- Construction works discharges.
- Wastewater discharges.
- Disturbed/exposed acid sulphate soils.

In terms of monitoring parameters, the following parameters were considered in developing the monitoring program:

- pH.
- Salinity.
- Turbidity and Total Suspended Solids.
- Nutrients (Nitrogen and Phosphorus).
- Heavy metals and metalloids.
- Hydrocarbons and their derivatives.

These parameters were reviewed and the following were not included in the monitoring program for the following reasons:

- In regard to heavy metals and metalloids (with the exception of aluminium and iron – which may be related to potential acid sulphate soils on site), based on data collected in South East Queensland, including sites on the Sunshine Coast, there should be minimal sources of such materials from this predominantly urban residential site other than in road runoff. As all road runoff will be extensively treated using advanced Water Sensitive Urban Design (WSUD) techniques (which are highly effective at removing particulate bound metals), monitoring for these constituents was not considered necessary.
- In regard to hydrocarbons, the same comment as per heavy metals is made.
- As there are no wastewater discharges from the site to Bells Creek or Pumicestone Passage, monitoring for wastewater-related parameters (e.g. coliforms) is also not required. Any impacts of accidental spills will be detected by the ambient nutrient monitoring.

Noting these exceptions, the surface water quality monitoring program consists of the following components:

- Freshwater Ambient Monitoring.

- Estuarine Monitoring – undertaken by Healthy Land and Water as part of the Estuarine Health Monitoring Program (EHMP).
- Real Time Turbidity (and Flow) Monitoring.
- Precinct-scale Construction Stage Monitoring by Construction Contractor.

Note that event-based monitoring and load-based monitoring has been completed.

Figure 5-1 presents the surface water monitoring locations. The monitoring activities which will occur at each of these locations are described below and summarised in Table 2-2.

2.1.2 Freshwater Ambient Monitoring

Monthly ambient water quality surveys are conducted at nine locations within the site, four in Bells Creek North, three in Bells Creek South and two in Lamerough Creek. Sites commenced being monitored in the respective waterways a minimum of six months ahead of any development works occurring within local catchments (encompassing wet and dry conditions) and will continue for a minimum of 12 months after the completion of development works have been completed within the respective catchments.

The following water quality parameters are measured by these surveys via a combination of in situ measurements using a pre-calibrated water quality instrument and water sampling and subsequent laboratory analyses:

- pH.
- Conductivity.
- Temperature.
- Turbidity.
- Dissolved oxygen.
- Total Suspended Solids.
- Total nitrogen, Organic N, Ammonia N and NOx.
- Total phosphorus and filterable reactive phosphorus.
- Chlorophyll-a.
- Total and dissolved iron and aluminium.

2.1.3 Event Based Monitoring (Completed)

Event based water quality samplers were installed at locations on Bells Creek North in March 2014 and in Bells Creek South in June 2017 at the upper and lower boundaries of the Aura site. Monitoring in the respective waterways was commenced six months ahead of any development works occurring within local catchments (encompassing wet and dry conditions). An additional monitoring station was deployed midway along Bells Creek North in July 2016 six (6) months before substantial urban land development works commenced in the areas upstream of this location.

These event based monitoring stations were decommissioned upon endorsement of this version of the WQMP (September 2020). However, flow monitoring will still continue at the real-time turbidity monitoring sites.

These samplers were triggered by flows in either of the creeks, and collected composited, flow proportional samples from significant run-off events. These samples were analysed for the following parameters:

- Flow.
- Total Suspended Solids.
- Total Nitrogen.
- Total Phosphorus.

2.1.4 Estuarine EHMP Monitoring

Two Ecosystem Health Monitoring Program (EHMP) sites have been located within Bells Creek downstream of the development (see **Figure 2-1.**). These sites are being tested on a monthly basis by Healthy Land and Water as a component of regular monthly surveys of Pumicestone Passage. The full suite of regular EHMP analyses is conducted at each of these sites.

Monitoring at these sites has been undertaken since mid-2012, and the data are being included in current EHMP reporting regimes. Monitoring will continue for a period of three (3) years after the completion of development works in Bells Creek North and South catchments.

For efficiency in sampling effort and to provide synergy between the Aura site monitoring and the regional EHMP monitoring program, Stockland committed to fund the monitoring of the additional two EHMP sites as part of this Plan. However, if EHMP monitoring was to cease or change, Stockland would continue monitoring of the two sites by including them in the monthly ambient surface water monitoring program (Section 2.1.2) for the required duration of this Plan.

2.1.5 Real Time Continuous Turbidity Monitoring

Real time continuous turbidity monitoring stations are located at the following five locations:

- The upstream confluences of the site with Bells Creek North (BN3) and Bells Creek South (BS3).
- The downstream confluences of the site with Bells Creek North (BN1) and Bells Creek South (BS1).
- The downstream extent of the development footprint within the Lamerough Creek Catchment (L1).

Turbidity monitoring in the respective waterways commenced a minimum of six (6) months ahead of development works occurring within each catchment and will continue for a minimum of twelve (12) months after the completion of development works within the respective catchments.

These stations collect and transmit turbidity data (measurements logged every 10 minutes) in near real-time, with alert systems installed such that should predefined triggers or increases in turbidity levels occur, appropriate site personnel are notified via text message and email such that rectification actions to address the causes of the turbidity exceedance are immediately undertaken.

These sites also record stream flow (and water level) data.

2.1.6 Load Based Monitoring (Completed)

Load based monitoring was conducted on catchments within the site to better understand the quality of water discharging from the site. Two sites were established in January 2016 within the ultimate development footprint from which data was collected for over two (2) years (commencing within one year of construction starting elsewhere on the site) to thoroughly quantify the baseline quality of run-off from the site.

These sites (shown in Figure 2-1) were decommissioned in June 2018 after collection of twenty (20) representative storms over a two (2) year period. Samples collected by the stormwater samplers were composited and the event mean concentration for each storm event derived.

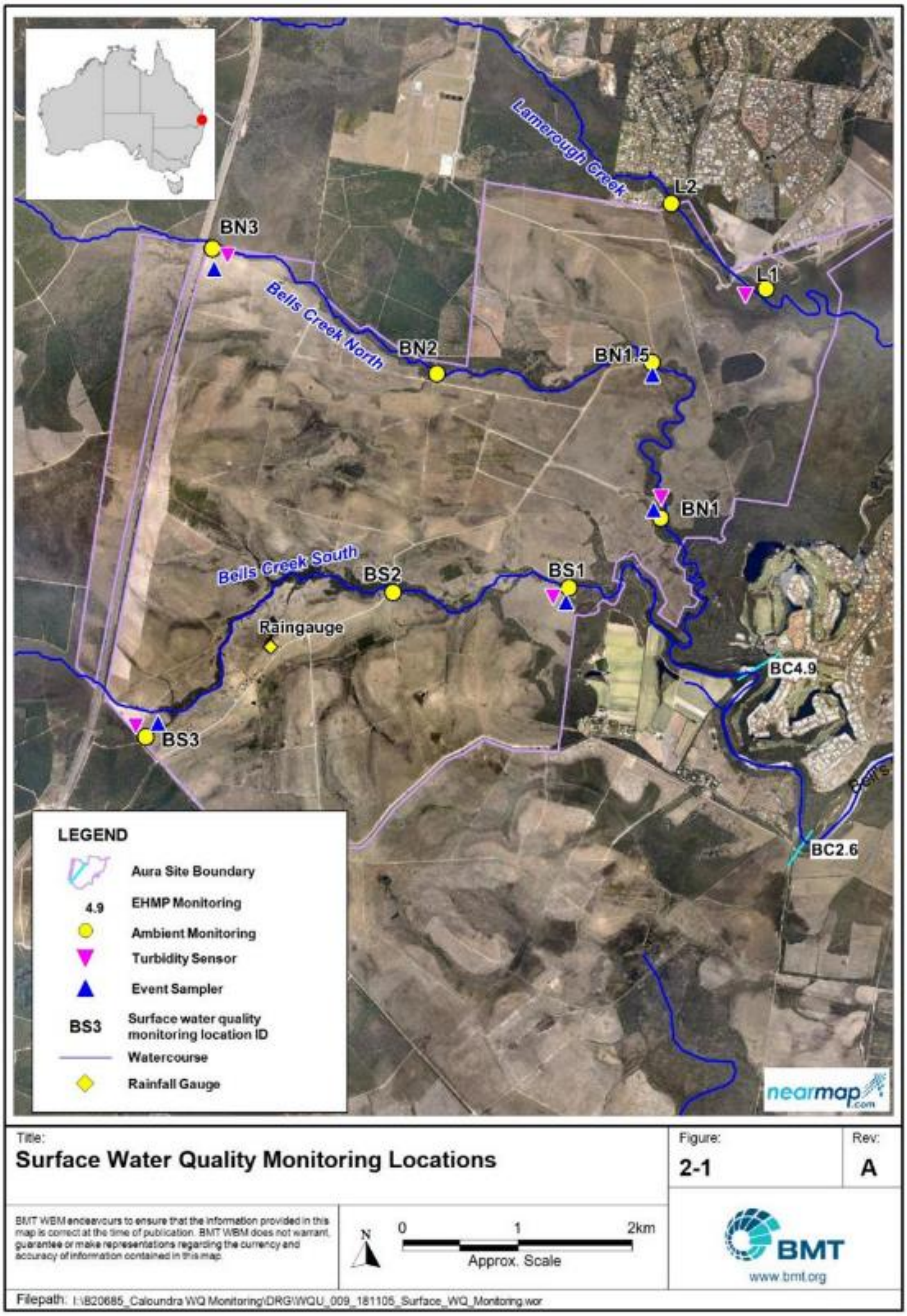


Figure 2-1 Surface Water Quality Monitoring Locations

2.1.7 Precinct-scale Monitoring by Construction Contractor

Precinct-scale construction stage monitoring to be undertaken by the Construction Contractor will be included in the details of precinct-scale Construction Environmental Management Plans (CEMP's). The following monitoring regime will be required in each Precinct-scale CEMP:

- Regular (daily and after major rain events of greater than 25 mm in 24 hours) site inspections of all erosion and sediment control measures.
- Regular (daily and after major rain events of greater than 25 mm in 24 hours) inspections of areas surrounding construction site to detect and manage any occurrence of sediment deposition off-site.
- Rainfall will be recorded at 9am each working day from an installed rain gauge.
- All construction activities will be monitored daily for compliance with erosion and sediment control measures.
- Within sediment basins, turbidity, pH and Dissolved Oxygen (DO) will be measured prior to discharge.

Within sediment basins within each precinct, turbidity and pH will be measured prior to discharge. Monitoring measures related to receiving water quality (e.g. outside of the sedimentation basins) are described in Sections 2.1.2, 2.1.3, 2.1.4 and 2.1.5 above.

Specific within site construction stage monitoring will cease at the completion and stabilisation of development works. During the civil construction phase that follows, the majority of erosion and sediment controls will be the responsibility of each construction contractor responsible for lot scale works.

2.1.8 Cessation of Monitoring

2.1.8.1 Construction monitoring (by the contractor)

Precinct-scale construction monitoring (as undertaken by the construction contractor) ceases in each precinct at the completion of development works in that precinct as the construction contractor moves to the next precinct and civil construction works commence.

2.1.8.2 Surface water quality monitoring in creeks (within the site)

Surface water monitoring components, such as monthly ambient and real-time turbidity, will cease a minimum of 12 months after the completion of development works have been completed within the respective catchment being Lamerough Creek, Bells Creek North or Bells Creek South catchments.

Prior to the cessation of monitoring in a catchment, certification will be provided to DAWE by a suitably qualified professional demonstrating that water quality has stabilised in the catchment. Following the provision of the certification, catchment monitoring may cease.

2.1.8.3 Monitoring in Bells Creek estuary (external to the site)

The EHMP monitoring will cease a minimum of three years after the completion and stabilisation of development works in both Bells Creek North and Bells Creek South catchments.

The cessation of monitoring for each catchment and monitoring sites is included in Table 2-1.

Table 2-1 Cessation of Monitoring – Surface Water

<table>
<tr><th>Catchment</th><th>Monitoring Component</th><th>Timeframe</th><th>Monitoring Sites</th></tr>
<tr><td>Sub-catchment Precincts</td><td>Precinct-scale construction monitoring</td><td>Completion of development works in each precinct</td><td>N/A</td></tr>
<tr><td rowspan="2">Lamerough Creek</td><td>Ambient monthly</td><td rowspan="6">Minimum of 12 months after all development work has been completed within the respective catchment</td><td>L1, L2</td></tr>
<tr><td>Real-time continuous turbidity</td><td>L1</td></tr>
<tr><td rowspan="2">Bells Creek North</td><td>Ambient monthly</td><td>BN1, BN1.5, BN2, BN3</td></tr>
<tr><td>Real-time continuous turbidity</td><td>BN1, BN3</td></tr>
<tr><td rowspan="2">Bells Creek South</td><td>Ambient monthly</td><td>BS1, BS2, BS3</td></tr>
<tr><td>Real-time continuous turbidity</td><td>BS1, BS3</td></tr>
<tr><td>All Catchments</td><td>EHMP monitoring</td><td>Minimum of 3 years after all development work has been completed on the site</td><td>BC2.6 and BC4.9</td></tr>
</table>

2.1.9 Summary of Surface Water Quality Monitoring

Table 2-2 Surface Water Quality Monitoring Summary

Monitoring Category	Nature of works	Commencement / Status	Cessation
Freshwater Ambient	• Monthly ambient water quality surveys at nine locations within the site, four in Bells Creek North, three in Bells Creek South and two in Lamerough Creek • The following water quality parameters to be measured via a combination of in situ measurements using a pre-calibrated water quality instrument and water sampling and subsequent laboratory analyses: – pH; – Conductivity; – Temperature; – Turbidity; – Dissolved oxygen – Total Suspended Solids; – Total nitrogen, Organic N, Ammonia N and NOx; – Total phosphorus and filterable reactive phosphorus; – Chlorophyll 'a'; – Total and dissolved iron and aluminium.	6 months[1] before development starts in upstream catchments	A minimum of 12 months after all development work has been completed within the respective catchment
Event Based	• Event based water quality samplers were installed on Bells Creek North and South at the upper and lower boundaries of the Aura site. • Additional event based water quality samplers to be deployed midway along Bells Creek North and South before substantial urban land development works are to commence in the areas upstream of these locations. • These samplers are be triggered by flows in either of the creeks, and collect composited, flow proportional samples from significant run-off events. These samples are analysed for the following parameters: – Flow – Total Suspended Solids; – Total Nitrogen; – Total Phosphorus	Event based sampling sites decommissioned	Completed
Estuarine EHMP	Two Ecosystem Health Monitoring Program (EHMP) sites within Bells Creek downstream of the development	Immediately	3 years after all development work has been completed on the site
Real Time Turbidity	• Real time turbidity monitoring stations at the following locations (five stations in total): – Bells Creek North and South at the lower boundary of the Aura site – Bells Creek North and South at the upper boundary of the Aura site; and – The downstream extent of the development footprint within the Lamerough Creek Catchment	6 months[3] before development starts in upstream catchments	12 months after all development work has been completed within the respective catchment
Load Based	• Two sites were established within the ultimate development footprint and data collected for a two (2) year period to quantify the quality of run-off from the site, commencing within one year of construction starting elsewhere on the site. • At each site, an event-based stormwater sampler was installed and stormwater flow and quality data collected from 20 representative storms over a two year period. Samples collected were composited and event mean concentrations for each storm event derived.	Completed	Completed
Precinct-scale Construction Stage by Construction Contractor	• Regular (daily and after major rain events) site inspections of all erosion and sediment control measures. • Regular (daily and after major rain events) inspections of areas surrounding construction site to detect and manage any occurrence of sediment deposition off-site. • Rainfall will be recorded at 9am each working day from an installed rain gauge. • All construction activities will be monitored daily for compliance with erosion and sediment control measures. • Turbidity, pH and Dissolved Oxygen (DO) will be measured prior to discharge (initiated when rainfall exceeds the design rainfall event and sediment basins are at capacity) within sediment basins within each precinct.	With the commencement of construction works in any precinct	At the completion and stabilisation of development work in a Precinct.

[1] As described earlier, weather patterns during this period need to be taken into consideration when the collected data are interpreted

2.2 Groundwater

2.2.1 Monitoring Bore Network

A network of groundwater monitoring bores is located across the site, as illustrated in Figure 3-3. The monitoring bore network is comprised of:

- Sentinel bores – located in close proximity to designated conservation areas (creek corridors and frog conservation zones) and to be maintained until the monitoring program is complete in the respective catchment. These bores are the major sources of reliable and defensible surveillance data to enable the assessment of any potential impacts to Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES) (hereafter collectively referred to as Protected Matters) and/or downstream receiving environments. Triggers for further investigation (Appendix B) and corrective actions have been developed from data collected at these Sentinel bores.
- Construction bores - located within the development footprint. These bores are used to identify potential groundwater issues within the active areas of construction, and to guide ‘cause and effect’ assessments and associated corrective actions should changes be detected in the data being collected at the Sentinel bores. These bores will be decommissioned when proximate development land reforming (cut and/or fill) works occurs.
- Control bores - located at the up-gradient boundary of the development footprint to monitor for any potential offsite influences on groundwater level and quality and to serve as a reference or control for changes in groundwater levels and quality in the (down-gradient) Sentinel bore network. These bores will be maintained until the monitoring program is complete in the respective catchment.

The locations of these bores is shown in Figure 2-2.

The monitoring bore network was developed to ensure it is adequate to detect potential construction related groundwater impacts on Protected Matters.

Note that the monitoring bore network focuses on groundwater quality in the shallow alluvial aquifer as it is assumed that any construction-related groundwater impacts will be reflected in the shallow aquifer.

2.2.2 Scope of Monitoring

A stratified program of monitoring, depending upon whether works are occurring in particular catchments, consists of the following:

- Pre-construction baseline monitoring was carried out prior to commencement of construction works in a catchment. All bores were monitored on a monthly basis at least 12 months prior to construction until a sufficient baseline bore-specific data set was available (i.e. at least 10 data points over at a least a 12 month period).
- For bores where a sufficient baseline bore-specific data set was unable to be collected (e.g. new bores), site-specific baseline data was assigned to the bore (refer to Section 3.2).

- All bores within catchments with development works occurring are sampled on a biannual basis where practicable (depending on construction activities occurring), up to and for 12 months after development works are completed in their respective catchments.
- Construction bores within catchments where there are construction activities occurring and which are in close proximity (i.e. within approximately 500m) to areas of development works are sampled on a **monthly** basis. These bores will be decommissioned when proximate development land reforming (cut and/or fill) works occurs.
- All Sentinel and Control bores within catchments where development works are occurring are monitored on a **monthly** basis.

2.2.3 Pre-construction Baseline

Prior to construction commencing in a catchment, at least ten (10) rounds of data was collected over at least a 12 month period at all bores within the catchment where practicable. This involved sampling and analysis of the following:

Field Parameters:

- Water level.
- pH.
- Electrical conductivity.
- Temperature.
- Dissolved oxygen.

Analytical Parameters:

- Major Anions (Alkalinity).
- Major Cations.
- Total nitrogen, Organic N, Ammonia N and NOx.
- Total phosphorus and filterable reactive phosphorus.
- Soluble sulfate (Cl^-:SO_4^{2-}) ratio.
- Nutrients (e.g. Nitrate and nitrite).
- Dissolved metals.
- PAHs including BTEXN, TPH, TRH.

Information gathered as part of this pre-construction monitoring program updated the baseline data sets that have been collected on the site over many years.

2.2.4 Construction Phase Monthly Monitoring

During construction works within each catchment, monthly monitoring is conducted at all Construction bores within 500m of development works, and all Sentinel and Control bores. This involves sampling and analysis of the following:

- Water level.
- pH.
- Electrical Conductivity.
- Total nitrogen, Organic N, Ammonia N and NOx.
- Total phosphorus and filterable reactive phosphorus.
- Dissolved Iron.
- Dissolved Aluminium.

Water quality testing for the full suite of parameters, including heavy metals (cadmium, chromium, copper, nickel, lead, and zinc), is conducted in association with the biannual surveys below.

2.2.5 Construction Phase Biannual Monitoring

Biannual monitoring (once every six months) is undertaken at all bores within catchments with development works occurring. The aim of this monitoring is to maintain currency of data for bores not included in the monthly monitoring. Further, if there are exceedances in the monthly monitoring data, the biannual data may be used to guide further investigations using longer term data of additional parameters (e.g. extended suite of metals). This biannual monitoring involves sampling and analysis of the following:

Field Parameters:

- Water level.
- pH.
- Electrical conductivity.
- Temperature.
- Dissolved oxygen.

Analytical Parameters:

- Major Anions (Alkalinity).
- Major Cations.
- Total nitrogen, Organic N, Ammonia N and NOx.
- Total phosphorus and filterable reactive phosphorus.
- Soluble sulfate (Cl^-:SO_4^{2-}) ratio.
- Nutrients (e.g. Nitrate and nitrite).
- Dissolved metals.
- PAHs including BTEXN, TPH, TRH.

2.2.6 Cessation of Monitoring

Once development works are completed and civil construction works commence, the potential for impacts to groundwater greatly diminishes. Therefore, groundwater monitoring will cease a minimum of 12 months following completion of development works in each catchment

Prior to the cessation of monitoring in a catchment, certification will be provided to DAWE by a suitably qualified professional demonstrating that water quality has stabilised in the catchment. Following the provision of the certification, catchment monitoring may cease.

The cessation of monitoring for each catchment and monitoring sites is included in Table 2-3.

Table 2-3 Cessation of Monitoring – Groundwater

Catchment	Timeframe	Groundwater Bores
Lamerough Creek	Minimum of 12 months after all development works have been completed within the respective catchment	BV1,BV2,BV7,G1/DS1,LC1
Bells Creek North		BH3,BV6,G2/DS2,BV10,FCZ2, BV8,C1,C2,GW10/FCZ5,IF1
Bells Creek South		C3,C4,C5,IF3,IF4,IF5,IF6,IF7,IF8,IF9,IF10, IF11,IF12,IF15,IF16,BH7,GW5/U3/G4,GW8/FCZ5, GW9/U2/G5,G3/DS3,G6/U1,G7/FCZ3

2.2.7 Summary of Groundwater Quality and Hydrology Monitoring

Table 2-4 Groundwater Quality Monitoring Summary

Monitoring Category	Nature of Works	Commencement	Cessation
Pre-construction Baseline	• Within at least 12 months of commencing development works in a catchment, all bores within the catchment proposed for development works will be monitored on a monthly basis until a sufficient bore-specific data set is available (at least ten rounds of data collected over at least a 12 month period prior to construction). • Field Parameters: – Water level; – pH; – Electrical conductivity; – Temperature; and – Dissolved oxygen. • Analytical Parameters: – Major Anions (Alkalinity); – Major Cations; – Total nitrogen, Organic N, Ammonia N and NOx; – Total phosphorus and filterable reactive phosphorus; – Soluble sulfate (Cl-:SO42-) ratio; – Dissolved metals; and • PAHs including BTEXN, TPH, TRH.	• At least 12 months prior to commencing construction in a catchment, where practicable. • Should construction occur prior to the completion of pre-construction monitoring (e.g. new bores), site-specific baseline data (i.e. baseline data from across the entire site) will be assigned to the bore.	• Commencement of development works in a catchment
Biannual Monitoring	• Biannual monitoring (once every six months) is undertaken at all bores within catchments with development works occurring. • Field Parameters: – Water level; – pH; – Electrical conductivity; – Temperature; and – Dissolved oxygen. • Analytical Parameters: – Major Anions (Alkalinity); – Major Cations; – Total nitrogen, Organic N, Ammonia N and NOx; – Total phosphorus and filterable reactive phosphorus; – Soluble sulfate (Cl-:SO42-) ratio; – Dissolved metals; and – PAHs including BTEXN, TPH, TRH.	• Once development works commence in a catchment, all bores within the catchment will be sampled on a biannual basis.	• 12 months after development works are completed in respective catchments
Construction Phase Monthly Monitoring	• Monthly monitoring conducted at all 'Construction' bores within 500m of development works. • Monthly monitoring conducted at all 'Sentinel' and 'Control' bores. • Monitoring conducted for the following parameters: – Water level; – pH; – Electrical Conductivity; – Total nitrogen, Organic N, Ammonia N and NOx; – Total phosphorus and filterable reactive phosphorus; – Dissolved Iron; and – Dissolved Aluminium.	• 'Construction' bores within catchments where there are construction activities occurring and which are in close proximity (i.e. within approximately 500m) to areas of development works will be sampled on a **monthly** basis. • All 'Sentinel' and 'Control' bores within catchments where development works are occurring will be monitored on a **monthly** basis.	• 12 months after development works are completed in respective catchments

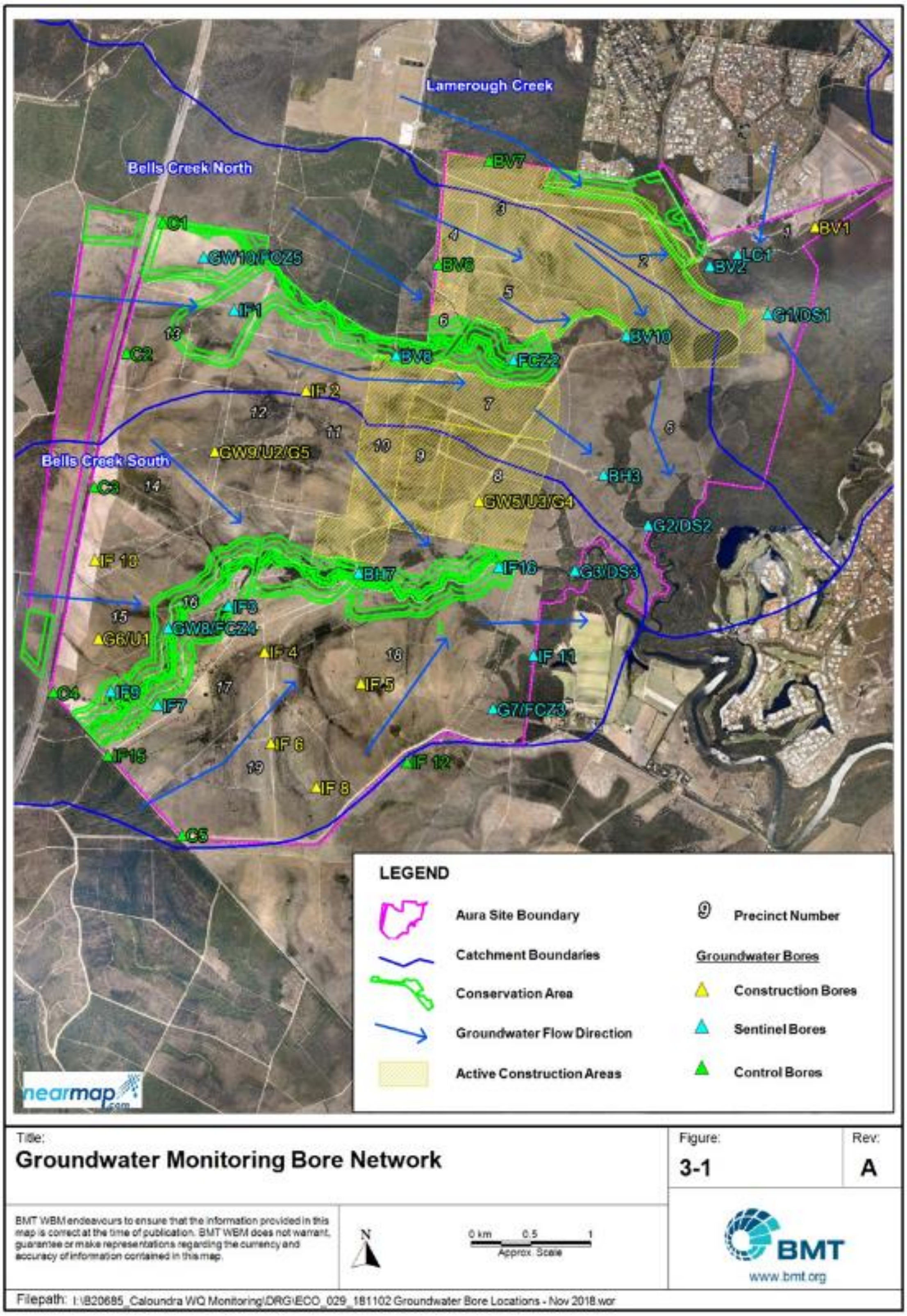


Figure 2-2 Groundwater Monitoring Locations

3 Performance Objectives and Parameters

This section includes the performance objectives and parameters in accordance with Condition 4(b) of the DAWE approval.

The performance objectives and parameters will be outlined in the following sections:

- Surface water quality for onsite sediment basins.
- Surface water quality at the downstream boundary of the Aura site.
- Surface water quality in the downstream receiving waters of Bells Creek estuary and Pumicestone Passage.
- Groundwater quality and levels.

3.1 Surface Water Quality

The fundamental surface water quality performance objective is for the project to have no adverse impacts on surface quality outside the development footprint as such changes could affect Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES).

3.1.1 Baseline Conditions

To assess baseline conditions (refer to Appendix A), water quality objectives (WQOs) from Schedule 1 of the *Environmental Protection (Water) Policy 2009* (EPP Water) were used. These WQOs are included in Table 3-1.

As detailed in Appendix A, the baseline data typically exceeds the WQOs listed in Table 3-1. Therefore, site-specific trigger values were developed for construction purposes for the Aura development using baseline data (refer to Appendix B).

Table 3-1 Water Quality Objectives – Baseline Phase

Parameter	Units	WQOs		
		Wallum / tannin[1]	Middle Estuary[2]	Pumicestone Passage (20th, 50th, 80th % percentiles)[3]
TSS	mg/L	6	20	6 – 12 – 16
Turbidity	NTU	20	8	2 – 4 – 6
Chlorophyll a	µg/L	5	4	1 – 1.6 – 2.5
Total nitrogen	mg/L	0.5	0.3	0.15 – 0.19 – 0.22
NOx	mg/L	0.06	0.01	0.002 – 0.002 – 0.003
Organic nitrogen	mg/L	0.42	0.28	0.15 – 0.18 – 0.21
Ammonia	mg/L	0.02	0.01	0.002 – 0.004 – 0.006
Total phosphorus	mg/L	0.05	0.025	0.015 – 0.018 – 0.025
Reactive phosphorus	mg/L	0.02	0.006	0.004 – 0.005 – 0.007
Dissolved oxygen	% saturation	85 – 110	85 – 105	90 – 95 – 105
pH	-	5 – 7	7 – 8.4	8.0 – 8.2 – 8.3
EC	µS/cm	500	-	-

[1] WQOs relevant to Upper Bells Creek and Lamerough Creek
[2] WQOs relevant to lower Bells Creek (BN1 and BS1) and Bells Creek Estuary EHMP sites (BC2.6 and BC4.9)
[3] WQOs as per 'Area PLE1 – Pumicestone Passage North' in EPP Water

3.1.2 Aura Site – Construction Phase

Measurable performance objectives for surface water relevant for the construction phase (bulk earthworks) of the Aura development include the following:

- Onsite sediment basins:
  - Performance criteria for site sedimentation basins are included in precinct-scale Construction Environmental Management Plans (CEMPs).
- Downstream receiving water quality (i.e. downstream of discharge points from all sedimentation basins):
  - During periods of flow in Bells Creek North or South and for any such flow events up to and including the design rainfall event (as specified below), discharge turbidity offsite (as measured by the downstream automated turbidity monitor) to be no greater than 10% above background with background being the quality of water entering the site via the culverts where Bells Creek North and South pass under the Bruce Highway.

Design Rainfall Event

Sediment basins onsite have been designed to manage stormwater flows up to the following design rainfall events:

- For traditional sediment basins, the design rainfall event is 77 mm over a 5 day period.

- For high efficiency sediment (HES) basins, rainfall intensity and inflow duration govern the time available for suspended sediment to settle in the basin. The design rainfall event for these basins is 0.5 times the peak 1 year ARI discharge.

Surface water quality performance criteria are also specified within groundwater performance indicators (refer to Section 3.2). In accordance with water quality guideline documents (ANZECC/ARMCANZ 2000, ANZG 2018), local site-specific trigger values were developed to assess monthly monitoring data for Aura, instead of using more generic, regional WQOs (Table 3-1).

Site-specific trigger values were developed for surface water using an extensive baseline dataset. Using the baseline data, 20th and 80th percentiles for each monitoring site were calculated and are included in Table 3-2.

Further detail in regard to the development of the surface water quality trigger values and assessment methods are included in Appendix B.

Table 3-2 Surface Water Trigger Values – Baseline Percentiles

Parameters	Units	Baseline Percentiles 80th (20th)					
		Lamerough Creek		Bells Creek North		Bells Creek South	
		L1	L2	BN1	BN3	BS1	BS3
Temperature	ºC	22.8	23.3	26.2	25.1	28.8	23.9
EC	µS/cm	220	216	41,750	243	48,370	229
Salinity	ppt	0.11	0.12	26.8	0.12	31.6	0.1
pH	pH units	6.50 (6.29)	6.43 (6.21)	6.72 (4.94)	6.50 (5.66)	6.71 (5.92)	7.30 (6.18)
Turbidity	NTU	12.2	20.6	22.7	51.9	8.9	24.0
Dissolved oxygen	% sat	28.3 (12.8)	40.5 (14.9)	73.7 (33.4)	72.0 (31.5)	68.5 (26.6)	28.3 (10.8)
Total suspended solids	mg/L	14.0	7.0	12.0	19.0	11.4	14.4
Ammonia	mg/L	0.13	0.06	0.13	0.04	0.07	0.04
Oxidised Nitrogen	mg/L	0.04	0.24	0.02	0.02	0.024	0.058
Organic Nitrogen	mg/L	1.20	1.00	0.90	1.20	0.98	1.10
Total Kjeldahl Nitrogen	mg/L	1.30	1.00	1.00	1.20	1.04	1.10
Total Nitrogen	mg/L	1.30	1.20	1.00	1.40	1.10	1.14
Total Phosphorus	mg/L	0.08	0.06	0.10	0.04	0.31	0.13
Reactive Phosphorus	mg/L	0.01	0.01	0.01	0.01	0.01	0.01
Chlorophyll-a	µg/L	27.0	2.0	30	4.0	4.4	7.0
Aluminium (dissolved)	mg/L	0.22	0.32	0.53	0.95	0.14	0.31
Iron (dissolved)	mg/L	1.02	0.80	1.30	2.41	0.52	1.10
Aluminium (total)	mg/L	0.36	0.48	0.97	1.89	0.74	1.01
Iron (total)	mg/L	2.36	1.39	3.03	4.85	1.20	3.36

3.1.3 Bells Creek Estuary and Pumicestone Passage – Construction and Operation Phases

From a surface water quality and quantity perspective, key objectives that the Aura development is required to satisfy are as follows:

- The Queensland Department of Environment and Science (DES) has defined adjacent sections of Pumicestone Passage as having High Ecological Value (HEV) status in the Environmental Protection (Water) Policy (EPP Water) – 2009. The commensurate Water Quality Objective (WQO) which accompanies this designation is of the nature of 'no change', but more specifically is quantified as:

  "maintain existing water quality (20th, 50th and 80th percentiles)".

- The Commonwealth and Queensland Governments have defined large sections of Pumicestone Passage and associated waterways as having Ramsar wetland status. The associated significance criteria which accompany this designation are as follows:

(1) Areas of the wetland being destroyed or substantially modified;

(2) A substantial and measurable change in the hydrological regime of the wetland (e.g. volume, timing, duration and frequency of surface and groundwater flows);

(3) The habitat or lifecycle of native species being seriously affected;

(4) A substantial and measurable change in the water quality of the wetland (e.g. salinity, pollutants, nutrients and water temperature) which may adversely impact on biodiversity, ecological integrity, social amenity or human health; and

(5) An invasive species that is harmful to the ecological character of the wetland becoming established, or an existing invasive species spreading.

In line with the above objectives, Condition 4h of the approval states:

"*a scientifically robust method be developed and implemented for detecting a 10% change in water quality parameters in Bells Creek and 5% change in water quality in Pumicestone Passage, unless an alternate is approved by the Minister*"

In accordance with condition 4(h), an alternative method was approved by the minister in 2014 (WQMP version R.B20318.001.003) as detailed in Appendix B. Section 4.1.2 summarises the approved methodology

3.2 Groundwater

The fundamental groundwater quality performance objective is for the project to have no adverse impacts on groundwater quality or levels outside the development footprint as such changes could affect Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES) (hereafter collectively referred to as Protected Matters).

Measurable performance objectives for groundwater, which focus on the protection of Protected Matters, include the following:

- The project will not result in changes to groundwater levels or groundwater quality in Wallum Sedge Frog (WSF) breeding areas that are outside the acceptable limits as specified in the Wallum Sedge Frog Management Plan (WSFMP) (i.e. pH 3 to 5 and electrical conductivity 8 to 77 µs/cm).
- The project does not result in poor quality groundwater seepage into surface water bodies (indicated by three month rolling median being maintained within 20th and 80th percentile values of baseline surface water quality - Table 3-2). Section 4 describe the process for assessing these performance objectives.

Trigger values have been developed for all bores, including ‘Construction’, ‘Sentinel’ and ‘Control’ bores. Exceedance of trigger values at ‘Sentinel’ bores trigger further investigation. Trigger values at ‘construction’ bores are used to identify potential impacting activities within the project area, and to guide corrective action if required (Table 5-2), while trigger values at ‘Control’ bores are used to monitor for offsite influences on groundwater quality and to serve as a reference for changes in groundwater quality in Sentinel bores.

Groundwater trigger values are included in Appendix B and are reproduced in Table 3-3 to Table 3-6.

Table 3-3 Groundwater Trigger Values

Catchment	GW Bore	SWL (mbGL)		EC	pH		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	TN	TP	Reactive P	Aluminium	Iron	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
		low	high	us/cm	low	high	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lamerough Creek	BV1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	BV2	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	G1/DS1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	LC1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	BV7	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
Bells Creek North	BH3	1.79	0.96	324	5.12	6.24	0.82	0.01	0.16	0.16	2.10	3.00	3.12	0.328	0.084	0.12	0.30	0.001	0.0001	0.001	0.002	0.001	0.004	0.014	0.0001
	G2/DS2	1.81	1.33	4211	4.24	4.88	0.14	0.01	0.06	0.06	5.88	5.98	5.98	0.682	0.010	0.08	2.74	0.001	0.0001	0.002	0.002	0.003	0.011	0.025	0.0001
	BV10 shallow	1.23	0.49	183	5.14	5.69	0.08	0.01	0.02	0.02	0.40	0.38	0.38	0.232	0.010	0.02	0.22	0.001	0.0001	0.001	0.002	0.001	0.006	0.032	0.0001
	IF13	1.45	0.52	1080	4.67	5.20	0.07	0.01	0.13	0.13	0.64	0.70	0.70	0.210	0.010	0.02	0.16	0.001	0.0001	0.002	0.004	0.001	0.004	0.049	0.0001
	FCZ2	1.40	0.83	189	4.88	5.48	0.16	0.01	0.04	0.04	1.84	1.86	1.92	0.174	0.010	0.55	1.90	0.001	0.0001	0.002	0.001	0.001	0.002	0.014	0.0001
	BV6	1.94	1.00	505	3.89	4.36	0.10	0.01	0.05	0.05	2.10	2.00	2.00	0.41	0.05	2.71	3.86	0.002	0.000	0.035	0.011	0.002	0.015	0.049	0.000
	BV8	1.44	0.70	566	4.74	5.38	0.08	0.01	0.36	0.36	2.00	2.00	2.20	0.282	0.010	0.29	1.30	0.001	0.0001	0.001	0.001	0.001	0.006	0.096	0.0001
	C1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	C2	1.73	1.00	136	4.99	5.51	0.32	0.01	0.58	0.58	0.50	0.82	1.26	0.124	0.010	0.03	0.37	0.001	0.0001	0.001	0.002	0.015	0.005	0.023	0.0001
	GW10/FCZ4	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF1	1.52	0.65	191	4.90	5.72	0.08	0.01	0.02	0.02	0.60	0.60	0.60	0.322	0.010	0.10	0.75	0.001	0.0001	0.001	0.001	0.001	0.003	0.031	0.0001
	IF2	1.22	0.50	174	5.00	5.54	1.09	0.01	0.03	0.04	1.18	2.16	2.16	0.580	0.010	0.03	4.10	0.002	0.0001	0.001	0.001	0.001	0.002	0.026	0.0001
	S1	1.13	0.52	280	4.94	5.73	1.48	0.01	0.05	0.05	6.30	6.56	6.60	0.412	0.080	0.06	5.35	0.001	0.0001	0.001	0.001	0.001	0.001	0.036	0.0001
Bells Creek South	C3	1.17	0.47	3468	5.69	6.18	0.16	0.01	0.05	0.05	1.22	1.62	2.00	0.456	0.010	0.02	1.75	0.001	0.0001	0.001	0.001	0.001	0.005	0.049	0.0001
	C4	1.49	0.98	276	5.12	5.73	0.03	0.01	0.06	0.06	1.46	1.62	1.72	0.512	0.010	1.53	0.69	0.001	0.0001	0.002	0.003	0.001	0.004	0.017	0.0001
	C5	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF3	1.87	0.75	420	4.66	5.24	0.55	0.01	0.01	0.01	27.68	23.02	23.02	1.858	0.010	0.32	7.29	0.001	0.0001	0.002	0.001	0.001	0.002	0.011	0.0001
	IF4	1.19	0.35	252	5.16	6.08	2.21	0.01	0.05	0.04	2.30	4.76	4.76	1.198	0.206	0.01	9.69	0.004	0.0001	0.001	0.001	0.001	0.003	0.027	0.0001
	IF5	1.69	0.66	148	5.10	5.56	0.55	0.01	0.39	0.39	6.18	3.26	5.06	0.648	0.112	0.07	0.53	0.001	0.0001	0.001	0.001	0.001	0.001	0.069	0.0001
	IF6	1.40	0.76	263	5.33	5.75	0.59	0.01	0.26	0.26	3.76	3.94	6.38	1.042	0.016	0.20	1.46	0.001	0.0001	0.001	0.002	0.001	0.001	0.101	0.0001
	IF7	2.46	0.59	160	5.05	5.40	0.13	0.01	0.11	0.11	1.48	1.50	1.52	0.244	0.010	0.03	0.98	0.001	0.0001	0.001	0.001	0.001	0.002	0.083	0.0001
	IF8	2.13	1.01	197	4.55	5.91	1.96	0.01	0.33	0.34	3.04	4.80	4.80	0.720	0.068	0.04	1.87	0.002	0.0001	0.001	0.001	0.001	0.002	0.028	0.0001
	IF9	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF10	1.52	0.89	333	4.96	5.52	1.41	0.01	0.17	0.17	1.70	3.34	3.40	0.692	0.010	0.06	2.25	0.001	0.0001	0.001	0.001	0.001	0.009	0.021	0.0001
	IF11	2.04	0.72	11002	4.33	4.80	0.05	0.01	0.01	0.01	0.82	1.06	0.68	0.152	0.010	1.17	6.39	0.002	0.0001	0.023	0.003	0.006	0.188	0.518	0.0001
	IF12	1.36	0.46	427	4.66	5.09	0.04	0.01	0.07	0.07	0.54	0.60	0.60	0.150	0.010	0.12	0.23	0.001	0.0001	0.001	0.002	0.001	0.004	0.111	0.0001
	IF14	1.18	0.37	232	5.19	5.82	0.48	0.01	0.02	0.02	2.76	5.30	5.30	0.640	0.060	0.02	2.60	0.005	0.0001	0.001	0.001	0.001	0.001	0.011	0.0001
	IF15 shallow	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF16	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	BH7	1.41	0.76	280	5.50	5.93	13.94	0.01	0.03	0.03	2.66	14.96	14.96	2.370	2.234	0.53	1.64	0.001	0.0001	0.001	0.001	0.001	0.002	0.031	0.0001
	GW5/U3/G4	1.71	0.81	330	5.20	5.74	13.30	0.01	0.79	0.82	9.50	26.68	26.68	4.184	1.408	0.12	1.94	0.002	0.0001	0.001	0.002	0.001	0.001	0.038	0.0001
	GW8/FCZ5	1.80	1.09	3504	6.64	7.04	1.25	0.01	0.02	0.06	1.02	2.82	2.82	0.650	0.432	0.01	0.51	0.004	0.0001	0.001	0.001	0.001	0.002	0.011	0.0001
	GW9/U2/G5	1.07	0.40	274	5.29	5.85	0.18	0.01	0.14	0.14	0.50	1.44	1.46	0.480	0.010	0.03	5.59	0.006	0.0001	0.002	0.003	0.001	0.012	0.030	0.0001
	G3/DS3	2.74	1.27	4225	4.87	5.30	0.51	0.01	0.03	0.03	6.48	12.78	12.78	1.626	0.010	0.40	7.80	0.006	0.0001	0.005	0.002	0.002	0.007	0.055	0.0001
	G6/U1	1.91	1.01	256	5.54	5.89	1.66	0.01	0.02	0.02	8.40	9.60	10.10	0.780	0.278	0.02	7.12	0.003	0.0001	0.001	0.002	0.001	0.001	0.044	0.0001
	G7/FCZ3	1.25	0.55	268	5.00	5.80	0.12	0.01	0.05	0.05	2.72	3.60	3.60	0.540	0.010	0.58	2.40	0.002	0.0001	0.002	0.001	0.001	0.001	0.046	0.0001

(Shaded) Denotes bores with insufficient basline data, therefore site-wide triggers used

Table 3-4 Groundwater Trigger Values (continued)

Catchment	GW Bore	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Alkalinity	Total Alkalinity	Sulfate	Chloride	Calcium	Magnesium	Sodium	Potassium	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	BV1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	BV2	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
Lamerough Creek	G1/DS1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	LC1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	BV7	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	BH3	1	1	40	40	10	66	1	4	39	1	1	1	1	1	1	1	1	1	1	1
	G2/DS2	1	1	6	6	213	1174	8	30	735	28	1	1	1	1	1	1	1	1	1	1
	BV10 shallow	1	1	23	23	12	36	3	3	26	1	1	1	1	1	1	1	1	1	1	1
	IF13	1	1	10	10	11	345	1	11	195	1	1	1	1	1	1	1	1	1	1	1
	FCZ2	1	1	9	9	9	33	1	3	24	1	1	1	1	1	1	1	1	1	1	1
	BV6	1	1	1	1	27	127	2	10	68	1	1	1	1	1	1	1	1	1	1	1
Bells Creek North	BV8	1	1	7	7	12	148	1	12	73	1	1	1	1	1	1	1	1	1	1	1
	C1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	C2	1	1	19	19	3	27	2	2	17	1	1	1	1	1	1	1	1	1	1	1
	GW10/FCZ4	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF1	1	1	15	15	21	33	2	2	24	1	1	1	1	1	1	1	1	1	1	1
	IF2	1	1	7	7	6	33	1	2	22	1	1	1	1	1	1	1	1	1	1	1
	S1	1	1	32	32	15	39	7	4	25	1	1	1	1	1	1	1	1	1	1	1
	C3	1	1	249	249	20	987	44	110	452	1	1	1	1	1	1	1	1	1	1	1
	C4	1	1	28	28	30	26	2	3	33	1	1	1	1	1	1	1	1	1	1	1
	C5	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF3	1	1	14	14	18	130	2	7	73	1	1	1	1	1	1	1	1	1	1	1
	IF4	1	1	31	31	5	38	1	3	26	1	1	1	1	1	1	1	1	1	1	1
	IF5	1	1	8	8	4	23	1	2	16	1	1	1	1	1	1	1	1	1	1	1
	IF6	1	1	30	30	10	58	7	4	35	3	1	1	1	1	1	1	1	1	1	1
	IF7	1	1	11	11	7	33	2	2	22	1	1	1	1	1	1	1	1	1	1	1
	IF8	1	1	6	6	5	36	1	3	23	1	1	1	1	1	1	1	1	1	1	1
	IF9	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF10	1	1	8	8	4	84	1	6	43	1	1	1	1	1	1	1	1	1	1	1
Bells Creek South	IF11	1	1	1	1	1508	3314	48	268	2018	40	1	1	1	1	1	1	1	1	1	1
	IF12	1	1	4	4	11	129	3	6	68	1	1	1	1	1	1	1	1	1	1	1
	IF14	1	1	24	24	13	40	2	3	31	1	1	1	1	1	1	1	1	1	1	1
	IF15 shallow	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF16	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	BH7	1	1	110	110	6	40	2	3	40	1	1	1	1	1	1	1	1	1	1	1
	GW5/U3/G4	1	1	89	89	15	62	4	4	46	3	1	1	1	1	1	1	1	1	1	1
	GW8/FCZ5	1	1	506	506	122	833	33	60	612	2	1	1	1	1	1	1	1	1	1	1
	GW9/U2/G5	1	1	33	33	14	54	2	4	42	1	1	1	1	1	1	1	1	1	1	1
	G3/DS3	1	1	25	25	113	1320	11	50	796	27	1	1	1	1	1	1	1	1	1	1
	G6/U1	1	1	35	35	6	35	1	2	26	1	1	1	1	1	1	1	1	1	1	1
	G7/FCZ3	1	1	10	10	6	63	2	4	36	1	1	1	1	1	1	1	1	1	1	1

(Grey shading) Denotes bores with insufficient basline data, therefore site-wide triggers used

Table 3-5 Groundwater Trigger Values (continued)

Catchment	GW Bore	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1.2.3.cd)pyrene	Dibenz(a.h)anthracene	Benzo(g.h.i)perylene	Sum of polycyclic aromatic hydrocarbons	Benzo(a)pyrene TEQ (zero)	C6 - C9 Fraction	C10 - C14 Fraction	C15 - C28 Fraction	C29 - C36 Fraction	C10 - C36 Fraction (sum)	C6 - C10 Fraction	C6 - C10 Fraction minus BTEX (F1)
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Lamerough Creek	BV1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	BV2	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	G1/DS1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	LC1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	BV7	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
Bells Creek North	BH3	1	1	0.5	1	1	1	0.5	0.5	20	240	1402	578	2654	20	20
	G2/DS2	1	1	0.5	1	1	1	0.5	0.5	20	50	170	52	214	20	20
	BV10 shallow	1	1	0.5	1	1	1	0.5	0.5	20	50	340	140	520	20	20
	IF13	1	1	0.5	1	1	1	0.5	0.5	20	50	110	54	206	20	20
	FCZ2	1	1	0.5	1	1	1	0.5	0.5	20	50	188	50	230	20	20
	BV6	1	1	0.5	1	1	1	0.5	0.5	20	50	266	100	382	20	20
	BV8	1	1	0.5	1	1	1	0.5	0.5	20	50	130	50	218	20	20
	C1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	C2	1	1	0.5	1	1	1	0.5	0.5	20	50	386	160	594	20	20
	GW10/FCZ4	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF1	1	1	0.5	1	1	1	0.5	0.5	20	50	160	54	228	20	20
	IF2	1	1	0.5	1	1	1	0.5	0.5	20	50	170	80	260	20	20
	S1	1	1	0.5	1	1	1	0.5	0.5	20	96	1630	614	2104	20	20
Bells Creek South	C3	1	1	0.5	1	1	1	0.5	0.5	20	50	240	78	290	20	20
	C4	1	1	0.5	1	1	1	0.5	0.5	20	50	174	50	184	20	20
	C5	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF3	1	1	0.5	1	1	1	0.5	0.5	20	50	534	148	734	20	20
	IF4	1	1	0.5	1	1	1	0.5	0.5	60	688	1424	726	2720	60	20
	IF5	1	1	0.5	1	1	1	0.5	0.5	28	50	256	258	560	28	20
	IF6	1	1	0.5	1	1	1	0.5	0.5	20	50	200	150	350	20	20
	IF7	1	1	0.5	1	1	1	0.5	0.5	20	50	442	80	528	20	20
	IF8	1	1	0.5	1	1	1	0.5	0.5	20	360	622	826	1482	20	20
	IF9	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF10	1	1	0.5	1	1	1	0.5	0.5	20	50	360	208	566	20	20
	IF11	1	1	0.5	1	1	1	0.5	0.5	20	50	130	60	200	20	20
	IF12	1	1	0.5	1	1	1	0.5	0.5	20	50	120	50	210	20	20
	IF14	1	1	0.5	1	1	1	0.5	0.5	20	154	182	186	742	20	20
	IF15 shallow	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF16	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	BH7	1	1	0.5	1	1	1	0.5	0.5	134	50	1296	726	2146	122	32
	GW5/U3/G4	1	1	0.5	1	1	1	0.5	0.5	364	58	1580	1060	2900	372	80
	GW8/FCZ5	1	1	0.5	1	1	1	0.5	0.5	20	90	692	246	958	20	20
	GW9/U2/G5	1	1	0.5	1	1	1	0.5	0.5	20	82	470	176	718	20	20
	G3/DS3	1	1	0.5	1	1	1	0.5	0.5	20	50	360	192	552	20	20
	G6/U1	1	1	0.5	1	1	1	0.5	0.5	132	1350	2196	966	5018	134	42
	G7/FCZ3	1	1	0.5	1	1	1	0.5	0.5	20	50	140	50	140	20	20

(grey shading) Denotes bores with insufficient basline data, therefore site-wide triggers used

Table 3-6 Groundwater Trigger Values (continued)

Catchment	GW Bore	C10 - C16 Fraction	C16 - C34 Fraction	C34 - C40 Fraction	C10 - C40 Fraction (sum)	C10 - C16 Fraction minus Naphthalene (F2)	Benzene	Toluene	Ethylbenzene	meta- & para-Xylene	ortho-Xylene	Total Xylenes	Sum of BTEX	Naphthalene
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Lamerough Creek	BV1	100	254	100	354	100	1	2	2	2	2	2	1	5
	BV2	100	254	100	354	100	1	2	2	2	2	2	1	5
	G1/DS1	100	254	100	354	100	1	2	2	2	2	2	1	5
	LC1	100	254	100	354	100	1	2	2	2	2	2	1	5
	BV7	100	254	100	354	100	1	2	2	2	2	2	1	5
Bells Creek North	BH3	262	2214	294	2976	280	1	2	2	2	2	2	1	5
	G2/DS2	100	184	100	184	100	1	2	2	2	2	2	1	5
	BV10 shallow	100	430	100	540	100	1	2	2	2	2	2	1	5
	IF13	100	202	100	202	100	1	2	2	2	2	2	1	5
	FCZ2	100	204	100	204	100	1	2	2	2	2	2	1	5
	BV6	100	340	100	408	100	1	2	2	2	2	2	1	5
	BV8	100	156	100	156	100	1	2	2	2	2	2	1	5
	C1	100	254	100	354	100	1	2	2	2	2	2	1	5
	C2	100	556	100	600	100	1	7	2	2	2	2	7	5
	GW10/FCZ4	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF1	100	188	100	188	100	1	2	2	2	2	2	1	5
	IF2	100	250	100	270	100	1	2	2	2	2	2	1	5
	S1	112	2052	124	2136	112	1	2	2	2	2	2	1	5
Bells Creek South	C3	100	272	100	272	100	1	2	2	2	2	2	1	5
	C4	100	204	100	204	100	1	2	2	2	2	2	1	5
	C5	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF3	100	686	122	686	100	1	4	2	2	2	2	4	5
	IF4	742	1852	232	2706	742	1	42	2	2	2	2	42	5
	IF5	100	520	100	580	100	1	9	2	2	2	2	9	5
	IF6	100	280	100	420	100	1	14	2	2	2	2	14	5
	IF7	100	492	100	492	100	1	2	2	2	2	2	1	5
	IF8	518	1228	240	1612	518	1	2	2	2	2	2	1	5
	IF9	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF10	100	528	100	648	100	1	4	2	2	2	2	4	5
	IF11	100	180	100	180	100	1	2	2	2	2	2	1	5
	IF12	100	150	100	150	100	1	2	2	2	2	2	1	5
	IF14	140	330	100	584	140	1	2	2	2	2	2	1	5
	IF15 shallow	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF16	100	254	100	354	100	1	2	2	2	2	2	1	5
	BH7	100	2072	216	2298	100	1	96	2	2	2	2	96	5
	GW5/U3/G4	100	2800	196	3010	100	1	294	2	2	2	2	294	5
	GW8/FCZ5	116	878	128	908	116	1	2	2	2	2	2	1	5
	GW9/U2/G5	116	602	100	678	116	1	2	2	2	2	2	1	5
	G3/DS3	100	454	134	610	100	1	2	2	2	2	2	1	5
	G6/U1	1814	2976	438	5252	1814	1	95	2	2	2	2	95	5
	G7/FCZ3	100	148	100	148	100	1	2	2	2	2	2	1	5

(Grey shading) Denotes bores with insufficient basline data, therefore site-wide triggers used

4 Methods to Detect Impacts

The methods used to detect changes in water quality in accordance with Condition 4(h) of the DAWE approval are summarised in this section and detailed further in Appendix B.

4.1 Surface Water

4.1.1 Aura Site

Exceedance of the turbidity performance criteria (no greater than 10% above background) from the automated turbidity monitor at the downstream boundary of the site will trigger further investigations. These further investigations are discussed in Section 5.1. If further investigations indicate that construction activities have caused impacts to receiving waters, then corrective actions will be implemented as discussed in Section 5.2.

Ambient monthly surface water data are used to detect longer term changes to water quality. The trigger values in Table 3-2 are used to determine whether water quality is trending outside natural variability for the following purposes:

- To assess long term changes in surface water quality in key waterways within Aura.
- To assess whether any changes to groundwater quality resulting from project activities may be impacting on surface water quality. This assessment is part of the groundwater assessment methodology (Section 4.1.3).
- To aid in further investigations of exceedances in the downstream receiving waters of Bells Creek estuary and Pumicestone Passage (refer to Section 4.1.2). Ambient surface water data for Aura can be used to determine if water quality changes within Aura are causing similar changes in the downstream receiving waters.

The assessment process involves comparing the median of the most recent three (3) consecutive routine monitoring samples for each site to relevant surface water trigger values (Table 3-2). Any exceedance of trigger values initiates further investigations and corrective actions as detailed in Section 4 of the WQMP.

4.1.2 Bells Creek Estuary and Pumicestone Passage

Water quality within Bells Creek estuary and Pumicestone Passage during the construction and operational stages of the project is to be maintained within limits of natural variability. Note that the operational stage of the project refers to a minimum period of three (3) years post-construction, with approval for cessation of monitoring provided by the regulator as outlined in Section 2.2.6.

The assessment approach involves comparing water quality data for key water quality parameters from two ‘impact’ sites within Bells Creek estuary and one ‘impact’ site in Pumicestone Passage (near the mouth of Bells Creek) to relevant ‘control’ sites in Pumicestone Passage to define if investigation and corrective action works are necessary. The locations of these sites are shown in **figure 2-3**. The assessment approach is detailed in Appendix B and is summarised as follows:

- Monthly EHMP data is analysed to calculate three month rolling averages for each EHMP monitoring site.
- The three month rolling average data is progressively plotted in correlation graphs developed using pre-construction baseline data, with lines developed for 'further investigation' and 'corrective action' – refer to **figure 4-2.** as an example and Appendix B for further information.
- Any data recorded at the impact sites during the construction and/or operational stages of the project that is located within the two 'further investigation' lines will not require any action as these data are indicating water quality levels in Bells Creek estuary and Pumicestone Passage that is effectively comparable to pre-construction conditions.
- Any data recorded at the impact sites during the construction and/or operational stages of the project fall between the 'further investigation' and 'corrective action' lines, then further investigations as outlined in Section 5.1 will be triggered to determine whether development works are affecting receiving water quality and, if necessary, corrective action to be implemented.
- Should data recorded at the impact site during the construction and/or operational stages of the project fall outside the 'corrective action' lines, then more detailed assessments and site-specific actions will be triggered.

Regular (2 yearly) reviews of the relationships between the control and impact sites (see Appendix B) will be conducted to capture any potential overall long-term changes in water quality within Bells Creek estuary and Pumicestone Passage which may result from works being conducted elsewhere in the catchment.

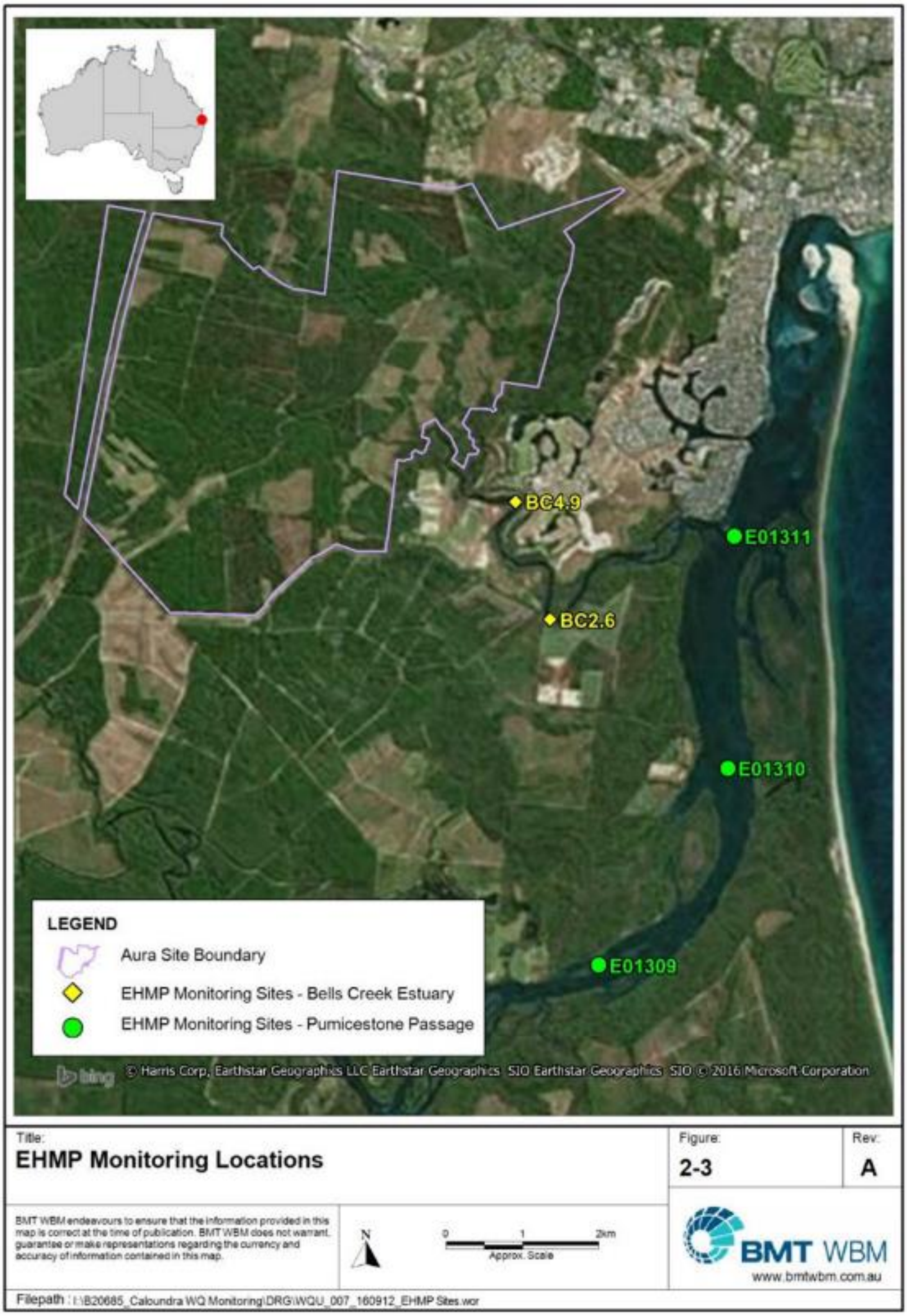


Figure 4-1 EHMP Data Collection Locations

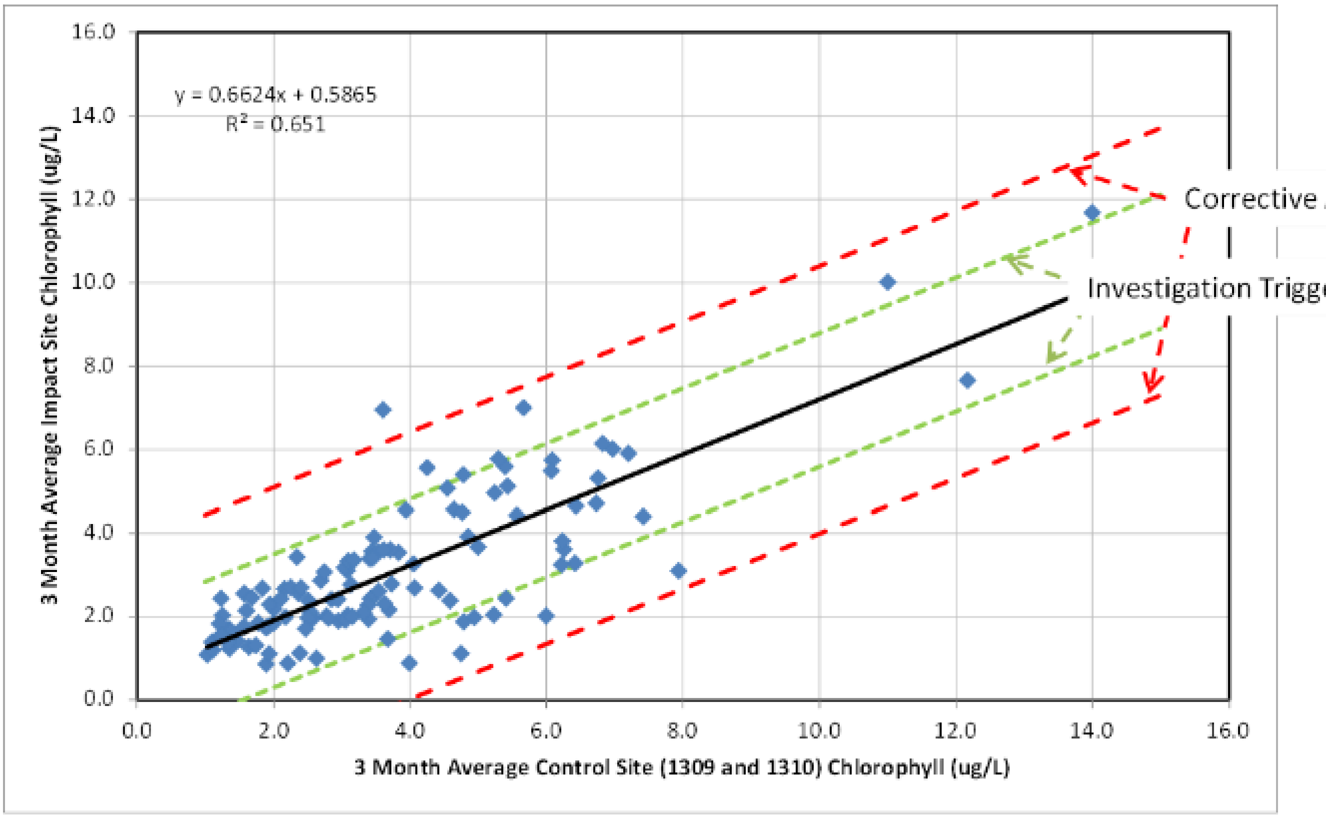


Figure 4-2 Example of EHMP Data Assessment Approach

4.1.3 Groundwater Quality

Groundwater quality data is analysed to determine the median from the most recent three (3) consecutive routine monitoring samples. This 'rolling median' is used to compare with site-specific or bore-specific trigger values as appropriate.

Note that assessment of groundwater quality data against trigger values will only be undertaken for bores within catchments with development works (up to 12 months after development works are completed).

The following methodology is used to assess groundwater quality in catchments with development works:

- For bores with less than ten (10) baseline data points (captured over at least 12 months), groundwater monitoring data is compared with **site-specific** groundwater quality trigger values.
- For bores with more than ten (10) baseline data points (captured over at least 12 months), groundwater monitoring data is compared with **bore-specific** trigger values.
- If the monitoring data for Sentinel bores exceeds the 80th percentile trigger value (or 20th percentile for parameters with a lower limit), this triggers an initial investigation into whether Protected Matters and/or receiving environments are being impacted.
- Impacts to Protected Matters and/or receiving environments are assessed as follows:

(a) Assess whether the three month rolling median of surface water quality data (only for parameters exceeded in groundwater) at the downstream boundary of site (e.g. BN1) is outside the $20^{th}/80^{th}$ percentile range of baseline data (Appendix B). If so, review the surface water quality data record at the upstream boundary of the site (e.g. BN3) to determine if parameters of concern are naturally elevated. If upstream surface water quality is within $20^{th}/80^{th}$ percentile of baseline data at this location, project related impacts may be occurring at downstream receiving environments.

(b) Assess whether pH and electrical conductivity (EC) levels in site frog ponds are within acceptable limits.

(c) Assess whether trigger values at up-gradient Control bores are also being exceeded – indicating potential offsite influences on groundwater quality.

- If the monitoring data comparison indicates that Protected Matters or the receiving environment may be being impacted, this triggers corrective action as per Section 5.2.
- Construction phase monitoring data for Construction bores is compared to trigger values (either site-specific or bore-specific) to identify potential areas of concern, or point sources, within the construction areas. This assists with targeting of locally specific corrective actions (Table 5-2).

To illustrate the above points, a construction phase groundwater quality monitoring decision tree is presented in Figure 4-3.

Note: In the 12 month monitoring period after development works are completed in respective catchments, the above process of assessment against trigger values will continue. While corrective actions will not be able to be implemented, the purpose of this is to confirm that there are no lingering impacts to groundwater.

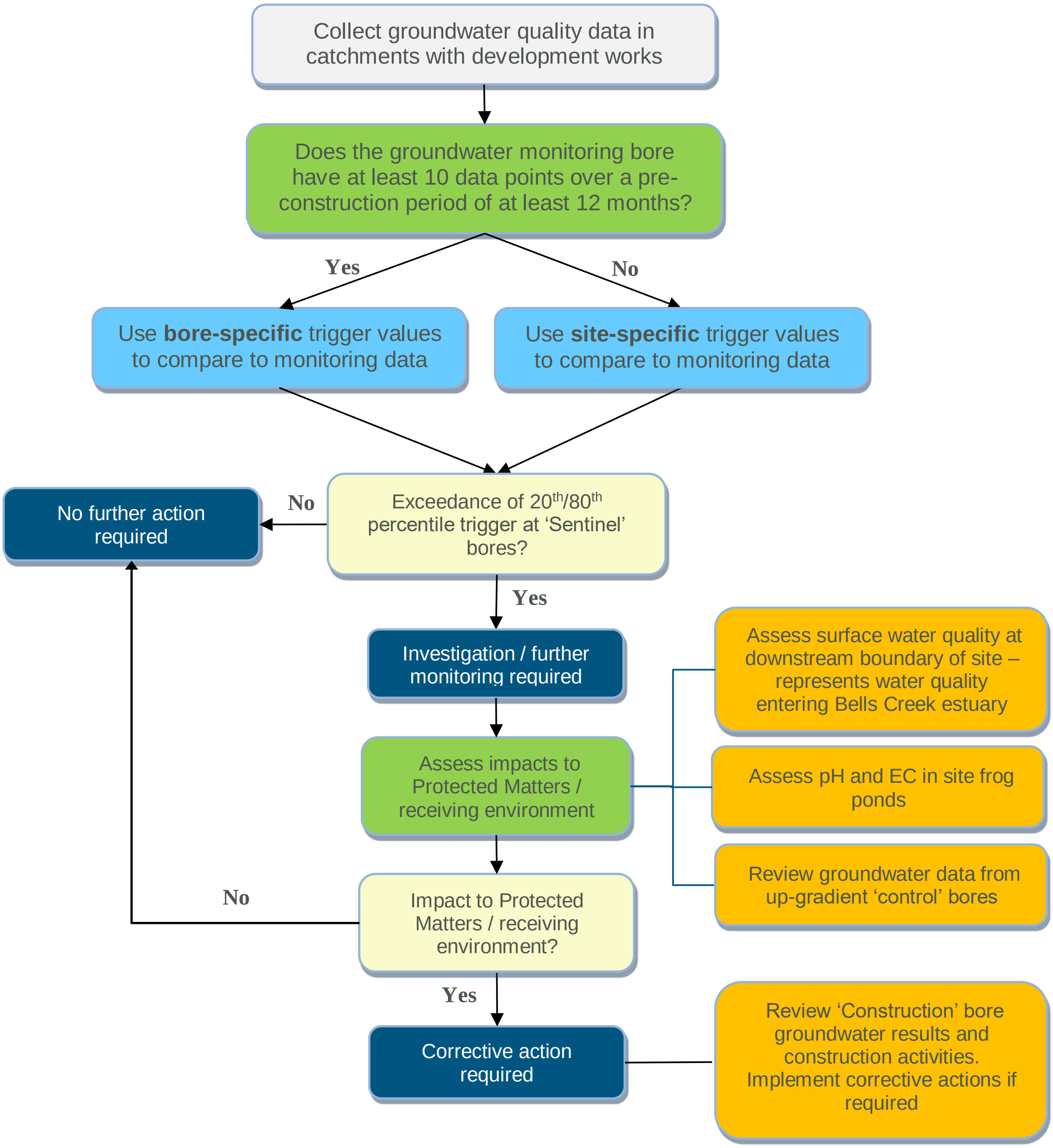


Figure 4-3 Construction Phase Groundwater Quality Monitoring Decision Tree

4.1.3.1 Groundwater Level

Note that assessment of groundwater level data against trigger values will only be undertaken for bores within catchments with development works (up to 12 months after development works are completed).

The following methodology is used to assess groundwater levels in catchments with development works:

- For bores with more than ten (10) baseline data points (captured over at least 12 months), groundwater monitoring data is compared with bore-specific groundwater level trigger values.
- For bores with less than ten (10) baseline data points (captured over at least 12 months), groundwater monitoring data is plotted as time series with CRD curve to assess trends in data compared to rainfall.
- If the monitoring data for Sentinel bores exceeds the 80th percentile trigger value (upper limit) or 20th percentile (lower limit), or if the trend in the previous three (3) months of data does not correlate with the trend in the CRD curve, this triggers an initial investigation into whether Protected Matters are being impacted.
- Impacts to Protected Matters are to be assessed as follows:
  - (a) Assess whether water levels in frog ponds are within acceptable limits.
  - (b) Assess whether trigger values at up-gradient Control bores are exceeded - indicating natural fluctuations in groundwater levels.
- If Protected Matters are being impacted, this may trigger corrective action as per Section 5.2.
- Construction phase monitoring data for construction bores is compared with trigger values (either site-specific or bore-specific) to identify potential areas of concern within construction areas. This will assist with targeting of corrective actions (Table 5-2).

To illustrate the above points, a groundwater level monitoring decision tree is presented in Figure 4-13.

Note: In the 12 month monitoring period after development works are completed in respective catchments, the above process of assessment against trigger values will continue. While corrective actions will not be able to be implemented, the purpose of this is to confirm that there are no lingering impacts to groundwater.

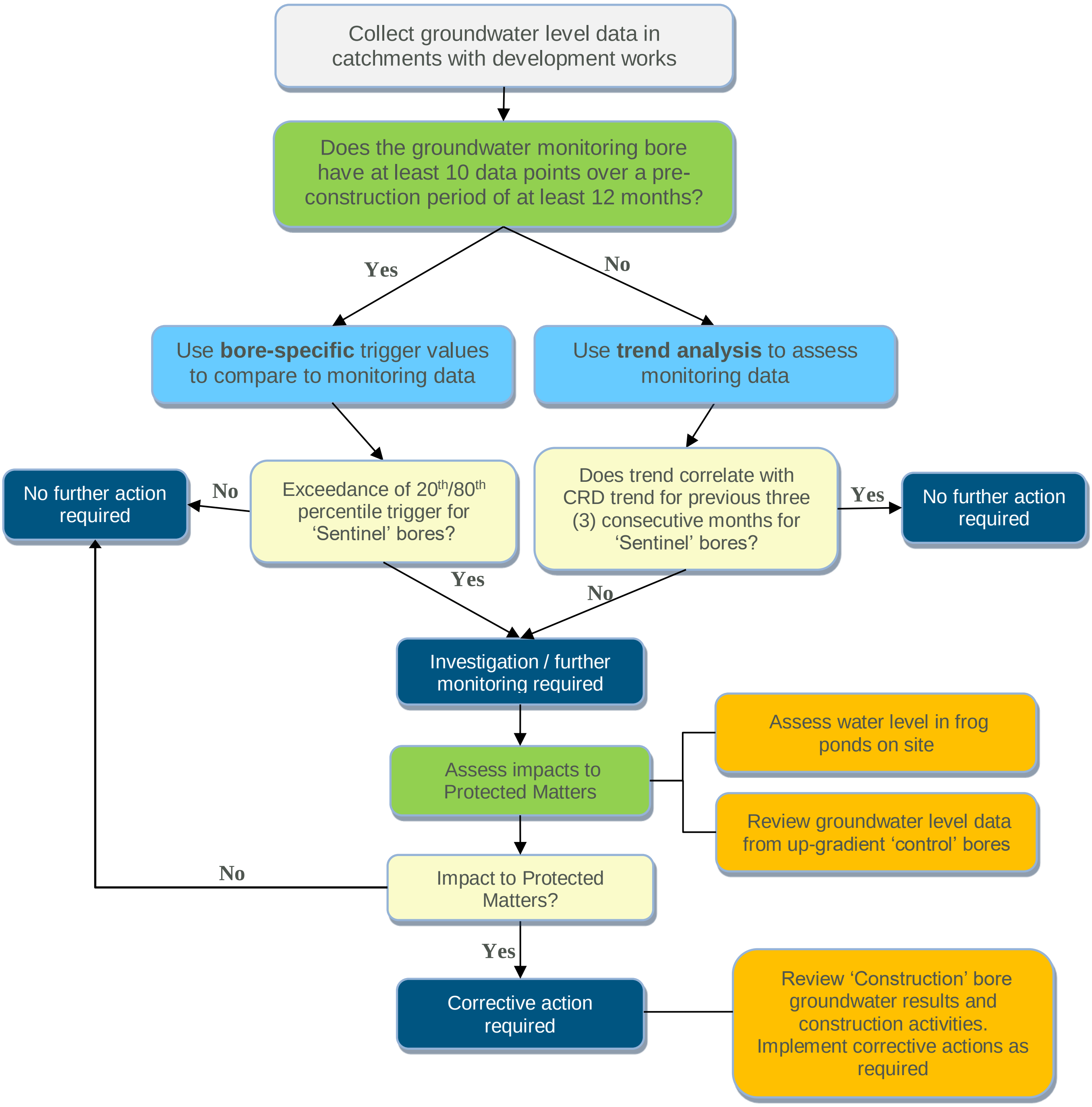


Figure 4-4 Groundwater Level Monitoring Decision Tree

5 Further Investigations and Corrective Actions

5.1 Further Investigations

Exceedance of trigger values/performance criteria in Section 3 trigger the following further investigations.

Table 5-1 Further Investigations – Actions and Responsibilities

Action	Responsibility
Groundwater	
Assess monitoring data to determine which data point/s caused the exceedance (e.g. monitoring location and sampling date can be used to pinpoint the location and time of the exceedance when using three-month rolling medians).	Water quality monitoring contractor
Assess bore location compared to project activities to determine whether or not works are potentially causing exceedance at a bore (e.g. the groundwater bore may be up-gradient of works).	Water quality monitoring contractor
Undertake site inspections and liaison with construction contractors to determine whether nearby works or other activities may be causing (or have caused) impacts to groundwater.	Water quality monitoring contractor and construction contractor/s
Assess monitoring undertaken as part of precinct scale Construction Environmental Management Plans (CEMPs).	Construction contractor/s
EHMP data - Bells Creek estuary and Pumicestone Passage	
Assess monitoring data to determine which data point/s caused the exceedance (e.g. monitoring location and sampling date can be used to pinpoint the location and time of the exceedance when assessing three-month rolling medians).	Water quality monitoring contractor
Assess water quality discharging into Bells Creek estuary (i.e. Bells Creek North and South) at the time of exceedance to determine whether or not the source of exceedance is from catchments where works are located.	Water quality monitoring contractor
Construction contractor to determine whether nearby works or other activities may be causing (or have caused) impacts to surface waters.	Construction contractor/s
Review monitoring undertaken as part of precinct scale Construction Environmental Management Plans (CEMPs).	Construction contractor/s
Continuous real-time turbidity	
Undertake assessment of monitoring equipment to determine whether instrument fouling has caused exceedance.	Water quality monitoring contractor
Construction contractor to determine whether nearby works or other activities may be causing (or have caused) elevated downstream turbidity.	Construction contractor/s
Construction contractor to determine quality of discharge from onsite sediment basins and whether all erosion and sediment controls are in place and effective.	Construction contractor/s

Action	Responsibility
Assess monitoring undertaken as part of precinct scale Construction Environmental Management Plans (CEMPs).	Construction contractor/s

5.2 Corrective Actions

If further investigations as outlined in Section 5.1 indicate that construction activities or operation of the site have contributed to water quality impacts, corrective actions will be implemented.

During the construction stage, corrective actions are described in the Precinct-based CEMPs, but may include the actions outlined in Table 5-2.

During the operational stage, the water quality of the Aura development will be highly dependent upon the performance of specific treatment measures within the development. Corrective actions are therefore focussed on the treatment measures, but also consider overall implementation of the various management measures across the development. These corrective actions are outlined in Table 5-2.

The implementation of correction actions in Table 5-2 are dependent on what parameters are exceeded. Trigger exceedances codes are included in Table 5-2 for each corrective action, and these exceedance codes and linkages to trigger values are further detailed in Table 5-3.

Table 5-2 Corrective Actions – Actions and Responsibilities

Trigger Exceedance Code	Action	Responsibility
Water Quality – Construction Stage		
1,2,3,4	Contractor to amend erosion and sediment control measures as required in consultation with the Superintendent to address deficiencies through regular monitoring and inspections and in consultation with relevant regulatory agencies.	Construction contractor/s
1,2,3,4	Erosion and sediment control devices will be cleaned, repaired or replaced whenever inspections show signs of noncompliance or ineffective capability/capacity.	Construction contractor/s
1,2,3,4	Works will cease and/or other corrective actions taken (e.g. not allowing release of water from sedimentation basins) where erosion and sediment control devices are found not to be in accordance with the management and mitigation actions outlined in this plan or otherwise the performance requirements outlined above.	Construction contractor/s
1,2,3,4	Areas of exposed soils and extensive scour or erosion will be rehabilitated as soon as practicable after detection.	Construction contractor/s
Water Quality – Operational Stage (EHMP Monitoring – 3 years post-construction)		
1,2,3	Review of existing data sets to examine trends and spatial context of any failures of WQOs.	Water quality monitoring contractor

Trigger Exceedance Code	Action	Responsibility
1,2,3	Identification of the source of the outliers (chronic or acute failure).	Water quality monitoring contractor
1,2,3	Where sources are identified, investigate implementation of water quality management measures in these locations to ensure that they are established appropriately and functioning as designed. Specific rectification measures will be identified as part of the design process for each treatment measure.	Stockland
2,3	Investigate potential spills/contamination event.	Water quality monitoring contractor
2,3	Undertake targeted sampling along the gradient of waterways of concern (e.g. Bells Creek North) to identify potential sources of contamination. If treatment devices are identified as a potential source, then undertake focussed monitoring of treatment device (e.g. assess water quality entering and discharging from device). If treatment device is found to be not working as designed, measures are to be implemented to rectify the issue.	Water quality monitoring contractor
Groundwater		
5,6,7	Review of site management practices.	Construction contractor/s
5	Localised temporary filling or excavation works to adjust land elevations if required.	Construction contractor/s
5	Review of current and planned filling and excavation works.	Construction contractor/s
5	Changes to proposed re-vegetation and ecological enhancement strategies.	Stockland
6,7	Review of site surface water management devices (WSUD) and stormwater harvesting practices.	Stockland
6,7	Detection and remediation of spills or other contaminant releases (if groundwater quality is detected as being affected).	Construction contractor/s
6,7	Review and amendment of acid sulphate soil management practices in the context of unusually low groundwater pH or the presence of dissolved metals at downstream monitoring locations.	Construction contractor/s

Trigger Exceedance Codes:

1 – turbidity in surface waters - Aura site and downstream receiving waters of Bells Creek estuary and Pumicestone Passage (EHMP data)

2 – Physico-chemical stressors (pH, DO, EC, temperature) - Aura site and EHMP sites

3 – Nutrients in surface waters – Aura site and EHMP sites

4 – Metals in surface waters – Aura site

5 – Groundwater levels

6 – Nutrients in groundwater

7 – Metals in groundwater

Table 5-3 Links between Trigger Exceedance Codes and Trigger Values

Trigger Exceedance Code	Description	Performance Criteria / Trigger Values
1	Turbidity in surface waters - Aura site and downstream receiving waters of Bells Creek estuary and Pumicestone Passage (EHMP data)	• Downstream to remain within 10% of upstream for continuous turbidity (Section 3.1.2). • EHMP turbidity data to remain within natural variability as per correlation graphs (Appendix B).
2	Physico-chemical stressors (pH, DO, EC, temperature) - Aura site and EHMP sites	• Table 3-2 for Aura site. • EHMP data to remain within natural variability as per correlation graphs (Appendix B).
3	Nutrients in surface waters – Aura site and EHMP sites	• Table 3-2 for Aura site. • EHMP data to remain within natural variability as per correlation graphs (Appendix B).
4	Metals in surface waters – Aura site	• Table 3-2
5	Groundwater levels	• Table 3-3
6	Nutrients in groundwater	• Table 3-3
7	Metals in groundwater	• Table 3-3

6 Adaptive Management Mechanisms

Adaptive implementation of treatment measures across the Aura site is planned through the adoption of the various monitoring programs, especially those focussed on treatment measure performance. Initial stages of the development occurred in the Lamerough Creek catchment and the implementation of the construction and operational treatment systems in this catchment were 'trialled' and modified through design and implementation such that when the development staging moved into the Bells Creek catchments, the performance and implementation of the treatment measures were able to be optimised.

Furthermore, the ongoing review of monitoring outputs will provide sufficient data with which to undertake regular reviews of effectiveness of the management actions and make appropriate changes where necessary. An adaptive management framework underlies the monitoring program and corrective actions identified (refer to Table 6-1).

In regard to adaptive management on the site, we note the following:

- Stockland and their nominated contractors undertaking works on the site will be the parties ultimately responsible and accountable for ensuring that actions associated with adaptive management take place.
- Stockland will appoint a suitable external consultant to implement, coordinate and oversight all environmental monitoring works. This consultant will be **independent** of the development contractor and will ensure appropriate accountability of monitoring as a trigger for corrective actions.
- The effectiveness of corrective actions will be reviewed through the continuation of the monitoring program. Further exceedances of trigger values will indicate that corrective actions were not effective and will need to be reviewed/revised.
- Regular reports will be provided to relevant regulatory authorities and to the wider community as required by all Development Approvals in regard to:
  - (a) The overall nature and results of monitoring works.
  - (b) Any trends in the results obtained by these works.
  - (c) What, if any, corrective action triggers have been initiated as a result of the monitoring.
  - (d) How effective these measures have been.
  - (e) Review and compare measures to contemporary industry best practice.
  - (f) Adapt project works as required to meet monitoring goals (see Table 5-2).
- Should actions be required, Stockland and their nominated development contractors will be responsible for the implementation and refinement of these actions to ensure that appropriate environmental protection goals associated with the project are achieved.

Table 6-1 Summary of Adaptive Management Framework

Monitoring Activity	Triggers	Further Investigations / Corrective Actions	Review of WQMP	Adaptive Management
Surface water and groundwater monitoring undertaken as per Section 2	Performance objectives and triggers as per Section 3	• Further investigations implemented as per Table 4-2 • Corrective actions implemented as per Table 5-2	• Periodically review WQMP in terms of risks, including: ○ in response to altered risk level ○ changing circumstances ○ results from implementing corrective actions • Frequent review of the effectiveness of corrective actions through monitoring outputs • Review the WQMP under the following circumstances: ○ performance reports indicate performance targets not achieved ○ according to approved timeframes ○ significant environmental incidents.	• Incorporate new data/information into the WQMP • Modify corrective actions to achieve objectives • Address consequences of significant environmental incidents • Respond to changed risk level and circumstances

7 Reporting and Review

An Annual Compliance Report (ACR) will be prepared and published on the project website within three (3) months of every twelve (12) month anniversary of the commencement of works that reports on the groundwater and surface water quality monitoring activities outlined in this Plan.

This report will summarise compliance with the conditions of approval and the implementation of any management plans, reports, strategies and methods over the previous twelve (12) month period as required under the conditions of approval. Within five (5) days of publication, a copy of the report will be forwarded to DAWE.

Non-compliance with any of the conditions of the approval will be reported to the relevant federal government minister responsible for the approval within two (2) business days of becoming aware of the non-compliance. Triggers for water quality related corrective actions to prevent non-compliance are outlined in the sections below.

Within three (3) months of every three (3) year anniversary of the commencement of works, an independent audit of compliance will be undertaken to evaluate accordance with the conditions of approval and all associated management plans, reports, strategies and methods. The audit report will be submitted to the relevant federal government minister responsible for the approval within three (3) months of the date of completion of the audit and will identify any remedial actions that have been taken in response to the audit in addition to any proposed changes to management plans, reports, strategies or methods.

Appendix A Baseline Water Quality

Baseline water quality data have been collected in and around Aura for many years by Stockland, Sunshine Coast Council and the Ecosystem Health Monitoring Program. These data are presented in detail in other reports, with a summary provided below.

A.1 Background

A.1.1 Pumicestone Passage

Pumicestone Passage has a large catchment containing a mix of mostly rural land uses, with large areas of intensive agricultural activities (horticulture) and plantation forestry (pine). Urban development is primarily located within the northernmost portions of the catchment where tidal flushing is highest, with the majority of the rural catchments discharging to the more poorly mixed zones in the central part of the estuary. The Aura development discharges into the northern part of Pumicestone Passage via Bells Creek and Lamerough Creek.

The Ecosystem Health Monitoring Program (EHMP), a multi-agency funded (lead by the Queensland Government) environmental monitoring program, has been collecting water quality data at monthly intervals at a number of sites within Pumicestone Passage for more than 10 years.

A.1.2 Bells Creek Estuary

Prior to construction, the Bells Creek catchment area was occupied by active and dormant (fallow) plantation forestry, with some casual grazing in places and several pockets of conservation zones. The western part of the catchment is intersected by the 6 lane Bruce Highway which travels through both the Bells Creek North and South catchments.

A.2 Water Quality Objectives

Water quality objectives (WQOs) relevant to the area where the Aura development site is located are defined in Schedule 1 of the *Environmental Protection (Water) Policy 2009* (EPP Water). As shown in Plan WQ1413 (extract shown in Figure 6 1), the monitoring sites in Bells Creek North, Bells Creek South and Lamerough Creek are mostly located within the ‘wallum / tannin freshwater’ waterway type. The exceptions were the downstream monitoring sites on Bells Creek North (BN1) and Bells Creek South (BS1) which are located in the ‘middle estuary’ waterway type.

The EHMP monitoring sites in Bells Creek estuary also fall into the ‘middle estuary’ waterway type, while the Pumicestone Passage EHMP sites are located in Area PLE1 in Plan WQ1413.

As per the EPP Water, water quality objectives for these waterway types are included in Table A 1.

It should be noted that the baseline data typically exceeds the WQOs listed in Table A 1. Therefore, site-specific trigger values were set for construction purposes for the Aura development using baseline data (refer to Appendix B).

Table A-1 Water Quality Objectives

Parameter	Units	WQOs		
		Wallum / tannin[1]	Middle Estuary[2]	Pumicestone Passage (20^{th}, 50^{th}, 80^{th} % percentiles)[3]
TSS	mg/L	6	20	6 – 12 – 16
Turbidity	NTU	20	8	2 – 4 – 6
Chlorophyll a	µg/L	5	4	1 – 1.6 – 2.5
Total nitrogen	mg/L	0.5	0.3	0.15 – 0.19 – 0.22
NOx	mg/L	0.06	0.01	0.002 – 0.002 – 0.003
Organic nitrogen	mg/L	0.42	0.28	0.15 – 0.18 – 0.21
Ammonia	mg/L	0.02	0.01	0.002 – 0.004 – 0.006
Total phosphorus	mg/L	0.05	0.025	0.015 – 0.018 – 0.025
Reactive phosphorus	mg/L	0.02	0.006	0.004 – 0.005 – 0.007
Dissolved oxygen	% saturation	85 – 110	85 – 105	90 – 95 – 105
pH	-	5 – 7	7 – 8.4	8.0 – 8.2 – 8.3
EC	µS/cm	500	-	-

[1] WQOs relevant to Upper Bells Creek and Lamerough Creek
[2] WQOs relevant to lower Bells Creek (BN1 and BS1) and Bells Creek Estuary EHMP sites (BC2.6 and BC4.9)
[3] WQOs as per 'Area PLE1 – Pumicestone Passage North' in EPP Water

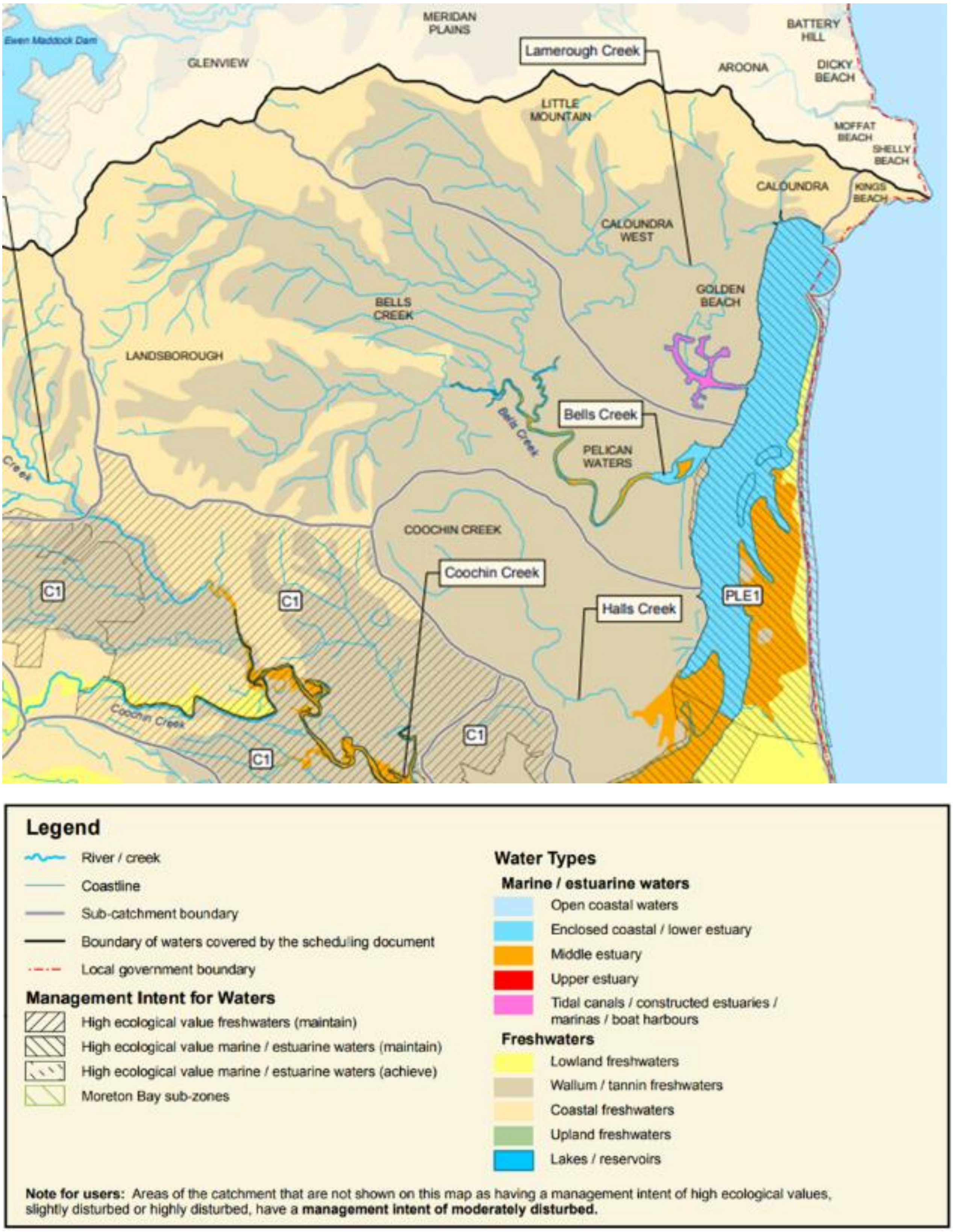


Figure A-1 Waterway Types - Extract of EPP Water Plan WQ1413

A.3 Summary of Baseline Data

Initial baseline monitoring extended from 2002 to 2010, while further intensive baseline monitoring extended from 2013 up to commencement of construction in each catchment. As the pre-construction baseline data for the Aura development site typically exceeded the EPP Water WQOs, site-specific trigger values were developed for use during construction.

The baseline data is summarised in Table A-2 to Table A-4.

Table A-2 Surface Water Quality – Aura Site

Category	Summary
Suspended sediment/turbidity	• Total suspended solids (TSS) and turbidity was generally higher at upstream freshwater sites compared to downstream estuarine sites during baseflow and event flow conditions. • TSS exceeded the WQO of 6 mg/L at most freshwater sites, while the downstream estuarine sites (BN1 and BS1) were below the WQO of 20 mg/L for mid-estuary sites. • TSS was higher at all sites during event flow compared to baseflow. • Turbidity exceeded the relevant WQO at most Bells Creek North sites, but was below the WQO in Bells Creek South and Lamerough Creek. • Continuous turbidity data shows that turbidity in Bells Creek (North and South) and Lamerough Creek was approximately 5-50 NTU during dry periods (baseflow) but increased significantly in response to rainfall events. Turbidity levels typically recorded were of the order of 100-300 NTU in Bells Creek North and South, and 50-90 NTU in Lamerough Creek following significant rainfall events.
Nutrients	• Nutrients were typically lower at downstream estuarine sites compared to freshwater sites further upstream in the catchments. • Median values of total nitrogen and organic nitrogen were higher than the relevant WQOs at all sites, while ammonia and total phosphorus was also higher than the WQOs at downstream sites. • Total nitrogen was typically higher (up to 3 times higher) during event flow conditions compared to baseflow conditions, while total phosphorus concentrations were similar during event flow and baseflow conditions.
Metals	• Aluminium and iron concentrations were lower at downstream estuarine sites compared to upstream freshwater sites, with upstream Bells Creek North recording the highest concentrations. • Aluminium is naturally elevated on the Aura site as indicated by the dissolved aluminium concentrations (~0.6 mg/L in upstream freshwater reaches) being much higher than the ANZG (2018) guideline value of 0.055 mg/L at most sites.
Physico-chemical	• Median pH ranged between 5.35 and 6.44, which is within the acceptable pH range of 5-7 for wallum/tannin freshwaters as per EPP Water. The downstream estuarine sites (BN1 and BS1) had slightly higher pH (6.22 and 6.44). • Dissolved oxygen (DO) levels are typically low throughout all waterways within the Aura site, with median values between 10% and 54% saturation. • Electrical conductivity (EC) was consistent across the site, with median values at most sites approximately 150-200 µS/cm. The exceptions were the downstream estuarine sites in Bells Creek North (BN1) and

Category	Summary
	Bells Creek South (BS1) which had median values of 16,700 µS/cm and 36,387 µS/cm respectively, reflective of their location within tidally influenced estuarine waters.

Table A-3 Receiving Water Quality – Bells Creek Estuary and Pumicestone Passage

Category	Summary
Pumicestone Passage	• The northern sections of Pumicestone Passage, which receive runoff from the Aura site and adjacent catchment areas, were well flushed, as evidenced by the relatively high salinity levels (25 – 35 g/L). • pH levels were slightly alkaline (7.6 – 8.2) which is typical of a coastal open estuary, but were slightly below the WQO range of 8.0 – 8.3. • Dissolved oxygen levels were quite good, typically within the range of 85% - 110%, which is similar to the WQO range of 90% - 105%. • Nutrient levels were typically quite low, with the exception of when heavy rainfall conditions triggered significant catchment runoff. Total nitrogen ranged between approximately 0.2 mg/L and 0.4 mg/L which exceeds the WQOs. Total phosphorus levels ranged between approximately 0.01 mg/L and 0.025 mg/L which is compliant with WQOs, indicating that the catchment was contributing very low levels of phosphorus. • Turbidity levels typically ranged between 5 NTU and 15 NTU which is higher than the WQO, reflecting the influence of rural land disturbance in catchments draining to the northern section of Pumicestone Passage. • Chlorophyll-a was typically low at approximately 1 µg/L to 3 µg/L.
Bells Creek Estuary	• Bells Creek estuary receives significant catchment runoff as evidenced by the regular and significant variations in salinity levels, ranging from 10 g/L (brackish) up to 35 g/L (marine water). • pH levels vary from those similar to marine waters (up to 7.8) under dry conditions to near just below neutral (6.5) when there is significant freshwater inflow, indicating no significant ASS runoff or other such influences from the catchment. The pH range in Bells Creek estuary (6.5 – 7.8) is similar to the WQO range of 7.0 – 8.4. • Dissolved oxygen levels in Bells Creek estuary range from 60% to 85% saturation, which is lower than the WQO range of 85 – 105%. This is reflective of lower tidal flushing in the estuary, combined with low dissolved oxygen waters (<50% sat) being discharged from Bells Creek. • Nutrient levels are typically quite low, with the exception of when heavy rainfall conditions trigger significant catchment runoff. Total nitrogen ranged between approximately 0.2 mg/L and 0.5 mg/L, with some values exceeding the WQO (0.3 mg/L). Total phosphorus levels ranged between approximately 0.01 mg/L and 0.03 mg/L which is mostly compliant with WQO (0.025 mg/L), indicating that the catchment was contributing low levels of phosphorus. • Turbidity levels typically ranged between 3 NTU and 10 NTU, with a median value of approximately 6.5 NTU which is compliant with the WQO of 8 NTU. • Chlorophyll-a was typically low at approximately 1 µg/L to 5 µg/L.

Table A-4 Groundwater

Category	Summary
Physico-chemical	• Groundwater across the site is mostly freshwater, with electrical conductivity (EC) typically ranging between 100 µS/cm and 500 µS/cm. There are a number of bores (G2, IF11, G3 and IF11) with elevated EC of up to 9,000 µS/cm, indicating some level of saline intrusion which is to be expected due to their proximity to mangrove areas. However, some bores in the upper catchment (C3, GW8 and IF13) also had elevated EC, indicating brackish groundwater may be present in localised pockets in these areas. • pH in groundwater across the site is acidic, with a pH range of approximately 4 to 6. The only exception was bore GW8 with a neutral pH typically around 7.
Nutrients	• Nutrient data indicates slightly elevated concentrations of nitrogenous compounds in the groundwater. The total nitrogen data has a range of median values of 0.2 mg/L to 9.6 mg/L, with total nitrogen higher in bores BV6, C3, C4, IF11, BH7 and G2. Similarly, organic nitrogen data has a range of 0.2 mg/L to 12.15 mg/L, with higher values in bores IF3, GW5, G3 and G2. Ammonia has a range of median values of 0.02 mg/L to 5.9 mg/L, with higher values at bores IF4 and GW5. • Total phosphorus data has a range of median values between 0.04 mg/L to 1.42 mg/L, with higher values at bores IF3, GW5 and G3.
Metals	• Dissolved iron median concentrations ranged from 0.05 mg/L to 7.58 mg/L, with higher values recorded at bores BV6, S1, IF4 and G6. • Dissolved aluminium concentrations ranged from 0.01 mg/L to 2.26 mg/L, with higher values recorded at bores BV6, C3, C4, IF11, BH7 and G2. The majority of groundwater bores had median values which exceeded the ANZG (2018) guideline value of 0.055 mg/L. • All other metals were generally consistent across the site and recorded at relatively low levels.

Appendix B Trigger Values and Methods to Detect Changes in Water Quality

This appendix provides details on the methods, including development of trigger values, used to detect changes in water quality in Bells Creek and Pumicestone Passage as part of the Water Quality Management Plan (WQMP) for the Aura Development.

The purpose of this appendix is to address Condition 4(h) of the Department of Agriculture, Water and the Environment (DAWE) approval as follows: *Include a scientifically robust method for detecting a 10% change in water quality parameters in Bells Creek and 5% change in water quality in Pumicestone Passage unless an alternate is approved by the Minister.*

Note that the methods to detect changes in water quality described in this appendix represent an alternate approach. This approach has been independently reviewed by Healthy Land and Water scientific personal in 2013 and defined as being robust and defensible. This approach has been endorsed by the minister in accordance with Condition 4h (EPBC Ref 2011/5987 dated 6/6/2013). The approach has also been endorsed by the Minister for Economic Development Queensland (MEDQ).

This appendix also addresses Condition 4(d) of the DAWE approval to describe scientifically robust methods for sampling and data collection, including statistical analysis of the data.

B.1 Trigger Values

Trigger values are used to indicate the bounds of ***natural*** variability in water quality to assist with the assessment of impacts (i.e. are development activities causing water quality at a site to move beyond natural variability). These trigger values are also used to initiate further investigations and/or corrective actions.

B.1.1 Ambient Surface Water – Aura Site

Water quality objectives (WQOs) relevant to the area where Aura is located are defined in Schedule 1 of the *Environmental Protection (Water) Policy 2009* (EPP Water). While these WQOs were used to assess the general condition of baseline surface water quality (Appendix A of the WQMP), the baseline data already typically exceeds the WQOs. Therefore, and in accordance with water quality guideline documents (ANZECC/ARMCANZ 2000, ANZG 2018), local site-specific trigger values were developed to assess monthly monitoring data for Aura, instead of using more generic, regional, WQOs.

Site-specific trigger values were developed for surface water using an extensive baseline dataset collected at and around Aura prior to the commencement of development works. Initial surface water baseline data was collected between 2009 and 2010. A further intensive baseline data collection period commenced in late 2013/early 2014 and extended up until construction commenced in each catchment (2016-2017).

Using the baseline data, 20th and 80th percentiles for each monitoring site/groundwater bore were calculated as per the ANZECC/ARMCANZ (2000) methodology (Section 7.4.4.1). The 80th percentile of these data is used as the trigger value for most parameters, while the 20th percentile is used for stressors that cause problems at low concentrations, such as dissolved oxygen and pH.

Surface water trigger values are included in Table B-1.

Table B-1 Surface Water Trigger Values – Baseline Percentiles

Parameters	Units	Baseline Percentiles 80th (20th)					
		Lamerough Creek		Bells Creek North		Bells Creek South	
		L1	L2	BN1	BN3	BS1	BS3
Temperature	ºC	22.8	23.3	26.2	25.1	28.8	23.9
EC	µS/cm	220	216	41,750	243	48,370	229
Salinity	ppt	0.11	0.12	26.8	0.12	31.6	0.1
pH	pH units	6.50 (6.29)	6.43 (6.21)	6.72 (4.94)	6.50 (5.66)	6.71 (5.92)	7.30 (6.18)
Turbidity	NTU	12.2	20.6	22.7	51.9	8.9	24.0
Dissolved oxygen	% sat	28.3 (12.8)	40.5 (14.9)	73.7 (33.4)	72.0 (31.5)	68.5 (26.6)	28.3 (10.8)
Total suspended solids	mg/L	14.0	7.0	12.0	19.0	11.4	14.4
Ammonia	mg/L	0.13	0.06	0.13	0.04	0.07	0.04
Oxidised Nitrogen	mg/L	0.04	0.24	0.02	0.02	0.024	0.058
Organic Nitrogen	mg/L	1.20	1.00	0.90	1.20	0.98	1.10
Total Kjeldahl Nitrogen	mg/L	1.30	1.00	1.00	1.20	1.04	1.10
Total Nitrogen	mg/L	1.30	1.20	1.00	1.40	1.10	1.14
Total Phosphorus	mg/L	0.08	0.06	0.10	0.04	0.31	0.13
Reactive Phosphorus	mg/L	0.01	0.01	0.01	0.01	0.01	0.01
Chlorophyll-a	µg/L	27.0	2.0	30	4.0	4.4	7.0
Aluminium (dissolved)	mg/L	0.22	0.32	0.53	0.95	0.14	0.31
Iron (dissolved)	mg/L	1.02	0.80	1.30	2.41	0.52	1.10
Aluminium (total)	mg/L	0.36	0.48	0.97	1.89	0.74	1.01
Iron (total)	mg/L	2.36	1.39	3.03	4.85	1.20	3.36

B.1.2 Continuous Turbidity

Continuous 'real time' turbidity stations are installed on Bells Creek North and Bells Creek South at the upstream and downstream boundaries of Aura. These stations record continuous (once every 10 minutes) readings of turbidity, water depth, velocity and flow rate. A downstream turbidity station is also installed on Lamerough Creek.

The continuous turbidity data is downloaded remotely once per hour and the data is stored and displayed on a project-specific web portal. The web portal continually compares data from the downstream stations to the upstream stations.

The performance criteria for this monitoring component in the WQMP is for turbidity at the downstream site to be no greater than 10% above the upstream site during periods of flow in the creeks, which addresses Condition 4(h) of the DAWE approval by being able to detect a 10% change to water quality in Bells Creek.

B.1.3 Groundwater

Groundwater trigger values were developed for all bores to assess potential impacts from construction activities.

The majority of groundwater bores had baseline data collection commence in late 2013, with an intensive 12-month baseline data collection program from mid-2015 to mid-2016.

Groundwater quality trigger values were established based on a minimum of ten (10) data points over at least a 12-month period to capture seasonality. However, as the available baseline data for some existing groundwater bores was less than this requirement, **bore-specific** trigger values could not be developed for all monitoring bores. Therefore, **site-specific** groundwater quality trigger values were developed for use for bores with limited baseline data.

Site-specific trigger values were developed by grouping data from approximately 40 historical monitoring bores across the site and calculating the 80^{th} percentile (and/or 20^{th} percentile for parameters where issues arise from low levels). This method provided a large number of data points across a number of years and as such a statistically sound approach for assessing potential construction related groundwater impacts for bores with limited baseline data.

For groundwater bores with sufficient baseline data (i.e. more than ten data points over at least 12 months), bore-specific trigger values using the methodology described above were developed and used in preference to site-specific triggers.

For bores where site-specific triggers are used, there may be an opportunity for the site-specific triggers to gradually be replaced by bore-specific triggers using data from continued monitoring if groundwater quality is demonstrated to be unaffected by construction works in the catchment.

The groundwater trigger values are presented in Table B-2 to Table B-5.

For groundwater level, site-specific trigger values cannot be developed as groundwater level is unique to each monitoring bore. Therefore, for bores with limited or no baseline groundwater level data, a trend analysis is used to assess whether construction activities are affecting groundwater levels. This trend analysis involves plotting time series groundwater level data to provide an indication of whether groundwater levels are trending up or down.

In addition to the time series groundwater level data, a cumulative rainfall departure curve (CRD) is plotted on the same graph. This CRD represents above or below average rainfall for each month (cumulative departures from the arithmetic mean). A rising slope on the curve equates to a period of above average rainfall, while a falling slope equates to a period of lower than average rainfall.

These CRD curves are useful to correlate groundwater level fluctuations with precipitation events at Aura. Groundwater levels within bores unaffected by construction activities typically correlate with fluctuations of the CRD, especially when direct recharge from rainfall is the dominant recharge process. Correlation of groundwater level fluctuations with the CRD provides an indication of whether groundwater level declines or rises are a result of climatic conditions or are influenced by construction activities.

For bores with sufficient baseline groundwater level data, bore-specific trigger values were calculated and used to identify potential impacts to groundwater level during construction. These bore-specific trigger values are included in Table B-2.

Table B-2 Groundwater Trigger Values

Catchment	GW Bore	SWL (mbGL)		EC	pH		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	TN	TP	Reactive P	Aluminium	Iron	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
		low	high	us/cm	low	high	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lamerough Creek	BV1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	BV2	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	G1/DS1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	LC1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	BV7	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
Bells Creek North	BH3	1.79	0.96	324	5.12	6.24	0.82	0.01	0.16	0.16	2.10	3.00	3.12	0.328	0.084	0.12	0.30	0.001	0.0001	0.001	0.002	0.001	0.004	0.014	0.0001
	G2/DS2	1.81	1.33	4211	4.24	4.88	0.14	0.01	0.06	0.06	5.88	5.98	5.98	0.682	0.010	0.08	2.74	0.001	0.0001	0.002	0.002	0.003	0.011	0.025	0.0001
	BV10 shallow	1.23	0.49	183	5.14	5.69	0.08	0.01	0.02	0.02	0.40	0.38	0.38	0.232	0.010	0.02	0.22	0.001	0.0001	0.001	0.002	0.001	0.006	0.032	0.0001
	IF13	1.45	0.52	1080	4.67	5.20	0.07	0.01	0.13	0.13	0.64	0.70	0.70	0.210	0.010	0.02	0.16	0.001	0.0001	0.002	0.004	0.001	0.004	0.049	0.0001
	FCZ2	1.40	0.83	189	4.88	5.48	0.16	0.01	0.04	0.04	1.84	1.86	1.92	0.174	0.010	0.55	1.90	0.001	0.0001	0.002	0.001	0.001	0.002	0.014	0.0001
	BV6	1.94	1.00	505	3.89	4.36	0.10	0.01	0.05	0.05	2.10	2.00	2.00	0.41	0.05	2.71	3.86	0.002	0.000	0.035	0.011	0.002	0.015	0.049	0.000
	BV8	1.44	0.70	566	4.74	5.38	0.08	0.01	0.36	0.36	2.00	2.00	2.20	0.282	0.010	0.29	1.30	0.001	0.0001	0.001	0.001	0.001	0.006	0.096	0.0001
	C1	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	C2	1.73	1.00	136	4.99	5.51	0.32	0.01	0.58	0.58	0.50	0.82	1.26	0.124	0.010	0.03	0.37	0.001	0.0001	0.001	0.002	0.015	0.005	0.023	0.0001
	GW10/FCZ4	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF1	1.52	0.65	191	4.90	5.72	0.08	0.01	0.02	0.02	0.60	0.60	0.60	0.322	0.010	0.10	0.75	0.001	0.0001	0.001	0.001	0.001	0.003	0.031	0.0001
	IF2	1.22	0.50	174	5.00	5.54	1.09	0.01	0.03	0.04	1.18	2.16	2.16	0.580	0.010	0.03	4.10	0.002	0.0001	0.001	0.001	0.001	0.002	0.026	0.0001
	S1	1.13	0.52	280	4.94	5.73	1.48	0.01	0.05	0.05	6.30	6.56	6.60	0.412	0.080	0.06	5.35	0.001	0.0001	0.001	0.001	0.001	0.001	0.036	0.0001
Bells Creek South	C3	1.17	0.47	3468	5.69	6.18	0.16	0.01	0.05	0.05	1.22	1.62	2.00	0.456	0.010	0.02	1.75	0.001	0.0001	0.001	0.001	0.001	0.005	0.049	0.0001
	C4	1.49	0.98	276	5.12	5.73	0.03	0.01	0.06	0.06	1.46	1.62	1.72	0.512	0.010	1.53	0.69	0.001	0.0001	0.002	0.003	0.001	0.004	0.017	0.0001
	C5	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF3	1.87	0.75	420	4.66	5.24	0.55	0.01	0.01	0.01	27.68	23.02	23.02	1.858	0.010	0.32	7.29	0.001	0.0001	0.002	0.001	0.001	0.002	0.011	0.0001
	IF4	1.19	0.35	252	5.16	6.08	2.21	0.01	0.05	0.04	2.30	4.76	4.76	1.198	0.206	0.01	9.69	0.004	0.0001	0.001	0.001	0.001	0.003	0.027	0.0001
	IF5	1.69	0.66	148	5.10	5.56	0.55	0.01	0.39	0.39	6.18	3.26	5.06	0.648	0.112	0.07	0.53	0.001	0.0001	0.001	0.001	0.001	0.001	0.069	0.0001
	IF6	1.40	0.76	263	5.33	5.75	0.59	0.01	0.26	0.26	3.76	3.94	6.38	1.042	0.016	0.20	1.46	0.001	0.0001	0.001	0.002	0.001	0.001	0.101	0.0001
	IF7	2.46	0.59	160	5.05	5.40	0.13	0.01	0.11	0.11	1.48	1.50	1.52	0.244	0.010	0.03	0.98	0.001	0.0001	0.001	0.001	0.001	0.002	0.083	0.0001
	IF8	2.13	1.01	197	4.55	5.91	1.96	0.01	0.33	0.34	3.04	4.80	4.80	0.720	0.068	0.04	1.87	0.002	0.0001	0.001	0.001	0.001	0.002	0.028	0.0001
	IF9	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF10	1.52	0.89	333	4.96	5.52	1.41	0.01	0.17	0.17	1.70	3.34	3.40	0.692	0.010	0.06	2.25	0.001	0.0001	0.001	0.001	0.001	0.009	0.021	0.0001
	IF11	2.04	0.72	11002	4.33	4.80	0.05	0.01	0.01	0.01	0.82	1.06	0.68	0.152	0.010	1.17	6.39	0.002	0.0001	0.023	0.003	0.006	0.188	0.518	0.0001
	IF12	1.36	0.46	427	4.66	5.09	0.04	0.01	0.07	0.07	0.54	0.60	0.60	0.150	0.010	0.12	0.23	0.001	0.0001	0.001	0.002	0.001	0.004	0.111	0.0001
	IF14	1.18	0.37	232	5.19	5.82	0.48	0.01	0.02	0.02	2.76	5.30	5.30	0.640	0.060	0.02	2.60	0.005	0.0001	0.001	0.001	0.001	0.001	0.011	0.0001
	IF15 shallow	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	IF16	N/A	N/A	1130	5.00	6.37	0.12	0.01	1.87	1.88	1.08	1.2	1.26	0.46	0.013	0.28	11.2	0.001	0.001	0.001	0.005	0.003	0.006	0.15	0.0001
	BH7	1.41	0.76	280	5.50	5.93	13.94	0.01	0.03	0.03	2.66	14.96	14.96	2.370	2.234	0.53	1.64	0.001	0.0001	0.001	0.001	0.001	0.002	0.031	0.0001
	GW5/U3/G4	1.71	0.81	330	5.20	5.74	13.30	0.01	0.79	0.82	9.50	26.68	26.68	4.184	1.408	0.12	1.94	0.002	0.0001	0.001	0.002	0.001	0.001	0.038	0.0001
	GW8/FCZ5	1.80	1.09	3504	6.64	7.04	1.25	0.01	0.02	0.06	1.02	2.82	2.82	0.650	0.432	0.01	0.51	0.004	0.0001	0.001	0.001	0.001	0.002	0.011	0.0001
	GW9/U2/G5	1.07	0.40	274	5.29	5.85	0.18	0.01	0.14	0.14	0.50	1.44	1.46	0.480	0.010	0.03	5.59	0.006	0.0001	0.002	0.003	0.001	0.012	0.030	0.0001
	G3/DS3	2.74	1.27	4225	4.87	5.30	0.51	0.01	0.03	0.03	6.48	12.78	12.78	1.626	0.010	0.40	7.80	0.006	0.0001	0.005	0.002	0.002	0.007	0.055	0.0001
	G6/U1	1.91	1.01	256	5.54	5.89	1.66	0.01	0.02	0.02	8.40	9.60	10.10	0.780	0.278	0.02	7.12	0.003	0.0001	0.001	0.002	0.001	0.001	0.044	0.0001
	G7/FCZ3	1.25	0.55	268	5.00	5.80	0.12	0.01	0.05	0.05	2.72	3.60	3.60	0.540	0.010	0.58	2.40	0.002	0.0001	0.002	0.001	0.001	0.001	0.046	0.0001

(Grey shading) Denotes bores with insufficient basline data, therefore site-wide triggers used

Table B-3 Groundwater Trigger Values (continued)

Catchment	GW Bore	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Alkalinity	Total Alkalinity	Sulfate	Chloride	Calcium	Magnesium	Sodium	Potassium	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Lamerough Creek	BV1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	BV2	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	G1/DS1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	LC1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	BV7	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
Bells Creek North	BH3	1	1	40	40	10	66	1	4	39	1	1	1	1	1	1	1	1	1	1	1
	G2/DS2	1	1	6	6	213	1174	8	30	735	28	1	1	1	1	1	1	1	1	1	1
	BV10 shallow	1	1	23	23	12	36	3	3	26	1	1	1	1	1	1	1	1	1	1	1
	IF13	1	1	10	10	11	345	1	11	195	1	1	1	1	1	1	1	1	1	1	1
	FCZ2	1	1	9	9	9	33	1	3	24	1	1	1	1	1	1	1	1	1	1	1
	BV6	1	1	1	1	27	127	2	10	68	1	1	1	1	1	1	1	1	1	1	1
	BV8	1	1	7	7	12	148	1	12	73	1	1	1	1	1	1	1	1	1	1	1
	C1	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	C2	1	1	19	19	3	27	2	2	17	1	1	1	1	1	1	1	1	1	1	1
	GW10/FCZ4	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF1	1	1	15	15	21	33	2	2	24	1	1	1	1	1	1	1	1	1	1	1
	IF2	1	1	7	7	6	33	1	2	22	1	1	1	1	1	1	1	1	1	1	1
	S1	1	1	32	32	15	39	7	4	25	1	1	1	1	1	1	1	1	1	1	1
Bells Creek South	C3	1	1	249	249	20	987	44	110	452	1	1	1	1	1	1	1	1	1	1	1
	C4	1	1	28	28	30	26	2	3	33	1	1	1	1	1	1	1	1	1	1	1
	C5	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF3	1	1	14	14	18	130	2	7	73	1	1	1	1	1	1	1	1	1	1	1
	IF4	1	1	31	31	5	38	1	3	26	1	1	1	1	1	1	1	1	1	1	1
	IF5	1	1	8	8	4	23	1	2	16	1	1	1	1	1	1	1	1	1	1	1
	IF6	1	1	30	30	10	58	7	4	35	3	1	1	1	1	1	1	1	1	1	1
	IF7	1	1	11	11	7	33	2	2	22	1	1	1	1	1	1	1	1	1	1	1
	IF8	1	1	6	6	5	36	1	3	23	1	1	1	1	1	1	1	1	1	1	1
	IF9	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF10	1	1	8	8	4	84	1	6	43	1	1	1	1	1	1	1	1	1	1	1
	IF11	1	1	1	1	1508	3314	48	268	2018	40	1	1	1	1	1	1	1	1	1	1
	IF12	1	1	4	4	11	129	3	6	68	1	1	1	1	1	1	1	1	1	1	1
	IF14	1	1	24	24	13	40	2	3	31	1	1	1	1	1	1	1	1	1	1	1
	IF15 shallow	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	IF16	N/A	N/A	N/A	23	150	374	43	62	277	8	1	1	1	1	1	1	1	1	1	1
	BH7	1	1	110	110	6	40	2	3	40	1	1	1	1	1	1	1	1	1	1	1
	GW5/U3/G4	1	1	89	89	15	62	4	4	46	3	1	1	1	1	1	1	1	1	1	1
	GW8/FCZ5	1	1	506	506	122	833	33	60	612	2	1	1	1	1	1	1	1	1	1	1
	GW9/U2/G5	1	1	33	33	14	54	2	4	42	1	1	1	1	1	1	1	1	1	1	1
	G3/DS3	1	1	25	25	113	1320	11	50	796	27	1	1	1	1	1	1	1	1	1	1
	G6/U1	1	1	35	35	6	35	1	2	26	1	1	1	1	1	1	1	1	1	1	1
	G7/FCZ3	1	1	10	10	6	63	2	4	36	1	1	1	1	1	1	1	1	1	1	1

(Grey shading) Denotes bores with insufficient basline data, therefore site-wide triggers used

Table B-4 Groundwater Trigger Values (continued)

Catchment	GW Bore	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1.2.3.cd)pyrene	Dibenz(a.h)anthracene	Benzo(g.h.i)perylene	Sum of polycyclic aromatic hydrocarbons	Benzo(a)pyrene TEQ (zero)	C6 - C9 Fraction	C10 - C14 Fraction	C15 - C28 Fraction	C29 - C36 Fraction	C10 - C36 Fraction (sum)	C6 - C10 Fraction	C6 - C10 Fraction minus BTEX (F1)
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Lamerough Creek	BV1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	BV2	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	G1/DS1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	LC1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	BV7	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
Bells Creek North	BH3	1	1	0.5	1	1	1	0.5	0.5	20	240	1402	578	2654	20	20
	G2/DS2	1	1	0.5	1	1	1	0.5	0.5	20	50	170	52	214	20	20
	BV10 shallow	1	1	0.5	1	1	1	0.5	0.5	20	50	340	140	520	20	20
	IF13	1	1	0.5	1	1	1	0.5	0.5	20	50	110	54	206	20	20
	FCZ2	1	1	0.5	1	1	1	0.5	0.5	20	50	188	50	230	20	20
	BV6	1	1	0.5	1	1	1	0.5	0.5	20	50	266	100	382	20	20
	BV8	1	1	0.5	1	1	1	0.5	0.5	20	50	130	50	218	20	20
	C1	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	C2	1	1	0.5	1	1	1	0.5	0.5	20	50	386	160	594	20	20
	GW10/FCZ4	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF1	1	1	0.5	1	1	1	0.5	0.5	20	50	160	54	228	20	20
	IF2	1	1	0.5	1	1	1	0.5	0.5	20	50	170	80	260	20	20
	S1	1	1	0.5	1	1	1	0.5	0.5	20	96	1630	614	2104	20	20
Bells Creek South	C3	1	1	0.5	1	1	1	0.5	0.5	20	50	240	78	290	20	20
	C4	1	1	0.5	1	1	1	0.5	0.5	20	50	174	50	184	20	20
	C5	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF3	1	1	0.5	1	1	1	0.5	0.5	20	50	534	148	734	20	20
	IF4	1	1	0.5	1	1	1	0.5	0.5	60	688	1424	726	2720	60	20
	IF5	1	1	0.5	1	1	1	0.5	0.5	28	50	256	258	560	28	20
	IF6	1	1	0.5	1	1	1	0.5	0.5	20	50	200	150	350	20	20
	IF7	1	1	0.5	1	1	1	0.5	0.5	20	50	442	80	528	20	20
	IF8	1	1	0.5	1	1	1	0.5	0.5	20	360	622	826	1482	20	20
	IF9	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF10	1	1	0.5	1	1	1	0.5	0.5	20	50	360	208	566	20	20
	IF11	1	1	0.5	1	1	1	0.5	0.5	20	50	130	60	200	20	20
	IF12	1	1	0.5	1	1	1	0.5	0.5	20	50	120	50	210	20	20
	IF14	1	1	0.5	1	1	1	0.5	0.5	20	154	182	186	742	20	20
	IF15 shallow	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	IF16	1	1	0.5	1	1	1	0.5	0.5	20	50	204	78	372	20	20
	BH7	1	1	0.5	1	1	1	0.5	0.5	134	50	1296	726	2146	122	32
	GW5/U3/G4	1	1	0.5	1	1	1	0.5	0.5	364	58	1580	1060	2900	372	80
	GW8/FCZ5	1	1	0.5	1	1	1	0.5	0.5	20	90	692	246	958	20	20
	GW9/U2/G5	1	1	0.5	1	1	1	0.5	0.5	20	82	470	176	718	20	20
	G3/DS3	1	1	0.5	1	1	1	0.5	0.5	20	50	360	192	552	20	20
	G6/U1	1	1	0.5	1	1	1	0.5	0.5	132	1350	2196	966	5018	134	42
	G7/FCZ3	1	1	0.5	1	1	1	0.5	0.5	20	50	140	50	140	20	20

[grey box] Denotes bores with insufficient basline data, therefore site-wide triggers used

Table B-5 Groundwater Trigger Values (continued)

Catchment	GW Bore	C10 - C16 Fraction	C16 - C34 Fraction	C34 - C40 Fraction	C10 - C40 Fraction (sum)	C10 - C16 Fraction minus Naphthalene (F2)	Benzene	Toluene	Ethylbenzene	meta- & para-Xylene	ortho-Xylene	Total Xylenes	Sum of BTEX	Naphthalene
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Lamerough Creek	BV1	100	254	100	354	100	1	2	2	2	2	2	1	5
	BV2	100	254	100	354	100	1	2	2	2	2	2	1	5
	G1/DS1	100	254	100	354	100	1	2	2	2	2	2	1	5
	LC1	100	254	100	354	100	1	2	2	2	2	2	1	5
	BV7	100	254	100	354	100	1	2	2	2	2	2	1	5
Bells Creek North	BH3	262	2214	294	2976	280	1	2	2	2	2	2	1	5
	G2/DS2	100	184	100	184	100	1	2	2	2	2	2	1	5
	BV10 shallow	100	430	100	540	100	1	2	2	2	2	2	1	5
	IF13	100	202	100	202	100	1	2	2	2	2	2	1	5
	FCZ2	100	204	100	204	100	1	2	2	2	2	2	1	5
	BV6	100	340	100	408	100	1	2	2	2	2	2	1	5
	BV8	100	156	100	156	100	1	2	2	2	2	2	1	5
	C1	100	254	100	354	100	1	2	2	2	2	2	1	5
	C2	100	556	100	600	100	1	7	2	2	2	2	7	5
	GW10/FCZ4	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF1	100	188	100	188	100	1	2	2	2	2	2	1	5
	IF2	100	250	100	270	100	1	2	2	2	2	2	1	5
	S1	112	2052	124	2136	112	1	2	2	2	2	2	1	5
Bells Creek South	C3	100	272	100	272	100	1	2	2	2	2	2	1	5
	C4	100	204	100	204	100	1	2	2	2	2	2	1	5
	C5	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF3	100	686	122	686	100	1	4	2	2	2	2	4	5
	IF4	742	1852	232	2706	742	1	42	2	2	2	2	42	5
	IF5	100	520	100	580	100	1	9	2	2	2	2	9	5
	IF6	100	280	100	420	100	1	14	2	2	2	2	14	5
	IF7	100	492	100	492	100	1	2	2	2	2	2	1	5
	IF8	518	1228	240	1612	518	1	2	2	2	2	2	1	5
	IF9	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF10	100	528	100	648	100	1	4	2	2	2	2	4	5
	IF11	100	180	100	180	100	1	2	2	2	2	2	1	5
	IF12	100	150	100	150	100	1	2	2	2	2	2	1	5
	IF14	140	330	100	584	140	1	2	2	2	2	2	1	5
	IF15 shallow	100	254	100	354	100	1	2	2	2	2	2	1	5
	IF16	100	254	100	354	100	1	2	2	2	2	2	1	5
	BH7	100	2072	216	2298	100	1	96	2	2	2	2	96	5
	GW5/U3/G4	100	2800	196	3010	100	1	294	2	2	2	2	294	5
	GW8/FCZ5	116	878	128	908	116	1	2	2	2	2	2	1	5
	GW9/U2/G5	116	602	100	678	116	1	2	2	2	2	2	1	5
	G3/DS3	100	454	134	610	100	1	2	2	2	2	2	1	5
	G6/U1	1814	2976	438	5252	1814	1	95	2	2	2	2	95	5
	G7/FCZ3	100	148	100	148	100	1	2	2	2	2	2	1	5

Denotes bores with insufficient basline data, therefore site-wide triggers used

B.1.4 EHMP Sites – Bells Creek Estuary and Pumicestone Passage

The Public Environment Report (PER) and supplementary PER works proposed a performance indicator approach which involved reviewing the relationship between three-month average water quality levels at relevant 'control' and 'impact' sites within Bells Creek estuary and Pumicestone Passage to define when investigation and corrective action works would be triggered. This approach, using EHMP data, represented a robust way in which the efficacy of site water quality management intervention can be measured and directed.

The assessment approach involves comparing water quality data from two 'impact' sites within Bells Creek estuary and one 'impact' site in Pumicestone Passage (near the mouth of Bells Creek) to relevant 'control' sites in Pumicestone Passage to define if investigation and corrective action works are necessary. The assessment approach is summarised as follows:

- Baseline water quality in Bells Creek estuary and Pumicestone Passage was quantified using historical EHMP data. Baseline EHMP data included data between 2012 and 2016 (when construction commenced in the Bells Creek North catchment). These baseline data were used to determine a pre-construction correlation between two 'control' sites (EHMP sites 1309 and 1310) with one 'impact' site in Pumicestone Passage (EHMP site 1311) and two 'impact' sites in Bells Creek estuary (BC2.6 and BC4.9). The locations of these sites are shown in Figure B-1. The relationship between the control and impact sites uses three month running averages of EHMP water quality data as a key performance metric.
- Three month rolling averages from baseline data were used to produce scatter plots showing correlations between impact site data and control site data for key water quality parameters. These graphs, included in Section B.1.4.1 and B.1.4.2, indicate the following:
  - A 'line of best fit' describing the relationship between the water quality at the control and impact sites – which, as shown, in most cases indicates a very good level of fit between the two datasets.
  - 'Further investigation' and 'corrective action' lines, defined respectively as being located 1.5 and 3 standard deviations outside the 'line of best fit'. These lines effectively encompass the majority of **natural** variability in water quality levels in Bells Creek estuary and Pumicestone Passage.

As discussed in Section B.2.3, monitoring data collected during the construction and/or operational stages of the project is plotted on these graphs to determine whether further investigations and/or corrective actions are triggered.

This approach has been independently reviewed by Healthy Land and Water scientific personal and has been defined as being robust and defensible. This approach has also been approved by State and Federal government agencies.

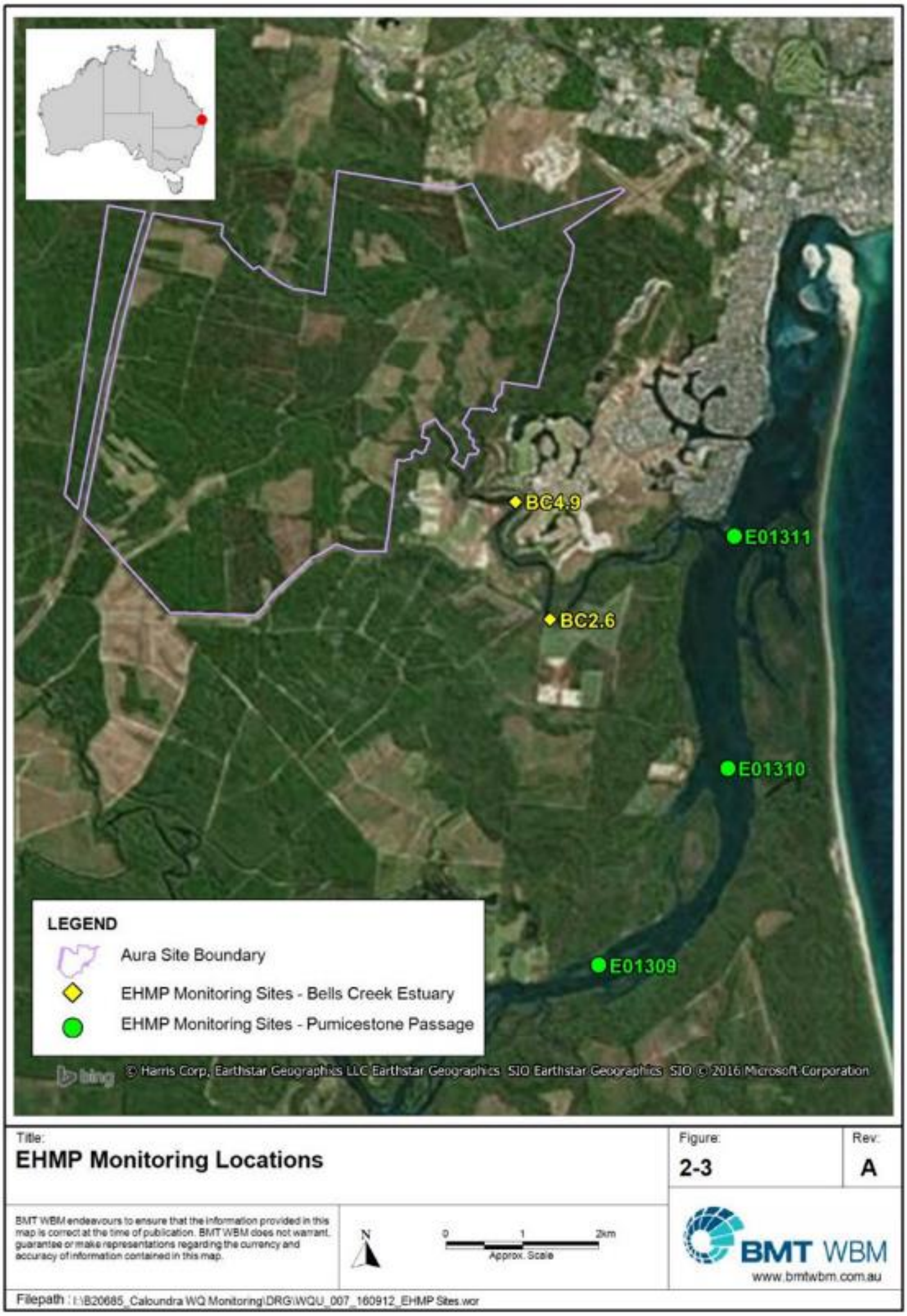
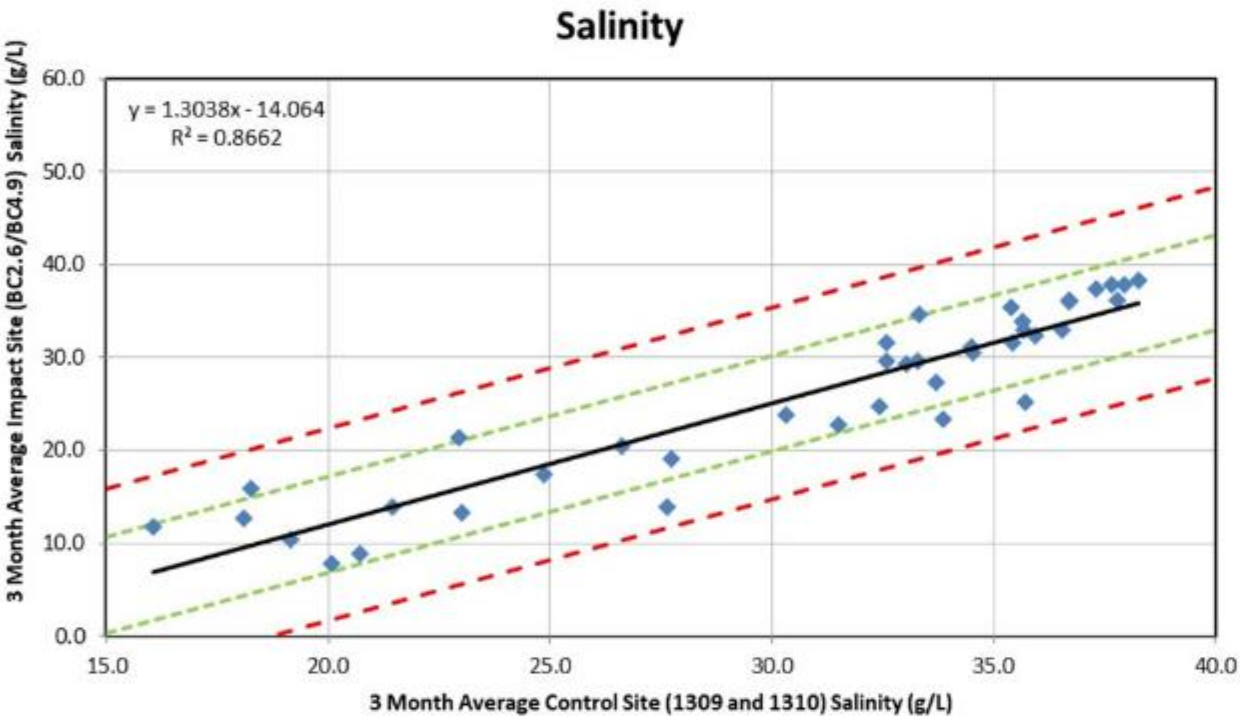
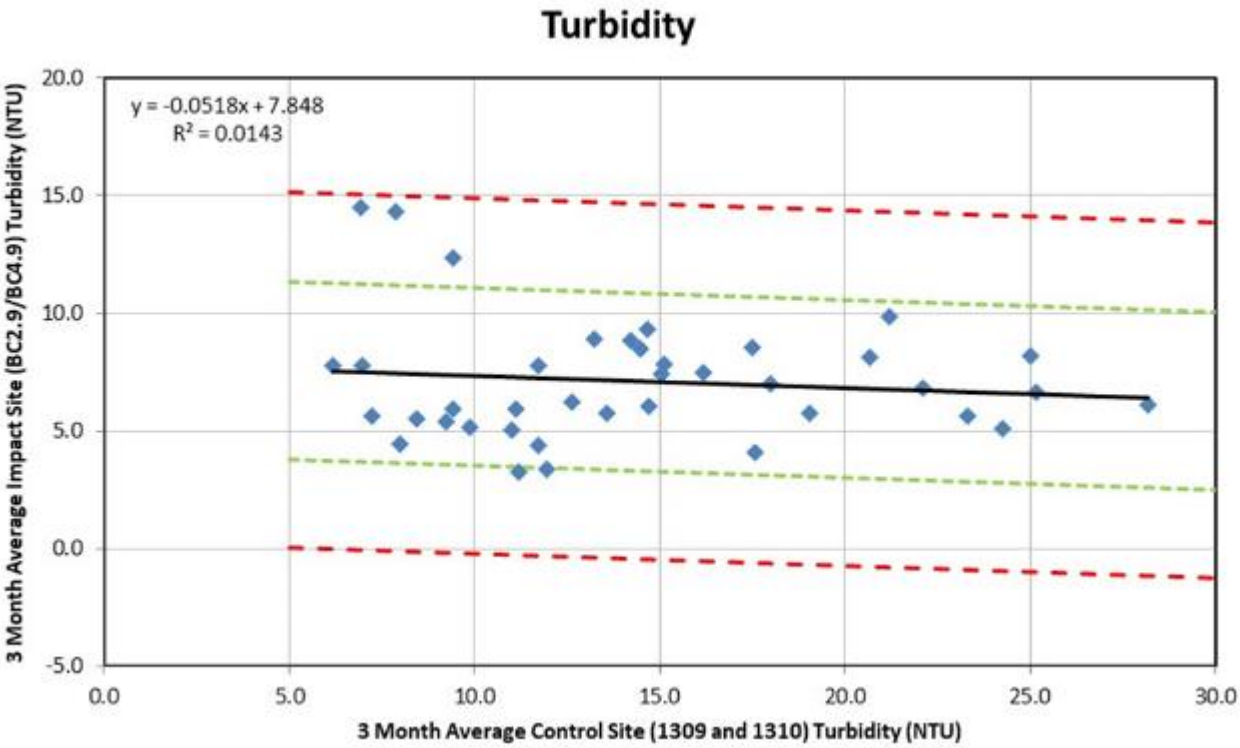
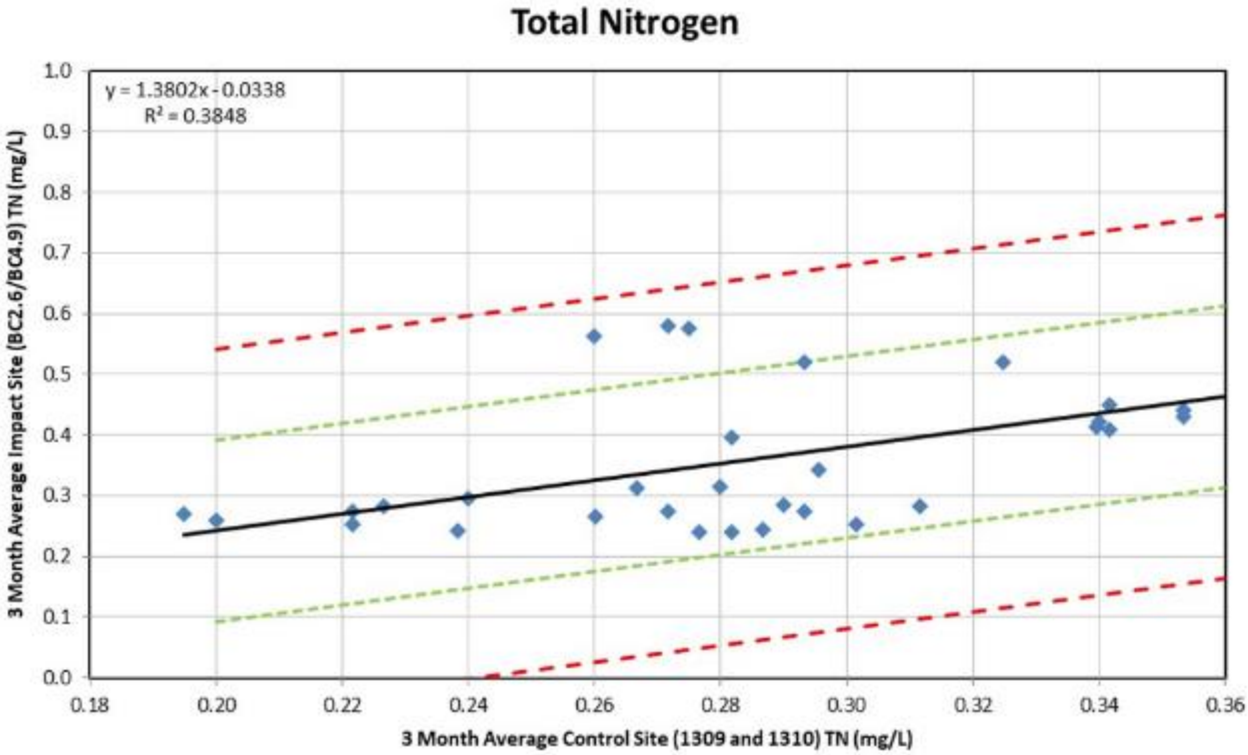


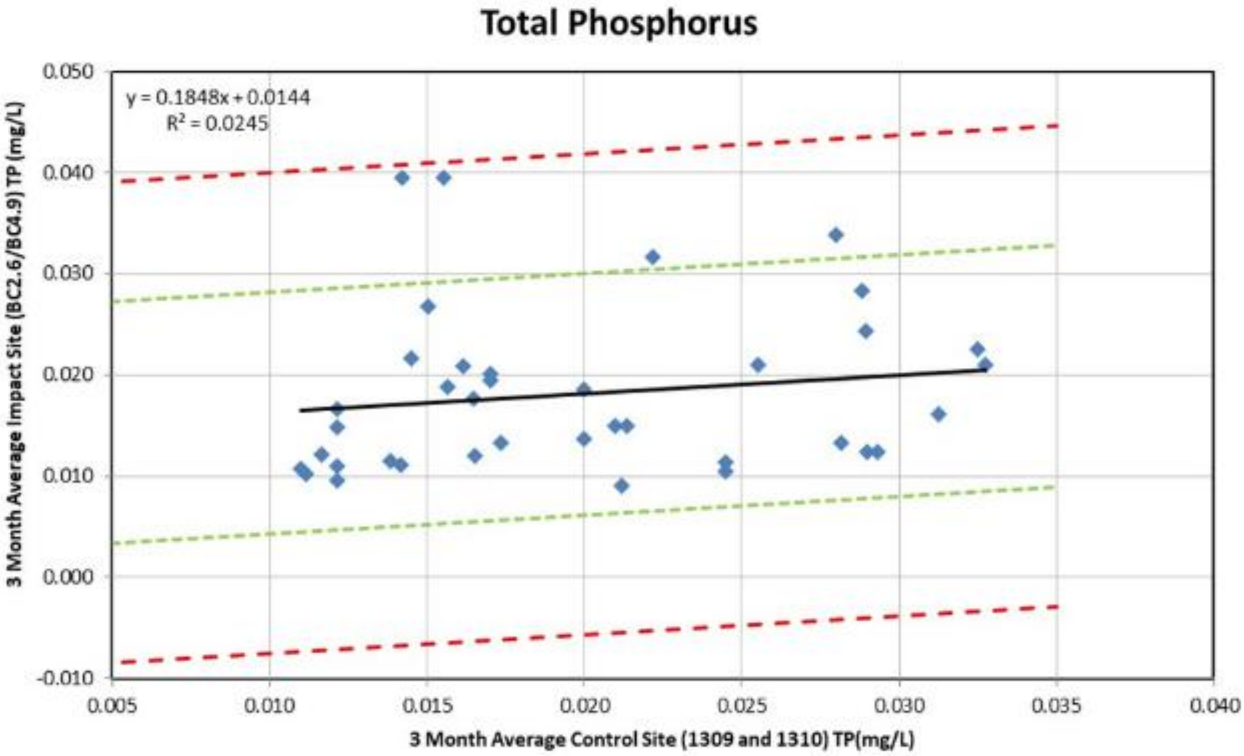
Figure B-1 EHMP Data Collection Locations

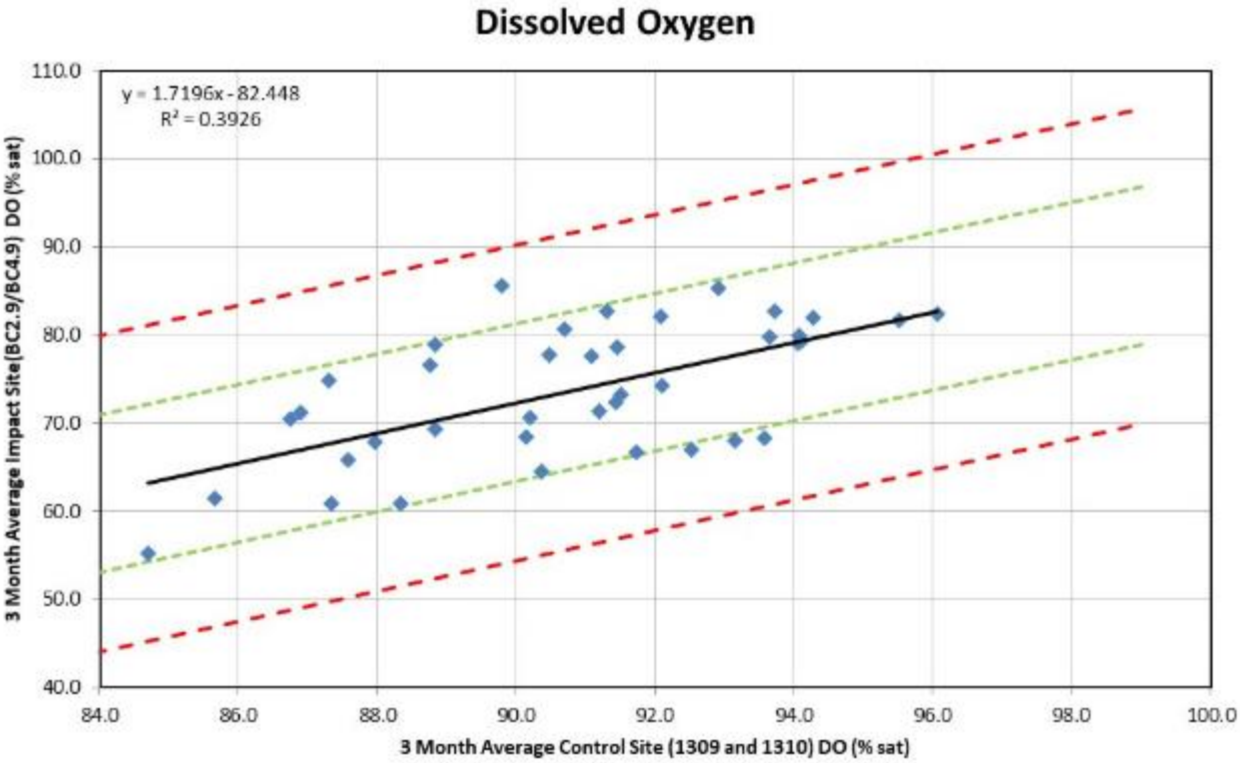
B.1.4.1 Bells Creek Estuary Plots

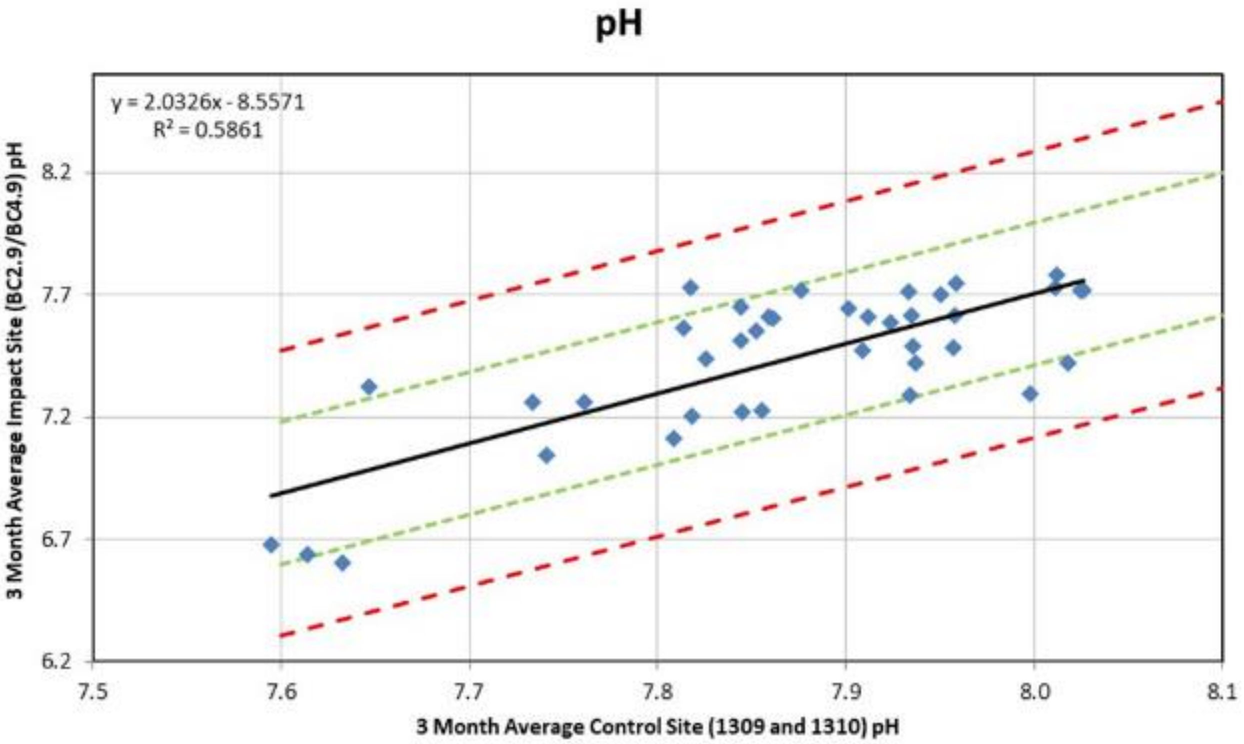


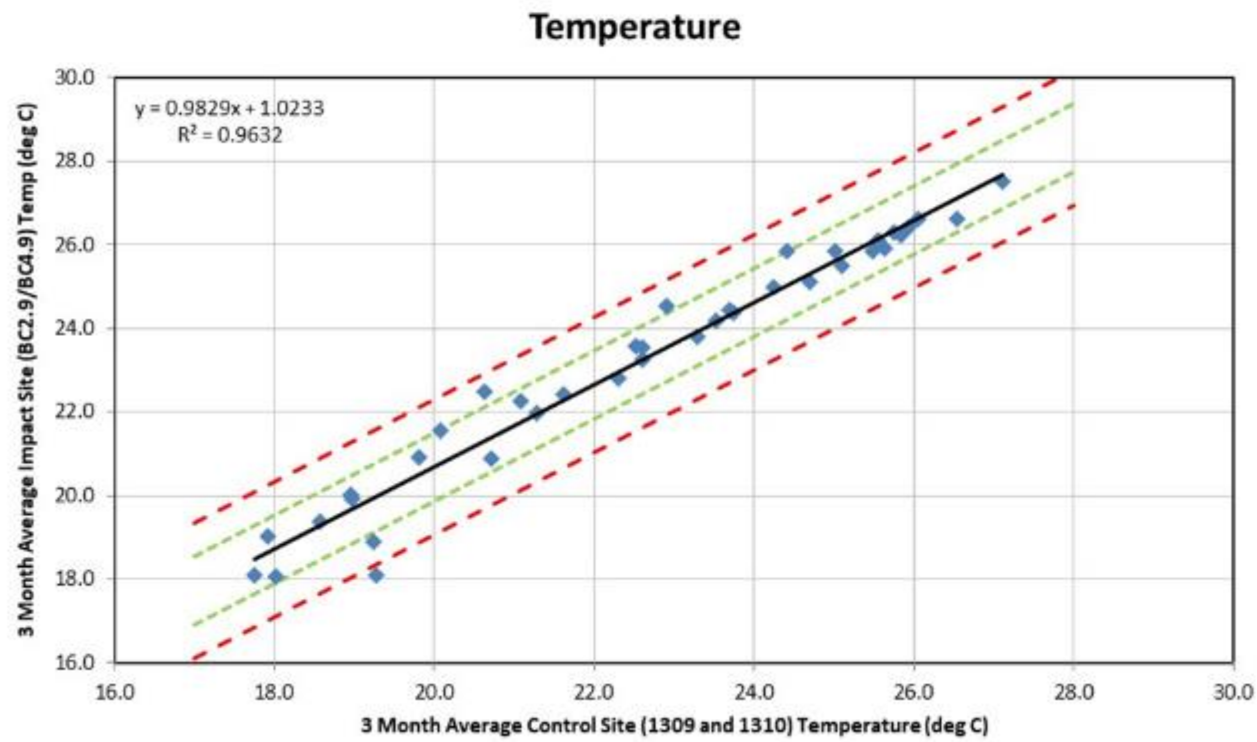


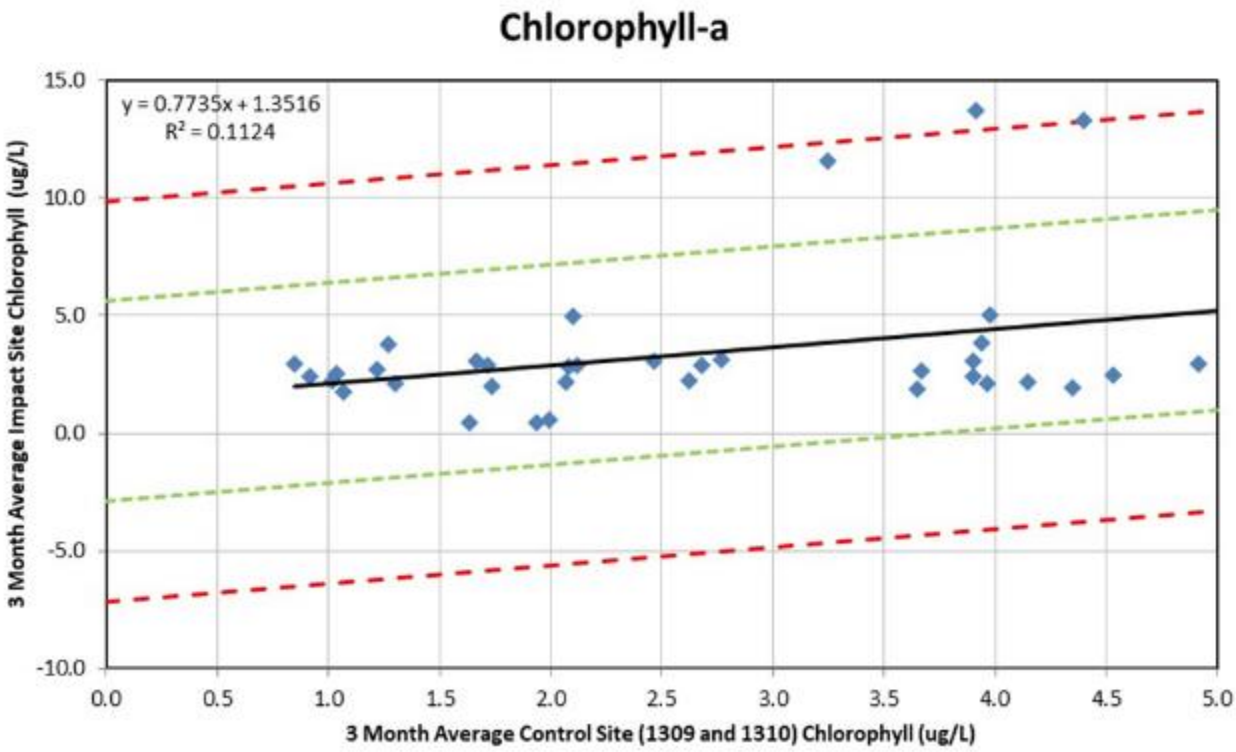

Total Nitrogen
y = 1.3802x - 0.0338
R² = 0.3848
3 Month Average Impact Site (BC2.6/BC4.9) TN (mg/L)
3 Month Average Control Site (1309 and 1310) TN (mg/L)


Total Phosphorus
y = 0.1848x + 0.0144
R² = 0.0245
3 Month Average Impact Site (BC2.6/BC4.9) TP (mg/L)
3 Month Average Control Site (1309 and 1310) TP(mg/L)

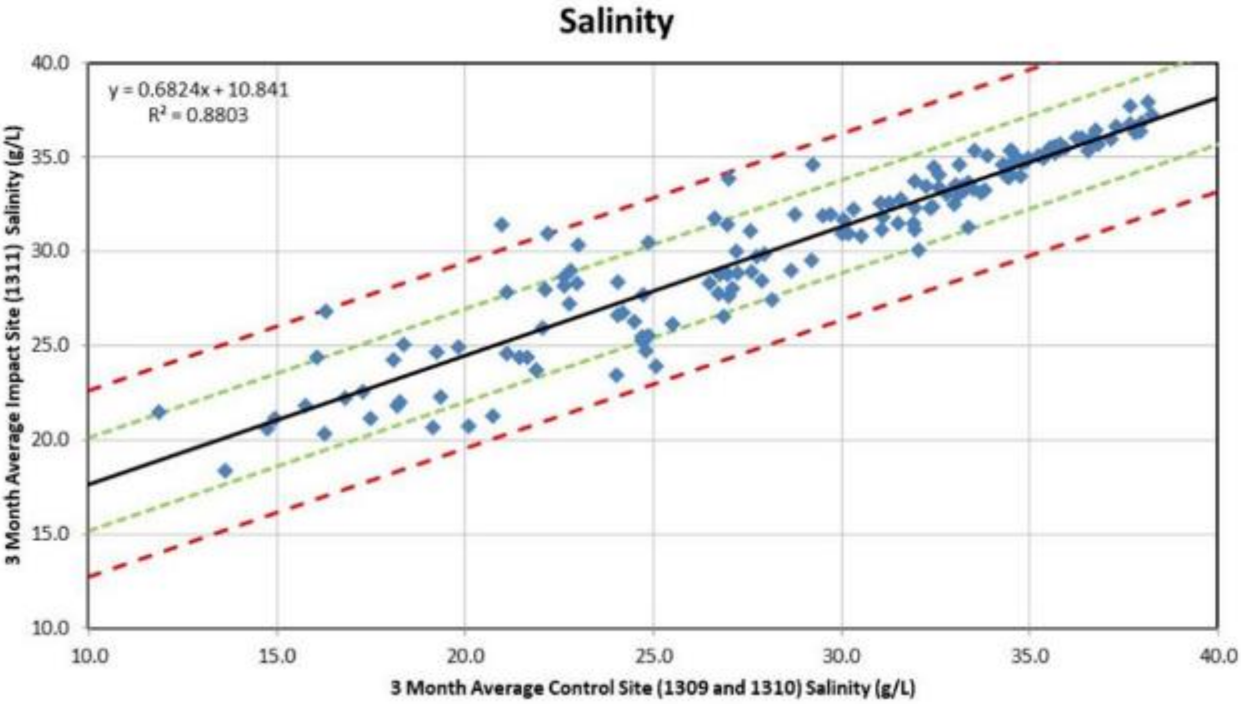

Dissolved Oxygen
y = 1.7196x - 82.448
R² = 0.3926
3 Month Average Impact Site (BC2.9/BC4.9) DO (% sat)
3 Month Average Control Site (1309 and 1310) DO (% sat)

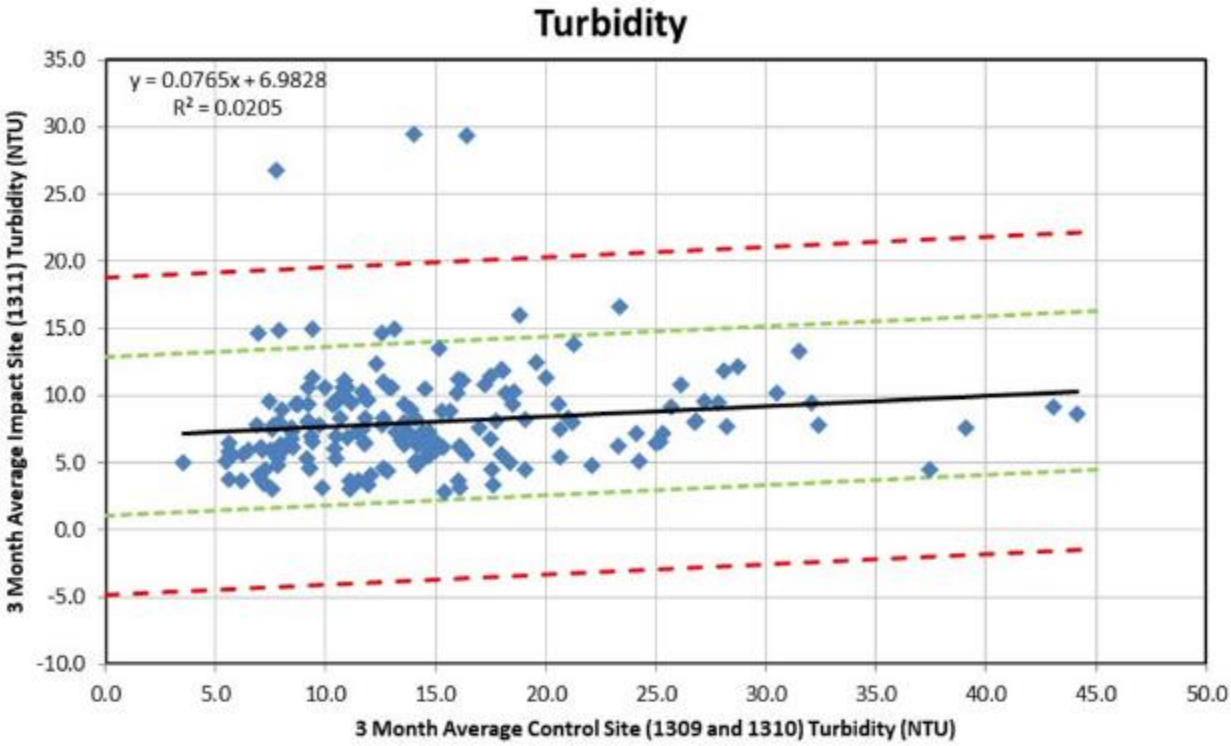

pH
y = 2.0326x - 8.5571
R² = 0.5861
3 Month Average Impact Site (BC2.9/BC4.9) pH
3 Month Average Control Site (1309 and 1310) pH

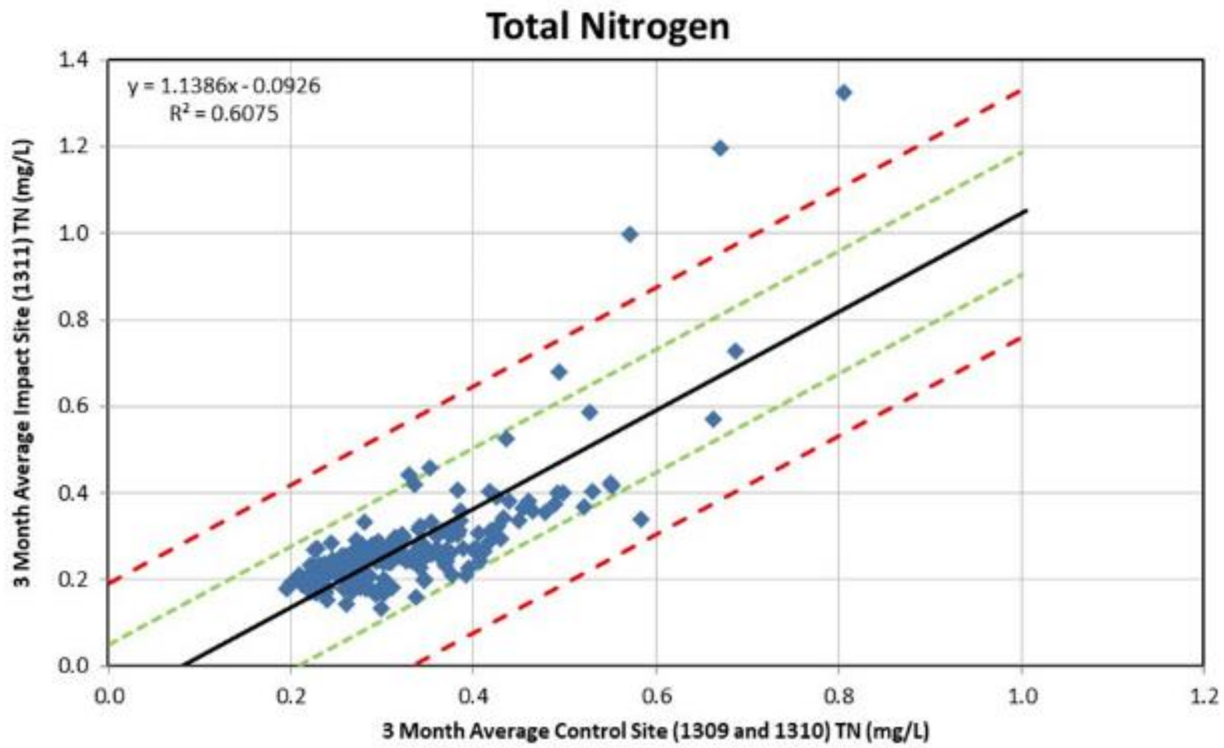

Temperature
y = 0.9829x + 1.0233
R² = 0.9632
3 Month Average Impact Site (BC2.9/BC4.9) Temp (deg C)
3 Month Average Control Site (1309 and 1310) Temperature (deg C)

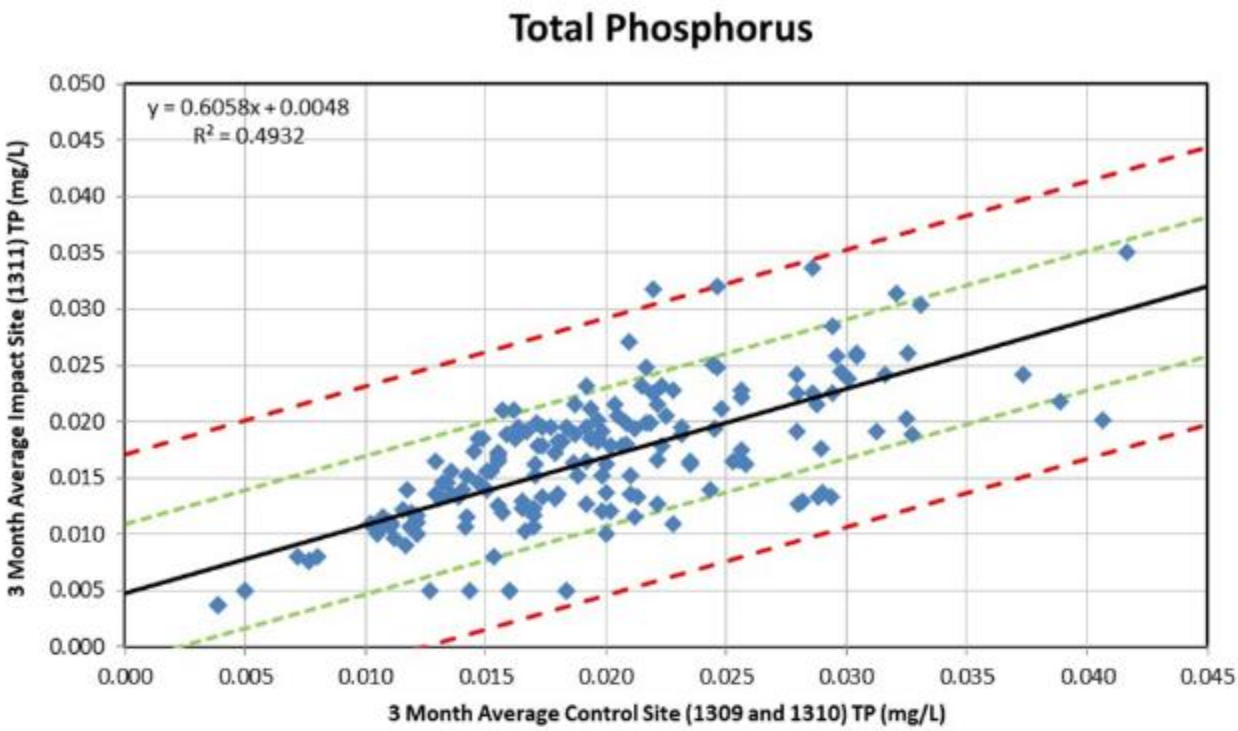

Chlorophyll-a
y = 0.7735x + 1.3516
R² = 0.1124
3 Month Average Impact Site Chlorophyll (ug/L)
3 Month Average Control Site (1309 and 1310) Chlorophyll (ug/L)

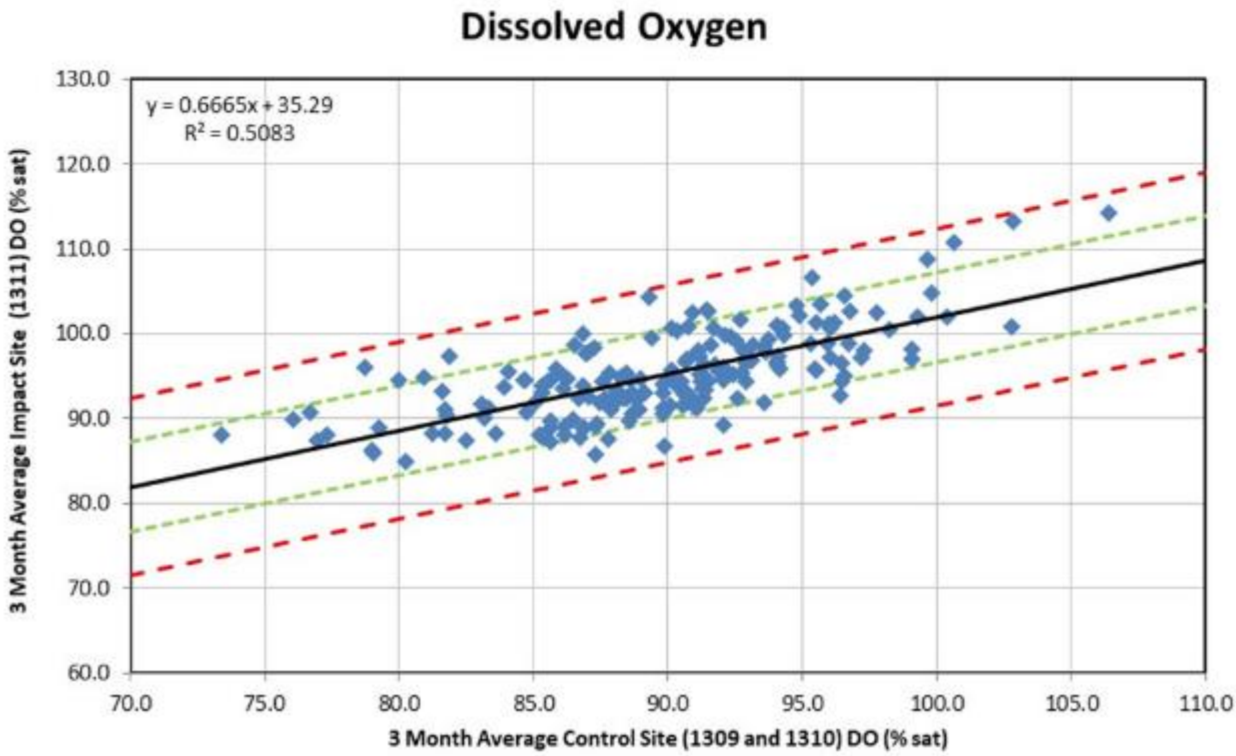
B.1.4.2 Pumicestone Passage Plots

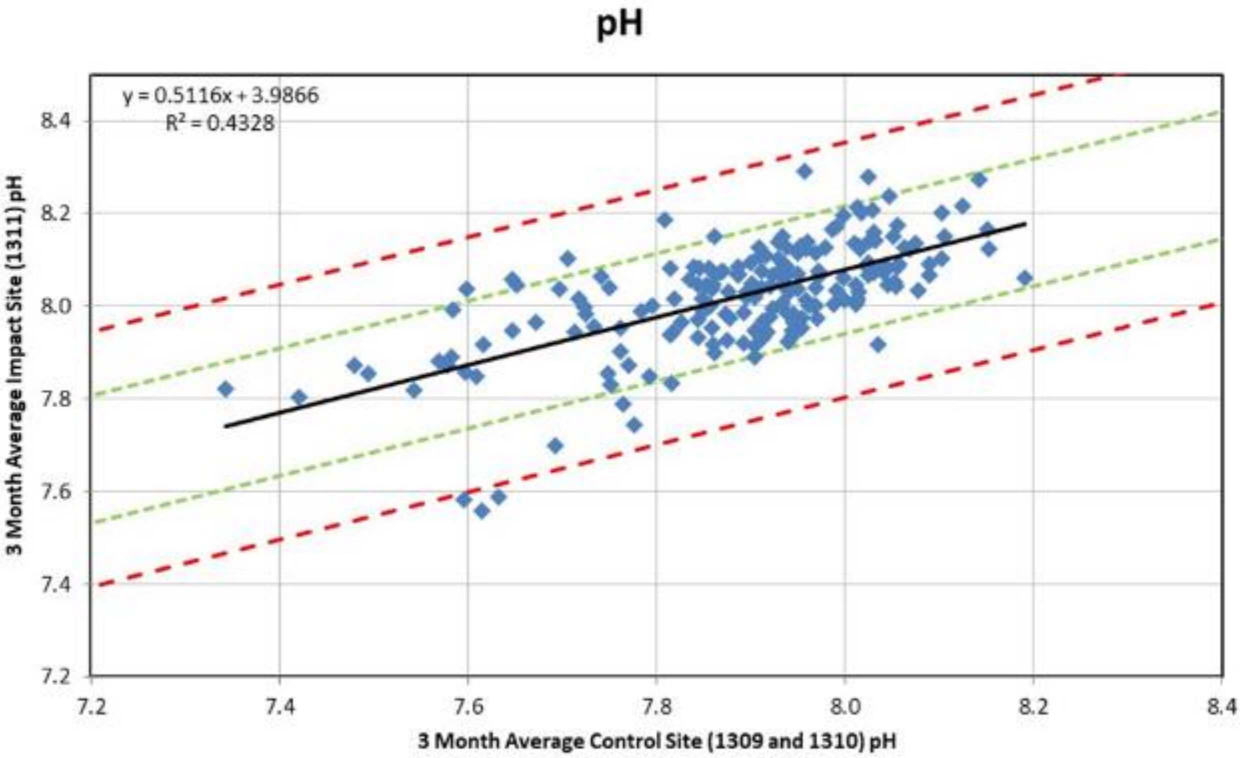


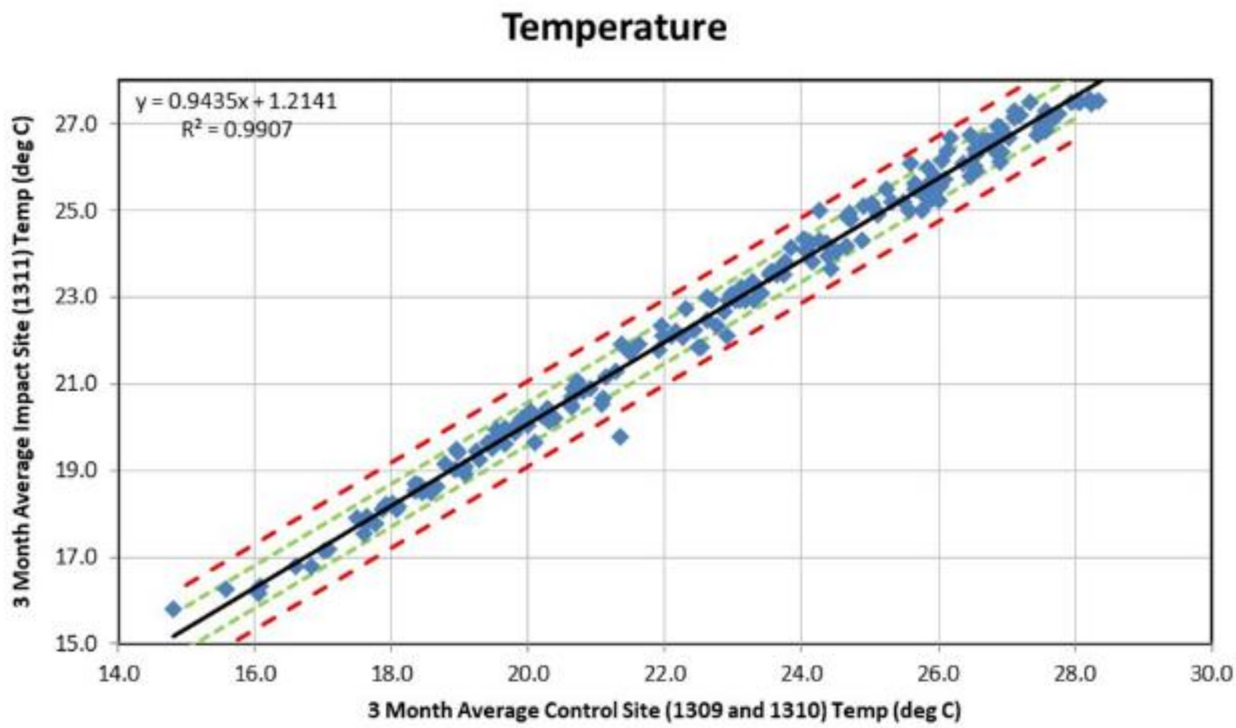


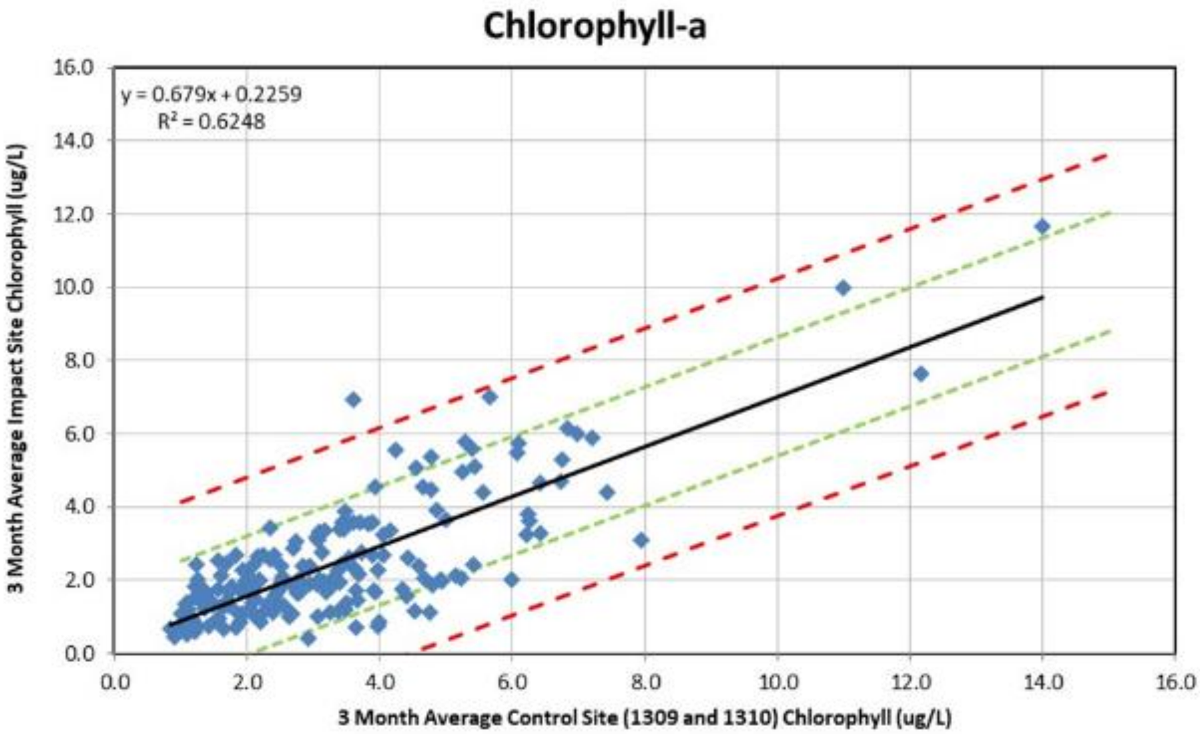

Total Nitrogen
y = 1.1386x - 0.0926
R² = 0.6075
3 Month Average Impact Site (1311) TN (mg/L)
3 Month Average Control Site (1309 and 1310) TN (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4


Total Phosphorus
y = 0.6058x + 0.0048
R² = 0.4932
3 Month Average Impact Site (1311) TP (mg/L)
3 Month Average Control Site (1309 and 1310) TP (mg/L)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050


Dissolved Oxygen
y = 0.6665x + 35.29
R² = 0.5083
3 Month Average Impact Site (1311) DO (% sat)
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
105.0
110.0
3 Month Average Control Site (1309 and 1310) DO (% sat)


pH
y = 0.5116x + 3.9866
R² = 0.4328
3 Month Average Impact Site (1311) pH
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.2
7.4
7.6
7.8
8.0
8.2
8.4
3 Month Average Control Site (1309 and 1310) pH


Temperature
y = 0.9435x + 1.2141
R² = 0.9907
3 Month Average Impact Site (1311) Temp (deg C)
3 Month Average Control Site (1309 and 1310) Temp (deg C)


Chlorophyll-a
y = 0.679x + 0.2259
R² = 0.6248
3 Month Average Impact Site Chlorophyll (ug/L)
3 Month Average Control Site (1309 and 1310) Chlorophyll (ug/L)

B.2 Methods to Detect Impacts

B.2.1 Surface Water – Aura Site

For surface water, a key compliance parameter is turbidity due to risk from mobilised sediments from disturbed areas during and after rainfall events. Upstream and downstream ‘real-time’ continuous turbidity sensors are used to understand the sediment risk, with real-time data providing early warning of potential impacts (refer to Section B.2.2 below).

Ambient monthly surface water data includes a broad range of water quality parameters that are used to detect longer term changes to water quality within Aura. The trigger values in Section B.1.1 are used to determine whether water quality is trending outside natural variability for the following purposes:

- To assess long term changes in surface water quality in key waterways within Aura.
- To assess whether any changes to groundwater quality resulting from project activities may be impacting on surface water quality. This assessment is part of the groundwater assessment methodology (Section B.2.4).
- To aid in further investigations of exceedances in the downstream receiving waters of Bells Creek estuary and Pumicestone Passage (refer to Section B.2.3). Ambient surface water data for Aura can be used to determine if water quality changes within Aura are causing similar changes in the downstream receiving waters.

The assessment process involves comparing the median of the most recent three (3) consecutive routine monitoring samples for each site to relevant surface water trigger values (Table B-1). This is in accordance with ANZECC/ARMCANZ (2000) which states that a trigger for further investigation will be deemed to have occurred when the median concentration of 3-5 samples taken at a test site exceeds the 80^{th} percentile (or 20^{th} percentile) site-specific trigger value.

Any exceedance of trigger values initiates further investigations and corrective actions as detailed in Section 4 of the WQMP.

B.2.2 Continuous Turbidity

Continuous ‘real time’ turbidity data is downloaded remotely once per hour and the data is stored on a project-specific web portal. Water level data is also downloaded and stored.

The web portal continually compares turbidity data from the downstream station (BN1 and BS1) to the relevant upstream station (BN3 and BS3). If the downstream turbidity exceeds the upstream turbidity by more than 10%, and it is during periods of flow in the creeks, then an automatic alert is sent out to key project personnel via the web portal. This alert triggers further investigations as detailed in Section 4 of the WQMP.

Periods of flow in each creek are determined using the water depth data at each upstream monitoring station (BN3 and BS3). The creek is deemed to be flowing if the water depth is above the cease-to-flow (CTF) depth in the creek as follows:

- Bells Creek North upstream station – 0.5 m CTF.

- Bells Creek South upstream station – 0.15 m CTF.

These CTF depths may change depending on the location of the water level sensor at each monitoring station (e.g. if the station or depth sensor needs to be relocated for some reason).

At times when water depth is below the CTF levels, the performance criteria is deemed to be not applicable as the creeks are not flowing and are comprised of disconnected pools of water.

B.2.3 Surface Water – Bells Creek Estuary and Pumicestone Passage

The detection of impacts in the receiving waters of Bells Creek estuary and Pumicestone Passage is undertaken as follows.

- Monthly EHMP data collected during the construction and/or operational stages of the project is analysed to calculate three month rolling averages for each EHMP monitoring site.
- The three-month rolling average data is progressively plotted on the correlation graphs described in Section B.1.4. If the data from one of the impact sites is located between the two 'investigation' lines, no further action is required as this data indicates that water quality in Bells Creek estuary and Pumicestone Passage is effectively comparable to pre-development conditions.
- If any data recorded at the impact sites during the construction and/or operational stages of the project falls between the 'investigation' and 'corrective action' lines, then further investigations as outlined in Section 5.1 of the WQMP will be triggered to determine whether development works are affecting receiving water quality and, if necessary, corrective action can be implemented.
- Should data recorded at the impact site during the construction and/or operational stages of the project fall outside the 'corrective action' lines, then more detailed assessments and site-specific actions will be triggered.

Regular (2 yearly) reviews of the relationships between the control and impact sites will be conducted to capture any potential overall long-term changes in water quality within Bells Creek estuary and Pumicestone Passage which may result from works being conducted elsewhere in the catchment.

B.2.4 Groundwater

For groundwater, key compliance parameters are groundwater level, metals and pH. The risks to groundwater during construction are:

- Changes to groundwater levels from bulk earthworks; and
- Mobilisation of dissolved metals and changes in pH from disturbance of acid sulfate soils.

Groundwater quality data is analysed to determine the median from the most recent three (3) consecutive routine monitoring samples. This 'rolling median' is used to compare with site-specific or bore-specific trigger values as appropriate (refer to Section B.1.3).

The following methodology is used to assess groundwater in catchments with development works:

- For bores with less than ten (10) baseline data points (captured over at least 12 months), groundwater monitoring data is compared with **site-specific** groundwater quality trigger values.

- For bores with more than ten (10) baseline data points (captured over at least 12 months), groundwater monitoring data is compared with **bore-specific** trigger values. For groundwater level, groundwater monitoring data is plotted as time series with CRD curve to assess trends in data compared to rainfall.
- If the monitoring data for Sentinel bores exceeds the 80th percentile trigger value (or 20th percentile for parameters with a lower limit), or if the groundwater level trend in the previous three (3) months of data does not correlate with the trend in the CRD curve, this triggers an initial investigation into whether Protected Matters and/or receiving environments are being impacted.
- Impacts to Protected Matters and/or receiving environments are assessed as follows:
  - Assess whether the three month rolling median of surface water quality data (only for parameters exceeded in groundwater) at the downstream boundary of site (e.g. BN1) is outside the 20th/80th percentile range of baseline data (Table B-1). If so, review the surface water quality data record at the upstream boundary of the site (e.g. BN3) to determine if parameters of concern are naturally elevated. If upstream surface water quality is within 20th/80th percentile of baseline data at this location, project related impacts may be occurring at downstream receiving environments.
  - Assess whether pH and electrical conductivity (EC) levels in site frog ponds are within acceptable limits.
  - Assess whether water levels in frog ponds are within acceptable limits.
  - Assess whether trigger values at up-gradient Control bores are also being exceeded – indicating potential offsite influences on groundwater quality.
- If the monitoring data comparison indicates that Protected Matters or the receiving environment may be being impacted, this triggers corrective action as per Section 5.2 of the WQMP.
- Construction phase monitoring data for Construction bores is compared to trigger values (either site-specific or bore-specific) to identify potential areas of concern, or point sources, within the construction areas. This assists with targeting of locally specific corrective actions (Table 5-2 of the WQMP).

Further detail and flowcharts on the above process is included in Sections 4.1.3 and 4.1.3.1 of the WQMP.

Appendix C Risk Assessment of Modelling

C.1 Background

All modelling undertaken utilising predictive modelling tools is highly dependent on the quality of the input data, the calibration and validation processes performed and the assumptions made in conducting the modelling. The aim when developing models is to develop purposeful, credible models from data and prior knowledge, in consort with end-users.

With respect to Caloundra South, several tranches of modelling were undertaken to investigate the development impacts and potential mitigation measures. These included:

- Catchment modelling of the site and subcatchments upstream, within and downstream of the development;
- Receiving water quality modelling to examine impacts on Bells Creek and Pumicestone Passage;
- Precinct scale stormwater quality modelling; and
- Precinct and development scale water balance modelling.

It is not appropriate in this section to outline all the details and assumptions of each modelling package, however a basic risk assessment has been performed for these modelling tasks as set out below. Complete details of the models used, their parameterisation and assumptions are contained within the relevant reports prepared for the PER and PER supplement, with the following summaries being provided herein:

- Catchment modelling;
- Receiving water quality modelling;
- Stormwater quality modelling; and
- Water balance modelling.

C.2 Risk Assessment

This risk assessment was undertaken in general accordance with the risk management standard AS/NZS ISO 31000:2009, which includes the following steps:

- Identify the risks;
- Analyse the risks;
- Evaluate the risks; and
- Mitigate or treat the risks.

Whilst the risks associated with predictive modelling do not necessarily fit well into a ‘typical’ risk assessment process, where possible the elements defined above have been used to conduct this assessment.

C.2.1 Identify the Risks

As with any modelling effort, the risks in utilising predictions based on the modelling are dictated by several factors. These risk factors include:

- The purposes for modelling are clearly stated and understood;
- The suitability of the models chosen to represent the processes and characteristics of the problem being modelled;
- Uncertainties within the forcing data used are understood and quantified where possible;
- Use of forcing data considers the specifics of the location being modelled (both temporally and spatially);
- Model parameters chosen are locally relevant and suitable for the chosen models;
- Model operators have sufficient skill to use the predictive tools chosen and understand the implications of model outputs and uncertainties;
- Quantified calibration and verification is undertaken where necessary and applicable; and
- Model outputs are compared to other techniques.

Each of the above represents a risk to the reliability and robustness of the model predictions and any decisions that may have been supported by modelling outputs.

C.2.2 Analyse the Risks

Each of the identified risk factors are analysed below.

a) *The purposes for modelling are clearly stated and understood* – In the case of the Caloundra South, the primary purpose of each model was to quantify the likely impacts from development of the site on specific environmental objectives, and to provide forcing data for “downstream” models such as catchment and receiving water models. Secondary objectives were identified such as minimising the extent of impact, optimising treatment measure performance and sizing and minimising overall demands on water resources. In each case, these purposes were clearly identified at the commencement of each modelling task.

b) *The suitability of the models chosen to represent the processes and characteristics of the problem being modelled* – Each of the model frameworks chosen were those that represented the latest model developments (such as MUSIC, Source, Urban Developer etc all developed through Australian based research), or those which had previously been applied to the region.

c) *Uncertainties within the forcing data used are understood and quantified where possible* – A large range of forcing data was used for each of the modelling frameworks applied to Caloundra South. In all cases, the best available locally specific data was chosen, however the uncertainty in some of that forcing data was not always explicit (e.g. rainfall data). As with any monitoring data, there is likely to be some degree of uncertainty in the results, for example water quality monitoring data from laboratory analysis has explicit uncertainties calculated and these vary with the magnitude of the result, such that numbers closer to detection limits of the analyses have higher uncertainties than those with higher analysis results.

d) *Use of forcing data considers the specifics of the location being modelled (both temporally and spatially)* – Any forcing data used for Caloundra South modelling was that which was the most locally specific for the site. In some cases there may be variability across the site for some spatial characteristics (e.g. rainfall), in which case more forcing data was obtained to mitigate such issues.

e) *Model parameters chosen are locally relevant and suitable for the chosen models* – Model parameters used in the Caloundra South modelling were selected based on industry guidance (e.g. SEQ MUSIC Modelling Guidelines), or from applications of the same models in similar regions.

f) *Model operators have sufficient skill to use the predictive tools chosen and understand the implications of model outputs and uncertainties* – If modellers do not have sufficient experience in the use of models, it is highly likely that significant errors could be made without recognition that this has occurred. In the case of Caloundra South, all modelling tasks were undertaken and/or supervised by highly experienced professional modellers with specific experience in applying the model frameworks to similar sites and in the same region.

g) *Quantified calibration and verification is undertaken where necessary and applicable*. – Calibration and verification of model outputs are essential where definitive representation of existing conditions are required. Where this was completed for the Caloundra South site's existing conditions, the catchment and receiving water quality models utilised significant local observed data to undertake calibration and verification for each framework and these works were outlined in various modelling reports.

h) *Model outputs are compared to other techniques* - Where possible, model outputs should be compared to other modelling outputs or appropriate quantification techniques. In the case of the work undertaken for Caloundra South, outputs from smaller scale models were compared to the larger regional models. For example, outputs from MUSIC stormwater models were compared to the catchment models and other techniques for estimating flows and pollutant export.

C.2.3 Evaluate the Risks

The identified risks were evaluated utilising risk tables included in Appendix A. The method for evaluating risks involved assessing the 'likelihood' of an environmental impact occurring with the 'consequence' of an environmental impact occurring. This likelihood and consequence ratings are based on the analysis of risks as discussed above.

C.2.4 Mitigating the Risks

Of all the risks described above, the only one that was identified as a moderate risk was if the uncertainties within the forcing data used were understood and quantified where possible. In terms of Caloundra South, a large range of forcing data was used for the modelling frameworks applied.

In each case, the forcing data used was that which was considered "best practice" or industry standard. As such, the outputs of the models are likely to be consistent with any other models developed for similar sites across Australia and represent best modelling practice. This was recognised as such in the reviews of the modelling works undertaken.

Table C-1 Risk Evaluation

Risk Factor	Description of Impact	Likelihood of Impact	Consequence of Impact	Risk Rating
The purposes for modelling are clearly stated and understood;	If the purpose of a model is not understood, then incorrect modelling predictions may be derived or may not be appropriate to the site	Very unlikely (1)	Minor (2)	Low (3)
The suitability of the models chosen to represent the processes and characteristics of the problem being modelled;	Models which do not portray the processes or characteristics are not likely to account for the dynamics of changes across the site or on receiving environments	Very unlikely (1)	Minor (2)	Low (3)
Uncertainties within the forcing data used are understood and quantified where possible;	If the uncertainties are too large, the model outputs may not be able to discretise any potential changes in impacts as a result of the modelled scenarios	Moderate (3)	Minor (2)	Moderate (5)
Use of forcing data considers the specifics of the location being modelled (both temporally and spatially);	Where forcing data is not locally specific, it may result in model outputs that do not account for spatial or temporal variability of the local environment	Unlikely (2)	Minor (2)	Low (4)
Model parameters are chosen are locally relevant and suitable for the chosen models;	If inappropriate parameters are chose the model outputs are not likely to represent the site and give misleading outputs	Unlikely (2)	Minor (2)	Low (4)
Model operators have sufficient skill to use the predictive tools chosen and understand the implications of model outputs and uncertainties;	Inexperienced modellers will not have a full understanding of the implications of data, parameters and assumptions used and can result in outputs that do not adequately account for impacts or site conditions	Very unlikely (1)	Moderate (3)	Low (4)
Quantified calibration and verification is undertaken where necessary and applicable; and	Uncalibrated and unverified models are usually worse than no model at all	Unlikely (2)	Minor (2)	Low (4)
Model outputs are compared to other techniques	Without some cross verification of techniques, the decision maker has no concept of the robustness and reliability of the model prediction	Unlikely (2)	Minor (2)	Low (4)

C.2.5 Risk Assessment Tables

Score		TABLE OF CONSEQUENCE Environment
5	Very High/ Catastrophic	Catastrophe, irreversible damage to sensitive environment. Likely prosecution.
4	High/ Major	Disaster, high levels of media attention, prolonged but reversible damage to environment.
3	Moderate	Substantial environmental nuisance but full recovery expected.
2	Low/ Minor	Minor detrimental effect to environment.
1	Very Low/ Insignificant	Low environmental impact

TABLE OF LIKELIHOOD		
Score		Likelihood
5	Almost certain	The event is expected to occur in most circumstances. Likely to occur frequently.
4	Likely/ probable	The event will probably occur in most circumstances.
3	Moderate/ occasional	The event should occur at some time. Likely to occur sometime.
2	Remote/ unlikely	The event could occur at some time. Unlikely but possible.
1	Rare/ very unlikely	The event may occur only in exceptional circumstances. Assumed it may not be experienced.

Risk= Consequence +Likelihood						
		Risk Rating				
Consequence	5	6	7	8	9	10
	4	5	6	7	8	9
	3	4	5	6	7	8
	2	3	4	5	6	7
	1	2	3	4	5	6
		1	**2**	**3**	**4**	**5**
		Likelihood				

Risk Rating	Definitions
8-10	Intolerable
7	High
6	Significant Risk
5	Moderate Risk
2-4	Low Risk

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