Central Queensland Coal Project

Appendix 5a – Surface Water Quality Technical Report

Central Queensland Coal

CQC SEIS, Version 3

October 2020

Central Queensland Coal Project

Surface Water Quality Technical Report

Central Queensland Coal

CQC-SCP-RT001, Rev 0

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Author:	Marc Walker
Contact Details:	Orange Environmental Pty Ltd +61 417 791 061 admin@orangeenvironmental.com.au
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Contents

Appendices

Attachment D

Main Site Descriptions

Attachment E

Pools Locations and Permanence

Figures

Tables

Terms and Abbreviations

AWQGs	The Australian Water Quality Guidelines - the Australian & New Zealand Guidelines for fresh & Marine Water quality (ANZG 2018)
BTEX	Suite of hydrocarbons including Benzene, Toluene, Ethylbenzene and Xylenes.
CHPP	Coal Handling Preparation Plants
CQC	Central Queensland Coal, the proponent
DES	Queensland Department of Environment and Science
DGV	Default Guideline Value – terminology from AWQGs that is analogous to Water Quality Objectives and Trigger Values
DO	Dissolved Oxygen
EC	Electrical conductivity
EHP	Queensland Department of Environment Heritage Protection
EMC	Event Mean Concentration
EP Act	Environmental Protection Act 1994
EP Regulation	Environmental Protection Regulation 2019
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPP (Water)	Environmental Protection (Water and Wetland Biodiversity) Policy 2019
ERA	Environmentally Relevant Activity
EV	Environmental Value
FBA	Fitzroy Basin Association
GBRMP	Great Barrier Reef Marina Park
IECA	International Erosion Control Association, publishes the IECA (2008) guidelines
LOR	limits of reporting
m/s	Metres per second
mg/L	milligrams per litre (or ppm)
MNES	Matters of National Environmental Significance
NATA	National Association of Testing Authorities
NTU	Nephelometric Turbidity Units
NWQMS	National Water Quality Management Strategy
PAH	Polycyclic aromatic hydrocarbons
QA/QC	Quality Assurance / Quality Control
QWQGs	The Queensland water quality guidelines (EHP 2013)

REMP	Receiving Environment Monitoring Program
ROM	run of mine coal
RPD	Relative Percent Difference
SEISv3	Current version of the SEIS at the time of reporting
SMD	Slightly-Moderately disturbed (relating to receiving waters)
SRN	Sample Receipt Notification
SSTV	Site Specific Trigger Values
TDS	Total Dissolved Solids
TLF	Train Loadout Facility
TN	Total nitrogen
TP	Total phosphorous
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
TSS	Total Suspended Solids
WQO	Water Quality Objective
µS/cm	Microsiemens per centimetre

1 Introduction

1.1 Overview

Central Queensland Coal Proprietary Limited (Central Queensland Coal) and Fairway Coal Proprietary Limited (Fairway Coal) (the joint Proponents), propose to develop the Central Queensland Coal Mine Project (the Project). As Central Queensland Coal is the senior proponent, Central Queensland Coal (CQC) is referred to throughout this report.

The surface water assessments for the Project have been presented in a previous Environmental Impact Statement (EIS) (CDM Smith, 2017) and two Supplementary EIS's (SEISv1 and SEISv2) (CDM Smith, May 2018 and December 2018). Since the completion of the EIS and SEIS, further monitoring and assessments have been undertaken to improve the understanding of surface water on the site. The site water management system and infrastructure have also been refined.

This technical report has been prepared to provide an overview and summary of the results of the surface water quality assessment and monitoring program for the Project to date to support this version (i.e. Version 3) of the Supplementary Environmental Impact Statement (SEIS v3).

1.2 Scope

This report presents the methodology and results of the surface water quality assessment undertaken for the Project, including:

- An assessment of the existing surface water environment
- Analysis of historical, regional and project specific water quality data and
- Description of environmental values and development of Site-Specific Trigger Values.

2 Project Description

2.1 The Project

The Project will be located within ML 80187 and ML 700022, which are adjacent to Mineral Development Licence (MDL) 468 and Exploration Permit for Coal (EPC) 1029, both of which are held by the Proponent. The area is located in the Styx Basin, Central Queensland, approximately halfway between Rockhampton and Mackay as shown in Figure 2-1. The key components of the Project include:

- Construction of the coal mine and associated infrastructure
- Two open cut operations, two waste rock stockpiles, dams, and two separate mine industrial areas and Coal Handling Preparation Plants (CHPP), a conveyor and associated mining activities
- A Train Loadout Facility (TLF) to load coal onto trains and provide a new connection to the North Coast Rail Line, and
- A transport corridor to transport coal from the mine to the TLF.

The Project involves mining a maximum combined tonnage of up to 10 Mtpa of semi-soft coking coal (SSCC) and high grade thermal coal (HGTC) that will be mined using a truck and shovel methodology. The run of mine (ROM) coal will ramp up to approximately 2 Mtpa during Stage 1, where coal will be crushed, screened and washed to SSCC grade with an estimated 80% yield. Stage 2 of the Project will include further processing of up to an additional 4 Mtpa ROM coal within another CHPP to SSCC and up to 4 Mtpa of HGTC with an estimated 95% yield. Rehabilitation works will occur progressively through mine operation.

The layout of the coal mine and associated infrastructure is shown on Figure 2-2.

2.2 Water Management System

The site water management system will capture, treat, reuse and release water from the mine area under the proposed controlled release conditions, as well as manage dewatered groundwater from mine pits. The site water management system includes the following components:

- A large (2,783 ML) mine water dam (Dam 1) which is the main storage for runoff from active mining areas and groundwater inflows to the open cut pits. Dam 1 will also collect undisturbed catchment runoff in the early stages of the Project to provide water supply for mining operations.
- A controlled release system from Dam 1 to Deep Creek. The controlled release system will enable site water volumes to be managed during wet periods when significant inflows to the site water management system are expected. Releases will only occur during flow events in Deep Creek.
- Sediment dams to collect and treat runoff from overburden emplacements.
- Environmental dams to collect and contain runoff from the haul road and rail loop.

2.3 Water Supply

Water is required for CHPP operation, haul road dust suppression and service water (for vehicle washdown, fire water demand and ROM pad dust suppression). The site water management system aims to maximise the reuse of captured surface water runoff and groundwater inflows and minimise the volume of water required from external sources.

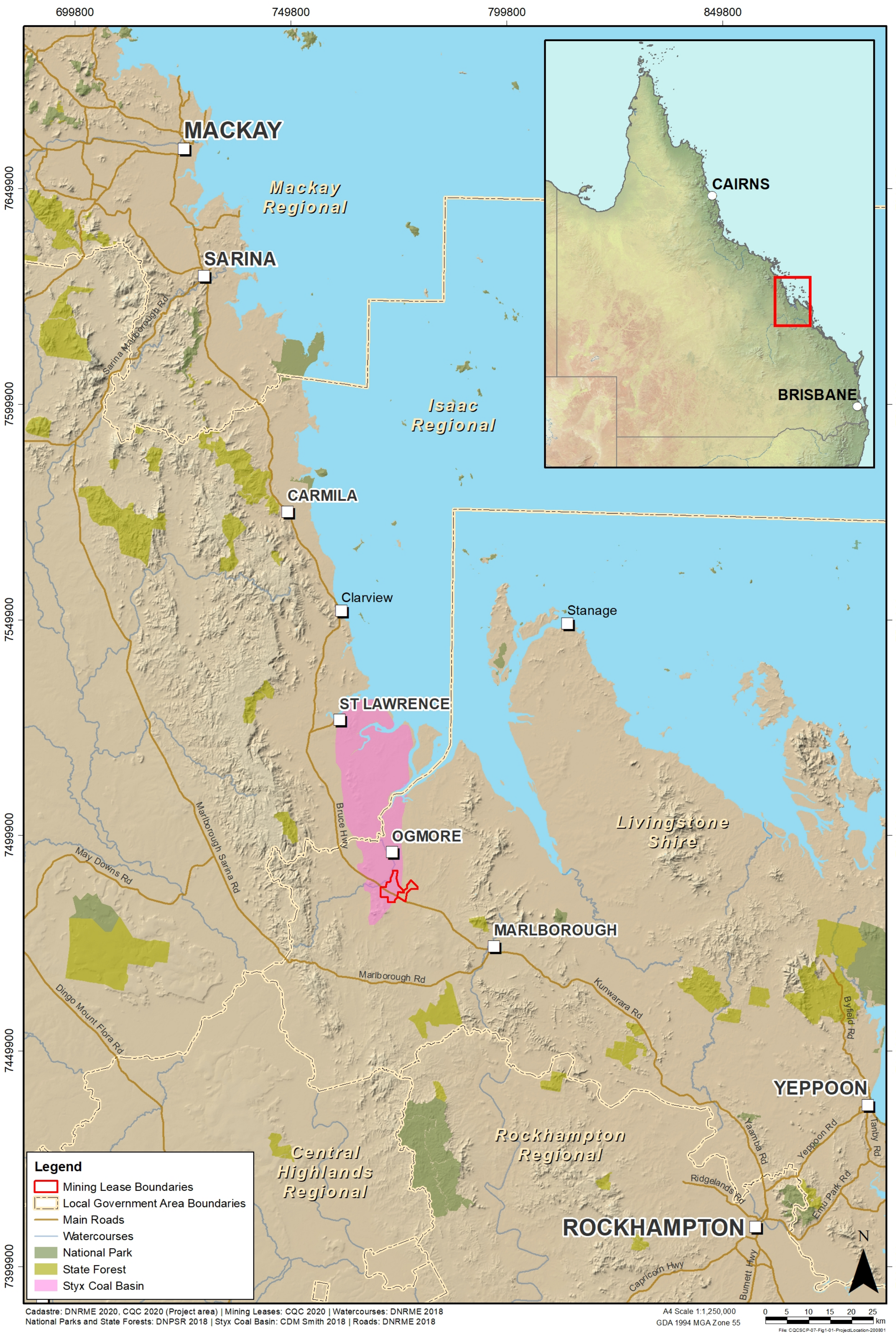


Figure 2-1: Project Location

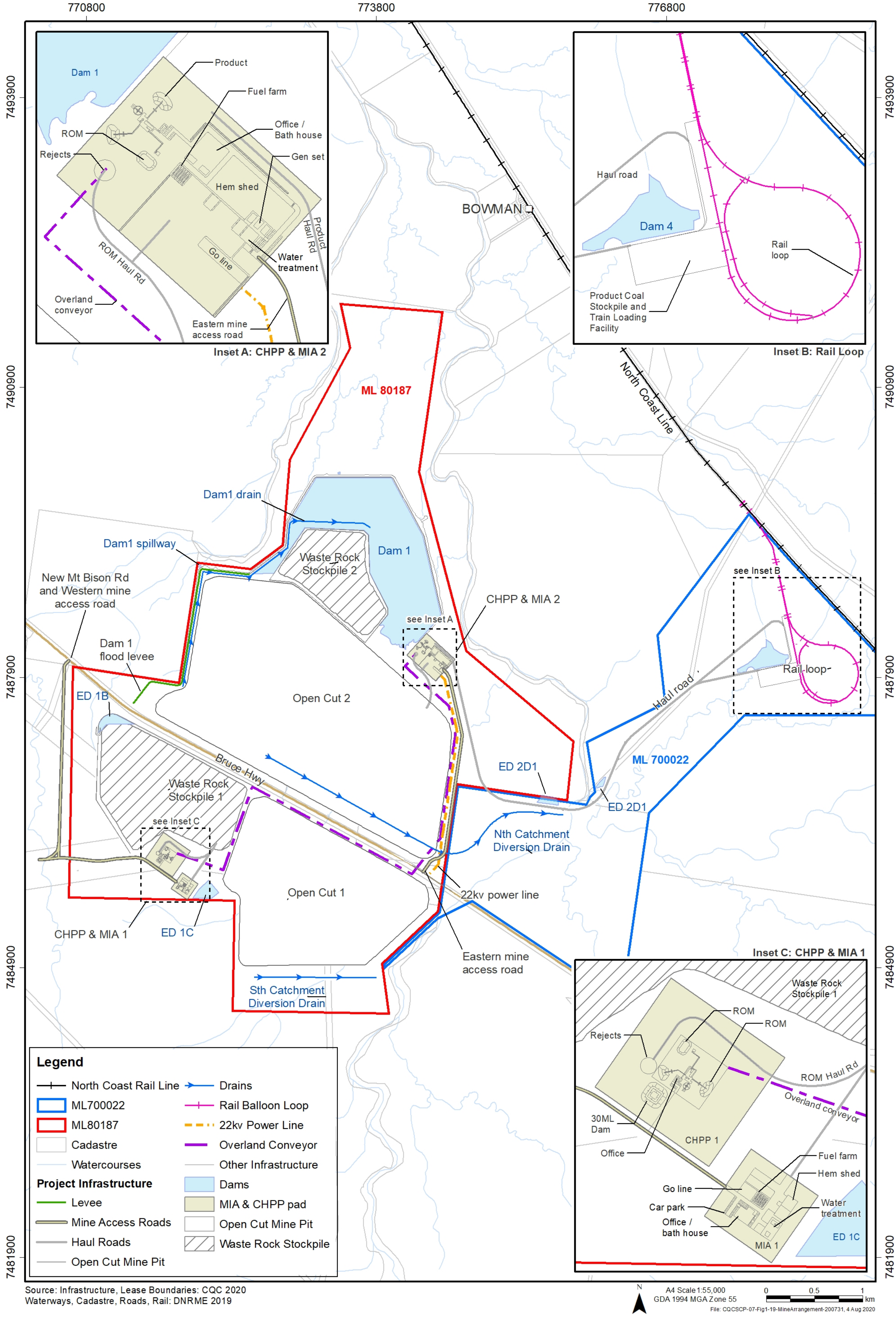


Figure 2-2: Mine Layout.

3 Relevant Legislation and Guidelines

3.1 Legislation

The key pieces of legislation relating to water quality management in Queensland are as follows:

- *Environmental Protection Act 1994* (EP Act)
  - Subordinate *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP [Water])
- *Fisheries Act 1994*
- *Water Act 2000*

In addition, due to the proximity of the project to the coast and the Great Barrier Reef Marine Park area, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* is potentially relevant to the project in terms of water quality.

These are described in more detail below.

3.1.1 *Environmental Protection Act 1994* (Qld)

The EP Act provides the key legislative framework for environmental management and protection in Queensland. The object of the EP Act is to 'Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains ecological processes on which life depends' (s3).

The EP Act has a range of subordinate legislation, including the Environmental Protection Regulation 2019 (EP Regulation) and EPP (Water). The EP Regulation controls activities with potential to release contaminants into the environment (Environmentally Relevant Activities [ERAs]), contains referrable wetland requirements, prescribes water contaminants (Schedule 9) and sets Environmental Values (EVs) for wetlands (s 81A). The EP Act and EP Regulation regulate mining and associated ERAs through EA conditions. These conditions provide a means to regulate surface water management for the Project.

With the passing of the *Environmental Protection (Great Barrier Reef Protection Measures) and Other Legislation Amendment Bill 2019*, the EP Act has been amended to address land-based sources of water pollution flowing to the Great Barrier Reef. The new 'Reef protection regulations' came into effect on 1 December 2019 and are to be rolled out over three years, including:

- New, expanded or intensified regulated industrial land use activities such as sewage and water treatment plants, land-based aquaculture or mining in any Reef region must meet new discharge standards to ensure there is no increase in nutrient or sediment pollutant loads from 1 June 2021
- Other primary producer requirements, including compliance with industry specific minimum practice agricultural standards, farm nutrient budgets, environmental authorities for new or expanded cropping or horticulture.

The regulations apply to specific reef regions, with the Project being located in the Fitzroy reef region, in the Styx river basin (no. 127).

3.1.1.1 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The EPP (Water) seeks to achieve the objectives set within the EP Act in relation to Queensland waterways. That is, it seeks to: 'Protect Queensland's waters while allowing for development that is ecologically sustainable' (s3 EP Act).

This purpose of this policy is achieved by:

- Identifying EVs and management goals for Queensland waters.
- Stating water quality guidelines and water quality objectives to enhance or protect the EVs.
- Providing a framework for making consistent, equitable and informed decisions about Queensland waters, and
- Monitoring and reporting on the condition of Queensland waters.

The Styx River basin, including all waters of the basin, Broad Sound and adjacent coastal waters (basin 127 and adjacent to basin 127) are scheduled waters under Schedule 1 to the EPP (Water). EVs and water quality objectives (WQOs) are described for these waters in the document *Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives* (EHP 2014), made pursuant to the previous Environmental Protection (Water) Policy 2009. These are shown in Section 6.4 in comparison to the collected data.

3.1.2 *Fisheries Act 1994* (Qld)

The *Fisheries Act 1994* is the key piece of legislation regulating fishing, development in fisheries habitat areas, and damage to marine plants in Queensland. It regulates land-based activities that may damage declared fish habitat areas and marine plants such as mangroves, with technical detail for mechanisms created by the act outlined in the Fisheries Regulation 2008 (Qld), including:

- Closed waters and protected areas (e.g. Green Zones in the Great Barrier Reef Marine Park)
- Protected species (e.g. dugongs).

The Act is administered by the Department of Agriculture and Fisheries.

The freshwaters in the region house habitat areas for some species of fish, including Barramundi and sea mullet, and a declared Fish Habitat Area (FHA-047) is located downstream of the site, terminating at the Styx River bridge at Ogmore.

Marine plants are also located downstream of the site, within the declared Fish Habitat Area.

3.1.3 Water Act 2000 (Qld)

The Water Act 2000 and subsidiary Water Regulation 2016 provide a framework for the sustainable management of Queensland's water resources, primarily for the planning, allocation and use of groundwater and surface water, provision of a sustainable and secure water supply and demand management, and the management of groundwater impacts due to the exercise of underground water rights by the resources sector. Authorisation under the Water Act is generally required for the taking of water from overland flow, groundwater, a watercourse, lake or spring; for destroying vegetation, excavation or placing fill in a watercourse, lake or spring; or removal of quarry material from a watercourse or lake, unless an exemption applies. For resources activities, the taking or interfering of water in the area of the mineral development licence or mining lease is exempt from further approvals under the Act if it takes place during the course of, or results from, the carrying out of an authorised activity for the licence or lease.

The Water Act provides for the protection of natural ecosystems and security of supply to water users through the development of water resource plans (WRPs), and other activities. Each managed catchment in Queensland has a separate WRP and associated Resource Operations Plan (ROP) to provide a framework to apply (under the Water Act, Chapter 2 Part 6) and regulate water extractions to ensure that they are maintained as a sustainable resource. The Project is located within the Styx River Basin, which is not covered by any WRP or ROP. Should a future catchment-specific water plan be developed, relevant licensing requirements for the Project will need to be considered at that time.

The Act also provides for the identification of watercourses, including downstream limits of defined watercourses.

3.1.4 *Environment Protection and Biodiversity Conservation Act 1999* (Cwth)

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) regulates:

- impacts on Matters of National Environmental Significance (MNES)
- impacts on the environment involving the Commonwealth or Commonwealth land
- killing or interfering with listed marine species and cetaceans (e.g. whales), and
- international trade in wildlife.

Importantly, the Act administers the approval for actions with a significant impact on MNES.

These, and actions by the Commonwealth or involving Commonwealth land with a significant impact on the environment are termed controlled actions and require approval under the Act.

The Project was identified as having the potential to impact on MNES and was determined to be a controlled action (EPBC ref 2016/7851) requiring assessment and approval under the EPBC Act. The controlling provisions are:

- World Heritage properties (sections 12 & 15A)
- National Heritage places (sections 15B & 15C)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)
- Great Barrier Reef Marine Park (sections 24B & 24C)
- A water resource, in relation to coal seam gas development and large coal mining development (section 24D & 24E).

In terms of water resources for the project, the World Heritage and Great Barrier Reef Marine Park (GBRMP) MNES are potentially triggered, as well as groundwater resources potentially impacted by dewatering activities. Based on the results of other assessments for the Project, it is not anticipated that downstream water quality will be affected by the mine to the extent that they can impact on the GBRMP and world heritage area.

3.2 Applicable Guidelines

The National Water Quality Management Strategy (NWQMS) presents the overarching national approach to improving and managing water quality in Australia’s waterways. The Australian & New Zealand Guidelines for Fresh & Marine Water quality (ANZG 2018) (hereafter the Australian Water Quality Guidelines, or AWQG) are a key part of the NWQMS and provide authoritative guidance on the management of water quality in Australia and New Zealand. The AWQGs are implemented through the Water Quality Management Framework - a framework providing a logical process to be followed for the long-term management of receiving water/sediment quality.

The AWQGs provide guidance on developing monitoring programs, selecting relevant indicators, and adopting relevant guideline values to assess change in receiving environments, including a framework for developing locally derived guideline values.

In Queensland, the approach to adopting guideline values for receiving waters is:

- EPP (Water) scheduled environmental values (EVs) and water quality objectives (WQOs) (same as guideline values), unless sufficient local data is available to derive improved local guideline values from appropriate reference sites
- End of catchment anthropogenic pollutant reduction targets in Great Barrier Reef catchments contained in the Great Barrier Reef River Basins, End-of-Basin Load Water Quality Objectives (DES 2019a), derived from the Reef 2050 Water Quality Improvement Plan 2017–2022 (State of Queensland, 2018)
- Queensland water quality guidelines (EHP 2013) (QWQGs) - in the absence of EPP (Water) scheduled values
- AWQG Default guideline values.

As noted in Section 3.1.1.1, the Styx basin is scheduled under the EPP (Water). The QWQGs provide regional guideline values for Queensland water types and regions, and approaches that complement the AWQGs for Queensland conditions, including a framework for deriving and applying local guideline values.

Water monitoring protocols are contained in the Queensland Monitoring and Sampling Manual (DES 2018).

Note that the use of the terms *Water Quality Objectives*, *Guideline Values* and *Trigger Values* is somewhat interchangeable. In this report, the term Default Guideline Value (DGV) is used when referring to the existing default criteria after the AWQG approach. WQOs within the EPP (Water) documentation are referred to as Water Quality Objectives (WQOs) in that document, and so in some limited instances this term has been used in this report (Section 3.1.1.1 and above). Otherwise, these too are referred to as DGVs.

For generating site specific criteria for further action, and to ensure clarity from existing DGVs, the term Site-Specific Trigger Values (SSTVs) have been used. This follows the use of the terminology in Queensland and the QWQGs. As noted above, this would be interchangeable with the term site specific guideline values as it may be used under the AWQGs.

4 Existing Environment

4.1 Climate

The Project region experiences a sub-tropical climate, with cool winters and hot summers. Mean winter (July) temperatures range between around 8 and 25°C, whilst mean summer (December-January) temperatures range between around 23 and 33°C.

The Study Area experiences a distinct wet season with more rainfall occurring during the summer months (December to March), and drier periods predominating in the winter and early spring months (June to September). The wet season experiences an increased number of storm events leading to relatively short-lived but intense rainfall events and cyclonic rain depressions can develop over the area. The average annual rainfall at Strathmuir (BoM Station 033189) is 759 mm, with the highest average rainfall month (143 mm) being February and the lowest average rainfall month (16 mm) being September (Figure 4-1). Recharge and stream runoff potential is highest during the summer months, when most rainfall occurs, although long lasting rainfall events at other times of the year could also give rise to sustained rates of recharge.

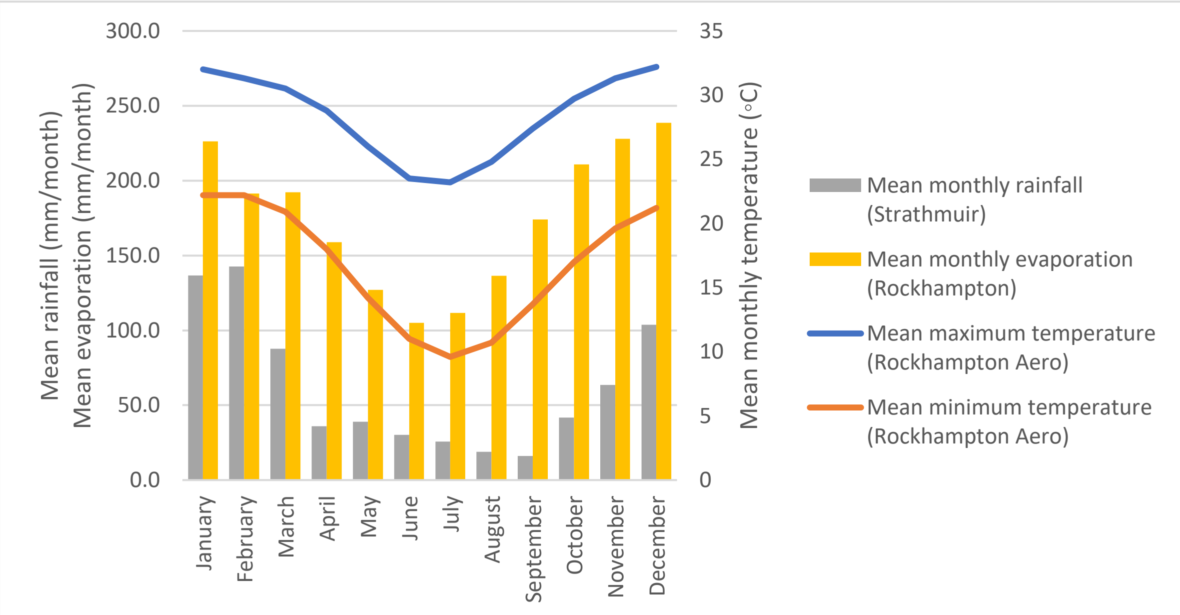


Figure 4-1: Mean climatic conditions

The mean monthly evaporation (calculated from the long-term average daily evaporation at Rockhampton Aero (BoM Station 039083) ranges from a maximum of around 240 mm/month in the summer months to a minimum of around 105 mm/month in the winter months. Total average annual evaporation (around 2,100 mm) is considerably higher than average annual rainfall, and on average evaporation rates exceed rainfall rates in every month of the year (Figure 4-1).

4.1.1.1 Rainfall during water sampling events

Figure 4-2 shows the actual rainfall for the November to May period (which covers wet season events) and full years versus the long-term average annual rainfall from the BOM Strathmuir rainfall gauge (BOM station 033189, prior to 2011, and from the Mamelon weather station (after July 2011, with some infill rainfall from the St. Lawrence Post Office station -BOM station 033065, March, June 2011; May – June 2017).

As can be seen, the FBA monitoring specifically targeted high rainfall events, while the other monitoring by the Proponent covered a range of rainfall periods, from above average (2011, 2017) to well below average (2018, 2019). Most of the data available covers the 2011 – 2020 period, which includes a good range of wetter and drier years.

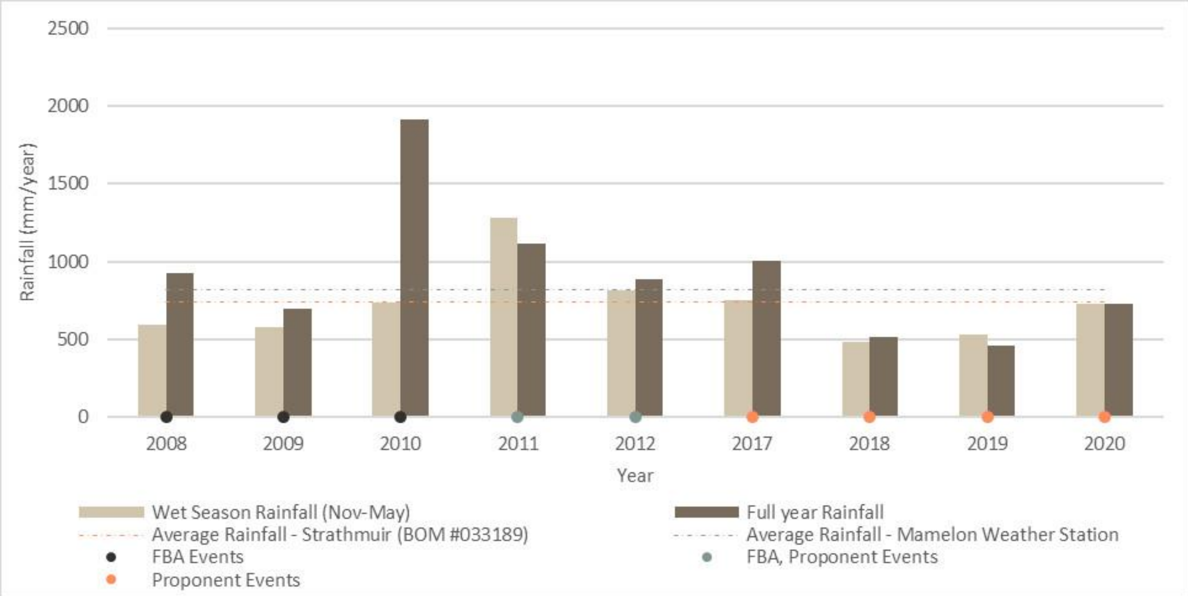


Figure 4-2: Average vs Actual Annual Rainfall - Sampling

4.2 Surface Water Catchments

4.2.1 Styx Basin

The Project is located within the North East Coast Drainage Division, within the Styx River basin (Queensland river basin 127), a small basin of around 3,000 km^2 discharging into the Coral Sea adjacent to Rosewood Island (in the vicinity of the Project) with an estimated annual average discharge (for all rivers) of 271GL/year (Dougall et al. 2014). It is formed by the Connors and Broadsound Ranges to the west and is located within the Central Queensland Coast region. No Water Plan is in force over the catchment.

Landuse in the basin is predominantly 'Production from relatively natural environments' (91%) – predominantly grazing - followed by 'Conservation and natural environments' (8%) and 'Intensive uses' (1%) which comprise transport and communication, residential and farm infrastructure, services and mining (DES 2019b). The remainder is predominantly water (saline coastal wetland areas, rivers and dams), with minor areas of dryland and irrigated agriculture (0.5%). The Styx basin has been extensively cleared for grazing.

An earlier land condition survey conducted by Melzer *et al* (2008) found the catchment to be degraded, noting that around 30% of the Styx catchment was in a high to very high disturbance class, generally represented by bare ground and eroded surfaces. The study noted several points in the catchment where 'erosion and land degradation must be considered severe'. The land condition survey noted that these most likely represent significant point sources of sediment to the streams, and places threats to road infrastructure. Seven very severe and six severe cases were identified where there was direct discharge to streams.

The most recent catchment condition assessment related to water quality for the Styx basin is included in the Reef Water Quality Report Card 2017 and 2018 (DES 2019c). The results against the three target areas were as follows:

- water quality targets - minimal anthropogenic dissolved inorganic nitrogen, particulate nitrogen and phosphorous and sediment loads, against a target of *Maintain Current Loads*, with the target for minimal pesticide risk met.
- Catchment management targets - groundcover and natural wetlands (lakes, swamps and estuarine wetlands) extent were both provided a B grade (89% area with target cover against a 90% target, <0.1% loss against a no loss target respectively), with riparian extent receiving a D grade, for 0.97% loss (with a no loss target). Groundcover does appear to be reducing over time (from 97% in 2010), but this may be a result of lower rainfall trends.
- Land management targets - grazing was graded a D, with 29.4% adoption of best management practice systems for water quality outcomes (soil, nutrient and pesticides), against a target of 90%. This was based on:
  - gully management (20.7% adoption, grade E)
  - pasture management (26.7% adoption, grade D) and
  - streambank management (40.9% adoption, grade D).

The two assessments (Melzer *et al* 2008; DES 2019c) approached the issue from different perspectives, and observations in the Deep and Tooloombah Creek catchments have identified areas of potentially severe erosion with a number of gullies identified as potential sources of high sediment loads (Gippel 2020).

4.2.2 Sub-catchments

The Styx subbasin comprises several coastal catchments, grouped into three overarching areas (after the EPP [Water]), namely:

- Northern Styx Freshwaters:
  - Clairview, St Lawrence, Waverley and Amity Creeks
- Styx River, St Lawrence, Waverley and other creeks (estuarine reaches):
  - Estuarine coastal areas mostly north of the Styx River and Broadsound Estuaries, but including a strip along the southern shore of the Styx River and Broadsound Estuarines
- Southern Styx Freshwaters:
  - Granite and Montrose Creeks
  - Tooloombah and Deep Creeks
  - Styx River and Wellington Creeks.

The location of the Project in relation to the catchments and waterways is shown in Figure 4-3 and Figure 4-4.

4.2.2.1 Project Catchments

The Project is located predominantly within the Deep Creek sub-catchment with a smaller area within the Tooloombah Creek sub-catchment, within the Southern Styx Freshwaters EPP (Water) catchment area. These Creeks drain into the Styx River and then into the Styx River and Broadsound Estuaries. The downstream limit of the Styx River as defined under the *Water Act 2000* is located approximately 4km downstream of the lease boundary, approximately 1.7km further downstream from the confluence of Deep Creek into Tooloombah Creek (refer Figure 4-4).

The Broad Sound Declared Fish Habitat Area (FHA-047) and a General Use Zone of the Great Barrier Reef Marine Park are located within the Styx River approximately 10km downstream of the Project lease boundary.

The upper reaches of Tooloombah and Deep creeks extend west to the Broadsound Range which is characterised by steep topography with grades of approximately 10%. The majority of the lower reaches of the catchment where the Project is located are characterised by generally flat terrain with slopes less than 0.5%. The main watercourses are deeply incised, with Tooloombah Creek channel significantly larger than the Deep Creek channel.

The upper catchments are well vegetated with significant portions of the lower catchment cleared, although most of the incised creek channels of Tooloombah and Deep creeks remain well vegetated. Both creeks are ephemeral waterways, and flow for approximately 20% of the time (so no flow for ~80%), predominantly during the wet season (WRM 2020). At other times, the creeks are dry or form a series of disconnected pools, which gradually reduce in size due to evaporation. Some pools are fed by groundwater, resulting in their persistence during the dry season for longer than other pools.

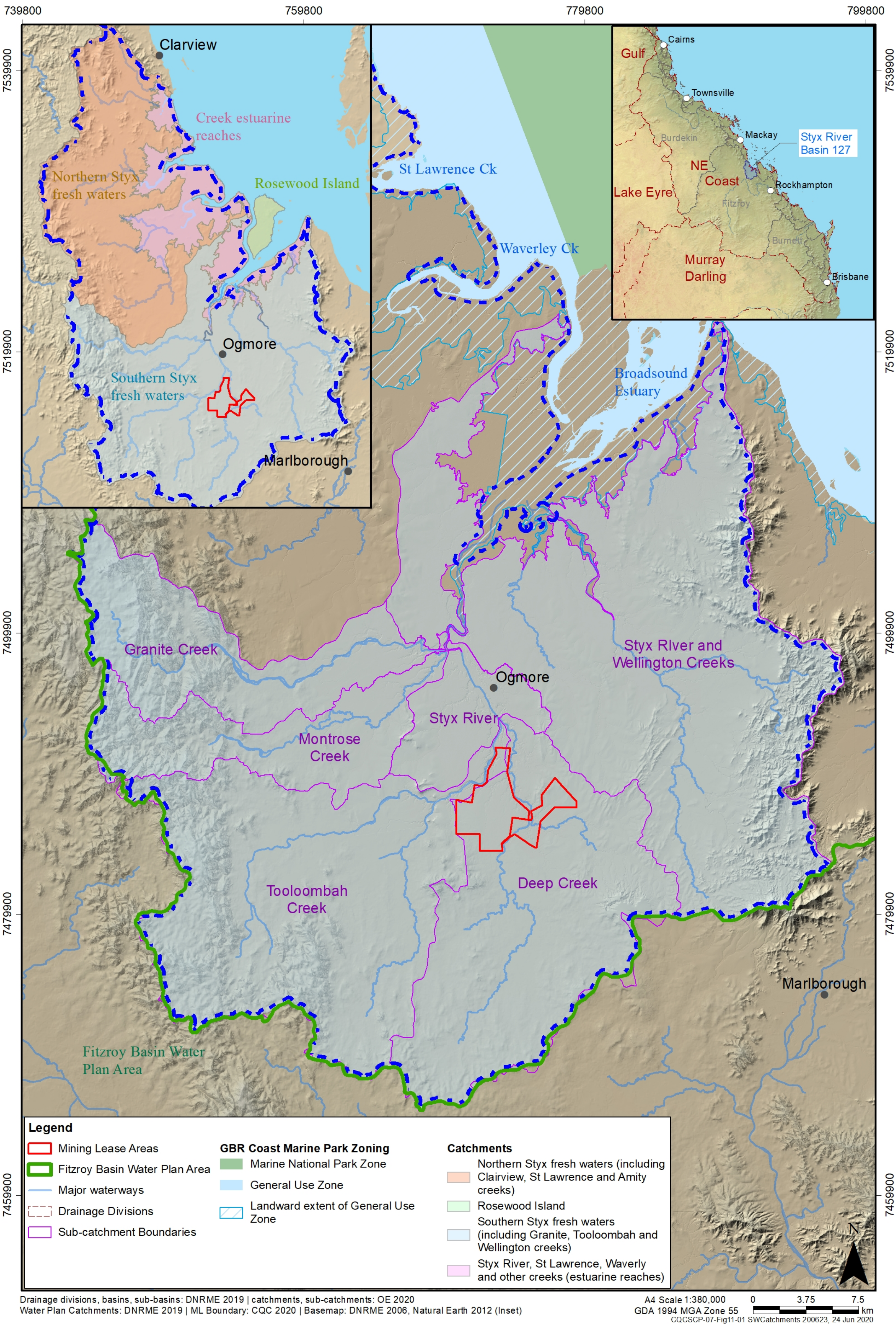
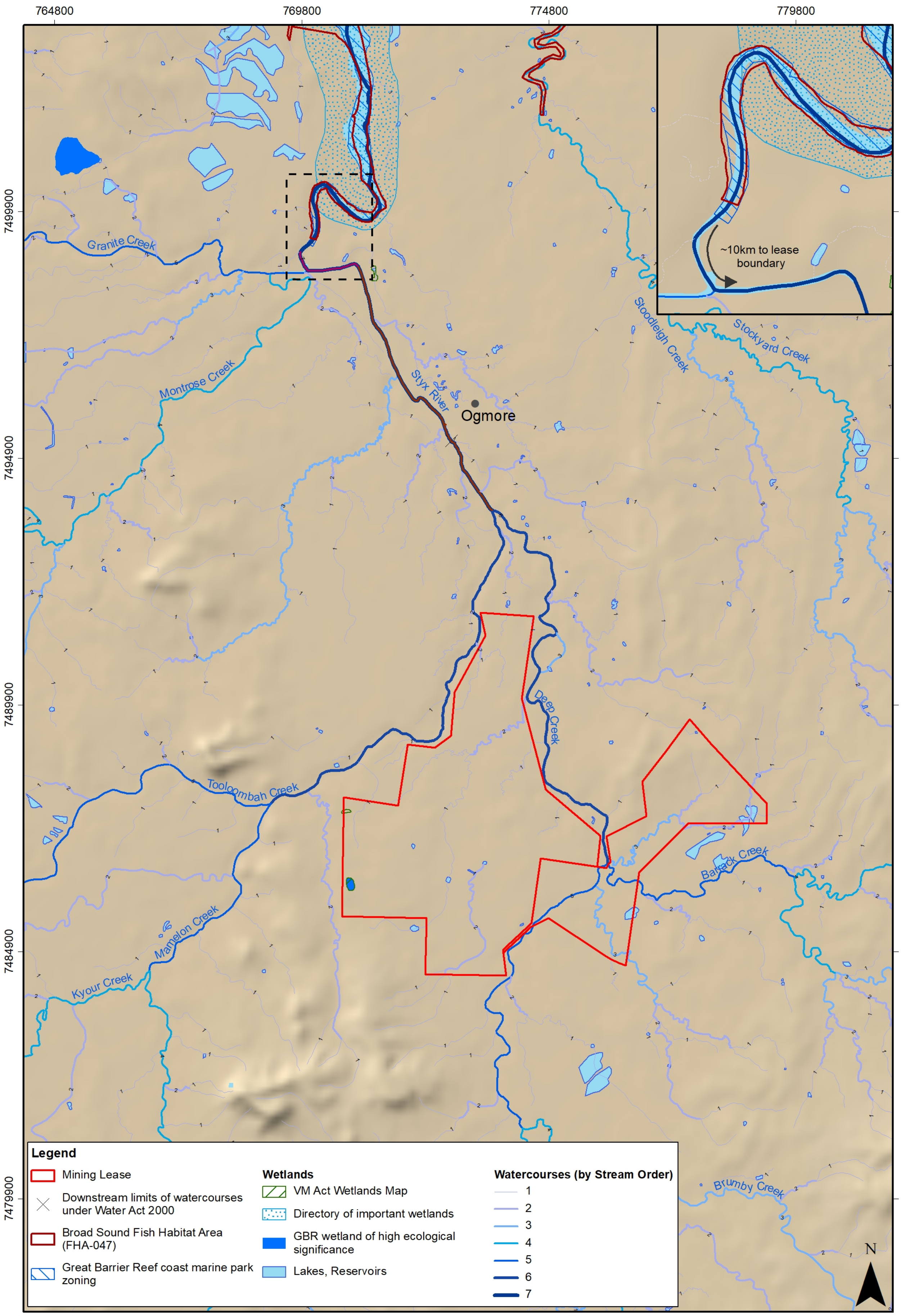


Figure 4-3: Catchments



Sub-catchment areas: OE 2020 | Fish Habitat Areas: DNPSR 2016 | Downstream Limits: DNRME 2019 | VM Wetlands: DNRME 2019
Directory of important wetlands: DES 2005 | GBR Wetlands: DES 2019 | GBR Coast Marine Park Zoning: DERM 2009
ML Boundary: CQC 2020 | Lakes, Reservoirs: DNRME 2019 | Basemap: DNRME 2006

A4 Scale 1:110,000
GDA 1994 MGA Zone 55
0 1 2 km
CQCSCP-07-Fig11-02-DrainageFeatures-200625, 25 Jun 2020

Figure 4-4: Waterways

Key parameters of the catchments and sub-catchment areas within the Styx basin are summarised in Table 4-1.

Table 4-1. Catchment summary information

Catchment	Total Area (km²)[1]	Main Reach Length (km)	Highest Elevation (m AHD)	Project Area within catchment (km²)[1]		Flow Proportion (ephemerality)
				Lease Area	Disturbance Area	
Styx River Basin	3013	-	616	26.6	13.7	-
Northern Styx Freshwaters	1002 (33%)	-	608	-	-	-
Styx River, St Lawrence, Waverly and other creeks (estuarine reaches)	377 (13%)	-	27	-	-	-
Southern Styx fresh waters	1633 (54%)	-	616	26.6	13.7	-
Deep Creek	303 (19%)	46.2	249	24.5 (8.1%)	13.3 (4.4%)	20%
Tooloombah Creek	370 (23%)	47.6	534	2.1 (0.6%)	0.4 (0.1%)	
Granite Creek	155 (9%)	43.5	616	-	-	-
Montrose Creek	122 (7%)	42.8	550	-	-	-
Styx River and Wellington Creeks	683 (42%)	~45.7[2]	510	-	-	-

Table notes:

1 percentages represent the proportion of the catchment at the next level up – for Southern Styx fresh waters sub-catchments, these represent the percentage of the Southern Styx fresh waters; for the Southern Styx fresh waters, it is the proportion of the entire Styx River basin. For the Project areas, the percentage provides the proportion of Deep and Tooloombah sub-catchments

2 Channel Length of Wellington Creek

4.2.2.2 Catchment Flow Characteristics

WRM (2020) undertook an assessment of natural catchment runoff in Tooloombah and Deep Creek catchments, with flow duration curves shown in Figure 4-5 and Figure 4-6 respectively, each calculated at the creek flow gauging stations (ToGS1 and DeGS1 respectively). These include indicative flow regimes based on the QWQG guidance (Section 2.5, EHP 2013) and the modelled runoff data as follows:

- Both Creeks are highly ephemeral, with flow approximately 20% of the time (flow above 1L/s, or 24% of the time flows above 0.1L/s)
- Stormflows account for <1% of flows, with stormflows typically above 30-40 m^3/s for Deep and Tooloombah Creeks respectively
- Flow modelling indicates storm flows to persist for 1 - 2 days, sometimes perhaps 3 days after an event (perhaps due to compounded rainfall). Based on turbidity levels recorded during storm event sampling by the Fitzroy Basin Association (FBA) from 2008 - 2012, levels would reduce after a peak over 1 - 2 days, matching the modelled flow data and qualitatively that found from field observations.

- Baseflows account for the bulk of flow events, at approximately 19% of flows between 1L/s and 30-40 m^3/s (or 23% of flows between 0.1L/s and 30 – 40 m^3/s).
- Baseflows persist for around 1 – 3 months after a single stormflow event, averaging around 2 months (20th to 80th percentiles 1.5 – 2.3 months)

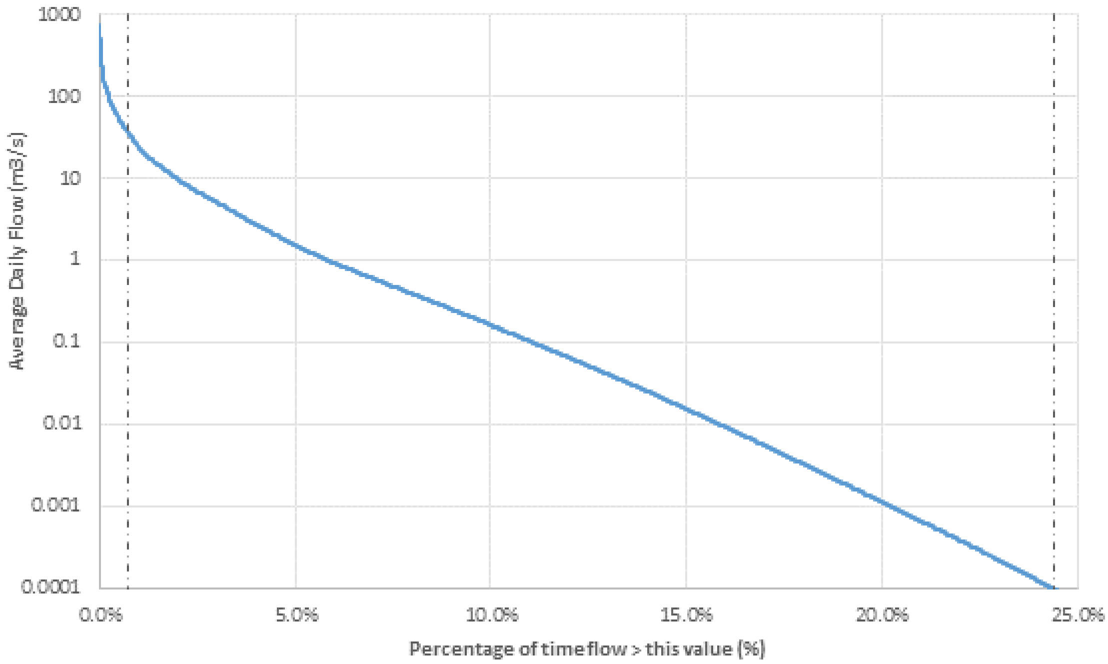


Figure 4-5: Tooloombah Creek Simulated Flow Duration Curve (after WRM, 2020)

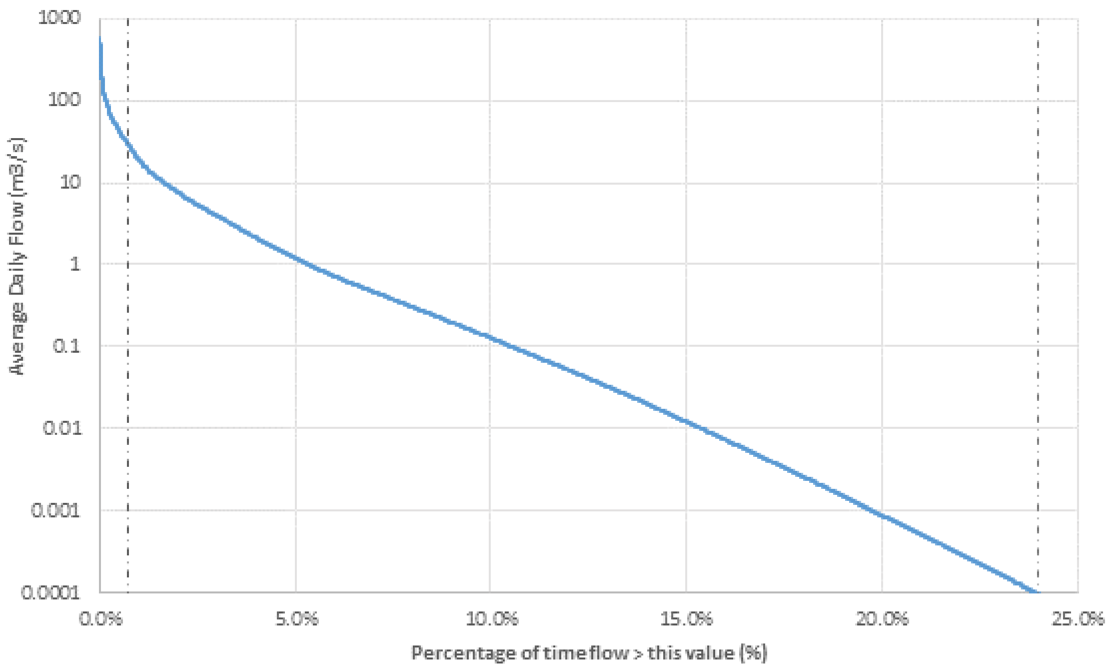


Figure 4-6: Deep Creek Simulated Flow Duration Curve (after WRM, 2020)

4.3 Water Types

With reference to the EPP (Water) as shown in Figure 4-7, the receiving waterways for the project are all identified as Lowland freshwaters, with Mid-estuary waters mapped downstream in the Styx River Estuary and lower estuary / enclosed coastal waters further to seaward.

Two palustrine wetlands are mapped within the western side of the lease boundary, representing Wetlands 1 and 2 (Wet 1 and Wet 2).

Given the predominantly modified grazing nature of the catchment, a slightly-moderately disturbed ecosystem type is adopted, both for fresh and estuarine waters. This is consistent with the designation under the EPP (Water) for these areas.

Lowland Freshwaters

Lowland freshwater streams are defined by the QWQG as freshwater streams below 150m or otherwise larger (third, fourth and fifth order or greater), slow-flowing and meandering streams and rivers. Their gradient is generally very slight, with substrates rarely cobble and gravel, and more often sand, silt or mud.

Estuarine Waters

The Styx River is a tidally influenced river and estuary, approximately 35 km long (to the Broadsound estuary) and is subject to one of the largest tidal ranges in Queensland. It is known for its tidal bore, a wave or series of waves that propagate upstream in certain rivers subject to large tidal ranges.

The tidally influenced portion of the Styx River is located up to approximately the Ogmore Road Bridge crossing with a transitional zone extending during peak tides (i.e. tidal bore) to the Tooloombah Creek / Deep Creek confluence.

This location is consistent with the DNRME (2019) highest astronomical tide mapping, and salinity levels monitored at both the bridge and confluence are consistent with tidally influenced waters (salinity up to approximately 40 ppt, with average seawater salinity ~35 ppt). A major assemblage of Marine Couch (*Sporobolus virginicus*) has also been observed up to just upstream of the Ogmore bridge, with lesser occurrences up to the Deep and Tooloombah Creek confluence (CDM Smith 2018). Marine Couch is a widespread ecologically important costal species of the tropics and subtropics that commonly occurs along beaches, estuaries, and in mangrove communities and salt marshes where there is interaction with highly brackish to saline water (CDM Smith 2018).

Using the decision tree from the QWQG (Figure B.1: Decision tree to determine presence/absence of an upper estuarine zone), no upper estuary can be defined for the Styx River Estuary. The middle estuary begins below the freshwater/estuarine cut-off and extends downstream to near the mouth of the estuary at the coast. From this and the monitoring results it may be concluded that the St1 site would be mid-estuary or freshwater, with the St2 site mid-estuary. However, Since the St1 site is so heavily influenced by upstream flows, it is considered more appropriate to adopt the lowland streams water type.

4.4 Surface Water Pools

Given the highly ephemeral nature of waterways within the Project area, an assessment of the location and nature of pools within the main waterways was undertaken, with the results provided in Attachment E.

4.5 Historical Water Quality

Little historical data is available for the catchment prior to monitoring by the proponent, with the exception of monitoring by the FBA, who established a monitoring site on the Styx River at Ogmore (at the St1 monitoring site). Water quality sampling was undertaken by the FBA for five years during wet season months with around 19 distinct events captured between January 2008 and March 2012 (some of which were rainfall events, some individual monitoring events during low flow).

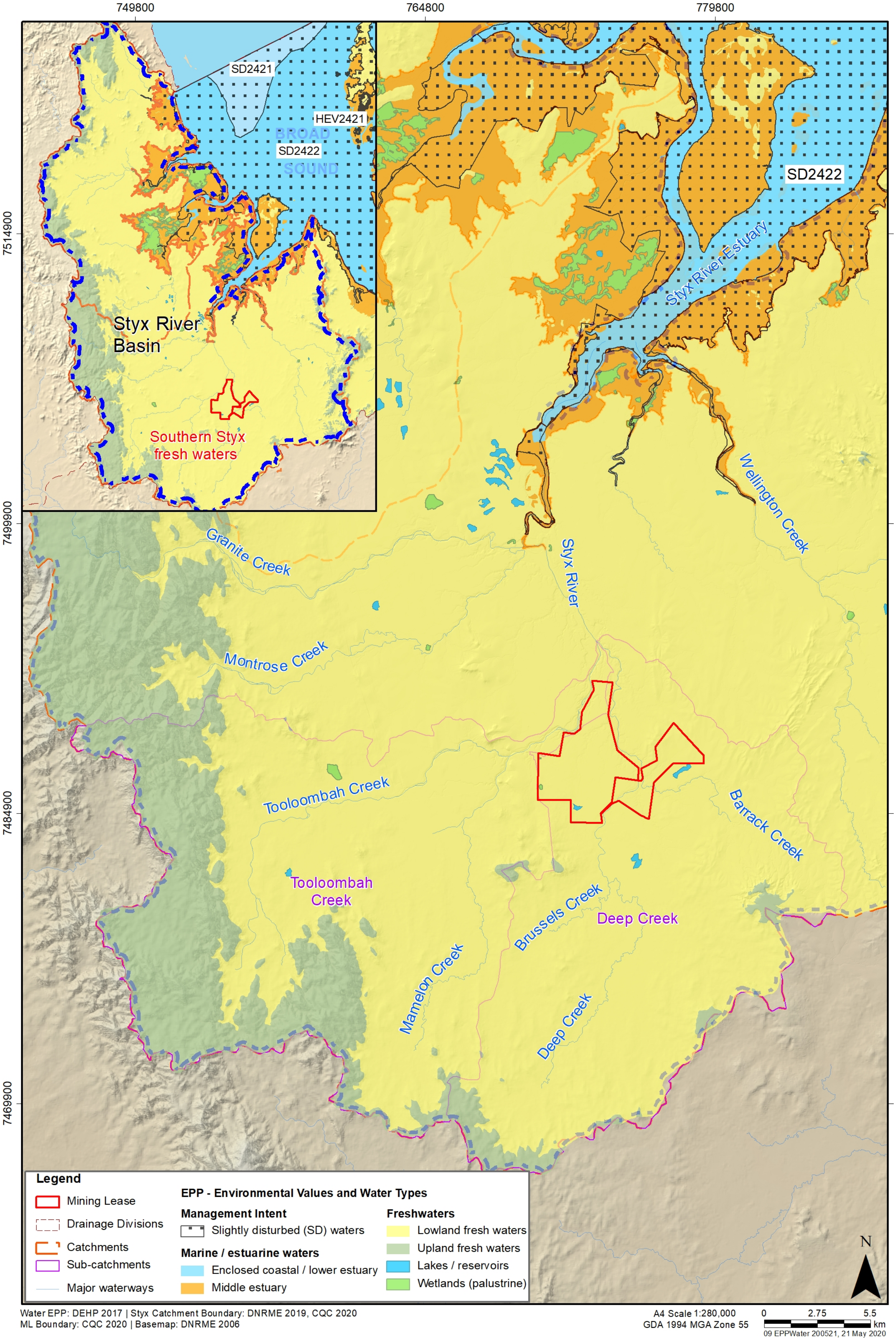


Figure 4-7: EPP (Water) Water Types and Management Intent

5 Environmental Values

Environmental Values (EVs) for water are the qualities of water that support a level of aquatic ecosystem function and / or human water uses. These EVs can be impacted by the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use.

Specific EVs were developed for the Styx River, Shoalwater Creek and Water Park Creek Basins in 2014 under the Environmental Protection (Water) Policy 2009 (EPP Water) in the document *Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives* (EHP 2014) as shown in Table 5-1.

Table 5-1 Environmental Values for Project catchments

Symbol	Environmental Value	SURFACE FRESH WATERS (rivers, creeks, streams) in developed areas (e.g. urban, industrial, rural residential, agriculture, farmlands) - Southern Styx fresh waters (including Granite, Tooloombah and Wellington creeks)	ESTUARIES / BAYS, COASTAL AND MARINE WATERS - Styx River, St Lawrence, Waverley and other creeks (estuarine reaches)
	Aquatic ecosystems (SMD)	✓	✓
	Irrigation	✓	
	Farm supply	✓	✓[1]
	Stock water	✓	✓[1]
	Aquaculture		
	Human consumer	✓	✓
	Primary recreation	✓	
	Secondary recreation	✓	✓
	Visual recreation	✓	✓
	Drinking water	✓	
	Industrial use		
	Cultural and spiritual values	✓	✓

Table notes:

1 It is considered unlikely that the true estuarine waters of the Styx River would be suitable for farm supply or stock water, although suitably fresh flows do occur in the upper reaches during flow periods

6 Water Quality

6.1 Overview

Surface water quality data was available between January 2008 to the present, from the following sources:

- January 2008 to March 2012 – 21 discrete monitoring events by the FBA covering mostly storm events
- June 2011 to July 2012 – 12 approximately monthly events by the proponent covering several storm events and otherwise mostly baseflow events, and
- February 2017 to the present – 37 approximately monthly events by the proponent up to 28 May 2020 (for the purposes of this assessment), predominantly 'no flow' events – that is, events with little to no discernible longitudinal flow along the creeks, due to the extended dry conditions.

The sections below outline the key methodology utilised in the above monitoring rounds, an analysis of the data for any perceived bias, comparison with existing DGVs for the catchment, and derivation of new SSTVs based on the available data. For the purposes of assessing the data, all of the results from the various sources have been combined.

6.2 Sampling Sites and Events

Surface water quality monitoring datasets have been collected in the Styx River catchment since 2008, at the locations shown in Figure 6-1. Water quality sampling events and monitoring sites are summarised in Table 6-1.

Based on the total flow duration curve, one would expect sample events to encounter, on average, around 1% stormflows, approximately 19% baseflows (so ~20% flow events), and the remainder (80%) either no-flow or dry events. The proportion of samples is reasonably close to this as follows:

- Deep Creek - averaging ~4% of events for stormflow, and close to 20% for storm + baseflow
- Tooloombah Creek - a little higher stormflow average, at ~13% of events, and 35% for storm + baseflow). However, the longer duration sites To1, To2 and To3 averaged 3.5% stormflows and ~27% for storm + baseflow.
- Other Creeks - higher stormflow proportion, averaging ~37% stormflows.

It is expected that there are missing 'dry' records for some of the sites, as well as some tendency to target events after rainfall rather than dry periods in sampling, and this would likely explain the small discrepancy (the slightly higher proportion of stormflows sampled than would be expected, given the relatively low frequency of flow). The long term Deep and Tooloombah Creek sites appear to be suitably unbiased for determination of long-term overall statistics, with the exception of the St1 site. This site included targeted storm event monitoring to derive Event Mean Concentrations (EMCs) by the FBA. While useful for that purpose, in determining overall statistics, the FBA data biases the results towards stormflows. As such, this should be considered separately from the remaining (non-FBA collected) data.

Table 6-1. Surface Water Monitoring Sites

System		Site	Number of events[1]				Number of events by flow category				
			Jan-08 to Mar-11	Jun-11 to Jul-12	Feb-17 to May-20	Total	Dry	No flow (pooling)	Baseflow	No flow + Baseflow	Stormflow
Deep Creek		SW-WMP08	-	-	1	1	-	1 (100%)	-	1 (100%)	-
		De1	-	10 (6f)	36 (1f, 18c)	46	18 (39.1%)	18 (39.1%)	8 (17.4%)	26 (56.5%)	2 (4.3%)
		De2	-	12	36 (11c)	48	9 (18.8%)	27 (56.3%)	8 (16.7%)	35 (72.9%)	4 (8.3%)
		De2.1	-	1	-	1	-	-	1 (100%)	1 (100%)	-
		De3	-	8	37 (14c)	45	13 (28.9%)	24 (53.3%)	7 (15.6%)	31 (68.9%)	1 (2.2%)
		De4	-	-	36 (4c)	36	4 (11.1%)	27 (75%)	4 (11.1%)	31 (86.1%)	1 (2.8%)
		De5	-	-	32 (1f, 2c)	32	2 (6.3%)	25 (78.1%)	4 (12.5%)	29 (90.6%)	1 (3.1%)
		De5.1	-	1	-	1	-	-	1 (100%)	1 (100%)	-
Tooloombah Creek		St1	14	17 (3f)	31	62	-	23 (37.1%)	17 (27.4%)	40 (64.5%)	22 (35.5%)
		SW-WMP02	-	-	2	2	-	2 (100%)	-	2 (100%)	-
		To1	-	12 (1f)	38 (2c)	50	2 (4%)	30 (60%)	14 (28%)	44 (88%)	4 (8%)
		To2	-	6	35 (1c)	41		28 (68.3%)	12 (29.3%)	40 (97.6%)	1 (2.4%)
		To3	-	-	32 (2c)	32	1 (3.1%)	27 (84.4%)	4 (12.5%)	31 (96.9%)	-
		To4	-	-	7 (1c)	7	1 (14.3%)	3 (42.9%)	1 (14.3%)	4 (57.1%)	2 (28.6%)
		ToGS1[2]	-	-	1	1	-	-	1 (100%)	1 (100%)	-
Styx River		St2	-	12	32 (3f)	44	N/A				
Wetlands		Wet1	-	-	5	5	-	-	-	-	-
		Wet2	-	-	6	6	-	-	-	-	-
Other Creeks	Amity Creek	Am1	-	2 (1f)	8 (3c)	10	3 (30%)	2 (20%)	2 (20%)	4 (40%)	3 (30%)
	Barrack Creek	Ba1	-	-[3]	14 (13c)	14	13 (92.9%)	1 (7.1%)	-	1 (7.1%)	-
		Ba1x	-	-	4 (2c)	4	2 (50%)	-	2 (50%)	2 (50%)	-
		Bar02	-	-	3	3	-	1 (33.3%)	-	1 (33.3%)	2 (66.7%)
	Granite Creek	Gr1	-	12	8 (3c)	20	3 (15%)	5 (25%)	8 (40%)	13 (65%)	4 (20%)

System		Site	Number of events[1] Jan-08 to Mar-11	Jun-11 to Jul-12	Feb-17 to May-20	Total	Number of events by flow category Dry	No flow (pooling)	Baseflow	No flow + Baseflow	Stormflow
	Hefer Creek	Hf1	-	1 (1c)	-	1	-	1 (100%)	-	1 (100%)	-
	Mamelon Creek	Mam01	-	-	4	4	-	1 (25%)	1 (25%)	2 (50%)	2 (50%)
	Montrose Creek	Mo1	-	11	8 (3c)	19	2 (10.5%)	5 (26.3%)	9 (47.4%)	14 (73.7%)	3 (15.8%)
		Mo2	-	11 (1f)	8 (1c)	19	1 (5.3%)	8 (42.1%)	6 (31.6%)	14 (73.7%)	4 (21.1%)
	Neerim Creek	Nee1	-	-	5	5	-	2 (40%)	1 (20%)	3 (60%)	2 (40%)
	Prospectors Creek	Pr1	-	1 (1c)	-	1	-	1 (100%)	-	1 (100%)	-
	Sandy Creek	Sandy01	-	-	2	2	-	-	1 (50%)	1 (50%)	1 (50%)
Estuarine Sites		STL_DS	-	1	-	1	-	-	-		-
		STL_US	-	1	-	1	-	-	-		-
		STYX_DS1	-	1	-	1	-	-	-		-
		STYX_DS2	-	1	-	1	-	-	-		-
		STYX_MID	-	1	-	1	-	-	-		-
		STYX_US	-	1	-	1	-	-	-		-
		WAV_DS	-	1	-	1	-	-	-		-
		WAV_US	-	1	-	1	-	-	-		-
		WELL	-	1	-	1	-	-	-		-
Dams		BPEast	-	-	3 (1c)	3	1 (33.3%)	-	-		-
		Ringtank	-	-	4	4	-	1 (25%)	-		-
		Surveyors	-	-	7	7	-	-	-		-
Other Pools	Tributary to Deep Ck	Dam PL	-	-	1	1	-	1 (100%)	-	1 (100%)	-
	Tributary to Barrack Ck	Pool 19	-	-	1	1	-	1 (100%)	-	1 (100%)	-
	Confluence Deep and Brussels Cks	De_Brussels Pool 7	-	-	1	1	-	1 (100%)	-	1 (100%)	-
	Tributary to Brussells Ck	Br Pool 15	-	-	1	1	-	1 (100%)	-	1 (100%)	-

Table notes:

1 Number refers to total number of sampling events, with the brackets providing, of the total, the number of (f) field only samples; (L) lab only samples; and (c) events where the site was visited, but no records taken (generally because it was dry)

2 This is the streamflow gauging station, and continuous pH, EC, temperature and flow are recorded. The events listed in this table for this site are field collected and laboratory analysed samples available

3 The site was visited and was always dry during sampling, however clear records of these events are not available. Dry records are expected to be similar to the longer running sites for this period (~10 – 12 events)

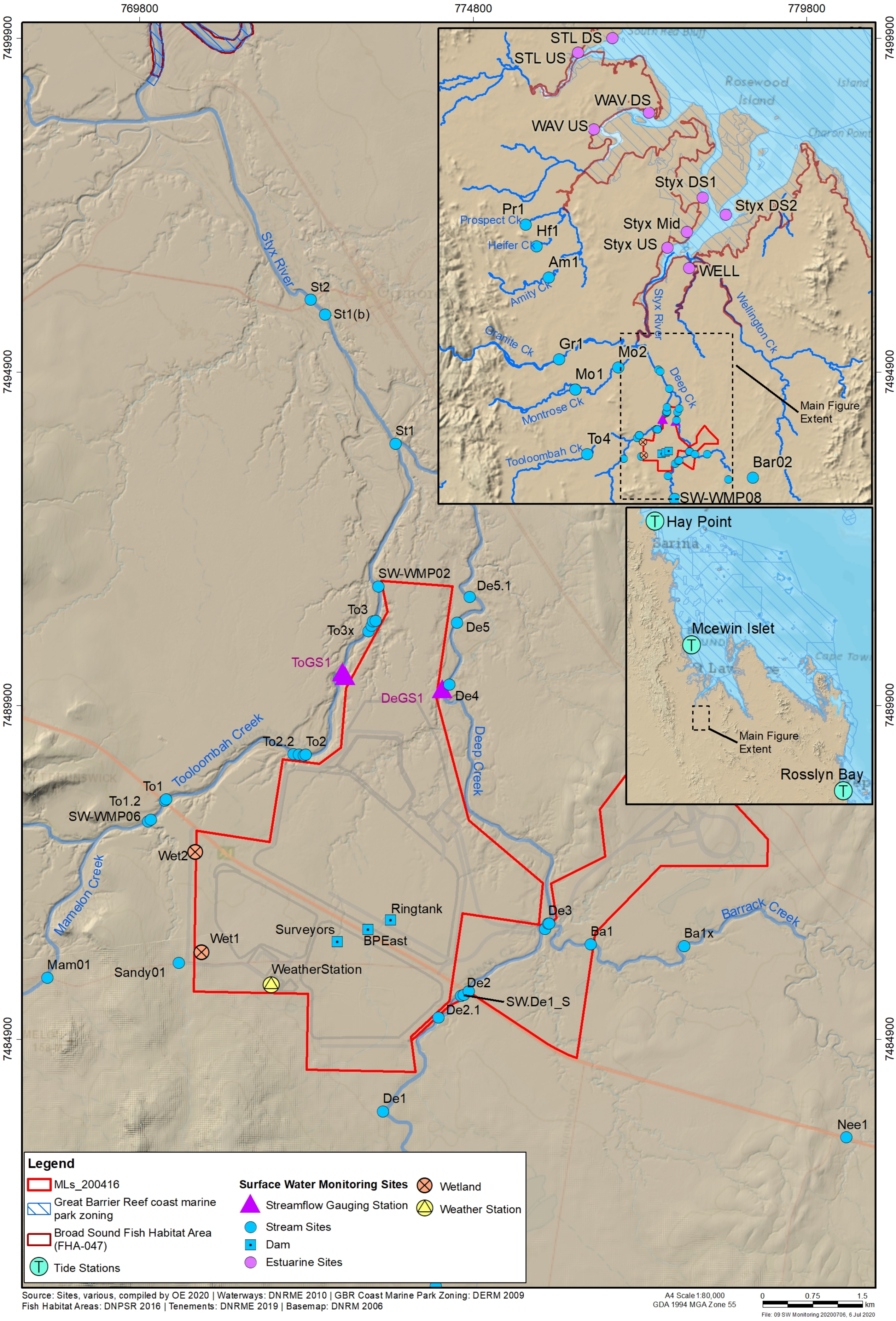


Figure 6-1: Surface Water Monitoring Sites

In terms of the number of sample events, sites De1, De2, De3, De4, De5, To1, To2, To3, St1 and St2 all exceeded the AWQG recommended 24 sample events. While not a concurrent monthly program, the high number of events, many of which were on a monthly basis, make these likely to be quite suitable for deriving SSTVs.

Several other sites were sampled over 18 times (taken as a suitable number for setting SSTVs under the QWQGs) – Gr1, Mo1 and Mo2. These sites provide good reference site data.

The number of sampling events are shown in Figure 6-2. This shows that the overall program has excellent coverage of the main Project site and lease area, with locations upstream and downstream. Sites with >24 sampling events are located along both Tooloombah and Deep Creeks, the confluence of both creeks and at the Ogmore Bridge, representing both upstream, adjacent and downstream reaches of these creeks in relation to the Project. Reference sites on Montrose and Granite Creeks have a good number of events recorded (19 and 20 respectively).

These sites provide excellent sample numbers for derivation of SSTVs, and for a before-after control-impact style assessment to be carried out. Some additional sampling should be conducted prior to the Project commencement, particularly at To4, Am1, and perhaps some of the downstream estuarine sites.

Based on the above, it is considered that the sites containing many events are likely to be representative of overall flow conditions, with any bias towards stormflows likely due to non-reporting of dry periods. Coverage is suitable to derive SSTVs for the potentially impacted watercourses, both immediately upstream of the Project, adjacent and downstream.

6.2.1 General Water Quality

In terms of general water quality parameters, all rounds included general physico-chemical parameters (pH, EC, TDS, etc.), with all but one including nutrients (this was for the purpose of radioisotope and fingerprinting of waters via major cations and anions). Cations and anions were included in all rounds other than the FBA monitoring. Radioisotopes were measured during one round (July 2018).

6.2.2 Toxicants

While the FBA monitoring rounds focused solely on phys-chem and nutrients, the CQC driven sampling program included a number of other constituents, with the proportion of events (excluding FBA rounds) as follows:

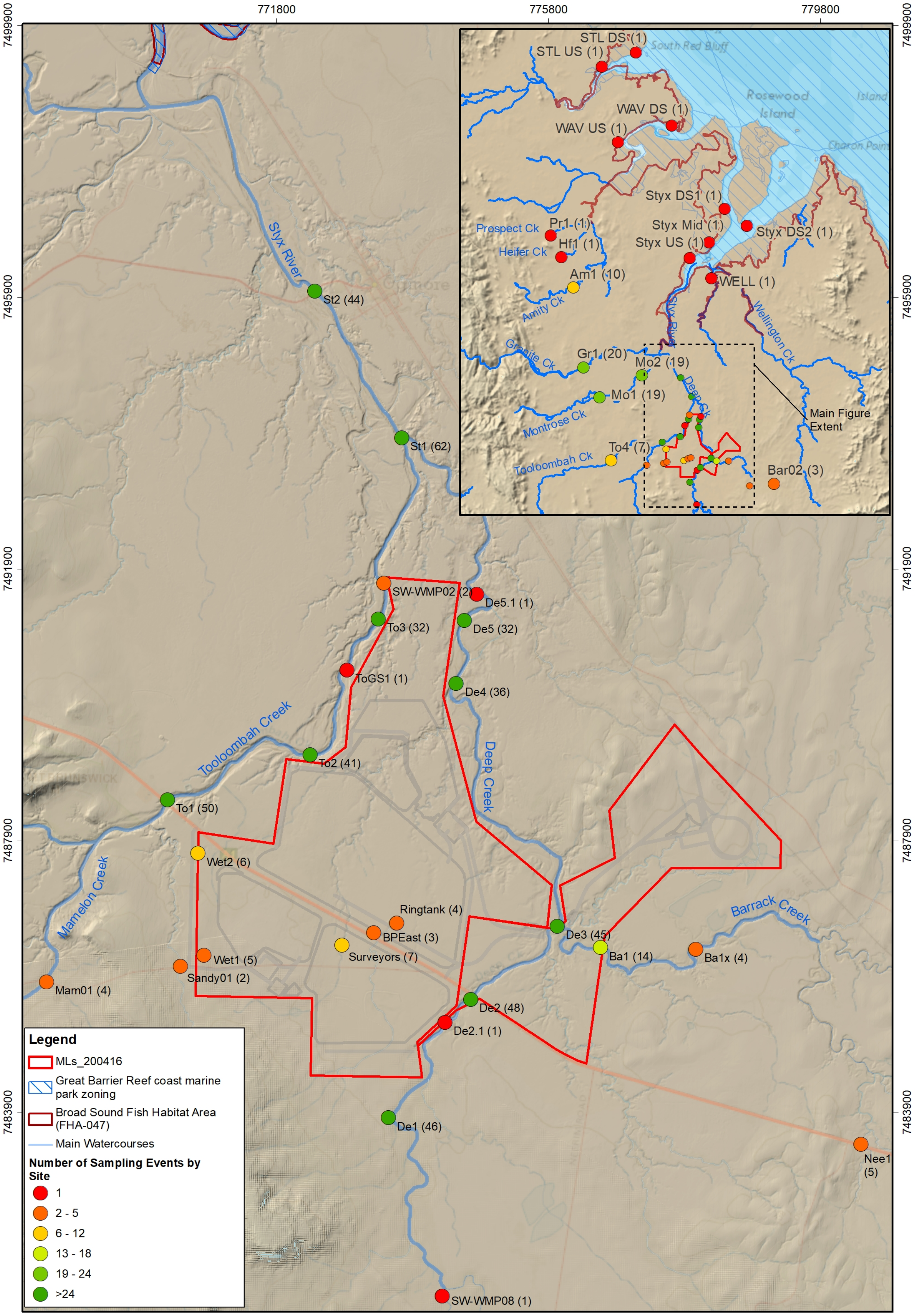
- Dissolved and total metals – dissolved metals were sampled in most rounds (96% of events), with total metals collected in only 9 (17%) of rounds
- Hydrocarbons – TPH / TRH and BTEX were sampled on 60% of rounds, mostly from 2017 to the end of 2019, with PAHs and phenolic compounds added in 2019 (a full suite was also conducted in November 2011).

6.2.3 Sediment Sampling

ALS (2012) undertook estuarine and sediment sampling in November 2011. Otherwise, no sediment sampling has been conducted.

The SEIS v2 committed to assessing sediments at each of the water quality monitoring locations prior to the commencement of construction activities, to be detailed in the Receiving Environment Monitoring Program (REMP). This commitment is reaffirmed in the current SEISv3, and is incorporated into the REMP (SEISv3, Appendix A10f).

ORANGEENVIRONMENTAL



Source: Sites, various, compiled by OE 2020 | Waterways: DNRME 2019 | GBR Coast Marine Park Zoning: DERM 2009
Fish Habitat Areas: DNPSR 2016 | Tenements: DNRME 2019 | Basemap: DNRM 2006

A4 Scale 1:80,000
GDA 1994 MGA Zone 55
0 0.75 1.5 km
File: CQCSCP-24-FigX MonNums 200717, 17 Jul 2020

Figure 6-2: Number of events per sampling site

6.3 Methodology

6.3.1 Parameters and analytical methods

In-situ physical water quality measurements were taken while on site and water quality samples were collected for laboratory analysis.

The following physical parameters were tested in-situ from streams and pools at a depth at least 0.10 m below the surface and 0.10 m above the watercourse bed (typically 0.30m) using a hand-held water quality meter:

- Water temperature (°C)
- pH (pH units)
- Dissolved Oxygen (DO) (mg/L, and % [percent saturation])
- Electrical conductivity (EC) (µS/cm [Microsiemens per centimetre])
- Turbidity (NTU (Nephelometric Turbidity Units)) and
- In 2011 alkalinity was also measured using Chemetrics titration kits.

Dissolved oxygen as % saturation was not measured in all events, particularly 2017 onwards. Instead, % saturation was calculated from DO (mg/L), temperature, EC and barometric pressure as described in Appendix B.

Water samples for laboratory analysis were tested for the parameters outlined in Table 6-2 using appropriate methods and limits of reporting (LOR).

Table 6-2 Water Sample Testing Parameters and Methods by Year

Parameter	2011	2012	2017	2018	2019	2020	ALS Method	LOR	Unit
Phys-chem									
Electrical Conductivity @ 25°C	✓	✓	✓	✓	✓	✓	EA010	1	µS/cm
Total Dissolved Solids (TDS)	✓	✓	✓	✓	✓	✓	EA015	10	mg/L
Total Suspended Solids (TSS)	✓	✓	✓	✓	1 round	✓	EA025	5	mg/L
Alkalinity (Hydroxide, Carbonate, Bicarbonate, Total) as $CaCO_3$	✓	✓	✓	✓	✓	✓	ED037P	1	mg/L
Nutrients and Major ions									
Sulfate	✓	✓	✓	✓	✓	✓	ED041G	1	mg/L
Chloride	✓	✓	✓	✓	✓	✓	ED045G	1	mg/L
Ammonia	✓	✓	✓	✓	✓	✓	EK055G	0.01	mg/L
Nitrite	✓	✓	✓	✓	✓	✓	EK057G	0.01	mg/L
Nitrate	✓	✓	✓	✓	✓	✓	EK058G	0.01	mg/L
Total Kjeldahl Nitrogen as N	✓	✓	✓	✓	1 round	✓	EK061G	0.1	mg/L
Total Nitrogen	✓	✓	✓	✓	1 round	✓	EK062G	0.1	mg/L

Parameter	2011	2012	2017	2018	2019	2020	ALS Method	LOR	Unit
Total Phosphorus	✓	✓	✓	✓	1 round	✓	EK067G	0.01	mg/L
Reactive Phosphorus	✓	✓	✓	✓	✓	✓	EK071G	0.01	mg/L
Fluoride	✓	✓	✓	✓	-	-	EK040P	0.1	mg/L
Dissolved Major Cations (Calcium, Magnesium, Sodium & Potassium)	✓	✓	✓	✓	✓	✓	ED093F	1	mg/L
Total Hardness as CaCO3	-	-	-	-	-	3 rounds	EDO93F	1	mg/L
Total anions/Cations, Ionic Balance	✓	✓	✓	✓	✓	✓	EN055	0.01	mg/L
Dissolved metals and metalloids									
Aluminium	✓	✓	✓	✓	1 round	✓	EG005F Dissolved metals by ICP_AES (2011/12) EG020F Dissolved metals by ICP-MS	0.01	mg/L
Antimony	✓	✓	-	-	-	-		0.01	mg/L
Arsenic	✓	✓	✓	✓	✓	✓		0.001	mg/L
Barium	✓	✓	✓	✓	-	-		0.001	mg/L
Beryllium	✓	✓	-	-	-	-		0.01	mg/L
Boron	✓	✓	-	-	-	-		0.1	mg/L
Cadmium	✓	✓	✓	✓	✓	✓		0.0001	mg/L
Chromium	✓	✓	✓	✓	✓	✓		0.001	mg/L
Cobalt	✓	✓	✓	✓				0.001	mg/L
Copper	✓	✓	✓	✓	✓	✓		0.001	mg/L
Iron	✓	✓		✓	1 round	✓		0.05	mg/L
Lead	✓	✓	✓	✓	✓	✓		0.001	mg/L
Manganese	✓	✓	✓	✓	1 round	✓		0.001	mg/L
Molybdenum	✓	✓	✓	✓	1 round	✓		0.001	mg/L
Nickel	✓	✓	✓	✓	✓	✓		0.001	mg/L
Selenium	✓	✓	✓	✓	1 round	✓		0.01	mg/L
Silver	✓	✓	✓	✓	-	-		0.001	mg/L
Strontium	✓	✓	-	-	-	-		0.1	mg/L
Thallium	✓	✓	-	-	-	-		0.01	mg/L
Tin	✓	✓	-	-	-	-		0.01	mg/L
Titanium	✓	✓	-	-	-	-		0.01	mg/L
Uranium	✓	✓	✓	✓	-	-		0.001	mg/L
Vanadium	✓	✓	✓	✓	1 round	✓		0.01	mg/L
Zinc	✓	✓	✓	✓	✓	✓		0.005	mg/L
Mercury	✓	✓	✓	✓	✓	✓	EG035F by FIMS	0.0001	mg/L
Total metals and metalloids (from March 2020)									
Aluminium	1 round	✓	-	-	-	✓	EG005T Total metals by ICP_AES	0.01	mg/L
Antimony	-	✓	-	-	-	-		0.001	mg/L
Arsenic	1 round	✓	-	-	-	✓		0.001	mg/L

Parameter	2011	2012	2017	2018	2019	2020	ALS Method	LOR	Unit
Beryllium	-	✓	-	-	-	-	(2011/12) EG020T: Total Metals by ICP-MS (others)	0.001	mg/L
Bismuth	-	2 rounds	-	-	-	-		0.001	mg/L
Boron	1 round	✓	-	-	-	-		0.05	mg/L
Cadmium	1 round	✓	-	-	-	✓		0.0001	mg/L
Caesium	-	2 rounds	-	-	-	-		0.001	mg/L
Cerium	-	2 rounds	-	-	-	-		0.001	mg/L
Chromium	1 round	✓	-	-	-	✓		0.001	mg/L
Cobalt	1 round	✓	-	-	-	-		0.001	mg/L
Copper	1 round	✓	-	-	-	✓		0.001	mg/L
Dysprosium	-	2 rounds	-	-	-	-		0.001	mg/L
Erbium	-	2 rounds	-	-	-	-		0.001	mg/L
Europium	-	2 rounds	-	-	-	-		0.001	mg/L
Gadolinium	-	2 rounds	-	-	-	-		0.001	mg/L
Gallium	-	2 rounds	-	-	-	-		0.001	mg/L
Hafnium	-	2 rounds	-	-	-	-		0.01	mg/L
Holmium	-	2 rounds	-	-	-	-		0.001	mg/L
Indium	-	2 rounds	-	-	-	-		0.001	mg/L
Iron	1 round	✓	-	-	-	✓		0.05	mg/L
Lanthanum	-	2 rounds	-	-	-	-		0.001	mg/L
Lead	1 round	✓	-	-	-	✓		0.001	mg/L
Lithium	-	2 rounds	-	-	-	-		0.001	mg/L
Lutetium	-	2 rounds	-	-	-	-		0.001	mg/L
Manganese	1 round	✓	-	-	-	✓		0.001	mg/L
Molybdenum	1 round	✓	-	-	-	✓		0.001	mg/L
Neodymium	-	2 rounds	-	-	-	-		0.001	mg/L
Nickel	1 round	✓	-	-	-	✓		0.001	mg/L
Praseodymium	-	2 rounds	-	-	-	-		0.001	mg/L
Rubidium	-	2 rounds	-	-	-	-		0.001	mg/L
Samarium	-	2 rounds	-	-	-	-		0.001	mg/L
Selenium	1 round	✓	-	-	-	✓		0.01	mg/L
Silver	1 round	✓	-	-	-	-		0.001	mg/L
Strontium	-	✓	-	-	-	-		0.001	mg/L
Tellurium	-	2 rounds	-	-	-	-		0.005	mg/L
Terbium	-	2 rounds	-	-	-	-		0.001	mg/L
Thallium	-	✓	-	-	-	-		0.001	mg/L
Thorium	-	2 rounds	-	-	-	-		0.001	mg/L
Thulium	-	2 rounds	-	-	-	-		0.001	mg/L
Tin	-	✓	-	-	-	-		0.001	mg/L
Titanium	-	✓	-	-	-	-		0.01	mg/L
Uranium	1 round	2 rounds	-	-	-	-		0.001	mg/L
Vanadium	1 round	✓	-	-	-	✓		0.01	mg/L
Ytterbium	-	2 rounds	-	-	-	-		0.001	mg/L

Parameter	2011	2012	2017	2018	2019	2020	ALS Method	LOR	Unit
Yttrium	-	2 rounds	-	-	-	-		0.001	mg/L
Zinc	1 round	✓	-	-	-	✓		0.005	mg/L
Zirconium	-	2 rounds	-	-	-	-		0.005	mg/L
Mercury	1 round		-	-	-	✓	EG035T Total Recoverable Mercury by FIMS	0.0001	mg/L
Bacteriological									
Escherichia coli	1 round	-	-	-	-	-	MW006 by MF	1	cfu/100ml
Hydrocarbons									
TPH/TRH	1 round	-	✓	✓	✓	-	EP080/071	20-100	µg/L
BTEX	1 round	-	✓	✓	✓	-	EP080	1	µg/L
Polynuclear Aromatic Hydrocarbons (PAH)	1 round	-	-	2 rounds	✓	-	EP075(SIM)TB (surrogates)	1.0	µg/L
Phenolic Compounds	1 round	-	-	2 rounds	✓	-	EP075(SIM)AS (surrogates)	0.1- 1.0	µg/L
Radioisotopes	-	-	-	1 round	-	-	Subcontracted to Environmental Isotopes Pty Ltd		

6.3.2 Sampling and sample handling

Water samples were collected in general accordance with the Queensland Government's *Monitoring and Sampling Manual* (DES 2018, and earlier versions EHP 2009a and DERM 2010).

Sample collection for laboratory analysis was generally undertaken using a 2 – 5m sampling pole with replaceable sample cup. Prior to sampling at each site, the cup was inspected for obvious contamination (weeds, etc.) and pre-washed with water from the sample site at least three times prior to sample collection (with waste disposed of downstream or on land). Samples were collected from between 20 – 30 cm below the surface (by first upending the sample container and turning up when underwater to avoid sampling the surface).

For dissolved metals analysis, samples were pre-filtered through a 0.45 µm disposable filter connected to a disposable, sterile and hand operated syringe.

Water was decanted directly into pre-labelled and appropriately preserved sample containers supplied by ALS Laboratory suitable for each analyte.

Samples were placed immediately into an esky on ice and maintained between sampling days in a refrigerator at or below 4°C, as per National Association of Testing Authorities (NATA) guidelines. Samples were transferred with a chain of custody to a NATA accredited lab for analysis.

6.3.3 Quality Assurance / Quality Control

The Quality Assurance / Quality Control (QA/QC) data available was reassessed for the purposes of this report, based on guidance from DES (2018), covering the following general elements:

- Correct bottles and preservation, storage after sampling, and achieving required laboratory holding times
- Chain of custody documentation, and
- Quality control samples.

Collection and Laboratory Submission

Chain of Custody forms were submitted with samples, and Sample Receipt Notification (SRN) documentation were signed and dated by the laboratory to confirm that samples were received in good condition and within acceptable holding times. The analytical methods used for the laboratory's internal QA/QC program are NATA accredited, and detailed in the laboratory documentation.

The laboratory (ALS Environmental) provided quality control interpretive documentation with each batch of samples submitted. Where incorrect preservative and/or field filtering or holding time breaches were recorded, results were coded as a lower confidence, and either weighted down compared to other results, or excluded from the statistical analysis where considered a potential issue.

For the key parameters used in deriving SSTVs and assessing against DGVs in this report, most parameters recorded very low levels of holding time breaches or similar errors (0.2% or less). Potential errors were identified in around 1 - 2% of dissolved oxygen, temperature and turbidity measurements due to questionable meter readings (faulty or potentially faulty). Some issues were identified in holding times for pH measurements, comprising 1.8% of the available sampling events (field measurements were preferenced over lab results due to the short holding time, and other events included suitable field data). Around 3.5% of results for TDS and TSS involved holding time breaches, however given the nature of these analytes, and the relatively low level of breaches in the overall record (typically only 1 - 2 days over), these are not considered problematic and were not excluded from the dataset.

Nitrite and FRP recorded the highest levels of data quality problems, at 16.6% and 15.6% respectively, relating to holding time breaches. However, the data are mostly censored (<0.01mg/L), and the breaches do not appear sufficient to change resultant statistics. Regardless, statistics generated on the data were completed with and without these data points to determine their importance.

Sampling during 2019 – 2020 has involved multiple laboratory batches per event to avoid further holding time breaches - i.e. sets of samples sent as they are collected rather than waiting for the entire sample run to be completed.

QA/QC Samples

Based on the Queensland Monitoring and Sampling Manual (DES 2018), the program should aim to include a minimum 10% field QA/QC samples. The available data indicates only around 40% of sampling events adopted QA/QC samples, with the rate averaging 7 QA/QC per 100 samples, for those events including QA/QC samples.

The 2011 – 2012 program generally included replicates and duplicates for metals analysis to test the repeatability of sampling and analysis techniques. One duplicate sample was included in the analytical batch (ALS Brisbane), and another sent to a different (ALS) laboratory – either Sydney or Melbourne. For several events, a third duplicate was tested for the full range of analytes at the second laboratory. Overall, the 2011 – 2012 program included QA/QC samples in 57% of events, equalling 10% or more of field QA/QC.

QA/QC samples were collected during the CDM Smith sampling program between 2017 – 2018, however only around 40% of events included QA/QC samples, at between 4 – 8% of samples. Sampling from late 2018 to late 2019 did not include QA/QC samples, with these again included from December 2019 onwards, equating to around 40% of events, and 2 – 4% of samples.

Field duplicates were assessed using the Relative Percent Difference (RPD) approach from DES (2018), who state that *'As a rule of thumb, a RPD of ≤ 20% may indicate an acceptable result for duplicate aqueous samples (Equation 1), provided the result is five to ten times the limit of reporting (LOR). In those circumstances where the result is close to the LOR, RPD may exceed 20%.'…*

$$RPD = \frac{|C_1 - C_2|}{\left(\frac{C_1 + C_2}{2}\right)} \times 100\%$$ ***Equation 1***

Analysis indicates generally good agreement between primary and QC/QC samples for surface waters – one event was found with questionable metals results, and coded as such, but otherwise results were generally within an acceptable range. Nutrient RPDs were on occasion higher, and an examination of the inherent variability between sample events indicates this may be due to natural variability (and perhaps some poor sample splitting) - metals results were generally highly comparable. Some of the sampling events utilised groundwater samples for QA/QC comparisons, which are more variable and therefore less useful in comparing sampling and laboratory errors.

Overall, the QA/QC samples indicate the surface water data is suitable for use, albeit their collection is below what should be undertaken.

6.3.4 Flow

Flow has generally been recorded either as an indicative flow speed (m/s), or as a dry, no flow, slow, medium, fast range of criteria. This has been used to derive flow categories for each sample event, namely:

- Dry – no water (unable to sample)
- No flow – water can be sampled, but no flow is evident. At times, a no flow recording was change to baseflow based on other evidence
- Baseflow – flow evident at the sample location, but evidence and timing indicates baseflow rather than stormflow runoff
- Stormflow – using indications from sample sheets, proximity to rainfall events and the results of flow modelling by WRM (2020).

For the St2 (Ogmore bridge) site, flow was categorised based on flow at the St1 site further upstream, at the confluence of Tooloombah and Deep Creeks, to enable suitable comparisons, as well as (where possible) tidal state.

Flow (along with field pH, EC and temperature) has been continuously logged at the ALS Gauging Stations (No. 330451 and No. 330452) installed on Tooloombah Creek and Deep Creek, respectively, since October 2019. The first recorded flow event since installation of the gauging stations occurred in January 2020.

Flow categories were used to assess bias in the data and in setting baseflow / stormflow statistics, as well as in assisting with the ephemeral classification of the systems.

6.3.5 Data analysis

Data were coded with a confidence value to indicate potential issues, and further investigated to ensure only reliable data were included. In addition, measurements taken close together at the same sites were combined into a single value by averaging, to ensure reasonably independent events were utilised (results less than 2 weeks apart was used as the cut off).

Statistics were generated from the data based on the AWQG approach, with censored data (results < limit of reporting [LOR]) managed after Helsel (2012) as follows:

- the statistics were generated first assuming all <LOR values were 0 (a lower statistic), and then where all <LOR values were equal to the LOR (an upper statistic)
- where the lower and upper statistics were equal, this was adopted as the relevant statistic
- where they were not, the methods of Helsel (2012) were adopted, with the regression on order statistics imputation method generally utilised, after Table 6.11, Section 6.7.1 of Helsel (2012), where censored observations were not greater than 80%
- these censored statistics were then compared to the lower – upper statistic range, and where the censored statistic fell outside (or other errors were encountered in the censored statistic), the range was instead adopted. For plotting purposes, an average of the range was used, however the range statistic is otherwise retained pending further data.

Data were then analysed in different groups depending on flow, including:

1. a ‘no FBA stormflow’ set - as noted earlier to avoid bias, the FBA stormflow records for site ST1 were removed from the dataset for separate analysis, so as to avoid bias towards stormflow results, and enable overall unbiased analysis of the overall dataset. Results for the creeks other than Deep and Tooloombah may remain skewed towards stormflows, but were not otherwise amended to avoid significant loss of data (this factor was considered in the analysis)
2. a ‘baseflow only’ set, containing only baseflows. As noted in Section 6.3.4, the flow category for St2 was based on St1 (or where not available, the other creek sites) to enable effective comparison
3. a ‘baseflow and no flow (pools)’ set – effectively a no stormflow data set
4. a ‘no flow’ set, providing data from monitored pools (short term, ephemeral and permanent pools).

The result of all of the above is a set of statistics for each site, based on independent events (or reasonably so), unbiased measurements, suitable to compare to existing DGVs and to develop new ones where relevant. A separate set of statistics was considered for each of the above sets, and compared to derive general water quality flow characteristics.

Statistics for the Deep, Tooloombah and Montrose Creek sites were combined by averaging to provide an overall system statistic for comparison, with a Standard Error determined based on the methods outlined in the QWQGs to provide an overall statistic for each system. Based on the results at To4 (possibly due to the short duration of monitoring), only To1, To2 and To3 were used for

Tooloombah Creek. De1-De5 were used for Deep Creek, and both Mo1 and Mo2 sites were used for Montrose Creek.

Given the available data, only the statistics for the Base-flow / No-flow set is provided in this report, as discussed further in Section 6.4.

6.4 Baseline Data

6.4.1 General Water Quality

Key statistics for three different flow regimes are tabulated in Attachment A1, comprising baseflow / no flow, baseflow only and stormflow flow regimes, and showing the median, 80th percentiles and 20 – 80th percentile ranges for pH and dissolved oxygen. The statistics are shown figuratively in boxplots in Attachment A2 for the baseflow / no flow regime, and as timeseries graphs for selected parameters in Attachment A3.

An overview of the key parameters is discussed in the sections below.

Importantly, the results are compared to the EPP (Water) 2014 DGVs, which are baseflow only criteria. While baseflow results were calculated (and are discussed below), insufficient sample numbers are available for good interpretation of a baseflow only dataset, and significant no-flow pool data is available. As such, and as noted in Section 6.3.5, the Baseflow – No flow data set has been used, and so while non-compliance is reported below, it must be remembered that the no flow pool measurements might be expected to exceed criteria, particularly for elements such as dissolved oxygen which decay in small still pool systems.

6.4.1.1 Salinity, Chloride and Sulfate

The five Deep Creek sites have generally similar levels, but a clear increasing trend in salinity is seen between the upstream To4 site downstream in Tooloombah Creek to the St2 Styx River site. Chloride levels follow a similar trend, but are a little more pronounced, with the To2 and downstream sites recording higher salinity and chloride levels than Deep Creek. The other creek sites are similar to Deep Creek, with dams and wetland 1 lower, and wetland 2 the lowest, albeit none of these are based on many samples or cover a long period of time.

Salinity can be seen to respond to rainfall in the creeks, with the effect more pronounced in Tooloombah Creek, which shows higher levels of salinity, particularly in the To2 and To3 sites. Deep Creek shows some of the same pattern though the levels are generally too low to see much of a difference. The effect of upstream runoff can be seen in both the St1 and St2 sites, which remain relatively unperturbed for smaller events, but drop sharply for larger sustained events.

Sulfate levels are relatively similar between the Deep and Tooloombah Creek sites, with no increase in levels in Tooloombah Creek until the St1 and St2 sites, with an increase from St1 to St2 similar to that for salinity - this combined with chloride levels (and Boron – see below) is indicative of the effect of seawater, with sulfate being one of the most abundant ions in seawater, and both St1 and St2 known to be tidally affected (St2 more so than St1). Other sites are fairly similar to Deep and Tooloombah Creeks, although Granite Creek has quite low sulfate, and as would be expected the Dams and Wetland sites have the lowest salinity and sulfate levels.

The Deep Creek sites show little change over time, although high levels were identified in 2011/2012 which have not been seen since. Tooloombah Creek shows some variable levels, with some of the peaks corresponding to higher salinity levels, but not clearly increasing due to rainfall induced flow or no-flow periods. The St1 and St2 sites show clear increases in sulfate in dry periods, more so at the more tidal St2 site, mirroring the salinity pattern seen at these sites.

6.4.1.2 Dissolved Oxygen

Dissolved oxygen levels are generally lowest in the Deep Creek sites, along with Amity Creek and the two dam sites, with other sites being relatively similar other than a larger range and high values recorded at the wetland 1 site. Calculated medians and 20th to 80th percentiles are below the lower DGV for all Deep Creek sites, with all other 20th percentiles below the DGV range, the 80th percentile marginally within the DGV range for To1 and the Surveyors dam, and close to the upper DGV for the To2 and To3 Tooloombah Creek sites, St1, St2 and the other creek systems, as well as Wetland 2. Wetland 1 shows a very high 80th percentile value (although based on few samples) at 150%, representative of high primary productivity (likely algae in the water).

When only baseflow data is assessed, the data aligns much better to the existing DGVs, with De2, St1, St2, Granite Creek and the Mo2 Montrose Creek sites being fairly close the DGV range. However, the other Deep Creek sites remain below, and 20th percentiles at To1, To2 and Mo2 remain well below the lower DGV range. As such, the existing DGVs appear to be too high for the systems under investigation.

Over time, a pattern of highly variable low dissolved oxygen levels is seen in dry periods in Deep Creek, with a drop immediately after rainfall events, and then rises during and immediately after flow periods cease, followed by a decline as flows stop and pools stagnate. Tooloombah Creek shows a similar drop in first flush flows, but levels appear to rise in some dry periods, and fall in others, possibly depending on algal growth (as Deep Creek sites are much more turbid). Tooloombah Creek maintains slightly higher dissolved oxygen levels than Deep Creek.

At the St1 and St2 sites, dissolved oxygen levels are more stable, though rises are seen during dry periods, and drops for the first flush flows, as for Tooloombah Creek. Comparison of the St2 site to the estuarine DGV range indicates it is too narrow – while the baseflow only data contains the median (i.e. is compliant with the DGV), the 20th and 80th percentiles both lie outside of the range. However, the baseflow data is quite close to the existing DGV range, other than a slightly lower 20th percentile.

These results reflect the ephemeral nature of the creek systems, with dissolved oxygen dropping with first flush flows, fluctuating but generally higher during flow periods, and then as flows slow and cease dropping again as pool systems stagnate, particularly so in the less permanent and lower flow systems of Deep Creek and the dams. In some situations, it appears that primary productivity, particularly in larger systems in Tooloombah Creek with clearer water, may cause it to rise.

6.4.1.3 pH

pH levels are above neutral, at 7.7 – 7.9 for the creeks, around 7.5 pH units for the dams and approximately neutral for the wetlands (6.9 – 7.3). All medians are within the DGV range other than To2 and Neerim Creek (marginally above) and To4 (above), and most 80th percentiles are above the upper range, with the exception of De4, Mo1 and the wetland sites, with the Ringtank dam being equal. With the exception of the wetland sites and Surveyors dam, all ranges are much narrower and high when compared to the DGV range. Comparison to the baseflow only data shows similarly high ranges, with this time more site medians being above the upper DGV (De1, De2, De3).

The data indicate that new guideline values may be suitable for these sites, with the possible exception of St2, which sits centrally to the estuarine pH DGVs, although as noted above the estuarine DGVs do not appear suitable for many other parameters and so perhaps would be worth calculating again based on available data.

Over time, fluctuations are seen in pH, appearing to rise slightly during dry periods, and falling in dry periods, although these patterns are not entirely clear at all times.

6.4.1.4 Suspended Solids and Turbidity

Total suspended solids appear to increase moving downstream in Deep Creek, which is also seen but to a lesser extent in Tooloombah Creek, which in general has lower suspended solids levels. Site To4 appears more like the Deep Creek sites than Tooloombah Creek sites, with the St2 site also similar to Deep Creek. Other creeks are variable, with Amity Creek, Barrack Creek, Granite and Montrose Creeks low and below the DGV, Mamelon and Neerim Creeks higher and above the DGV, and the dams and wetlands above the DGV. Essentially all 80th percentiles are above the DGV.

Turbidity shows a similar pattern to suspended solids, although in comparison to the DGV more sites are below the criterion – Deep Creek remains above, as do Mamelon, Neerim Creeks, and the dams.

Turbidity shows at times the expected behaviour in relation to rainfall and dry events, with low levels generally seen in dry periods in Tooloombah Creek, and in some dry periods in Deep Creek, followed by spikes in rainfall periods. In Deep Creek, the highest levels were seen in the middle of the 2018 dry season, which is not explained by the data, but perhaps reflects suspended fine sediments in still pools, and the effect of cattle access to these systems. Levels at St1 and St2 remained low throughout the monitoring period, other than a spike with the latest large wet season rains (January 2020), and a large rise at St2 in March 2012, which it is difficult to determine whether the result is genuine and if so, what the cause may be.

Deep Creek shows much higher suspended solids and turbidity levels than any other site, with an overall median of 30 mg/L and 165 NTU respectively, compared to around 10 mg/L and 10 NTU for the other sites. Baseflow only results are better (lower), though still above the DGV for Deep Creek and St2, with 80th percentiles above the DGV for Deep Creek and the St1 and St2 sites - Tooloombah Creek and Montrose Creek include the DGV in their margins of error.

Overall, revised criteria for Deep Creek are relevant, and potentially Tooloombah Creek may retain the existing DGV. Other sites vary.

6.4.1.5 Nutrients

Nitrogen

All of the Deep Creek sites, plus To4, Neerim Creek, the dams and wetlands exceeded the DGV for total nitrogen, with the calculated 80th percentile being above the DGV for all sites but Montrose Creek. Deep Creek was higher than the other creeks, with both De5 and To4 (in Tooloombah Creek) at the highest levels across the two creeks (the statistics for To4 also seem anomalous to the other Tooloombah Creek sites, but perhaps due to the short duration of sampling).

Of the other creek systems, Amity Creek was borderline to the DGV, and Neerim Creek was well above, similar to De5/To4. Dams and wetlands were the highest, with wetland 1 being the highest of the wetlands, and surveyors being the highest of the dams.

In terms of nitrogen species, all sites other than Neerim Creek were above the DGV for ammonia, with a broadly similar pattern seen to total nitrogen between the sites. All sites other than Amity Creek were below the DGV for oxidised nitrogen, with the median at most sites being at or below the limit of reporting - only Amity, Granite and Montrose Creeks, Surveyors Dam and Wetland 1 recorded medians above the limit of reporting. However, the 80th percentile was able to be comfortably calculated for most of the sites (To4, Neerim Creek and the Ringtank dam gave it within a small range, and To3 a <LOR value). These showed a sustained drop in both Deep and Tooloombah Creeks between the upstream and downstream sites.

Looking at the baseflow only dataset, sites De1, De5, and the dam and wetland sites still exceeded the DGV for total nitrogen. Oxidised nitrogen results at De1 and De4 were still above the DGV, and ammonia results were still above at all sites except for To3 which was equal to the DGV. Given these results, the TN and ammonia DGV appears too low for most of the sites, particularly Deep Creek, with only Montrose Creek in agreement (median below and 80th percentile matches the DGV). Most of the sites were compliant with the DGV for oxidised nitrogen, with Deep, Amity and Neerim Creeks, the Surveyors dam and both wetlands returning 80th percentiles above the DGV. The data indicates, however, that in both Deep and Tooloombah Creeks, the higher upstream 80th percentile (De1, To4) may be overly affecting the statistic closer to the Project. Given the results, it appears that the DGV is suitable for Deep Creek, too high for Tooloombah Creek and possibly too high for Montrose Creek.

The estuarine DGV for nitrogen (total, oxidised nitrogen and ammonia) is well below the freshwater DGV, and so is even less suitable at the St2 site than the freshwater DGV, particularly when baseflow only data is assessed, with total nitrogen changing from compliant (median below the freshwater DGV) to non-compliant (median above the estuarine DGV).

Over time, total nitrogen increases in response to rainfall, and appears to drop once rainfall ceases and still flow conditions prevail, with the effect more observable in Deep Creek than in Tooloombah Creek or the lower St1 and St2 sites, other than for the large January 2020 wet season event. Ammonia and oxidised nitrogen (as nitrate) appears to follow a similar trend, but less obvious for nitrate with many <LOR results.

Phosphorous

As with nitrogen, Deep Creek has the highest total phosphorous levels, with both the median and 80th percentiles above the DGV at De2, De4 and De5, and medians above at De1 and De3. In general Tooloombah and the other creeks (Amity, Granite and Montrose) are relatively low and below the DGV. Neerim is high, similar to the dams and wetlands, with all well above the DGV. St2 also marginally exceeded the DGV.

As also for nitrogen, total phosphorous at To4 appears anomalous to the other Tooloombah Creek sites, again possibly due to the short record. Filterable reactive phosphorous, the most bioavailable form of phosphorous, was very low across all of the sites, with medians at or below the limit of reporting for all sites. The 80th percentile for most sites was also below the LOR, other than De1 (similarly high for nitrogen) and the Surveyors dam site and both wetlands - Wetland 1 was quite high compared to other sites. Maximums recorded at the Deep Creek sites were exceeded at the St1, St2 and Mo1 Montrose Creek sites, as well as Surveyors and Wetland 1, but otherwise no meaningful patterns can be derived.

Baseflow only data show broadly similar overall levels across all of the sites, with the Granite and Montrose Creek sites being higher than both Deep and Tooloombah Creeks. Baseflow results were this time below the DGV for most Deep Creek sites, with only De5, St2 and the dam and wetland sites above the DGV. FRP gave only 80th percentile results for Mo1, Surveyors dam and the wetland sites above the LOR, with only Wetland 1 above (well above) the DGV.

Over time, similar rainfall induced peaks in total phosphorous are seen as for nitrogen, which are more pronounced in Deep Creek than Tooloombah Creek. The St1 and St2 sites are similar to Tooloombah Creek generally, although several spikes appear related more to levels within Deep Creek than Tooloombah at the time.

Overall, the total phosphorous DGV appears too low for Deep Creek, St1 and St2, and Montrose Creek, with potentially Amity and Granite Creeks having results that may support the current DGV. The baseflow only results show that calculated 80th percentiles are still well above the current DGV, other than for Tooloombah Creek, with results close to the DGV for the Baseflow-no flow data set, and at the current DGV for the Baseflow only dataset - as such the current DGV could possibly be retained for that system for baseflows. Given that median FRP values were below the DGV, but that some 80th percentiles were similar to it the current filterable reactive phosphorous DGV may be suitable for the sites.

The estuarine DGV is much lower than the freshwater DGV for both total and filterable reactive phosphorous, with the data at St2 well above the total phosphorous DGV. The limit of reporting is slightly above the filterable reactive phosphorous DGV, but given the low levels encountered may be suitable for the St2 site.

Summary

Taken together, the results for nutrients show a pattern of high nutrient levels in stormflow reflecting both runoff from the catchment and washout of stored nutrients in pool systems; lower total and ammonia levels in baseflows reflecting the system after this first flush, with nutrients retained in particulate form but loss of oxidised nitrogen stored up in the system during no flow periods (i.e. higher oxidised nitrogen in the water column); and finally elevated nutrients particularly ammonia when flows cease and particularly during extended dry periods in isolated pools, where organic matter is broken down, and altered sediment oxidation / reduction processes may release phosphorous into the water column. These no flow periods may be responsible for much of the nutrient processing within the catchment.

6.4.2 Toxicants

6.4.2.1 Dissolved Metals

A total of 25 metals species were analysed, with the number of samples available ranging from 3 - 8 (newer sites such as Mamelon, Neerim, Barrack, Amity Creeks, To4 in Tooloombah Creek, the dams and the wetlands), up to 45 (lead at To1). A larger set of metals were analysed in 2011/2012, which was reduced in later years, dropping Antimony, Beryllium, Boron, Strontium, Thallium, Silver and Titanium - these were generally below the LOR, and either below the DGV or had no DGV, other than for silver (<LOR, but > DGV).

Dissolved metals had a high proportion of non-detects, with only 7 analytes having no non-detects for a number of sites, and one having no detections recorded (mercury). Table 6-3 summarises the sampling and the non-detect numbers for each of the metal and metalloids investigated.

Table 6-3. Summary of metal and metalloid sampling and non-detects

Analyte	2011 - 2012	2017 - 2020	No non-detects	Not detected	Non-detects >80% - <100%
Aluminium	✓	✓	Wetlands	Am1	Mo1, St1
Antimony	✓		-	De1, De3, Granite Creek, St1 and St2, To2	Mo1, To1

Analyte	2011 - 2012	2017 - 2020	No non-detects	Not detected	Non-detects >80% - <100%
Arsenic	✓	✓	Am1, dams, To4, Wetland 1	-	Granite Creek
Barium	✓	✓	De4, De5, To3	Granite and Montrose Creeks	Not detected -
Beryllium	✓	-	-	De1, De2, De3, Granite and Montrose Creeks, St1 and St2, To1, To2	Be: not detected -
Boron	✓	-	-	De2, Granite and Montrose Creeks, To1, To2	De3, St1 and St2
Cadmium	✓	✓	-	All other sites	De1, De4, St1 and St2, To1, Surveyors dam
Chromium	✓	✓	-	Am1, Granite Creek, Mo1, Neerim Creek, Ringtank dam and To3, To4	De1, De4, De5, Mo2, To1, To2, Surveyors dam
Cobalt	✓	✓	-	De1, De2, Granite and Montrose Creeks, St1 and St2, To2, To3	De3, De4, De5, To1
Copper	✓	✓	De5, Neerim Creek, Ringtank dam, To4	-	-
Iron	✓	✓	Ringtank dam, wetlands	To4	St1, To2, To3
Lead	✓	✓	-	Am1, Bar02, Gr1, Mam01, Mo2, St1, St2, Survyeors, To1, To3, To4, wetlands	Deep Creek sites, Mo1, To2
Manganese	✓	✓	Am1, De1, De3, De4, Neerim Creek, St1, Surveyors dam, To2, To3, Wetlands	-	-
Mercury	✓	✓	-	All sites	-
Molybdenum	✓	✓	-	Am1, Barrack, De5, Granite, Mamelon, Mo1, Neerim Creek, Wetland 1	Other Deep Creek sites, Mo2, Tooloombah Creek other than To4
Nickel	✓	✓	Neerim Creek, Ringtank dam	Am1, Granite Creek	Mo1, To1, To2
Selenium	✓	✓	-	Am1, Bar02, De3, De4, De5, Mam01, Nee1, dams, St1, To3, To4, wetlands	All other sites
Silver	✓	✓	-	All sites	-
Strontium	✓	-	-	De1, De2, Mo2, St1, To1, To2	-

Analyte	2011 - 2012	2017 - 2020	No non-detects	Not detected	Non-detects >80% - <100%
Thallium	✓	-	-	De1, De3, Granite Creek, St1 and St2, To1 and To2	De2, Montrose Creek
Tin	✓	-	-	De2, Granite Creek, Mo2, St1, St2, To2	De3, Mo1, To1
Titanium	✓	-	-	De3, To2	Gr1, Mo1, St1
Uranium	✓	-	-	Deep, Granite and Montrose Creeks, To3	St1, To1, To2
Vanadium	✓	✓	-	Amity, Barrack, Granite, Mamelon, Neerim Creeks, De3, Mo1, dams and wetlands, Tooloombah Creek other than To1	All other sites
Zinc	✓	✓	-	Mamelon Creeks, To4	De5, Gr1, Mo1, To1

Each of the above metals are discussed below based on the 95th percentile of the data after the AWQG approach for toxicants.

- Aluminium
  - Only Amity Creek was below the LOR, with other sites above the DGV - more so for stormflows than otherwise. The levels increase moving downstream in Deep Creek and higher values were recorded at Granite and Montrose Creeks and To1 and St2.
- Antimony
  - All sites were at or below the LOR, which is approximately equivalent to the DGV (0.01 mg/L compared to the DGV of 0.009 mg/L).
- Arsenic
  - Sufficient data exists to show that all sites are below the DGV. No particular pattern can be identified between the sites.
- Barium
  - Levels in Deep, Tooloombah Creeks and the Styx river were above the LOR, and below in Granite and Montrose Creeks. No DGV is available, although all sites are below the drinking water standard of 2mg/L (NHMRC & NRMMC 2018). Levels are relatively constant in the Deep Creek sites, and increase downstream in Tooloombah Creek, with the highest at St1, dropping again to St2. Barium primarily comes from natural sources and is likely linked to the increasing salinity in Tooloombah Creek as one moves downstream (not from seawater, as evidenced by the lower levels at St2 - i.e. from the minerology of the surrounding environment).
- Beryllium
  - All sites are below the LOR of 0.01 mg/L, and no DGV is available, although an interim working level is available, well below the LOR (0.00013 mg/L).
- Boron
  - All sites are at or below the LOR other than at St1 and St2. Boron is primarily sourced from seawater, given the lack in other freshwaters. All levels are below the DGV.

- Cadmium
  - All sites are below the LOR, which is below the DGV.
- Chromium
  - All sites are below the LOR which is below the DGV, other than St1 and St2, though these are both based on a single 0.002mg/L measurement (in December 2011 and March 2012 respectively).
- Cobalt
  - All sites are below the LOR, which was higher than the DGV in 2011-2012, but below from 2017 onwards. Based on the available evidence, all sites are considered below the DGV other than August - September 2017 at De4, De5 in August and October 2018 and To1 in August 2018. Overall, the DGV considered likely to be sound for these systems, with 95th percentiles generally below other than rare detections.
- Copper
  - All statistics measurable and above the LOR, with higher levels in Deep Creek. Otherwise all other creek sites are essentially the same, other than slightly higher levels at Granite Creek. The Dams also recorded slightly higher values, similar to the Deep Creek sites. All results were above the DGV.
- Iron
  - Measurable results were again recorded, and again with higher levels in Deep Creek, with an increasing trend moving downstream from De3 to De5. Other systems show a range in statistics from <0.05 to 2mg/L, with no clear pattern. Most sites were above the DGV, with the exception of To4, To2, To3, St1, Am1 and Mam01.
- Lead
  - All sites were below the LOR, which was higher than the DGV in 2011-2012, but below from 2017 onwards. All sites were below the DGV, with only occasional detections found.
- Manganese
  - Lots of detections were recorded across sites, and statistics were all measurable, and all below the DGV. Deep Creek appears to show a decline from De2, De3 and De5, but elevated levels at the De4 site, while Tooloombah Creek increases from upstream to downstream, remaining at To3 levels at St1 and St2. Other sites are very low, other than Mo1 (same levels as To1, To2, De3), and the Surveyors dam (similar to De4).
- Mercury
  - All sites were below the LOR, which is higher than the DGV.
- Molybdenum
  - Most results are <LOR or close to, with the LOR (and so all results) less than the DGV. Several events come close to the DGV - St2 in December 2019 and January 2020, but otherwise results are well below the DGV or were not detected.
- Nickel
  - A relatively higher proportion of non-censored results was found compared to many other metals, with results generally close to the LOR which was below the DGV. All statistics are comfortably below the DGV. All sites are relatively similar other than elevated results at Mo1 and the Ringtank dam.

- Selenium
  - Most results are below the LOR, which is also above the DGV. Occasional detections at or above the detection limit of 0.01mg/L mean that a viable 95th percentile above the DGV is calculated for De2, Gr1, Mo1, Mo2 and St2, with all other sites being <LOR. No pattern can be discerned based on the data.
- Silver
  - All sites were less than LOR, which is above the DGV, although the DGV is very low.
- Strontium
  - Measurable statistics were generated, based on fairly low levels of non-detects, though also on few data points (4 - 11). Levels are approximately the same across the creek sites, with higher levels found at St1 and St2.
- Thallium
  - Recorded many non-detects (82 - 100%), with occasional detections at or near the LOR. The data indicates there may be slightly higher levels in Deep and Montrose Creeks than elsewhere, though this is based on relatively fewer results (~10).
- Tin
  - As for Thallium, with occasional detections at or near the LOR, and possibly slightly higher levels in Deep and Montrose Creeks, again with smaller sample numbers (~10).
- Titanium
  - Peaks are observed in De1, De2, To1, St1, St2 and Montrose Creek, as a result of relatively high values compared to the LOR (0.1 - 0.2, and up to 0.3 at St1 and St2). No particular pattern beyond this can be found.
- Uranium
  - Uranium is generally below detection limits, other than at the St1 and St2 sites (with St2 being higher). Only the St1 and St2 sites and To1 and To2 detected Uranium, though the proportion of non-detects still were high. The LOR was above the DGV and so it cannot be known if the results are above or not, other than for St1 and St2.
- Vanadium
  - Virtually all results were non-detect, with only 4 sites detecting anything, all due to one measurement near to the LOR (which was above the DGV). Mostly these occurred in January 2012, with October 2018 and March 2020 also recording results at De5 and De4 respectively.
- Zinc
  - Zinc recorded on average around 65% non-detects, ranging from 14% (Surveyors dam) to 100% (Mamelon Creek). Viable statistics above the LOR were determined for Deep Creek sites De1, De2 and De4; Tooloombah Creek sites To2 and To3, St1 and St2, Amity and Granite Creeks, Mo2 and the dam and wetland sites, all above the DGV.

In summary, metals concentrations vary between the sites, with most measurements being below the detection limits of the laboratory methods used. Exceedances of the DGV were found for aluminium, copper, iron and zinc, with mercury, selenium, silver, uranium and vanadium levels below the LOR (or mostly below) which was above the DGV (and so cannot be definitively identified as above or below the DGV).

Metals appear to be higher in stormflows, with dissolved aluminium levels peaking at the end of wet season flows, rather than the beginning as might be anticipated, perhaps due to return bankflow entering the systems. Dissolved copper levels exhibited some storm associated peaks, but not at all times, and dissolved zinc was more variable, with peaks occurring during the wet season, rather than defined at the end. Dissolved iron was very similar to aluminium.

6.4.2.2 Hydrocarbons

As noted in Section 6.3.1, hydrocarbons (as TPH / TRH and other components) were sampled once in the 2011 – 2012 rounds, but more routinely between 2017 – 2019. An examination of the TPH and TRH fractions found that:

- Elevated hydrocarbons were found in all sites other than De1, To2 and St1, with TPH comprising predominantly the C15 – C28 fraction (approximately 2/3), followed by C29 – C36 (approximately 1/3), and TRHs comprising the C16 – C34 fraction
- Levels increase downstream within Deep Creek (from <LOR at De1 to ~376 mg/L at De5), remaining at similar levels between To1 to St1 and dropping at St2 to levels similar to the LOR
- No clear pattern can be seen over time, although the highest levels were observed during the dry season (peaks were also observed during the wet season).

Given the nature of the catchment and the persistent detection in surface waters (not constant, but detected on multiple occasions throughout the assessment period), it is unlikely these results reflect anthropogenic sources of pollution, and more likely show natural levels of biogenic and likely coal sourced hydrocarbons in the natural environment (coal bearing strata have been observed on the bank at one of the Tooloombah Creek sites – CQC, pers.comm, 2020).

Follow up monitoring at these locations should be conducted to obtain further hydrocarbon fingerprint results to assist in setting an appropriate baseline, and silica gel cleanup (or similar) to provide baseline data demonstrating the source as biogenic.

7 Receiving Water Guideline Values

7.1 Overview

As noted in Sections 3.2 and 5, the relevant existing DGVs for the Project area are contained in the *Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives* (EHP 2014), made pursuant to the previous Environmental Protection (Water) Policy 2009. As discussed in Section 6.4, many of the DGVs in that document are not directly applicable to the immediate receiving waters of Deep and Tooloombah Creeks, the St1 confluence or St2 Styx River sites, nor to some of the other reference creek sites.

As such, Attachment A1 tabulates the relevant DGVs against the statistics for each of the main sites, and the combined systems where data is available – Deep, Tooloombah and Montrose Creeks, as well as from the two dams with suitable amounts of data. These statistics include the median (Table A1, A3, A5) and percentiles (Tables A2, A4 and A6) for comparison of site-specific guideline values with the DGVs, to assist in deriving SSTVs - the 80th percentile is provided for an upper limit, and 20th percentile for lower limits.

Table A7 provides the 95th percentile for metals and metalloids.

Non-compliance with the DGVs is highlighted in the table in red as follows (after the AWQGs):

- For general water quality, including nutrients and physico-chemical analytes, the median is compared to the guideline value
- For toxicants, such as dissolved metals, the 95th percentile is compared to the guideline value.

An analysis of the stability of the generated SSTVs (how the statistic changes from the earliest to the latest sample points) found most analytes have become relatively stable, with sites either having stabilised or involving movements of the statistics within a very small range - ammonia, dissolved oxygen, electrical conductivity, total dissolved solids, oxidised nitrogen, pH, filterable reactive phosphorous and turbidity. Some movement in the statistics is seen for chloride (generally rising slightly), total nitrogen (falling in Deep Creek, rising in Tooloombah Creek and St2), sulfate (generally stable in Deep Creek and the St1 and St2 sites, and changing slightly in the Tooloombah Creek sites) and total phosphorous and suspended solids (both slightly falling).

As such, some additional monitoring is recommended, but in general the generated statistics are suitable to derive SSTVs.

Under the QWQGs, the 75th percentile is used instead of the 80th percentile for EC, to allow for the wide range between 75th and 80th percentiles in some areas in Queensland. Comparing the 75th and 80th percentiles provides the following differences:

- Deep Creek: 80th %ile = 606, 75th %ile = 511, difference of 16%
- Tooloombah Creek: 80th %ile = 1,405, 75th %ile = 1,246, difference of 11%
- St1 confluence site: 80th %ile = 14,520, 75th %ile = 13,400, difference of 8%
- St2 Ogmore Bridge: 80th %ile = 38,360, 75th %ile = 37,800, difference of 2%.

For St2, the difference is negligible. For the other sites, the difference is 8 – 16%. Compared to other parameters, the differences are:

- Ammonia – Deep Creek, 7%; Tooloombah Creek, 2%
- Dissolved oxygen – Deep Creek, 3%; Tooloombah Creek, 8%

- Oxidised nitrogen – Deep Creek, 48%; Tooloombah Creek, 29%
- pH – Deep Creek, 1%; Tooloombah Creek, 1%
- Filterable Reactive Phosphorous – Deep Creek, 14%; Tooloombah Creek, no change (<LOR)
- Sulfate – Deep Creek, 6%; Tooloombah Creek, 20%
- Total Nitrogen – Deep Creek, 18%; Tooloombah Creek, 6%
- Total Phosphorous – Deep Creek, 25%; Tooloombah Creek, 10%
- Total Suspended Solids – Deep Creek, 33%; Tooloombah Creek, 18%
- Turbidity – Deep Creek, 13%; Tooloombah Creek, 28%.

Given that the relative differences between these statistics for EC is comparable and even lower than many of the other parameters, it does not appear to make sense to selectively change the default statistic for EC. Given the high variability in salinity in the receiving environment due to the ephemeral nature of these systems, the lower guideline value is not adopted, noting that being highly ephemeral the natural systems are acclimated to relatively large changes in EC.

7.2 Adopted Trigger Values

7.2.1 General water quality and nutrients

Given the slightly to moderately disturbed water types identified for the receiving waters (Section 4.3), the AWQGs recommend the use of 80th percentile reference data (and 20th to 80th percentiles for ranges) for the derivation of local guideline values. Table 7-1 provides a summary of the calculated percentiles provided in Attachment A1 for general water quality and nutrients. These are provided for the three flow categories of baseflow, stormflow and baseflow / no flow combinations, and with a combined value for Deep and Tooloombah Creeks, computed as an average from the different creek sites:

- five for Deep Creek (De1, De2, De3, De4 and De5), and
- three for Tooloombah Creek (To1, To2 and To3 – To4 is excluded as too different in general from the other sites).

Mostly, the percentiles for Deep and the Tooloombah Creek sites are in a similar range (and so reflect the same underlying statistical population), and so the group percentile has been adopted from Attachment A. However, some percentiles do differ between the sites for particular parameters and sites, and have been addressed as follows, generally aiming to fine tune them towards waters adjacent to the Project site:

- Electrical Conductivity (EC) - the different sites for Deep and the To1 – To3 Tooloombah Creek sites are generally in a similar range, although levels increase going downstream in Tooloombah Creek. As such, the overall percentile for Tooloombah Creek should only apply to grouped data and the percentile for each site used otherwise. The group percentile for Deep Creek has been adopted from Attachment A.
- Sulfate (SO_4^{2-}) – while the Tooloombah Creek sites were in agreement, the Deep Creek sites showed a slight peak at De2, and a decline thereafter. As such and similarly to oxidised nitrogen below, the percentile provided is based only on De3, De4 and De5 to represent waters adjacent or downstream to the Project.
- Total Suspended Solids (TSS) – the different sites for Deep and the To1 – To3 Tooloombah Creek sites are generally in a similar range, although percentiles increase going downstream. As such,

the overall percentile for Deep and Tooloombah Creeks should only apply to grouped medians and the site-specific percentile for each site used otherwise.

- Turbidity – the percentiles for the De2, De3, De4 and De5 Deep Creek sites appear similar, but higher than De1. As such, De1 was excluded from the percentile calculated for Deep Creek. Since the De2 site percentile was >880 NTU, the true overall value is >748 NTU. Instead, an interim percentile of 750 NTU has been adopted. Tooloombah Creek sites are in agreement and the group percentile has been adopted from Attachment A.
- Oxidised Nitrogen (NO_x) – the percentile declines moving down Deep Creek, with De3, De4 and De5 approximately equal. As such, only these sites were used for the percentile related to the Project adjacent waters. The To1 – To3 Tooloombah Creek sites are generally in a similar range, and so the group percentile has been adopted from Attachment A.
- Total Phosphorous – as found for turbidity, the percentiles for the De2, De3, De4 and De5 Deep Creek sites appear similar, but higher than De1. As such, De1 was excluded from the percentile calculated for Deep Creek. The Tooloombah Creek sites appeared similar and so the group percentile has been adopted from Attachment A.

Values have also been simplified to fewer significant figures than reported in Attachment A (e.g. for EC).

An adopted interim Site-Specific Trigger Value (SSTV) has also been included to provide for triggers for further investigation and action. These have been chosen cognisant of the range of data for the different flow categories, the available data points for each category (and therefore the confidence that can be applied), and the existing EPP (Water) 2014 DGVs, and has been adapted to best simplify its application across the multiple sites where possible. They are intended for short term triggers for further action or investigation, while the site specific statistics presented herein are intended to be used in the detection of longer term departures from baseline, as part of further investigations where an SSTV trigger is exceeded, and to derive long term site specific guideline values for the waters.

An explanation for the selection of SSTVs is provided for each parameter as follows:

- pH - the range is similar to the Water (EPP) DGV, allowing for the slightly higher upper range found, and allowing for compliance checks during all flow categories to use one SSTV range
- Dissolved oxygen – while the full range extends to as low as 37 % saturation, a lower SSTV of 65 % has been chosen based on the St1 and St2 sites, which show the effect of no flow periods but without extended stagnation in isolated pools. This will have the effect of some low exceedances being recorded during no flow periods in the creeks (which can be explained at the time by the system conditions), without allowing impacts causing actual low levels within receiving waters without triggering action. The upper limit was set equal to the EPP (Water) DGV which is reasonably consistent with the calculated upper ranges across the sites and flow categories
- EC – given the differences between the two creeks, the trigger values have adopted the baseflow only value (which is higher than the baseflow / no flow category), with no SSTV adopted for the St1 or St2 sites due to the wide range resulting from both freshwater and seawater influences confounding Project related impacts
- Sulfate - the higher baseflow only percentile was adopted, which covers all three flow categories - SSTVs for the St1 and St2 sites were not adopted, since the levels at these sites is unduly influenced by seawater sulfate again confounding Project related impacts

Table 7-1. Calculated Statistics (80th percentiles, or 20 – 80th percentiles for ranges) and adopted SSTVs

Parameter and existing freshwater DGVs (EPP (Water) 2014)	Flow Category*	Deep Creek	Tooloombah Creek	Deep and Tooloombah Creek Confluence (St1)	Styx River at Ogmore Bridge (St2)
pH DGV: 6.5 - 8.0	BFNF	7.3 - 8.1	7.6 - 8.3	7.4 - 8.2	7.5 - 8.1
	BF[3]	*7.6 - 8.3*	*7.7 - 8.2*	*7.4 – 8.0*	*7.1 - 8.1*
	SF	*6.4 – 8.1[1]*	*6.6 – 7.4[4]*	*6.7 – 7.4*	*7.0 – 7.5[2]*
	Adopted SSTV	6.5 - 8.3			
DO (%Sat) DGV: 85 - 110	BFNF	37 - 81	54 - 104	66 - 95	65 - 107
	BF[3]	*68 - 89*	*68 - 99*	*77 - 108*	*76 - 111*
	SF	*73 - 120[1]*	*66 - 117[4]*	*ID*	*79 - 105[2]*
	Adopted SSTV	*65 – 110*			
EC (µS/cm)	BFNF	606	1405	14,520	38,360
	BF[3]	*740*	*1637*	*3,802*	*19,200*
	SF	*355[1]*	*357[4]*	*240*	*1,892[2]*
	Adopted SSTV	*740*	*1,640*	-	-
SO_4^{2-} (mg/L)	BFNF	14	33	588	1866
	BF[3]	*25*	*54*	*112*	*714*
	SF	*10[1]*	*15[4]*	*ID*	*40[2]*
	Adopted SSTV	*25*	*54*	-	-
TSS (mg/L) DGV: 10	BFNF	111	17	15	32
	BF[3]	*26*	*11*	*15*	*30*
	SF	*127[1]*	*44[4]*	*424*	*209[2]*
	Adopted SSTV	*26*	*11*	*15*	*30*
Turbidity (NTU) DGV: 50	BFNF	750	46	24	35
	BF[3]	*130*	*12*	*27*	*69*
	SF	*172[1]*	*145[4]*	*532[5]*	*259*
	Adopted SSTV	*50*			
NH_4 (mg/L) DGV: 0.020	BFNF	0.088	0.055	0.060	0.130
	BF[3]	*0.049*	*0.040*	*0.060*	*0.112*
	SF	*0.208[1]*	*0.426[4]*	*ID*	*0.112[2]*
	Adopted SSTV	*0.088*	*0.055*	*0.060*	*0.130*
NO_x (mg/L) DGV: 0.060	BFNF	0.023	0.014	0.020	0.028
	BF[3]	*0.305*	*0.017*	*0.038*	*0.041*
	SF	*0.750[1]*	*0.136[4]*	*ID*	*0.330[2]*
	Adopted SSTV	*0.023*	*0.014*	*0.020*	*0.028*
TN (mg/L) DGV: 0.500	BFNF	2.48	0.69	0.60	0.74
	BF[3]	*1.10*	*0.493*	*0.52*	*0.60*
	SF	*1.90[1]*	*1.24[4]*	*1.99*	*1.70[2]*
	Adopted SSTV	*2.48*	*0.69*	*0.60*	*0.74*
FRP (mg/L) DGV: 0.020	BFNF	0.012	<0.010	<0.010	0.010
	BF[3]	*<0.010*	*<0.010*	*<0.010*	*<0.010*
	SF	*0.086[1]*	*0.036[4]*	*ID*	*0.066[2]*

Parameter and existing freshwater DGVs (EPP (Water) 2014)	Flow Category*	Deep Creek	Tooloombah Creek	Deep and Tooloombah Creek Confluence (St1)	Styx River at Ogmore Bridge (St2)
	Adopted SSTV	*<0.010*			
TP (mg/L) DGV: 0.050	BFNF	0.484	0.065	0.090	0.180
	BF[3]	*0.129*	*0.047*	*0.072*	*0.200*
	SF	*0.200*[1]	*0.158*[4]	*0.616*	*0.258*
	Adopted SSTV	*0.484*	*0.065*	*0.090*	*0.180*

Table notes:

* BNFN – baseflow / no flow, basically all events where water can be sampled, including pools without flow, excluding stormflow events
SF – stormflow events, typically within 1 – 3 days of the initiation of a storm flow event

1 Based on only 4 events, and only site De2 (other sites had only 1 or 2 events)

2 Based on only 5 events

3 Based on a range of events – for Deep Creek, 4-8 events; Tooloombah Creek, 3 – 13 events; St1, 15 – 19 events; and St2, 14 – 17 events

4 Based on only 4 events, and only site To1 (other sites had only 1 or 2 events)

- Total suspended solids - the baseflow only percentiles were adopted as trigger values, since it is anticipated that any discharge from the Project would be likely to occur only during flow periods rather than no flow periods, and that while exceedances during storm events would be expected, these will require both further data to have confidence in the adopted values and upstream monitoring at the time of monitoring, which will enable any exceedances to be explained if they are a non-Project related effect. Baseflow only levels were slightly lower than the baseflow / no flow category.

  For the Deep Creek site, no flow periods appear to result in elevated DGVs, which will trigger further investigation, however as for dissolved oxygen, this can be explained at the time by the system conditions and examination of before-after data
- Turbidity - given the range of results are generally below the EPP (Water) DGV of 50, this has been adopted as a trigger value for the systems. The high results in Deep Creek are in large part a result of no flow periods, as the results for baseflow only, excluding one high level occasion at the De5 site, are less than 50NTU. As such, while some site related exceedances may occur, these can (as for TSS) be explored and explained in terms of site conditions and examination of before-after data, while still triggering investigation for exceedances during flow events where further assessment is required. Storm flows would be expected to result in exceedances, but can again be investigated in terms of upstream - downstream levels and before-after data.
- Nutrients - The SSTVs were chosen as baseflow / no flow periods, reflecting the need to compare long term changes rather than short term spikes that are expected to occur, which therefore should be based on both the data with more confidence (more data points), and that representing the type of conditions likely to be encountered (baseflow, no flow periods). As for turbidity and suspended solids, SSTVs reflect the need to avoid genuinely elevated levels being missed in low flow periods, while allowing for before-after / control-impact assessments to explain natural processes where justified.

  Filterable Reactive Phosphorous in Tooloombah Creek, including St1, has a calculated percentile of <0.01. For Deep Creek, the calculated percentile with standard error is 0.012 ±0.005 which includes the <0.01 range, and the St2 site is at 0.01. As such, <0.010 has been adopted to best match all locations, which may result in some further investigation at times, but provides for a slightly more conservative approach to triggering investigation / action. Note FRP results suffered from a relatively high censoring rate (values < limit of reporting) explaining some of these results.

The adopted SSTVs are summarised from the above into Table 7-2.

Table 7-2. Summary of Adopted SSTVs

Parameter	Deep Creek	Tooloombah Creek	Deep and Tooloombah Creek Confluence (St1)	Styx River at Ogmore Bridge (St2)
pH	6.5 - 8.3			
Dissolved Oxygen (%Sat)	65 – 110			
EC (µS/cm)	740	1,640	-	-
Sulfate (mg/L)	25	54	-	-
Total Suspended Solids (mg/L)	26	11	15	30
Turbidity (NTU)	50			
Ammonia – as N (mg/L)	0.088	0.055	0.060	0.130
Oxidised Nitrogen – as N (mg/L)	0.023	0.014	0.020	0.028
Total Nitrogen – as N (mg/L)	2.48	0.69	0.60	0.74
Filterable Reactive Phosphorous – as P (mg/L)	<0.010			
Total Phosphorous – as P (mg/L)	0.484	0.065	0.090	0.180

7.2.2 Metals and metalloids

Table 7-3 shows the calculated 80th percentiles for metals and metalloids, and the adopted SSTVs for each. These have been chosen as follows:

- Where the calculated statistic is below the DGV, or the statistic is similar to or contains the DGV in its error range, the DGV has been retained.
- Some of the statistics ranges are above the DGV, and as such the calculated statistic has been adopted as the SSTV (highlighted in green in Table 7-3)
- Otherwise, the DGV has been adopted, but highlighted in red in Table 7-3, indicating further work is required to be able to determine whether the DGV or a different SSTV is more appropriate – this is generally due to limits of reporting above the DGV.

The DGV from ANZG (2018) and the DES (2013) *Model Water Conditions for Coal Mines in the Fitzroy Basin* guideline have been used, with the DES (2013) value adopted as the default where available in preference to the ANZG (2018) DGV.

Table 7-3. Calculated 80th percentiles and adopted SSTVs for metals and metalloids*

Parameter	Existing DGVs (ANZG 2018)		Deep Creek	Tooloombah Creek	Deep and Tooloombah Creek Confluence (St1)	Styx River at Ogmore Bridge (St2)
	Freshwater[1]	Marine[2]				
Aluminium	0.055	0.0005[4]	0.24 ±0.096	0.04 ±0.023	<0.1	0.01
		Adopted SSTV	0.24	0.055	0.055	0.0005
Antimony	0.009[3]	0.27[4]	<0.01 ±0.001	<0.01	<0.01	<0.01

Parameter	Existing DGVs (ANZG 2018) Freshwater[1]	Marine[2]	Deep Creek	Tooloombah Creek	Deep and Tooloombah Creek Confluence (St1)	Styx River at Ogmore Bridge (St2)
Adopted SSTV			0.009			
Arsenic	0.013	0.0023[4]	0.003 ±0.0002	0.002 ±0.0003	0.003	0.006
Adopted SSTV			0.013		0.003	0.006
Barium	-	-	0.053 ±0.0059	0.102 ±0.0165	0.271	0.2
Adopted SSTV			0.053	0.102	0.271	0.200
Beryllium	0.00013[3]		<0.01	<0.01	<0.01	<0.01
Adopted SSTV			0.00013			
Boron	0.37	5.1[4]	<0.1	<0.1	<0.1	0.4
Adopted SSTV			0.37			0.4
Cadmium	0.0002	0.0007[5]	<0.0001	<0.0001	<0.0001	<0.0005
Adopted SSTV			0.0002			0.0007
Chromium	0.001	0.0044	<0.001	<0.001	<0.001	<0.005
Adopted SSTV			0.001			0.0044
Cobalt	0.0014[3] (0.090[7])	0.001	<0.006 ±0.0032	<0.01	<0.01	<0.01
Adopted SSTV			0.090			0.001
Copper	0.0014 (0.002[7])	0.0013	0.003 ±0.00024	0.001 ±0.00033	0.002	0.003
Adopted SSTV			0.003	0.002		0.003
Iron	0.3[3]		0.22 ±0.049	<0.05 ±0.013	<0.05	0.06
Adopted SSTV			0.3			
Lead	0.0034 (0.004[7])	0.0044	<0.0052 ±0.00213	<0.004 ±0.0031	<0.01	<0.01
Adopted SSTV			0.004		0.004	0.0044
Manganese	1.9	0.08[4]	0.13 ±0.0473	0.07 ±0.0096	0.283	0.286
Adopted SSTV			1.9			0.286
Mercury	0.00006[6] (0.0002[7])	0.0001[5]	<0.0001	<0.0001	<0.0001	<0.0001
Adopted SSTV			0.0002			0.0001
Molybdenum	0.034[3]	0.023[4]	<0.001	<0.006 ±0.004	0.002	0.004
Adopted SSTV			0.034			0.023
Nickel	0.011	0.007	0.002 ±0.0002	<0.004 ±0.0038	0.001	0.002
Adopted SSTV			0.011			0.007
Selenium	0.005[6] (0.010[7])	0.003[4]	<0.01	<0.01	<0.01	<0.02
Adopted SSTV			0.010			0.003

Parameter	Existing DGVs (ANZG 2018) Freshwater[1]	Marine[2]	Deep Creek	Tooloombah Creek	Deep and Tooloombah Creek Confluence (St1)	Styx River at Ogmore Bridge (St2)
Silver	0.00005 (0.001[7])	0.0014	<0.001	<0.001	<0.001	<0.001
Adopted SSTV			0.001			0.0014
Strontium	-	-	0.4	0.5	0.9	1.2
Adopted SSTV			0.4	0.5	0.9	1.2
Thallium	0.00003[3]	0.017	<0.01	<0.01	<0.01	<0.01
Adopted SSTV			0.00003			0.017
Tin	0.003[3]	0.01[4]	<0.017 ±0.0077	<0.01	<0.01	<0.01
Adopted SSTV			0.003			0.01
Titanium	-	-	0.04 (0.01 - 0.07)	<0.02 ±0.006	<0.01	0.02
Adopted SSTV			0.04	0.02	0.01	0.02
Uranium	0.00005[3] (0.001[7])		<0.001	<0.001	<0.001	0.002
Adopted SSTV			0.001			
Vanadium	0.006[3] (0.010[7])	0.1	<0.01	<0.01	<0.01	<0.02
Adopted SSTV			0.010			0.1
Zinc	0.008	0.015	0.006 (0.003 - 0.007)	0.01 ±0.0025	0.006	<0.005 - 0.025
Adopted SSTV			0.008			0.015

Table notes:

Red denotes where the SSTV has adopted the DGV in the interim, but where there is insufficient information to confirm whether it is appropriate at the site, generally because the LOR is too high.

1 Freshwater 95% protection value, unless otherwise noted
2 Marine 95% protection value, unless otherwise noted
3 Low reliability freshwater value
4 Low reliability marine value
5 Marine 99% protection level
6 Freshwater 99% protection level
7 Release contaminant trigger investigation level from DES (2013)

7.3 Ephemerality

As stated in the QWQG, the effect of ephemerality on guideline values may differ depending on the type of constituent:

- For toxicants, the QWQG state it is appropriate to apply normal guideline values, as the effects on the biota under stagnant conditions will be similar to those during flowing conditions. As such, guideline values for toxicants for receiving waters will be derived from the existing DGVs and, where appropriate, from the statistical characteristics of background monitoring datasets. As such, the entire dataset (all flow types) were considered together.

- The QWQG note that application of normal guidelines for physico-chemical parameters such as pH and dissolved oxygen and nutrients to small waterholes in nonflow conditions is inappropriate. This is relevant for all waterways, but particularly so for Deep Creek.

As such, the data was analysed for four categories – stormflow, baseflow, baseflow-no flow and no-flow. The baseflow-no flow set was the main focus for the purposes of this report as it best represents the highly ephemeral nature of the systems, supports the work of other specialists focused on persistent pools, and takes best advantage of the available data.

Additional stormflow and baseflow monitoring would provide valuable data, including stormflow Event Mean Concentration data (flow-based averaging), but the approach herein allows for long term overall comparisons and detection of change for the bulk of flow conditions, as well as the definition of shorter term trigger values for further action.

7.4 Release Criteria

Release rules for the Project are presented in the *Flood study and site water balance technical report* (WRM 2020), repeated in Table 7-4. WRM (2020) conducted an assessment of the impact of EC and sulfate and found with these limits there was negligible change in downstream water quality, with the predicted concentrations well within the range of the typical historical receiving water concentrations. Assessment of these release rules and of uncontrolled releases using a number of other toxicants also found negligible change in downstream water quality.

Table 7-5 and Table 7-6 provide release criteria for other parameters, based on the DES (2013) *Model Water Conditions for Coal Mines in the Fitzroy Basin* guideline.

Table 7-4. Flow based release criteria (from WRM, 2020)

Receiving Water Flow Criteria for Discharge	Maximum release rate	Release Limits
Low Flow		
0.1 m^3/s (8.64 ML/d)	0.018 m^3/s (1.55 ML/d)	Electrical conductivity – 1,000 µs/cm Sulfate (SO_4^{2-}) - 38 mg/L
Medium Flow		
4 m^3/s	0.142 m^3/s	Electrical conductivity – 2,000 µs/cm Sulfate (SO_4^{2-}) - 80 mg/L
High Flow		
50 m^3/s	1.09 m^3/s	Electrical conductivity – 3,000 µs/cm Sulfate (SO_4^{2-}) - 120 mg/L
Very High Flow		
100 m^3/s	2.02 m^3/s	Electrical conductivity – 4,000 µs/cm Sulfate (SO_4^{2-}) – 160 mg/L
Flood Flow		
250 m^3/s	3.07 m^3/s	Electrical conductivity – 8,000 µs/cm Sulfate (SO_4^{2-}) – 330 mg/L

Table 7-5. Mine affected water release limits – pH and Turbidity

Parameter	Trigger Level
pH (pH units)	6.5 – 9.0[1]
Turbidity	50[2]

Table notes:

1 From DES (2013) Model Water Conditions for Coal Mines in the Fitzroy Basin

2 Based on achievable release limits from sediment basins for suspended solids (Appendix 2, Table A Construction phase – stormwater management design objectives, Queensland State Planning Policy July 2017) and adopted SSTV for turbidity in receiving waters (from the EPP (Water) DGV)

Table 7-6. Release contaminant trigger investigation levels*

Parameter	Trigger Level (mg/L)	
	Deep Creek	Tooloombah Creek
Aluminium (dissolved)	0.24	0.055
Arsenic (dissolved)	0.013	
Boron (dissolved)	0.37	
Cadmium (dissolved)	0.0002	
Chromium (dissolved)	0.001	
Cobalt (dissolved)	0.090	
Copper (dissolved)	0.003	0.002
Iron (dissolved)	0.3	
Lead (dissolved)	0.004	
Manganese (dissolved)	1.9	
Mercury (dissolved)	0.0002	
Molybdenum (dissolved)	0.034	
Nickel (dissolved)	0.011	
Selenium (dissolved)	0.010	
Silver (dissolved)	0.001	
Uranium (dissolved)	0.001	
Vanadium (dissolved)	0.010	
Zinc (dissolved)	0.008	
Ammonia – as N	0.900	
Nitrate – as N	1.100	
Petroleum Hydrocarbons (C6-C9)	0.020	
Petroleum Hydrocarbons (C10-C36)	0.100	
Fluoride (total)	2.0	

Table notes:

List of parameters from the DES (2013) Model Water Conditions for Coal Mines in the Fitzroy Basin

8 Potential Impacts

This report is primarily concerned with reporting and analysing the existing baseline water quality dataset. However, WRM (2020), ELA (2020a, b) and the previous SEIS v2 (CDM Smith, 2018) have provided a range of assessments which provide information or direct assessments of changes in water quality in receiving waters. These have been summarised here and compared to the background levels reported in earlier sections of this report.

The general potential impacts to surface water systems as a result of the Project can be summarised as follows:

- Point source discharges to waterways – from intentional dam releases, unintentional dam overflow / releases, localised erosion and sedimentation, and spills and leaks, including from waste rock storages or groundwater affected by mining operations (such as from waste rock or in-pit storage)
- Area sources – altered loads from larger catchment areas as a result of land use change, including increases in erosion and sedimentation of waterways, broad based leakage from groundwater and waste rock storages
- Changes to flow patterns from concentration of flows due to constrictions in flow passages, alterations of floodplain areas, and the like, resulting in changes to erosion, sedimentation and bed load.

8.1 Anticipated discharge water quality

Water on the site is managed under an overall Water Management System, involving segregating and management of waters differently on the site depending on water quality, namely:

- Clean up-catchment water, to be either diverted around the site or captured in site storages and used for the Project
- Sediment only contaminated water, such as from haul roads and soil or relatively clean rock emplacements, and
- Potentially contaminated waters, comprising low level contaminants (such as from ROM pads and MIA / CHPP) – typical mine affected water - and high level contaminants (such as oil, fuel and chemical storages).

Sediment only contaminated waters are directed through sediment basins, or Dam 1, where settlement would occur to achieve required discharge quality. Typically under the IECA (2008) design approaches for construction activities, sediment basins would be expected to not exceed 50mg/L for the design storm (the State Planning Policy, July 2017, states the objective as ‘at least 80% of the average annual runoff volume of the contributing catchment treated (i.e. 80% hydrological effectiveness) to 50mg/L Total Suspended Solids (TSS) or less’).

Oil, fuel and chemical storages, and other wastes such as general waste and contaminated wastes will be managed for nil discharge, typically bunded and/or roofed, with any incident stormwater managed to remove contaminants before any release, or removal off-site.

For mine affected water releases, WRM undertook a water quantity and quality balance, incorporating salinity (as EC), sulfate and four metals (arsenic, molybdenum, selenium and vanadium), based on the potential for elevated levels of these parameters due to groundwater dewatering and surface runoff sources, including mineral waste dump runoff. As such, the controlled release quality for EC and sulfate would be as shown in Table 7-4, Section 7.4.

The WRM modelling provided probabilistic results of water quality within Dam 1, which can be interpreted as the likely water quality for an uncontrolled release event. However, levels for these six parameters are higher in the first 10 years in which uncontrolled releases are relatively unlikely (1% chance or less) than in after (approximately a 10% chance), due it is expected to lower release volumes (and therefore lower flushing of Dam 1). As such, approximate water quality in uncontrolled dam releases for the first 10 years and after the first 10 years is provided separately below:

Uncontrolled Releases – first 10 years (1% chance of release or less)

- EC: median ranges from 5,000 - 10,000 µS/cm, with a maximum (very low likelihood) of ~20,000 µS/cm
- Sulfate: median ranges from ~150 - 250 mg/L, with a maximum (very low likelihood) of ~540 mg/L
- Arsenic: median ranges from ~0.005 – 0.007 mg/L, with a maximum (very low likelihood) of ~0.015 mg/L
- Molybdenum: increases in Dam 1 over time, with median ranges from ~0.005 mg/L in the early years to ~0.013 mg/L in the later years, with a maximum (very low likelihood) of ~0.017 mg/L
- Selenium: gradual increases in Dam 1 over time, with median ranges from ~0.01 – 0.02 mg/L, with a maximum (very low likelihood) of ~0.05 mg/L
- Vanadium: very gradual increases in Dam 1 over time, with median ranges from ~0.01 – 0.02 mg/L, with a maximum (very low likelihood) of ~0.05 mg/L

Uncontrolled Releases – after first 10 years (~10% chance of release):

- EC: median ~2,500 µS/cm, with a maximum (very low likelihood) of ~8,500 µS/cm
- Sulfate: median ~130 - 200 mg/L, with a maximum (very low likelihood) of ~550 mg/L
- Arsenic: median ranges from ~0.005 – 0.008 mg/L, with a maximum (very low likelihood) of ~0.018 mg/L
- Molybdenum: continues to increase over time, with median ranges from ~0.010 to 0.016 mg/L, with a maximum (very low likelihood) of ~0.040 mg/L
- Selenium: gradual increases in Dam 1 over time, with median ranges from ~0.015 to 0.024 mg/L, with a maximum (very low likelihood) of ~0.054 mg/L
- Vanadium: gradual increases in Dam 1 over time, with median ranges from ~0.015 to 0.024 mg/L, with a maximum (very low likelihood) of ~0.054 mg/L.

8.2 Potential impacts on water quality

The proposed mine water management system has been designed to contain runoff from mining disturbance within the site. During wet climatic conditions, releases from the mine water management system to Deep Creek may be required to manage site water inventory. As shown in Section 7.4, suitable release rules have been developed to ensure that receiving water quality is not adversely affected. The release rules are based on a minimum dilution ratio of five, so that the receiving water flow rate is at least five times greater than the release rate. As the receiving water flow rate increases, the target dilution ratio also increases so that the receiving water flow volume is 30 to 80 times greater than the release volume.

The site water balance conducted by WRM (2020) quantified both controlled and overflow releases from the site storages, and conducted modelling of water quality changes due to the project, based on six key parameters - EC, arsenic, molybdenum, selenium, sulfate and vanadium (EC and sulfate are typical indicators of potential mining related impacts, and the metals were indicated as potentially elevated in leachate testing by RGS (2020)). The results of the modelling showed that downstream levels were well within historical levels in receiving waters for all parameters – i.e. negligible change.

Given the existing grazing land management on the site, and the planned destocking of the Mamelon property coupled with erosion and sediment controls on the site, Engeny (2020) estimated that sediment loss rates would approximately halve, resulting in an overall improvement in water quality. Given also that the predominant grazing land use in the catchment also results in elevated nutrient levels, then the planned destocking of cattle and the improvement of native vegetation due to the proposed biodiversity offsets for the Project (to be located on the Mamelon property) would be expected to result in a reduction in nutrients leaving the site. As such, no worsening of water quality would be expected due to land use change in general.

The results of the revised flood modelling study by WRM (2020) show that the Project will have a small impact on design flood levels along Tooloomba and Deep creeks. Flooding is confined to the main channel of both creeks and most of the proposed mine infrastructure is located outside the flood extent. Impacts of the Project on flow velocities in the creeks are also very small.

Gippel (2020) identified potential sources of high sediment loads to the local creeks from alluvial gullies and small tributaries incised into old alluvium, but found that broadly there was negligible change in velocity and bed shear stress due to the Project. A number of areas were identified with the potential for higher risk of erosion and instability. However, with routine monitoring and, where required, mitigation, this is not expected to result in changes to water quality. Geomorphic monitoring is presented in Gippel (2020) to ensure these and other areas of instability not identified in the report are identified and rectified as required.

The groundwater assessment (HA, 2020) concluded that the Project may affect baseflow within Tooloombah Creek, and therefore affect the amount of time pools remained in the affected reaches. Further work summarised in Chapter 10 – Groundwater of the SEIS v3 confirms that while some pools may be affected, it is not anticipated that impacts would be seen in Deep Creek, nor in many of the Tooloombah Creek pools as the source of baseflow is bank storage rather than a direct connection to the adjacent water table. HA (2020) found that the Project was too far away to have any discernible effects downstream on the Broad Sound Fish Habitat Area (Plan FHA-087), nor based on groundwater-surface water interactions on Barrack and Mamelon Creeks.

Overall, then, there could be reductions in the amount of water within some pools in Tooloombah Creek, and to a lesser extent Deep Creek, which would affect the quality of water in terms of possibly less time to stagnate. However, as noted by WRM (2020), reductions in groundwater inflow would also lower salinity in those areas investigated (since groundwater is typically more saline). ELA (2020a) note that the while water levels of the pools may reduce more quickly, the water quality would likely be better due largely to the above effects. In terms of aquatic fauna, they also concluded that there is likely to be little impact as the species that exist in these pools are habituated to variable water quality.

HA (2020) concluded that no appreciable change in groundwater quality was likely as a result of the Project, with appropriate control of ex and in-pit waste storages, particularly rejects emplacement –

refer Chapter 8 - Waste Rock and Rejects of the SEISv3. From a long-term closure perspective, the presence of carbon and sulfur in the subsurface capped mine waste areas (pit and ex-pit final landforms) would be expected to lead to anoxic and reducing conditions leading to the immobilisation of sulfate and most metal and metalloids. This further reinforces the lack of anticipated impacts from groundwater to surface waters.

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Attachment A

Summary Statistics

A1 – Tabulated Statistics

Table A1. Median Statistics and DGVs from Water (EPP) – Baseflow / No flow events*

	Parameters	NH_4	Cl	DO	EC[5]	NO_3	NO_x	pH	FRP	SO_4^{2-}	TDS	Temp	TN	TP	TSS	Turb
	Freshwater DGVs	0.020		85 - 110			0.060	6.5 - 8.0	0.02				0.500	0.050	10	50
	Estuarine DGVs	0.010		85 - 100			0.010	7.0 - 8.4	0.01				0.300	0.025		
Deep Creek	De1	0.04	88	64	410	-	-	8	<0.01	14	373	25.6	0.9	0.03	9	21
	De2	0.04	75	66	349	0.02	0.02	7.7	<0.01	11	562	25.1	0.6	0.07	11	60
	De3	0.03	86	51	500	0.01	0.01	7.6	<0.01	8.5	418	24.1	0.6	0.04	17	60
	De4	0.04	32	49	244	-	-	7.5	<0.01	5	483	22.6	1.05	0.12	31	200
	De5	0.06	33	52	238	-	-	7.7	<0.01	6	774	23.7	1.55	0.325	81	486
	Combined	*0.042 ±0.005*	*63 ±13*	*56.3 ±3.6*	*348 ±50*	*<0.012 ±0.003*	*<0.012 ±0.003*	*7.7 ±0.1*	*<0.01*	*8.9 ±1.6*	*522 ±70.6*	*24.2 ±0.5*	*0.94 ±0.176*	*0.117 ±0.054*	*29.7 ±13.4*	*165.5 ±85.7*
Tooloombah Creek	To4	0.075	46		356	<0.01	<0.01	8.4	0.01	14.5	458	31.7	1.75	0.195	83	97
	To1	0.03	89	66	490	<0.01	<0.01	7.9	<0.01	10	305	22.9	0.4	0.035	6	15
	To2	0.025	228	82	887	<0.01	<0.01	8.1	<0.01	10	615	24.8	0.4	0.02	9	9
	To3	0.03	312	82	1110	<0.01	<0.01	7.8	<0.01	9	726	23.7	0.45	0.025	8	6
	Combined (excl. To4)	*0.028 ±0.002*	*210 ±65*	*76.6 ±5.2*	*829 ±181*	*<0.01*	*<0.01*	*7.9 ±0.1*	*<0.01*	*9.7 ±0.3*	*548.7 ±126*	*23.8 ±0.6*	*0.417 ±0.017*	*0.027 ±0.004*	*7.7 ±0.9*	*10 ±2.5*
	St1	0.04	1220	78	4180	<0.01	<0.01	7.7	<0.01	126	2460	25	0.4	0.02	10	11
Styx River	St2	0.07	8280	81	24400	<0.01	<0.01	7.8	<0.01	974	17100	24.8	0.5	0.06	16	15
Montrose Creek	Mo1	0.05	84	83	532	0.02	0.02	7.7	<0.01	10	285	24.7	0.2	0.03	5	3
	Mo2	0.03	82	81	423	0.01	0.01	7.9	<0.01	7	274	24.7	0.3	0.03	<5	8
	Combined	*0.04 ±0.01*	*83 ±1*	*82 ±1.4*	*478 ±55*	*0.015 ±0.005*	*0.015 ±0.005*	*7.8 ±0.1*	*<0.01*	*8.5 ±1.5*	*279.5 ±5.5*	*24.7 ±0*	*0.25 ±0.05*	*0.03 ±0*	*<5*	*5.5 ±2.2*
Other Creeks	Am1	0.03	71	69	437	0.15	0.15	7.9	<0.01	4	244	22.8	0.5	0.03	<5	5
	Gr1	0.03	54	89	386	0.02	0.02	7.7	<0.01	2	211	25.1	0.2	0.02	<5	4
	Nee1	0.02	53		305	<0.01	<0.01	8.1	<0.01	12	448	20	1.1	0.13	37	343
Dams	Ringtank	0.045	22	37	182	-	-	7.6	<0.01	1	157	25.7	2	0.17	43	87
	Surveyors	0.06	9	57	179	0.04	0.04	7.4	<0.01	-	212	30.5	2.5	0.215	72	71

	Parameters	NH_4	Cl	DO	EC[5]	NO_3	NO_x	pH	FRP	SO_4^{2-}	TDS	Temp	TN	TP	TSS	Turb
	Freshwater DGVs	0.020		85 - 110			0.060	6.5 - 8.0	0.02				0.500	0.050	10	50
	Estuarine DGVs	0.010		85 - 100			0.010	7.0 - 8.4	0.01				0.300	0.025		
	Combined	*0.053 ±0.008*	*15 ±6*	*47.4 ±10*	*181 ±2*	*<0.025 ±0.016*	*<0.025 ±0.016*	*7.5 ±0.1*	*<0.01*	*<1.3 ±0.4*	*184.5 ±27.5*	*28.1 ±2.4*	*2.25 ±0.25*	*0.193 ±0.023*	*57.3 ±14.3*	*78.9 ±8.3*
Wetlands	Wet1	0.04	14	108	90	0.03	0.03	6.9	<0.01	<1	126	33.9	2.4	0.16	36	38
Wetlands	Wet2	0.05	4	91	62	0.01	0.01	7.3	<0.01	<1	56	31.1	1.6	0.1	19	32

Table notes:

* Ranges represent the 20th to 80th percentile range for pH and dissolved oxygen. Where a range is provided for other analytes, this is due to uncertainty in the data likely due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

Table A2. Calculated Statistics (80th percentiles, or 20th – 80th percentiles for ranges) and DGVs from Water (EPP) – Baseflow / No flow events*

	Parameters	NH_4 (mg/L)	Cl (mg/L)	DO (%Sat)	EC (µS/cm)	NO_3 (mg/L)	NO_x (mg/L)	pH	FRP (mg/L)	SO_4^{2-} (mg/L)	TDS (mg/L)	Temp (°C)	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (ntu)
	Freshwater DGVs	0.020		85 - 110			0.060	6.5 - 8.0	0.02				0.500	0.050	10	50
	Estuarine DGVs	0.010		85 - 100			0.010	7.0 - 8.4	0.01				0.300	0.025		
Deep Creek	De1	0.088	128	47 - 90	329	0.34	0.344	7.5 - 8.2	0.024	18	1350	29.1	1.94	0.152	31	97
	De2	0.12	128	38 - 85	181	0.08	0.08	7.3 - 8.2	0.01	27.6	1350	27.3	3.02	0.684	91	>880
	De3	0.074	129	23 - 81	256	0.03	0.03	7.3 - 8.2	0.01	16.2	1670	26.6	2.56	0.376	48	791
	De4	0.07	118	34 - 78	168	0.02	0.02	7 - 7.8	0	13	764	27.6	1.7	0.344	150	539
	De5	0.09	47	44 - 72	169	0.02	0.02	7.3 - 8.1	0.01	11.6	1110	27.4	3.2	0.53	238	781
	Combined	*0.088 ±0.009*	*110 ±16*	*37.3 - 80.8 (33.2, 83.8)*	*606 ±86*	*0.098 ±0.062*	*0.099 ±0.062*[1]	*7.3 - 8.1 (7.2, 8.2)*	*0.012 (<0.01 - 0.016)*	*17.3 ±2.8*[2]	*1248.8 ±150.4*	*27.6 ±0.4*	*2.484 ±0.293*	*0.417 ±0.09*[4]	*111 ±38*	*>618 ±142*[3]
Tooloombah Creek	To4	0.146	62	-	318	0.036 - 0.042	0.036 - 0.042	7.8 - 8.5	0.01	25.2	1330	32.7	3.34	0.452	356	519
	To1	0.06	229	49 - 90	337	0.018	0.018	7.5 - 8.3	<0.01	33.6	608	26.8	0.6	0.06	12	51
	To2	0.04	400	67 - 110	404	0.01	0.01	7.7 - 8.3	<0.01	33.4	874	29.3	0.68	0.058	17	58
	To3	0.064	587	46 - 113	605	<0.01	<0.01	7.7 - 8.3	<0.01	33	1250	27.8	0.8	0.076	23	29
	Combined (excl. To4)	0.055 ±0.007	405 ±103	53.6 - 104.3 (47.1, 111.6)	1407 ±306	0.014 ±0.004	0.014 ±0.004	7.6 - 8.3 (7.5, 8.3)	<0.01	33.3 ±0.2	910.7 ±186.2	28 ±0.7	0.693 ±0.058	0.065 ±0.006	17 ±3	46 ±9
	St1	0.06	4970	66 - 95.3	14500	0.02	0.02	7.4 - 8.2	<0.01	588	9680	29.4	0.6	0.09	15	24
Styx River	St2	0.13	13500	65.2 - 107	38400	0.028	0.028	7.5 - 8.1	0.01	1870	28700	27.9	0.74	0.18	32	35
Montrose Creek	Mo1	0.092	143	70 - 109	359	0.02	0.02	7.1 - 7.9	<0.01	19.5	413	27.5	0.4	0.13	7	11
	Mo2	0.046	142	58 - 113	303	0.032	0.032	7.5 - 8.3	<0.01	10	404	29.2	0.56	0.056	5	48
	Combined	*0.069 ±0.023*	*143 ±1*	*63.9 - 111 (58.2, 113)*	*727 ±8*	*0.026 ±0.006*	*0.026 ±0.006*	*7.3 - 8.1 (7.1, 8.3)*	*<0.01*	*14.8 ±4.8*	*408.5 ±4.5*	*28.4 ±0.9*	*0.48 ±0.08*	*0.093 ±0.037*	*6 ±1*	*30 ±19*
Other Creeks	Am1	0.036	72	55.7 - 76.4	465	0.864	0.864	7.5 - 8.3	<0.01	4.6	257	23.5	1.28	0.036	<5	6
	Gr1	0.046	89	78 - 104	495	0.036	0.036	7.3 - 8.3	<0.01	2	304	27.6	0.56	0.05	7	7
	Nee1	0.044	68	-	364	0.564 - 0.568	0.564 - 0.568	7.8 - 8.8	<0.01	12.6	821	24.6	2.54	0.25	68	617

	Parameters	NH_4 (mg/L)	Cl (mg/L)	DO (%Sat)	EC (µS/cm)	NO_3 (mg/L)	NO_x (mg/L)	pH	FRP (mg/L)	SO_4^{2-} (mg/L)	TDS (mg/L)	Temp (ºC)	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (ntu)
	Freshwater DGVs	0.020		85 - 110			0.060	6.5 - 8.0	0.02				0.500	0.050	10	50
	Estuarine DGVs	0.010		85 - 100			0.010	7.0 - 8.4	0.01				0.300	0.025		
Dams	Ringtank	0.18	43	30 - 65	62	0.008 - 0.014	0	7.4 - 8	0	2.4	414	26.4	6.38	0.752	1030	495
Dams	Surveyors	0.732	44	35 - 90	69	0.16	0.16	6.7 - 8.4	0.016	0	298	31.4	6.9	0.51	106	280
Dams	*Dams combined*	*0.456 ±0.276*	*43 ±0*	*32.7 - 77.6 (30.4, 89.9)*	*358 ±37*	*<0.087 ±0.074*	*<0.087 ±0.074*	*7 - 8.2 (6.7, 8.4)*	*<0.013 ±0.004*	*<1.7 ±0.8*	*356 ±58*	*28.9 ±2.5*	*6.64 ±0.26*	*0.631 ±0.121*	*568 ±462*	*388 ±108*
Wetlands	Wet1	0.05	17	70.9 - 150	110	0.072	0.072	6.4 - 7.2	0.154	<1.8	152	34.4	3.04	0.224	205	126
Wetlands	Wet2	0.076	5	69.1 - 101	68	0.064	0.064	7 - 7.6	0.016	<1	78	31.7	2.48	0.278	34	111

Table notes:

* Ranges represent the 20th to 80th percentile range for pH and dissolved oxygen. Where a range is provided for other analytes, this is due to uncertainty in the data likely due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

1 Since NO_x declines moving downstream, the true group statistic for Deep Creek adjacent to the Project is likely better estimated from sites De3, De4 and De5 (0.023 ±0.003 mg/L)

2 Since SO_4^{2-} changes from upstream to downstream, the true group statistic for Deep Creek adjacent to the Project is likely better estimated from sites De3, De4 and De5 (13.6 ±1.4 mg/L)

3 Given that turbidity for De1 is much lower than the other downstream sites, the true group statistic for Deep Creek adjacent to the Project is likely better estimated from sites De2, De3, De4 and De5 (>748 ±73 NTU).

4 Given that TP for De1 is lower than the other downstream sites, the true group statistic for Deep Creek adjacent to the Project is likely better estimated from sites De2, De3, De4 and De5 (0.484 ±0.078)

Table A3. Median Statistics and DGVs from Water (EPP) – Baseflow only events

	Parameters	NH_4 (mg/L)	Cl (mg/L)	DO (%Sat)	EC (µS/cm)	NO_3 (mg/L)	NO_x (mg/L)	pH	FRP (mg/L)	SO_4^{2-} (mg/L)	TDS (mg/L)	Temp (°C)	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (ntu)
	Freshwater DGVs	0.02		85 - 110			0.06	6.5 - 8.0	0.02				0.5	0.05	10	50
	Estuarine DGVs	0.01		85 - 100			0.01	7.0 - 8.4	0.01				0.3	0.025		
Deep Creek	De1	0.035	130	89	518	0.14	0.14	8.1	<0.01	26	367	23.3	1.05	0.03	5	19
	De2	0.03	116	90	559	0.025	0.025	8.2	<0.01	36.9	389	22.6	0.3	0.025	6	21
	De3	0.04	112	80	629	0.03	0.03	8.1	<0.01	17	341	20	0.4	0.03	12	44
	De4	0.025	114	76	576	0.14	0.14	7.6	<0.01	16.5	329	22.4	0.5	0.04	8	11
	De5	0.03	67	54	394	0	0	7.9	<0.01	10	324	26.5	0.9	0.065	41	79
	Combined	*0.032 ±0.003*	*108 ±11*	*77.9 ±6.5*	*535 ±39*	*0.069 (0.037 - 0.101)*	*0.069 (0.037 - 0.101)*	*8 ±0.1*	*<0.01*	*21.3 ±4.7*	*349.9 ±12.3*	*23 ±1*	*0.63 ±0.146*	*0.038 ±0.007*	*14.4 ±6.8*	*34.8 ±12.3*
Tooloombah Creek	To1	0.03	167	88	565	<0.01	<0.01	7.8	<0.01	27.3	432	22.8	0.4	0.02	5	6
	To2	0.02	228	92	907	0.01	0.01	7.9	<0.01	35	674	24.1	0.4	0.03	9	5
	To3	0.02	708		2610	<0.01	<0.01	8	<0.01	58	1590	22.6	0.3	0.02	8	4
	Combined (excl. To4)	*0.023 ±0.003*	*368 ±171*	*89.9 ±2.2*	*1361 ±632*	*<0.01*	*<0.01*	*7.9 ±0*	*<0.01*	*40.1 ±9.2*	*898.7 ±352.7*	*23.2 ±0.5*	*0.367 ±0.033*	*0.023 ±0.003*	*7.3 ±1.2*	*4.7 ±0.7*
	St1	0.04	531	90	1950	<0.01	<0.01	7.6	<0.01	60	1050	24.4	0.4	0.02	9	8
Styx River	St2	0.05	1200	93	4190	0.02	0.02	7.9	<0.01	138	2460	24.3	0.4	0.06	12	10
Montrose Creek	Mo1	0.05	93	85	605	0.02	0.02	7.7	<0.01	12	331	24.8	0.3	0.05	<5	3
	Mo2	0.03	97	97	525	0.01	0.01	7.9	<0.01	4	335	23.8	0.3	0.05	<5	6
	Combined	*0.04 ±0.01*	*95 ±2*	*90.8 ±6.3*	*565 ±40*	*0.015 ±0.005*	*0.015 ±0.005*	*7.8 ±0.1*	*<0.01*	*8.2 (4 - 12.1)*	*333 ±2*	*24.3 ±0.5*	*0.3 ±0*	*0.05 ±0*	*<5*	*4.8 ±1.5*
Other Creeks	Gr1	0.03	61	89	355	0.014	0.014	7.7	<0.01	2	217	24.7	0.25	0.045	<5	5

Table notes:

* Ranges represent the 20^{th} to 80^{th} percentile range for pH and dissolved oxygen. Where a range is provided for other analytes, this is due to uncertainty in the data likely due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

Table A4. Calculated Statistics (80th percentiles, or 20th – 80th percentiles for ranges) and DGVs from Water (EPP) – Baseflow only events

Parameters		NH_4 (mg/L)	Cl (mg/L)	DO (%Sat)	EC (µS/cm)	NO_3 (mg/L)	NO_x (mg/L)	pH	FRP (mg/L)	SO_4^{2-} (mg/L)	TDS (mg/L)	Temp (°C)	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (ntu)
Freshwater DGVs		0.02	-	85 - 110	-	-	0.06	6.5 - 8.0	0.02	-	-	-	0.5	0.05	10	50
Estuarine DGVs		0.01	-	85 - 100	-	-	0.01	7.0 - 8.4	0.01	-	-	-	0.3	0.025	-	-
Deep Creek	De1	0.07	143	84 - 91	339	0.76	0.76	7.5 - 8.6	<0.01	47	388	27.7	1.7	0.03	8	24
	De2	0.04	185	82 - 112	483	0.036	0.036	7.3 - 8.5	<0.01 - 0.01	56.2	558	26.7	0.52	0.076	8	31
	De3	0.048	195	78 - 90	505	0.176	0.176	7.7 - 8.3	<0.01	42	524	25.2	0.66	0.072	19	70
	De4	0.044	148	57 - 78	493	0.6	0.6	7.5 - 7.8	<0.01	17.8	394	25.5	1.06	0.092	10	16
	De5	0.042	115	39 - 74	231	0.138	0.138	7.7 - 8.3	<0.01	16	712	29.5	1.56	0.276	85	404
	Combined	*0.049 ±0.005*	*157 ±15*	*68.1 - 89.1 (59.4, 95.6)*	*740 ±56*	*0.342 ±0.142*	*0.342 ±0.142*	*7.6 - 8.3 (7.5, 8.4)*	*<0.01*	*35.8 ±8*	*515.2 ±59.8*	*26.9 ±0.8*	*1.1 ±0.235*	*0.109 ±0.043*	*25.9 ±14.9*	*109 ±74.4*
Tooloombah Creek	To1	0.06	247	68 - 93	467	0.02	0.02	7.6 - 8.3	<0.01	42	630	26.7	0.4	0.04	9	14
	To2	0.04	270	68 - 105	658	0.02	0.02	7.8 - 8.4	<0.01	41	778	29.5	0.6	0.07	12	19
	To3	0.02	743		1724	0.01	0.01	7.7 - 8	<0.01	79	1668	23.2	0.48	0.032	13	4
	Combined (excl. To4)	*0.04 ±0.012*	*420 ±162*	*68.2 - 98.7 (68.2, 104.6)*	*1637 ±498*	*0.017 ±0.003*	*0.017 ±0.003*	*7.7 - 8.2 (7.7, 8.3)*	*<0.01*	*54 ±12.5*	*1025.2 ±324.2*	*26.5 ±1.8*	*0.493 ±0.058*	*0.047 ±0.012*	*11.1 ±1.3*	*12.3 ±4.5*
	St1	0.06	1096	77 - 107.7	3802	0.038	0.038	7.4 - 8	<0.01	111.6	2248	25.2	0.52	0.072	15	27
Styx River	St2	0.112	6480	75.8 - 110.7	19200	0.041	0.041	7.1 - 8.1	<0.01	714	12440	26.1	0.6	0.2	30	69
Montrose Creek	Mo1	0.168	142	70 - 104	376	0.02	0.02	7 - 8	0.012	21.9	438	27.4	0.72	0.154	39	24
	Mo2	0.112	124	81 - 117	402	0.042	0.042	7.5 - 8.3	0	15.2	435	29.6	0.42	0.194	5	25
	Combined	*0.14 ±0.028*	*133 ±9*	*75.7 - 110.4 (70, 116.7)*	*699 ±33*	*0.031 ±0.011*	*0.031 ±0.011*	*7.2 - 8.2 (6.9, 8.3)*	*<0.011 ±0.002*	*18.6 ±3.4*	*436.8 ±1.6*	*28.5 ±1.1*	*0.57 ±0.15*	*0.174 ±0.02*	*22.2 ±17.2*	*24.5 ±0.6*
Other Creeks	Gr1	0.076	79	82 - 109.7	429	0.042	0.042	6.9 - 8.3	<0.01	3.8	302	27.5	0.56	0.056	8	15

Table notes:

* Ranges represent the 20th to 80th percentile range for pH and dissolved oxygen. Where a range is provided for other analytes, this is due to uncertainty in the data likely due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

Table A5. Median Statistics and DGVs from Water (EPP) – Stormflow only events

Parameters		NH_4 (mg/L)	Cl (mg/L)	DO (%Sat)	EC (µS/cm)	NO_3 (mg/L)	NO_x (mg/L)	pH	FRP (mg/L)	SO_4^{2-} (mg/L)	TDS (mg/L)	Temp (°C)	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (ntu)
Freshwater DGVs		0.02	-	85 - 110	-	-	0.06	6.5 - 8.0	0.02	-	-	-	0.5	0.05	10	50
Estuarine DGVs		0.01	-	85 - 100	-	-	0.01	7.0 - 8.4	0.01	-	-	-	0.3	0.025	-	-
Deep Creek	De2	0.1	41	86	275	0.345	0.355	7.3	0.045	6.5	260	29.4	1.65	0.135	59	140
Tooloombah Creek	To1	0.16	26	89	292	0.015	0.015	7.2	0.012	12	228	29.6	1.2	0.145	33	122
	St1	-	-	-	195	-	-	7.1	-	-	-	-	1.265	0.286	238	335
Styx River	St2	0.075	84	91	1212	0.158	0.165	7.3	0.035	16	340	29.9	1.3	0.21	78	189
Montrose Creek	Mo1	0.06	19	101	131	0.02	0.02	7	0.02	2	179	26.7	0.6	0.1	15	68
	Mo2	0.06	15	94	145	0.04	0.04	7.3	0.02	3	176	28	1.15	0.14	27	69
	Combined	*0.06 ±0*	*17 ±2*	*97.3 ±3.3*	*138 ±7*	*0.03 ±0.01*	*0.03 ±0.01*	*7.1 ±0.1*	*0.02 ±0*	*2.5 ±0.5*	*177.4 ±1.6*	*27.3 ±0.6*	*0.875 ±0.275*	*0.12 ±0.02*	*20.8 ±5.8*	*68.2 ±0.4*
Other Creeks	Gr1	0.035	22	91	164	0.01 - 0.015	0.01 - 0.015	6.8	<0.01	1.1	136	28.8	0.4	0.04	6	54

Table notes:

* Ranges represent the 20th to 80th percentile range for pH and dissolved oxygen. Where a range is provided for other analytes, this is due to uncertainty in the data likely due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

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Table A6. Calculated Statistics (80th percentiles, or 20th – 80th percentiles for ranges) and DGVs from Water (EPP) – Stormflow only events

Parameters		NH_4 (mg/L)	Cl (mg/L)	DO (%Sat)	EC (µS/cm)	NO_3 (mg/L)	NO_x (mg/L)	pH	FRP (mg/L)	SO_4^{2-} (mg/L)	TDS (mg/L)	Temp (°C)	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (ntu)
	Freshwater DGVs	0.02	-	85 - 110	-	-	0.06	6.5 - 8.0	0.02	-	-	-	0.5	0.05	10	50
	Estuarine DGVs	0.01	-	85 - 100	-	-	0.01	7.0 - 8.4	0.01	-	-	-	0.3	0.025		
Deep Creek	De2	0.208	43	72.5 - 119.8	355	0.73	0.75	6.4 - 8.1	0.086	10.4	283	30.2	1.9	0.2	127	172
Tooloombah Creek	To1	0.426	35	65.7 - 116.6	357	0.132	0.136	6.6 - 7.4	0.036	14.8	240	29.9	1.24	0.158	44	145
	St1	ND	-	-	240	-	-	6.7 - 7.4	-	-	-	-	1.985	0.616	424	532
Styx River	St2	0.112	293	79.2 - 105.3	1892	0.321	0.33	7 - 7.5	0.066	40.4	718	31.9	1.7	0.258	209	259
Montrose Creek	Mo1	0.066	24	95 - 114	188	0.068	0.068	6.6 - 7.2	0.032	4.4	215	28	1.2	0.16	133	81
	Mo2	0.078	18	65 - 118	166	0.324	0.328	6.9 - 7.4	0.028	5	201	29	1.88	0.512	230	83
	Combined	*0.072 ±0.006*	*21 ±3*	*80 - 116 (64.5, 118)*	*177 ±11*	*0.196 ±0.128*	*0.198 ±0.13*	*6.8 - 7 (6.6, 7)*	*0.03 ±0.002*	*4.7 ±0.3*	*208 ±7*	*28.5 ±0.5*	*1.54 ±0.34*	*0.336 ±0.176*	*181.8 ±48.6*	*82.2 ±0.8*
Other Creeks	Gr1	0.058	27	71.7 - 105.8	193	0.02	0.02	5.9 - 7.1	0.01	4.4	160	29.4	0.5	0.052	7	73

Table notes:

* Ranges represent the 20th to 80th percentile range for pH and dissolved oxygen. Where a range is provided for other analytes, this is due to uncertainty in the data likely due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

Table A7. 95th percentile statistics and DGVs from Water (EPP) – Metals and metalloids, all data*

	Parameters	Al	An	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo
	Freshwater DGVs	0.055	0.009	0.013		0.00013	0.37	0.0002	0.001	0.0014	0.0014	0.3	0.0034	1.9	0.00006	0.034
	Estuarine DGVs	0.0005	0.27	0.0023		0.00013	5.1	0.0007	0.0044	0.001	0.0013	0.3	0.0044	0.08	0.0001	0.023
Deep Creek	De1	3.38	<0.01	0.002	0.059	<0.01	0.1	<0.0001 - 0.0001	0.002	<0.01	0.009	1.5	0.002 - 0.01	0.544	<0.0001	0.001 - 0.01
	De2	2.79	0.01	0.004	0.098	<0.01	<0.1	<0.0001	0.002	<0.01	0.008	1.63	0.001 - 0.01	0.752	<0.0001	0.001 - 0.01
	De3	3.3	<0.07	0.009	0.1	<0.07	<0.1 - 0.1	<0.0001	0.003	<0.001 - 0.019	0.004	1.17	<0.001 - 0.01	0.363	<0.0001	<0.01
	De4	4.02	-	0.004	0.082	-	-	<0.0001	0.003	0.002	0.011	3.19	0.004	1.42	<0.0001	<0.001 - 0.001
	De5	5.16	-	0.004	0.102	-	-	<0.0001	0.004	0.003	0.003	3.88	<0.001 - 0.001	0.176	<0.0001	<0.001
	Combined	*3.73 ±0.407*	*<0.03 ±0.021*	*0.005 ±0.0012*	*0.088 ±0.0081*	*<0.03 ±0.03*	*<0.1*	*<0.0001*	*0.0028 ±0.00037*	*<0.009 ±0.0041*	*0.007 ±0.00152*	*2.27 ±0.532*	*0.0042 (0.0007 - 0.0089)*	*0.651 ±0.2147*	*<0.0001*	*<0.006 ±0.003*
Tooloombah Creek	To4	0.02 - 0.03	-	0.003	-	-	-	<0.0001	<0.001		0.003	<0.05	<0.001	0.055	<0.0001	0.001
	To1	1.92	<0.01 - 0.01	0.003	0.092	<0.01	<0.1	<0.0001	<0.001	<0.01	0.002	1.28	<0.01	0.18	<0.0001	<0.001 - 0.01
	To2	0.15	<0.01	0.004	0.112	<0.01	<0.1	<0.0001	<0.001	<0.01	0.002	0.15	<0.01	0.18	<0.0001	0.001 - 0.01
	To3	0.05	-	0.003	0.19	-	-	<0.0001	<0.001	<0.001	0.003	0.11	<0.001	0.469	<0.0001	<0.001 - 0.001
	Combined (excl. To4)	*0.71 ±0.607*	*<0.01*	*0.003 ±0.0003*	*0.131 ±0.0299*	*<0.01*	*<0.1*	*<0.0001*	*<0.001*	*<0.001*	*0.002 ±0.00033*	*0.51 ±0.384*	*<0.007 ±0.0031*	*0.276 ±0.0963*	*<0.0001*	*<0.007 ±0.004*
	St1	0.02 - 0.1	<0.01	0.004	0.369	<0.01	0.16	<0.0005	<0.005	<0.01	0.002	<0.05 - 0.06	<0.01	0.481	<0.0001	0.005
Styx River	St2	1.75	<0.01	0.01	0.229	<0.01	0.65	<0.0005	<0.001 - 0.005	<0.01	0.003	1.18	<0.01	0.496	<0.0001	0.012
Montrose Creek	Mo1	3.5	0.01 - 0.06	0.005	<0.1	<0.06	<0.1	<0.0001	<0.001	<0.055	0.002	1.65	<0.001 - 0.033	0.31	<0.0001	<0.033
	Mo2	3.78	0.01	0.003	<0.1	<0.01	<0.1	<0.0001	<0.001 - 0.001	<0.01	0.002	1.97	<0.01	0.055	<0.0001	<0.001 - 0.01
	Combined	*3.64 ±0.14*	*0.023 (0.01 - 0.06)*	*0.004 ±0.001*	*<0.1*	*<0.04 ±0.035*	*<0.1*	*<0.0001*	*<0.001*	*<0.033 ±0.0235*	*0.002 ±0*	*1.81 ±0.16*	*<0.01*	*0.183 ±0.1275*	*<0.0001*	*<0.022 ±0.013*
Other	Am1	<0.01	-	0.002	-	-	-	<0.0001	<0.001	-	0.003	0.1	<0.001	0.038	<0.0001	<0.001

Parameters		Al	An	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo
	Freshwater DGVs	0.055	0.009	0.013		0.00013	0.37	0.0002	0.001	0.0014	0.0014	0.3	0.0034	1.9	0.00006	0.034
	Estuarine DGVs	0.0005	0.27	0.0023		0.00013	5.1	0.0007	0.0044	0.001	0.0013	0.3	0.0044	0.08	0.0001	0.023
	Gr1	3.42	<0.06	0.003 - 0.028	<0.1	<0.06	<0.1	<0.0008	<0.001	<0.051	0.004	1.52	<0.028	0.055	<0.0001	<0.028
	Nee1	0.58	-	0.001	-	-	-	<0.0001	<0.001	-	0.003	0.33 - 0.34	0.002	0.03	<0.0001	<0.001
Dams	Ringtank	0.49	-	0.005	-	-	-	<0.0001	<0.001	-	0.006	1.28	0.001		<0.0001	0.007
	Surveyors	0.05	-	0.004	-	-	-	<0.0001 - 0.0001	<0.001 - 0.001	-	0.004	0.98	<0.001	1.28	<0.0001	0.016
	Combined	*0.27 ±0.22*	-	*0.005 ±0.0005*	-	-	-	*<0.0001*	*<0.001*	-	*0.005 ±0.001*	*1.13 ±0.15*	*<0.001*	*1.28*	*<0.0001*	*0.012 ±0.005*
Wetlands	Wet1	0.17	-	0.003	-	-	-	<0.0001	0.002	-	0.002	1.95	<0.001	0.095	<0.0001	<0.001
	Wet2	0.04	-	0.002	-	-	-	<0.0001	0.001	-	0.003	0.75	<0.001	0.025	<0.0001	0.002

Table notes:

* Where a range is provided, this is due to uncertainty in the data due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

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Table A7 (Cont'd)

	Parameters	Ni	Se	Ag	Sr	Tl	Sn	Ti	U	V	Zn
	Freshwater DGVs	0.011	0.005	0.00005	-	0.00003	0.003	-	0.00005	0.006	0.008
	Estuarine DGVs	0.007	0.003	0.0014	-	0.017	0.01	-	0.00005	0.1	0.015
Deep Creek	De1	0.003	<0.01 - 0.01	<0.001	0.4	<0.01	0.02	0.17	<0.001	<0.01 - 0.01	0.015
	De2	0.004	0.01 - 0.02	<0.001	0.5	<0.01 - 0.01	<0.01	0.14	<0.001	<0.01	0.018
	De3	0.003	<0.01	<0.001	0.5	<0.07	0.03 - 0.08	<0.07	<0.001	<0.01	0.01
	De4	0.006	<0.01	<0.001	-	-	-	-	<0.001	<0.01 - 0.01	0.037
	De5	0.004	<0.01	<0.001	-	-	-	-	<0.001	<0.01 - 0.01	0.01
	Combined	*0.004 ±0.0005*	*<0.01*	*<0.001*	*0.5 ±0.03*	*<0.03 ±0.021*	*<0.037 ±0.0229*	*0.12 (0.05 - 0.16)*	*<0.001*	*0.005 (0 - 0.01)*	*0.018 ±0.005*
Tooloombah Creek	To4	0.002	<0.01	-	-	-	-	-	-	<0.01	<0.005
	To1	<0.001 - 0.01	<0.01	<0.001	0.6	<0.01	<0.01 - 0.01	0.14	<0.001	<0.01	0.009
	To2	0.002 - 0.01	<0.01 - 0.01	<0.001	0.6	<0.01	<0.01	<0.01	<0.001	<0.01	0.021
	To3	0.003	<0.01	<0.001	-	-	-	-	<0.001	<0.01	0.025
	Combined (excl. To4)	*0.005 (0.001 - 0.01)*	*<0.01*	*<0.001*	*0.6 ±0*	*<0.01*	*<0.01 ±0.001*	*0.07 ±0.07*	*<0.001*	*<0.01*	*0.018 ±0.0048*
	St1	0.002	<0.03	<0.001	1.4	<0.01	<0.01	0.16	0.001	<0.04	0.012
Styx River	St2	0.003	0.02 - 0.05	<0.005	1.7	<0.01	<0.01	0.19	0.002	<0.05	0.015 - 0.025
Montrose Creek	Mo1	<0.001 - 0.033	0.01 - 0.04	<0.001	0.3	0.01 - 0.06	<0.01 - 0.06	0.12 - 0.13	<0.001	<0.03	0.006
	Mo2	0.001	<0.01 - 0.02	<0.001	0.3	0.01 - 0.02	<0.01	0.14	<0.001	<0.01 - 0.01	0.026
	Combined	*0.009 (0.001 - 0.033)*	*0.02 (0.01 - 0.04)*	*<0.001*	*0.3*	*0.025 (0.01 - 0.06)*	*<0.035 ±0.026*	*0.14 (0.12 - 0.15)*	*<0.001*	*<0.02 ±0.011*	*0.016 ±0.01*
Other Creeks	Am1	<0.001	<0.01	-	-	-	-	-	-	<0.01	0.01
	Gr1	<0.028	0.01 - 0.04	<0.001	0.2	<0.06	<0.06	0.13	<0.001	<0.03	0.009
	Nee1	0.002	<0.01	-	-	-	-	-	-	<0.01	<0.005 - 0.006
Dams	Ringtank	0.024	<0.01	-	-	-	-	-	-	<0.01	0.037
	Surveyors	0.003	<0.01	-	-	-	-	-	-	<0.01	0.018
	Combined	*0.014 ±0.0105*	*<0.01*	-	-	-	-	-	-	*<0.01*	*0.028 ±0.0095*

Parameters		Ni	Se	Ag	Sr	Tl	Sn	Ti	U	V	Zn
Freshwater DGVs		0.011	0.005	0.00005	-	0.00003	0.003	-	0.00005	0.006	0.008
Estuarine DGVs		0.007	0.003	0.0014	-	0.017	0.01	-	0.00005	0.1	0.015
Wetlands	Wet1	0.001	<0.01	-	-	-	-	-	-	<0.01	0.016
	Wet2	0.002	<0.01	-	-	-	-	-	-	<0.01	0.016

Table A8. Calculated Statistics (80th percentile) and DGVs from Water (EPP) – Metals and metalloids, all data*

	Parameters	Al	An	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo
	Freshwater DGVs	0.055	0.009	0.013		0.00013	0.37	0.0002	0.001	0.0014	0.0014	0.3	0.0034	1.9	0.00006	0.034
	Estuarine DGVs	0.0005	0.27	0.0023		0.00013	5.1	0.0007	0.0044	0.001	0.0013	0.3	0.0044	0.08	0.0001	0.023
Deep Creek	De1	0.31	<0.01	0.002	0.058	<0.01	0.1	<0.0001	<0.001	<0.01	0.003	0.29	<0.004	0.071	<0.0001	<0.01
	De2	0.04	0.01	0.002	0.047	<0.01	<0.1	<0.0001	<0.001	<0.01	0.003	0.13	<0.01	0.069	<0.0001	<0.01
	De3	0.56	<0.01	0.003	0.062	<0.01	<0.1	<0.0001	0.001	<0.01	0.002	0.36	<0.01	0.201	<0.0001	<0.01
	De4	0.24	-	0.003	0.065	-	-	<0.0001	<0.001	<0.001	0.003	0.21	<0.001	0.28	<0.0001	<0.001
	De5	0.05	-	0.003	0.033	-	-	<0.0001	<0.001	<0.001	0.002	0.1	<0.001	0.03	<0.0001	<0.001
	Combined	*0.24 ±0.096*	*<0.01 ±0.001*	*0.028 (0.003 - 0.059)*	*0.053 ±0.0059*	*<0.01*	*<0.1*	*<0.0001*	*<0.001*	*<0.006 ±0.0032*	*0.003 ±0.00024*	*0.22 ±0.049*	*0.0026 (0 - 0.0072)*	*0.13 ±0.0473*	*<0.0001*	*<0.001*
Tooloombah Creek	To4	<0.01 - 0.01	-	0.003	-	-	-	<0.0001	<0.001	-	0.002	<0.05	<0.001	0.017	<0.0001	0.001
	To1	0.09	<0.01	0.002	0.074	<0.01	<0.1	<0.0001	<0.001	<0.01	0.001	0.06	<0.01	0.051	<0.0001	<0.01
	To2	0.02	<0.01	0.003	0.101	<0.01	<0.1	<0.0001	<0.001	<0.01	0.001	<0.05	<0.001	0.075	<0.0001	<0.007
	To3	0.02	-	0.002	0.131	-	-	<0.0001	<0.001	<0.001	0.002	<0.05	<0.001	0.083	<0.0001	<0.001
	Combined (excl. To4)	*0.04 ±0.023*	*<0.01*	*0.002 ±0.0003*	*0.102 ±0.0165*	*<0.01*	*<0.1*	*<0.0001*	*<0.001*	*<0.01*	*0.001 ±0.00033*	*<0.05 ±0.013*	*<0.004 ±0.0031*	*0.07 ±0.0096*	*<0.0001*	*<0.006 ±0.004*
	St1	<0.1	<0.01	0.003	0.271	<0.01	<0.1	<0.0001	<0.001	<0.01	0.002	<0.05	<0.01	0.283	<0.0001	0.002
Styx River	St2	0.01	<0.01	0.006	0.2	<0.01	0.4	<0.0005	<0.005	<0.01	0.003	0.06	<0.01	0.286	<0.0001	0.004
Montrose Creek	Mo1	<0.1	<0.01	0.002	<0.1	<0.01	<0.1	<0.0001	<0.001	<0.01	0.002	0.15	<0.01	0.19	<0.0001	<0.01
	Mo2	0.06	0.01	0.002	<0.1	<0.01	<0.1	<0.0001	<0.001	<0.01	0.002	0.12	<0.01	0.038	<0.0001	<0.01
	Combined	*<0.08 ±0.03*	*<0.01 ±0.001*	*0.002 ±0*	*<0.1*	*<0.01*	*<0.1*	*<0.0001*	*<0.001*	*<0.01*	*0.002 ±0*	*0.14 ±0.015*	*<0.01*	*0.114 ±0.076*	*<0.0001*	*<0.001*
Other Creeks	Am1	<0.01	-	0.001	-	-	-	<0.0001	<0.001	-	0.001	0.09	<0.001	0.031	<0.0001	<0.001
	Gr1	0.05	<0.01	<0.01	<0.1	<0.01	<0.1	<0.0001	<0.001	<0.01	0.002	0.14	<0.01	0.029	<0.0001	<0.01
	Nee1	0.15	-	0.001	-	-	-	<0.0001	<0.001	-	0.003	0.08 - 0.12	<0.001 - 0.001	0.028	<0.0001	<0.001
Dams	Ringtank	0.38	-	0.004	-	-	-	<0.0001	<0.001	-	0.006	1.04	0.001	-	<0.0001	0.005
	Surveyors	0.04	-	0.003	-	-	-	<0.0001	<0.001	-	0.003	0.89	<0.001	0.366	<0.0001	0.004

	Parameters	Al	An	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo
	Freshwater DGVs	0.055	0.009	0.013		0.00013	0.37	0.0002	0.001	0.0014	0.0014	0.3	0.0034	1.9	0.00006	0.034
	Estuarine DGVs	0.0005	0.27	0.0023		0.00013	5.1	0.0007	0.0044	0.001	0.0013	0.3	0.0044	0.08	0.0001	0.023
	Combined	*0.21 ±0.17*	-	*0.004 ±0.0005*	-	-	-	*<0.0001*	*<0.001*	-	*0.005 ±0.0015*	*0.97 ±0.075*	*<0.001*	*0.366*	*<0.0001*	*0.005 ±0.001*
Wetlands	Wet1	0.17	-	0.002	-	-	-	<0.0001	0.002	-	0.001	1.39	<0.001	0.064	<0.0001	<0.001
	Wet2	0.03	-	0.002	-	-	-	<0.0001	0.001	-	0.003	0.74	<0.001	0.021	<0.0001	<0.001 - 0.001

Table notes:

* Where a range is provided, this is due to uncertainty in the data due to <LOR values, and the true statistic lies in the stated range. Combined statistics show the average of the system sites, plus or minus the standard error, after the QWQGs

Table A8 (Cont'd)

Parameters		Ni	Se	Ag	Sr	Tl	Sn	Ti	U	V	Zn
Freshwater DGVs		0.011	0.005	0.00005	-	0.00003	0.003	-	0.00005	0.006	0.008
Estuarine DGVs		0.007	0.003	0.0014	-	0.017	0.01	-	0.00005	0.1	0.015
Deep Creek	De1	0.002	<0.01	<0.001	0.4	<0.01	<0.01 - 0.01	0.08 - 0.09	<0.001	<0.01	0.01
	De2	0.003	<0.01	<0.001	0.4	<0.01	<0.01	0.01 - 0.02	<0.001	<0.01	0.006
	De3	0.002	<0.01	<0.001	0.4	<0.01	<0.03	<0.01	<0.001	<0.01	0.005
	De4	0.002	<0.01	<0.001	-	-	-	-	<0.001	<0.01	0.006
	De5	0.002	<0.01	<0.001	-	-	-	-	<0.001	<0.01	<0.005
	Combined	*0.002 ±0.0002*	*<0.01*	*<0.001*	*0.4 ±0*	*<0.01*	*<0.017 ±0.0077*	*0.04 (0.01 - 0.07)*	*<0.001*	*<0.01*	*0.006 (0.003 - 0.007)*
Tooloombah Creek	To4	<0.001 - 0.001	<0.01	-	-	-	-	-	-	<0.01	<0.005
	To1	<0.01	<0.01	<0.001	0.5	<0.01	<0.01	0.02	<0.001	<0.01	<0.005
	To2	<0.002	<0.01	<0.001	0.5	<0.01	<0.01	<0.01	<0.001	<0.01	0.007
	To3	0.001	<0.01	<0.001	-	-	-	-	<0.001	<0.01	0.012
	Combined (excl. To4)	*0.002 (0 - 0.007)*	*<0.01*	*<0.001*	*0.5*	*<0.01*	*<0.01*	*<0.02 ±0.006*	*<0.001*	*<0.01*	*0.01 ±0.0025*
	St1	0.001	<0.01	<0.001	0.9	<0.01	<0.01	<0.01	<0.001	<0.01	0.006
Styx River	St2	0.002	<0.02	<0.001	1.2	<0.01	<0.01	0.02	0.002	<0.02	<0.005 - 0.025
Montrose Creek	Mo1	<0.01	<0.01	<0.001	0.3	<0.01	<0.01	<0.07	<0.001	<0.01	<0.005
	Mo2	0.001	<0.01	<0.001	0.3	<0.01	<0.01	0.04 - 0.05	<0.001	<0.01	0.015
	Combined	*0.004 (0.001 - 0.011)*	*<0.01*	*<0.001*	*0.3*	*<0.01*	*<0.01*	*<0.06 ±0.02*	*<0.001*	*<0.01*	*0.008 ±0.0075*
Other Creeks	Am1	<0.001	<0.01	-	-	-	-	-	-	<0.01	0.008
	Gr1	<0.01	<0.01	<0.001	0.2	<0.01	<0.01	<0.09	<0.001	<0.01	<0.005
	Nee1	0.002	<0.01	-	-	-	-	-	-	<0.01	<0.005 - 0.005
Dams	Ringtank	0.014	<0.01	-	-	-	-	-	-	<0.01	0.028
	Surveyors	0.002	<0.01	-	-	-	-	-	-	<0.01	0.015
	Combined	*0.008 ±0.006*	*<0.01*	-	-	-	-	-	-	*<0.01*	*0.028*

Parameters		Ni	Se	Ag	Sr	Tl	Sn	Ti	U	V	Zn
Freshwater DGVs		0.011	0.005	0.00005	-	0.00003	0.003	-	0.00005	0.006	0.008
Estuarine DGVs		0.007	0.003	0.0014	-	0.017	0.01	-	0.00005	0.1	0.015
Wetlands	Wet1	0.001	<0.01	-	-	-	-	-	-	<0.01	0.011
	Wet2	0.002	<0.01	-	-	-	-	-	-	<0.01	0.008

A2 – Water Quality Box Plots

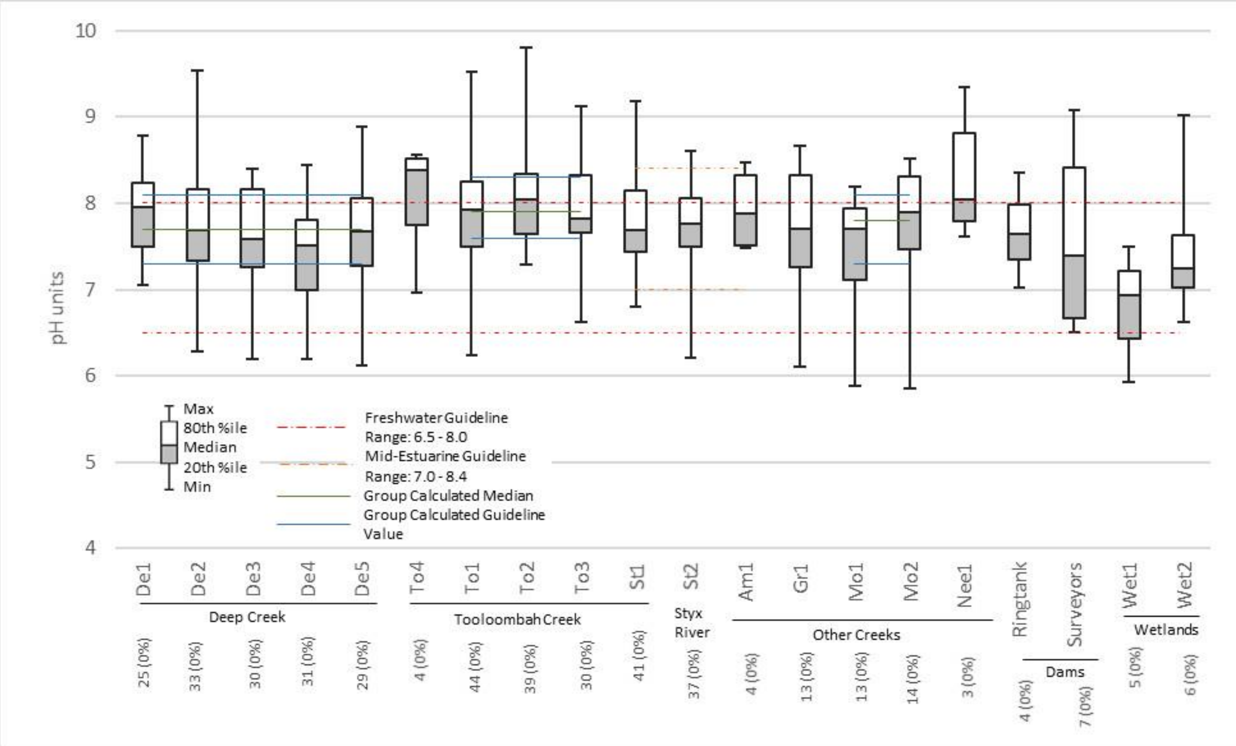


Figure A1. pH summary statistics, Base flow – no flow dataset

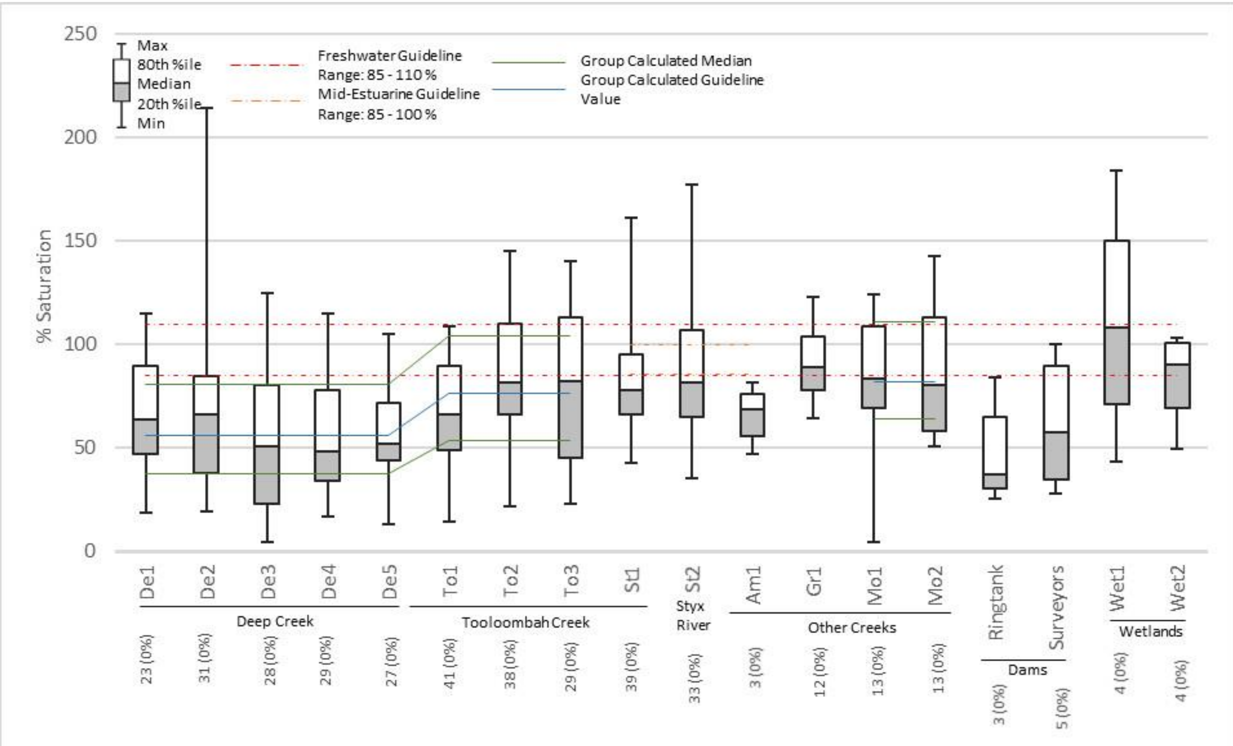


Figure A2. Dissolved Oxygen summary statistics, Base flow – no flow dataset

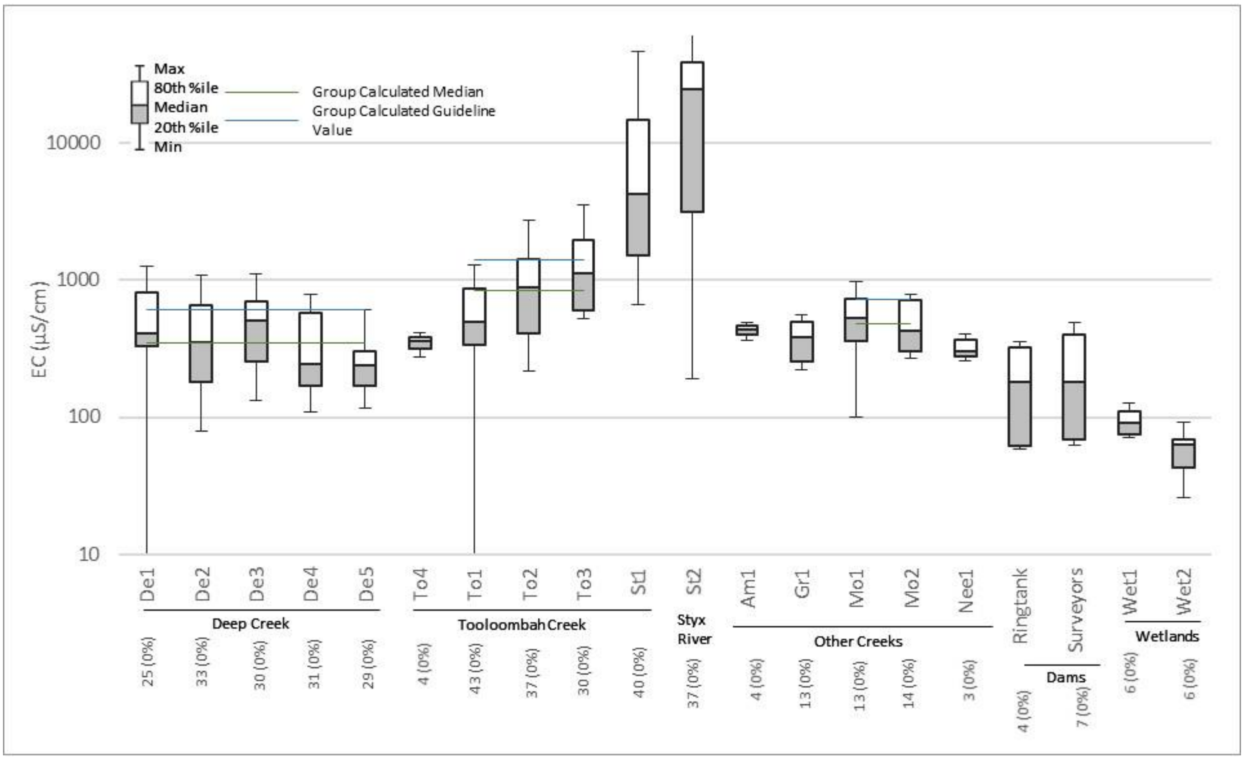


Figure A3. Electrical Conductivity summary statistics, Base flow – no flow dataset

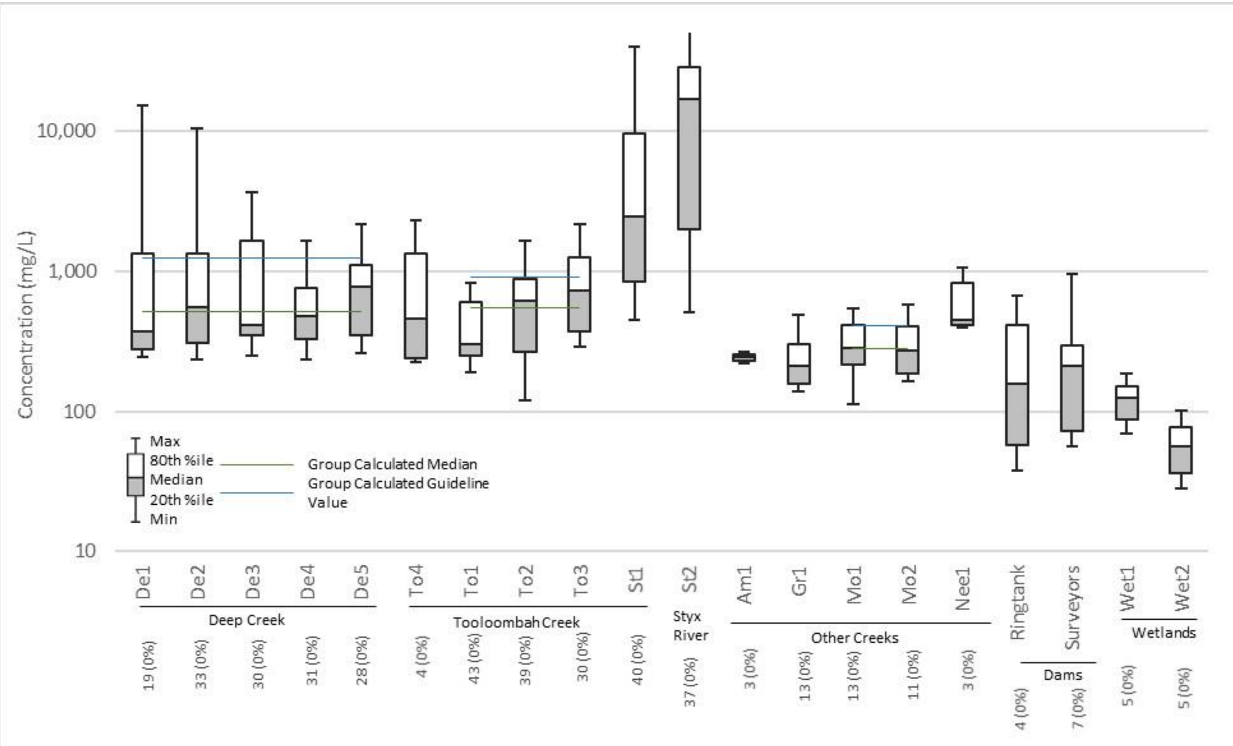


Figure A4. Total Dissolved Solids summary statistics, Base flow – no flow dataset

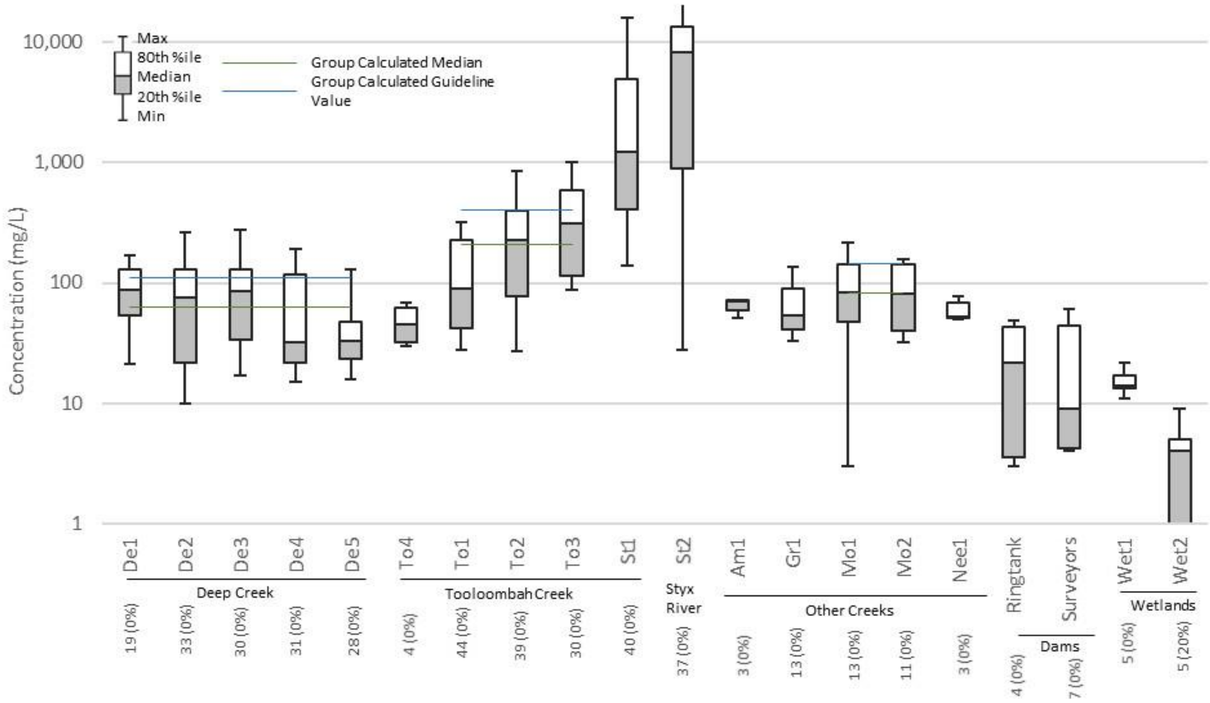


Figure A5. Chloride summary statistics, Base flow – no flow dataset

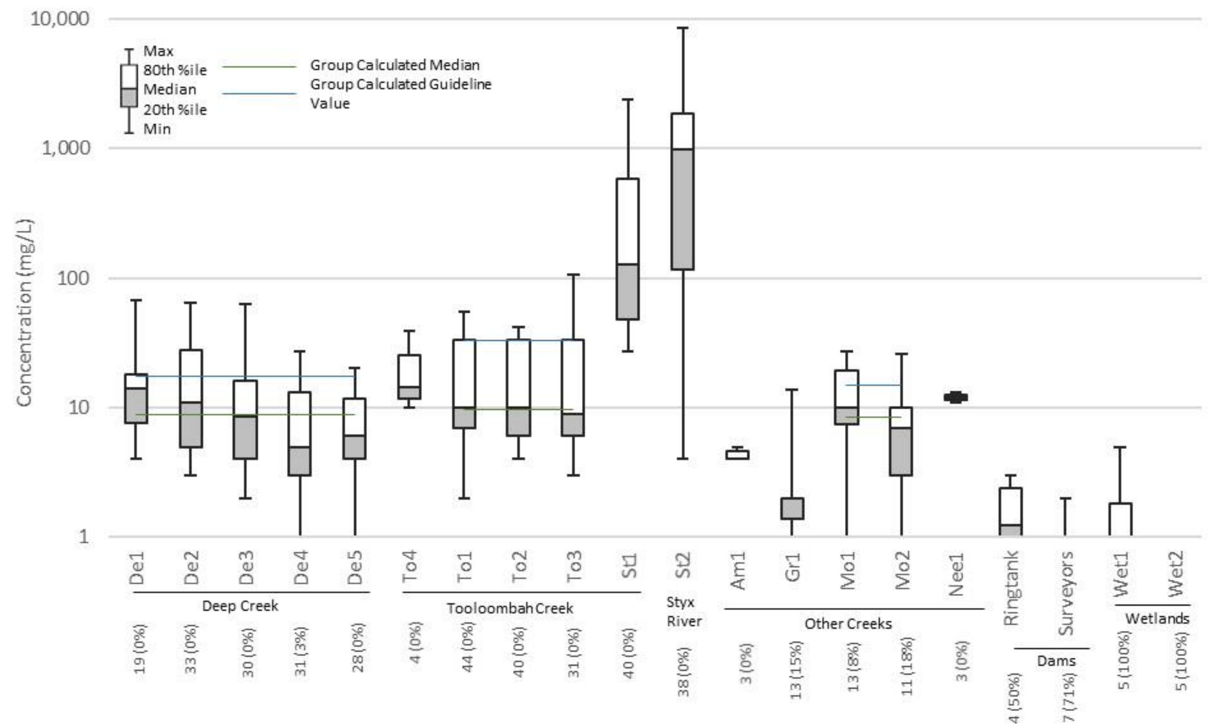


Figure A6. Sulfate summary statistics, Base flow – no flow dataset

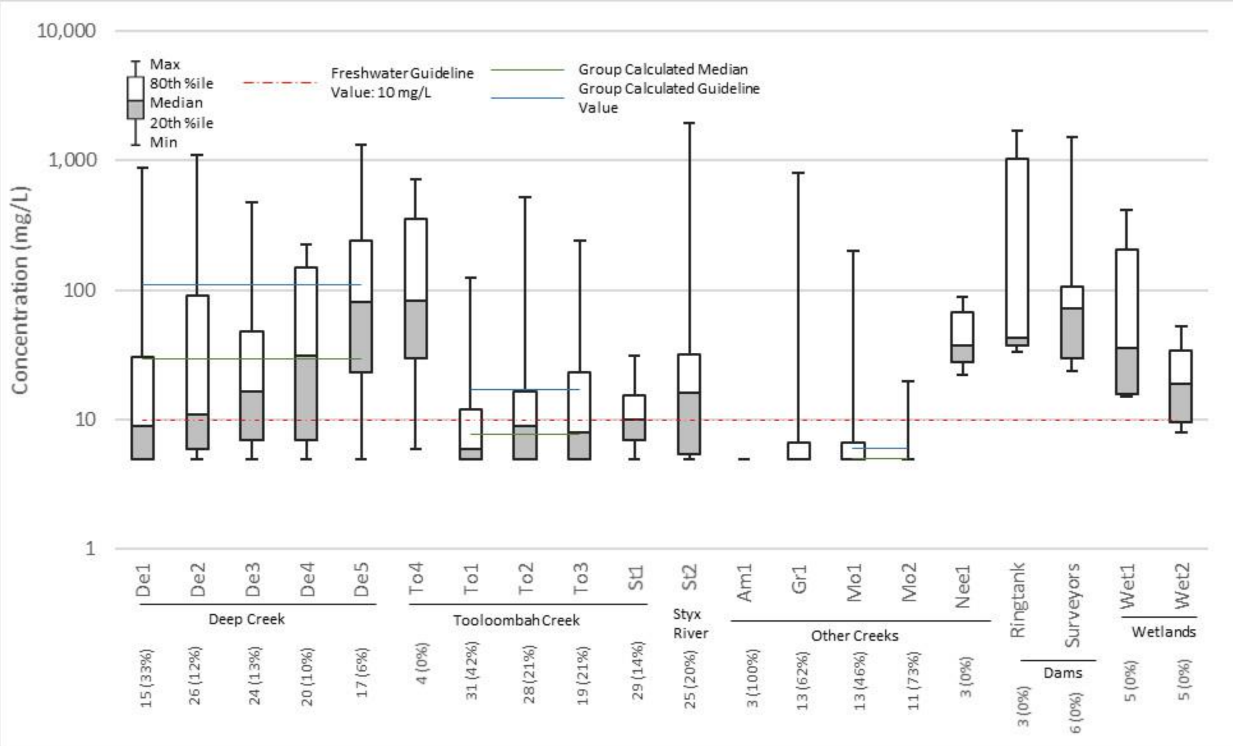


Figure A7. Total Suspended Solids summary statistics, Base flow – no flow dataset

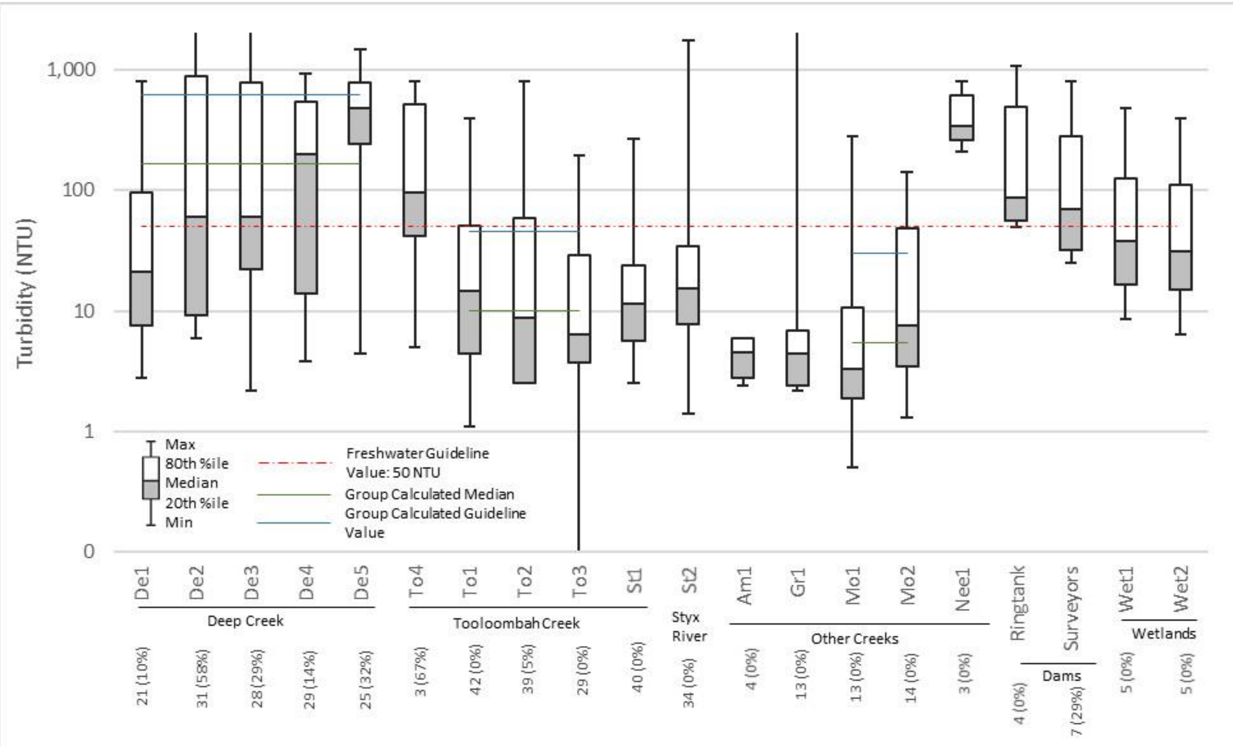


Figure A8. Turbidity summary statistics, Base flow – no flow dataset

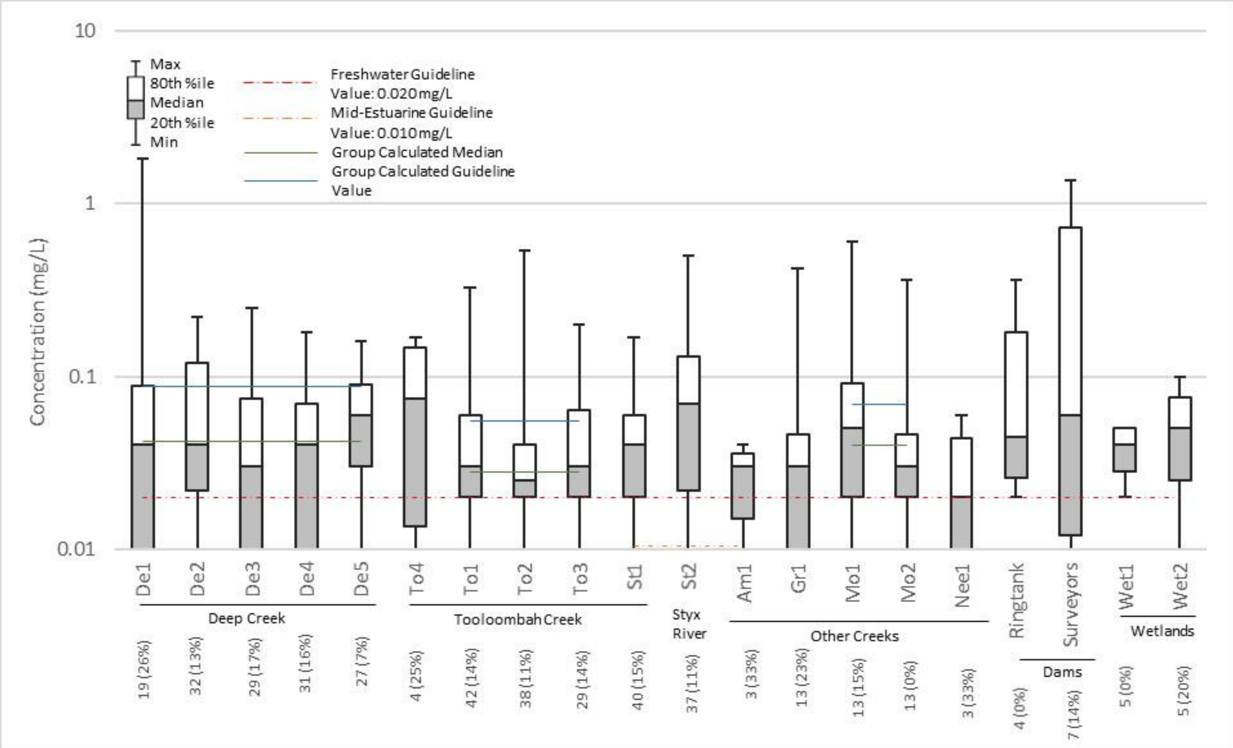


Figure A9. Ammonia summary statistics, Base flow – no flow dataset

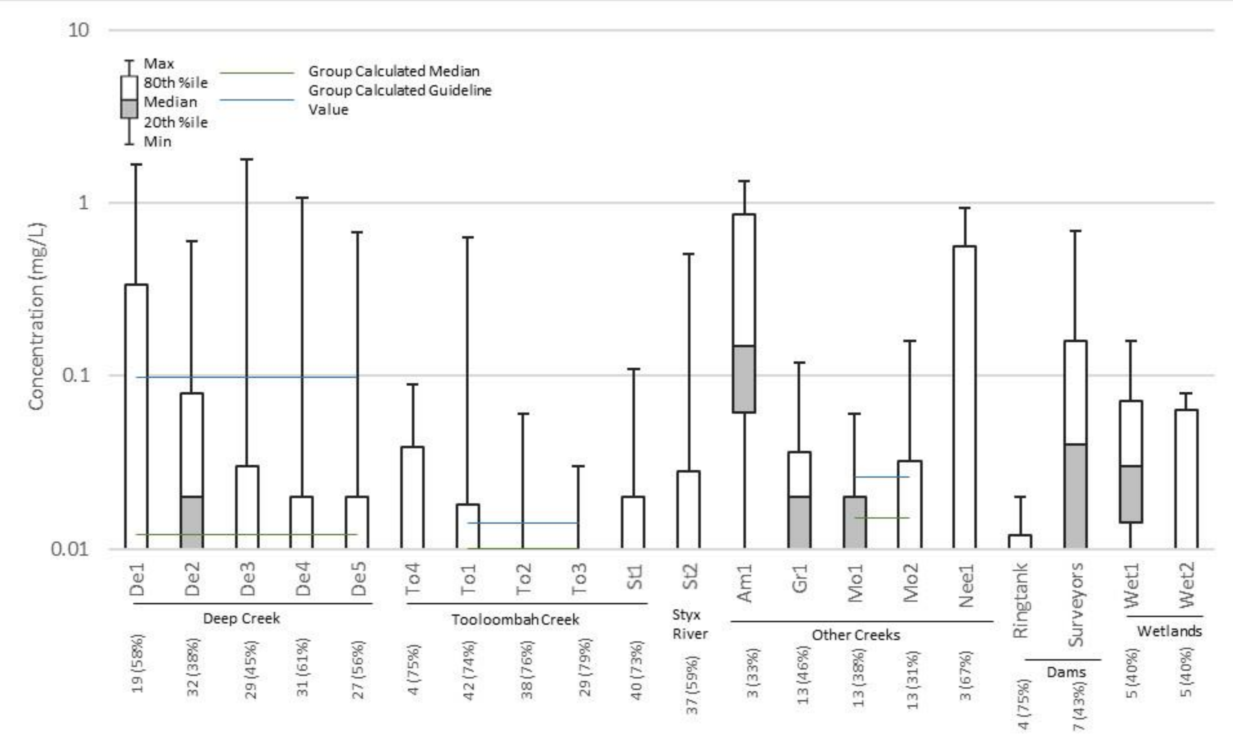


Figure A10. Nitrate summary statistics, Base flow – no flow dataset

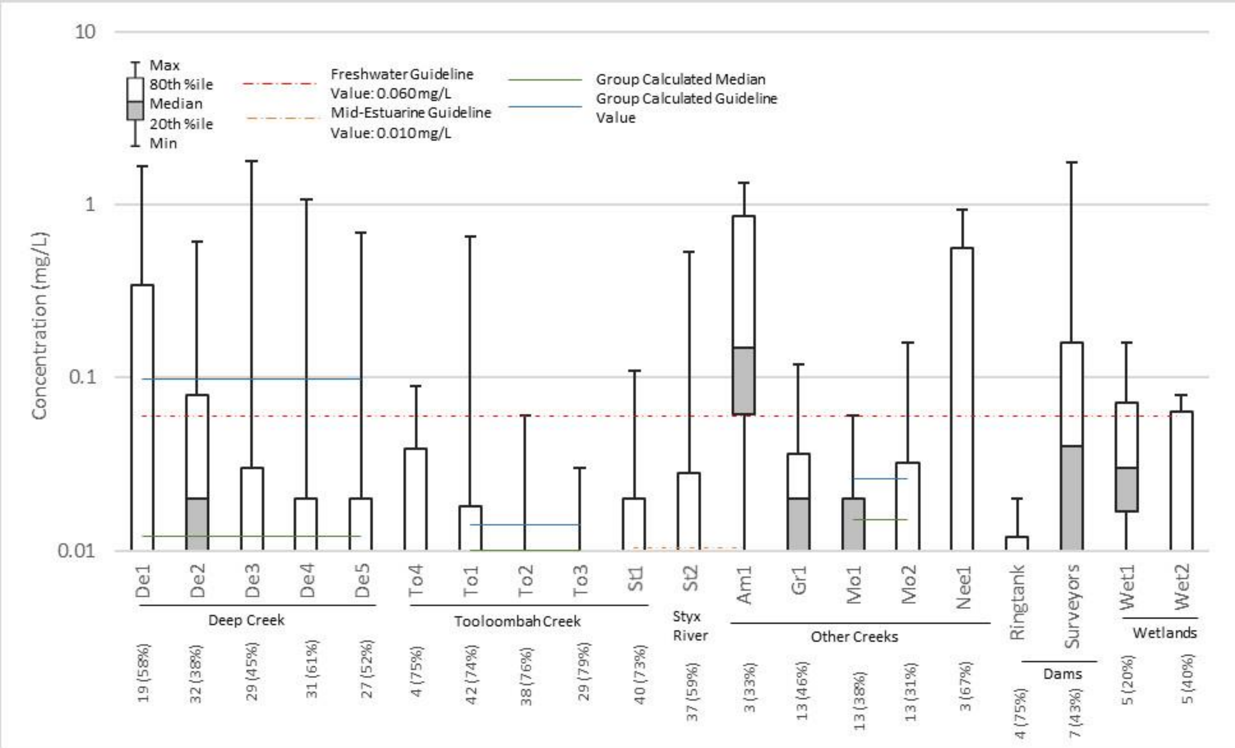


Figure A11. Oxidised Nitrogen summary statistics, Base flow – no flow dataset

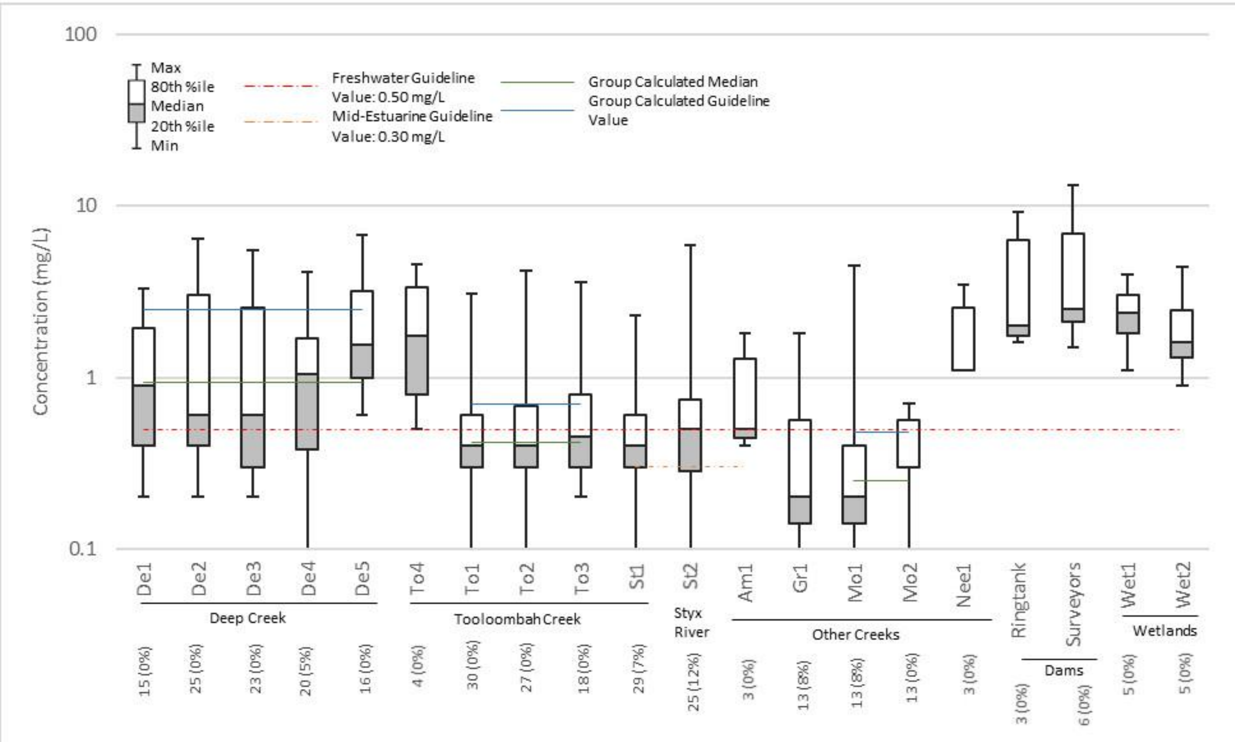


Figure A12. Total Nitrogen summary statistics, Base flow – no flow dataset

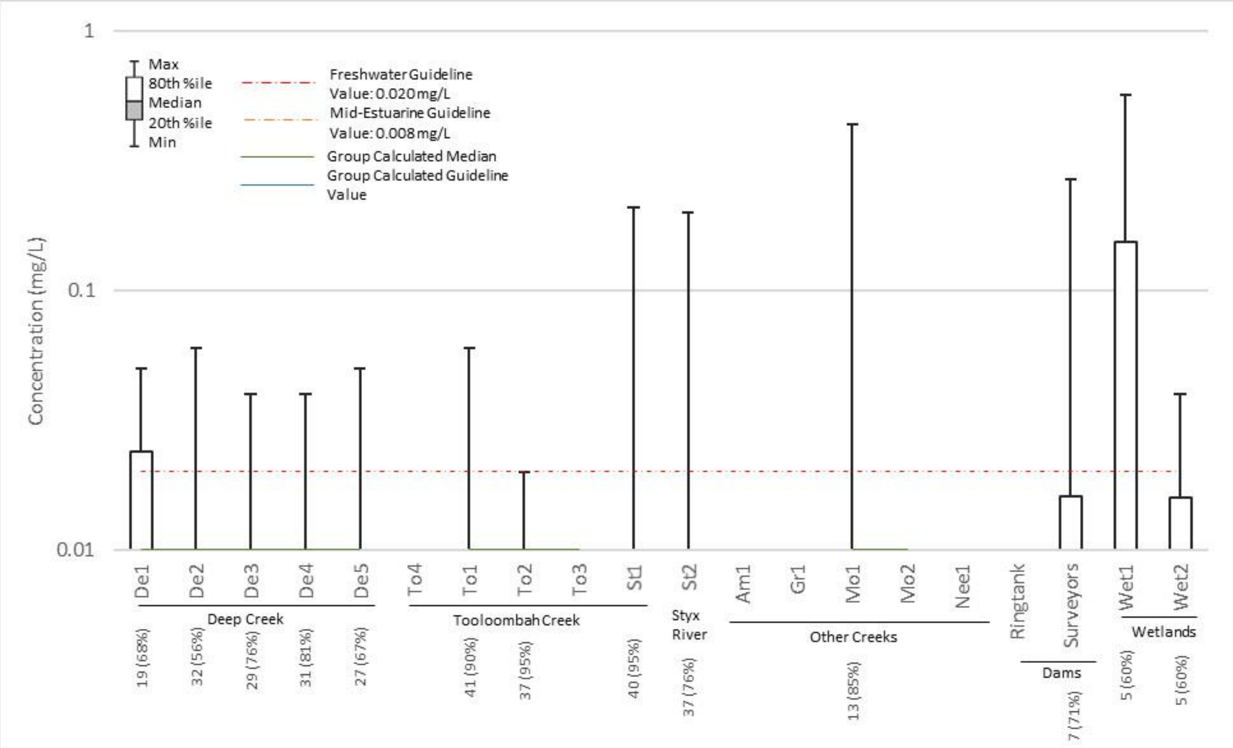


Figure A13. Filterable Reactive Phosphorous summary statistics, Base flow – no flow dataset

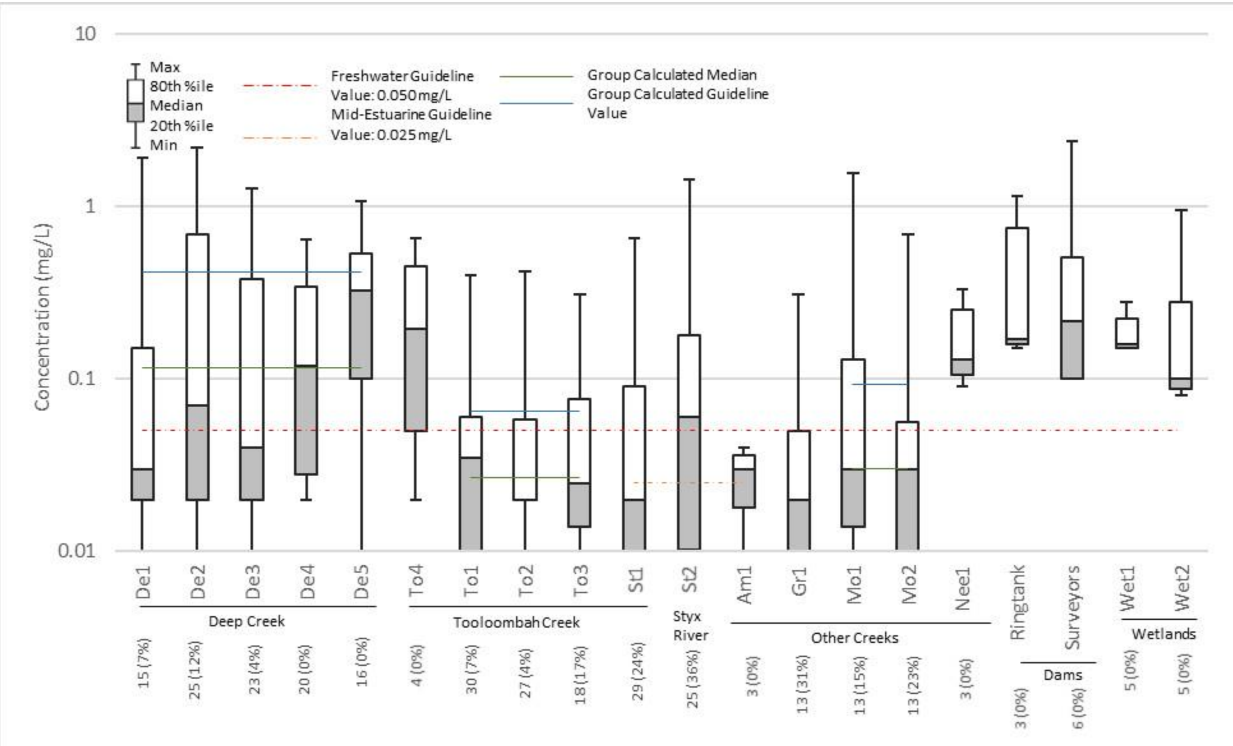


Figure A14. Total Phosphorous summary statistics, Base flow – no flow dataset

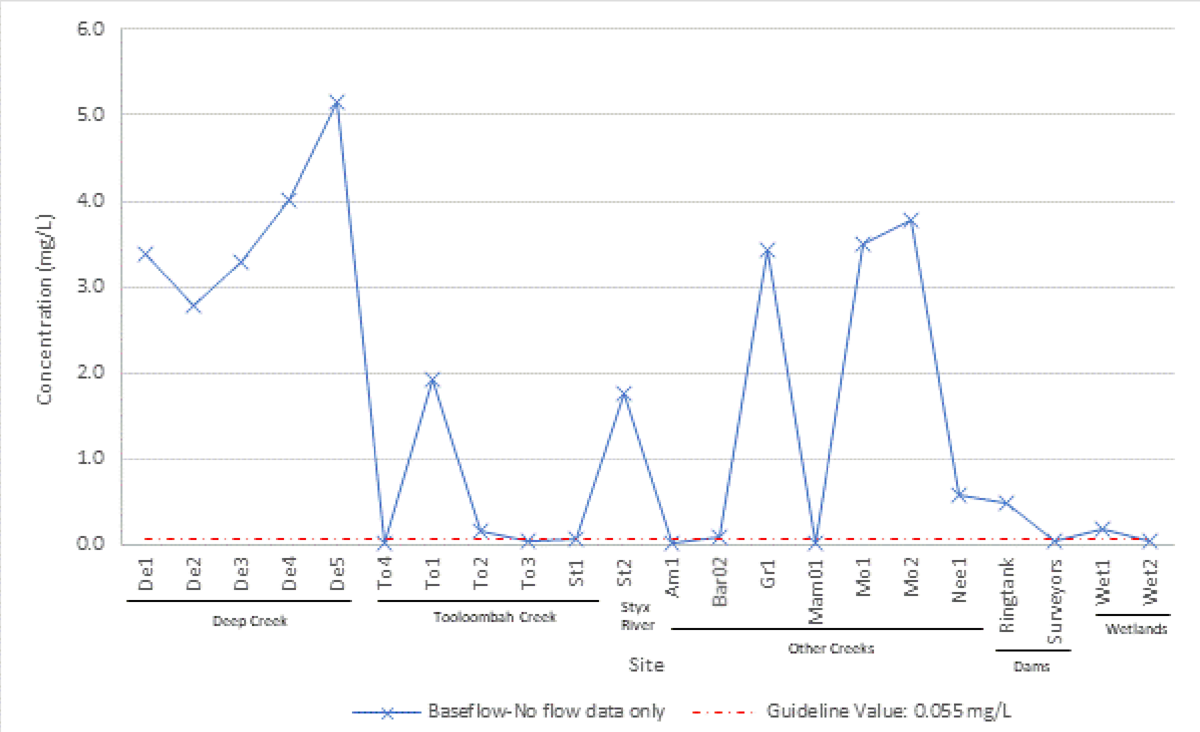


Figure A15. Dissolved aluminium 95th percentiles

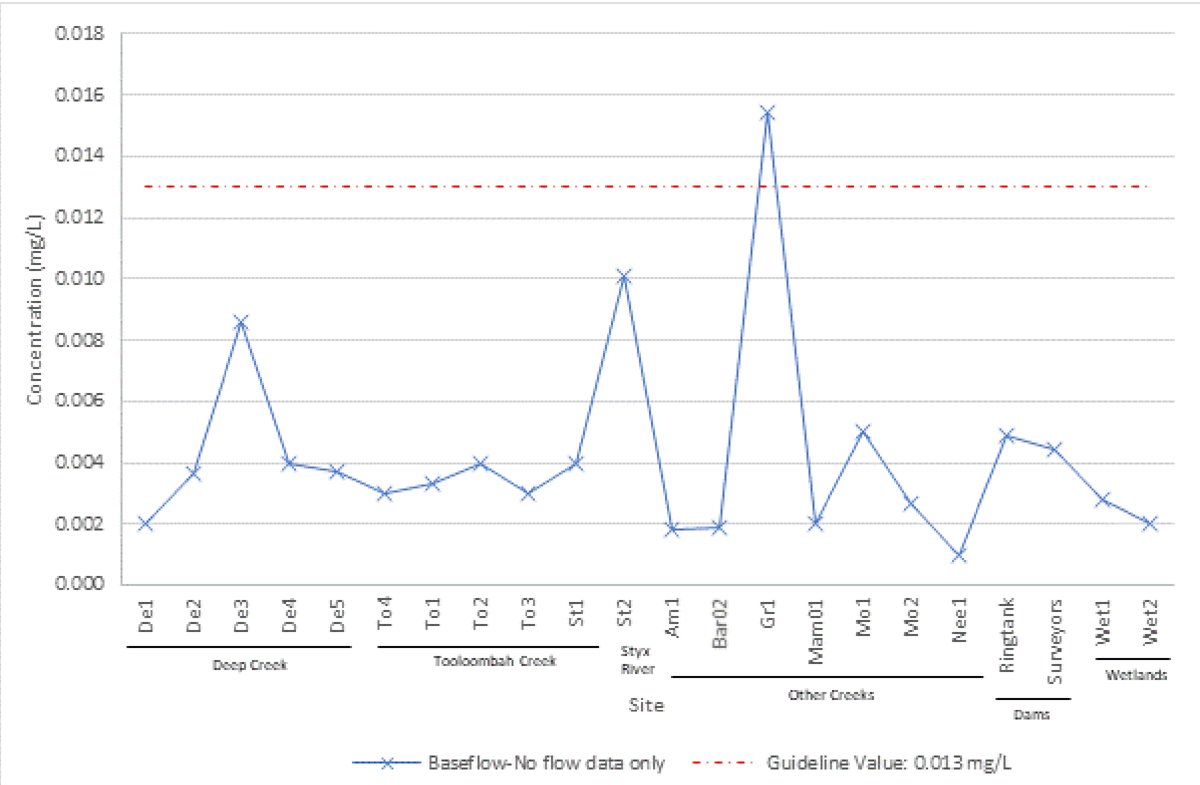


Figure A16. Dissolved Arsenic 95th percentiles

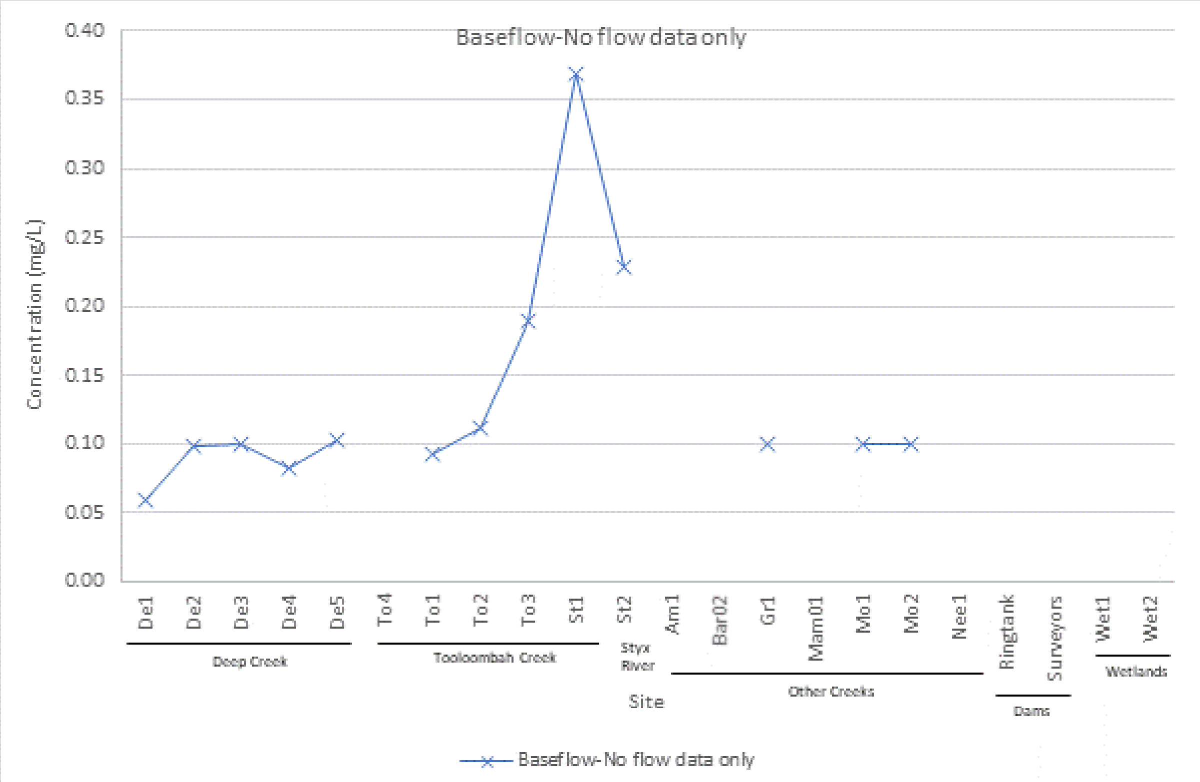


Figure A17. Dissolved Barium 95th percentiles

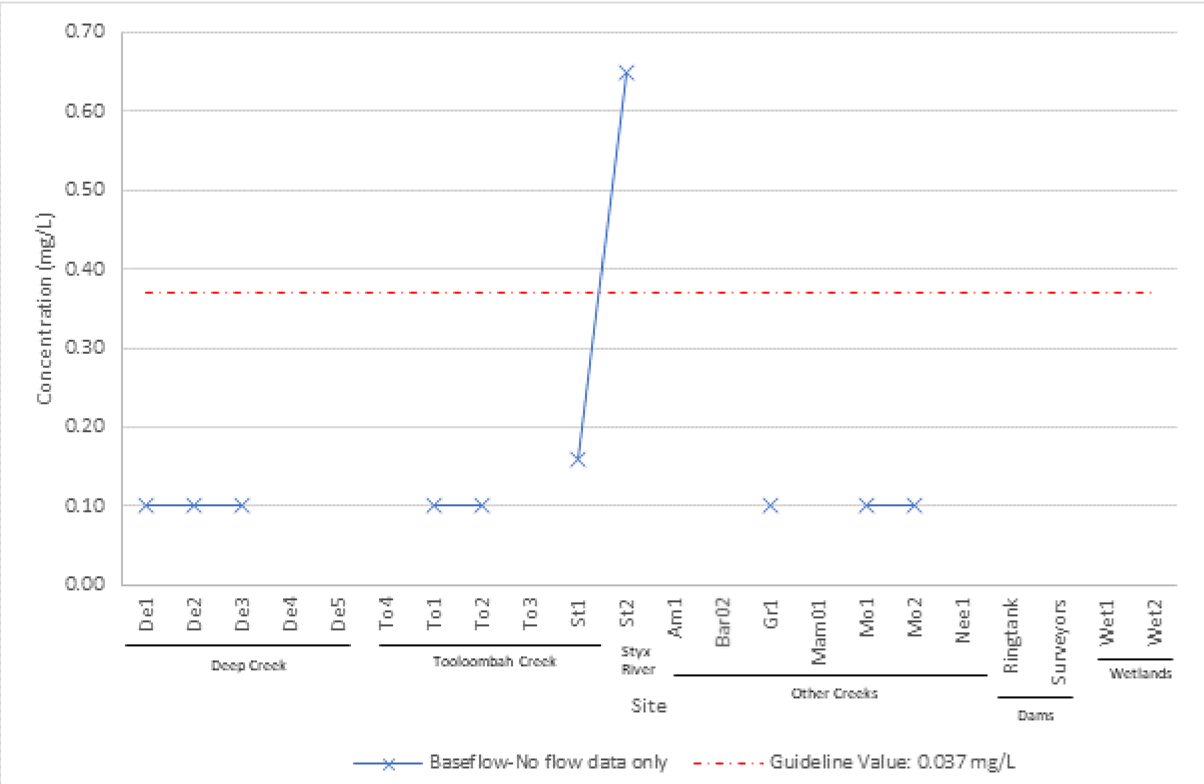


Figure A18. Dissolved Boron 95th percentiles

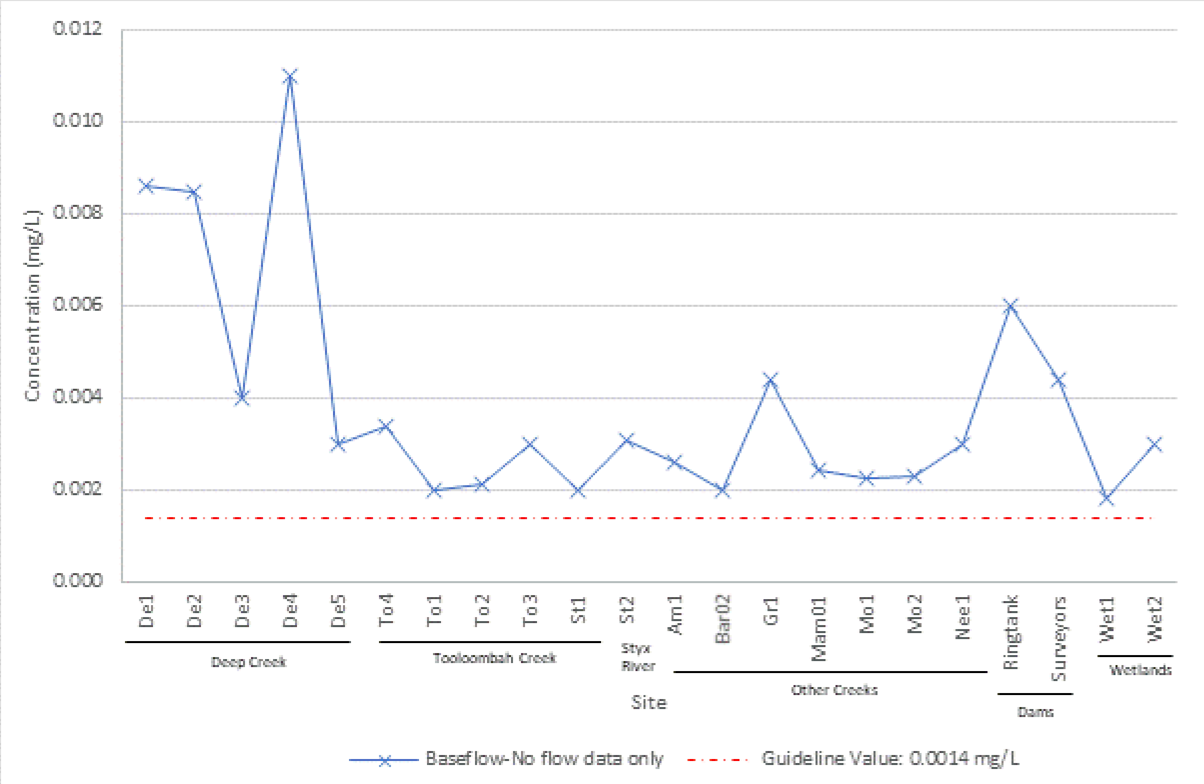


Figure A19. Dissolved Copper 95th percentiles

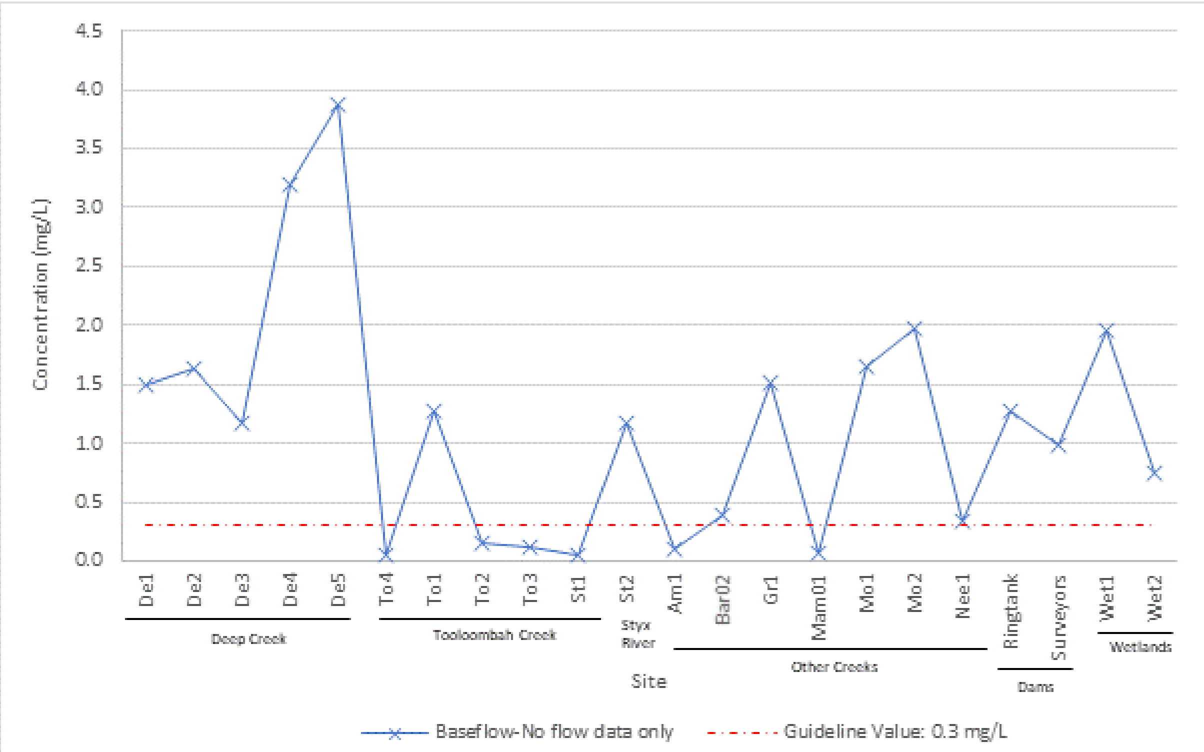


Figure A20. Dissolved Iron 95th percentiles

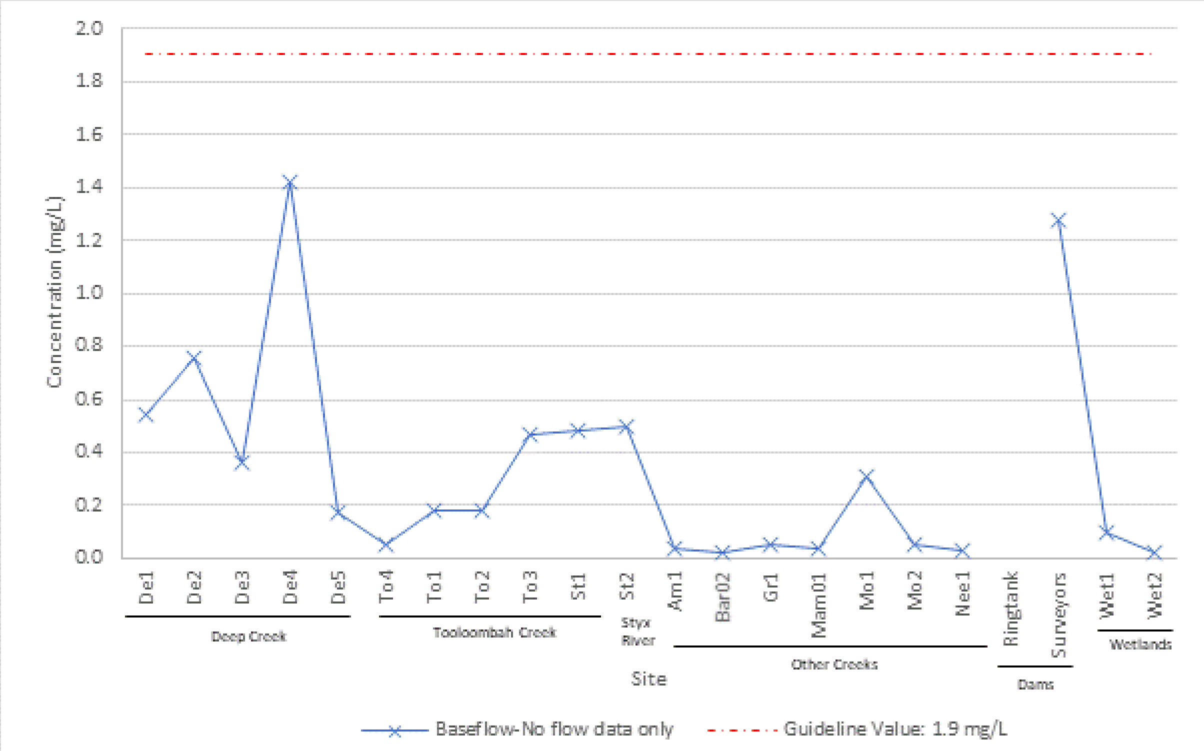


Figure A21. Dissolved Manganese 95th percentiles

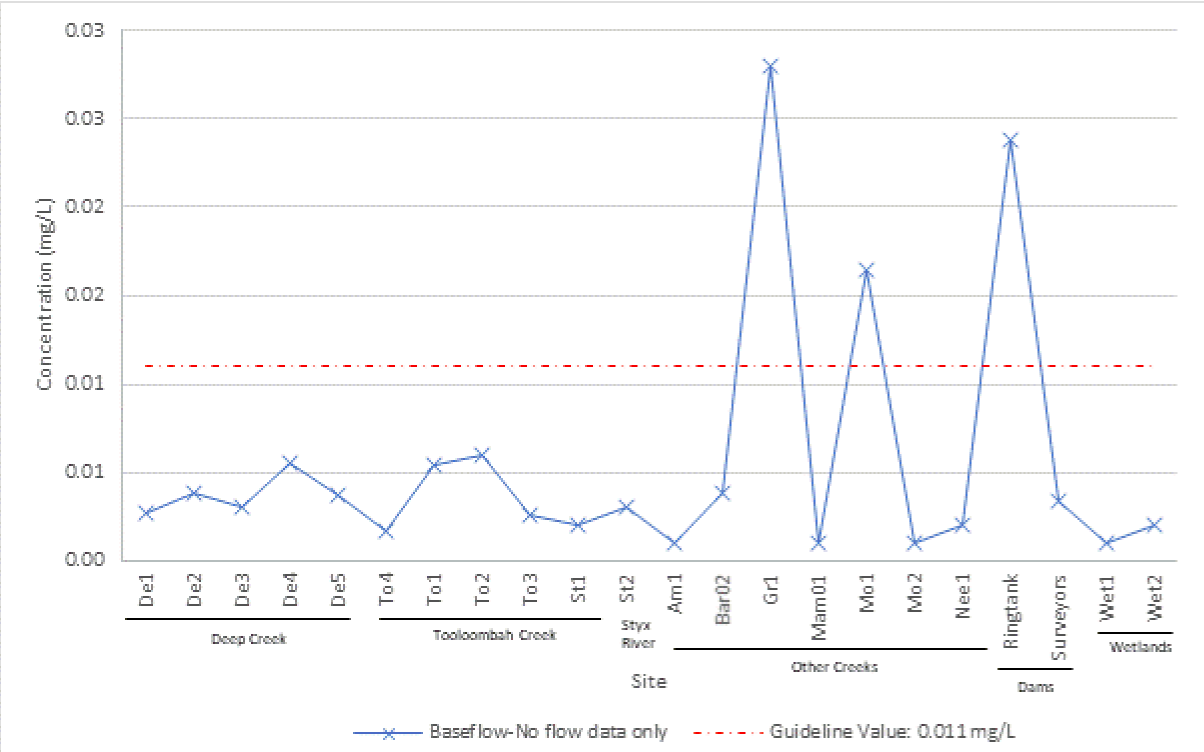


Figure A22. Dissolved Nickel 95th percentiles

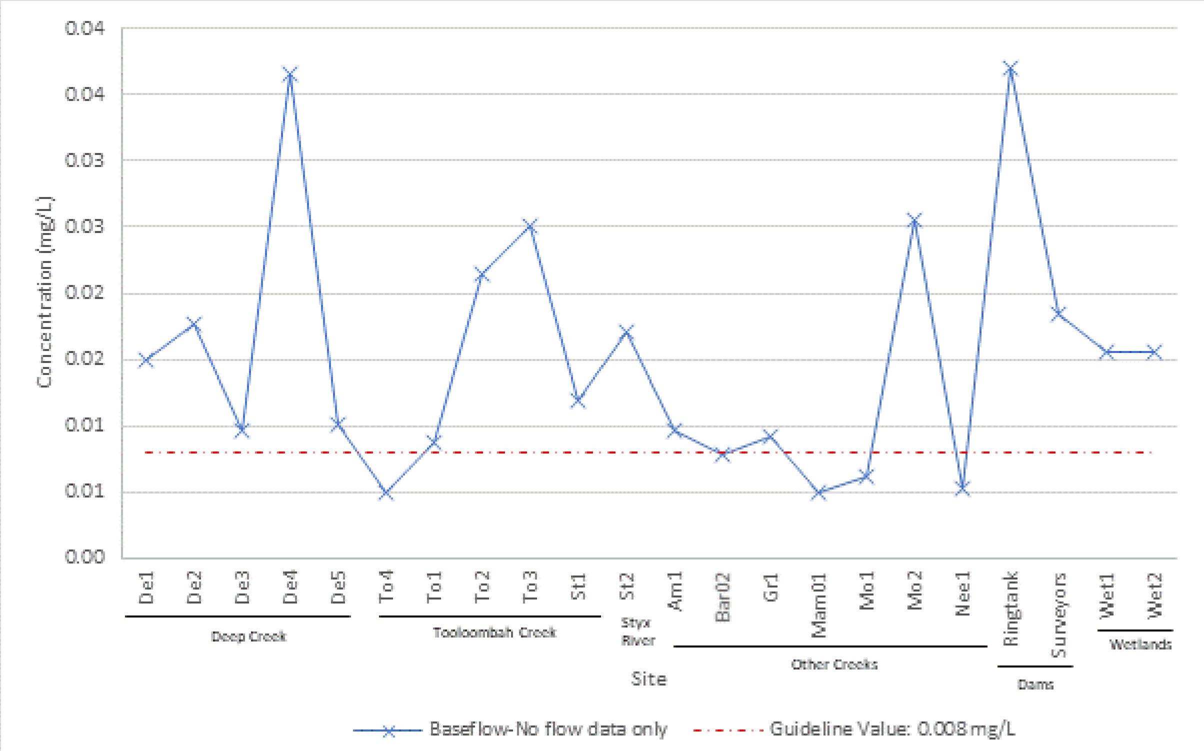


Figure A23. Dissolved Zinc 95th percentiles

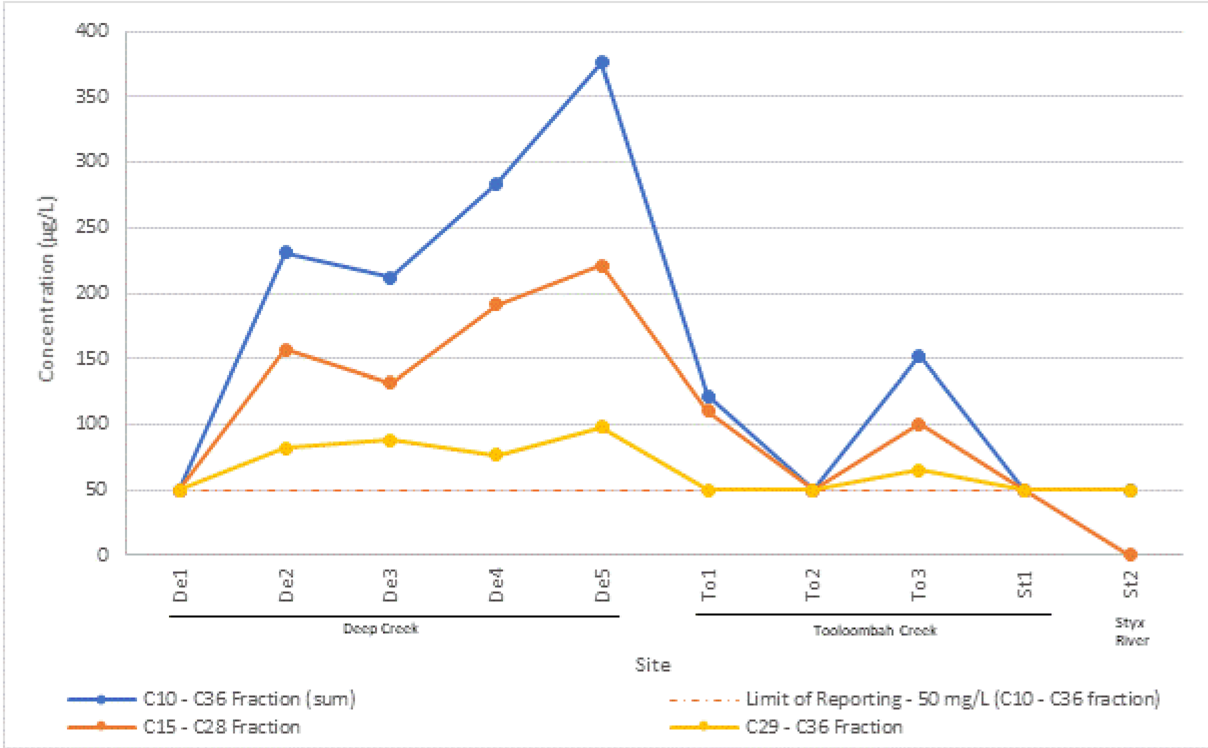


Figure A24. Total Petroleum Hydrocarbons in natural waters (95th percentile)

A3 – Water Quality Time Series Graphs

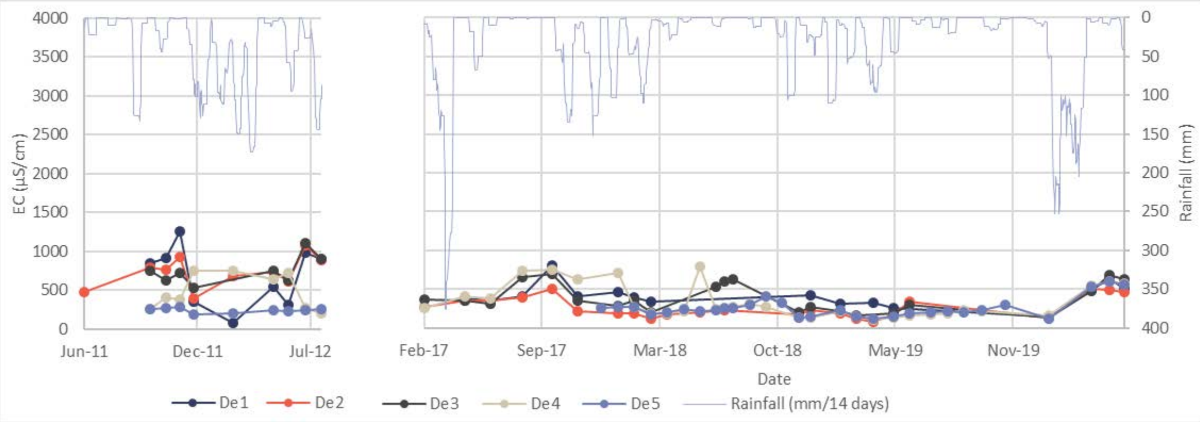


Figure A25. Timeseries of EC results, Deep Creek

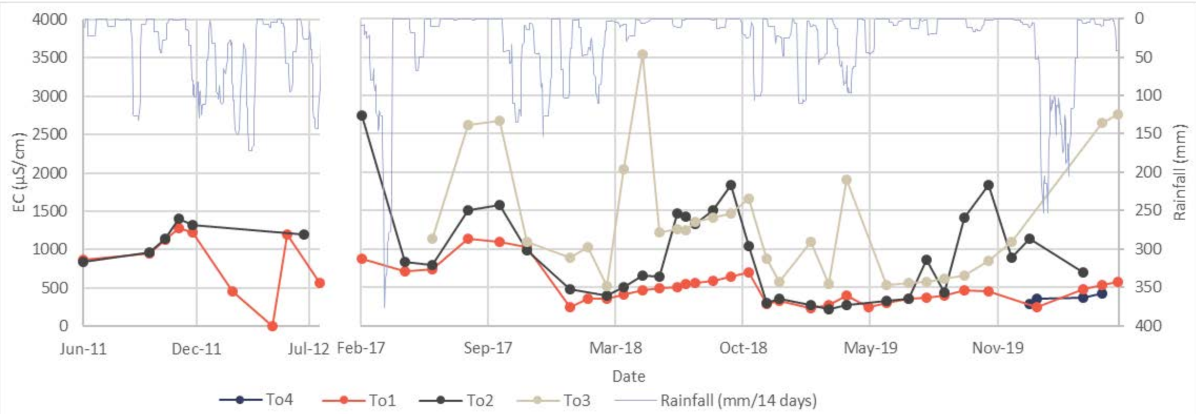


Figure A26. Timeseries of EC results, Tooloombah Creek

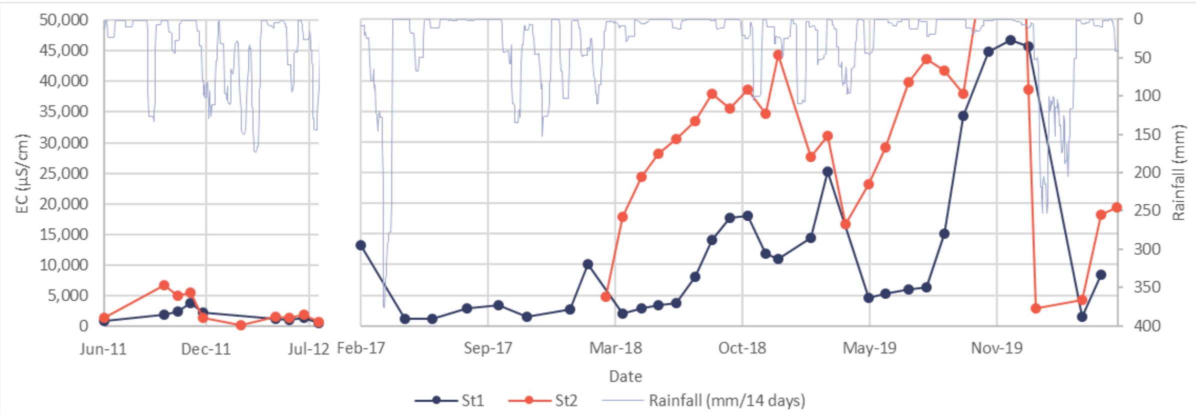


Figure A27. Timeseries of EC results, Confluence and Styx River

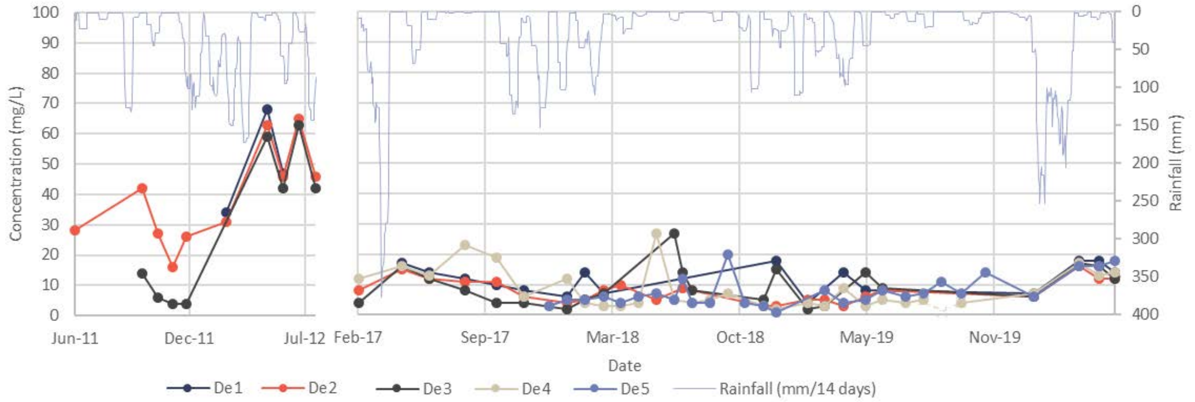


Figure A28. Timeseries of Sulfate results, Deep Creek

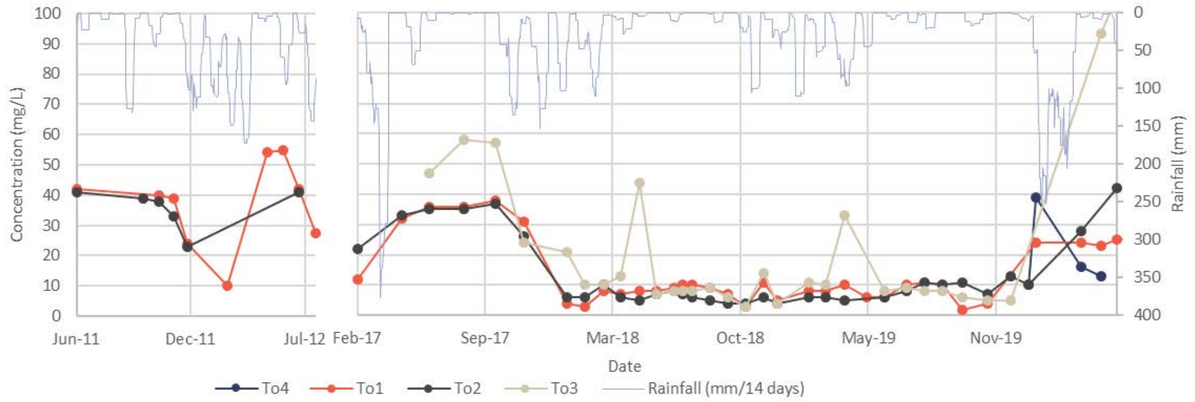


Figure A29. Timeseries of Sulfate results, Tooloombah Creek

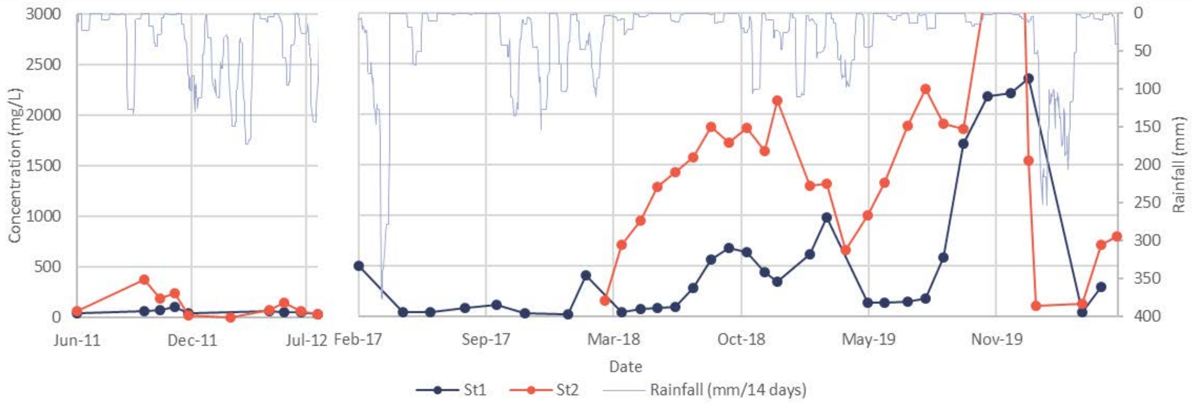


Figure A30. Timeseries of Sulfate results, Confluence and Styx River

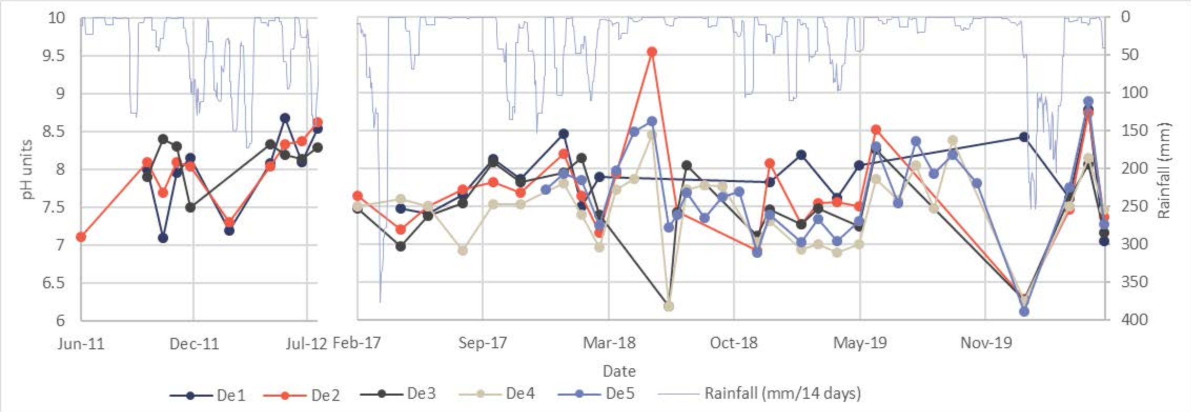


Figure A31. Timeseries of pH results, Deep Creek

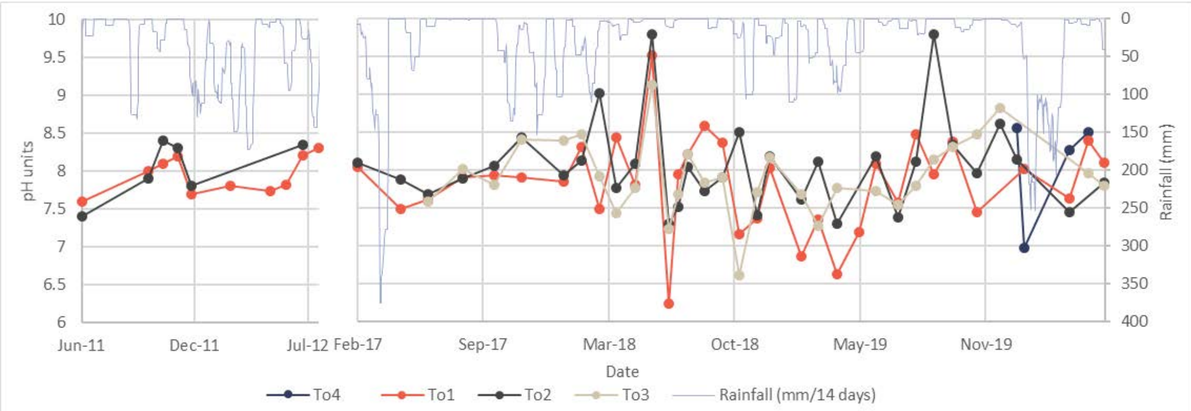


Figure A32. Timeseries of pH results, Tooloombah Creek

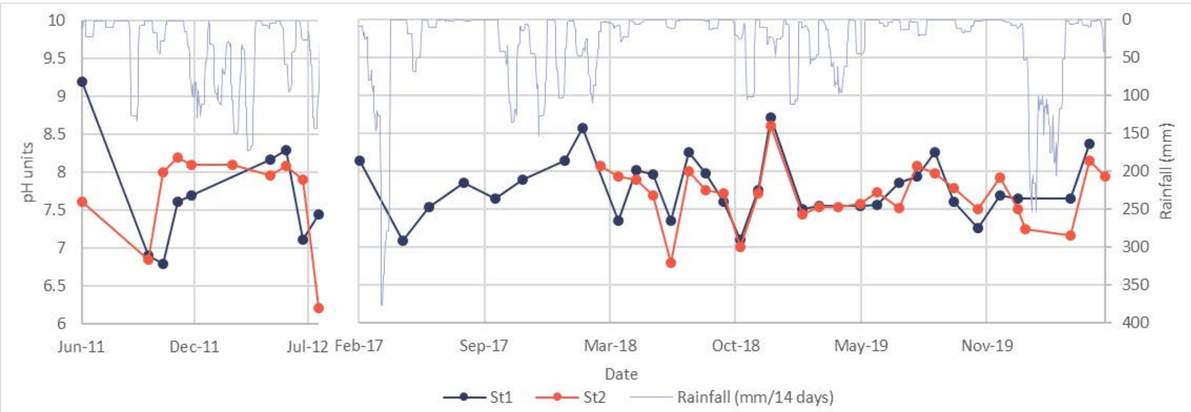


Figure A33. Timeseries of pH results, Confluence and Styx River

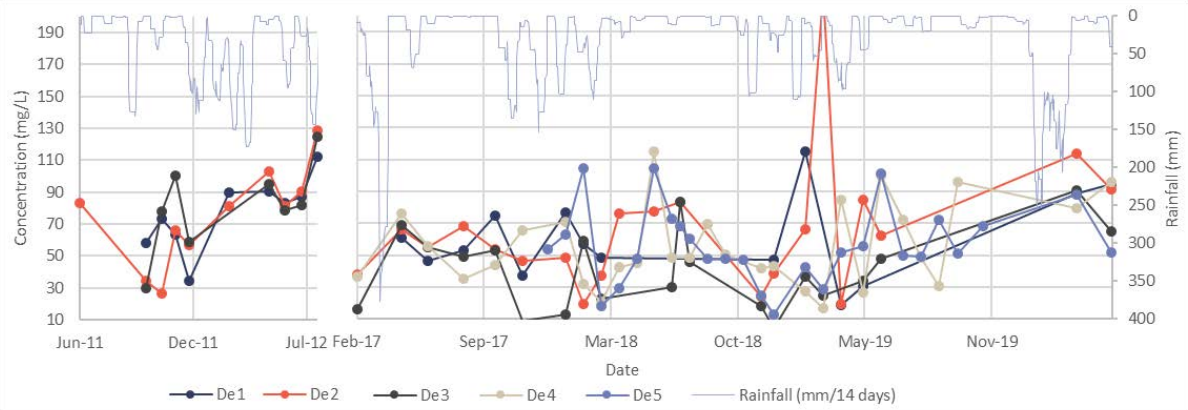


Figure A34. Timeseries of Dissolved Oxygen results, Deep Creek

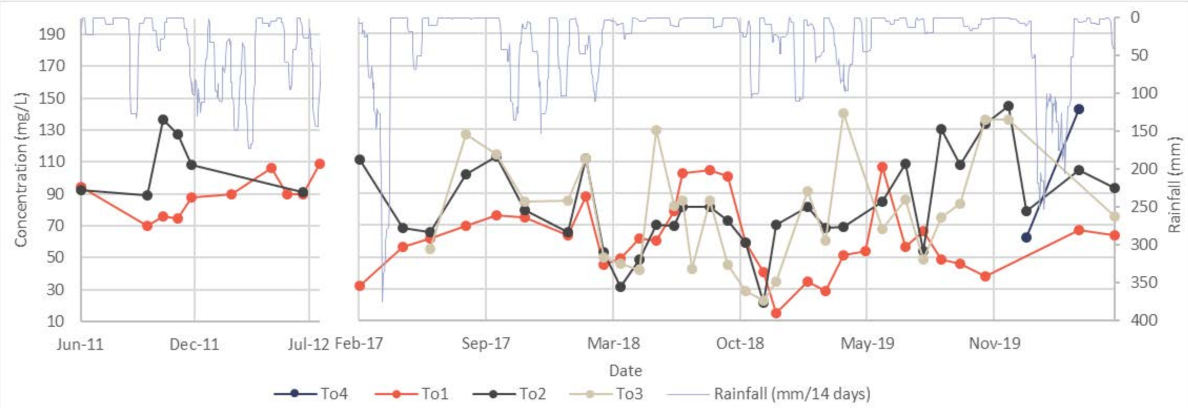


Figure A35. Timeseries of Dissolved Oxygen results, Tooloombah Creek

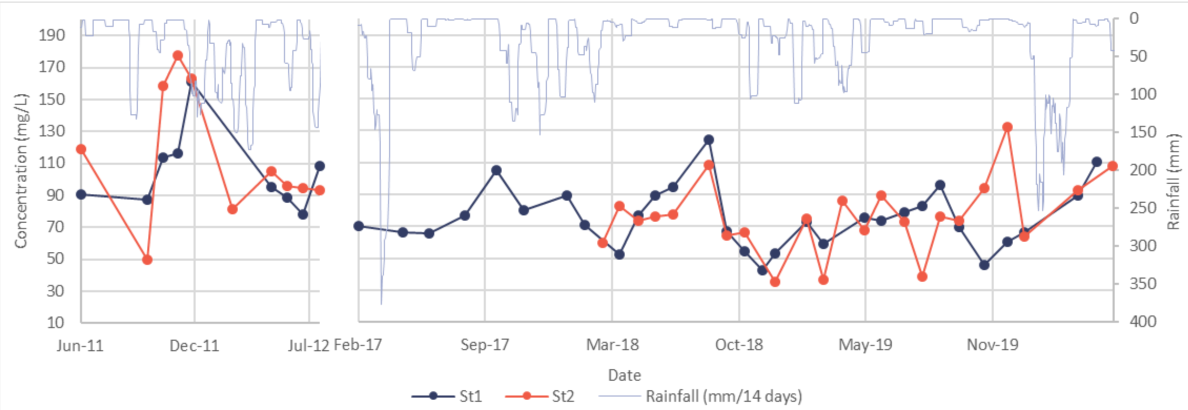


Figure A36. Timeseries of Dissolved Oxygen results, Confluence and Styx River

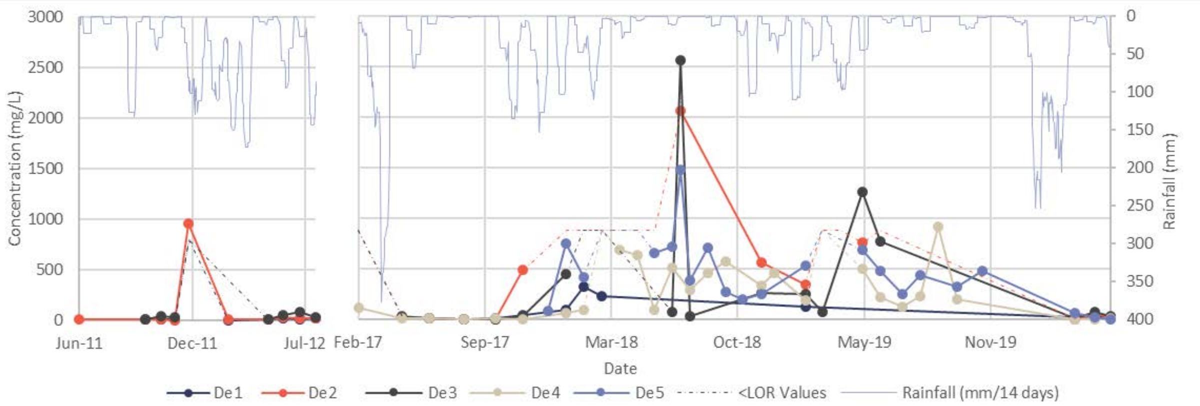


Figure A37. Timeseries of turbidity results, Deep Creek

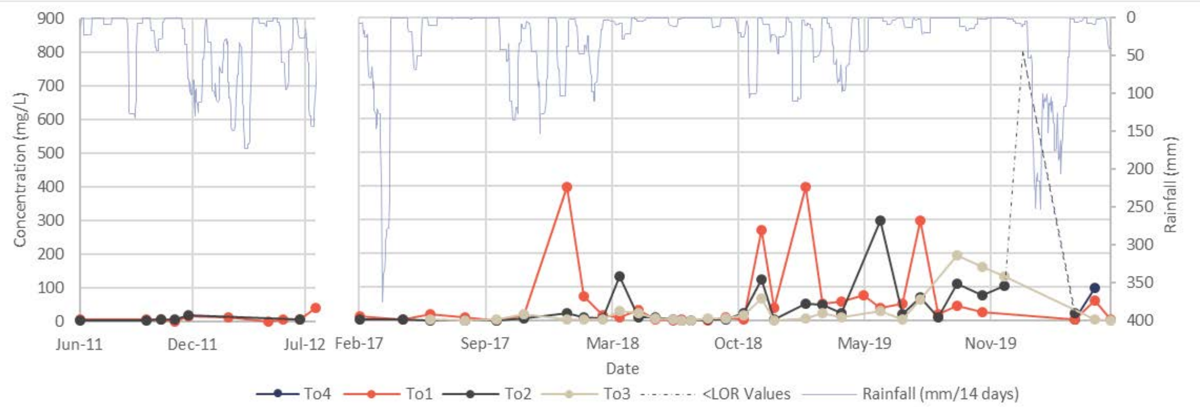


Figure A38. Timeseries of turbidity results, Tooloombah Creek

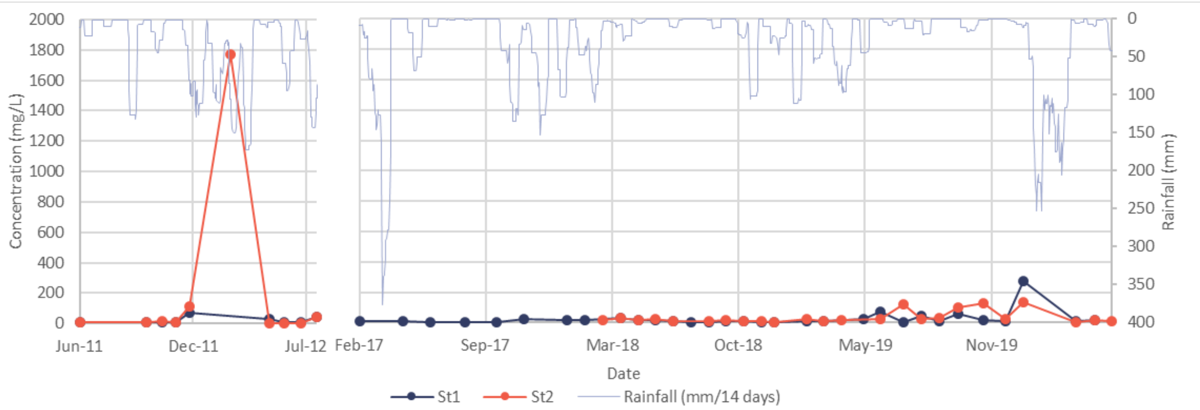


Figure A39. Timeseries of turbidity results, Confluence and Styx River

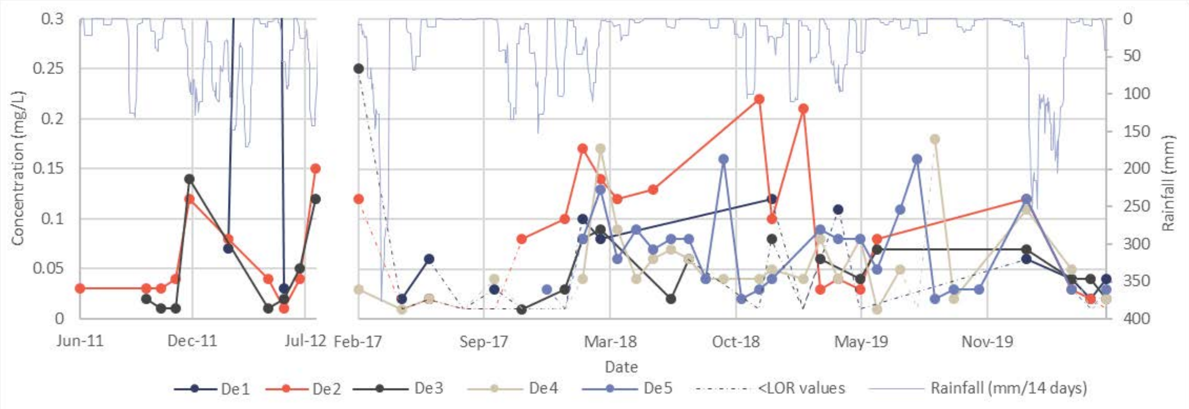


Figure A40. Timeseries of ammonia results, Deep Creek

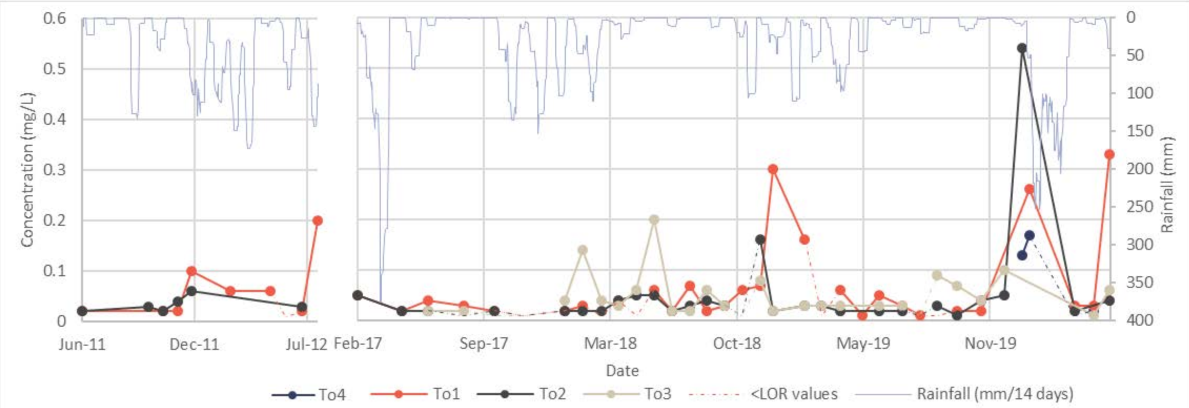


Figure A41. Timeseries of ammonia results, Tooloombah Creek

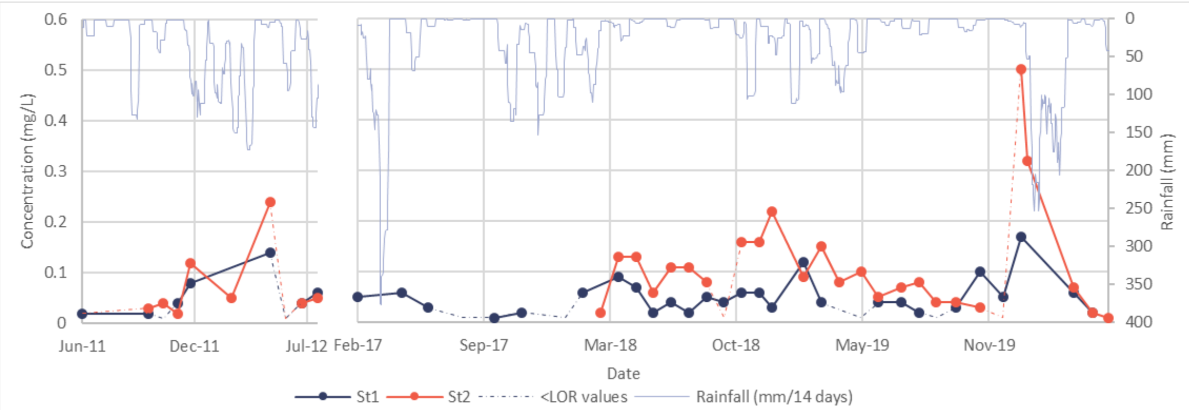


Figure A42. Timeseries of ammonia results, Confluence and Styx River

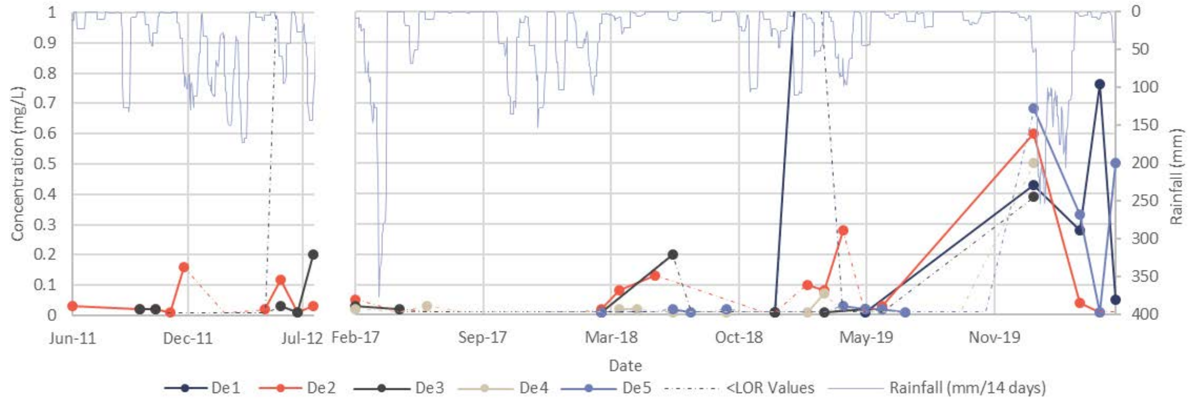


Figure A43. Timeseries of nitrate results, Deep Creek

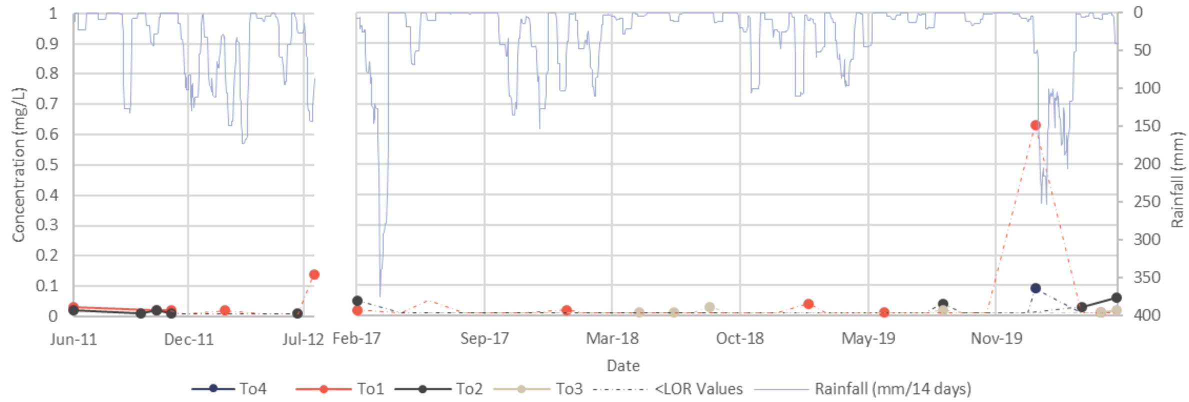


Figure A44. Timeseries of nitrate results, Tooloombah Creek

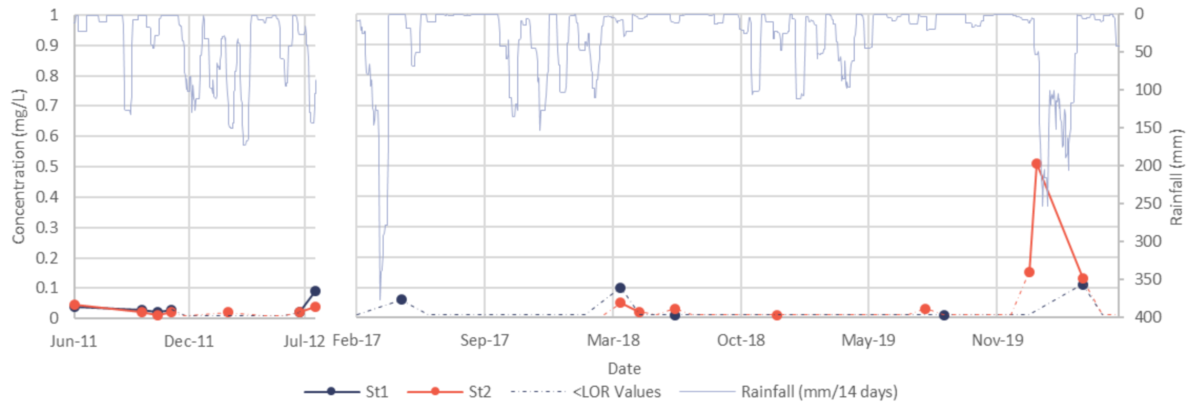


Figure A45. Timeseries of nitrate results, Confluence and Styx River

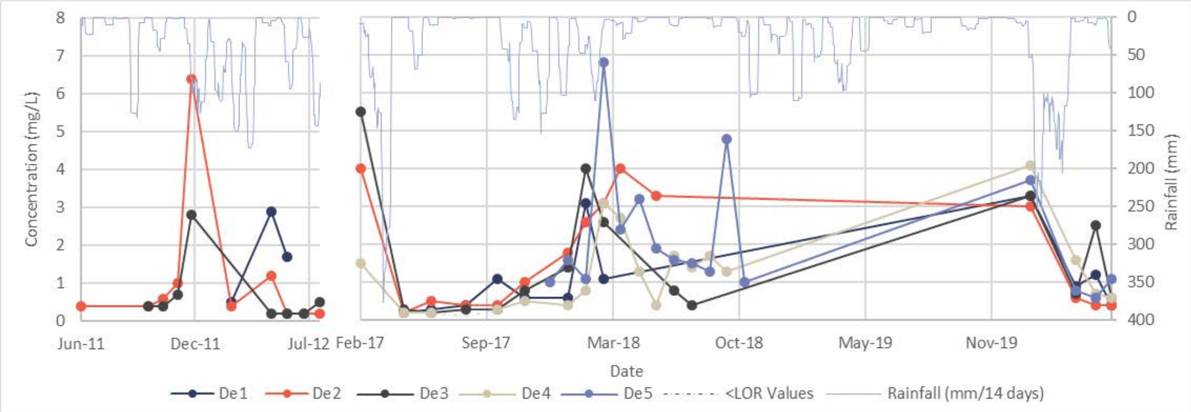


Figure A46. Timeseries of total nitrogen results, Deep Creek

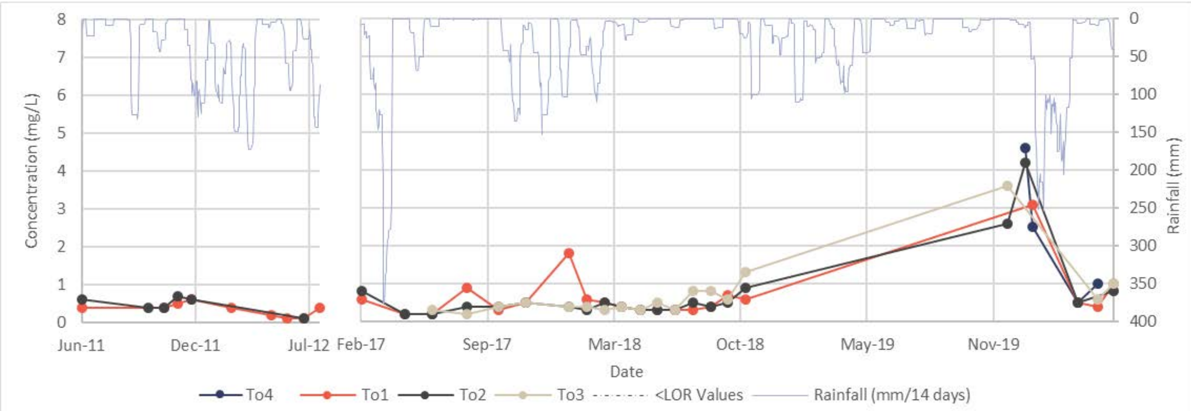


Figure A47. Timeseries of total nitrogen results, Tooloombah Creek

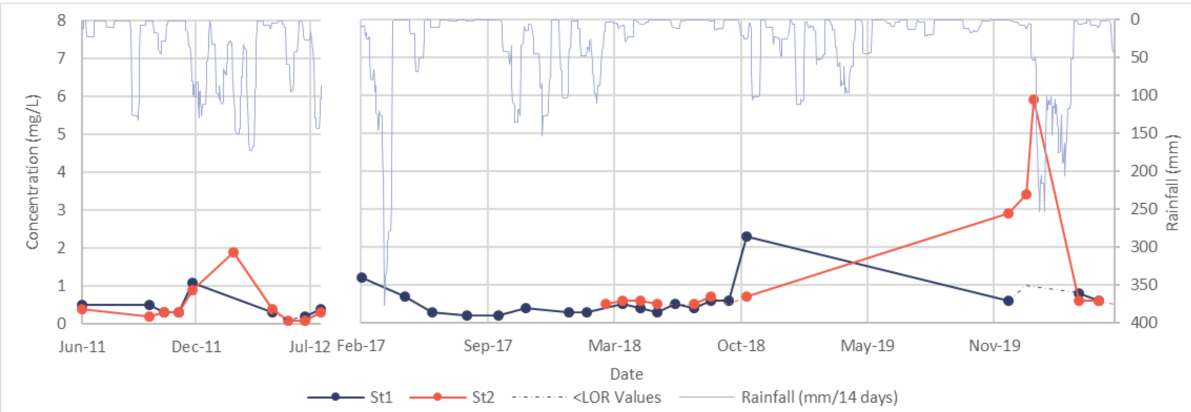


Figure A48. Timeseries of total nitrogen results, Confluence and Styx River

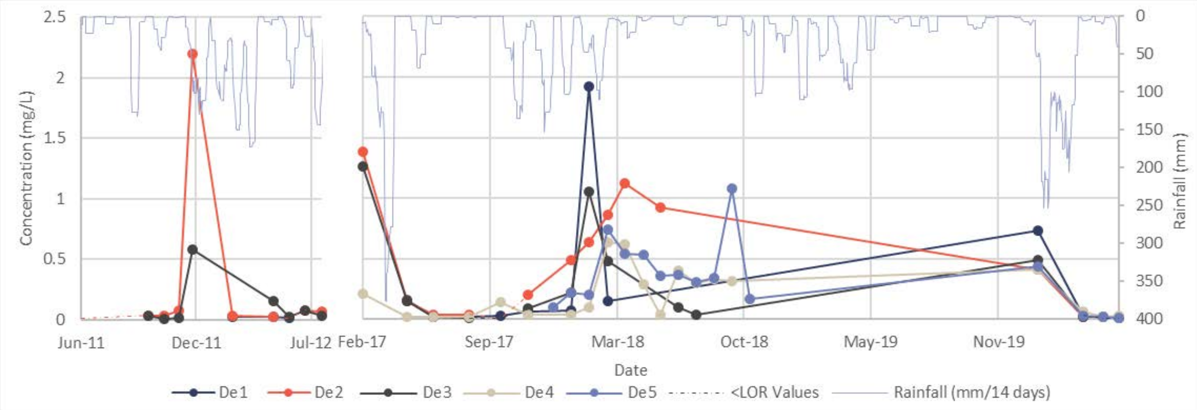


Figure A49. Timeseries of total phosphorus results, Deep Creek

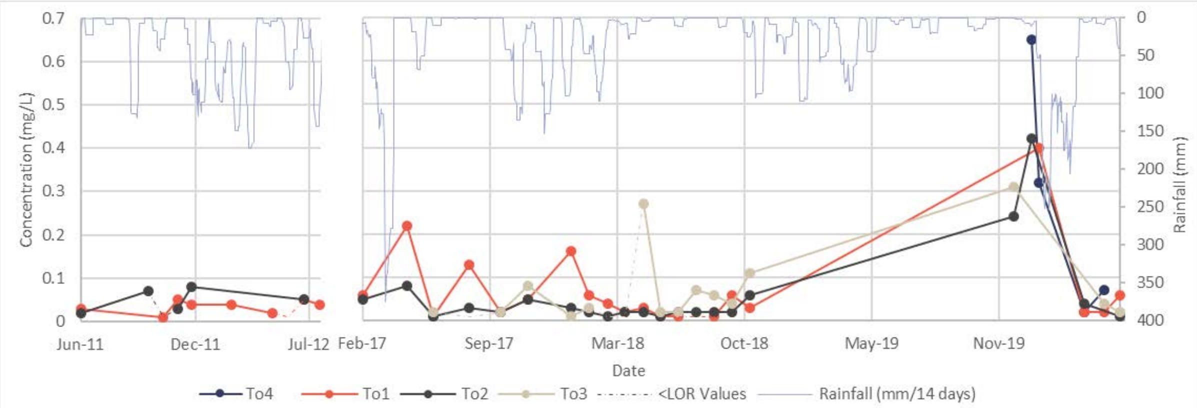


Figure A50. Timeseries of total phosphorus results, Tooloombah Creek

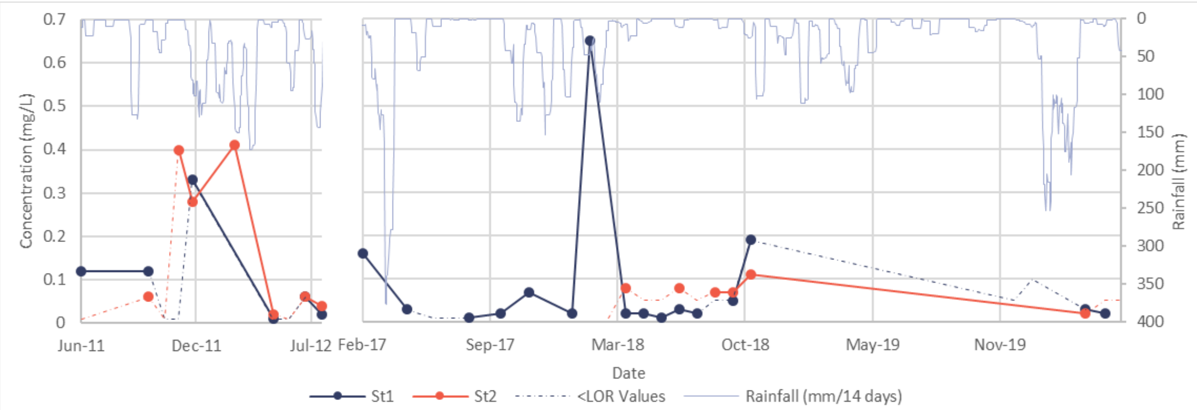


Figure A51. Timeseries of total phosphorus results, Confluence and Styx River

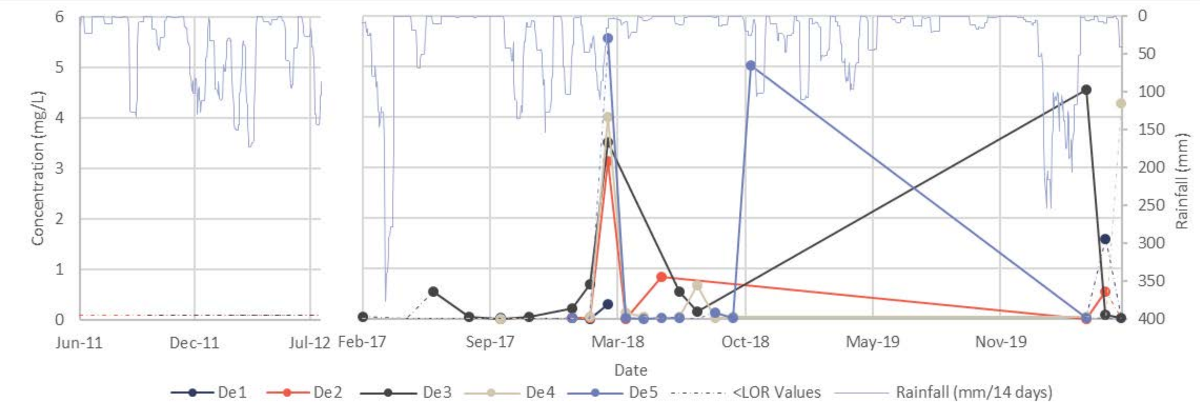


Figure A52. Timeseries of dissolved aluminium results, Deep Creek

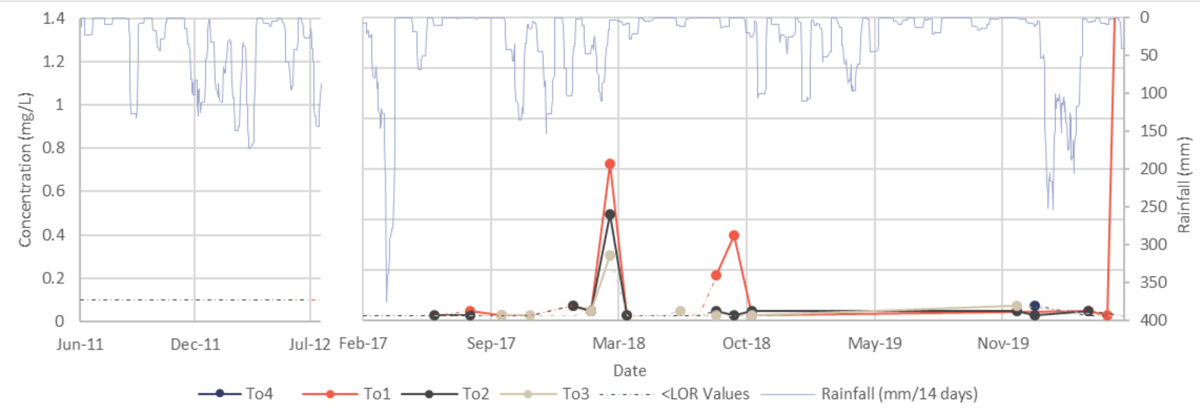


Figure A53. Timeseries of dissolved aluminium results, Tooloombah Creek

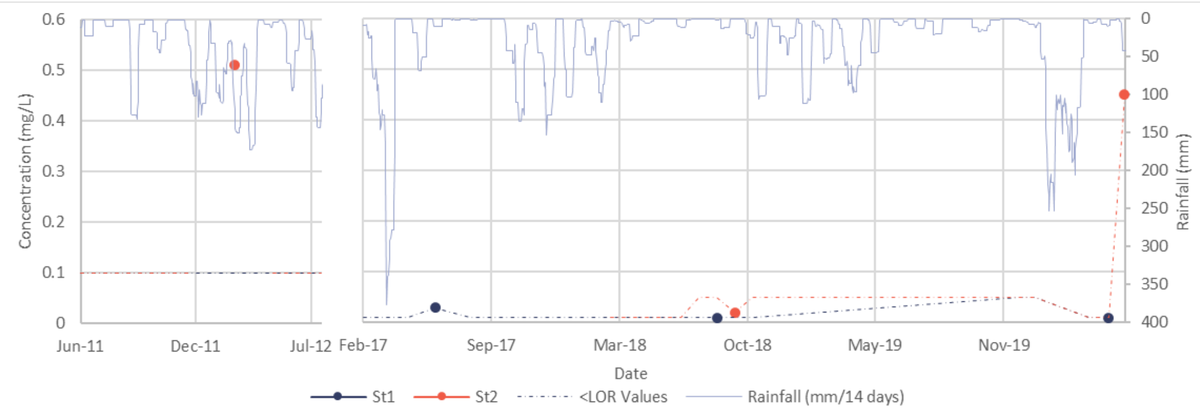


Figure A54. Timeseries of dissolved aluminium results, Confluence and Styx River

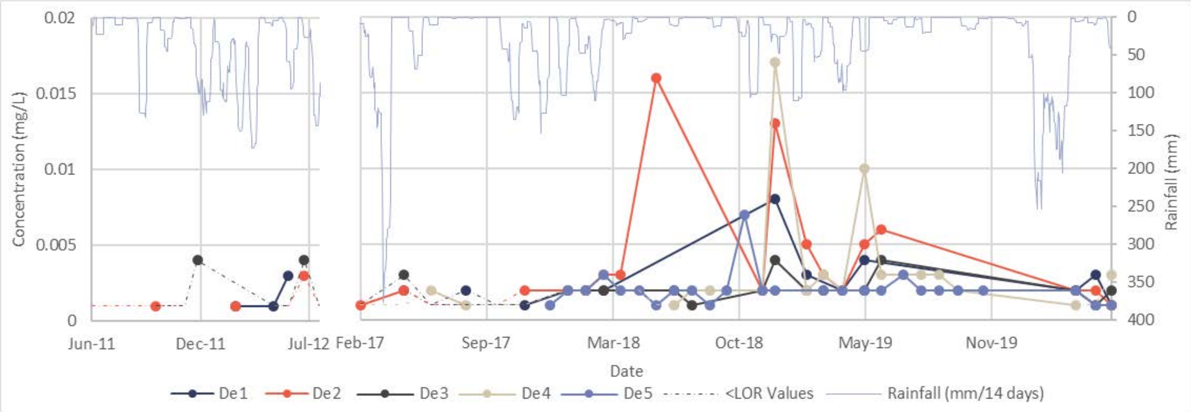


Figure A55. Timeseries of dissolved copper results, Deep Creek

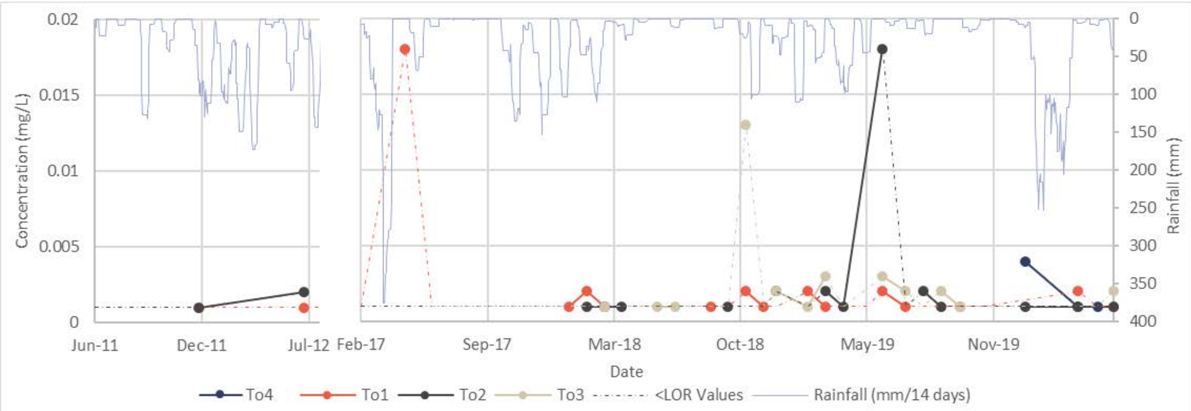


Figure A56. Timeseries of dissolved copper results, Tooloombah Creek

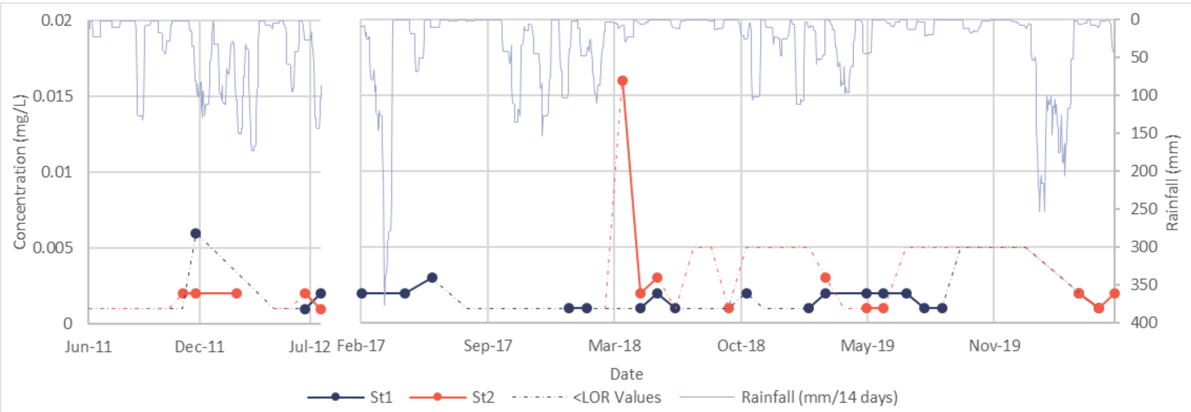


Figure A57. Timeseries of dissolved copper results, Confluence and Styx River

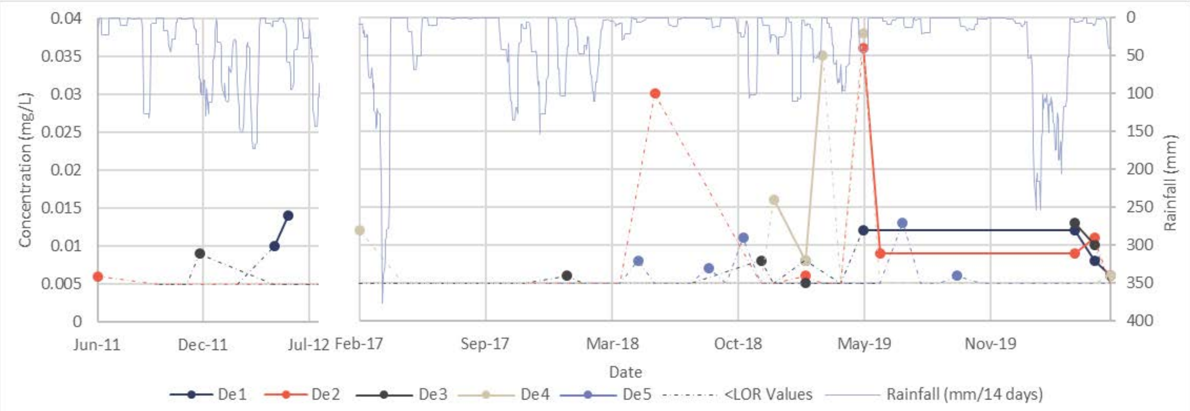


Figure A58. Timeseries of dissolved zinc results, Deep Creek

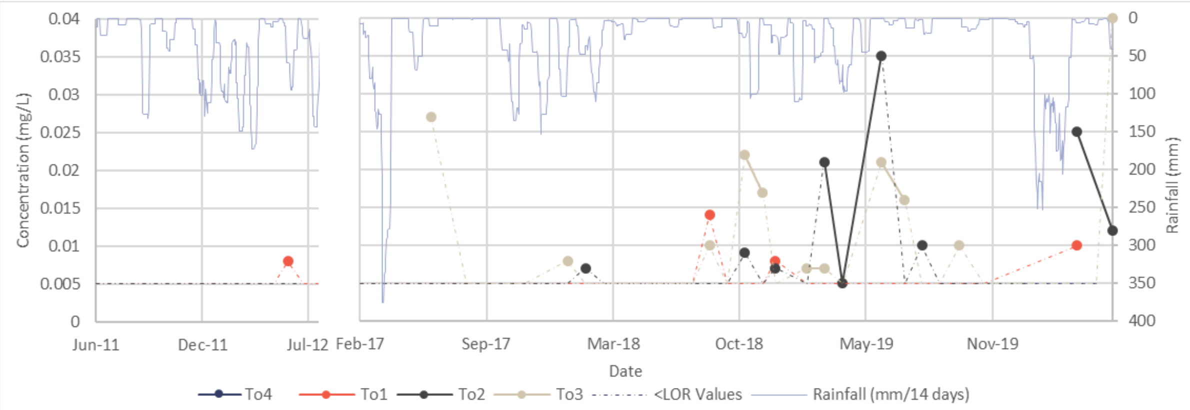


Figure A59. Timeseries of dissolved zinc results, Tooloombah Creek

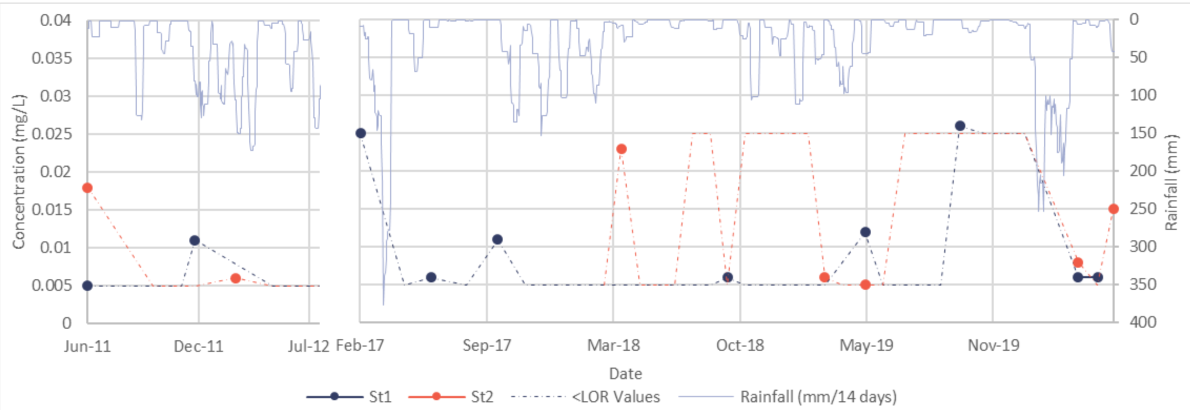


Figure A60. Timeseries of dissolved zinc results, Confluence and Styx River

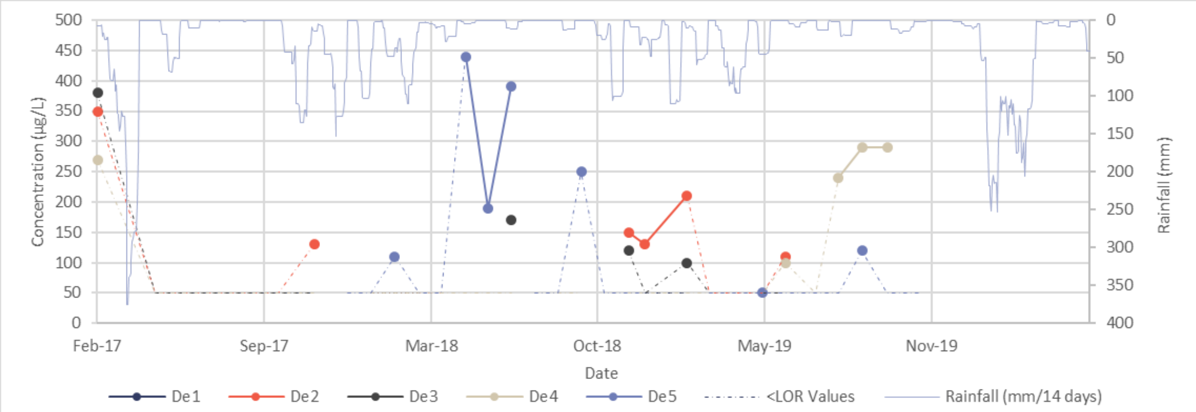


Figure A61. Timeseries of total petroleum hydrocarbons results, Deep Creek

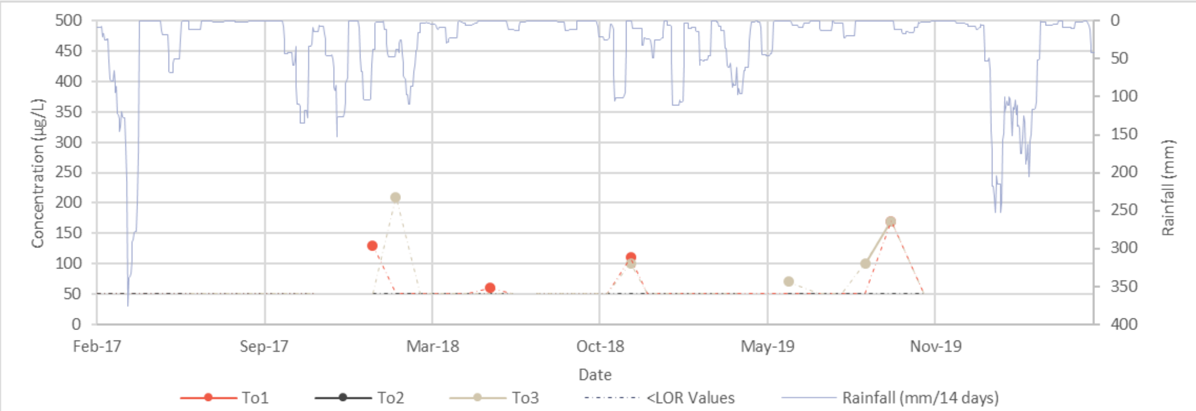


Figure A62. Timeseries of total petroleum hydrocarbons results, Tooloombah Creek

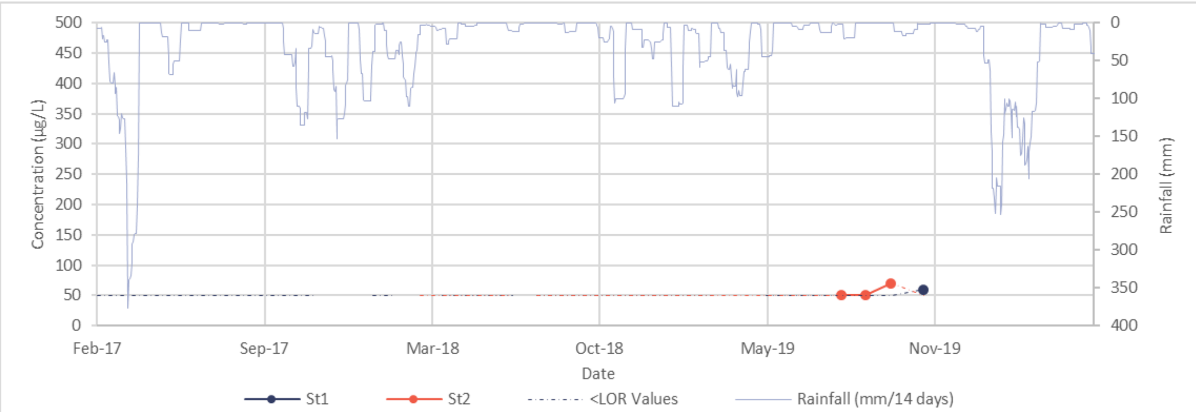


Figure A63. Timeseries of total petroleum hydrocarbons results, Confluence and Styx River

Attachment B

Other (non-aquatic ecosystem, non-AWQG toxicant) DGVs

Table B1. Guideline Values (DGVs) for non-aquatic ecosystem values (after EHP 2014)*

Criteria source (EV)	Parameter	DGV
Stock watering (ANZECC & ARMCANZ 2000)	Cyanobacteria (blue-green algae)	Increasing risk to livestock likely when Microcystis exceed 11,500 cells/mL and/or concentrations of microcystins exceed 2.3 µg/L expressed as microcystin-LR toxicity equivalents
	Pathogens and parasites	Median faecal coliforms <100 cfu / 100 ml
	Calcium	<1,000 mg/L (if dietary phosphorous levels are adequate, and magnesium and sodium are not high, and calcium not added to feed)
	Magnesium	<2,000 mg/L
	Nitrate	<400 mg/L
	Nitrite	≤30 mg/L
	Sulfate	≤1,000 mg/L
	Total Dissolved Solids	
	Beef	4,000 mg/L
	Dairy cattle	2,500 mg/L
	Sheep	5,000 mg/L
	Horses	4,000 mg/L
	Pigs	4,000 mg/L
	Poultry	2,000 mg/L
	Metal or metalloids – low risk trigger value (mg/L)	
	Aluminium	5
	Arsenic	0.5
	Boron	5
	Cadmium	0.01
	Chromium	1
	Cobalt	1
	Copper	0.4 (sheep), 1 (cattle), 5 (pigs and poultry)
	Fluoride	2
	Lead	0.1
	Mercury	0.002
	Molybdenum	0.15
	Nickel	1
	Selenium	0.02
	Uranium	0.2
	Zinc	20
	Pesticides and other organic contaminants	ANZECC & ARMCANZ (2000) recommend the adoption of the Australian Drinking Water Guidelines (NHMRC & NRMMC 2018)
	Radiological quality of livestock drinking water	Refer Vol 1, ANZECC & ARMCANZ (2000) Section 4.3.6
	General water uses	
	pH	6.0 – 9.0

Criteria source (EV)	Parameter	DGV	
Irrigation and general water use (ANZECC & ARMCANZ 2000)	Corrosion, fouling	Refer Section 4.2.10 from Vol 1, ANZECC & ARMCANZ (2000)	
	Human and animal pathogens	Table 8 from EHP (2014). For pasture and fodder for cattle grazing: • Median <1000 cfu / 100 mL thermotolerant coliforms	
	Irrigation salinity and sodicity	Complex – refer to ANZECC & ARMCANZ (2000), Volume 1, Section 4.2.4. As a general guide to salinity (as EC, µS/cm): • Very low <650 • Low 650 – 1,300 • Med 1,300 – 2,900 • High 2,900 – 5,200 • Very High 5,200 – 8,100 • Extreme >8,100	
	Chloride – Foliar injury	For plant sensitivities, chloride (mg/L): • Sensitive <175 • Moderately sensitive 175 – 350 • Moderately tolerant 350 – 700 • Tolerant >700	
	Risk of increased cadmium uptake in plants	Chloride (mg/L): • Low risk 0 – 350 • Medium risk 350 – 750 • High risk >750	
	Sodium – Foliar injury	For plant sensitivities, sodium (mg/L): • Sensitive <115 • Moderately sensitive 115 - 230 • Moderately tolerant 230 - 460 • Tolerant >460	
	Metals, metalloids and nutrients	Long-term trigger value (LTV) (up to 100 years) (mg/L)	Short-term trigger value (STV) (up to 20 years) (mg/L)
	Aluminium	5	20
	Arsenic	0.1	2
	Beryllium	0.1	0.5
	Boron	0.5	Refer to Vol 3, Table 9.2.18 of ANZECC & ARMCANZ (2000)
	Cadmium	0.01	0.05
	Chromium	0.1	1
	Cobalt	0.05	0.1
	Copper	0.2	5
	Fluoride	1	2
	Iron	0.2	10

Criteria source (EV)	Parameter	DGV	
	Lead	2	5
	Lithium	2.5	
	Manganese	0.2	10
	Mercury	0.002	
	Molybdenum	0.01	0.05
	Nickel	0.2	2
	Selenium	0.02	0.05
	Uranium	0.01	0.1
	Vanadium	0.1	0.5
	Zinc	2	5
	Nitrogen	5 mg/L	25 - 125 mg/L
	Phosphorous	0.05 mg/L	0.8 - 12 mg/L
	Other		
	Pesticides	Refer Sections 4.2.8 and 4.2.9 of Vol 1, ANZECC & ARMCANZ (2000)	
	Radiological quality of irrigation water		
Drinking water (QWQGs, ADWGs)	Drinking water supply before treatment - refer to EHP (2014) Table 4 Drinking water for consumption (after treatment as required) – refer to the Australian Drinking Water Guidelines (NHMRC & NRMMC 2018)		
Human consumer (QWQGs)	Food - guidelines as per ANZECC & ARMCANZ (2000) and Food Standards Code, Australia New Zealand Food Authority (1996) and updates – refer QWQGs Section 9		
Primary recreation Secondary recreation (QWQGs, NHMRC 2008)	Refer to the Guidelines for Managing Risks in Recreational Water (NHMRC 2008)		
Cultural & spiritual values (QWQGs)	Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans.		

Table notes:

In most cases, particularly for agricultural values (irrigation and stock watering), there are caveats to the DGVs provided, and the source must be consulted in the use of the values provided

Attachment C

Derivation of Dissolved Oxygen Saturation

C1. Dissolved Oxygen Calculations

The Guideline Values for surface waters are presented in the Water (EPP) as percent saturation, as this is more relevant for assessing surface water health than ppm (or mg/L). However, for some of the sample events, dissolved oxygen saturation was not available. Therefore, the saturation level was calculated from field readings.

Dissolved oxygen saturation was calculated following the method outlined by the USGS in their *Quality of Water Branch Technical Memorandum No. 81.11* (8 May 1981), being the Weiss' equation, and modified Weiss' equation (https://water.usgs.gov/admin/memo/QW/qw81.11.html). This requires:

- Dissolved oxygen
- Barometric pressure
- Electrical conductivity, and
- Temperature.

Barometric pressure was available from the site weather station, however a fault in the instruments occurred during the time many of the monitoring rounds were conducted. As such during these times, barometric pressure was determined from the St. Lawrence Post office (BOM Station no. 033065) as MSLP, and reduced to the Mamelon Station height of 44m AHD by the approximation of 1hPa / 9m change in height (therefore subtracting 5hPa).

Dissolved oxygen, temperature and electrical conductivity were necessarily required from the site measurement. For electrical conductivity, laboratory results were preferred over field to avoid potential field issues, such as faulty calibration or meters.

A comparison of measured and calculated dissolved oxygen saturation is shown in Figure C1 below, showing very good agreement (r^2 = 0.969) - as expected – the instruments utilised a similar calculation in showing ppm readings.

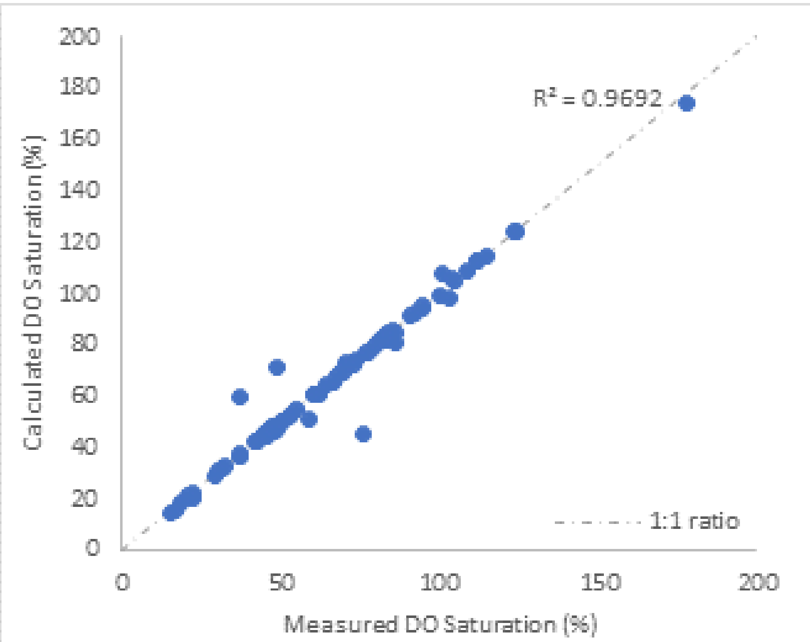


Figure C1. Comparison of measured versus calculated dissolved oxygen

Attachment D

Main Site Descriptions

Table D1. Site Descriptions (after ELA, 2020)

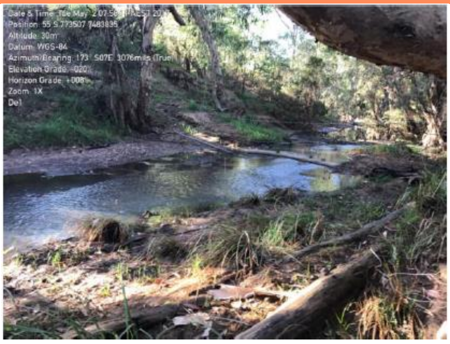
Photo	Site Description
	Deep Creek – De1 Located south of the mine area, with a stream bed width of 8 m (50° bank slope) and slow / minimal flow. Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest is present in addition to M. viminalis (Weeping Bottlebrush).
	Mamelon Creek - Mam01 Located along Mamelon Creek approximately 2 – 3 km upstream of the Tooloombah Creek confluence and west of the CQC Project.
	Tooloombah Creek – T04 To4 is the furthest upstream of all the Tooloombah Creek monitoring sites and is located upstream of the confluence with Mamelon Creek (west of the CQC Project).
	Montrose Creek – Mo1 Mo1 is the most upstream monitoring site along Montrose Creek, located north of the CQC Project. Flow from Mo1 travels downstream towards Mo2 before reaching the Styx River.

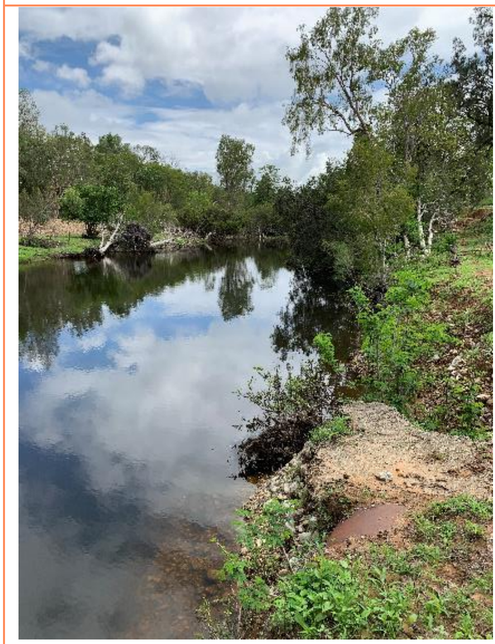
Photo	Site Description
	Montrose Creek – Mo2 Mo1 is the most downstream monitoring site along Montrose Creek, located north of the CQC Project. Flow from Mo2 travels downstream to the Styx River.
	Granite Creek – Gr1 Located north-west of the CQC Project along Granite Creek for monitoring of surface water upstream of the Styx River.
	Barrack Creek – Ba1x The Ba1x site is 10 m wide with a maximum water depth of 0.3 m and slow flow. Bank slope is approximately 45°. Vegetation present at the site includes Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest, in addition to M. viminalis (Weeping Bottlebrush).

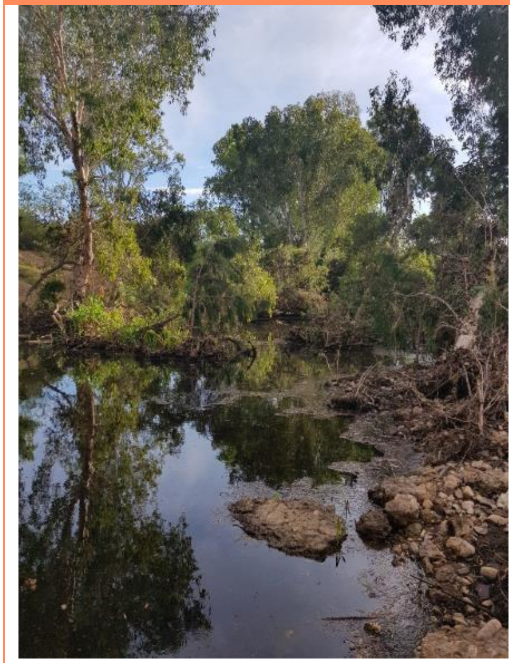
Photo	Site Description
	Amity Creek – Am1 Located to the north of the Project, being the northernmost freshwater reference site, flowing into Waverley Creek and Estuary.
	Tooloombah Creek – To1 To1 is located to the west of the Project. The creek bed is between 5 m and 10 m wide at this location with the bank slope estimated between 25° and 45°. Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest is present in addition to M. viminalis (Weeping Bottlebrush).
	Tooloombah Creek – To2 Located north of the mine, with slow flow within a 15 – 20 m wide stream bed. The water depth is described as 'deep' and bank slope is approximately 60°. Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest is present in addition to M. viminalis (Weeping Bottlebrush).

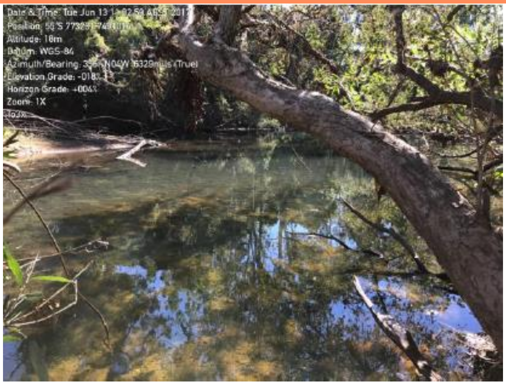
Photo	Site Description
	Tooloombah Creek – To3 To3 is located north of the mine. The creek is 5 – 10 m wide, with bank slope at 45° and flow is very slow to none. Vegetation present includes Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest, in addition to M. viminalis (Weeping Bottlebrush).
	Deep Creek – De2 Located east of the mine area and south of the Bruce Highway. The site contains slow flow, stream bed width is 5 – 10 m and bank slope is 45°. Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest is present in addition to M. viminalis (Weeping Bottlebrush).
	Deep Creek – De3 De3 is located to the east of the mine adjacent to the proposed Haul Road. The creek is 3 – 4 m wide with a bank slope of approximately 60° at this location. Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest is present in addition to M. viminalis (Weeping Bottlebrush).
	Deep Creek – De4 De4 is located north of the mine. The creek is approximately 3 m wide with a bank slope of approximately 30 - 45° at this location and slow flow observed. Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest is present in addition to M. viminalis (Weeping Bottlebrush).

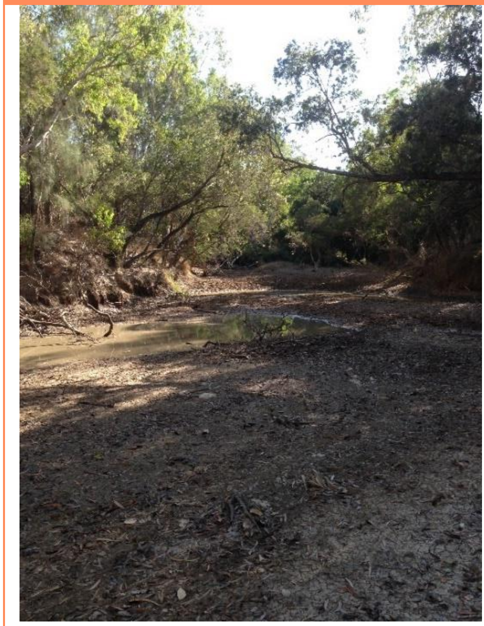
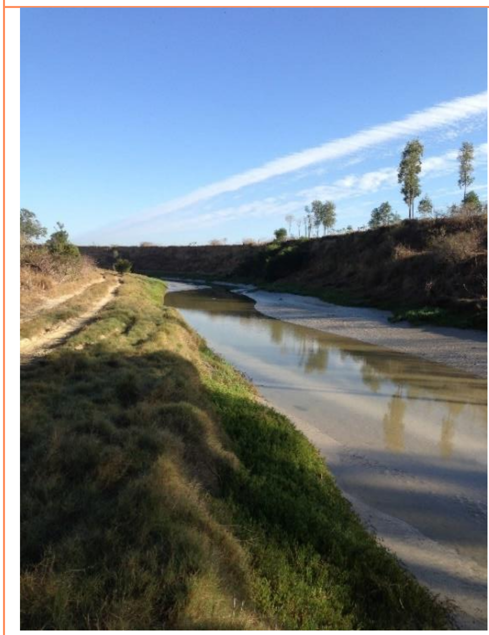
Photo	Site Description
	Deep Creek – De5 Located towards the north-eastern corner of ML80187, approximately 3 – 4 km upstream (south) of the confluence with Tooloombah Creek.
	Styx River – St1 Located to the north of the CQC Project area and west of the North Coast railway line. The site has a 20 m wide stream bed with bank slope at approximately 45°. Eucalyptus tereticornis (Forest Red Gum) and Melaleuca leucadendra (Weeping Tea-Tree) open forest is present in addition to M. viminalis (Weeping Bottlebrush).
	Styx River – St2 Located north of St1 and west of the town of Ogmore in the vicinity of Ogmore Bridge.
	Styx River - Styx US The upstream monitoring point where the Styx River meets the coast, at Broad Sound Estuary, located approximately 32 km north of the Project.
	Styx River – Styx DS2

Photo	Site Description
	The downstream monitoring point where the Styx River meets the Broad Sound Estuary, located approximately 35 km north of the Project.
	WAV US Waverly Creek monitoring site upstream of the Broad Sound Estuary and located north-west of the CQC Project. Amity Creek, and subsequently the Am1 monitoring site, is a tributary to Waverly Creek.
	WAV DS Waverly Creek downstream monitoring site located at the river mouth at Broad Sound Estuary at the coast.

Attachment E

Pools Locations and Permenence

E1. Pools Locations and Persistence

Figure E1 shows the locations of pools identified within the Project area, based on monitoring data (many of the creek sites were at pools), several targeted pools identification field trips, and review of satellite imagery as follows:

- Long term monitoring sites - Deep Creek (5 sites), Tooloombah Creek (4 sites), Barrack Creek (1 site – the earlier Ba1 site was generally always dry)
- Targeted field trips – June 2017, January to February 2018 and July 2018 by CDM Smith, as part of the previous SEIS v2
- Review of satellite imagery:
    - Quickbird 2.4 x 2.4 m pan sharpened Normalized Difference Vegetation Index (NDVI) (from the imagery provider) and true colour satellite imagery from June 2011
    - SPOT 6 multi-band 6 x 6 m pan sharpened satellite imagery, from 29 April 2018 and 13 September 2018, utilised as true colour, NDVI and Normalized Difference Water Index (NDWI) (prepared in ArcGIS from multi-band data).

The identified pools and their degree of permanence is summarised in Table E1. A comparison of two of the pools from the satellite imagery is shown in the figures following the table to illustrate the method used. Note that this satellite imagery assessment was coupled with other evidence wherever possible to derive the best estimate of water availability.

Figure E1. Identified pools locations

Table E1. Identified pools – persistence

Site Name	Permanence	Comments
4	Ephemeral	Medium pool. Ephemeral (satellite imagery shows water in 2011, dry in April and September 2018)
5	Permanent	Medium-large pool. Appears permanent (satellite imagery shows water in 2011, throughout 2018, observed in February 2018, part of To1 pool)
6	Permanent	Medium pool. Appears permanent (satellite imagery shows water in 2011, April and September 2018, though drying out in September 2018)
7	Unknown	Small pool. Water observed in January-February 2018. Otherwise satellite imagery inconclusive
11	Permanent	String of medium pools. Appears permanent (satellite imagery shows water in 2011, April and September 2018, field observations show water in May 2020).
12	Permanent	Stretch of medium to large pools leading up to confluence. Appears permanent (satellite imagery shows water in 2011, April and September 2018, field observations show water in May 2020).
13	Permanent	Permanent, tidally affected downstream from confluence. Observations, sampling and satellite imagery confirm (satellite imagery shows water in 2011, April and Sep 2018)
17	Permanent	Medium pool. Appears permanent (satellite imagery shows water in water in 2011, April and September 2018), but also appears to be the result of the damming of the creek lower down (dam present in satellite imagery 2011, 2018)
22	Ephemeral	Small pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral
23	Ephemeral	Medium pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral
24	Ephemeral	Medium pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral
25	Ephemeral	Medium pool, observed in June 2020. Satellite imagery inconclusive, likely ephemeral
26	Ephemeral	Small pool. Pool observed in June 2020. Satellite imagery inconclusive, likely ephemeral
27	Ephemeral	String of small to medium sized ephemeral pools, observed in June 2020
28	Ephemeral	String of small to medium sized ephemeral pools, observed in June 2020
29	Ephemeral	String of small to medium sized ephemeral pools, observed in June 2020
30	Ephemeral	Medium to large sized pool / string of pools, observed in June 2020. Satellite imagery inconclusive. Likely ephemeral
31	Ephemeral	String of small ephemeral pools, joining at times into larger pool. Water present in satellite imagery in 2011, and perhaps in April 2018, but the sandy river bed is evident in September 2018
32	Ephemeral	Medium pool, present in 2011 and April 2018 satellite imagery, but appears dry in September 2018 imagery. Since To1 upstream dries out, likely this is also ephemeral.
33	Permanent	Appears to be well connected to the confluence site, but Sep 2018 may show disconnection and drying up of this section
34	Ephemeral	Medium disconnected pools apparent in 2011, dissapear in 2018 (both April and September) satellite imagery

Site Name	Permanence	Comments
35	Ephemeral	Small pool identified in 2011, appears to dissapear in later satellite imagery (April, September 2018)
Ba1x	Ephemeral	Small pool. Dry in 2 out of 4 recorded events
Br 15	Ephemeral	Small pool, identified in May 2020, but not apparent in satellite imagery. Given location and size, likely to be ephemeral
De_Br 7	Unknown	Small pool visited May 2020, cannot be seen on satellite imagery
De1	Ephemeral	Small pool. Dry on 18 of 46 inspections
De2 Pool 1	Ephemeral	Medium pool. Observed July 2018, satellite imagery 2011, and monitored 20 May 2019 - 8 July 2019, when it went dry
De2 Pool 8	Ephemeral	Small pool, observed in February 2018, May 2020. Likely ephemeral based on nearby pools
De3	Ephemeral	Small pool. Dry on 13 of 45 inspections
De4	Ephemeral	Small pool. Dry on 4 of 36 inspections
De4 Pool 20	Ephemeral	Small pool below De4, observed in May 2020. Likely ephemeral based on nearby pools (especially De4)
De5	Semi-permanent	Small pool. Dry on 2 of 32 inspections
De5 Pool 14	Ephemeral	Small pool below De5. Appears ephemeral (water observed in July 2018, May 2020, but appears to be dry in satellite imagery – 2011, April and September 2018)
De5 Pool 21	Ephemeral	Small pool adjacent to Deep Creek. Appears ephemeral (water observed in May 2020, but appears to be dry in satellite imagery – 2011, April and September 2018.
DCS	Ephemeral	String of small ephemeral pools, observed in June 2020. Based on surrounding pools and size, appears ephemeral (no data from satellite imagery)
Pool 19A, B	Unknown	Pair of small pools. Water in May 2020. Otherwise satellite imagery inconclusive
St1	Permanent	Part of large pool. Water at all times during sampling, and in 2011, April and September 2018
To Pool 10	Permanent	Large pool, observed in May 2020. Appears permanent (water in 2011, April and September 2018, May 2020).
To1	Semi-permanent	Part of large Pool 5 when full (January - February 2018), otherwise medium sized. Dry on 2 of 50 inspections
To2Pool1	Permanent	Large pool. Water present on all of 41 inspections, and in 2011, 2018 satellite imagery
To3	Semi-permanent	Medium sized pool. Dry on 1 of 32 inspections
ToGS1	Permanent	Medium sized pool. Gauging station, containing water January 2020 onwards, and water in 2011, April and September 2018 satellite imagery

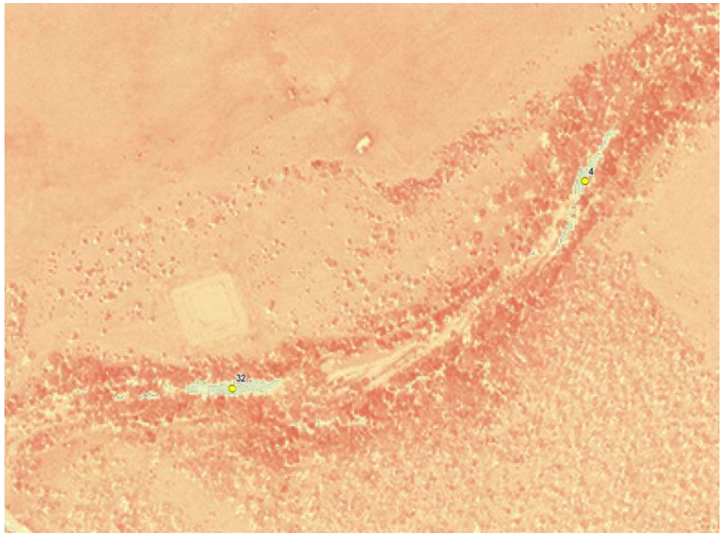


Figure E2. 2011 Quickbird NDVI Imagery – Pools 4 and 32

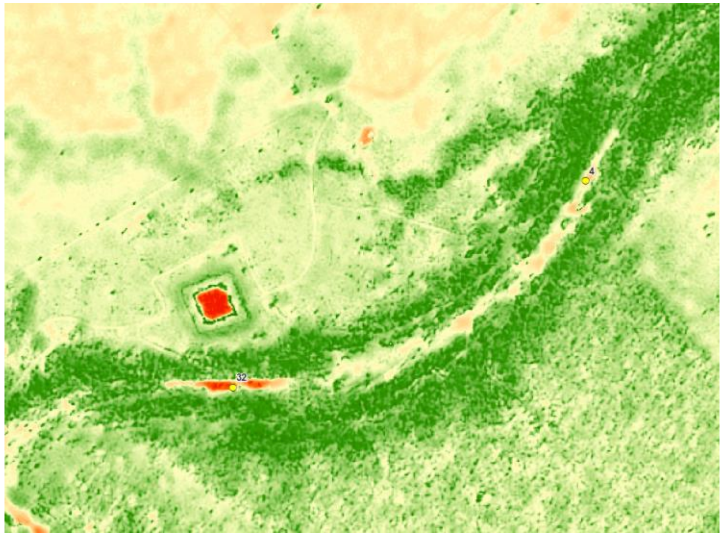


Figure E3. April 2018 SPOT 6 NDVI Imagery – Pools 4 and 32

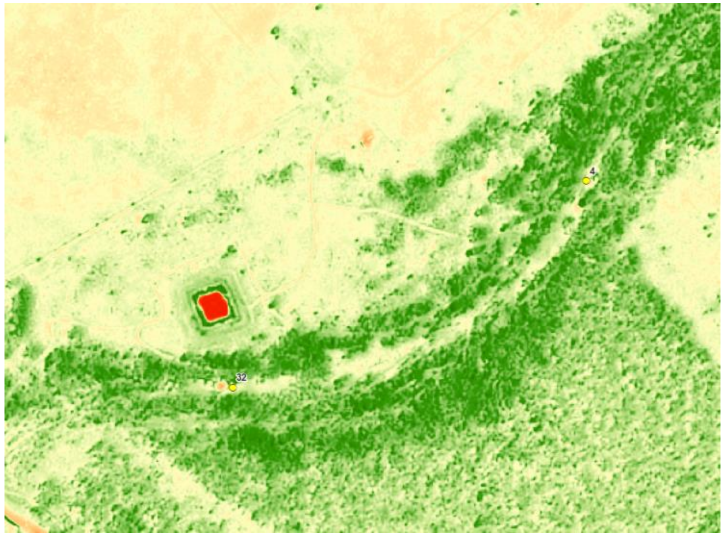


Figure E4. September 2018 SPOT 6 NDVI Imagery – Pools 4 and 32

Interpretation

The 2011 imagery shows the two pools clearly. In April 2018, Pool 4 has dried up – colouring shows possibly wetter creek substrate, or just reflective sands. In September 2018, both pools have dried up. The small patch of orange at Pool 32 is not water, as the colouration is not deep enough. It is possible a small amount of water remains, but this would then dry up soon after these images.

Pool is ephemeral.

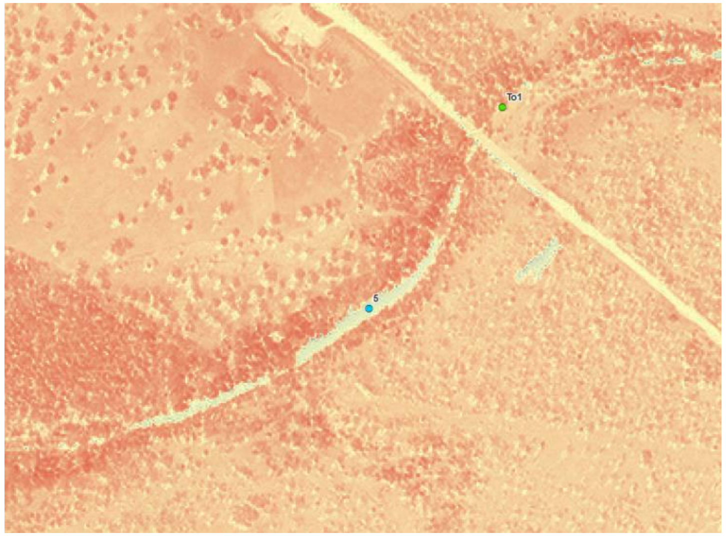


Figure E5. 2011 Quickbird NDVI Imagery – Pools 5 and To1

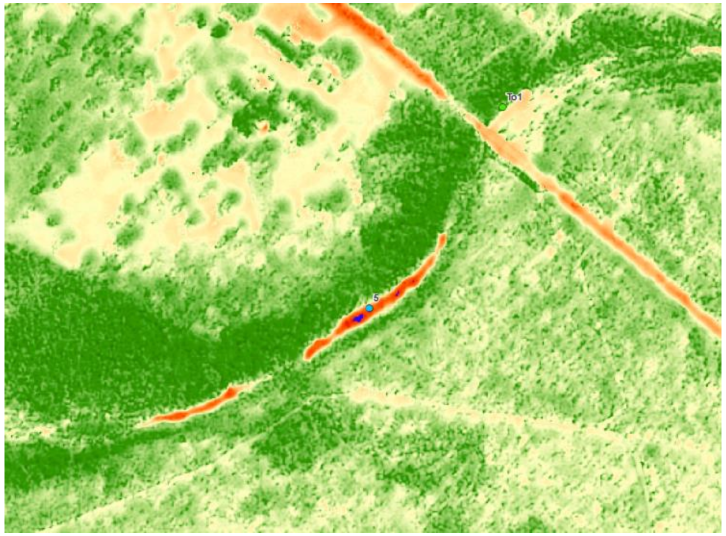


Figure E6. April 2018 SPOT 6 NDVI Imagery – Pools 5 and To1

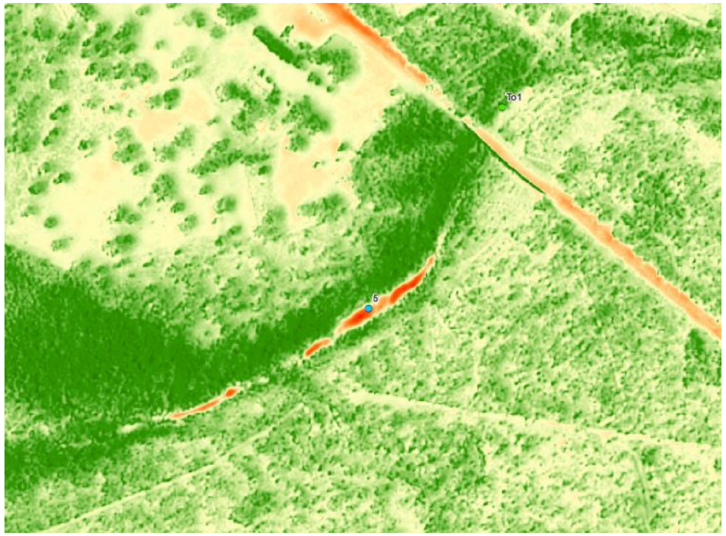


Figure E7. September 2018 SPOT 6 NDVI Imagery – Pools 5 and To1

Interpretation

All three images show Pool 5 clearly as not having dried, although the extent appears to reduce from 2011 through to September 2018. The To1 site shows sparse water evidence in 2011, with perhaps some evidence of recent water (or dried creek substrate) in April 2018, and no water seen in September 2018. Monitoring records indicate that it can dry out at this location (in December 2019), and September 2018 was almost dry.