Centennial Angus Place Pty Limited

Angus Place Colliery
Water Management Plan

June 2021

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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Table of contents

Table index

Figure index

Appendices

Glossary

Alluvial	Deposition from running waters.
Angus Place Haul Road Pipeline	Pipeline between Angus Place Pump Station at Angus Place Colliery to Mine Water Receipt Point 3 on the Springvale Water Treatment Project's Raw Water Pipeline. The pipeline follows the Wallerawang Haul Road.
Angus Place Water Transfer System	Pipeline between Mine Water Receipt Point 3 and Mount Piper Power Station's Pond D utilising existing sections of the Wallerawang Power Station to Mount Piper Power Station Brine Line.
Aquifer	Underground water storage within either disturbed or undisturbed strata.
Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level.
Baseflow	The component of streamflow that originates from groundwater.
Bord and pillar	Method of underground coal mining where the coal seam is divided into a regular block array (pillars) by driving roadways. In some cases, the pillars are partly or completely removed in a concurrent or later operation.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Brackish water	Water that has more salinity than fresh water, but not as much as sea water. Typically containing between 0.5 and 30 grams of dissolved salt per litre of water.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
Clean water	Waters within a site that have not come into physical contact with coal or mined carbonaceous material.
Coal handling plant	A facility where coal is crushed and screened.
Cross-section	A plot of ground elevation across a stream valley or a portion of it, usually along a line perpendicular to the flow direction.
Datum	A level surface used as a reference in measuring elevations.
Dewatering	Transfer of water from underground workings to the surface.
Dirty water	Waters within a site that have come into contact with coal or mined carbonaceous material or otherwise contain an elevated sediment load.
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Drawdown	A reduction in piezometric or hydraulic head within an aquifer.
Electrical conductivity	A measure of the concentration of dissolved salts in water.

Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.
Fractures	Cracks within the strata that develop naturally or as a result of underground works.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report, geomorphology relates to the form and structure of waterways.
Groundwater	Subsurface water that occurs in soils and geological formations.
Guideline	Numerical value or narrative statement that provides appropriate guidance for a designated water use or impact.
Hardness	The concentration of multivalent cations present in water. Generally hardness is a measure of the concentration of calcium and magnesium ions in water and is expressed in units of calcium carbonate (CaCO3) equivalent. Hardness may influence the toxicity and bioavailability of substances in water.
Headcut	Erosional feature where an abrupt vertical drop in the stream bed occurs, resembling a small waterfall when the stream is flowing or a short bluff when the stream is dry.
Headward erosion	The upstream lengthening and/or cutting of a valley or gully at its head, as the stream erodes away the rock and soil at its headwaters in the opposite direction that it flows.
Hydrograph	A graph which shows how a water level (either surface or underground) at any particular location changes with time.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Hydrology	The study of rainfall and surface water runoff processes.
Infiltration	The downward movement of water into soil and rock, which is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Interburden	The strata between coal seams.
Licensed discharge point	A location where a licensed operation discharges water to the environment in accordance with conditions stipulated within the site environment protection licence.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Mount Piper Power Station Industrial Water Management System	The approved Mount Piper Power Station Industrial Water Management System consists of: lined ponds for storage of brine, contaminated and treated water, cooling water system and forebay, boiler water system, demineralised water system, brine concentrators and reverse osmosis systems, chemical dosing plants and storage tanks, and pipelines, pumps, power and other auxiliary equipment

Outcrop	Where the bedrock is exposed at the ground surface.
Overburden	The strata between the coal seam being extracted and the surface.
Partial extraction	A continuous miner system of mining whereby some of the coal pillars in a panel, or parts thereof, are systematically extracted.
Percentile	The value of a variable below which a certain per cent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
Perennial	A watercourse or part of a watercourse that has continuous flow throughout the year.
Permian	The youngest geological period of the Palaeozoic era, covering a span between approximately 290 and 250 million years ago.
pH	Value measure used to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution. A value of 7 is applied to a water that is neither acidic or alkaline. A value less than 7 represents an acidic condition.
Quaternary	The most recent geological period spanning from approximately 2.5 million years ago to present.
Rainfall excess	Amount of rainfall that ends up as streamflow, also termed runoff.
Recharge	Inflow of water from surrounding strata into underground mine workings via infiltration. This can be as a result of rainfall events or from surrounding aquifers.
Riparian	Pertaining to, or situated on, the bank of a river of other water body.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Run of mine	Raw coal production (unprocessed).
Sediment	Soil or other particles that settle to the bed of lakes, rivers, oceans and other waters.
Slope	A landform element inclined from the horizontal at an angle, measured as degrees or as a percentage.
Springvale Water Treatment Project Raw Water Transfer Pipeline	Pipeline system that connects the Springvale-Delta Water Transfer Scheme, located on the Plateau and the Springvale Water Treatment Facility at Mount Piper Power Station. The pipeline is owned by MPWater Pty Ltd.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology related to the branching of streams.
Strata	Plural of stratum.
Stratum	Layer of rock or soil with internally consistent characteristics that distinguish it from other layers.

Subsidence	The vertical difference between the pre-mining surface level and the post-mining surface level at a point.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Guideline value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. A trigger value indicates a risk of impact if exceeded and should ‘trigger’ action to conduct further investigations or to implement management or remedial processes.
Triassic	The geological period that spans between approximately 250 and 200 million years ago.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Underground water	Water stored in underground aquifers. During the mining process a proportion of this water is released and managed by the underground settling and pumping system.
Wastewater	Liquid waste discharged by a community or industry.

Abbreviations

AHD	Australian height datum
AUSRIVAS	Australian Rivers Assessment System
BCS	Biodiversity, Conservation and Science Directorate
BOD	Biochemical oxygen demand
BOM	Bureau of Meteorology
Boulder Mining	Boulder Mining Pty Limited
Centennial	Centennial Coal Company Limited
Centennial Angus Place	Centennial Angus Place Pty Limited
Centennial Springvale	Centennial Springvale Pty Limited
CHP	Coal handling plant
DGV	Default guideline value
DO	Dissolved oxygen
DPIE	Department of Planning, Industry and Environment
DPIEW	Department of Planning, Industry and Environment – Water
EC	Electrical conductivity
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment protection licence
HPC	Heterotrophic plate count
GDE	Groundwater dependent ecosystem
ha	Hectare
kL/day	Kilolitre per day
km	Kilometre
LDP	Licensed discharge point
LOR	Limit of reporting
m	Metre
mg/L	Milligram per litre
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre

Mtpa	Million tonnes per annum
NTU	Nephelometric turbidity unit
OEH	Office of Environment and Heritage
ROM	Run of mine
SCADA	Supervisory control and data acquisition
SDWTS	Springvale-Delta Water Transfer Scheme
SILO	Scientific Information for Land Owners
Springvale Coal	Springvale Coal Pty Ltd
SSD	State significant development
SSGV	Site-specific guideline value
STP	Sewage treatment plant
SWTF	Springvale Water Treatment Facility
SWTP	Springvale Water Treatment Project, encompassing all infrastructure associated with the project
TARP	Trigger action response plan
TDS	Total dissolved solids
THPSS	Temperate Highland Peat Swamps on Sandstone
TSS	Total suspended solids
UCRAMP	Upper Coxs River Action and Monitoring Plan
VWP	Vibrating wire piezometer
WAL	Water access licence
WTS	Water Transfer System
WMP	Water management plan
µS/cm	Microsiemens per centimetre

1. Introduction

Angus Place Colliery is an underground coal mine located in the Western Coalfield approximately 5 km north of Lidsdale and approximately 15 km north-west of Lithgow, as shown in Figure 1-1. The colliery is operated by Centennial Angus Place Pty Limited (Centennial Angus Place) under a joint venture arrangement between Centennial Springvale Pty Limited (Centennial Springvale) and Boulder Mining Pty Ltd (Boulder Mining). Centennial Angus Place and Centennial Springvale are wholly owned subsidiaries of Centennial Coal Company Limited (Centennial), which is a wholly owned subsidiary of Banpu Public Company.

This site-specific Water Management Plan (WMP) has been prepared for Angus Place Colliery as part of a Regional Water Management Plan (GHD 2016a) that encompasses the coal operations owned by Centennial within the Western Coalfield. These management plans apply to all operations at Angus Place Colliery and include the existing and approved operations and associated infrastructure within the site boundary. The WMP will be progressively developed as water management requirements at the site change.

This WMP has historically been prepared by Tess Davies and reviewed by Dr Stuart Gray of GHD Pty Ltd in consultation with Centennial. Appendix A provides a record of revisions to the WMP and a summary of changes made to the plan.

The WMP was provided to the NSW Environment Protection Authority (EPA), the then NSW Department of Industry – Water (DIW), now Department Planning, Industry and Environment – Water (DPIEW), WaterNSW and the then NSW Office of Environment and Heritage (OEH), now Biodiversity, Conservation and Science Directorate (BCS) for consultation in October 2018. All correspondence with government regulators with regard to the WMP is provided in Appendix B. Consultation comments are provided in Appendix C, along with how these comments have been addressed in the WMP.

1.1 Overview of site operations

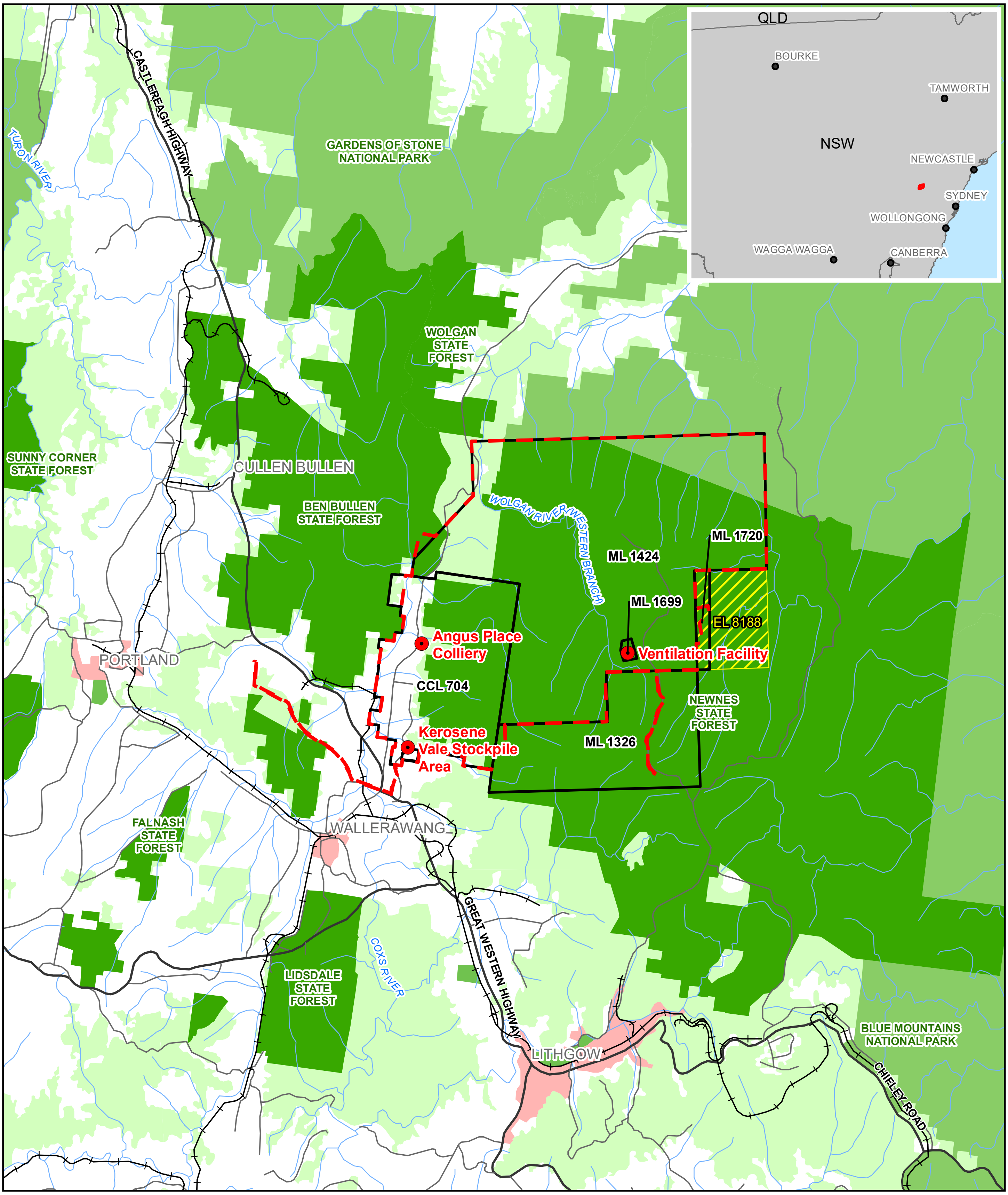
Angus Place Colliery commenced longwall mining operations in 1979, after being developed as an extension of the Newcom Mine bord and pillar operations at Kerosene Vale. The colliery moved to a care and maintenance phase in March 2015, during which mining operations have ceased but environmental management of the site, including dewatering of the underground workings, is ongoing. Mining operations are expected to recommence at Angus Place Colliery in 2025 following the completion of mining at the adjacent Springvale Mine.

The Kerosene Vale Stockpile Area (KVSA) represents the original pit top of Angus Place Colliery. Since the closure of these operations, the site has been used as a stockpile area with a capacity to cater for up to 500,000 tonnes of coal. The stockpile area also includes the staging pumps for the Angus Place Colliery water supply and is integral to coal transport logistics for the region. The KVSA is currently approved under development consent SSD-5579 for the Western Coal Services Project and is managed by Angus Place Colliery.

Currently, development consent PA 06_0021 allows the extraction of 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal from the Lithgow Seam using longwall mining methods. PA 06_0021 has been modified six times.

A State significant development (SSD) application was made for the Angus Place Mine Extension Project (SSD-5602) in November 2013. Assessment of this project, which involves the continuation of mining operations and the extension of the mining area to the east of the approved workings, is currently ongoing.

Figure 1-1 Locality plan



LEGEND

- Site
- Angus Place Holding Boundary
- Mining Lease Boundary
- Exploration Lease Boundary
- Existing rail
- Principal road
- Secondary road
- Minor road
- Waterway
- Built up area
- Recreation area
- Nature conservation
- State forest
- Forest or shrub

Paper Size A4
0 1 2 3 4
Kilometres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD Centennial Coal

Angus Place Colliery
Water Management Plan

Locality plan

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Figure 1-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\AngusPlace\2219614\2219614_WMP001_Locality_1.mxd

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Data source: Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3 2006; Centennial: Boundaries, 2013. Created by: fmackay, tmorton

1.1.1 Site features

The main site features at Angus Place Colliery include:

- Administration building and portable offices on the pit top site.
- Coal handling plant (CHP) used to crush coal.
- Coal stockpile area.
- Visitor and employee car parking areas.
- Various workshops, service buildings and material storage sheds.
- Personnel and materials drift for access to the underground workings.
- Coal conveyor drift and coal conveyor drive to transport coal from the underground workings to the surface.
- Mine dewatering and transfer system infrastructure.
- Water management facilities including various surface storages and both clean and dirty water diversion drains.
- Licensed discharge points (LDPs).
- Sewage processing through the on-site treatment system and maturation pond.
- Angus Place East Ventilation Facility on Newnes Plateau, that provides air to the underground mine workings.
- Power supply infrastructure.
- The Kerosene Vale Stockpile Area, which is approved to stockpile excess coal under development consent SSD-5579 for the Western Coal Services Project.

The site surface features associated with operations at Angus Place Colliery are provided in Figure 1-2 for the pit top, Figure 1-3 for the Ventilation Facility on the Newnes Plateau and Figure 1-4 for the KVSA.

1.1.2 Coal production

Angus Place Colliery currently has approval to extract up to 4 Mtpa of ROM coal from the Lithgow Seam using longwall mining methods. ROM and product coal is approved to be transported off site via dedicated private haul roads (managed by Western Coal Services) to Mount Piper Power Station.

1.1.3 Related Centennial operations

Springvale Mine

Springvale Mine is an underground coal mine adjacent to Angus Place Colliery and is managed by Springvale Coal Pty Ltd (Springvale Coal) . Groundwater inflows into the underground workings at both Angus Place Colliery and Springvale Mine are transferred to the Springvale-Delta Water Transfer Scheme (SDWTS). The SDWTS consists of a pipeline network from existing dewatering facilities on the Newnes Plateau that discharges through Springvale Mine's LDP009 to Sawyers Swamp Creek within the upper Coxs River catchment.

Figure 1-2 Site features – Pit top

Paper Size A4

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND
- Angus Place Colliery
- Licenced Discharge Point
- 1 ML Mine Water Tank
- Infrastructure
- Surface Water Storage
- Wetland

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Water Management Plan

Job Number 22-19614
Revision 1
Date 21 Jun 2021

Site features – Pit top

Figure 1-2

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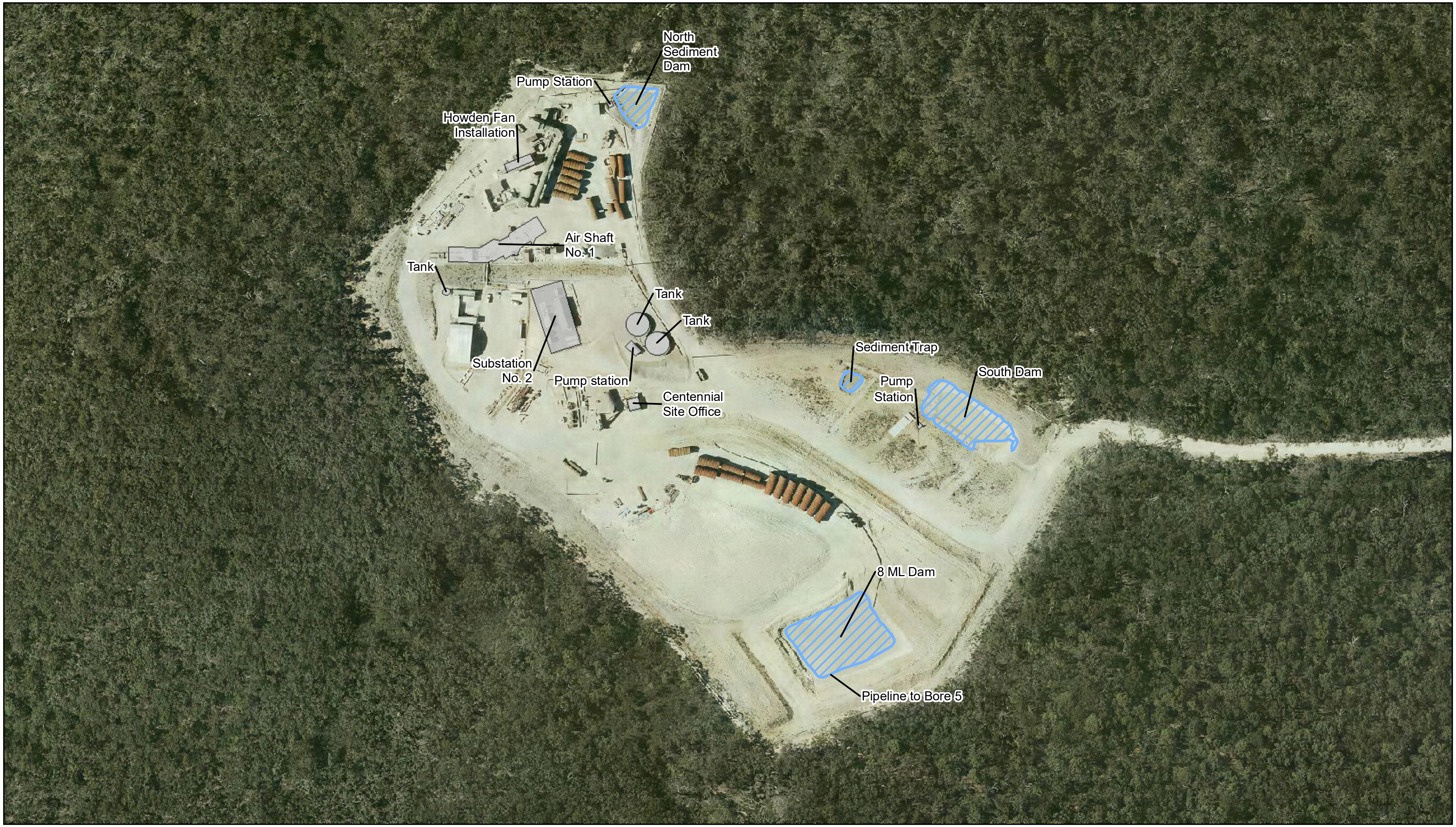
Data source: Centennial: Aerial Imagery, site features, 2017, 2013. Created by: smacdonald, fmackay, tmorton

Figure 1-3 Site features – Ventilation Facility



Paper Size A4

0 10 20 40 60 80

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

Surface Water Storage

Infrastructure

GHD

Centennial Coal

Angus Place Colliery
Water Management Plan

Job Number 22-19614
Revision 1
Date 21 Jun 2021

Site features - Ventilation Facility

Figure 1-3

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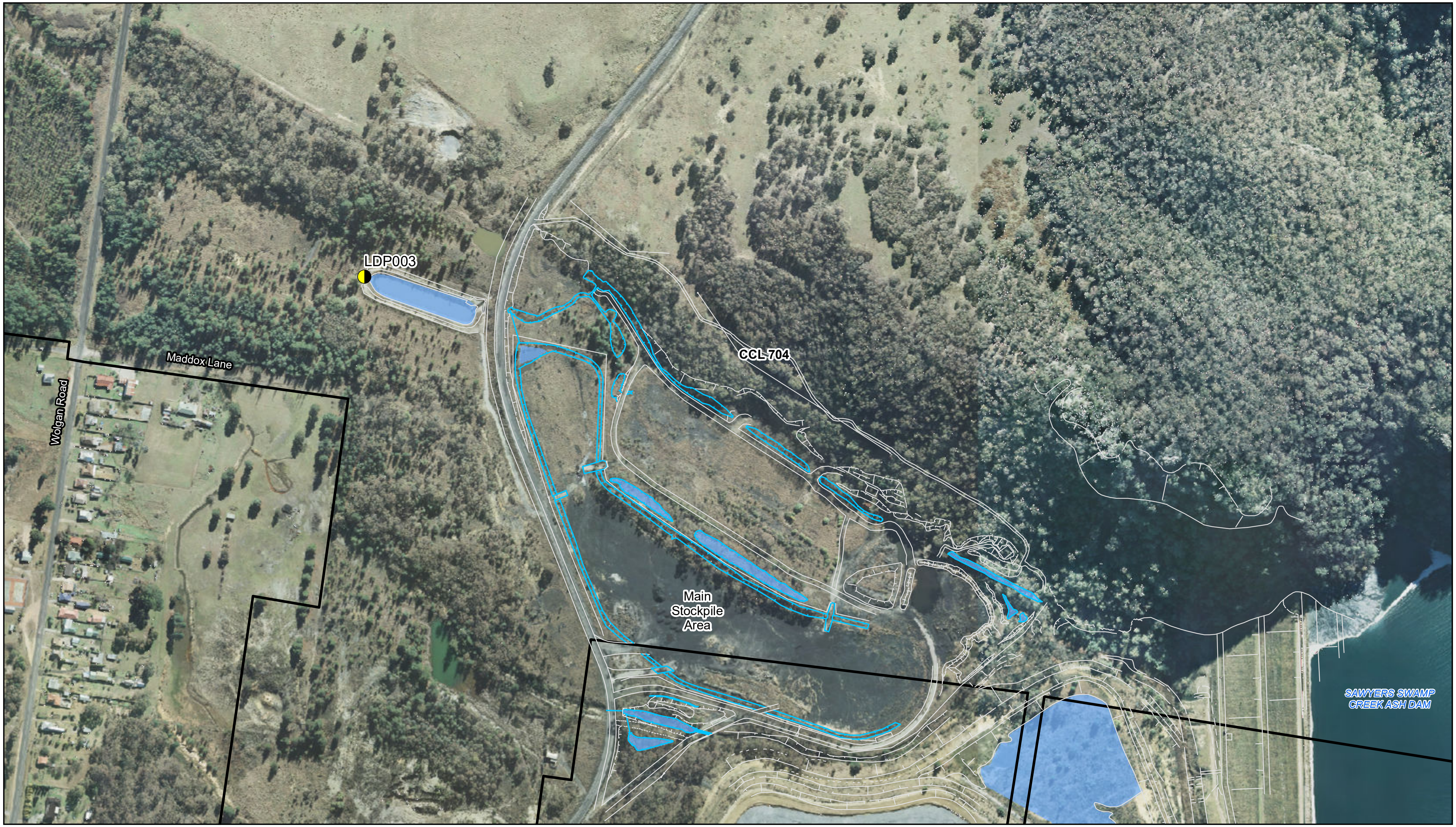
Data source: Centennial: Aerial Imagery, site features, 2017, 2013. Created by: fmackay, tmorton

Figure 1-4 Site features – Kerosene Vale Stockpile Area



Paper Size A4

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Mining Lease Boundary
- LDP
- Survey (Infrastucture)
- Drain
- Settling Ponds

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Angus Place Colliery
Water Management Plan

Job Number 22-19614
Revision 1
Date 21 Jun 2021

Site features -
Kerosene Vale Stockpile Area

Figure 1-4

G:\22\0105001\GIS\Maps\Deliverables\Western\AngusPlace\2219614\2219614_WMP016_SiteFeatures_KVSA_1.mxd

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Data source: Centennial: Aerial Imagery, site features, 2017, 2013. Created by: smacdonald, fmackay, tmorton

Springvale Water Treatment Project

Springvale Coal was granted development consent SSD 16_7592 for the Springvale Water Treatment Project (SWTP) on 19 June 2017. The SWTP involved the establishment of a pipeline and ancillary facilities to transfer water from existing and approved dewatering facilities associated with Angus Place Colliery and Springvale Mine on the Newnes Plateau for treatment via the Springvale Water Treatment Facility (SWTF) and reuse at Mount Piper Power Station (MPPS). This project was completed to achieve an improved environmental outcome for the upper Coxs River catchment and meet water quality performance measures for mine water discharges required under Springvale Mine's development consent SSD-5594. Discharges through LDP009 to the Coxs River have ceased following the commissioning of the SWTF in2019.

Western Coal Services

Western Coal Services is a coal handling and processing operation that is operated by Springvale Coal. The operation consists of the following key elements:

- The Springvale Coal Services site, which is a coal processing facility.
- Haul roads between Angus Place Colliery to Mount Piper Power Station (Mount Piper Haul Road) and to the Greenspot/Old Wallerawang Power Station (Wallerawang Haul Road). The Link Haul Road is a private road that has been approved to extend between the Mount Piper Haul Road and Springvale Coal Services site, however, has not yet been constructed.
- Overland conveyor system linking Springvale Mine to Mount Piper Power Station via the Springvale Coal Services site and from the Springvale Coal Services site to Lidsdale Siding Rail Loading Facility.

The Western Coal Services Project was granted development consent SSD-5579 on 4 April 2014, which involves an upgrade to the existing facilities at the Springvale Coal Services site and the management of the coal transport and handling logistics of the source mines (Angus Place Colliery and Springvale Mine). Western Coal Services is approved to receive up to 4 Mtpa of ROM coal from Angus Place Colliery. The KVSA is also approved by development consent SSD-5579 for Western Coal Services, however, is managed by Angus Place Colliery.

1.1.4 History

A summary of the history of Angus Place Colliery operations is provided in Table 1-1.

Table 1-1 History of Angus Place Colliery

Date	History
1975	Development consent granted by the Blaxland Shire Council.
1979	Longwall operations commenced, with an approval to produce up to 1.25 Mtpa of ROM coal.
1984	Development consent DA 81/11090 granted to increase annual maximum production to 2.3 Mtpa of ROM coal.
1990	Development consent DA 218/89 granted to construct an additional coal storage area west of Wolgan Road. Note that the coal storage area was not constructed.
2003	Development consent DA 413/03 granted to construct and operate a conveyor, stockpile and associated infrastructure on the surface of Angus Place Colliery.
September 2006	Development consent MP 06_0021 granted for continued mining operations with a production limit of 3.5 Mtpa of ROM coal.

August 2011	Development consent MP 06_0021 (modification 1) was modified for the addition of two longwall panels (910 and 900W) and an increase in production rate to 4 Mtpa of ROM coal.
April 2013	Development consent MP 06_0021 (modification 2) was modified to allow for the construction and operation of an additional ventilation facility on Newnes Plateau.
December 2013	Development consent MP 06_0021 (modification 3) was modified to allow for the extension of longwall panels 980 and 900W.
April 2014	Environmental impact statement submitted for the Angus Place Mine Extension Project, which involves the continuation of mining operations and the extension of the mining area to the east of the approved workings.
October 2014	Development consent MP 06_0021 (modification 4) was modified to allow for the development of longwall panels LW1001 and LW1003.
March 2015	Angus Place Colliery placed into care and maintenance.
August 2018	Development consent MP 06_0021 (modification 5) was modified to allow for increased discharge rate at LDP001[1].
March 2021	Development consent PA 06_0021 (modification 6) was modified to allow for the construction and operation of an alternate water management strategy.

1.2 Approvals and licensing requirements

1.2.1 Development consent

The WMP addresses specific water components of the conditions of development consent MP 06_0021, which was granted by the Minister for Planning on 13 September 2006. The relevant requirements of the WMP content are outlined in Table 1-2, along with the sections of the WMP where these have been addressed.

Table 1-2 Development consent MP 06_0021 conditions

<table>
<tr><th colspan="2">Condition</th><th>Where addressed</th></tr>
<tr><td colspan="3">Performance Measures – Natural and Heritage Features</td></tr>
<tr><td>Schedule 3 3.</td><td>The Proponent shall ensure that underground mining does not cause any exceedances of the performance measures in Table 1A, to the satisfaction of the Secretary.

Table 1A: Subsidence Impact Performance Measures
<table><tr><td colspan="2">Water</td></tr><tr><td>Natural watercourses.</td><td>No greater environmental consequences than predicted in EA – Mod 1.</td></tr></table></td><td>Section 6</td></tr>
</table>

[1] LDP001 is no longer in operation and is not included in the site EPL as a licenced discharge point.

Extraction Plans		
Schedule 3 3C.	The Proponent shall prepare and implement Extraction Plan/s for the second workings in Longwalls 910 and 900W to the satisfaction of the Secretary. Each Extraction Plan must: (ix) include appropriate revisions to the Site Water Management Plan required by conditions 8-13, which has been prepared in consultation with EPA, WaterNSW and DoI CL&W, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on surface water resources and groundwater resources.	This WMP
Schedule 3 3D	The Proponent shall ensure that the management plans required under conditions 8-13, 24, 36 and 37 include: (a) an assessment of the potential environmental consequences of the impacts identified in the Extraction Plan, incorporating any relevant information that has been obtained since this approval; (b) a detailed description of the measures that would be implemented to remediate predicted impacts; and (c) a contingency plan that expressly provides for adaptive management.	Section 6 Appendix H
Pollution of Waters		
Schedule 3 5.	Except as may be expressly provided by an EPA Environment Protection Licence, the Proponent shall comply with section 120 of the *Protection of the Environment Operations Act 1997* during the carrying out of the project.	Section 3
Discharge Limits		
Schedule 3 6.	Except as may be expressly provided by an EPA Environment Protection Licence, the Proponent shall ensure that the discharges from any licensed discharge points comply with the limits in Table 2. *Table 2: Discharge Limits* Pollutant / Units of measure / 100 percentile concentration limit pH / pH / 6.5 ≤ pH ≤ 8.5 Non-filterable residue / mg/litre / NFR ≤ 30 Oil and Grease / mg/litre / 10 *Note: This condition does not authorise the pollution of waters by any other pollutants.*	Section 6.1.2
Schedule 3 6A	The Proponent must ensure that water discharges from Licensed Discharge Point 001 comply with the performance measures in Table 2A. *Table 2A: Discharge Volume and Salinity Limit*	Section 6.1.2

Performance Measure	Unit of measure	Limit
Discharge volume until 31/12/2019	ML/day	10
Discharge volume after 31/12/2019	ML/day	0
Electrical Conductivity	µS/cm	350 (100th percentile)

Water Resources Impacts		
Schedule 3 7	The Proponent shall ensure that the project does not result in any significant: (a) reduction in pumping yield in privately-owned groundwater bores. (b) reduction in surface flows and groundwater baseflow to upland swamps (Newnes Plateau Shrub Swamps) and wetlands. (c) reduction in surface flows and groundwater baseflow to waterbodies including Kangaroo Creek, Wolgan River, Lambs Creek and Coxs River, to the satisfaction of the Secretary. *Note: The respective sub-plans of the Site Water Management Plan must include quantifiable impact assessment criteria for these water resource impacts, as well as measures to monitor, investigate and mitigate the impacts.*	Section 4 Section 6 Appendix H
Site Water Management Plan		
Schedule 3 8.	The Proponent shall prepare (and following approval implement) a Site Water Management Plan for the project, to the satisfaction of the Secretary. The Plan shall be prepared in consultation with EPA, WaterNSW and BCS, and be submitted to the Secretary within 12 months of the date of this approval. The Plan must include: (a) a Water Balance; (b) an Erosion and Sediment Control Plan; (c) a Surface Water Monitoring Program; (d) a Ground Water Monitoring Program; (e) a Surface and Ground Water Response Plan; (f) a Trigger Action Response Plan for Kangaroo Creek and Long Swamp; and (g) a Water Transfer Pipeline Monitoring Program for managing, monitoring and responding to leaks and spills from the water transfer pipeline; and (h) a strategy for decommissioning water management structures on site.	Appendix B Appendix C Appendix H
Schedule 3 9.	The Water Balance shall:	Section 3.8 Section 7.4

	(a) include details of all water extracted, dewatered, transferred, used and/or discharged by the mine, including protocols for managing temporary storage in underground workings / goaf areas as part of the water management system; and (b) provide for the annual re-calculation of the water balance and its reporting in the Annual Review.	
Schedule 3 10.	The Erosion and Sediment Control Plan shall: (a) be consistent with the requirements of the Department of Housing's *Managing Urban Stormwater: Soils and Construction* manual; (b) identify activities that could cause soil erosion and generate sediment; (c) describe measures to minimise soil erosion and the potential for the transport of sediment to downstream waters; (d) describe the location, function, and capacity of erosion and sediment control structures; and (e) describe what measures would be implemented to maintain the structures over time.	Section 3.2 Section 3.7 Regional Water Management Plan (GHD 2016a)
Schedule 3 11.	The Surface Water Monitoring Program shall include: (a) detailed baseline data on surface water flows (including ground water baseflows) and quality in waterbodies and wetlands above the mine; (b) surface water impact assessment criteria; (c) a program to monitor surface water flows (including ground water baseflows) and quality; (d) a protocol for the investigation, notification and mitigation of identified exceedances of the surface water impact assessment criteria; and (e) a program to monitor the effectiveness of the Erosion and Sediment Control Plan.	Section 5.2 Section 6.2.2 Section 4.3 Appendix H Section 4.1
Schedule 3 11A.	The Proponent shall revise the Surface Water Monitoring Program to provide for the establishment by 31 October 2011 of a program for investigating and monitoring water quality and aquatic ecosystems in the Kangaroo Creek / Coxs River system upstream and downstream of the project's licensed water discharge points, in consultation with EPA and WaterNSW and to the satisfaction of the Secretary.	Section 4
Schedule 3 11B.	By 31 October 2012, the Proponent shall report on this program of investigations and propose: (a) water quality criteria to be applied to any groundwater (mine water) discharged from the mine to the Kangaroo Creek / Coxs River catchment that will protect water quality and aquatic ecosystems within the catchment, having appropriate regard to relevant ANZECC water quality guidelines and WaterNSW's "neutral or beneficial impact" test; (b) measures to treat, transfer or re-use any groundwater (mine water) that does not meet these criteria; and	Report submitted to the then NSW Department of Planning and Environment on 30 October 2012, with outcomes incorporated into this WMP.

	(c) a timeline to implement these measures, to the satisfaction of the Secretary.	Section 4 Section 6
Schedule 3 12.	The Groundwater Monitoring Program shall include: (a) detailed baseline data on ground water levels and quality, based on statistical analysis; (b) ground water impact assessment criteria; (c) a program to monitor the volume and quality of ground water seeping into the underground mine workings; (d) a program to monitor regional ground water levels and quality; and (e) a protocol for the investigation, notification and mitigation of identified exceedances of the ground water impact assessment criteria.	Section 5.5 Section 6.2.4 Section 4.6.2 Section 4.6.1 Appendix H
Schedule 3 13.	The Surface and Ground Water Response Plan shall include: (a) the procedures that would be followed in the event of any exceedance of the surface or ground water impact assessment criteria, or other identified impact on surface or ground water; and (b) measures to mitigate, remediate and/or compensate any identified impacts.	Appendix H Appendix I
Schedule 3 13A	The Trigger Action Response Plan for Kangaroo Creek and Long Swamp shall include: (a) objectives and performance criteria for erosion and scouring in Kangaroo Creek and Long Swamp downstream of LDP001; (b) appropriate and measurable triggers to warn of increased risk of gully erosion or scouring; and (c) actions to respond to the increased risk of exceedance of the triggers; and (d) an assessment of remediation measures that may be implemented if exceedances occur and the capacity to implement the measures.	Section 6 Appendix H Appendix I
13B	The Proponent may transfer up to 2.6 ML of water per day to ‘Pond D’ at the Mount Piper Power Station using the Water Transfer Pipeline	3.2.2

The WMP also addresses specific water components of the conditions of development consent SSD-5579 with respect to the management of water at the KVSA. The relevant requirements of the WMP content are outlined in Table 1-3, along with the sections of the WMP where these have been addressed.

Table 1-2 Development consent SSD-5579 conditions

Condition		Where addressed
Schedule 3 24.	The Applicant shall prepare and implement a Water Management Plan for the development to the satisfaction of the Secretary. This plan must:	This WMP
Schedule 3 24. (a)	Be prepared in consultation with the EPA, WaterNSW, CL&W, LCC, Forestry Corporation of NSW and Energy Australia by suitably qualified and experienced person/s whose appointment has been approved by the Secretary.	Section 1 Appendix B
Schedule 3 24. (b)	Be submitted to the Secretary for approval within 4 months of the date of this consent, unless otherwise agreed by the Secretary.	Appendix B
Schedule 3 24. (c)	Include a:	
Schedule 3 24. (c) (i)	Site Water Balance, that:	
	Details of sources and security of water supply, including contingency supply for future reporting periods.	Section 3.8 Water and Salt Balance Assessment (GHD 2017a)
	Details of water use and management on site.	Section 3.2.3
	Details of any off-site water discharges.	Section 3.8.4
	Details of reporting procedures, including the preparation of a site water balance for each calendar year.	Section 7.4
	Investigates and implements all reasonable and feasible measures to minimise potable water use and to re-use and recycle water.	Section 3.8.2
Schedule 3 24. (c) (ii)	Surface Water Management Plan, that includes:	
	Detailed baseline data on water flows and quality in the watercourses that could potentially be affected by the development.	Section 5.2
	Detailed plans, including design objectives and performance criteria for: • Management of sodic and dispersible soils. • Reinstatement of appropriate drainage lines on the rehabilitated areas of the site. • Control of any potential water pollution from the rehabilitated areas of the site.	Section 6
	Performance criteria for the following, including trigger levels for investigating any associated potentially adverse impacts: • Downstream surface water quality.	Section 6
	A program to monitor and report on:	Section 4.3

Condition		Where addressed
	• Surface water flows and quality in the watercourses potentially affected by the development.	
	Reporting procedures for the results of the monitoring program.	Western Operations Regional Water Management Plan (GHD 2016a)
	A plan to respond to any exceedances of the performance criteria, and mitigate and/or offset and adverse surface water impacts of the development.	Appendix H

1.2.2 Statement of commitments

In addition to the conditions of development consent PA 06_0021 presented in Table 1-2, Centennial also committed to the management strategies and monitoring activities outlined in Table 1-4.

Table 1-3 Statement of commitments

Commitment	Where addressed
PA 06_0021 (granted 13/09/2006)	
The Mine will comply with the surface water quality and quantity limits of its Environmental Protection Licence.	Section 6.2.3
The Mine will monitor surface water quantity and quality at locations as required by its Environmental Protection Licence.	Section 4.4
The Mine will monitor surface water quantity and quality at locations up and downstream of its surface operations.	Section 4.3
The Mine will monitor stream flows within the Wolgan River tributary containing East Wolgan Swamp, the Wolgan River tributary containing Narrow Swamp and Kangaroo Creek relative to its mining area.	Section 4.3.2
A summary of the results from surface water monitoring will be included in the Annual Report.	Regional Water Management Plan (GHD 2016a)
The Mine will implement a Groundwater Monitoring Programme.	Section 4.6
A summary of the results of all groundwater and shrub swamp monitoring will be included in the Annual Report.	Regional Water Management Plan (GHD 2016a)
PA 06_0021 MOD 1 (granted 29/08/2011)	
Within six months of obtaining approval review the Site Water Management Plan that takes into account mitigation measures identified in Appendix 7.3 Surface Water Assessment.	Completed
Continue to assess the wider catchment areas and specific downstream influences of approved licensed discharge points. Angus Place Colliery has extended its current	Section 4

Commitment	Where addressed
aquatic monitoring suite aiming to achieve ANZECC trigger levels for high risk parameters.	
PA 06_0021 MOD 2 (granted 22/04/2013)	
The existing Site Water Management Plan will be updated to include the management actions identified in Section 9.4.4 of this EA.	Completed
The existing Groundwater Management Plan will be updated to include the management actions identified in Section 9.4.5 of this EA.	Completed
PA 06_0021 MOD 4 (granted 27/10/2014)	
The existing Site Water Management Plan will be reviewed and updated if necessary to take into consideration potential impacts from the Modification.	Completed
PA 06_0021 MOD 5 (granted 14/09/2018)	
No new commitments are proposed.	Completed
PA 06_0021 MOD 6 (granted 19/03/2021)	
A range of measures are proposed for the construction and operation of the included for the Angus Place water transfer system and water softening plant. Commitments are details in Table 7-1 of *Modification Report titled Angus Place Coal Project (MP_06_0021) and Springvale Water Treatment Project (SSD 7592) Modification 6 – Modification Report dated November 2020*.	Ongoing

1.2.3 Environment protection licence

Licensed discharge and monitoring points

Angus Place Colliery currently holds EPL 467, with water currently licensed to be discharged from the site through the following LDPs at the site:

- LDP002 – Discharge of surface water from facilities into the Coxs River through the Settling Ponds.
- LDP003 – Discharge of surface water from a sediment dam located at the KVSA.
- LDP005 – Discharge of treated sewage effluent via a spray irrigation network to a designated utilisation area.

Monitoring of the following locations is also required by EPL 467 to allow for early detection of any potential seepage migration from the 800 District as a result of emplacement of residuals from the WTP:

- Wolgan River (Spanish Steps) – water quality monitoring point (EPA ID 16) located on the Wolgan River upstream of any potential seepage from the 800 District.
- Wolgan River (Wolgah Property) – water quality monitoring point (EPA ID 17) located on the Wolgan River downstream of any potential seepage from the 800 District.
- AP1801DP – groundwater monitoring point (EPA ID 18) located down-dip (north-east) from the 800 District.
- 800D Goaf – underground water quality monitoring point (EPA ID 19) sampling of mine water in the 800 District underground workings.

As EPL monitoring points 16 to 19 inclusive were only required for twelve months post ceasing discharge from LDP001, it is envisioned that these will be removed from the EPL via a licence variation in 2021.

Volumetric limits and monitoring

No volumetric limits are specified for LDP002, LDP003 or LDP005. Monitoring of discharge volume is required for LDP005 (weekly during discharge). No monitoring of discharge volumes from LDP002 or LDP003 is required by EPL 467.

Water quality limits and monitoring

Water quality concentration limits specified by EPL 467 that apply to LDP002 and LDP003 at Angus Place Colliery are summarised in Table 1-5. The concentration limits for LDP002 and LDP003 do not apply when discharge occurs within five days after a rainfall event measured at the site which exceeds 44 mm over any consecutive five day period.

Table 1-4 Licensed discharge point water quality concentration limits

Parameter	Units	90th percentile concentration limit	100th percentile concentration limit
LDP002			
Oil and grease	mg/L	–	10
pH	pH units	6.5–8.5	6.5–9.0
TSS	mg/L	–	30
LDP003			
Oil and grease	mg/L	–	10
pH	pH units	–	6.5–8.5
TSS	mg/L	30	50
Turbidity	NTU	–	50

Water quality monitoring for selected parameters is also required at LDP002, LDP003, Wolgan River (Spanish Steps), Wolgan River (Wolgah Property) and 800D Goaf (underground workings), discussed further in Section 4.4.

No water quality limits or monitoring requirements are specified for LDP005.

Other operating conditions

Condition O5.3 requires the Settling Ponds at LDP’s 002 and 003 to be dewatered within five days following rainfall in order to maintain design storage capacity. Maintenance is required to be undertaken to de-silt all sediment basins to retain the design storage capacity.

Pollution studies and reduction programs

EPL 467 has no current pollution studies and reduction programs.

1.2.4 Water licences

Water access licences (WALs) under the *Water Management Act 2000* for the extraction of groundwater, are managed collectively across Angus Place Colliery, Springvale Mine and Clarence Colliery. Angus Place Colliery specifically holds five water access licences totalling 7059 ML/year. Licenses for groundwater extraction include:

- WAL 41881 – licences 1471 ML/year from the Sydney Basin Coxs River groundwater source.
- WAL 36445 – licenses 2701 ML/year from the Sydney Basin Coxs River groundwater source.
- WAL 37340 – licenses 329 ML/year from the Sydney Basin Coxs River groundwater source.
- WAL 36449 – licenses 2523 ML/year from the Sydney Basin Richmond groundwater source.
- WAL 37343 – licenses 35 ML/year from the Sydney Basin Richmond groundwater source.

Both the Sydney Basin Coxs River and Sydney Basin Richmond groundwater sources are part of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources.

The relevant water supply works approvals that allow for groundwater to be extracted include:

- 10WA122774 – Angus Place Pit Bottom Pump Station.
- 10WA118748 – Angus Place 48 C/T Pump Station.
- 10WA118750 – Bore 930 and Bore 940.

A number of licences are held by Angus Place Colliery under the *Water Act 1912* for groundwater monitoring bores. The details of these bores are provided in Section 4.6.

1.3 Water management plan objectives

The WMP has been developed to address the approvals and licensing requirements presented in Section 1.2 through the completion of the following:

- Collation and review of existing information and studies relating to water management and monitoring at Angus Place Colliery.
- Establish an understanding of the water management, treatment and transfer system at the site.
- Categorise the existing conditions that are specific to water management requirements.
- Develop catchment plans for the site.
- Identify the clean and dirty water management systems.
- Undertake a review of the capacity of dirty water surface storages in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004) and *Volume 2* (DECC 2008).
- Determine the suitability of waterway conditions.
- Undertake a water quality assessment and review of existing water quality assessment criteria.
- Determine the future water management requirements.
- Review and develop water monitoring requirements.

1.4 Relationship to other plans

1.4.1 Western Operations Regional Water Management Plan

The Regional Water Management Plan (GHD 2016a) has been developed to provide an overview of the water management requirements across Centennial sites within the Western Coalfield and to standardise the management of water. Site-specific WMPs, such as this plan, address specific development approval conditions and water management requirements for individual sites.

1.4.2 Upper Coxs River Action and Monitoring Plan

A number of water management performance measures are specified by Springvale Mine's development consent, including the requirement to eliminate toxicity and reduce the electrical conductivity (EC) of mine water discharges via LDPs in the upper Coxs River catchment. The Upper Coxs River Action and Monitoring Plan (UCRAMP; GHD 2017a) has been developed to identify actions and monitoring requirements undertaken by Centennial to meet long-term mine water discharge criteria. As the upper Coxs River catchment is defined as the catchment upstream of Lake Lyell, the UCRAMP applies to operations at Angus Place Colliery.

1.4.3 Western Region Stygofauna Monitoring and Assessment Plan

A regional Stygofauna Monitoring and Assessment Plan (GHD 2016b) has been developed in order to monitor and assess existing communities of aquatic subterranean fauna (stygofauna) across a number of Centennial sites located within the Western Coalfield, including Angus Place Colliery.

1.4.4 Upper Coxs River Catchment Aquatic Ecology Monitoring Program

The Upper Coxs River Catchment Aquatic Ecology Monitoring Program (GHD 2016c) is an integrated monitoring plan incorporating macroinvertebrate sampling, in situ water and sediment quality testing, riparian vegetation and macrophytes surveys and fish sampling data collection and analysis for the upper Coxs River catchment. The monitoring program has a catchment-wide approach, endeavouring to understand the cumulative impacts of the discharge of mine water on the receiving waters of the upper Coxs River catchment. The monitoring program details the locations, methodology and reporting requirements associated with aquatic ecology monitoring.

2. Environment

2.1 Climate

For assessments requiring a large historical set of climate data (i.e. greater than 50 years), point data are obtained from the Scientific Information for Land Owners (SILO) database hosted by the Science Division of the Queensland Government's Department of Environment and Science. SILO point data consist of interpolated estimates based on historically observed data from Bureau of Meteorology (BOM) stations. For this assessment, SILO data was obtained for the grid point located at -33.35N, 150.10E, which is located less than 1 km north of the Angus Place Colliery pit top.

2.1.1 Rainfall

Figure 2-1 presents the historical SILO point daily rainfall data between January 1889 and December 2018. Rainfall recorded at the Angus Place Colliery pit top between April 2009 and December 2018 is also presented in Figure 2-1.

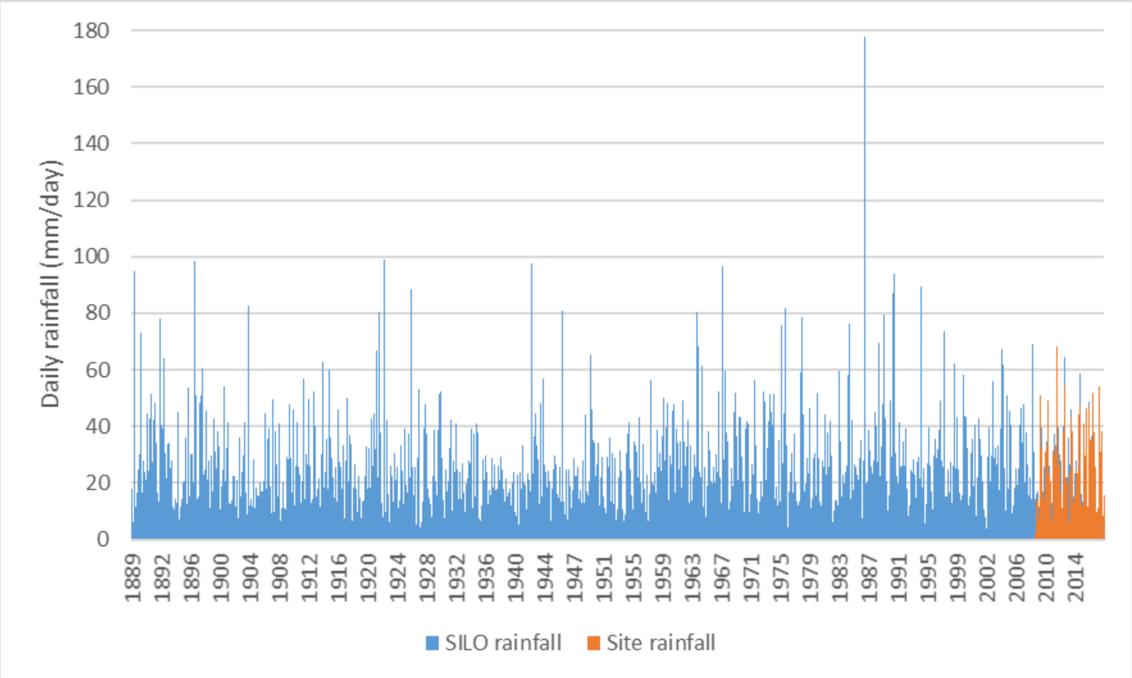


Figure 2-1 Historical daily rainfall at Angus Place Colliery

The annual statistics associated with the SILO point daily rainfall data for Angus Place Colliery presented in Figure 2-1 are:

- Minimum rainfall total – 362 mm in 2006.
- Average rainfall total – 759 mm.
- Median rainfall total – 739 mm.
- Maximum rainfall total – 1520 mm in 1950.

2.1.2 Evaporation

Average monthly evaporation rates were determined from the historical SILO point daily evaporation data between January 1889 and December 2018. The average daily evaporation rates are presented in Figure 2-2.

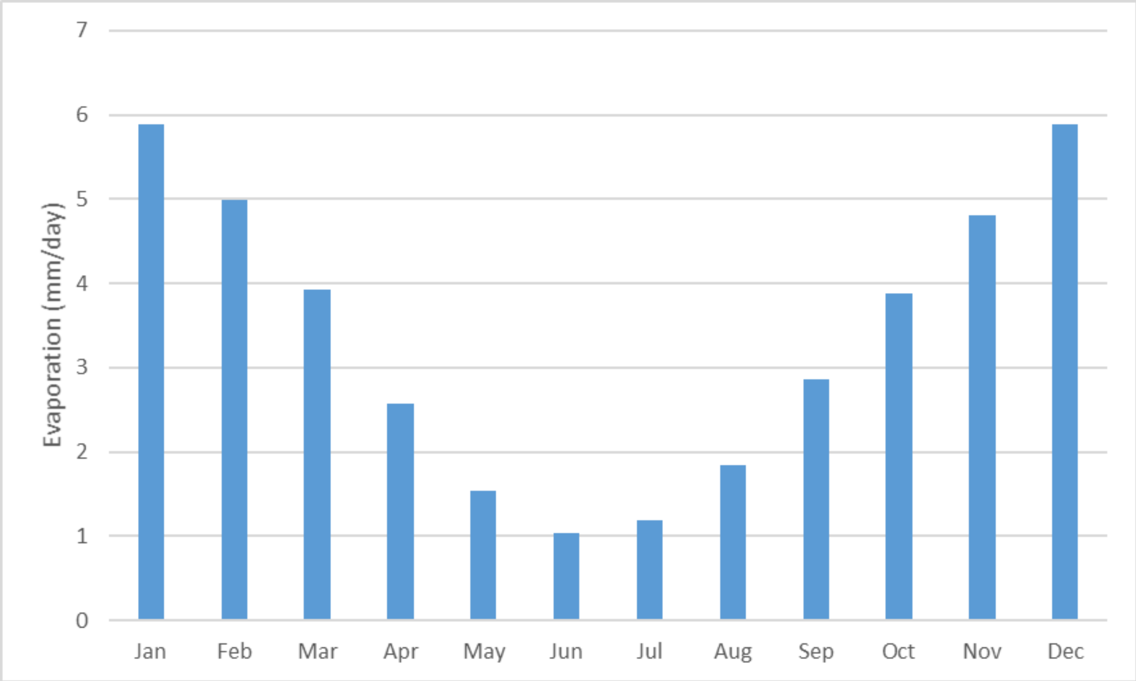


Figure 2-2 Average daily evaporation at Angus Place Colliery

Total average annual evaporation is approximately 1227 mm, compared to the annual average rainfall total of 759 mm. This gives an annual deficit (difference between annual rainfall and annual evaporation) of approximately 468 mm.

2.2 Topography

The topography around Angus Place Colliery comprises narrow gorges with high ridgelines and steep sided slopes of sandstone cliffs. The cliffs rise above incised valleys and hilly areas with relatively flat crests and some spurs with moderately sloped ephemeral drainage lines.

The majority of the land surface lies within the Newnes Plateau, which forms part of the divide between the Wolgan River and Coxs River catchments. Some swamps occur within the headwater valleys and are characterised by flat topography and impervious shale layers.

Site elevation varies from over 1100 m Australian Height Datum (AHD) on the plateau to approximately 900 m AHD in the south-western section of the site.

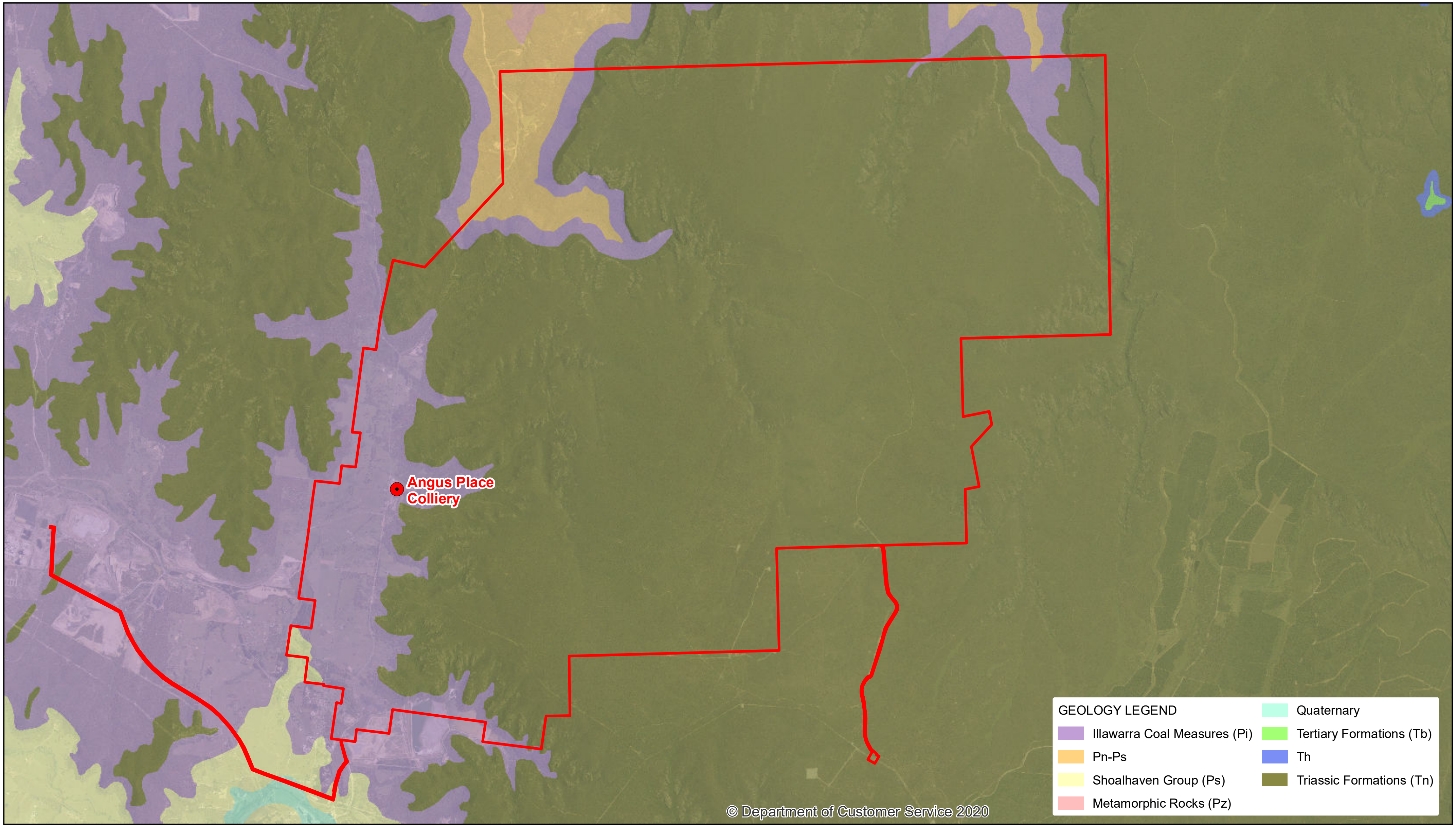
2.3 Geology

Angus Place Colliery is located within the southern part of the Western Coalfield of NSW, on the western edge of the Sydney Basin. The plateau comprises Triassic sandstone of the Narrabeen Group, which is underlain by the Illawarra Coal Measures. The existence of swamps on Newnes Plateau is attributed to the geology of the area.

The outcrop geology in the vicinity of Angus Place Colliery is shown in Figure 2-3. The stratigraphy at Angus Place Colliery is summarised in Table 2-1. This information has been sourced from the *Western Coalfield (south) Regional 1:100,000 Geology Map* (Yoo 1992).

The Grose sandstone of the Triassic Narrabeen Group outcrops throughout the Newnes Plateau, with small areas of Quaternary alluvium at lower elevations towards Coxs River as shown in Figure 2-3.

Figure 2-3 Geological map



Paper Size A4

0 0.65 1.3 1.95 2.6

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Angus Place Colliery
- Angus Place Holding Boundary

Angus Place Colliery
Water Management Plan

Job Number | 22-19614
Revision | 1
Date | 21 Jun 2021

Centennial Coal

Geological map

Figure 2-3

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Data source: Centennial: boundaries,2013; DPI: Geology, 2010; LPI: Aerial Imagery, 2017. Created by: smacdonald, fmackay, tmorton

The Permian Illawarra Coal Measures outcrop around the Triassic formations at areas of lower elevations, including Coxs River Valley. The Lithgow Seam within the lower Illawarra Coal Measures is the target coal seam at Angus Place Colliery. The thickness of the Lithgow Seam ranges between 3 m and 4 m with an average thickness of 3.4 m.

Table 1-5 Stratigraphy of Angus Place Colliery

Period	Stratigraphy			Lithology
	Group	Subgroup	Formation	
Quaternary	Alluvium			Silt, clay, sand, gravel
Tertiary				Basalt, dolerite
Triassic	Narrabeen	Grose	Burralow Formation Banks Wall Sandstone Mt York Claystone Burra-Moko Head Sandstone	Quartz sandstone, red-brown claystone
			Caley Formation	Claystone, shale, quartz sandstone
Permian	Illawarra Coal Measures	Wallerawang	Middle River Coal Gap Sandstone	Coal, lithic sandstone, claystone
		Charbon	Glen Davis Formation Irondale Coal Long Swamp Formation	Sandstone, claystone, coal, mudstone
		Cullen Bullen	Lidsdale Seam Blackmans Flat Conglomerate Lithgow Seam Marrangaroo Formation	Coal, claystone, siltstone, mudstone, conglomerate
	Shoalhaven Group		Berry Siltstone	Siltstone, lithic sandstone conglomerate
Devonian	Metamorphic rocks			Quartzite, shale, sandstone, limestone, tuff

2.4 Hydrogeology

2.4.1 Overview

Groundwater beneath the site is grouped into three main systems consisting of six aquifer zones (RPS 2014):

- A perched, unconfined groundwater system (AQ5 and AQ6).
- A shallow regional groundwater system ranging unconfined to semi-confined (AQ4).
- A deep confined groundwater system (AQ1, AQ2, AQ3 and coal seams).

Overall, the system is low water yeilding. Flow is primarily through fracture (secondary porosity) systems with minor primary porosity (Bish 1999). Groundwater flow typically follows the dip of the main strata toward the north-east (RPS 2014).

Perched groundwater is discontinuous and surficial systems hydraulically independent of the underlying regional groundwater system. Perched water results from rainfall pooling above claystone and siltstone horizons within the Burralow Formation. Perched water fundamentally supports groundwater dependent ecosystems (GDEs) on the Newnes Plateau.

The shallow groundwater system is a regional system extending to an average depth of 100 m below ground level (bgl). Flow is generally horizontal, along bedding planes. Regional flow direction is to the north-east (Bish 1999).

Deep groundwater lies at depths of more than 200 m bgl within fractured rock. Regional flow is to the north-east (Bish 1999).

The aquifer sequence is presented in Table 2-1.

Table 2-1 Regional stratigraphic summary

Formation	Unit code	Description
Alluvium	AQ6	A 10 m thick layer of unconsolidated, weathered materials.
Narrabeen Sandstone/Burralow Formation	AQ6	Aquifer of the upper Burralow Formation, largely unconfined perched water bodies at the top of the Newnes Plateau.
Burralow Formation	SP4	Aquitard of the Burralow Formation comprising thin claystone, sandstone and siltstone.
Burralow Formation	AQ5	Aquifer of the lower Burralow Formation.
Burralow Formation	YS6	Thin claystone layer.
Banks Wall Sandstone	AQ4	Shallow aquifer within medium to coarse grained sandstone.
Mount York Claystone	–	Continuous aquitard, approximately 20 m thick, separating the deep and shallow groundwater systems.
Burra-Moko Head Sandstone/Caley Formation	AQ3	Sandstone in hydraulic connection to the Katoomba Seam.
Farmers Creek Formation (Katoomba Seam/Middle River Coal Member)	SP2	Coal, siltstone and mudstone just below the Katoomba Seam.
Farmers Creek Formation/Gap Sandstone/State Mine Creek Formation/Watts Sandstone	AQ2	Aquifer of the Middle River Coal and adjoining sandstone and laminated siltstone.
Denman Formation	SP1	Aquitard located within the Baal Bone/Denman Formation comprising mudstone, siltstone and claystone.
Glen Davis Formation/Newnes Formation/Irondale Seam/Long Swamp Formation/Lidsdale Coal	AQ1	Aquifer of the Lidsdale/Lithgow Coal Seam. Hydraulically connected to the overlying Irondale Coal and Long Swamp Formation and the underlying Berry Siltstone.

AQ – aquifer; SP – semi-permeable

Overall, the system is low water yeilding. Flow is primarily through fracture (secondary porosity) systems with minor primary porosity (Bish 1999). Groundwater flow typically follows the dip of the main strata toward the north-east (RPS 2014).

2.4.2 Registered groundwater bores

A search of the database of registered groundwater bores managed by the Bureau of Meteorology (BOM 2018) was undertaken to identify registered bores within a 10 km radius of Angus Place Colliery. The search identified 90 bores and of these, only 16 were recorded as functioning. Registered uses included commercial and industrial, dewatering, irrigation, monitoring and water supply. Depths of installations ranged 1 m to 420 m bgl. No water level or quality information was provided. A summary of the available details is presented in Table 2-2.

Table 2-2 Summary of registered groundwater bores

Use	Registered	Registered as functional	Depth range (m bgl)
Commercial and industrial	12	3	24–232
Dewatering	7	Unknown	146–420
Irrigation	3	1	15–70
Monitoring	48	5	1–400
Unknown	2	Unknown	Unknown
Water supply	18	7	15–90

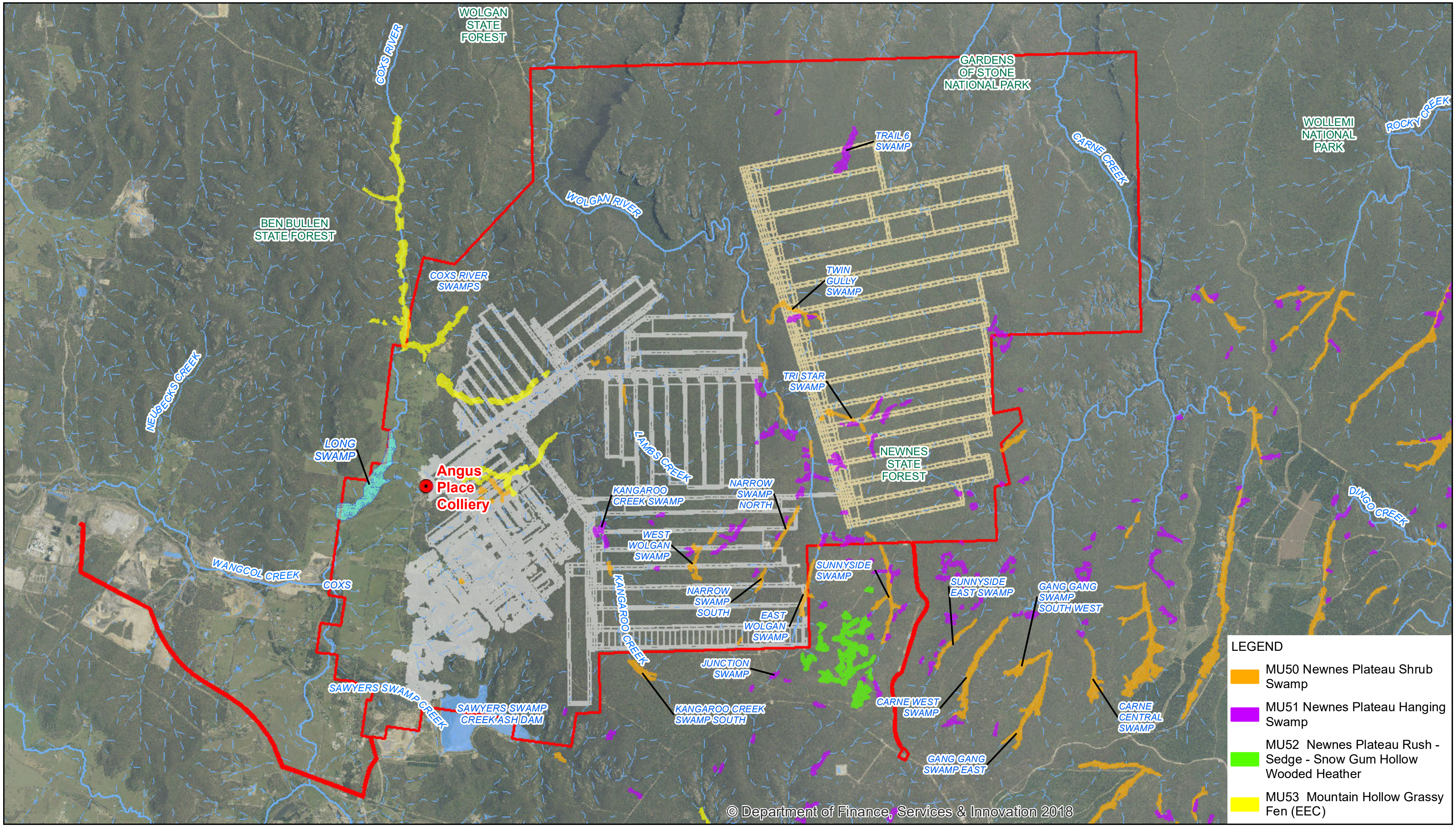
2.4.3 Groundwater dependant ecosystems

Newnes Plateau shrub swamps and hanging swamps occur within the Angus Place Colliery boundary, which are classified as Temperate Highland Peat Swamps on Sandstone (THPSS) in accordance with the federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). THPSS is listed as an endangered ecological community under the EPBC Act and the Newnes Plateau shrub swamps are also listed as an endangered ecological community under the NSW *Biodiversity Conservation Act 2016*.

Shrub swamps develop on the Newnes Plateau at altitudes in excess of 1000 m AHD at the base of valleys that are subject to temporary to permanent waterlogging from groundwater, surface water runoff and rainfall. Hanging swamps also develop on the Newnes Plateau at altitudes in excess of 1000 m AHD, on the sides of valleys where perched groundwater discharges and that are subject to infrequent waterlogging from perched groundwater, surface water runoff and rainfall.

Figure 2-4 presents the location of swamps within the vicinity of Angus Place Colliery.

Figure 2-4 Swamps at Angus Place Colliery



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0 0.65 1.3 1.95 2.6

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Angus Place Colliery
- Angus Place Holding Boundary
- Watercourse - Perennial
- Watercourse - Non Perennial
- Existing Mine Workings
- Proposed Mine Workings
- Waterbody
- Long Swamp

GHD

Centennial Coal

Angus Place Colliery
Water Management Plan

Swamps at Angus Place Colliery

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Figure 2-4

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Data source: LPI:DTDB / Imagery, 2012 / 2015. Centennial: Boundaries, workings, 2013; OEH: Vegetation, 2006. Created by: smacdonald, fmackay, tmorton

2.5 Hydrology

Angus Place Colliery lies within the greater Hawkesbury-Nepean catchment and covers two adjacent catchments for the upper Coxs River and Wolgan River. Underground mining operations traverse the catchment divide of the two rivers, while the pit top is located entirely within the upper Coxs River catchment. Watercourses in the vicinity of Angus Place Colliery are presented in Figure 2-5, including the following major creek systems:

- Carne Creek.
- Wolgan River.
- Lambs Creek.
- Kangaroo Creek.
- Sawyers Swamp Creek.
- Coxs River.

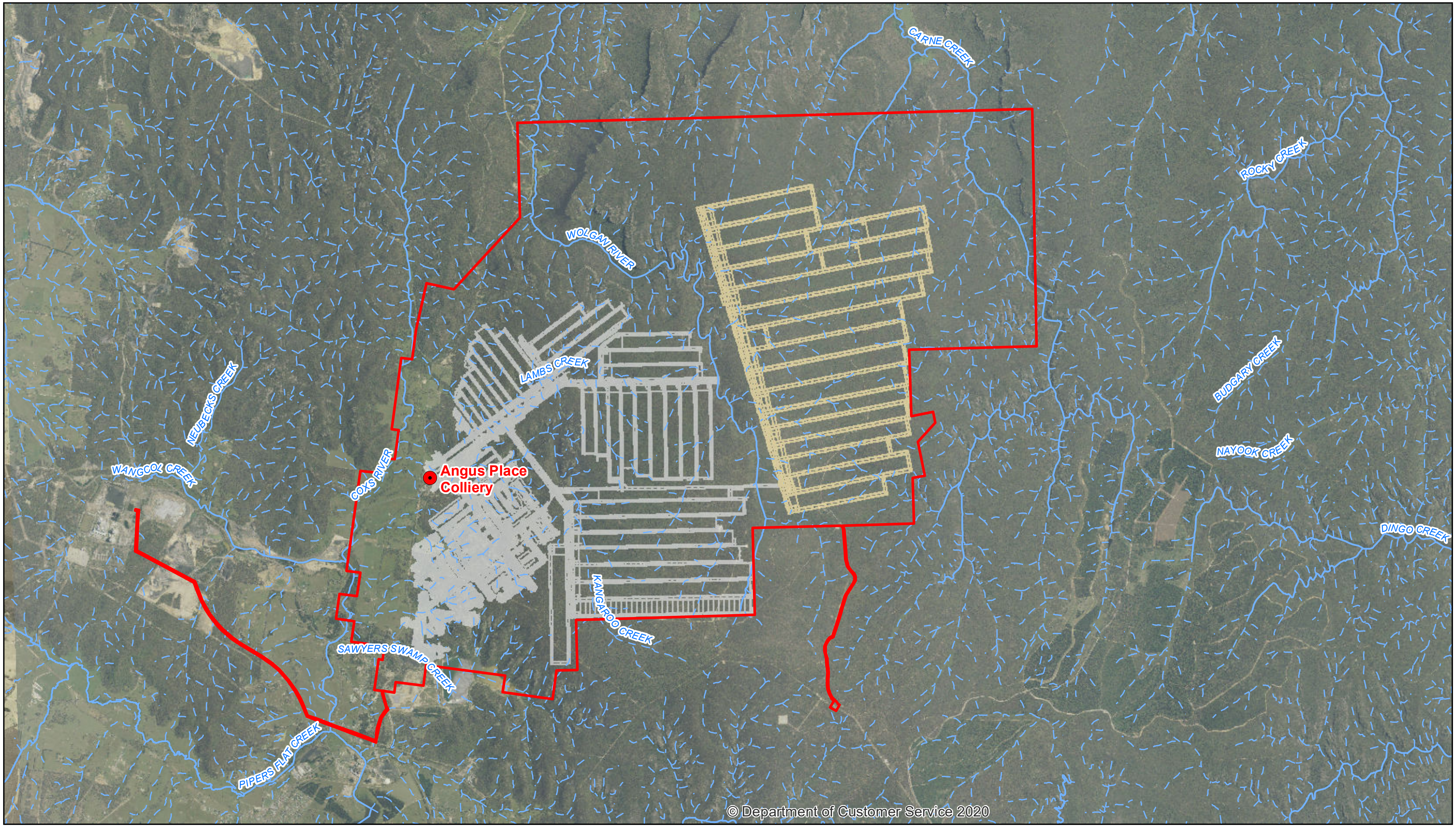
The Wolgan River catchment drains the eastern portion of Angus Place Colliery. The headwaters of the Wolgan River are located immediately south of the site boundary. Carne Creek flows in a north-easterly direction through the eastern portion of Angus Place Colliery before joining the Wolgan River to the north. The Wolgan River flows northerly off the Newnes Plateau into the Wolgan Valley to join the Capertee River in the Wollemi National Park to the east of Angus Place Colliery. The Colo River is formed by the confluence of the Wolgan River with the Capertee River to the north-east of the site.

Lambs Creek rises in the central area of the mining lease area and flows in a generally westerly direction to join the Coxs River. Kangaroo Creek rises immediately south of the Angus Place Colliery site boundary and flows in a northerly then westerly direction to the Coxs River downstream of Lambs Creek.

Sawyers Swamp Creek Ash Dam is located on the boundary between Angus Place Colliery and Springvale Mine and was previously used for disposal of ash from the Old Wallerawang Power Station (now Greenspot). Flow from Sawyers Swamp Creek is directed along the face of the ash dam before diverting around the Kerosene Vale Stockpile Area and discharging to the Coxs River.. The Kerosene Vale Stockpile Area site discharges to the south of the diverted tributary for Sawyers Swamp Creek, via LDP003

The Coxs River rises within the Ben Bullen State Forest to the north of Angus Place Colliery and flows generally in a south-east direction into Lake Burragorang, which is impounded by Warragamba Dam and is the primary reservoir for drinking water supply to Sydney. The flow in Coxs River is regulated by three reservoirs, Lake Wallace, Thompsons Creek Reservoir and Lake Lyell, which are used to supply water for power generation activities at Mount Piper Power Station.

Figure 2-5 Watercourses at Angus Place Colliery



Paper Size A4

0 0.75 1.5 2.25 3

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Angus Place Colliery
- Angus Place Holding Boundary
- Watercourse - Perennial
- Watercourse - Non Perennial
- Existing Mine Workings
- Proposed Mine Workings

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Angus Place Colliery
Water Management Plan

Watercourses at
Angus Place Colliery

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Figure 2-5

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Data source: LPI:DTDB / Imagery, 2012 / 2015. Centennial: Boundaries, workings, 2013. Created by: smacdonald, fmackay, tmorton

3. Water management

3.1 Water management overview and objectives

The water management system at Angus Place Colliery is comprised of clean and dirty surface, potable, waste and underground elements. Sources of water at the site include rainfall, runoff, external water supply and groundwater inflow to the underground mine workings. The primary water demands are for surface dust suppression, machinery wash down, fire-fighting storage and staff amenities as well as underground operations and the CHP during mining operations.

Surface water runoff from areas where there is no coal storage, transportation, handling or processing or any disturbance is considered to be clean water, as it is unlikely to be contaminated with coal fines or sediment. Runoff is diverted around dirty water and coal-contact catchments to avoid mixing with clean water runoff. Clean water runoff is typically from natural and impervious catchments such as areas of vegetation, sealed roads and sealed car parks.

Dirty water is runoff from disturbed areas and areas likely to contain suspended sediment, oils, grease and hydrocarbons. This typically includes workshop and fuel storage areas. Coal-contact water is runoff from catchments where coal storage, transportation, handling or processing occurs and is managed within the dirty water management system.

Angus Place Colliery has site-specific water management objectives that include:

- Maximise the separation of clean and dirty surface water systems.
- Manage water discharge from the site, in terms of volume and quality, to a level that is acceptable for environmental management and community expectations.
- Minimise water discharges from the premises by maximising, where practicable, opportunities for the reuse and recycling of water on site.
- Minimise discharges of dirty water from the site.
- Manage discharge to natural waterways in accordance with the relevant EPL conditions or as agreed with the EPA.

3.2 Surface water management

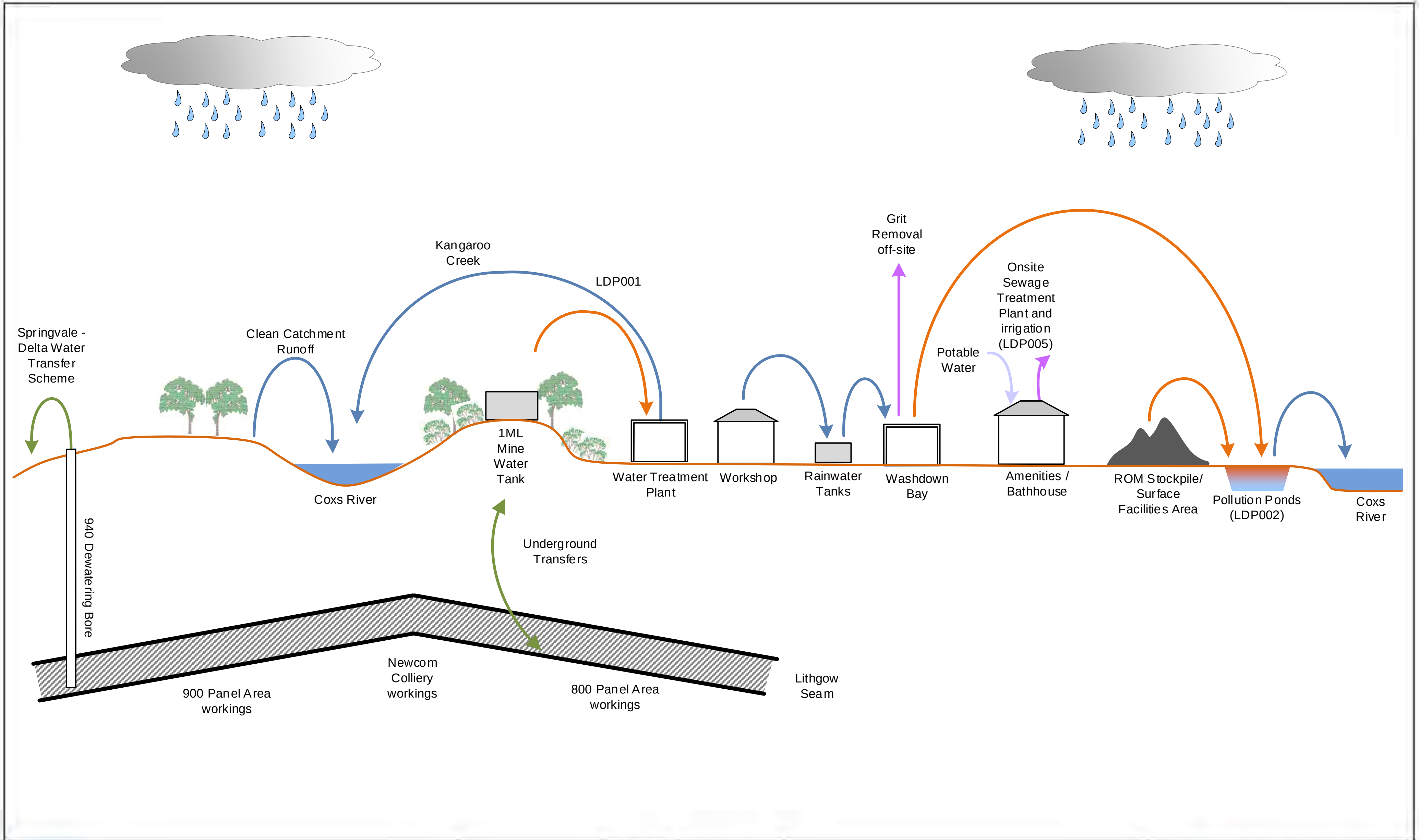
3.2.1 Pit top

Water management at the pit top of Angus Place Colliery focuses on the capture of surface water runoff across the site by surface water storages including the Primary Ponds, Secondary Pond and Filter Pond (collectively known as the Pollution Ponds) and the Settling Ponds. The primary functions of the surface water management system are as pollution control structures and to store water harvested from the site. Discharges from LDPs are minimised by the transfer and reuse of water across the site. A schematic of the overall water management system at Angus Place Colliery pit top is provided in Figure 3-1. Figure 3-2 shows the catchments contributing to the Angus Place Colliery pit top.

Clean water management

The clean water management system at the Angus Place Colliery pit top consists of a series of diversion bunds and drains that intercept clean runoff prior to it entering disturbed areas. This water is directed off-site into Kangaroo Creek. The clean water system is presented in Figure 3-3.

Figure 3-1 Water management schematic



Dirty Water
Clean Water
Underground Water
Potable Water
Waste Water

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LOCATION	Angus Place
SEAM	Lithgow
DRAWN	TT
CHECKED	LH
APPROVED	SG
SCALE	NTS

Angus Place Colliery
Water Management Plan

Water management schematic

Centennial Coal

DATE 28 Sep 2018

Figure 3-1

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Figure 3-2 Pit top catchments

Paper Size A4

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Licenced Discharge Point
- Surface Water Storage
- Wetland
- Site Catchment

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Job Number 22-19614
Revision 1
Date 21 Jun 2021

Pit top catchments

Figure 3-2

G:\22\0105001\GIS\Maps\Deliverables\Western\AngusPlace\2219614\2219614_WMP005a_PitTopCatchments_1.mxd

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Figure 3-3 Pit top clean water management system

Paper Size A4

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Licenced Discharge Point
- Surface Water Storage
- Wetland
- Site Catchment

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Job Number	22-19614
Revision	1
Date	21 Jun 2021

Pit top catchments

Figure 3-2

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Data source: LPI:DTDB, 2012. Centennial: Boundaries, imagery, 2013 / 2017. Created by: smacdonald, fmackay, tmorton

Dirty water management

The dirty water management structures at the Angus Place Colliery pit top form the basis of sediment control at the site. Dirty water runoff is managed by a number of dirty water storages which enable suspended solids to settle out of the water column and also allow for dirty water to be reused in site processes, thereby minimising the potential for dirty water discharges into the surrounding environment. The dirty water management structures are regularly de-silted to maximise available storage capacity.

The dirty water system consists of a number of drains, grit traps, kerb and gutter, collection pits, pipe networks, oil water separators and settling ponds. Runoff from the CHP and pit top is diverted to a network of Pollution Ponds.

Water is filtered through gabion baskets and ballast prior to entering the Settling Ponds. The Settling Ponds capture runoff while suspended solids, such as soil and coal fines, settle out to become sediment. If flocking or pH dosing is required at this point to meet EPL criteria, it is done within the settling ponds. Clean water from the Settling Ponds is discharged via LDP002 into the Coxs River.

Figure 3-4 presents the dirty water system at the Angus Place Colliery pit top. Table 3-1 provides a summary of the dirty water storages present at the pit top.

Table 3-1 Pit top dirty water storages

Storage	Maximum capacity	Function	Treatment	Design compliance	Overflow type	Discharge to
Primary Ponds	1.9 ML	Sediment control	Settlement	95th percentile, 5 day rainfall depth	Weir	Secondary Pond
Secondary Pond	2.6 ML	Sediment control	Settlement	95th percentile, 5 day rainfall depth	Weir	Filter Pond
Filter Pond	1.2 ML	Sediment control	Settlement	95th percentile, 5 day rainfall depth	Weir	Settling Ponds
Settling Ponds	7.5 ML	Sediment control	Settlement	95th percentile, 5 day rainfall depth	Weir	Coxs River via LDP002

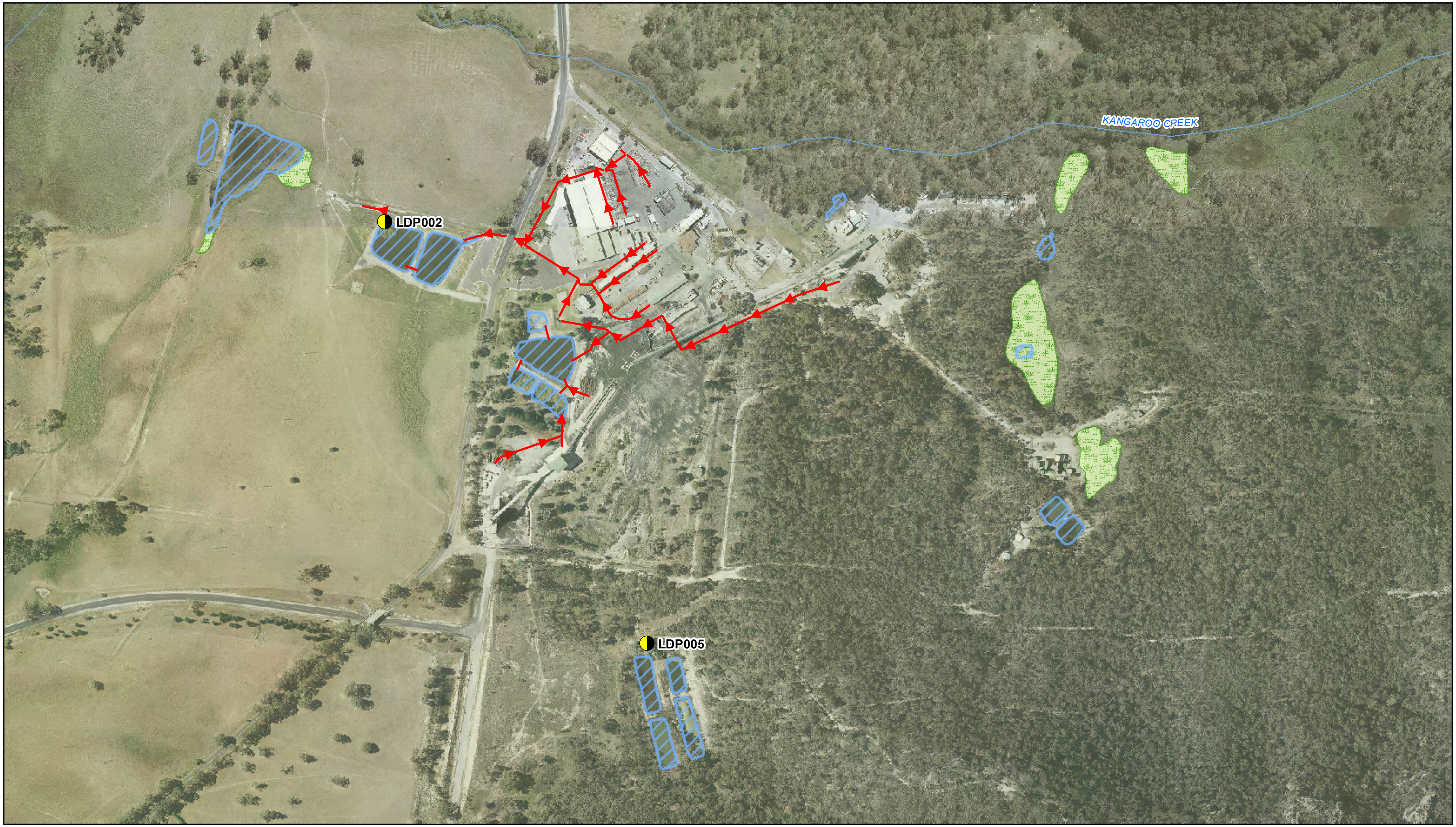
Primary Ponds

The Primary Ponds receive runoff from the CHP and its own dirty water catchment. The ponds overflow to the Secondary Pond.

Secondary Pond

The Secondary Pond receives dirty water runoff and overflows from the Primary Ponds. The pond overflows to the Filter Pond.

Figure 3-4 Pit top dirty water management system



Paper Size A4

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Licenced Discharge Point
- Dirty Water Diversions
- Surface Water Storage
- Wetland
- Waterway

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Pit top dirty water management system

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Figure 3-4

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Data source: LPI:DTDB, 2012. Centennial: Boundaries, imagery 2013 / 2017. Created by: smacdonald, fmackay, tmorton

Filter Pond

The Filter Pond receives dirty water runoff and overflows from the Secondary Pond. The pond overflows to the Settling Ponds.

Settling Ponds

The Settling Ponds receive catchment runoff and overflows from the Filter Pond and oil water separator. Overflows are discharged via LDP002 to the Coxs River.

Oil water separator

Excess water from the grit trap, wastewater from machinery washdown, hardstand areas, oil storage areas and workshop and runoff from contributing dirty water catchment is collected in a common wastewater collection drain which flows by gravity to an oil water separator. Water from the oil water separator is transferred to the Settling Ponds, while oil and grease is disposed of off-site by a licensed contractor.

3.2.2 Ventilation Facility

Diversion drains to the south-east and south-west of the Ventilation Facility divert clean runoff from external catchments around the site (refer to Figure 3-5). Runoff from disturbed and/or workshop areas is categorised as dirty water and is directed to a number of dirty water management structures. Dirty water is collected by the North Sediment Dam and South Sediment Dam . It is then either pumped to the 8ML Dam or to Springvale Bore 5. Dirty water stored in the South Sediment Dam and the 8 ML Dam is transferred as required to Springvale Bore 5.

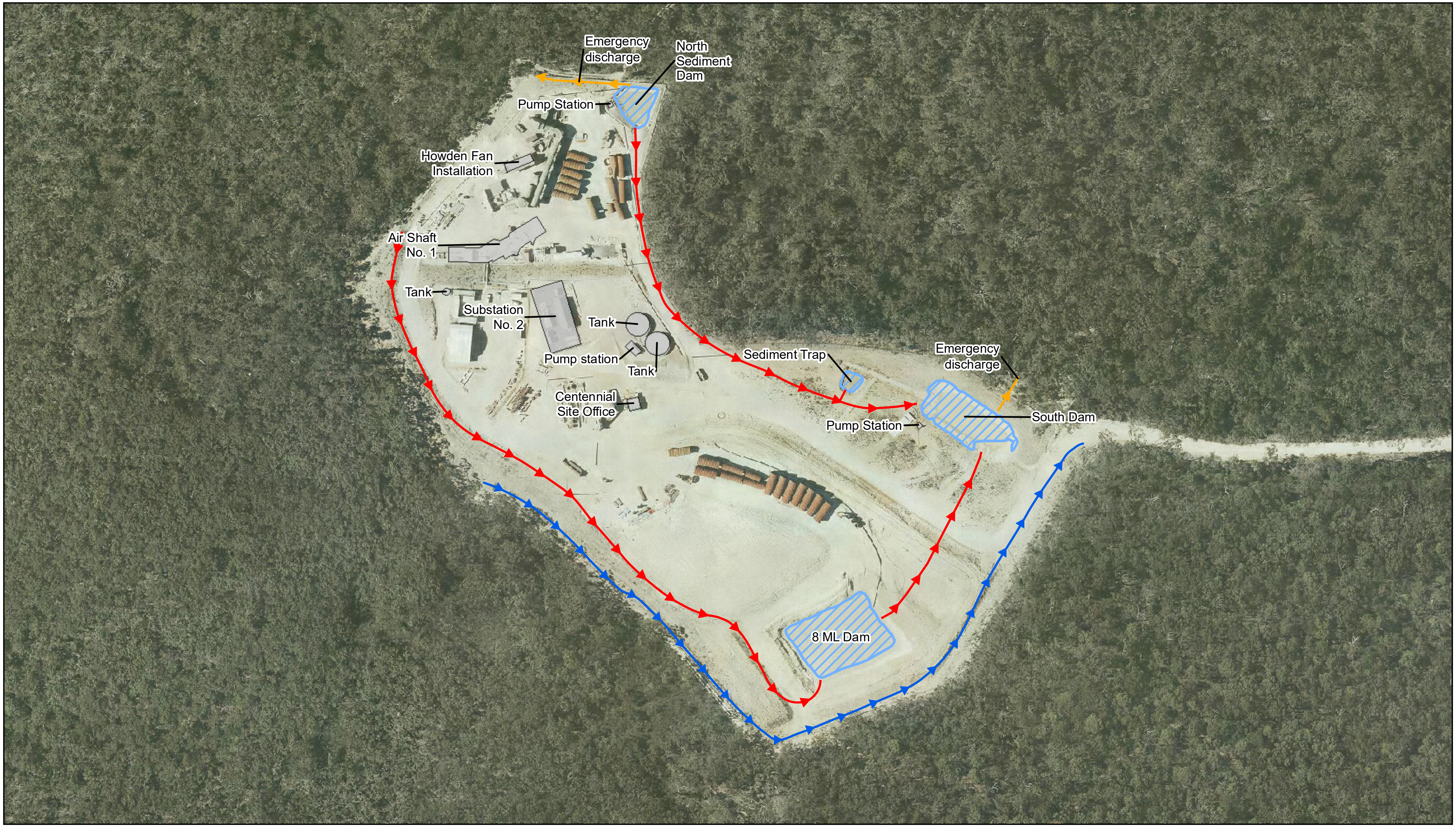
The dams were designed and approved to hold 90th percentile 5 day management period rainfall event of 37.8 mm (based on Modification 4) in accordance with *Managing Urban Stormwater, Soils and Construction Volume 1* (Blue Book). Rainfall events over this amount could be expected to exit the site via the emergency spillways on both the North and South Sediment Dams.

Table 3-2 Ventilation Facility dirty water storages

Storage	Maximum capacity	Function	Treatment	Design compliance	Overflow type	Discharge to
North Sediment Dam	0.5 ML	Capture sediment	Settlement	90th percentile, 5 day rainfall depth	Pump	North Sediment Dam
South Sediment Dam (Entrance Pond)	1.7 ML	Capture sediment	Settlement	90th percentile, 5 day rainfall depth	Pump	Off-site disposal
8 ML Dam	8 ML	Capture sediment	Settlement	90th percentile, 5 day rainfall depth	Gravity overflow	Entrance Pond

The management of captured water within the storages at the Ventilation Facility include treatment and discharge or pump out to an injection point at Springvale Mine, referred to as Bore 5. Following a rainfall event, the volume of disposal will be as high as 10.2 ML over 5 days.

Figure 3-5 Ventilation Facility water management system



Paper Size A4

0 10 20 40 60 80

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Surface Water Storage
- Infrastructure
- Clean water diversion
- Dirty water diversion
- Emergency discharge

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Job Number 22-19614
Revision 1
Date 21 Jun 2021

Ventilation Facility
water management system

Figure 3-5

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Data source: Centennial: Aerial Imagery, site features, 2017, 2013. Created by: fmackay, tmorton

3.2.3 Kerosene Vale Stockpile Area

The KVSA contains portions of temporary rehabilitation and woodland rehabilitation on its northern and eastern aspects. The majority of the site is comprised of a pad constructed of coal chitter.

Clean water management

Clean water diversion bunds are located on the northern side of the main stockpile area and impede runoff entering the disturbed area. The clean water diversion structure locations are provided in Figure 3-6.

Dirty water management

Dirty water runoff from the KVSA is directed through two settling ponds which discharge through LDP003. Water is filtered through gabion baskets and ballast prior to being treated with flocculant to further remove sediment if necessary to meet EPL requirements. The settling ponds at the KVSA are dewatered via LDP003 within five days following rainfall in order to maintain sufficient capacity to capture dirty water runoff.

The dirty catchment areas and diversion structure locations at the KVSA are provided in Figure 3-6. Table 3-3 provides a summary of the dirty water management system at the KVSA.

Table 3-3 Kerosene Vale Stockpile Area dirty water storages

Storage	Maximum capacity	Function	Treatment	Design compliance	Overflow type	Discharge to
Settling ponds (two storages)	2.5 ML (total)	Capture sediment	Settlement Flocculant	95th percentile, 5 day rainfall depth	Pump Spillway	Coxs River via LDP003

3.3 Underground water management

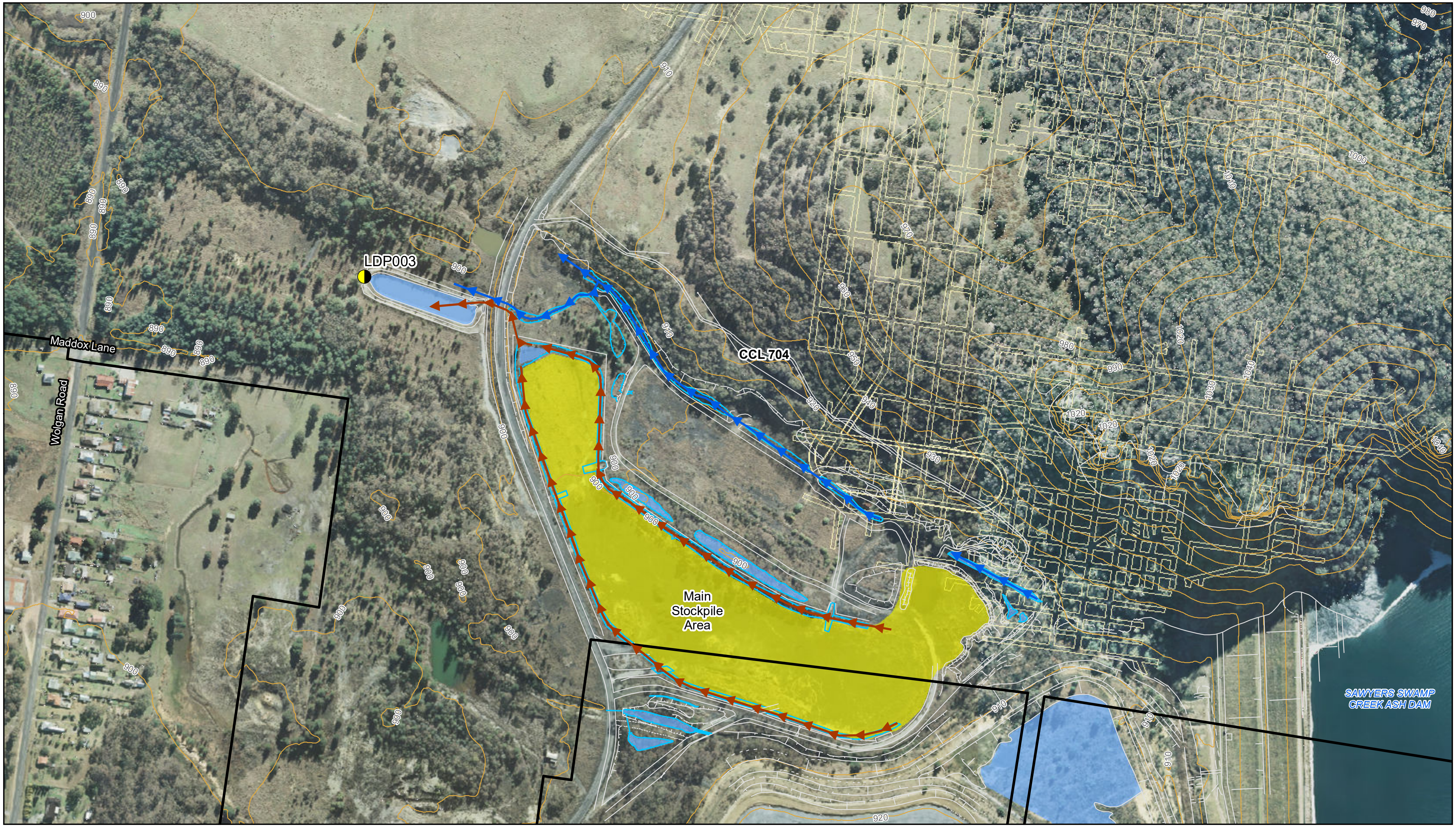
3.3.1 Underground water management system

Mining at Angus Place Colliery intersects the Lithgow Seam. This seam is considered to be a water bearing zone and there is moderate groundwater inflow into the workings. Groundwater is transferred and stored underground as necessary via a series of collection points and pumps to aid in sediment settlement prior to being pumped to the surface.

Groundwater extracted from the underground workings through the in-seam water management system is directed to the pit top where it can further managed as described in Section 3.4.

Groundwater inflows into the underground workings can also be extracted by the 940 Bore, which is located on the Newnes Plateau. This water is extracted using submersible pumps from the lowest point in the mine workings to the surface where it is transferred to the SDWTS which ultimately is transferred to the SWTF for treatment and reuse. This further discussed in Section 3.4.

Figure 3-6 Kerosene Vale Stockpile Area water management system



Paper Size A4

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Mining Lease Boundary
- LDP
- Survey (Infrastucture)
- Drain
- Settling Ponds
- Dirty Water Catchment
- Clean water diversions
- Dirty water flow paths
- 10m Contours
- Newcom First Workings

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Job Number	22-19614
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Kerosene Vale Stockpile Area
water management system

Figure 3-6

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Data source: Centennial: Aerial Imagery, site features, 2017, 2013. Created by: smacdonald, fmackay, tmorton

The current groundwater inflow rate approved for Angus Place Colliery is 13.4 ML/day. This rate was predicted by RPS (2014) based on an average extraction requirements as a result of mining and development work at Angus Place Colliery in 2014. At the time that Modification 4 to development consent PA 06_0021 was approved, groundwater inflow into the mine was estimated to be 9 ML/day. Groundwater inflow has reduced to approximately 8.7 ML/day currently in 2018 (JBS&G 2018).

Groundwater interception predictions are average only and actual flows can vary due to changes in operational and environmental conditions. Due to constraints in the discharge of mine water off-site, the underground workings at Angus Place Colliery have been accumulating water within the 800 and 900 districts. Increased dewatering from the mine occurred with Modification 5 and a temporary Water Treatment Plant (TWTP).

Where groundwater extractions are greater than 13.4 ML/day, operations will be undertaken within in current range of impacts assessed by groundwater impact assessments for Angus Place Colliery (RPS 2014; JBS&G 2018). Where impacts are identified beyond those previously assessed, dewatering rates will be reduced as specified by the trigger action response plans (TARPs) discussed in Section 6.3.

3.3.3 Hydrogeological predictions

The groundwater inflows into underground workings predicted by hydrogeological modelling for Angus Place Colliery and Springvale Mine are shown in Figure 3-7 (CSIRO 2016). Groundwater inflows are predicted to peak at 418 L/s (approximately 36 ML/day) in 2031 (CSIRO 2016). Note that the groundwater inflow predictions shown in Figure 3-7 are presented only to provide an indication of future groundwater management requirements as they assume the development of Angus Place East workings, which is part of the Angus Place Mine Extension Project that is currently undergoing assessment and not yet approved. The currently approved groundwater inflow rate for Angus Place Colliery is 13.4 ML/day.

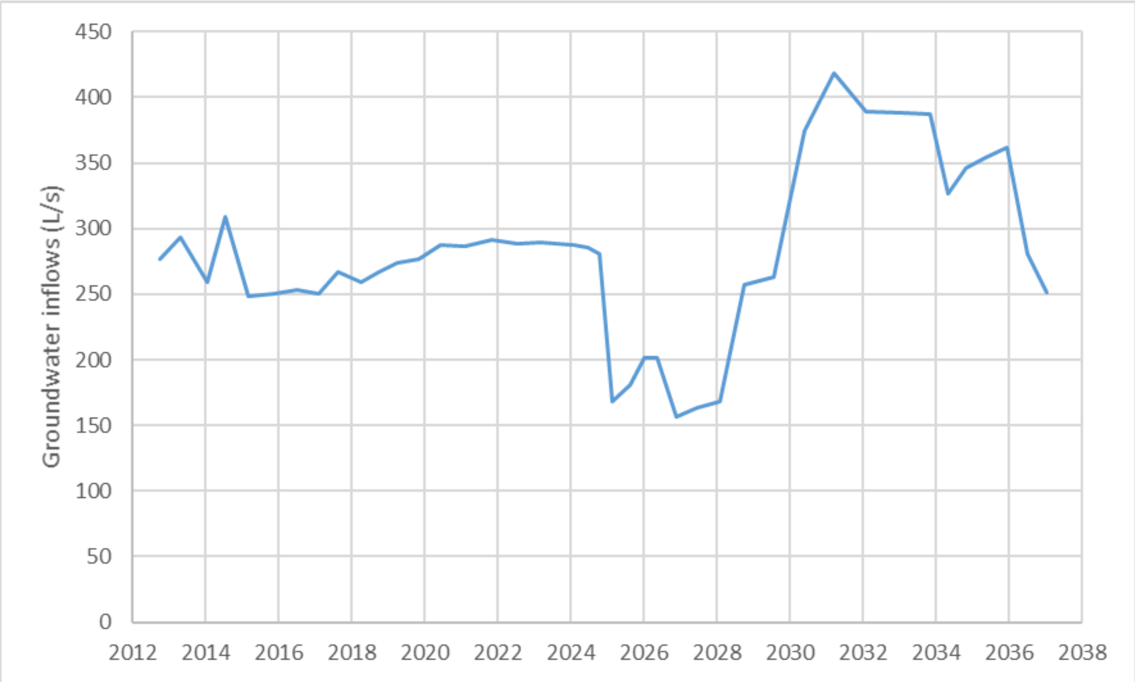

Figure 3-7 Predicted groundwater inflows into underground workings of Angus Place Colliery and Springvale Mine

3.4 Pipeline and Water Transfer Infrastructure

3.4.1 Angus Place Haul Road Pipeline

To enable transfers from the Angus Place Colliery Pit Top to the SWTF, the Angus Place Haul Road Pipeline enables water from the Pit Top and Inseam Dewatering System to be transferred via a pipeline located along the Wallerawang Haul Road to Mine Water Receipt Point 3 located on the SWTP Raw Water Pipeline. This system is generally rated for up 20 ML/day.

3.4.2 Angus Place Water Transfer System

The Angus Place Water Transfer System consist of pipeline system enable the transfer of water from Angus Place Colliery to Mount Piper Power Station. The pipeline starts from upstream of Mine Water Receipt Point 3 with an initial section of pipe through to the existing Wallerawang to Mount Piper Power Station Pipeline. There is also a section of pipeline that has been constructed to connect from the end of the Wallerawang to Mount Piper Power Station Pipeline to a storage pond, Pond D, which is part of the Mount Piper Power Station Industrial Water Management and Treatment System.

A maximum of 2.6 ML/day of Angus Place water can be transferred to Pond D for subsequent treatment and reuse in existing brine concentrators[3]. Water transferred from the Angus Place Mine that is of a suitable quality to be used in the generation of electricity, could effectively bypass Pond D and the brine concentrators and could report to the cooling water system or other existing approved water management infrastructure. This will maintain the operational flexibility required for the responsible transfer, storage and handling of varying water qualities being delivered from the Angus Place Mine over time. This will provide for the efficient treatment, recycling and reuse of water from the Angus Place Mine at the MPPS which is consistent with the objectives of the Modification 6 Report. Regardless, this activity is subject to the approval requirements granted under the SWTP Modification 6 (SSD-7592).

3.4.3 Springvale-Delta Water Transfer Scheme and SWTP Raw Water Transfer Pipeline

The SDWTS consists of a pipeline network that previously transferred extracted groundwater from bores located at Angus Place Colliery and Springvale Mine to the Old Wallerawang Power Station (now Greenspot). Following the closure of the power station in 2014, water from the SDWTS had been discharged through Springvale Mine's LDP009 to Sawyers Swamp Creek within the upper Coxs River catchment. This activity ceased in 2019 with the commissioning of the SWTF. Mine water from the SDWTS is directed to the SWTP Raw Water Transfer Pipeline where it is conveyed to the SWTF for treatment and reuse within MPPS.

Angus Place Colliery on average transfers 8 to 13 ML/Day to the SDWTS which is treated at the SWTF.

3.5 Springvale Water Treatment Facility

Treatment rates for the SWTF are on average 36 ML/day, with a maximum of up to 42 ML/day. Angus Place can transfer water to the SWTF via the SDWTS or the Angus Place Haul Road Pipeline up to 13.4 ML/day.

[3] Diversion of water to Pond D will commence following the installation and commissioning of the Water Transfer Pipeline, is shown in Appendix 2A of PA 06_0021.

Angus Place Colliery on average transfers 8 to 13ML/Day to the SDWTS and onto the SWTF for treatment and reuse at MPPS.

3.6 Potable and wastewater systems

Potable water is provided to the administration and bathhouse buildings at Angus Place Colliery's pit top by the municipal water supply from Lithgow City Council.

Grey water and sewage is collected in a tank before being directed to a series of ponds connected by spillways and disposed via spray irrigation at the utilisation area via LDP005, as shown in Figure 3-9.

Figure 3-8 Water Treatment Plant infrastructure

LEGEND

- Borehole
- Licenced Discharge Point
- Surface Water Storage
- Wetland
- Waterways
- Mine water pipeline

Paper Size A4
0 5 10 20 30 40 50 60
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Revision	1
Date	21 Jun 2021

Water Infrastructure

Figure 3-8

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Data source: LPI:DTDB, 2012. Centennial: Imagery, LDP's, Site features, 2017. Created by: smacdonald, ttinkler, fmackay, tmorton

Figure 3-9 Sewage treatment system layout

LEGEND

- PS Pump station
- Sprinkler
- Angus Place LDP
- Irrigation area
- Pond

Paper Size A4

0 5 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Date	21 Jun 2021

Sewage treatment system layout Figure 3-7

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

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Data source: LPI:DTDB, 2012. Centennial: Imagery, LDP's, Site features, 2017. Created by:fmackay

The utilisation area consists of woodland adjacent to the sewage ponds. A rise in effluent levels in Pond 4 triggers the activation of the pump, which distributes the effluent over the area via sprinklers. The pumping station may also be used for recirculation of effluent from Pond 4 to Pond 1 to improve the treatment efficiency.

The existing sewage treatment system is a typical oxidation and maturation ponds treatment system used for small size sewage treatment facilities in regional NSW.

The first two ponds (Pond 1 and Pond 2) are likely to be functioning as oxidation or facultative ponds. Oxidation ponds are relatively shallow storages whereby stabilisation of sewage occurs by biological oxidation as well as by algal growth. Solids settled in the pond may form an anaerobic layer beneath the surface aerobic layer. Organic matter is decomposed by facultative microorganisms and the rate of decomposition is dependent upon temperature, sunlight and diffusion of oxygen into the pond.

Due to low biological oxygen demand (BOD) in the effluent, Pond 3 and Pond 4 are likely to be functioning as maturation ponds. Maturation ponds provide disinfection of effluent by providing sufficient detention time to allow natural die-off of pathogens. Disinfection occurs by exposure of microorganisms to natural ultraviolet radiation in combination with a ‘food starved’ environment within the pond.

During care and maintenance period at Angus Place Colliery, it is unlikely that a sufficient volume of sewage will be produced to require the pumping of treated water from Pond 4, with the system expected to lose most of the effluent due to evaporation.

3.7 Erosion and sediment control

As part of surface water management, erosion and sediment control is undertaken to minimise excessive soil loss as a result of activities that require disturbance of existing groundcover. Erosion and sediment controls are implemented for all phases of operation including construction/maintenance activities, operational activities and rehabilitation to mitigate the impacts of operations on watercourses and the surrounding environment.

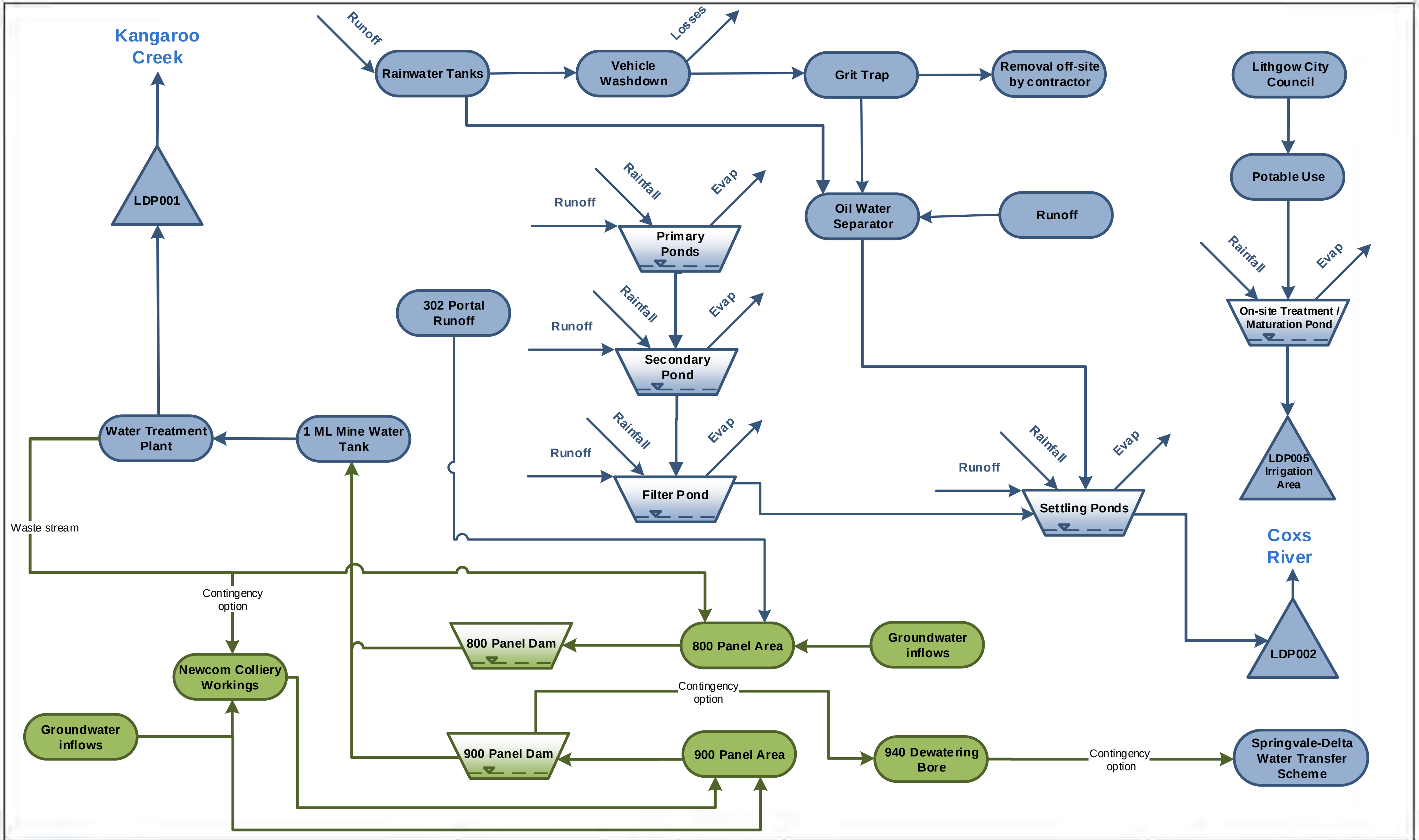
As Angus Place Colliery is an established underground mine, no new areas are disturbed for mine development. Disturbed areas are either active, such as coal stockpiles, or have been rehabilitated to prevent erosion. Sediment and erosion control materials and structures are installed and maintained as required. Further information on measures used to prevent erosion and sedimentation are presented in the Regional Water Management Plan (GHD 2016a).

3.8 Site water balance

3.8.1 Summary

An operational site water balance model for Angus Place Colliery pit top has been developed to quantify transfers within the site under existing and future operational conditions. The site water balance is updated annually to reflect the current operational conditions but has also been updated for Modification 6 to cover development consent PA 06_0021. A schematic of the overall pit top water management system is provided in Figure 3-10. The site water balance included the relatively minor volumes of catchment runoff and discharge from LDP003 at KVSA.

Figure 3-10 Water cycle schematic



LEGEND

Surface Transfer

Underground Transfer

Storage

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LOCATION	Angus Place
SEAM	Lithgow
DRAWN	TT
CHECKED	LH
APPROVED	AW
SCALE	NTS

Angus Place Colliery
Water Management Plan

Water cycle schematic

Centennial Coal

DATE 28 Sep 2018

Figure 3-10

\\ghdnet\ghd\AU\Newcastle\Projects\22\19614\Tech\Visio\2219614-VIS-Water_management_schematic.vsdx

A summary of the average annual inputs and outputs for the Angus Place Colliery pit top water management system are provided in Table 3-4. Results are based on the predicted average site conditions currently experienced at Angus Place Colliery. Table 3-4 shows that, on average, water balance modelling predicts that inflows to the pit top are almost entirely comprised of groundwater inflows. Groundwater inflows are dewatered predominately to the surface for treatment at the SWTF or transferred to Pond D at the WPPS.. A relatively small volume of catchment runoff from the pit top is discharged mainly through LDP002.

Table 3-4 Summary of site water balance results (EMM 2020)

Water management element	Existing Average annual volume (ML/year)	Future Average annual volume (ML/year)
INPUTS		
Direct rainfall onto storages and catchment runoff	116	116
Potable Water Supply	2	2
Groundwater inflows into underground workings	2,166	2166
TOTAL INPUTS	2,284	2284
OUTPUTS		
Evaporation	20	20
Discharge through LDP002	22	22
Discharge through LDP003	34	34
Discharge through LDP005	1	1
Transfer to SDWTS		
Transfer to SWTP	2085	1428
Transfer to Pond D	NA	657 (avg 1.8ML/day)
Transfer from ventilation facility at Springvale Mine	33	33
Losses from operations	1	1
TOTAL OUTPUTS	2196	2196
CHANGE IN STORAGE		
Surface water storages	88	88
Underground water storages	88	88
TOTAL CHANGE IN STORAGE	-	-
BALANCE		
Inputs – outputs – change in storage	0	0

3.8.2 Water supply security

Water supply to meet site operational demands is sourced from Lithgow City Council potable supply, surface water stored on site, including harvested runoff and groundwater inflows into underground workings. Water supply from clean water sources is minimised by reuse and recirculation of water on site. Given the security of groundwater extracted from the underground workings and local council potable supply, there are no significant water supply risks associated with achieving appropriate environmental management requirements.

3.8.3 Underground Storage and Transfer Protocols

The following operating protocols are applied to the underground storage and transfer of water:

- Groundwater inflows occur continuously within the underground working areas and must be constantly extracted to prevent flooding of key infrastructure and sterilisation of potential future coal reserves.
- Water is temporarily stored in goaf areas known as the 800 and 900 panel areas.
- Up to 42 ML/day of mine water from Springvale Mine and Angus Place Colliery mine dewatering facilities can be received at the SWTF for treatment and industrial reuse at MPPS.
- Up to 13.4 ML/day of mine water from the Angus Place Mine can be transferred via the SDWTS or via the Angus Place Water Transfer Pipeline located along the Wallerawang Haul Road directly to the SWTP Raw Water Pipeline for treatment at SWTF.
- Up to 2.6 ML/day can be transferred to Pond D at MPPS.

Depending on the availability of infrastructure or the water quality being experienced underground at Angus Place Colliery the utilisation of any one or a combination of dewatering and transfer systems may be required to manage mine water from the operations.

3.8.4 Discharge frequency

LDP002 discharge

The modelled daily distribution of discharges from LDP002 is summarised as a cumulative frequency plot in Figure 3-11. The water balance modelling indicates that discharges through LDP002 will vary with rainfall, up to approximately 3 ML/day due to frequent rainfall events.

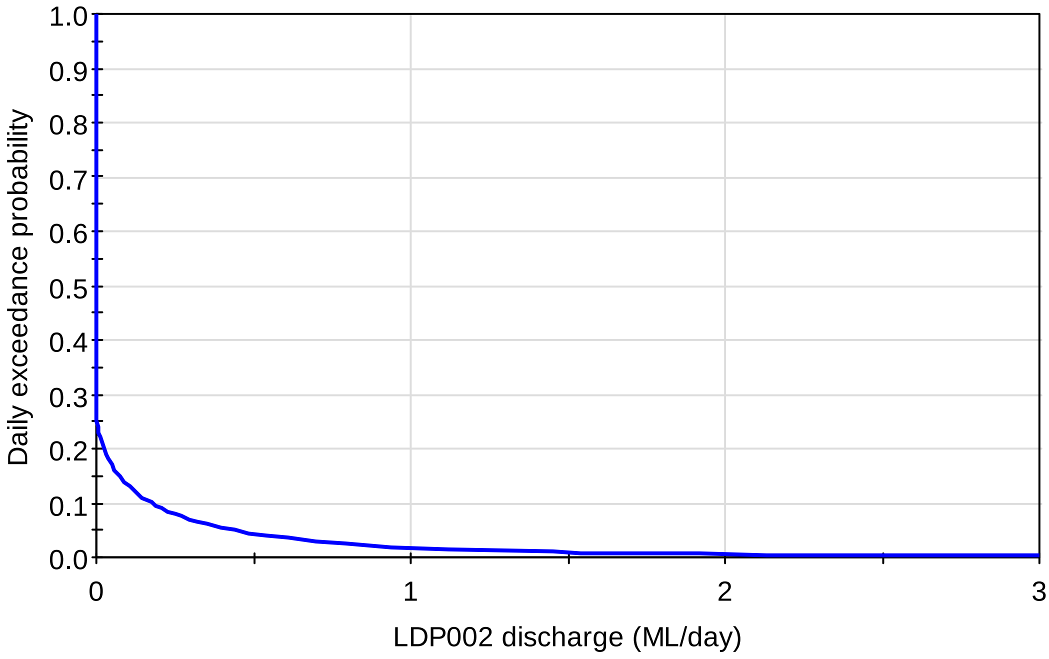


Figure 3-11 Daily exceedance probability of LDP002 discharge

LDP003 discharge

A site water balance was developed to quantify water transfers for the Western Coal Services Project using various rainfall patterns (GHD 2017). This water balance was used to predict the volume and frequency of discharges through LDP003 at the KVSA.

Discharges through LDP003 occur from controlled discharges and overflows from the sediment basin located downstream of the KVSA. A cumulative frequency distribution of LDP003 discharges is shown in Figure 3-12. Discharges exceeding 1 kL/day from LDP003 are predicted to occur on approximately 30% of days and unlikely to exceed 1 ML/day.

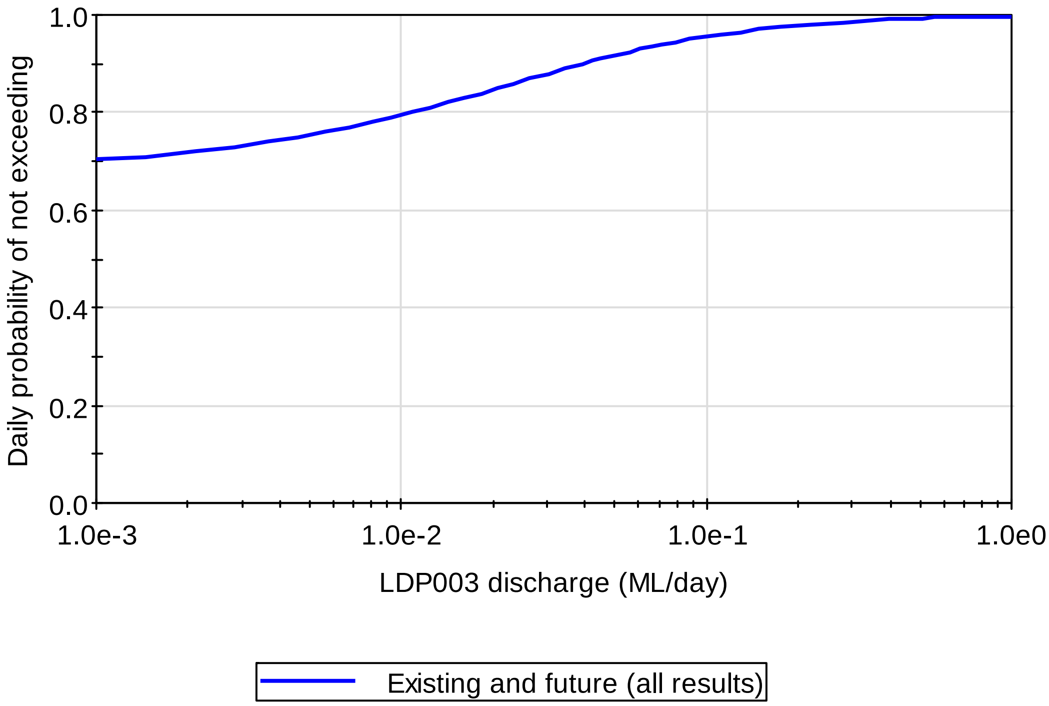


Figure 3-12 Predicted daily discharges from LDP003

4. Monitoring requirements

4.1 Inspections

Site inspections are completed by the Environment and Community Coordinator (or delegate) and occur:

- Monthly
- Within 24 hours following rainfall events that exceed 20 mm in 24 hours.
- Following any non-compliance or reported internal incident.

An example of a self-audit is undertaking the following activities:

- Walking around the site systematically.
- Inspecting water management and sediment control structures for capacity, structural integrity and effectiveness.
- Recording and reporting on the condition of each water management and sediment control structure in place.
- Recording where around the site sediment is deposited.

Maintenance of the water management and sediment control structures will be implemented following observations of visual defects.

4.2 Angus Place Water Transfer System Pipeline Monitoring Program

Monitoring of the Angus Place Water Transfer System pipeline for managing, monitoring and responding to leaks and spills consists of the following:

- Regular visual inspections.
- Transfer flow monitoring.
- Differential flow monitoring, managed through SCADA alarms.

Due to multiple different sections of the system, management and monitoring obligations will vary in both requirements and monitoring frequency. Where leaks and spills occur, these will be managed through an operational Trigger Action Response Plan (TARP).

4.3 Surface water monitoring

Surface water monitoring locations are presented in Figure 4-1.

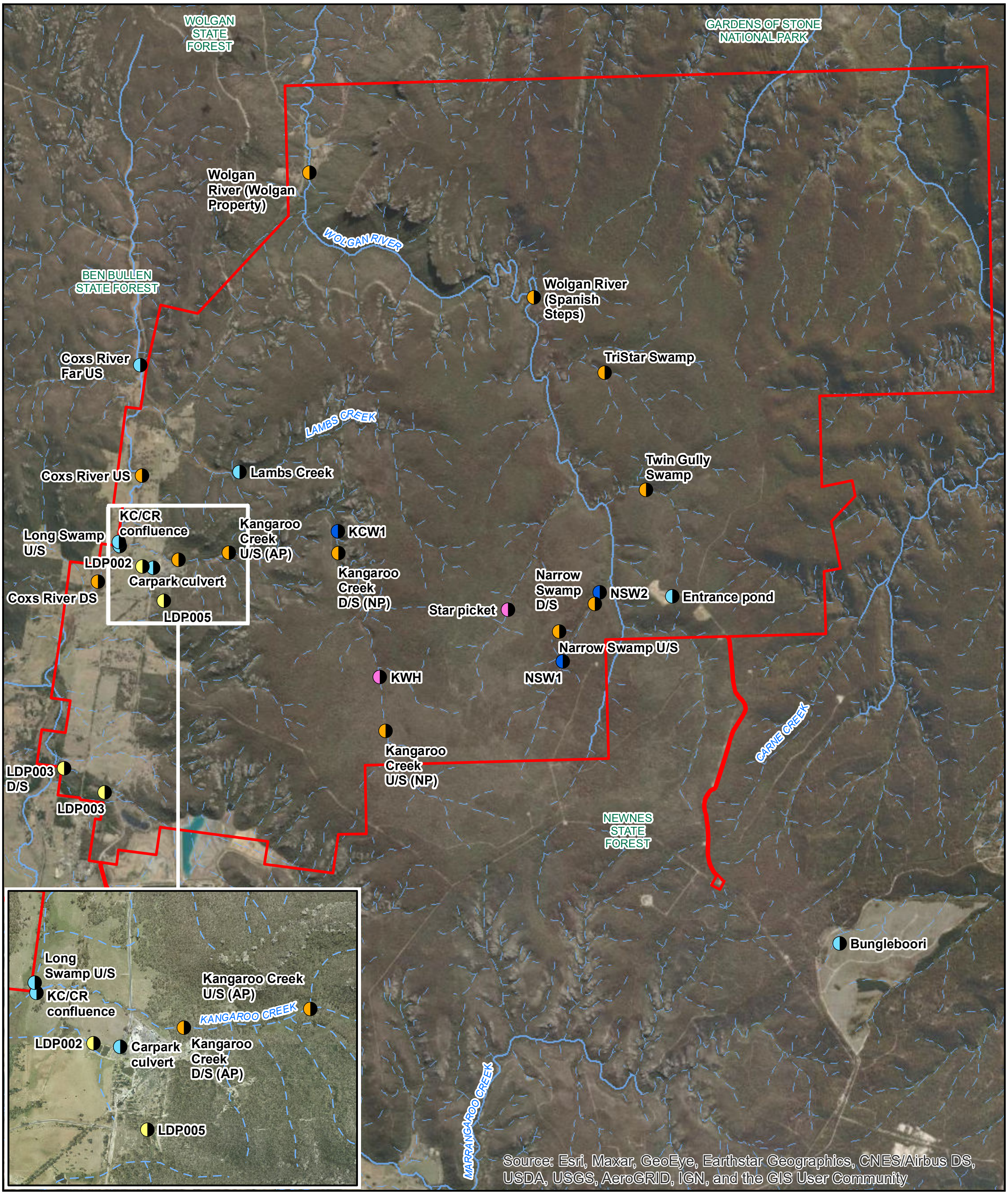
4.3.1 Surface water quality

Surface water quality at Angus Place Colliery is currently monitored at the following locations:

- Mining operations:
  - Carpark culvert – dirty water drain prior to entering the Settling Ponds.
  - South Sediment Dam (Entrance Pond) – sediment pond at ventilation facility on Newnes Plateau.
  - South Sediment Dam (Entrance Pond) discharge.

- Watercourses:
  - Bungleboori – monitored when South Sediment Dam (Entrance Pond) is discharging.
  - Coxs River Far U/S – Coxs River located approximately 600 m upstream of confluence with Lambs Creek.
  - Coxs River U/S – Coxs River located approximately 1 km upstream of confluence with Kangaroo Creek.
  - Long Swamp U/S – Coxs River upstream of the confluence with Kangaroo Creek.
  - Coxs River D/S – Coxs River located approximately 600 m downstream of confluence with Kangaroo Creek.
  - Lambs Creek – Lambs Creek located approximately 2 km upstream of confluence with Coxs River.
  - Long Swamp U/S – Coxs River in Long Swamp, immediately upstream of the confluence with Kangaroo Creek.
  - Kangaroo Creek U/S (AP) – Kangaroo Creek located approximately 500 m upstream of discharges from former LDP001.
  - Kangaroo Creek D/S (AP) – Kangaroo Creek located approximately 200 m downstream of discharges from former LDP001.
  - Kangaroo Creek U/S (NP) – located in the upper reaches of Kangaroo Creek on the Newnes Plateau.
  - Kangaroo Creek D/S (NP) – Kangaroo Creek located on Newnes Plateau approximately 2 km downstream of Kangaroo Creek U/S (NP).
  - KC/CR confluence – located at the confluence of the Coxs River and Kangaroo Creek.
  - Wolgan River (Spanish Steps) – located on the Wolgan River upstream of any potential seepage from the 800 District.
  - Wolgan River (Wolgah Property) – located on the Wolgan River downstream of any potential seepage from the 800 District.
  - LDP003 D/S – located on Sawyers Swamp Creek approximately 1 km downstream of LDP003 discharge from the KVSA.

Figure 4-1 Surface water monitoring locations



LEGEND

- Angus Place LDP
- Depth monitoring
- Flow Monitoring
- Flow and quality monitoring
- Water quality monitoring
- Angus Place Holding Boundary
- Watercourse - Perennial
- Watercourse - Non Perennial

Paper Size A4

0 0.55 1.1 1.65 2.2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD Centennial Coal

Angus Place Colliery
Water Management Plan

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Surface water monitoring locations **Figure 4-1**

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Data source: LPI: DTDB / Aerial Imagery, 2013, 2017. Centennial: Boundaries, 2013. Created by: fmackay, tmorton

- Swamps:
  - Narrow Swamp U/S.
  - Narrow Swamp D/S.
  - Tri Star Swamp.
  - Twin Gully Swamp.

Table 4-1 summarises the location, frequency and parameters of surface water quality monitoring for Angus Place Colliery.

Table 4-1 Surface water quality monitoring frequency and parameters

Location	Frequency	Parameters
Carpark culvert	Monthly	**Physicochemical:** pH, TSS. **Other:** oil and grease.
South Sediment Dam (Entrace Pond)	Weekly	**Physicochemical:** EC, pH, TSS, turbidity. **Other:** oil and grease.
South Sediment Dam (Entrance Pond) discharge point Bungleboori	Weekly when South Sediment Dam (Entrance Pond) discharging	**Physicochemical:** dissolved oxygen (DO), EC, pH, total dissolved solids (TDS), TSS, turbidity. **Major ions**: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate, total hardness. **Nutrients:** ammonia, nitrate, nitrite, nitrate + nitrite, total fluoride, total Kjeldahl nitrogen (TKN), total nitrogen, total phosphorus. **Dissolved metals:** aluminium, antimony, arsenic, barium, boron, cadmium, copper, iron, lead, lithium, manganese, molybdenum, nickel, rubidium, strontium, uranium, zinc. **Total metals:** aluminium, antimony, arsenic, barium, iron, lead, manganese, nickel, zinc. **Other:** chlorine (free and total), cyanide (total), oil and grease, phenols, silica, silicon, total organic carbon.
Coxs River Far U/S Coxs River U/S Long Swamp U/S Coxs River D/S Lambs Creek Long Swamp U/S Kangaroo Creek U/S (AP) Kangaroo Creek D/S (AP) KC/CR confluence Twin Gully Swamp Tri Star Swamp	Monthly	**Physicochemical:** DO, EC, pH, TDS, TSS, turbidity. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate, total hardness. **Nutrients:** ammonia, nitrate, nitrite, nitrate + nitrite, total fluoride, TKN, total nitrogen, total phosphorus. **Dissolved metals:** aluminium, antimony, arsenic, barium, boron, cadmium, copper, iron, lead, lithium, manganese, molybdenum, nickel, rubidium, strontium, uranium, zinc. **Total metals:** aluminium, antimony, arsenic, barium, iron, lead, manganese, nickel, zinc. **Other:** chlorine (free and total), cyanide (total), oil and grease, phenols, silica, silicon, total organic carbon.
Kangaroo Creek U/S (NP)	Fortnightly when flowing	**Physicochemical:** EC, pH, TSS.

Location	Frequency	Parameters
Kangaroo Creek D/S (NP) Narrow Swamp U/S Narrow Swamp D/S		Metals (dissolved and total): iron, manganese.
Wolgan River (Spanish Steps) Wolgan River (Wolgah Property)	Monthly	Physicochemical: DO, EC, pH, TDS, TSS, turbidity. Major ions: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate, total hardness. Nutrients: ammonia, nitrate, nitrite, nitrate + nitrite, TKN, total nitrogen, total phosphorus. Dissolved metals: aluminium, antimony, arsenic, barium, boron, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, strontium, uranium, zinc. Total metals: aluminium, arsenic, barium, boron, cadmium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, uranium, zinc. Other: anionic surfactants, chlorine (free and total), cyanide (total), oil and grease, phenols, silica, silicon, total organic carbon.
LDP003 D/S	Monthly when LDP003 is discharging	Physicochemical: DO, EC, pH, TDS, TSS, turbidity. Major ions: alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate, total hardness. Nutrients: ammonia, nitrate, nitrite, nitrate + nitrite, total fluoride, total Kjeldahl nitrogen, total nitrogen, total phosphorus. Dissolved metals: aluminium, antimony, arsenic, barium, boron, cadmium, copper, iron, lead, lithium, manganese, molybdenum, nickel, rubidium, strontium, uranium, zinc. Total metals: aluminium, antimony, arsenic, barium, iron, lead, manganese, nickel, zinc. Other: chlorine (free and total), cyanide (total), oil and grease, phenols, silica, silicon.

4.3.2 Surface water flow and depth

Surface water flow monitoring is undertaken at several watercourse and swamp locations. Monitoring of flow and depth is undertaken at Kangaroo Creek Swamp and Narrow Swamp at the following locations:

- KWH (Kangaroo Creek Waterhole) – a small pool downstream of a spring which feeds the lower part of the Kangaroo Creek Swamp.
- KCW1 (Kangaroo Creek Weir) – located 2 km downstream of the Kangaroo Creek Swamp.
- NSW1 (Narrow Swamp Weir 1) – located between the upper and lower sections of Narrow Swamp.
- NSW2 (Narrow Swamp Weir 2) – located downstream of Narrow Swamp at the far northern end.

- Star picket –waterhole north of West Wolgan Swamp.

The frequency of flow monitoring is presented in Table 4-2, with locations shown in Figure 4-1.

Table 4-2 Surface water flow monitoring frequency

Location	Frequency	Method
Coxs River U/S Coxs River D/S Kangaroo Creek U/S (AP) Kangaroo Creek D/S (AP) Twin Gully Swamp Wolgan River (Spanish Steps) Wolgan River (Wolgah Property)	Monthly	Hand-held flow meter in conjunction with surface water quality monitoring
Kangaroo Creek U/S (NP) Kangaroo Creek D/S (NP) Narrow Swamp U/S Narrow Swamp D/S	Fortnightly	Hand-held flow meter in conjunction with surface water quality monitoring
Star picket	Fortnightly	Depth measured manually
Tri Star Swamp	Continuous	In-line flow meter
KWH	Daily	Piezometer
KCW1		Weir
NSW1		
NSW2		

4.4 Discharge water monitoring

Table 4-3 outlines the discharge water quality monitoring requirements for each LDP at Angus Place Colliery, which fulfils the specifications of EPL 467.

Table 4-3 Discharge water quality monitoring frequency and parameters

Location	Frequency	Parameters
LDP002	Daily during discharge	**Physicochemical:** EC, pH, turbidity. Field monitoring only, no grab samples.
	Monthly during discharge	**Physicochemical:** EC, pH, turbidity, DO, TDS, TSS. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate, total hardness. **Nutrients:** ammonia, nitrate, nitrite, nitrate + nitrite, total fluoride, TKN, total nitrogen, total phosphorus.

		Dissolved metals: aluminium, antimony, arsenic, barium, boron, cadmium, copper, iron, lead, lithium, manganese, molybdenum, nickel, rubidium, strontium, uranium, zinc. **Total metals:** aluminium, arsenic, barium, iron, lead, manganese, nickel, zinc. **Other:** chlorine (free and total), oil and grease, phenols, silica, silicon, total cyanide, total organic carbon
	Quarterly during discharge	**Dissolved metals:** chromium, mercury. **Total metals:** boron, cadmium, cobalt, copper, mercury, selenium, silver, uranium. **Other:** anionic surfactants.
LDP003	Monthly during discharge	**Physicochemical:** DO, EC, pH, TDS, TSS, turbidity. **Major ions:** alkalinity (bicarbonate, carbonate, hydroxide, total), calcium, chloride, magnesium, potassium, sodium, sulfate, total hardness. **Nutrients:** ammonia, nitrate, nitrite, nitrate + nitrite, total fluoride, total Kjeldahl nitrogen, total nitrogen, total phosphorus. **Dissolved metals:** aluminium, antimony, arsenic, barium, boron, cadmium, copper, iron, lead, lithium, manganese, molybdenum, nickel, rubidium, strontium, uranium, zinc. **Total metals:** aluminium, arsenic, barium, iron, lead, manganese, nickel, zinc. **Other:** chlorine (free and total), cyanide (total), oil and grease, phenols, silica, silicon, total organic carbon.
	Quarterly during discharge	**Dissolved metals:** chromium, mercury. **Total metals:** antimony, boron, cadmium, chromium, cobalt, copper, mercury, selenium, sliver, uranium.

Continuous flow monitoring is undertaken at LDP002, LDP003 and LDP005. EPL 467 only requires volumetric monitoring at LDP005 which is to be weekly during discharge based on calculation (volume flow rate or pump capacity multiplied by operating time).

4.5 Potable and wastewater monitoring

In order to manage the risk associated with potable water use on site and to confirm the operation of the sewage treatment system that manages wastewater on site, the monitoring of both potable and wastewater systems are undertaken monthly. Monitoring requirements are summarised in Table 4-4.

Table 4-4 Potable and wastewater quality monitoring frequency and parameters

Location	Frequency	Parameters
Potable water	Monthly	**Microbiological:** *Escherichia coli*, faecal coliforms, heterotrophic plate count (HPC), total coliforms.
	Quarterly	**Physicochemical:** EC, pH, TSS. **Total metals:** iron, manganese, zinc.

		Other: oil and grease.
Sewage treatment system (Pond 4)	Monthly	**Physicochemical:** TSS. **Nutrients:** ammonia, nitrate + nitrite, total fluoride, TKN, total nitrogen, total phosphorus. **Total metals:** arsenic, boron, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, zinc. **Other:** BOD, phenols, volatile organic compounds.

4.6 Groundwater monitoring

4.6.1 Groundwater levels and quality

Current groundwater monitoring program

The groundwater monitoring program at Angus Place Colliery includes:

- One standpipe piezometer installed down-dip (north-east) from the 800 District to monitor any potential seepage.
- 14 standpipe piezometers installed in the elevated ridges between swamps that monitor shallow groundwater levels in the upper Banks Wall Sandstone aquifer.
- 18 standpipe piezometers monitoring water levels in the Newnes Plateau swamps.
- 15 vibrating wire piezometers (VWPs) monitoring the Narrabeen strata and the Permian Illawarra Coal Measures.
- Six monitoring locations within the Cox River including five standpipe piezometers and one VWP.

Groundwater monitoring locations are provided in Figure 4-2 and Figure 4-3., with details provided in Appendix D. Groundwater levels and piezometric pressure are recorded on a range of different frequencies with the majority saved to a data logger at each bore. Data loggers are downloaded every two months. Standpipe piezometers REN, RSE and RNW are manually monitored every two months.

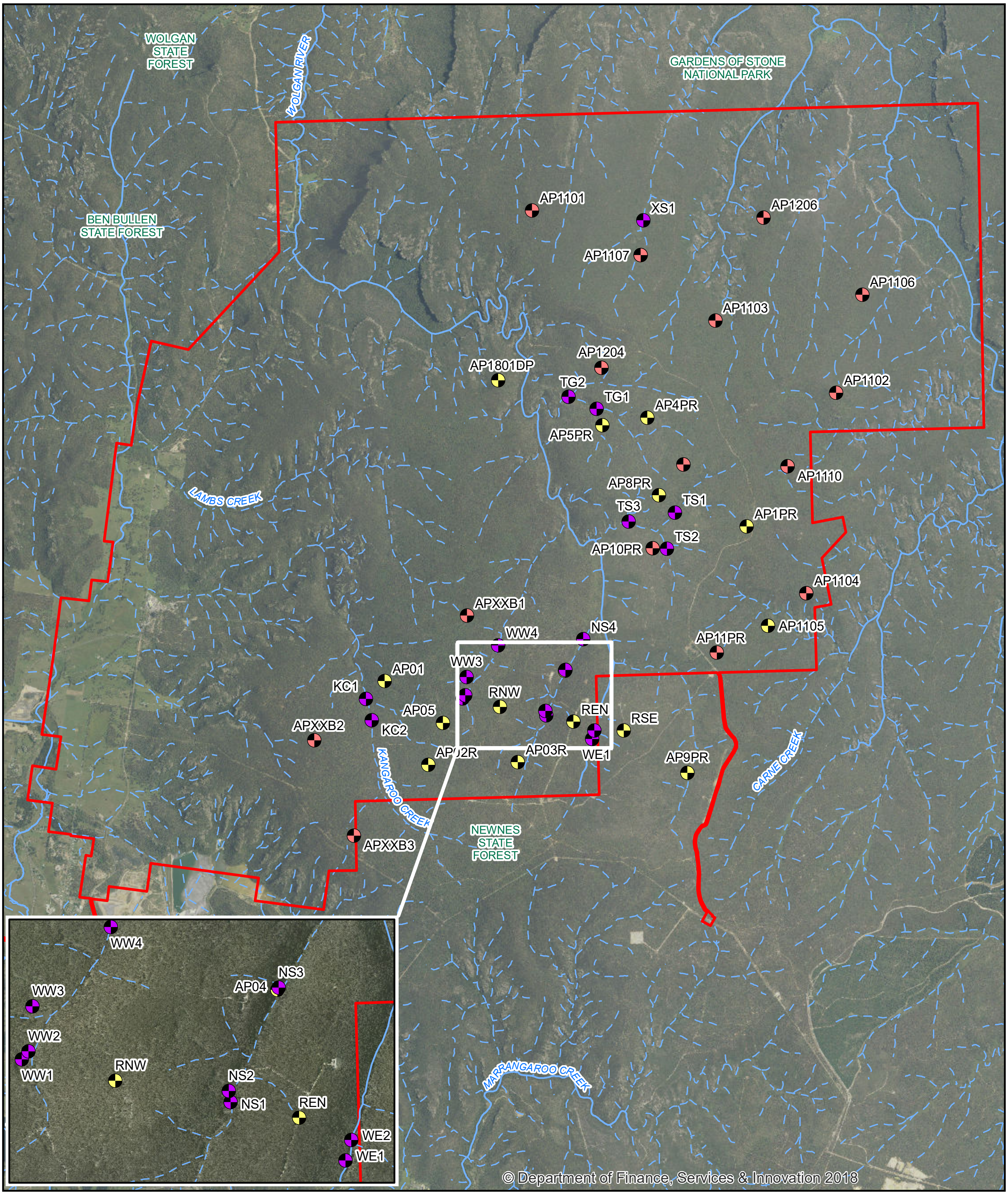
A number of groundwater monitoring locations were destroyed in the 2019/2020 Mt Gospers bushfire. These destroyed sites are outlined in Appendix D and are subject to an adequacy review and potential replacement program.

Table 4-5 summarises the location, frequency and parameters of groundwater quality monitoring for Angus Place Colliery.

Table 4-5 Groundwater quality monitoring frequency and parameters

Location	Frequency	Parameters
AP1801DP	Monthly	**Physicochemical:** EC, pH, TSS, turbidity. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. **Dissolved and total metals:** aluminium, arsenic, barium, boron, copper, iron, manganese, nickel, zinc. **Other:** anionic surfactants, oil and grease, silica.

Figure 4-2 Groundwater monitoring locations



LEGEND

- Standpipe
- Swamp
- VWP
- Angus Place Holding Boundary
- Watercourse - Perennial
- Watercourse - Non Perennial

Paper Size A4

0 0.55 1.1 1.65 2.2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Angus Place Colliery
Water Management Plan

Job Number	22-19614
Revision	1
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Groundwater monitoring locations **Figure 4-2**

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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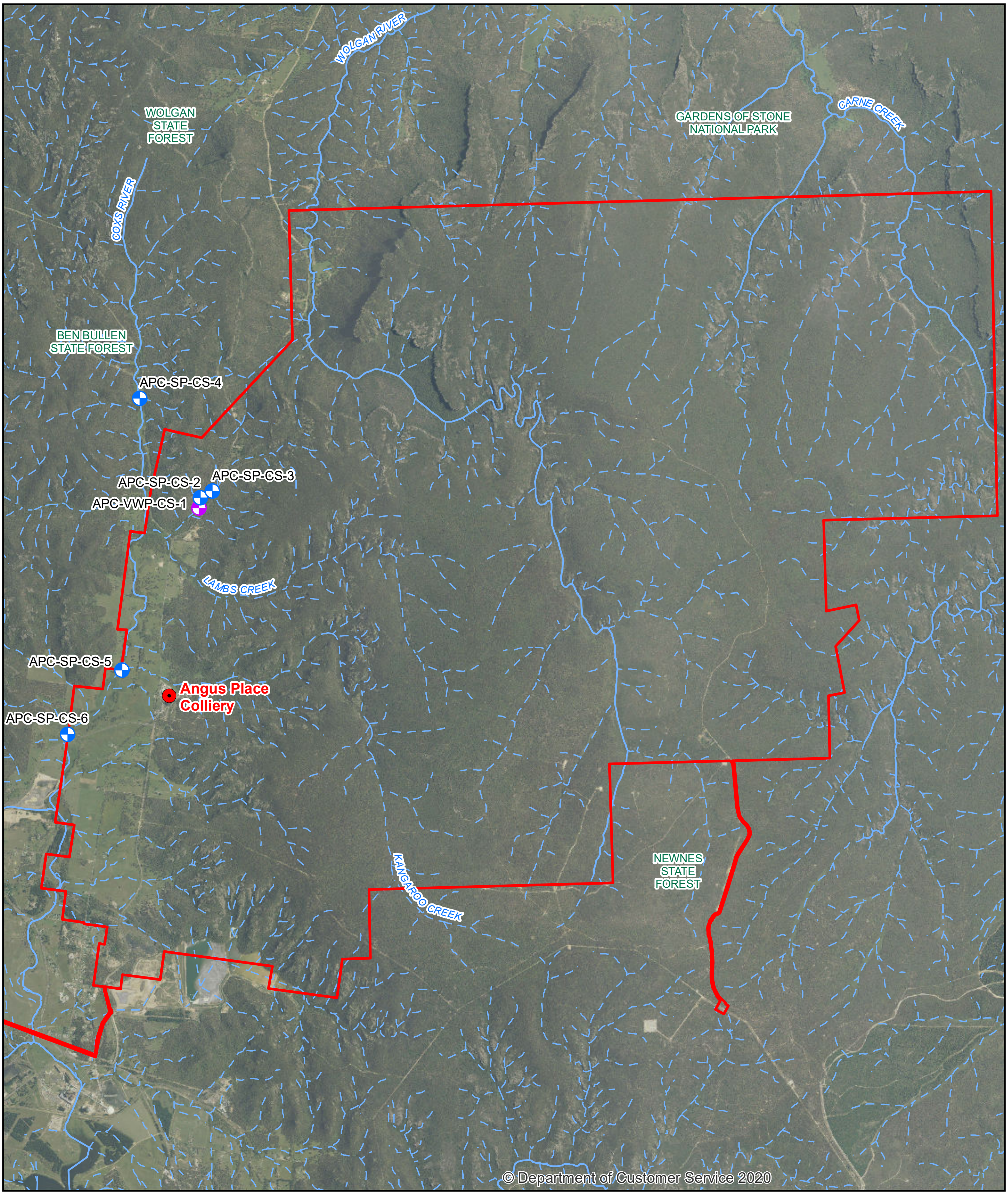
Figure 4-3 Coxs River groundwater monitoring locations



LEGEND

- Angus Place Colliery
- Angus Place Holding Boundary
- Watercourse - Perennial
- Watercourse - Non Perennial

Swamp Monitoring Locations

- Multi-level groundwater monitoring site
- Shallow groundwater monitoring site

Paper Size A4

0 0.55 1.1 1.65 2.2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Angus Place Colliery
Water Management Plan

Future groundwater monitoring locations

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Figure 4-3

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB / Aerial Imagery, 2013, 2017. Centennial: Boundaries, 2013. Created by: fmackay, tmorton

4.6.2

4.6.2 Underground water transfers

Daily monitoring of the transfer of water from the underground workings to the surface is undertaken using in-line flow meters, recorded within the Angus Place CITECT system. The data captured will be utilised for accounting operational water management requirements such that all relevant approvals and licences are compiled with. .

Table 4-6 summarises the water quality monitoring that is undertaken on groundwater dewatered by the 940 Bore transferred to the SDWTS as well as water sampled in the 800 District (monitoring point 800D Goaf).

Table 4-6 Underground water monitoring frequency and parameters

Location	Frequency	Parameters
940 Bore	Weekly	**Physicochemical:** EC, pH, TSS, turbidity. **Nutrients:** ammonia, total fluoride. **Dissolved metals:** aluminium, arsenic, boron, copper, iron, manganese, nickel, zinc. **Other:** oil and grease.
	Monthly	**Physicochemical:** DO, TDS. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate, total hardness. **Nutrients:** nitrate, nitrite, nitrate + nitrite, TKN, total nitrogen, total phosphorus. **Dissolved metals:** antimony, barium, cadmium, lead, lithium, molybdenum, rubidium, strontium, uranium. **Total metals:** aluminium, antimony, arsenic, barium, iron, lead, manganese, nickel, zinc. **Other:** chlorine (free and total), cyanide (total), phenols, silica, silicon, total organic carbon.
	Quarterly	**Dissolved metals:** chromium, mercury. **Total metals:** boron, cadmium, cobalt, copper, mercury, selenium, silver, uranium. **Other:** anionic surfactants.
800D Goaf	Monthly	**Physicochemical:** EC, pH, TDS, TSS, turbidity. **Major ions:** alkalinity, calcium, chloride, magnesium, potassium, sodium, sulfate. **Dissolved and total metals:** aluminium, arsenic, barium, boron, copper, iron, manganese, nickel, zinc. **Other:** anionic surfactants, oil and grease, silica, silicon.

4.7 Stream health monitoring

4.7.1 Geomorphic condition and watercourse stability

Visual monitoring of watercourses is carried out by suitably qualified professionals to identify any instabilities that may form as a result of discharges. As active mining is not currently being undertaken while Angus Place Colliery is in care and maintenance, there is no identified risk to watercourses located directly above mine workings.

Watercourse stability monitoring is undertaken on the Coxs River downstream of discharges from LDP002, as shown in Figure 4-4. Monitoring is undertaken biannually in spring and autumn in conjunction with the aquatic ecology monitoring program.

When mining operations recommence at Angus Place Colliery, stability monitoring will also be reinstated for watercourses in areas where subsidence survey monitoring indicates greater than predicted subsidence. Inspections will identify if any of the following potential subsidence impacts occur within the creek lines or immediate catchment flow paths:

- Change in stream bed or bank conditions.
- Incision or head cut development.
- Surface cracking.
- Ponding (particularly 'out of channel' ponding).
- Step changes in bed profile.
- Any notable/indicative changes in stream vegetation.

4.7.2 Aquatic ecology

Centennial has a comprehensive aquatic ecology monitoring program within the upper Coxs River catchment. Aquatic ecology monitoring occurs biannually in autumn and spring at the following monitoring locations, including shared monitoring locations with Springvale Mine) as shown in Figure 4-5:

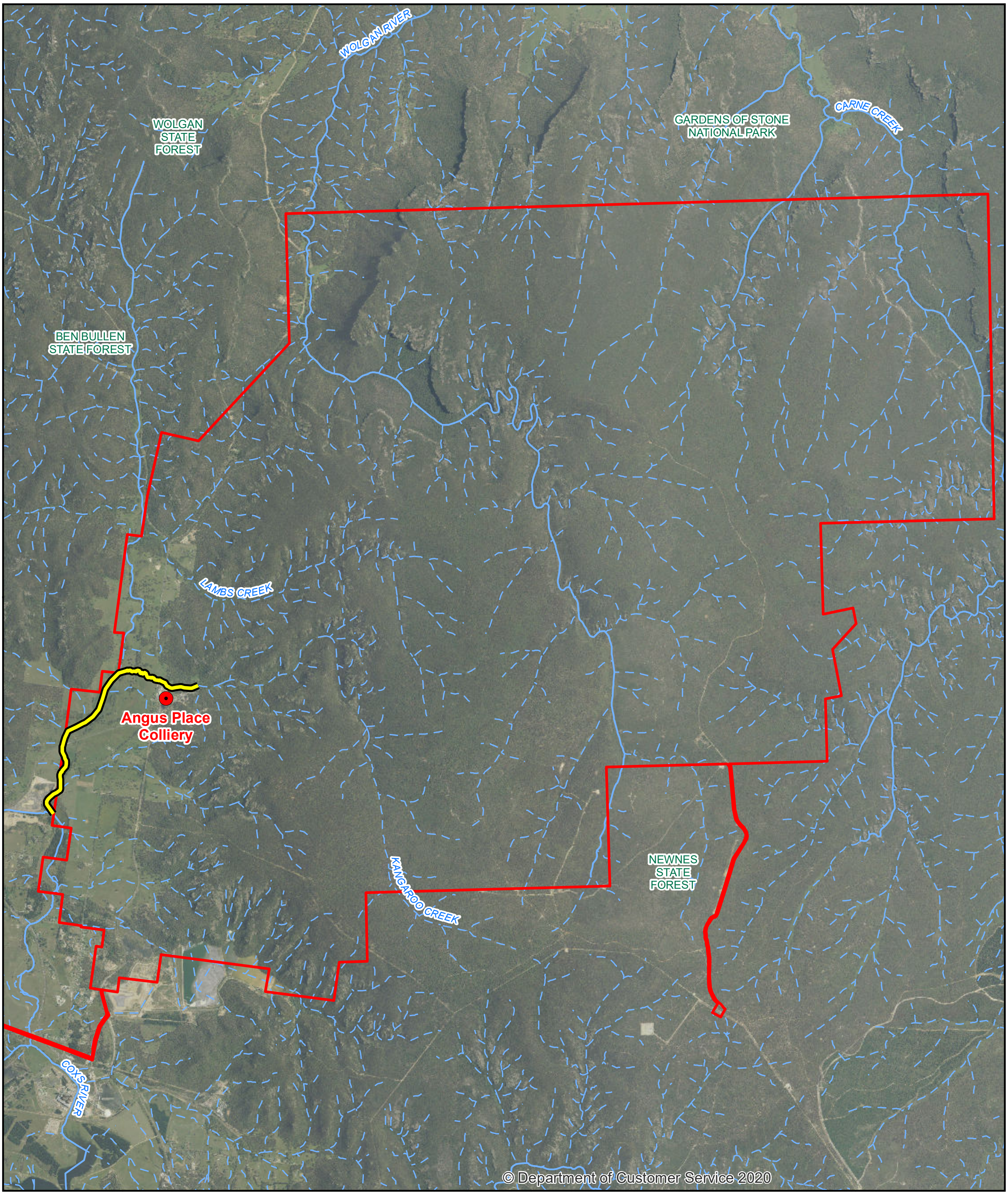
- Coxs River:
  - CR0 – located 3 km upstream of confluence with Kangaroo Creek.
  - CR1 – located 1 km upstream of confluence with Kangaroo Creek.
  - CR2 – located at the Mount Piper Haul Road crossing, approximately 1 km downstream of confluence with Kangaroo Creek.
  - CR3 – located downstream of Wangcol Creek and upstream of Sawyers Swamp Creek confluences.
  - CR4 – located at the Maddox Lane road crossing downstream of discharges from Angus Place Colliery, Springvale Mine and Western Coal Services.
  - CR5 – located at the Main Street road crossing downstream of discharges from Angus Place Colliery, Lidsdale Siding, Springvale Mine and Western Coal Services.
  - CR6 – located downstream of Lake Wallace, on the downstream side of Rocky Waterhole Drive.
  - CR7 – located in Marrangaroo National Park 300 m upstream of the Sugarmans Road Crossing.

The aquatic ecology monitoring methodology includes:

- Sampling, sorting and identification of macroinvertebrates, associated with pool edge habitat in accordance with the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak et al. 2004).
- Assessment of the condition of the aquatic habitat using modified NSW AUSRIVAS field sheets, including a modified Riparian, Channel and Environmental (RCE) inventory field sheet (Peterson 1992).
- Measurement of DO, EC, pH, temperature and turbidity just below the surface of the water column and at depth where sufficient water is available.
- Collection of surface water and sediment grab samples for water and sediment quality analysis.

Further detail of the aquatic ecology monitoring methodology and regional sampling extent is provided in the Upper Coxs River Catchment Aquatic Ecology Monitoring Program (GHD 2016c).

Figure 4-4 Watercourse stability monitoring



LEGEND

- Angus Place Colliery
- Angus Place Holding Boundary
- Watercourse stability monitoring
- Watercourse - Perennial
- Watercourse - Non Perennial

Paper Size A4

0 0.55 1.1 1.65 2.2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Angus Place Colliery
Water Management Plan

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Watercourse stability monitoring **Figure 4-4**

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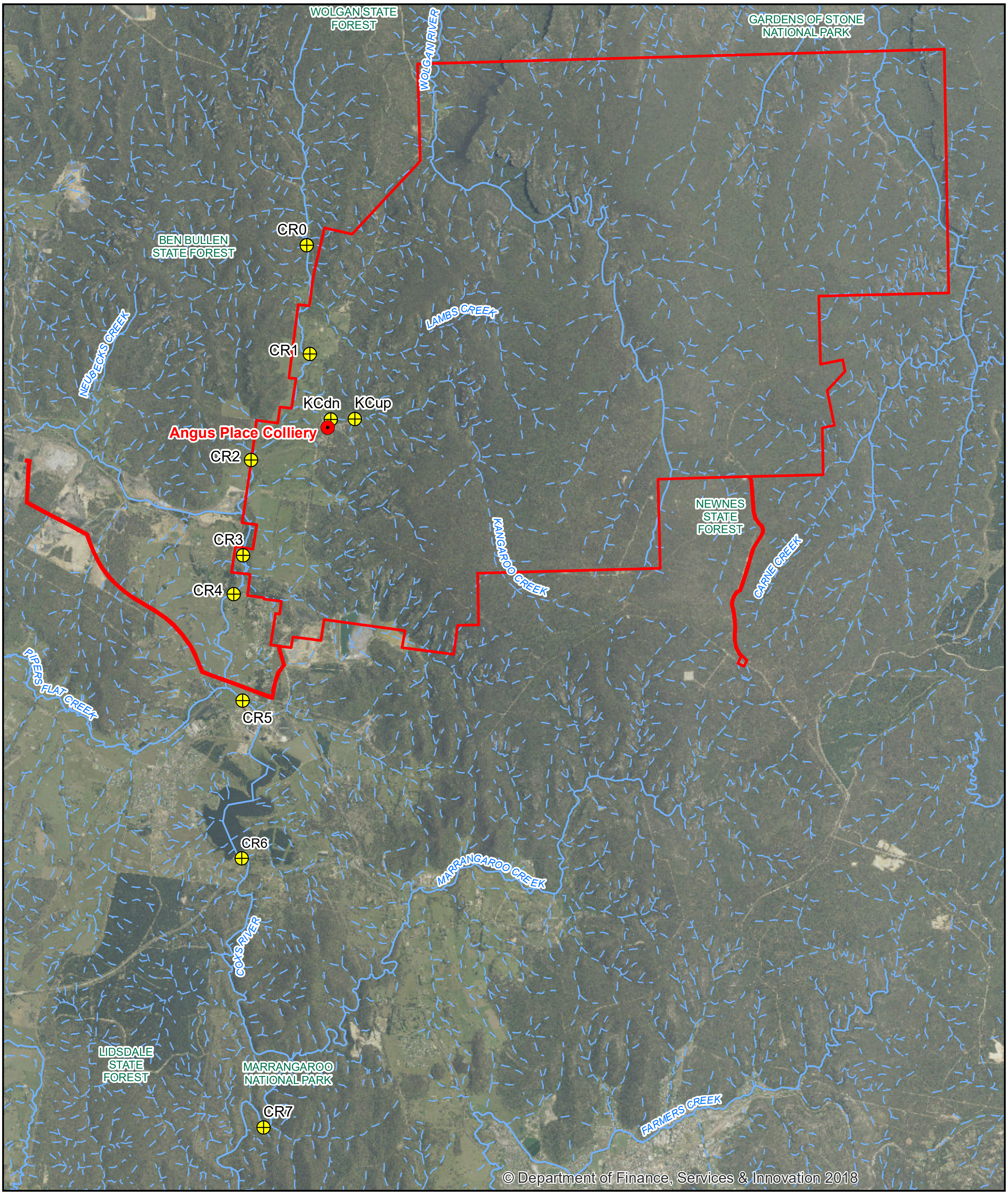
Data source: LPI: DTDB / Aerial Imagery, 2013, 2017. Centennial: Boundaries, 2013. Created by: fmackay, tmorton

Figure 4-5 Aquatic ecology monitoring locations



LEGEND

- Angus Place Colliery
- Aquatic ecology monitoring
- Angus Place Holding Boundary
- Watercourse - Perennial
- Watercourse - Non Perennial

Paper Size A4

0 0.75 1.5 2.25 3

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Angus Place Colliery
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Aquatic ecology monitoring locations

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Figure 4-5

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Data source: LPI: DTDB / Aerial Imagery, 2013, 2017. Centennial: Boundaries, 2013. Created by: fmackay, tmorton

5. Baseline data

5.1 Longwall extraction

Table 5-1 presents the longwall extraction start and finish dates for Angus Place Colliery. The mine workings are presented in Figure 5-1.

Table 5-1 Longwall extraction dates

Longwall	Start date	Finish date	Longwall	Start date	Finish date
1	31/08/1979	25/05/1980	20	25/04/1995	07/05/1996
2	26/08/1980	08/12/1980	21	17/06/1996	17/10/1997
3	16/02/1981	06/07/1981	22	02/12/1997	11/12/1998
4	11/08/1981	13/11/1981	23	04/01/1999	26/11/1999
5	16/2/1982	15/06/1982	24	20/12/1999	29/12/2000
6	13/07/1982	18/11/1982	25	21/02/2001	19/12/2001
7	17/01/1983	01/08/1983	26	14/02/2002	11/12/2002
8	10/08/1983	14/12/1984	26N	20/02/2003	30/09/2003
9	28/03/1985	08/07/1986	(27) 920	02/03/2004	18/10/2005
10	18/08/1986	27/08/1987	930	19/12/2005	11/02/2007
11	10/11/1987	24/10/1988	940	27/03/2007	23/06/2008
12	08/12/1988	02/09/1989	950	08/08/2008	15/02/2010
13	28/09/1989	25/06/1990	960	07/04/2010	05/07/2011
16	24/10/1990	09/09/1991	970	24/08/2011	08/10/2012
17	04/11/1991	28/10/1992	980	29/11/2012	11/03/2014
18	04/01/1993	13/12/1993	900W	30/04/2014	15/02/2015
19	19/03/1994	05/03/1995			

5.2 Surface water monitoring

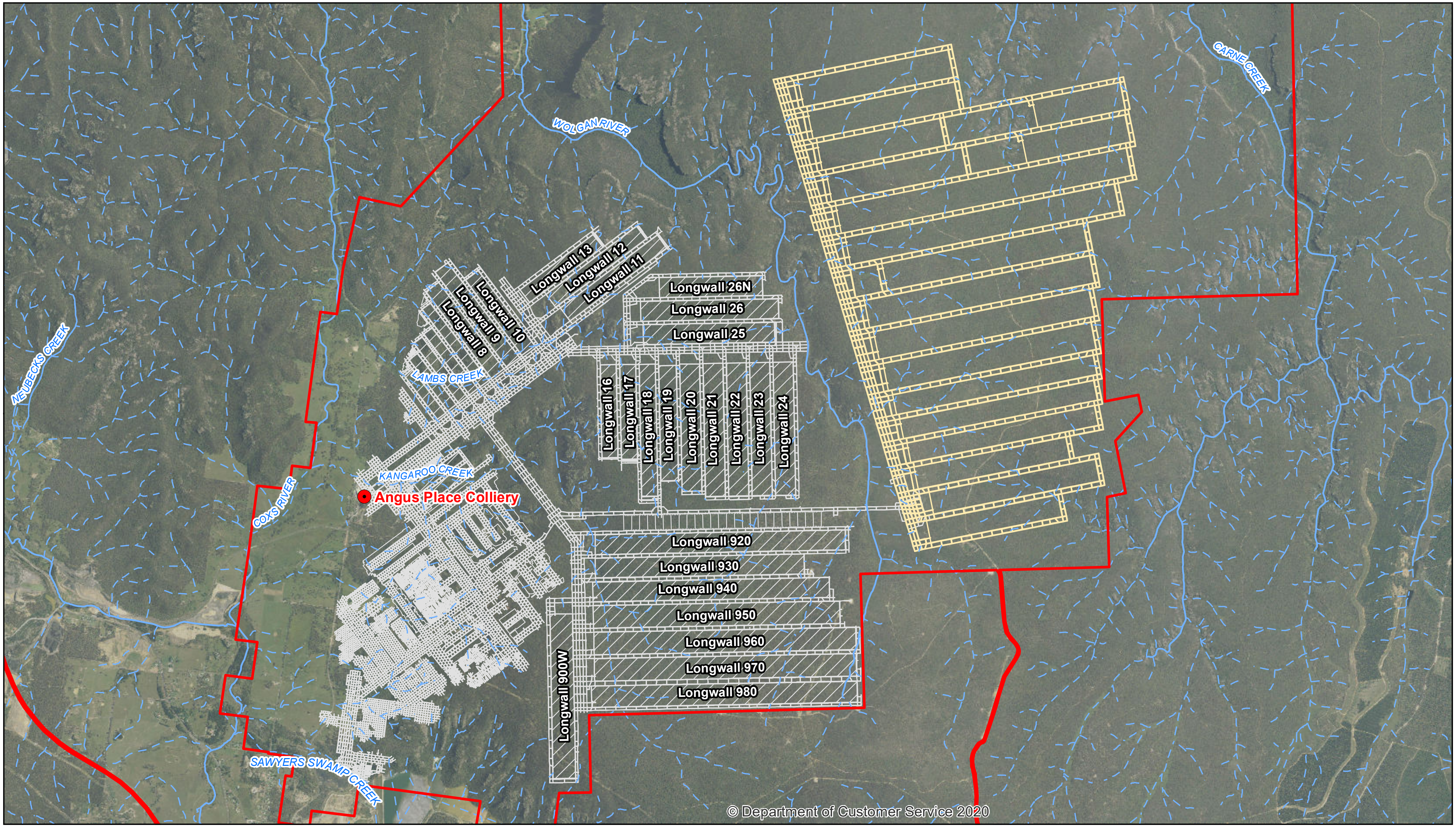
5.2.1 Surface water quality

Appendix E presents the baseline surface water quality data for selected parameters monitored at operational surface sites, watercourses upstream and downstream of operations and swamps. Table 5-2 presents the extent of baseline data considered.

Where the analytical result was below the limit of reporting (LOR) for a particular parameter, then the detection limit was included in the calculation.

Monitoring of Long Swamp U/S is expected to commence in early 2019.

Figure 5-1 Mine workings



Paper Size A4

0 0.5 1 1.5 2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Angus Place Colliery
- Angus Place Holding Boundary
- Existing Mine Workings
- Proposed Mine Workings
- Longwalls
- Watercourse - Perennial
- Watercourse - Non Perennial

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Angus Place Colliery
Water Management Plan

Job Number	22-19614
Revision	1
Date	21 Jun 2021

Mine workings

Figure 5-1

G:\22\01050011\GIS\Maps\Deliverables\Western\AngusPlace\2219614\2219614_WMP014_MineWorkings_1.mxd

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Data source: LPI:DTDB / Imagery, 2012 / 2015. Centennial: Boundaries, workings, 2013. Created by: smacdonald, fmackay, tmorton

Table 5-2 Details of baseline surface water quality data

Location	Period from	Period to	Number of points
Pit top			
Carpark culvert	16/01/2013	18/12/2018	68–72
South Sediment Dam (Entrance Dam)	14/04/2014	24/12/2018	232–244
South Sediment Dam (Entrance Dam) discharge	18/08/2014	24/12/2018	20–26
Watercourses			
Coxs River Far U/S	16/01/2013	18/12/2018	69–672
Coxs River U/S	16/01/2013	18/12/2018	63–67
Lambs Creek	16/01/2013	18/12/2018	66–69
Kangaroo Creek U/S (AP)	16/01/2013	18/12/2018	67–71
Kangaroo Creek U/S (NP)	17/01/2013	28/12/2018	8–9
Kangaroo Creek D/S (NP)	17/01/2013	28/12/2018	105–112
Bungleboori	18/08/2014	24/12/2018	4–5
Kangaroo Creek D/S (AP)	16/01/2013	18/12/2018	69–72
KC/CR confluence	16/01/2013	18/12/2018	62–71
Coxs River D/S	16/01/2013	18/12/2018	78-83
Wolgan River (Spanish Steps)	15/05/2018	10/12/2018	7–8
Wolgan River (Wolgah Property)	01/05/2018	10/12/2018	8–9
LDP003 D/S	16/01/2013	29/11/2018	15–21
Swamps			
Narrow Swamp U/S	17/01/2013	28/12/2018	7–8
Narrow Swamp D/S	17/01/2013	28/12/2018	9–10
Tri Star Swamp	23/01/2013	12/12/2018	68–72
Twin Gully Swamp	23/01/2013	12/12/2018	60–70

5.2.2 Surface water flow

Appendix E presents the baseline surface water flow and depth monitoring data observed in the Coxs River, Kangaroo Creek, Wolgan River and swamps. Table 5-3 presents the extent of baseline data considered.

No flows have been recorded at the Narrow Swamp U/S and Narrow Swamp D/S monitoring sites between January 2013 and December 2018 and so no data is presented in Appendix E.

Table 5-3 Details of baseline surface water flow and depth data

Location	Period from	Period to	Number of points
Watercourses			
Coxs River U/S	16/01/2013	18/12/2018	36
Coxs River D/S	16/01/2013	18/12/2018	35
Kangaroo Creek U/S (AP)	16/01/2013	18/12/2018	37
Kangaroo Creek D/S (AP)	16/01/2013	18/12/2018	64
Kangaroo Creek U/S (NP)	17/01/2013	28/12/2018	1
Kangaroo Creek D/S (NP)	17/01/2013	28/12/2018	70
Wolgan River (Spanish Steps)	15/05/2018	10/12/2018	8
Wolgan River (Wolgah Property)	01/05/2018	10/12/2018	7
Swamps			
Narrow Swamp U/S (NP)	17/01/2013	28/12/2018	0
Narrow Swamp D/S (NP)	17/01/2013	28/12/2018	0
Star Picket	17/01/2013	28/12/2018	41
Twin Gully Swamp	23/01/2013	12/12/2018	52
Tri Star Swamp	08/02/2013	31/12/2018	1835
KWH	06/11/2008	31/12/2018	3704
KCW1	06/11/2008	31/12/2018	3583
NSW1	28/05/2008	31/12/2018	3354
NSW2	28/05/2008	31/12/2018	3659

5.3 Discharge water monitoring

5.3.1 LDP002

Historical daily discharge volumes from LDP002 are shown in Figure 5-2 from September 2010 to December 2018.

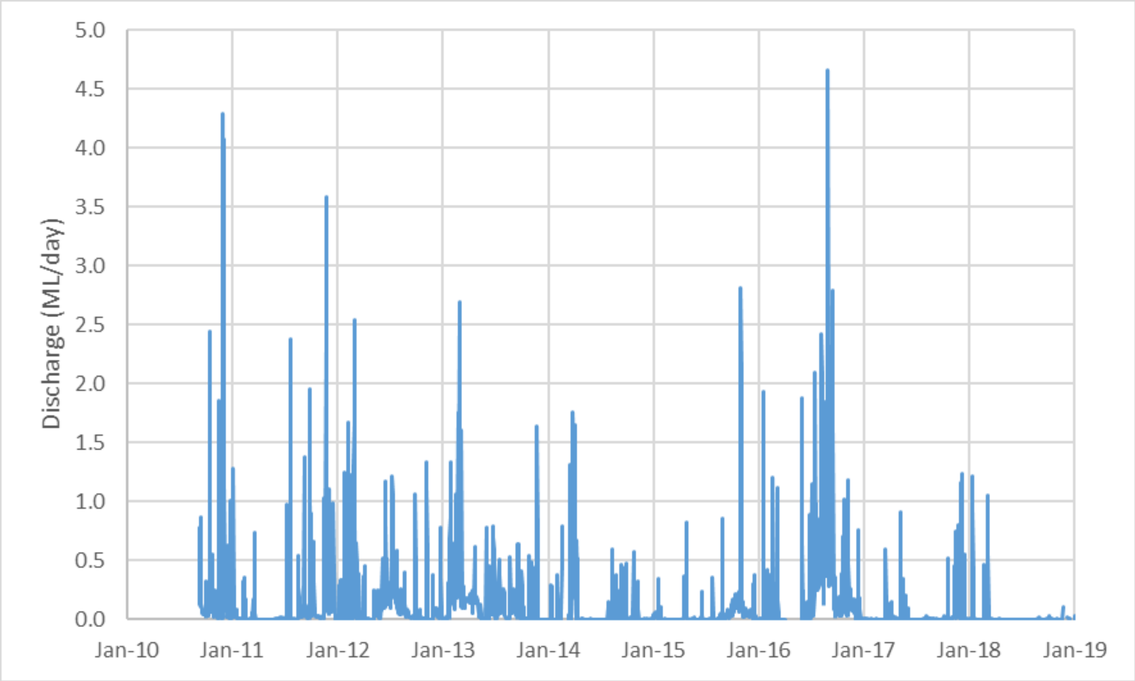

Figure 5-2 Recorded LDP002 discharge volume

Historical daily EC, pH and turbidity monitored at LDP002 from September 2010 to December 2018 are presented in Figure 5-3, Figure 5-4 and Figure 5-5 respectively. Note that the EC, pH and turbidity are monitored by an online meter within a concrete pit and are recorded regardless of whether water is discharging through the LDP.

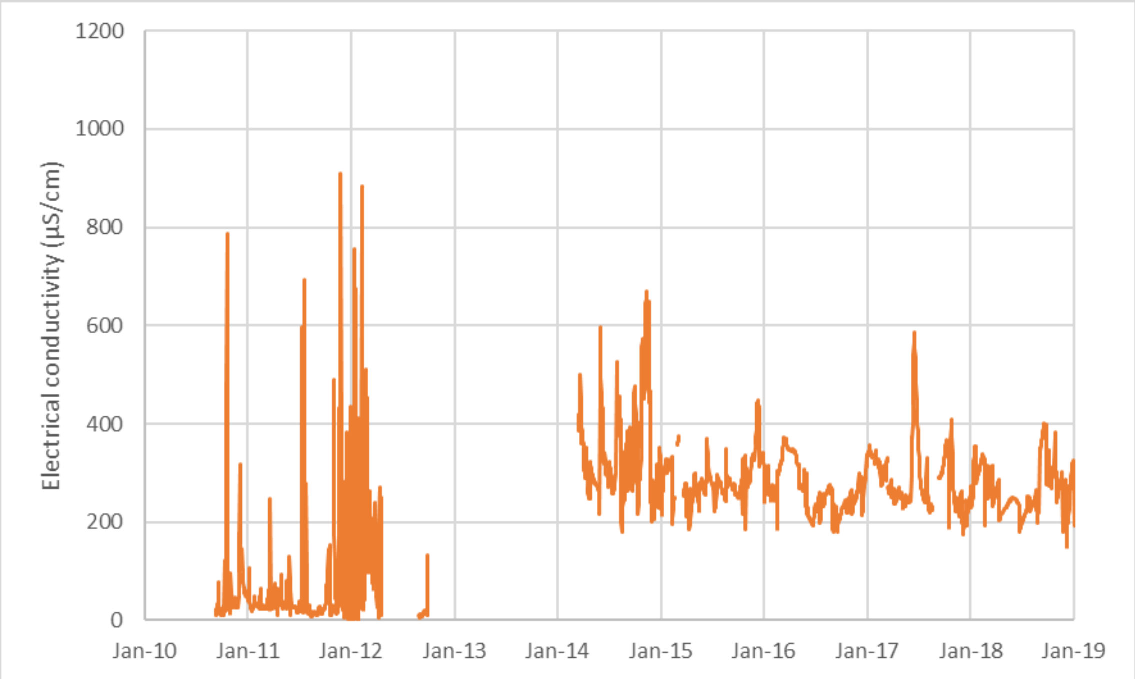

Figure 5-3 Recorded LDP002 discharge electrical conductivity

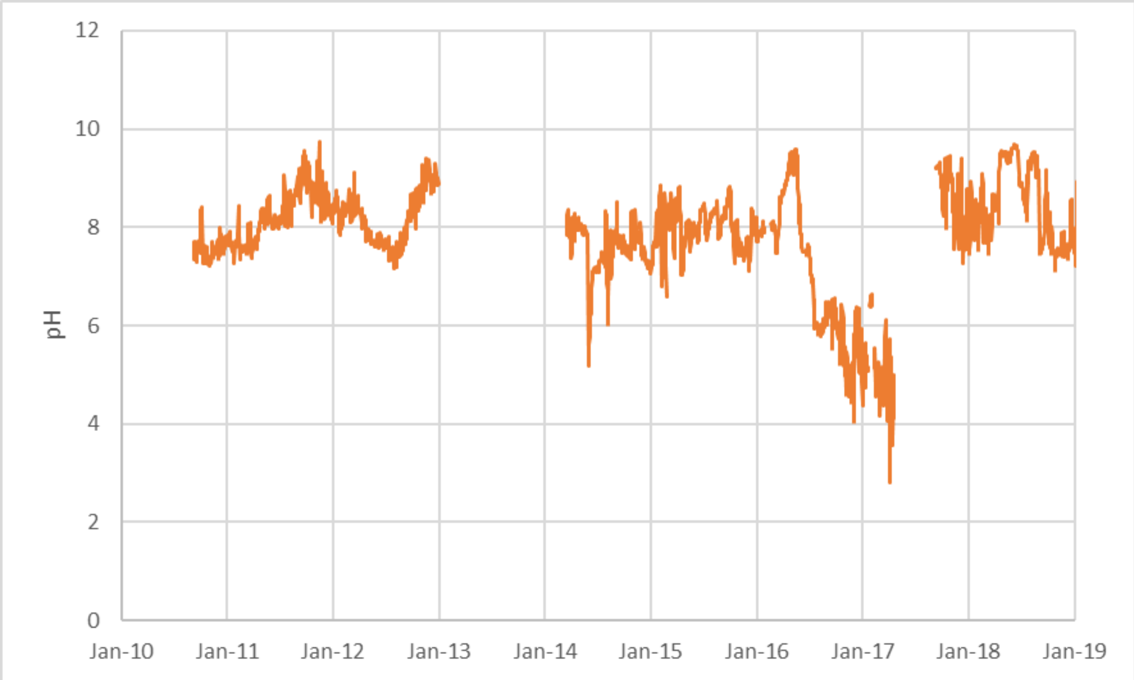

Figure 5-4 Recorded LDP002 discharge pH

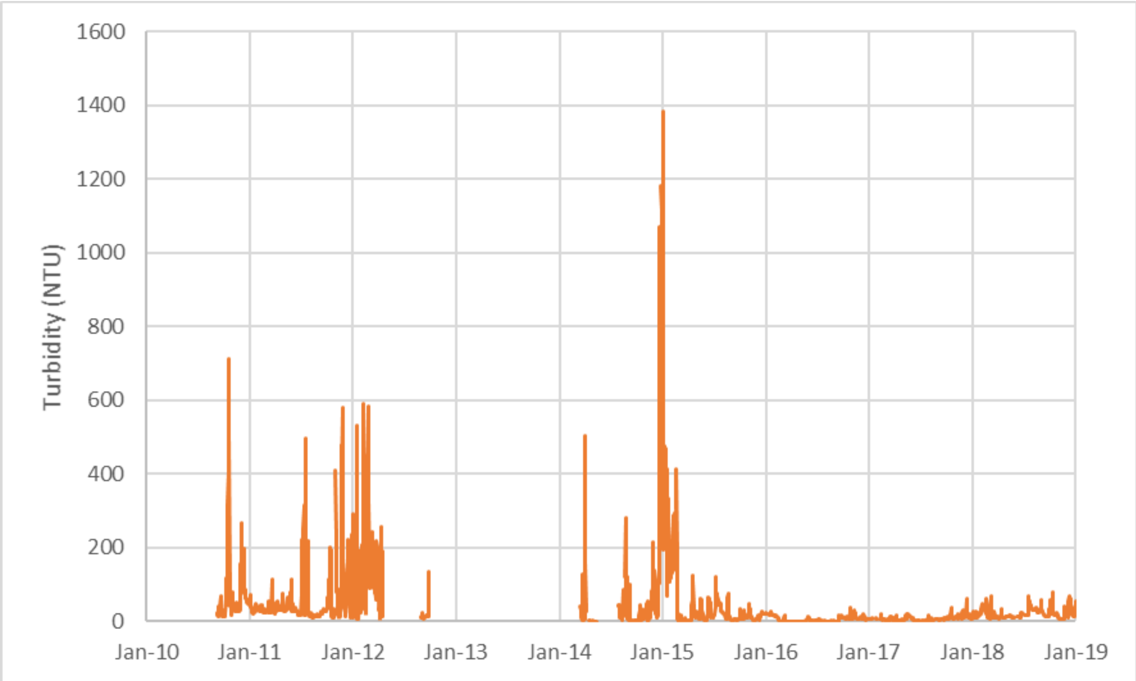

Figure 5-5 Recorded LDP002 discharge turbidity

5.3.2 LDP003

Historical daily discharge volumes from LDP003 are shown in Figure 5-6 from July 2010 to December 2018.

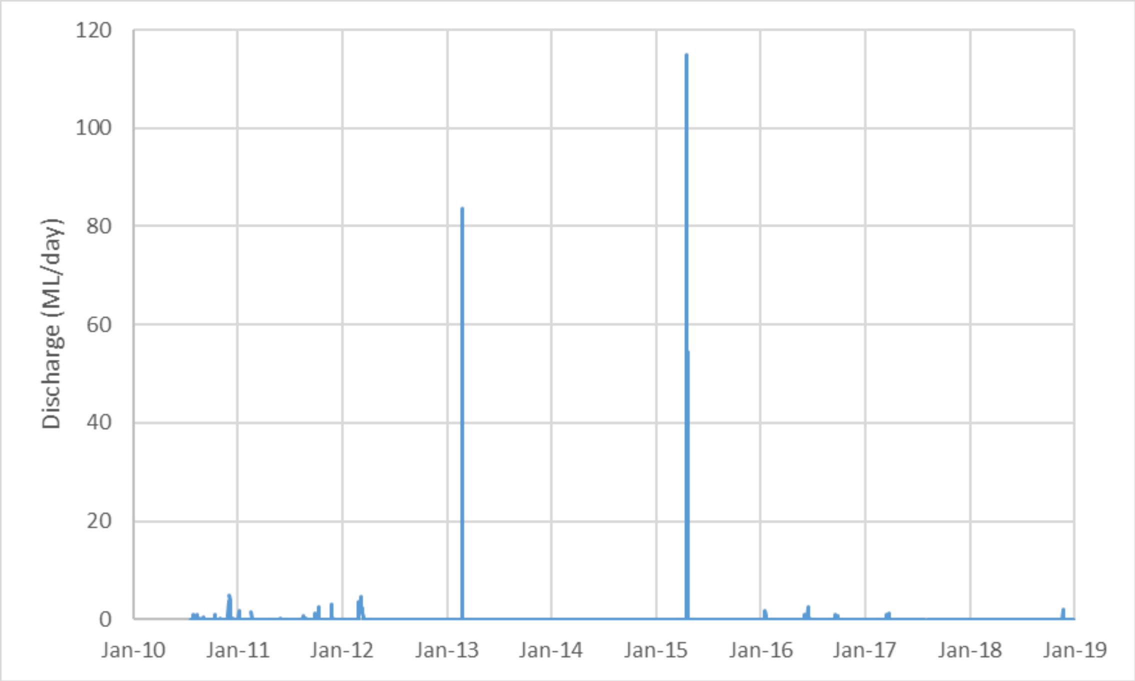

Figure 5-6 Recorded LDP003 discharge volume

Historical daily EC and pH monitored at LDP003 from September 2018 to December 2018 are presented in Figure 5-7, Figure 5-8 respectively. Turbidity monitored at LDP003 from July 2010 to December 2018 is presented in Figure 5-9. Note that the EC, pH and turbidity are monitored by an online meter within a concrete pit and are recorded regardless of whether water is discharging through the LDP.

Figure 5-7 Recorded LDP003 discharge electrical conductivity

Figure 5-8 Recorded LDP003 discharge pH

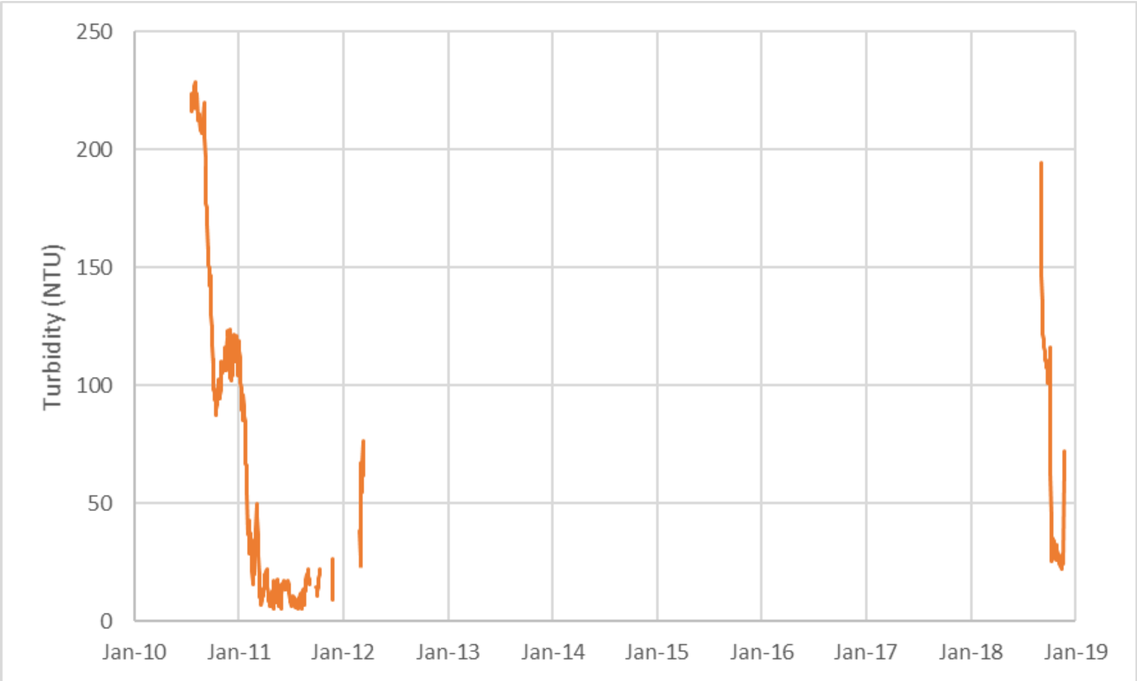

Figure 5-9 Recorded LDP003 discharge turbidity

5.3.3 LDP005

Historical daily discharge volumes from LDP005 are shown in Figure 5-10 from December 2011 to December 2018.

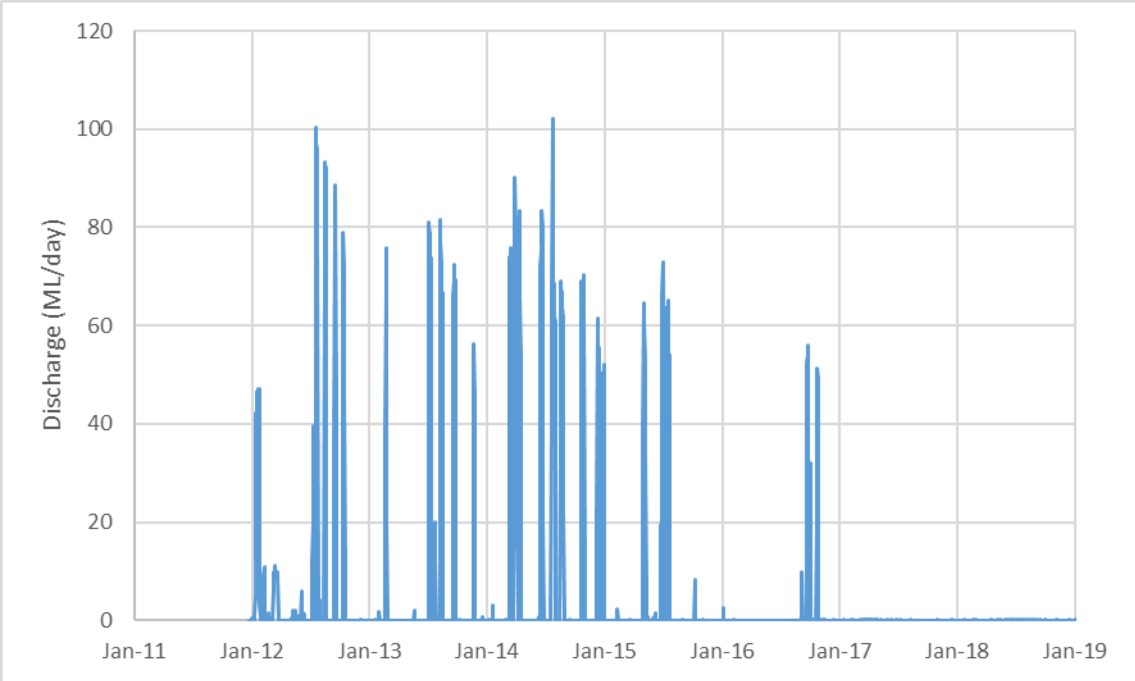

Figure 5-10 Recorded LDP005 discharge volume

5.3.4 Additional water quality monitoring

Water quality results for monthly and quarterly monitoring of LDP002 and LDP003 discharges are presented in Appendix F. Table 5-4 presents the extent of baseline data considered. Where the analytical result was below the LOR for a particular parameter, then the detection limit was included in the calculation.

Table 5-4 Details of baseline LDP002 and LDP003 monitoring data

Location	Period from	Period to	Number of points
LDP002	16/01/2013	18/12/2018	14–99
LDP003	16/01/2013	20/12/2018	13–83

5.4 Potable and wastewater monitoring

Appendix G presents the baseline data for the potable and wastewater monitoring. Table 5-5 presents the extent of baseline data considered. Where the analytical result was below the LOR for a particular parameter, then the detection limit was included in the calculation.

Table 5-5 Details of baseline potable and wastewater monitoring

Location	Period from	Period to	Number of points
Potable water	16/01/2013	18/12/2018	19–84
STP	16/01/2013	18/12/2018	35–62

5.5 Groundwater monitoring

5.5.1 Groundwater levels and quality

Appendix D presents the baseline groundwater level data for standpipe piezometers, swamp piezometers and VWPs.

5.5.2 Underground water transfers

Appendix D presents the baseline groundwater quality data for the 940 Bore and raw mine water transferred to the SDWTS. Table 5-6 presents the extent of baseline data for groundwater quality considered. Where the analytical result was below the LOR for a particular parameter, then the detection limit was used in the calculation.

Table 5-6 Details of baseline underground water quality data

Location	Period from	Period to	Number of points
Raw 940 Bore	23/12/2014	24/12/2018	13–188
940 Bore	23/01/2013	24/12/2018	14–309
800D Goaf	21/06/2018	24/12/2018	13–25

5.6 Stream health monitoring

5.6.1 Geomorphic condition and watercourse stability

Assessment of the geomorphology of the upper Coxs River has been undertaken in July 2017 (GHD 2017b) and November 2018 (GHD 2018c). This monitoring found the Coxs River in reaches directly upstream and downstream of the confluence with Kangaroo Creek to be in poor geomorphic condition. Upstream of the Kangaroo Creek confluence, the reach has been heavily impacted by agricultural land use, with diversions of the river channel evident, the likely historical motives for which being property management and stock watering. As a result of these diversions, there is a dual head cut which is migrating into the valley-fill swamp to the north.

Downstream of the Kangaroo Creek confluence, the Coxs River returns to a valley-fill river system, though there is a main incised channel on the eastern edge of the swamp to the north of the Angus Place to Mount Piper Haul Road. South of the haul road, the Commonwealth Mine open cut void forms part of the river channel. Historical mining has had an extensive impact on the river, as evidenced by the banks being almost completely comprised of overburden fill in this area.

The geomorphic condition of reaches of Kangaroo Creek and the Coxs River were monitored in November 2018 (GHD 2018c) where there was no evidence to indicate that discharges from the former LDP001 were influencing the geomorphic condition of the Coxs River. In December 2019, discharges from the former LDP001 ceased with no condition monitoring undertaken in 2020.

5.6.2 Aquatic ecology

Aquatic ecology monitoring at Angus Place Colliery has been undertaken within Coxs River and Kangaroo Creek biannually (autumn and spring) since 2010.

Monitoring of Coxs River and Kangaroo Creek in 2017 by GHD (2018c) indicated the following:

- Aquatic habitat condition in the Coxs River (as indicated by RCE scores) was best at downstream recovery site CR7, and poorest at CR2. In Kangaroo Creek, KCup received a higher RCE score than KCdn.
- EC in Coxs River in spring 2017 was lowest at CR0 (125 µS/cm) and highest at CR3 (1719 µS/cm). The EC observed at CR2 was seven times that of CR1 in autumn 2017 (no water quality data was collected at CR1 in spring 2017), indicating the impact of water contributed to the catchment by Kangaroo Creek. In Kangaroo Creek, the EC observed at KCup indicated low salinity (88 µS/cm), whereas KCdn had a higher salinity (1023 µS/cm).

- In the Coxs River, site CR2 had the highest taxa richness in spring 2017, with 31 and 32 macroinvertebrate families collected in replicate samples. The lowest taxa richness in the Coxs River was observed at CR0, where replicate samples contained 15 and 17 macroinvertebrate taxa. Taxa richness was below the long-term CR0/CR1 median at CR0, CR1 and CR6 in spring 2017. Taxa richness at KCdn was slightly higher than that observed in samples from KCup.
- The highest SIGNAL-2 (Chessman 2003) score observed in the Coxs River was at CR7, while the lowest was observed at CR0. At Kangaroo Creek sites, SIGNAL-2 scores were slightly lower at KCup, though more variation was observed between replicate samples than between sites. SIGNAL-2 results were below the KCup long-term median in all samples collected in spring 2017 with the exception of one replicate sample collected at KCdn.

6. Response plans

6.1 Triggers

6.1.1 Surface water quality triggers

Water quality monitored at the downstream sites KC/CR confluence and Coxs River D/S are assessed against site-specific guideline values (SSGVs), as shown in Table 6-1. SSGVs are based on a review of ANZECC (2000) default guideline values (DGVs) and water quality observed at an upstream reference site. Appendix E provides further detail on the methodology used to derive SSGVs.

Table 6-1 Site-specific guideline values for the assessment of watercourse quality

Parameter	Units	SSGV
Physicochemical		
EC	µS/cm	350
pH	pH units	6.3–8.0
TSS	mg/L	25
Turbidity	NTU	72
Nutrients		
Ammonia	mg/L	0.08
Total nitrogen	mg/L	2.44
Total phosphorus	mg/L	0.02
Dissolved metals		
Aluminium	mg/L	0.06
Antimony	mg/L	0.001
Arsenic	mg/L	0.024
Barium	mg/L	0.074
Boron	mg/L	0.37
Cadmium	mg/L	0.0002
Copper	mg/L	0.0014
Iron	mg/L	11.5
Lead	mg/L	0.0034
Lithium	mg/L	0.001
Manganese	mg/L	1.99
Mercury	mg/L	0.00006

Parameter	Units	SSGV
Molybdenum	mg/L	0.001
Nickel	mg/L	0.011
Rubidium	mg/L	0.009
Strontium	mg/L	0.049
Uranium	mg/L	0.001
Zinc	mg/L	0.008

6.1.2 Discharge water triggers

Water quality limits are specified by EPL 467 for discharges through LDP002 and LDP003, which are provided in Table 1-5. Note that the concentration limits for LDP002 and LDP003 do not apply when the discharge occurs within five days after a rainfall event measured at the site which exceeds 44 mm over any consecutive five-day period. No water quality limits are specified for LDP005.

LDP001 is no longer in operation and has been removed from the site EPL.

6.1.3 Groundwater triggers

Groundwater levels

Groundwater triggers have been assigned for groundwater levels monitored at standpipe piezometers, VWPs and swamp piezometers. Triggers have been developed based on statistical analysis of pre-mining groundwater level data. Note that the pre-mining data used includes all data up to the time at which the dataset indicates an impact.

Standpipe piezometers

The trigger values for standpipe monitoring bores are shown in Table 6-2. Review of monitoring data indicates that groundwater levels at the majority of standpipe monitoring bores vary by 2 m to 4 m. Groundwater trigger values have been defined as observed depth to groundwater falling 2 m below the 95th percentile pre-mining depth to groundwater for more than seven consecutive days.

Table 6-2 Standpipe piezometer trigger values

Location	Groundwater trigger value (m bgl)
AP1PR	20.27
AP4PR	39.56
AP5PR	17.76
AP8PR	75.91
AP9PR	65.63
AP10PR	19.80
AP1104	38.69
AP1105	31.77

Location	Groundwater trigger value (m bgl)
AP1110	71.93
AP1102	84.37
AP1204	53.48
REN	57.04
RSE	N/A – bore dry since June 2015
RNW	N/A – Dry since September 2013

REN was installed after the location was undermined. Therefore, the trigger level for REN was calculated using the entire monitoring dataset.

Trigger values for bore AP1801DP, installed in September 2018, will be defined when sufficient baseline monitoring has been undertaken. Due to the depth of the bore and difficulty to collect enough water to sample, some monitoring event samples do not have the required volume of water to complete all analytes.

Vibrating wire piezometers

The trigger values for VWPs are shown in Table 6-3. Groundwater level triggers have been defined as observed piezometric level falling 2 m below the minimum observed piezometric level for more than seven consecutive days.

Table 6-3 Vibrating wire piezometer trigger values

Location	Monitoring depth (m bgl)	Trigger value (m AHD)
AP2PR	411	880.07
	381	885.26
	299.5	921.47
	213	1020.11
	181	1048.87
	92	1081.61
AP10PR	343	812.01
	327	806.04
	300	820.46
	270	891.03
	248	902.78
	205	945.77
	150	995.89
	103	1050.13
	60	1063.64
AP11PR	320	889.83
	295	905.33
	263	923.40

Location	Monitoring depth (m bgl)	Trigger value (m AHD)
	223	959.64
	167	1059.11
	128	1052.62
	93	1065.13
	72	1102.95
	43	1109.50
AP1101	327.5	806.6
	299.5	804.53
	248	901.23
	235.5	913.35
	210	920.64
	150	962.78
	92	1046.95
AP1102	435.1	883.08
	426.3	885.78
	392	901.65
	338	906.49
	265	932.19
	210	962.18
	123	1025.99
AP1103	341.8	941.07
	290	954.25
	260	996.18
	200	1035.24
	153	1069.53
	105	1146.77
AP1104	370.8	811.87
	360	819.78
	300	832.98
	277	939.17
	255.6	935.21
	240	941.95
	170	966.69
AP1106	380.3	755.15

Location	Monitoring depth (m bgl)	Trigger value (m AHD)
	356.3	764.38
	335	758.59
	275	839.05
	251	901.27
	174	907.58
AP1107	290	822.46
	238	890.03
	212.5	917.32
	210	916.98
	147.5	962.20
	81	1035.90
	54	1069.98
AP1110	399.7	807.08
	383	913.53
	331.8	927.32
	304.4	938.26
	224	1022.20
	127	1060.60
AP1204	355.3	916.36
	332.2	919.47
	316.5	921.08
	269	921.52
	198.5	971.47
	138.5	1018.03
	92.5	1064.94
AP1206	342	718.27
	322	759.48
	305	759.11
	257.5	826.77
	244	877.21
	152	895.58
APXXB1	356.5	816.67
	335	843.24
	275	916.60

Location	Monitoring depth (m bgl)	Trigger value (m AHD)
	250	922.03
	179	995.37
	143	1074.12
APXXB2	320	837.33
	293	870.85
	243	923.35
	185	986.66
	160.5	1006.59
	135	1024.90
	69	1089.66
APXXB3	331.5	831.52
	301.5	854.96
	285	925.20
	242	927.95
	156.5	1031.59
	111.5	1090.06
	83.5	1091.48

Underground water management

The 800 District is maintained at its current capacity and underground water level of 808 m AHD. As this area is not treated as an active underground storage, the adopted trigger for the 800 District is set at 808 m AHD, with no significant change in excess of 1 m.

The 900 District is actively managed as an underground storage area. The spill level of the 900 District is approximately 805 m AHD. A 5 m freeboard buffer storage is required to be maintained. Hence, the adopted trigger value for the 900 District is 800 m AHD. Should this trigger be exceeded, it will be necessary to reduce inputs to the storage and/or increase the extraction rate.

In emergency situations where the SWTF cannot receive water, Angus Place Colliery may receive water from Springvale Mine. Water is transferred via a reverse flow configuration of the SDWTS whereby water from Bore 6 and 8 at Springvale Mine, is pushed to Angus Place Colliery's 930 Bore . The system is only operated in this way following after operational approval is granted from the Executive Management Team.

6.2 Performance criteria

Performance criteria have been developed from baseline information and the approach presented in the Regional Water Management Plan (GHD 2016a). These criteria have been developed to ensure that impacts as a result of operations are not greater than those predicted by environmental impact assessments and approved by the development consent for Angus Place Colliery. The triggers presented in Section 6.1 have been developed to prompt specific actions (identified in the TARPs provided in Appendix H) to prevent the exceedance of the performance criteria. Further information on the approach used to develop the performance criteria is provided in the Regional Water Management Plan (GHD 2016a).

6.2.1 Surface site operations

Performance criteria for surface water management are provided in Table 6-4.

Table 6-4 Surface site operations criteria

Aspect	Criteria
Surface water storages	Storages sized in accordance with Landcom (2004) and DECC (2008) and maintained within the capacity of each storage.
Water quality management	Clean and dirty water separation.
Erosion and sediment control	Minimise disturbance area. Surface disturbance and other construction activities to be managed in accordance with the approach and guidelines outlined in the Regional Water Management Plan (GHD 2016a). Where construction works are significant, an erosion and sediment control plan and construction environmental management plan will be prepared.
Hydrocarbon management	Chemical and hydrocarbon storage to be undertaken in accordance with Australian Standard AS1940:2004.

6.2.2 Watercourses

Performance criteria for watercourses are provided in Table 6-5.

Table 6-5 Watercourse criteria

Aspect	Criteria
Water quality	Within or below SSGVs provided in Table 6-1 for Coxs River. No statistically significant difference in monitoring results for upstream and downstream sites on the Wolgan River.
Flow volume	Above or within 50th percentile historical flow volume.

6.2.3 Discharge management

Performance criteria for discharge management are provided in Table 6-6.

Table 6-6 Discharge and water transfer management criteria

Aspect	Criteria
Water quality	Within or below water quality limits for LDP002 and LDP003 provided in Table 1-5.
Flow volume discharge and water transfers	Zero mine water discharges to the environment Water transfers to be consistent with both approved and engineered water transfer volume limits

6.2.4 Groundwater environment

Performance criteria for groundwater are provided in Table 6-7.

Table 6-7 Groundwater environment criteria

Aspect	Criteria
Groundwater level	Depth to groundwater is less than the depths outlined in Table 6-2 under the conditions outlined.
Piezometric pressure	Piezometric pressure is above levels provided in Table 6-3 under the conditions outlined.
Groundwater quality	Consistent with historical groundwater quality monitoring results.
Groundwater access	No complaints from landholders regarding groundwater access or quality.
Underground water level/storage	800 District – Water level is maintained below 808 m AHD. 900 District – Water level is maintained below 800 m AHD.

6.2.5 Stream health

Performance criteria developed for stream health are provided in Table 6-8.

Table 6-8 Stream health criteria

Aspect	Criteria
Geomorphic condition and watercourse stability	
Incisional processes and instabilities	Occurrence of erosional processes does not occur as a result of mining induced subsidence or discharges from LDPs.
Stream gradient	Change in stream gradient does not very beyond predictions of subsidence modelling.
Watercourse subsidence	No connective cracking between the surface and underground workings. Subsidence does not occur beyond predictions of modelling.
Aquatic ecology	
Instream/riparian vegetation	No change in vegetation type and density from previous monitoring rounds.
In situ water quality	No significant change in impact sites when compared to reference/baseline sites and previous monitoring rounds.
Macroinvertebrate metrics	No significant change in impact sites when compared to reference/baseline sites and previous monitoring rounds.

6.3 Trigger action response plans

TARPs have been provided in Appendix H for:

- Surface site operations.
- Watercourses.
- Discharge management.
- Groundwater environment.
- Stream health.

7. Site specific reviews and reports

7.1 Standard reporting requirements

Reporting at Centennial involves a number of internal and external reporting procedures that comply with statutory and operational requirements. These include:

- Annual review.
- Annual returns for EPLs.
- Environmental monitoring.
- Incidents.
- Complaints.
- Community Consultative Committee (CCC).

Annual Review

Each site prepares an annual review (previously an annual environmental management report) that reviews the performance of operations against the requirements of the RWMP and the site specific WMP, provides an overview of environmental management actions taken and summarises the monitoring results over the 12-month reporting period. Annual reviews are prepared based on the Annual Review Guideline provided by the NSW Government (2015).

The annual review typically includes the following elements specific to water management:

- Any amendments to licensing or statutory approvals.
- A summary of any complaints or incidents relating to the performance of the water management system over the reporting period.
- A summary of the monitoring results collected over the reporting period and assessment against any relevant criteria.
- An evaluation of any trends in the monitoring results occurring across the site over the life of the operation.
- Any non-compliance recorded during the reporting period and the actions taken to ensure compliance.
- Identification of any discrepancies between the predicted and actual impacts of operations and an analysis of the potential cause of any significant discrepancies.
- An evaluation of the site water balance.
- Volumes of water extracted under WALs held by the site.
- A summary of the management actions to be implemented over the next year to improve the environmental performance of the site.

Annual Return

EPLs require an annual report on compliance with the requirements of the licence including a summary of environmental monitoring. This report is on a prescribed form provided to each licence holder by the EPA.

Environmental Monitoring

In accordance with Section 66(6) of the POEO Act and requirements issued by the EPA, Centennial must publish monitoring data that has been collected as a result of EPL requirements. A summary of monitoring results is made publicly available on the Centennial website and is updated regularly.

Centennial must keep a record of the volume of water extracted from surface water or groundwater sources under the WALs held by Centennial which are outlined in Section 2.1.2. As required by the conditions set out in the licences, the record must be kept for at least five years and be produced for inspection when requested by DPIW. The record must include the following details:

- The date and period of time during which water is taken under the licence.

- The volume of water taken.
- The approval number of the water supply work used to take the water.
- The purpose for which the water was taken.

Incident Reporting

Any incident which occurs within a site boundary or is associated with Centennial's operations must be reported by the employee or contractor who has been associated with or witnessed the incident. The method for reporting incidents is outlined in the site PIRMP and Centennial's Incident Reporting Procedure.

In accordance with the requirements of EPLs, Centennial, its employees or contractors must notify the EPA of incidents causing or threatening material harm to the environment immediately after the person becomes aware of the incident. Notifications must be made by telephoning the Environment Line service on 131 555. Centennial must also provide written details about the notification to the EPA within seven days of the incident.

Centennial must notify DPIW in writing immediately upon becoming aware of a breach of any conditions set out in WALs held by the site.

Complaints

In accordance with the requirements of EPLs, each site must keep a record of any complaints made to Centennial or any employee or agent of Centennial in relation to pollution arising from any site activities. The record of complaint must be kept for at least four years and must include the following details:

- The date and time of the complaint.
- The method by which the complaint was made.
- Any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect.
- The nature of the complaint.
- The action taken by Centennial in relation to the complaint, including any follow-up contact with the complainant.
- If no action was taken by Centennial, the reasons why no action was taken.

Community Consultative Committee

The CCC meets on a regular basis for each of the operations. Some of the information reported at the CCC at a site scale includes:

- Progress at the mine.
- Operational issues.
- Monitoring and environmental performance.
- Community complaints and the response to complaints.

7.2 Aquatic ecology monitoring

A report is prepared annually that describes the aquatic ecology monitoring undertaken. The report includes an assessment of any impacts from Angus Place discharges or other operations on the condition of aquatic flora/fauna. A summary of the aquatic ecology monitoring results will be prepared as part of the Annual Review for Angus Place Colliery.

7.3 Site water balance

The site water balance will be reviewed and revised annually as a minimum or as necessary when there are changes to operations. The results of the site water balance will be reported in the Annual Review for Angus Place Colliery.

7.4 Hydrogeology model

The hydrogeological model validation program compares actual and modelled mine groundwater inflows and monitored and modelled groundwater level predictions every three years. Where the validation process identifies significant variances between monitored and predicted mine groundwater inflows or that the hydrogeological model is underestimating drawdown in groundwater level, then a recalibration process may be required to be undertaken in consultation with an independent reviewer. A summary of the hydrogeological model validation will be prepared as part of the Annual Review for Angus Place Colliery.

8. Decommissioning Strategy

Decommissioning of water management structures will be undertaken in accordance with Section 5 of the *Angus Place Mine Closure Strategy.*

The *Angus Place Mine Closure Strategy* dictates that a detailed investigation of all structures will be completed prior to closure to determine the appropriate techniques, equipment required, and the sequence for decommissioning and removal required to execute the demolition activities safely.

A site investigation will be completed during the decommissioning and demolition planning phase. The site investigation will be undertaken consistent with adopted and approved post mining land use and will include:

- The type, location and extent of underground services such as conduits, cables and pipe work owned and/or managed by Centennial Angus Place;
- The location and extent of underground structures to be retained and those to be removed;
- The location, type and extent of overhead services and structures such as power cables, conveyors, light poles and pipe work that are owned and/or managed by Centennial Angus Place;
- The location and condition of all tanks and vessels (with emphasis on remaining combustible materials and methods required for their removal);
- The presence of contaminated and hazardous materials and the classification and disposal of these materials;
- The general condition of adjacent structures; and
- Any infrastructure to remain following decommissioning (where appropriate).

- Prior to the commencement of any demolition activities the following tasks will be undertaken:
- All sumps will be dewatered;

- All items will be decommissioned, de-oiled, depressurised and isolated; and
- All hazardous materials will be removed and transported to appropriately licensed disposal facilities.

All buildings, including the main administration buildings, workshop areas, coal delivery systems (including conveyors and gantries), portals, decline tunnels and other surface infrastructure will be demolished unless there is a future landholder who is prepared to accept the on-going liability of a structure that they may wish to use. Opportunities for the sale and/or re-use of assets and recycling of scrap steel will be maximised where possible.

Specific details regarding decommissioning of water management structures will increase as Angus Place comes closer to closure, consistent with the approved post mining land use.

9. References

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Chessman BC (2003). *New sensitivity grades for Australian river macroinvertebrates*. *Marine and Freshwater Research* 54, 95-104.

GHD (2013) *Angus Place Mine Extension Project: Water and Salt Balance Assessment*, prepared by GHD Pty Ltd for Centennial Angus Place Pty Ltd.

GHD (2016a) *Western Operations: Regional Water Management Plan,* prepared by GHD Pty Ltd for Centennial Coal Company Limited.

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GHD (2018c) *Upper Coxs River 2018 monitoring – Long Swamp and Kangaroo Creek Watercourse Stability and Salinity Assessment*, prepared by GHD Pty Ltd for Centennial Angus Place Pty Limited.

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10. Appendices

Appendix A – Water management plan revisions

Version	Date	Summary of changes
0	24/10/2018	Original water management plan.
1	21/02/2018	Revised to incorporate recommendations following consultation with regulators (refer Appendix C); additional information on the Ventilation Facility; incorporation of Kerosene Vale Stockpile Area (previously associated with Western Coal Services water management plan).
2	16/06/2021	Revised following removal of Temporary Water Treatment Plant (Mod 5) and the approval of (Mod6)

Appendix B – Correspondence with regulators

Mr James Wearne
Group Approvals Manager
Centennial Angus Place Pty Ltd
PO Box 1000
Toronto, NSW, 2283

30 June 2021

Dear Mr Wearne,

Angus Place Coal Project (MP06_0021)
Site Water Management Plan - request for additional information

The Department requires additional information relating to the Site Water Management Plan submitted under the conditions of approval for the Angus Place Coal Project (MP06_0021).

Please submit a revised document that addresses the requirements outlined in the attached review table.

Please provide the information or notify us that you will not provide the information by Friday 09 July 2021. If this timeframe is not achievable, please provide and commit to an alternative timeframe for providing this information.

If you have any questions, please contact Callum Firth at Callum.Firth@dpie.nsw.gov.au.

Yours sincerely

Stephen O'Donoghue
Director Resource Assessments

3	11A
3	11B
3	12
3	13
3	13A
3	13B

Consultation through the Major Projects portal

Consultation required as part of the preparation of the document?

No

Attachment of Post Approval application

File Name	Category
2021 Angus_Place_Colliery_Water_Management_Plan-Rev2_Submis.docx	Revised Post Approval Document - Track Changes
2021 Angus_Place_Colliery_Water_Management_Plan-Rev2_Submis.pdf	Post Approval Document

Appendix C – Consultation outcomes

	Comment	Response
1	Choice of reference site and trigger value derivation	
	OEH agrees with the choice of Coxs River far upstream as an appropriate reference site. However, OEH consider that the ANZECC (2000) guidelines have been misapplied in determining trigger values because:	
	• Protection of the long-term ecosystem health of Coxs River should include consideration of the ANZECC (2000) Guidelines, through an agreed set of approval trigger discharge values and management protocols (IESC 2014). OEH is unaware of consultation or peer review of the proposed trigger values by government agencies.	The protection of aquatic ecosystems recommended by ANZECC (2000) has been taken into consideration in the derivation of SSGVs (refer Section E.3). As discussed in Section 1, this WMP has been provided to the EPA, DIW, WaterNSW and OEH in October 2018 for consultation, including consultation on the SSGVs and performance criteria for surface water quality.
	• At each point when adopting trigger levels, the assessment has chosen the highest value of either the ANZECC default guideline levels or local water quality trigger values (based on 80 percentile values at a reference site). This is an inconsistent and inappropriate application of ANZECC Guidelines trigger value derivation methods.	The methodology used to derive the SSGVs is consistent with the approach outlined in the ANZECC (2000) guidelines. Section 7.4.4.2 of the ANZECC (2000) guidelines states *"For those months, seasons or flow periods that constitute logical time intervals or events to consider and derive background data, the 80th percentile of background data (from a minimum of 10 observations) should be compared with the default guideline value. This 80th percentile value is used as the new trigger value for this period if it exceeds the default guideline value..."* The method of modifying the concentration limit if the local reference data shows that the background concentrations exceed the default values is thus consistent with the recommendations of the ANZECC (2000) guidelines. This methodology is replicated in the new ANZG (2018) water quality guidelines (refer http://www.waterquality.gov.au/anz-guidelines/monitoring/data-analysis/derivation-assessment) which provides further evidence that the method used to derive SSGVs is appropriate and consistent with the water quality guidelines (ANZECC 2000; ANZG 2018).
	• The ANZECC (2000) guidelines recommend an upper pH level of 7.5 for upland rivers, not 9.0 as stated in section 6.1.1 of the WMP.	It is noted that Table 3.3.2 (ANZECC 2000) indicates that pH limits for NSW upland rivers are 6.5–8.0 (note m). The upper pH limit of 9.0 was a typographical error and has been corrected to 8.0.

	Comment	Response
	• OEH advises that some of the site-specific guideline values appear to be incorrect. For example, table 6-1 of the WMP has a site-specific guideline value for total nitrogen of 2.44 mg/L. OEH and EPA data has found that total nitrogen in the Upper Coxs River is approximately 0.4 mg/L, and we question whether the figure of 2.44 mg/L should be 0.44 mg/L. Provision of raw water quality data would enable verification of the site-specific guideline values.	SSGVs have been derived from the most recent 24 monthly data points recorded at the Coxs River Far U/S monitoring point. The 80th percentile for total nitrogen over this period is 2.44 mg/L. All data points are presented in the time series graphs of water quality data in Appendix E of the WMP. The total nitrogen figure (refer Section E.1.2) shows that the total nitrogen concentrations have been elevated over the past two years, which has contributed to the elevated SSGV. The median value for total nitrogen over the entire baseline data period (72 points between January 2013 and December 2018) was 0.4 mg/L (refer Section E.1.2), which agrees with OEH and EPA data.
1.1	Proposed trigger values be revised using appropriate application of the ANZECC guidelines, and the WMP recirculated for review by government agencies including OEH.	As discussed above, the methodology used to derive SSGVs is consistent with the approach outlined in the ANZECC (2000) guidelines. The error of the upper pH limit has been corrected. No further revision to the SSGVs will be undertaken.
1.2	Raw water quality monitoring data should be forwarded to OEH to enable verification of site-specific guideline values.	All raw water quality data is presented in the time series graphs in Appendix E of the WMP.
2	Groundwater inflows	
	The WMP (section 3.3.3) predicts that groundwater inflows into Angus Place Colliery will peak at approximately 36 ML/day in 2031, assuming the development of the Angus Place Extension Project. CSIRO (2013) predicted average life of mine water inflow rates for Angus Place and Springvale would increase from about 26 ML/day and average around 35 ML/day to 42 ML/day between 2020 to 2032. This report states that mine water-inflow rates into the Springvale longwall panels are not affected by mining Angus Place and vice versa. Based on figure 3-5 of the WMP, mine water inflows for Angus Place (without Springvale) are estimated at 30 to 35 ML/day at about 2030. This appears to be an increase from the combined prediction for Angus Place and Springvale in CSIRO (2013). The WMP does not provide an explanation for this difference of approximately 10 ML/day.	The CSIRO (2013) model assumed that the Angus Place Mine Extension Project and the Springvale Mine Extension Project would occur concurrently. The results of the CSIRO (2013) model indicated the peak combined groundwater inflow rate for the two mines was approximately 540 L/s (47 ML/day) at the end of 2021, made up of approximately 215 L/s (19 ML/day) from Springvale Mine and 170 L/s (15 ML/day) from the Angus Place East workings. The remaining 155 L/s (13 ML/day) was predicted to occur from the existing longwall panels at Angus Place Colliery (i.e. excluding the Angus Place East workings). The groundwater model was revised by CSIRO (2015) to account for an increase in production rate at Springvale Mine and a delay in the commencement of the Angus Place Mine Extension Project. The CSIRO (2015) model assumed the Angus Place Mine Extension Project and the Springvale Mine Extension Project would occur sequentially instead of concurrently (as in the 2013 model). The peak total groundwater inflow rate predicted by the CSIRO (2015) model was approximately 420 L/s (36 ML/day), occurring at the end of 2029. As the Springvale Mine Extension Project was assumed

	Comment	Response
	The environmental impact assessment for Angus Place modification 5 identified inadequacies in the CSIRO COSFLOW numerical model used to predict mine inflow. Centennial Coal have developed an internal empirically-based groundwater model referred to as the CEY Empirical Model. The CEY model has not been calibrated or verified. In addition, a copy of the reference upon which this modelling is based, CSIRO (2016) *Angus Place and Springvale Colliery Operations: Groundwater Model Update from January 2016 to June 2016*, prepared for Centennial Coal Pty Limited, should be included with the WMP.	to be completed by 2024, the mine inflows were modelled to be entirely occurring from Angus Place Colliery. The groundwater model was most recently revised by CSIRO (2016) to include four approved longwalls that were previously not included in the CSIRO (2015) as their extraction was not considered to be financially viable at the time. The CSIRO (2016) model predicted the same peak total groundwater inflow rate of 420 L/s (36 ML/day) as the CSIRO (2015) model; however the peak was predicted to occur 16 months later in 2031.
2.1	The WMP should include:	
a)	An explanation of the reasons for the predicted increase in mine water.	There is a high level of consistency in the groundwater inflow rates predicted by the different model simulations (CSIRO 2013; 2015; 2016), with differences in the model results due to the changes in the assumed mine schedule.
b)	A discussion of the limitations of current groundwater modelling, and assumptions used, in generating predictions.	This WMP is not an appropriate place to discuss the limitations of the groundwater model. Centennial will consult with OEH directly on this issue.
c)	The reference CSIRO (2016) *Angus Place and Springvale Colliery Operations: Groundwater Model Update from January 2016 to June 2016*, prepared for Centennial Coal Pty Limited, should be included as an appendix.	This WMP is not an appropriate place to append the groundwater modelling results. Centennial will consult with OEH directly on this issue.
3	Waste water discharge	
	The WMP states that water balance modelling predicts that discharges through LDP001 will be at 10 ML/day at effectively all times. Up to 13.4 ML/day of mine water from the underground workings is transferred to the 1 ML Mine Water Tank prior to transfer to the WTP feed water system. This leaves up to 3.4 ML/day of waste product not clearly accounted for in the WMP.	By-products from the WTP transferred to the underground workings for temporary storage in the 800 Panel Area and recirculated to the WTP through the extraction of water from the underground workings. Mine water (including the by-products from the WTP) are transferred to the SWTP for treatment and reuse within the MPPS cooling water system.

	Comment	Response
	Section 3.4 of the WMP states that by-products from the water treatment plant (comprising the pre-treatment residuals, brine from the reverse osmosis process and clean-in-place waste from membrane cleaning) is transferred to the underground workings for temporary storage in the 800 panel area. There is no explanation included in the WMP about where the waste stream goes after temporary storage in the 800 panel area.	
3.1	The WMP should include a full explanation of the ultimate disposal of the waste water.	Section 3.4 has been updated to clearer description of the ultimate disposal of the by-products of the WTP.
4	Additional monitoring site in Long Swamp	
	OEH is concerned that Long Swamp downstream of the Kangaroo Creek confluence may have developed a concentration of salt and other contaminants from a history of waste water discharge. If so, this will make it difficult to ascertain impacts of Angus Place discharges on water quality. OEH recommend that an additional monitoring site is included in Long Swamp immediately upstream of the Kangaroo Creek confluence to provide a reference site not influenced by historic mine water discharge.	An additional water quality monitoring point has been added to the surface water quality monitoring program on the Coxs River upstream of the confluence with Kangaroo Creek. Monitoring of this site is expected to commence in early 2019.
4.1	An additional monitoring site to be placed in Long Swamp immediately upstream of the Kangaroo Creek confluence as shown in figure 1.	Monitoring point Long Swamp U/S has been added to Section 4.3.1.
5	Baseline data	
	Section 5 of the WMP details the collection of baseline data, including dates when data was collected, but does not include any detail of related mining activity. The WMP would benefit from a table of mining activities, including dates when longwalls commenced and finished, so that timing of baseline data collection can be related to timing of impacts.	Longwall extraction start and finish dates have been added to the WMP.

Comment		Response
5.1	Timing of mining impacts should be detailed in the WMP.	Section 5.1 has been added to the WMP.

Appendix D – Additional groundwater data

D.1 Groundwater monitoring program details

D.1.1 Standpipe piezometer monitoring details

Location	Monitoring commenced	Depth (m bgl)	Formation
AP1801DP	September 2018	336.3	Lithgow Seam
AP1PR	July 2010	37.76	Burralow Formation
AP4PR	July 2010	51.57	Burralow Formation
AP5PR	July 2010	93.82	Banks Wall Sandstone
AP8PR	July 2010	90.90	Banks Wall Sandstone
AP9PR	July 2010	82.31	Banks Wall Sandstone
AP10PR	July 2010	39.69	Banks Wall Sandstone
AP1104	February 2012	81.68	Banks Wall Sandstone
AP1105	November 2011	75.85	Banks Wall Sandstone
AP1110	February 2012	70.40	Burralow Formation
AP1102	April 2012	111.41	Banks Wall Sandstone
AP1204	July 2012	>100	Banks Wall Sandstone
REN	December 2005	54.98	Burralow Formation
RSE	September 2010	49.55	Burralow Formation
RNW	December 2005	55.50	Burralow Formation

D.1.2 Swamp piezometer monitoring details

Swamp	Location	Monitoring commenced	Depth (m bgl)
Kangaroo Creek Swamp	KC1	May 2005	1.10
	KC2	November 2008	1.56
Tri Star Swamp	TS1	October 2011	3.98
	TS2	October 2011	2.06
	TS3	November 2011	1.77
West Wolgan Swamp	WW1	May 2005	1.90
	WW2	May 2005	2.30
	WW3	December 2005	2.40
	WW4	February 2006	2.08
Trail Six Swamp	XS1	October 2011	1.44
Twin Gully Swamp	TG1	October 2011	1.16

Swamp	Location	Monitoring commenced	Depth (m bgl)
	TG2	April 2018	0.85
Narrow Swamp	NS1	May 2005	2.53
	NS2	May 2005	2.60
	NS3	February 2008	2.80
	NS4	April 2008	2.40
East Wolgan Swamp	WE1	May 2005	2.51
	WE2	May 2005	1.20

D.1.3 Vibrating wire piezometer monitoring details

Location	Monitoring commenced	Depth (m bgl)	Aquifer	Formation
AP2PR	February 2010	411	AQ1	Lidsdale/Lithgow coal seams
		381	AQ1	Irondale Coal Seam
		299.5	AQ3	Katoomba Coal Seam
		213	AQ3	Burra-Moko Head Formation
		181	AQ3	Burra-Moko Head Formation
		92	AQ4	Banks Wall Sandstone
AP10PR	May 2010	343	AQ1	Marrangaroo Formation
		327	AQ1	Long Swamp Formation
		300	AQ1	Newnes Formation
		270	Semi-permeable layer	Denman Formation
		248	AQ3	Gap Sandstone
		205	AQ3	Caley Formation
		150	AQ3	Burra-Moko Head Formation
		103	AQ4	Banks Wall Sandstone
		60	AQ4	Banks Wall Sandstone
AP11PR	May 2010	320	AQ3	Gap Sandstone
		295	AQ3	Caley Formation
		263	AQ3	Burra-Moko Head Formation
		223	AQ3	Burra-Moko Head Formation
		167	AQ4	Banks Wall Sandstone
		128	AQ4	Banks Wall Sandstone

Location	Monitoring commenced	Depth (m bgl)	Aquifer	Formation
		93	AQ4	Banks Wall Sandstone
		72	AQ4	Banks Wall Sandstone
		43	AQ4	Banks Wall Sandstone
AP1102	January 2012	435.1	AQ1	Lidsdale/Lithgow coal seams
		426.3	AQ1	Lidsdale/Lithgow coal seams
		392	Semi-permeable layer	Denman Formation
		338	Semi-permeable layer	Farmers Creek Formation
		265	AQ3	Caley Formation
		210	AQ3	Burra-Moko Formation
		123	AQ3	Burra-Moko Formation
AP1104	September 2012	370.8	AQ1	Lidsdale/Lithgow coal seams
		360	AQ1	Long Swamp Formation
		300	Semi-permeable layer	Denman Formation
		277	AQ2	State Mine Creek Formation
		255.6	AQ3	Katoomba Coal Seam
		240	AQ3	Caley Formation
		170	AQ3	Burra-Moko Head Formation
AP1106	February 2012	380.3	AQ1	Lidsdale/Lithgow coal seams
		356.3	AQ1	Long Swamp Formation
		335	Semi-permeable layer	Denman Formation
		275	AQ2	State Mine Creek Formation
		251	AQ3	Katoomba Coal Seam
		174	AQ3	Burra-Moko Head Formation
AP1110	September 2012	399.7	AQ1	Long Swamp Formation
		383	AQ1	Newnes Formation
		331.8	AQ3	Gap Sandstone
		304.4	AQ3	Caley Formation
		224	AQ3	Burra-Moko Head Formation
		127	AQ4	Banks Wall Sandstone
AP1206	September 2012	342	AQ1	Lidsdale Seam

Location	Monitoring commenced	Depth (m bgl)	Aquifer	Formation
		322	AQ1	Long Swamp Formation
		305	AQ2	Newnes Formation
		257.5	AQ2	Gap Sandstone
		244	AQ3	Middle River Coal
		152	AQ3	Burra-Moko Head Sandstone
APXXB2	January 2012	320	AQ1	Long Swamp Formation
		293	Semi permeable layer	Denman Formation
		243	AQ3	Gap Sandstone
		185	AQ3	Caley Formation
		160.5	AQ3	Burra Moko Head Formation
		135	AQ4	Banks Wall Sandstone
		69	AQ4	Banks Wall Sandstone
APXXB3	May 2012	331.5	AQ1	Long Swamp Formation
		301.5	AQ1	Long Swamp Formation
		285	AQ1	Irondale Seam
		242	AQ2	Middle River Seam
		156.5	AQ3	Burra-Moko Head Sandstone/Caley Formation
		111.5	AQ4	Banks Wall Sandstone
		83.5	AQ4	Banks Wall Sandstone

The following locations outlined in the Table below were destroyed as part of the 2019/2020 Mt Gospers Bushfire. Whilst the historical information is available for destroyed sites is up until November 2019, the sites listed in the Table below have not yet been reviewed as part of a replacement strategy as yet.

Location	Monitoring commenced	Depth (m bgl)	Aquifer	Formation
AP1101	February 2012–November 2019	327.5	AQ3	Gap Sandstone
		299.5	AQ3	Katoomba Coal Seam
		248	AQ3	Caley Formation
		235.5	AQ3	Burra-Moko Head Formation
		210	AQ3	Burra-Moko Head Formation

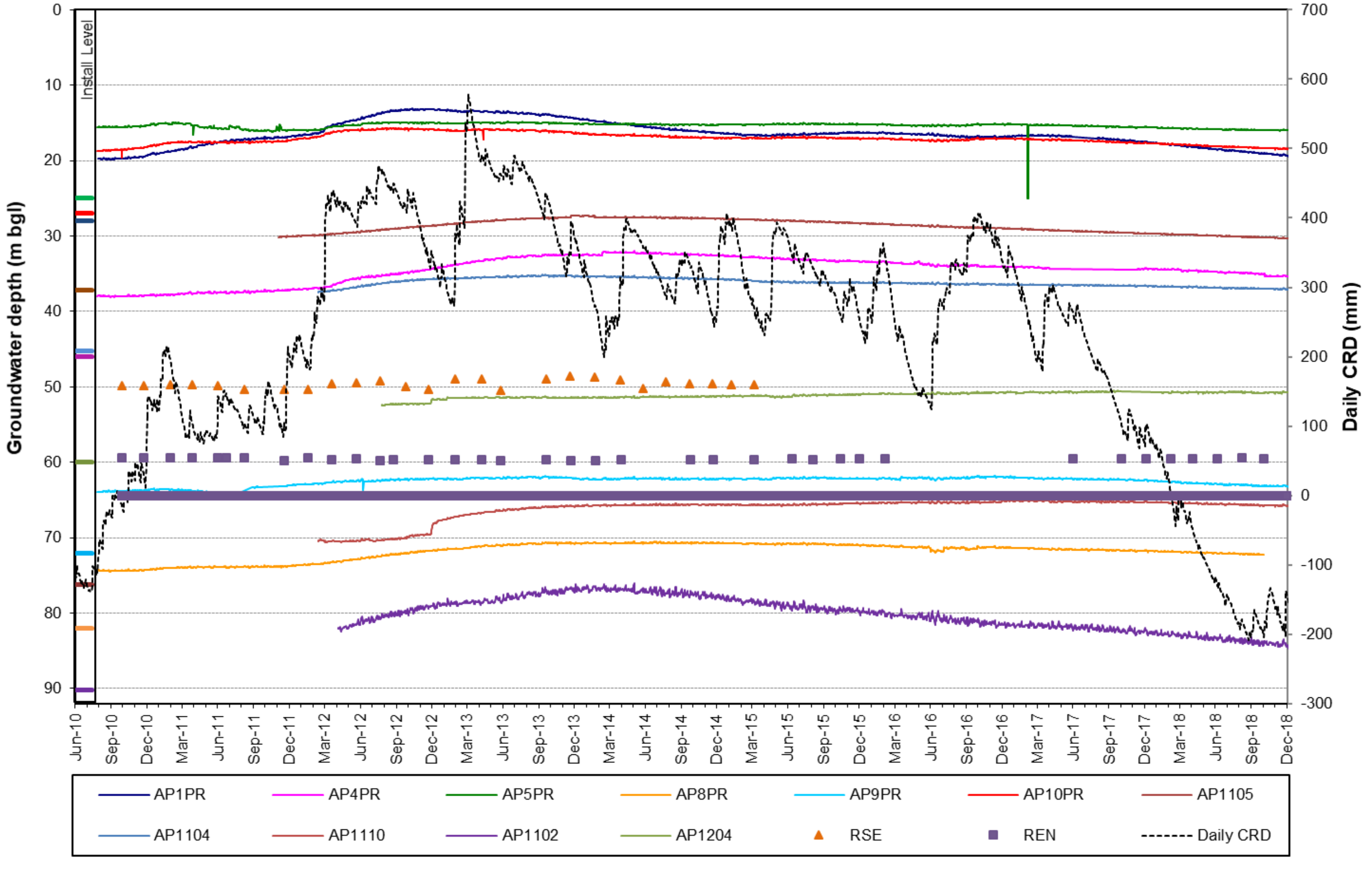
Location	Monitoring commenced	Depth (m bgl)	Aquifer	Formation
		150	AQ4	Banks Wall Sandstone
		92	AQ4	Banks Wall Sandstone
AP1107	December 2011–November 2019	290	AQ3	Gap Sandstone
		238	AQ3	Caley Formation
		212.5	AQ3	Caley Formation
		210	AQ3	Katoomba Coal Seam
		147.5	AQ3	Burra-Moko Head Formation
		81	AQ4	Banks Wall Sandstone
		54	AQ4	Banks Wall Sandstone
AP1103	May 2012–November 2019	341.8	Semi-permeable layer	Denman Formation
		290	AQ3	Caley Formation
		260	AQ3	Caley Formation
		200	AQ3	Burra-Moko Formation
		153	AQ3	Burra-Moko Formation
		105	AQ4	Banks Wall Sandstone
AP1204	July 2012–November 2019	355.3	AQ1	Lidsdale/Lithgow coal seams
		332.2	AQ1	Long Swamp Formation
		316.5	AQ1	Long Swamp Formation
		269	AQ2	State Mine Creek Formation
		198.5	AQ3	Caley Formation
		138.5	AQ3	Burra-Moko Head Formation
		92.5	AQ4	Banks Wall Sandstone
APXXB1	May 2012 – November 2019	356.5	AQ1	Lithgow Seam
		335	Semi permeable layer	Denman Formation
		275	AQ2	Middle River Coal
		250	AQ3	Katoomba Seam
		179	AQ3	Burra-Moko Head Sandstone
		143	AQ4	Banks Wall Sandstone

D.1.4 Coxs River ground monitoring details

Location	Monitoring commenced	Depth (mbgl)	Formation
LS5 (Long swamp)	February 2019	1.71	Alluvial
LS6 (Long swamp DS)	February 2019	1.86	Alluvial
CS4 (LEG Bridge)	February 2019	2.58	Alluvial
CS-2	February 2019	2.23	Alluvial
CS-3	February 2019	1.92	Alluvial
AP VWP CS1	August 2019	15 50 97	Alluvial Denman Formation Lithgow Seam

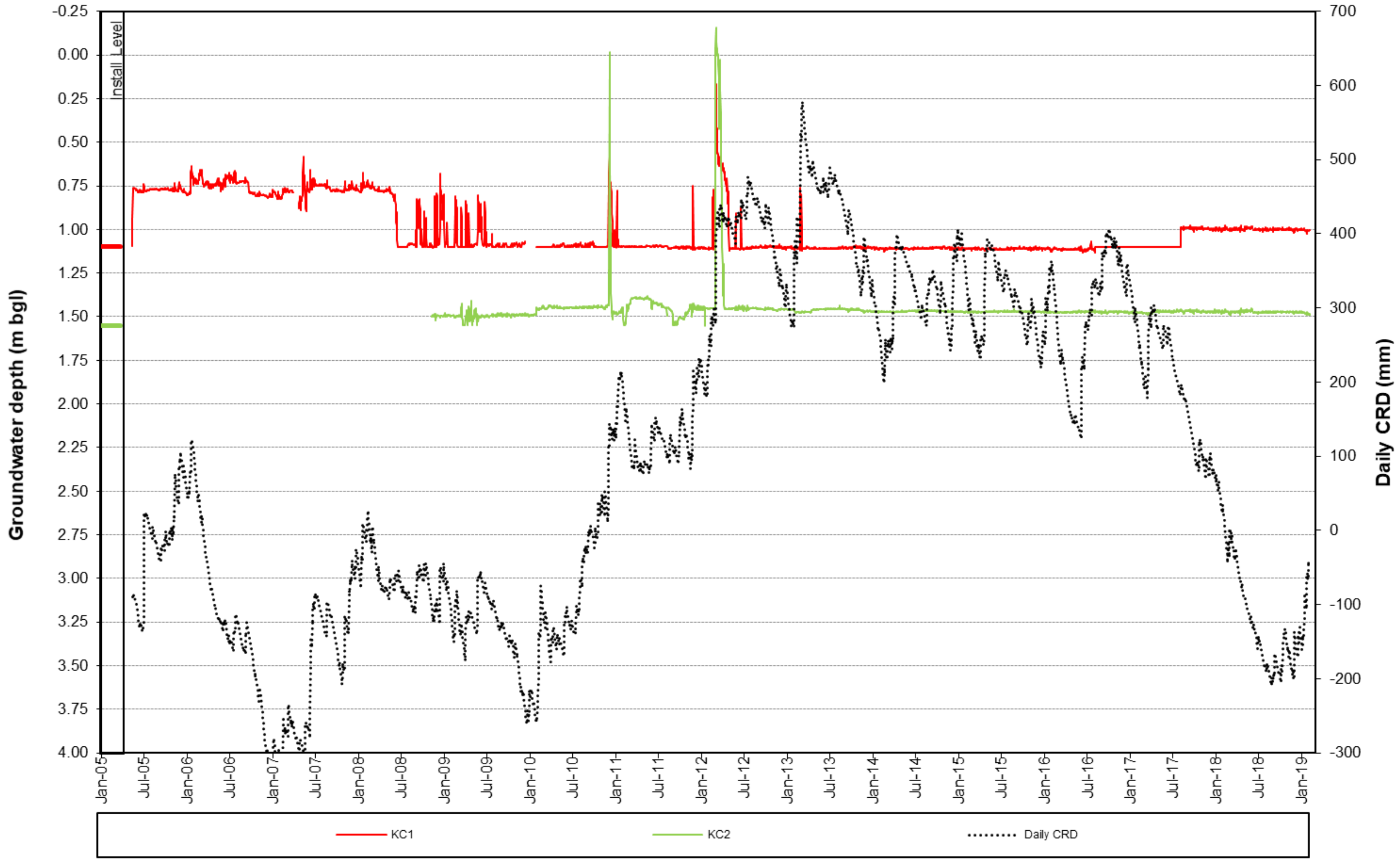
D.2 Baseline monitoring data

D.2.1 Standpipe piezometer monitoring

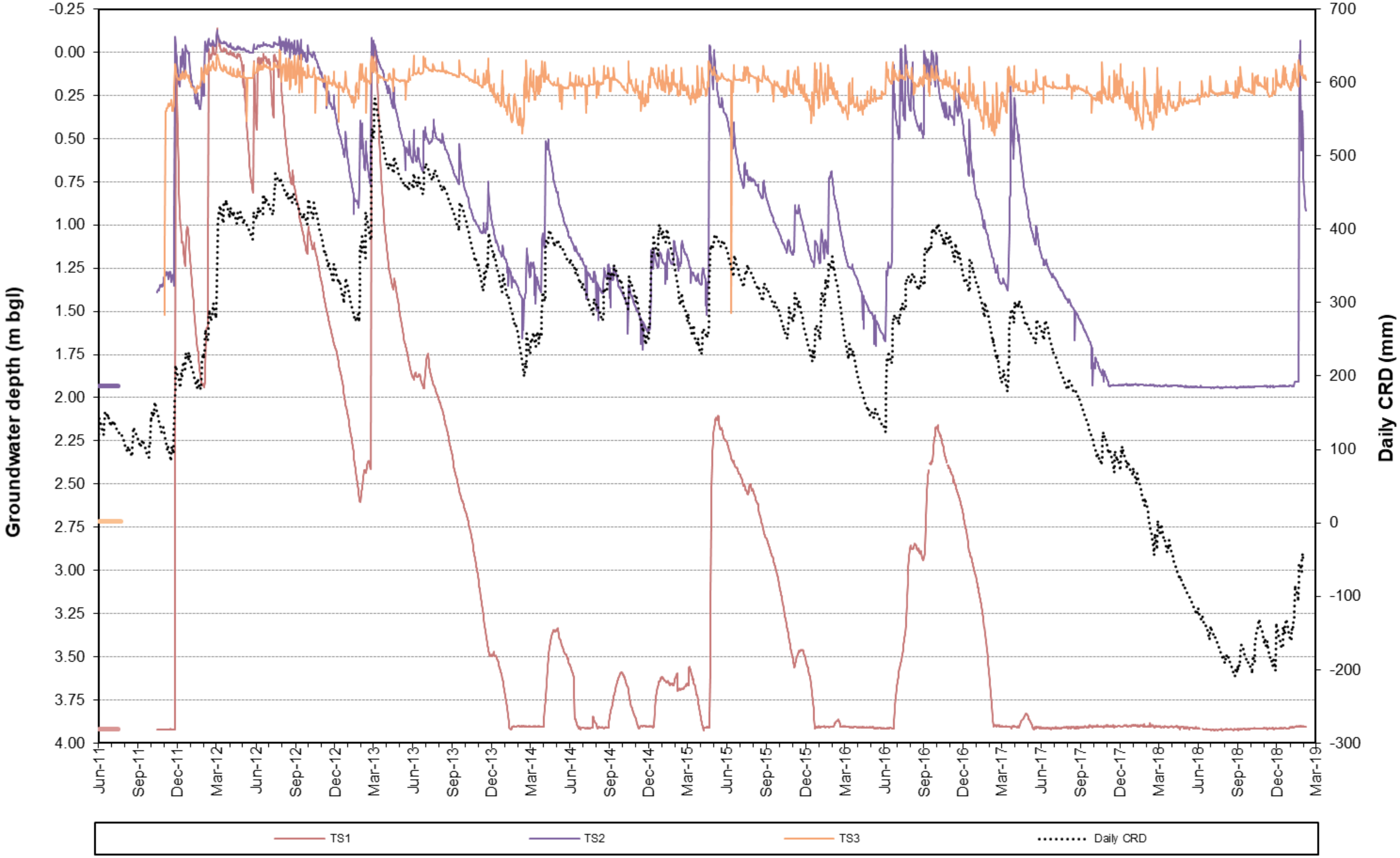


D.2.2 Swamp piezometer monitoring

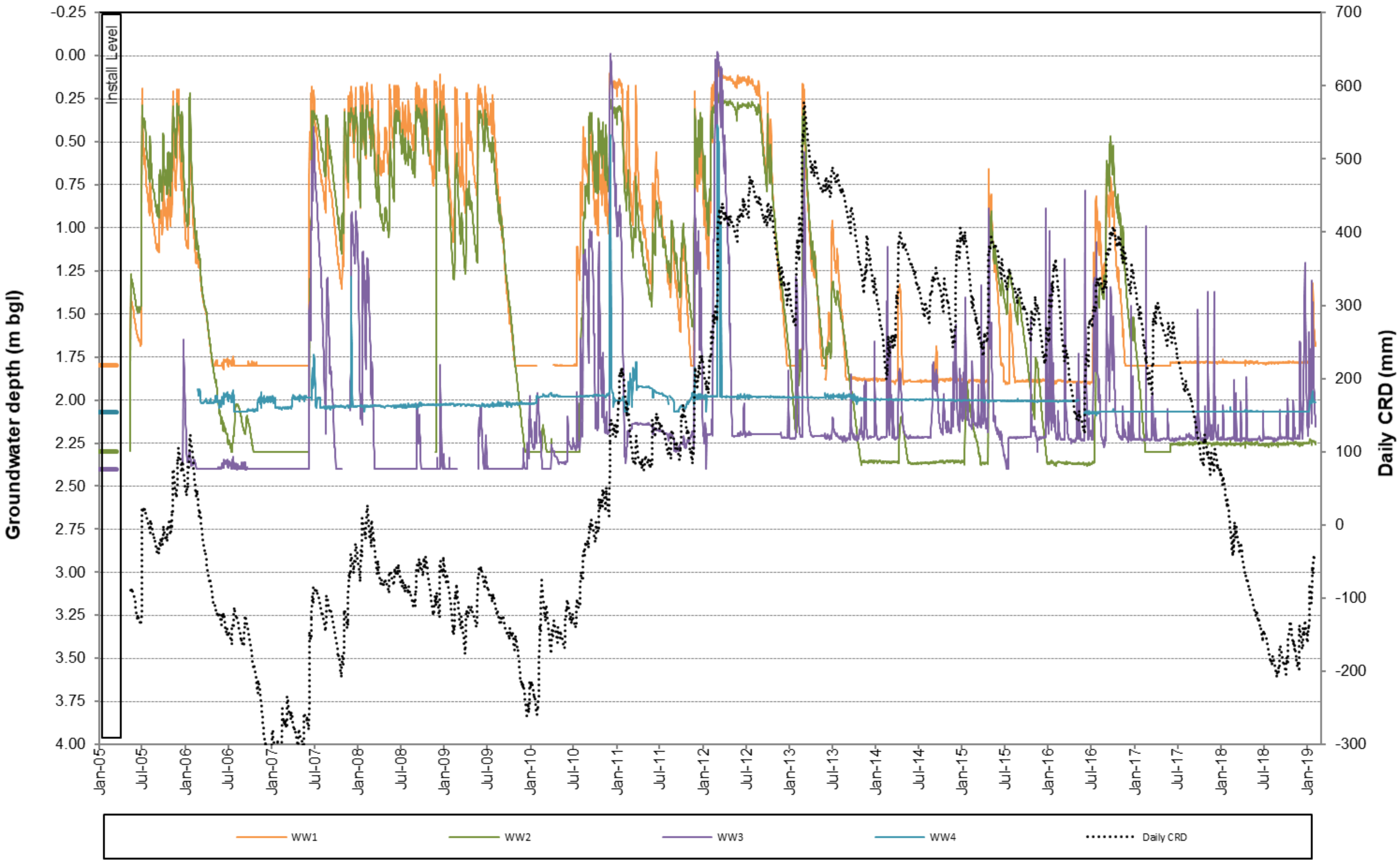
Kangaroo Creek Swamp



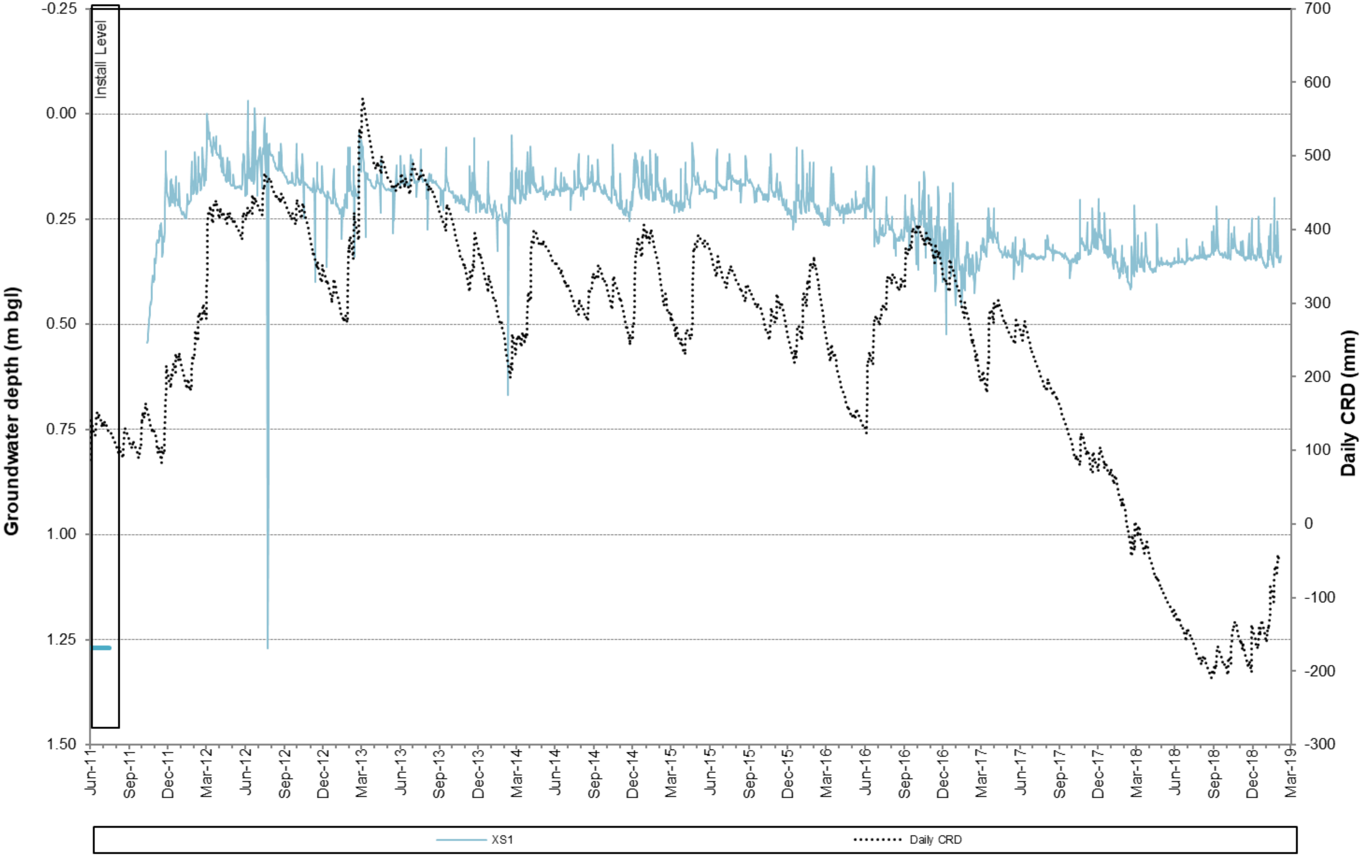
Tri Star Swamp



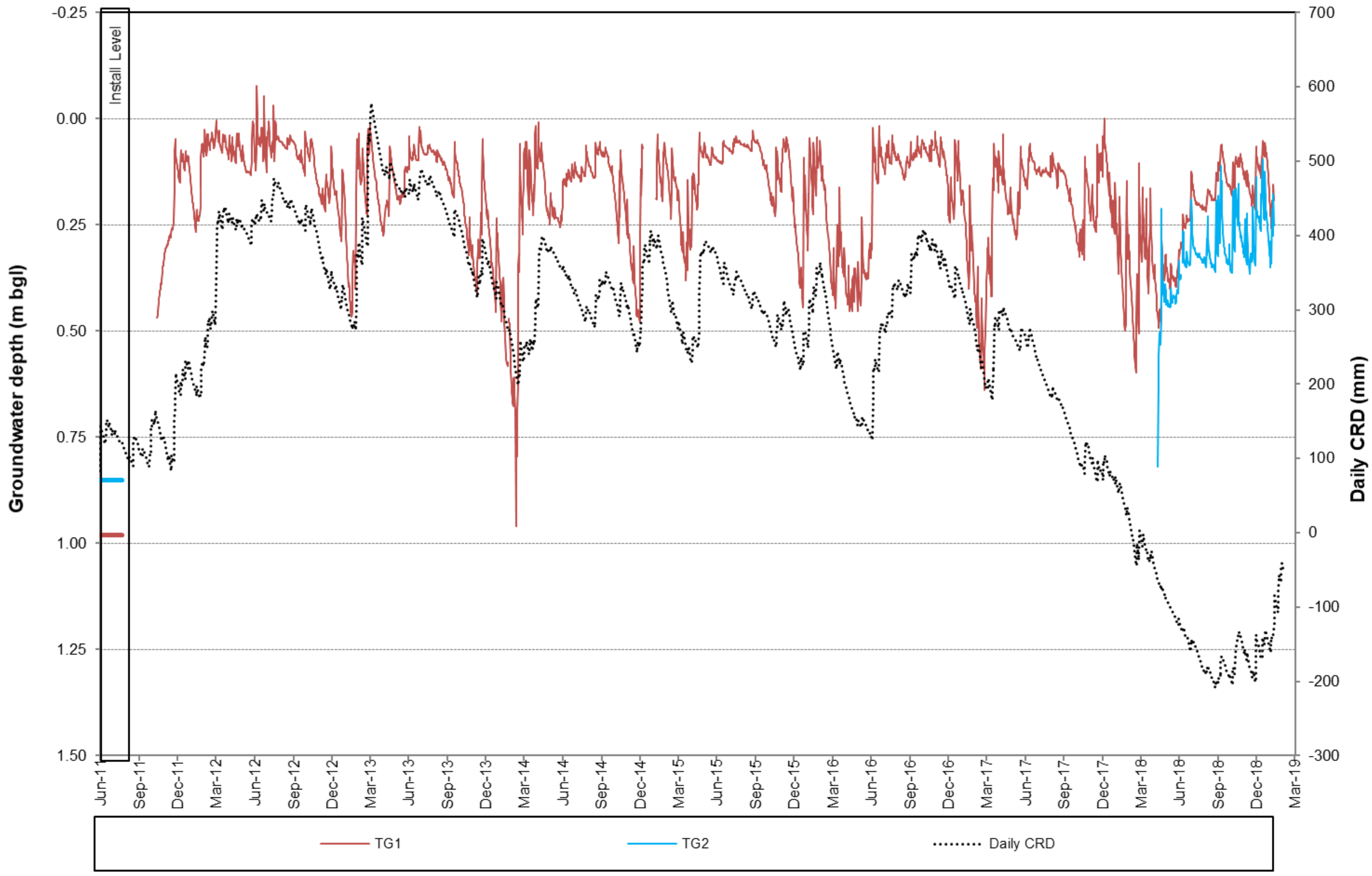
West Wolgan Swamp



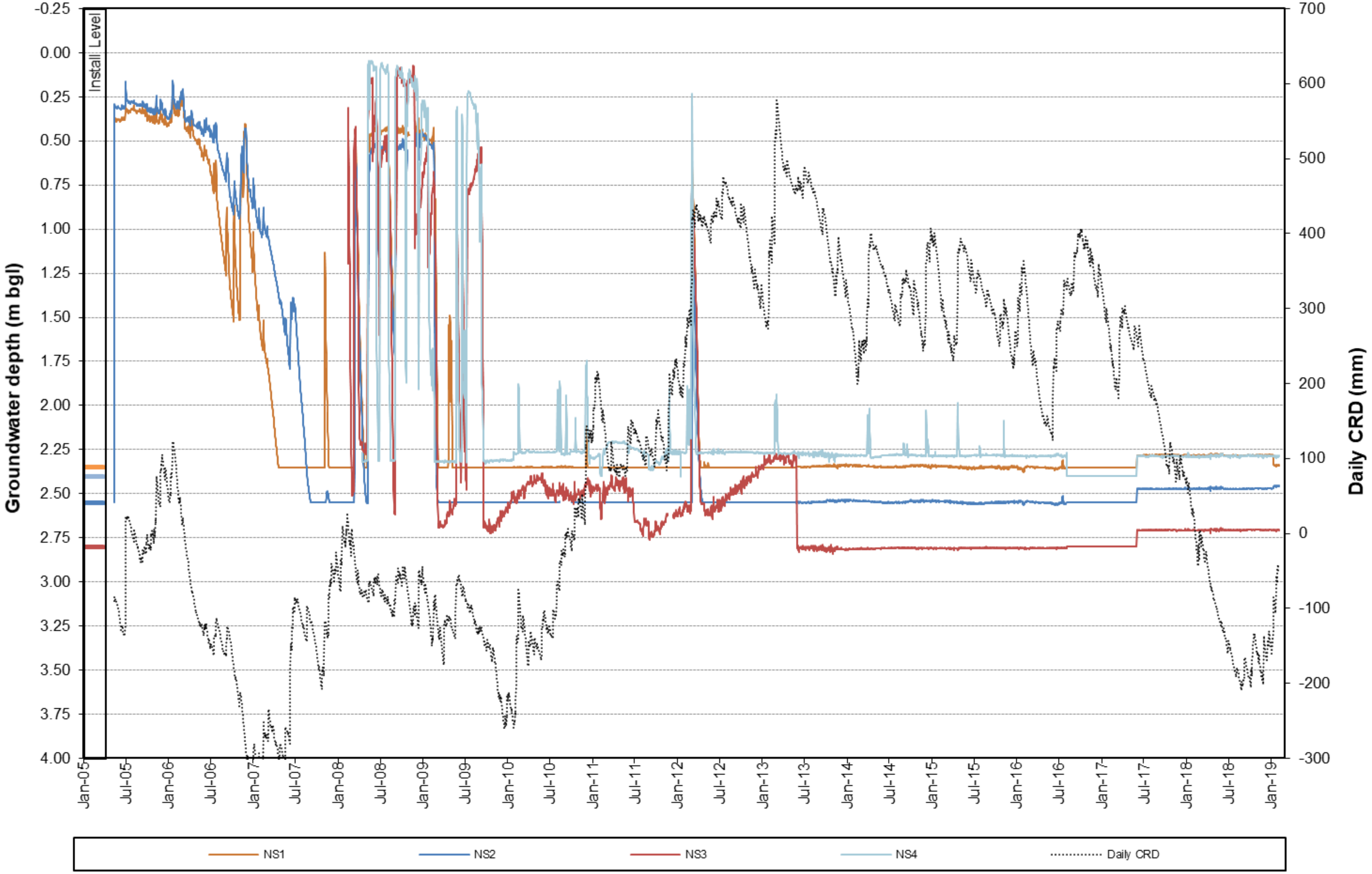
Trail Six Swamp



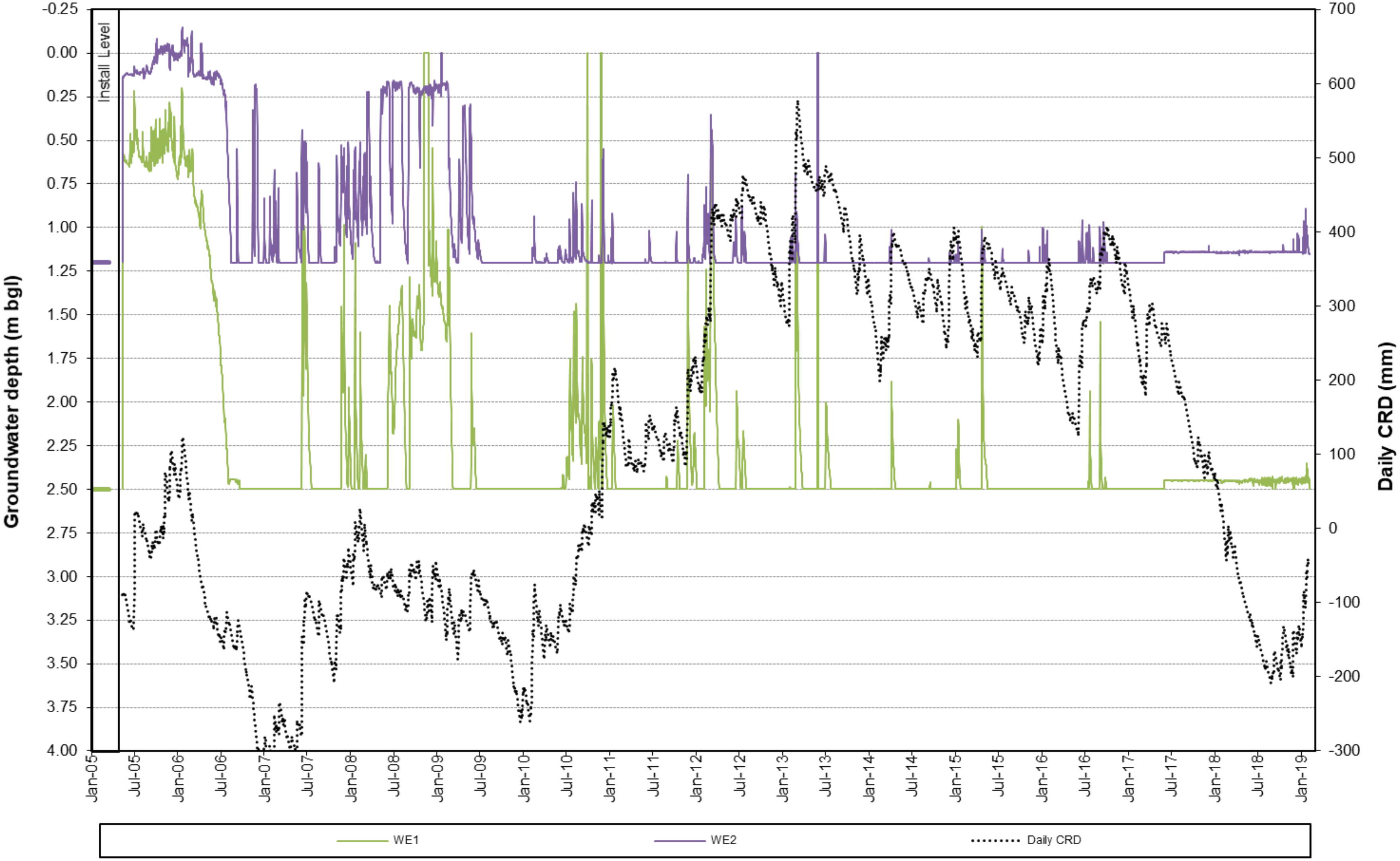
Twin Gully Swamp



Narrow Swamp

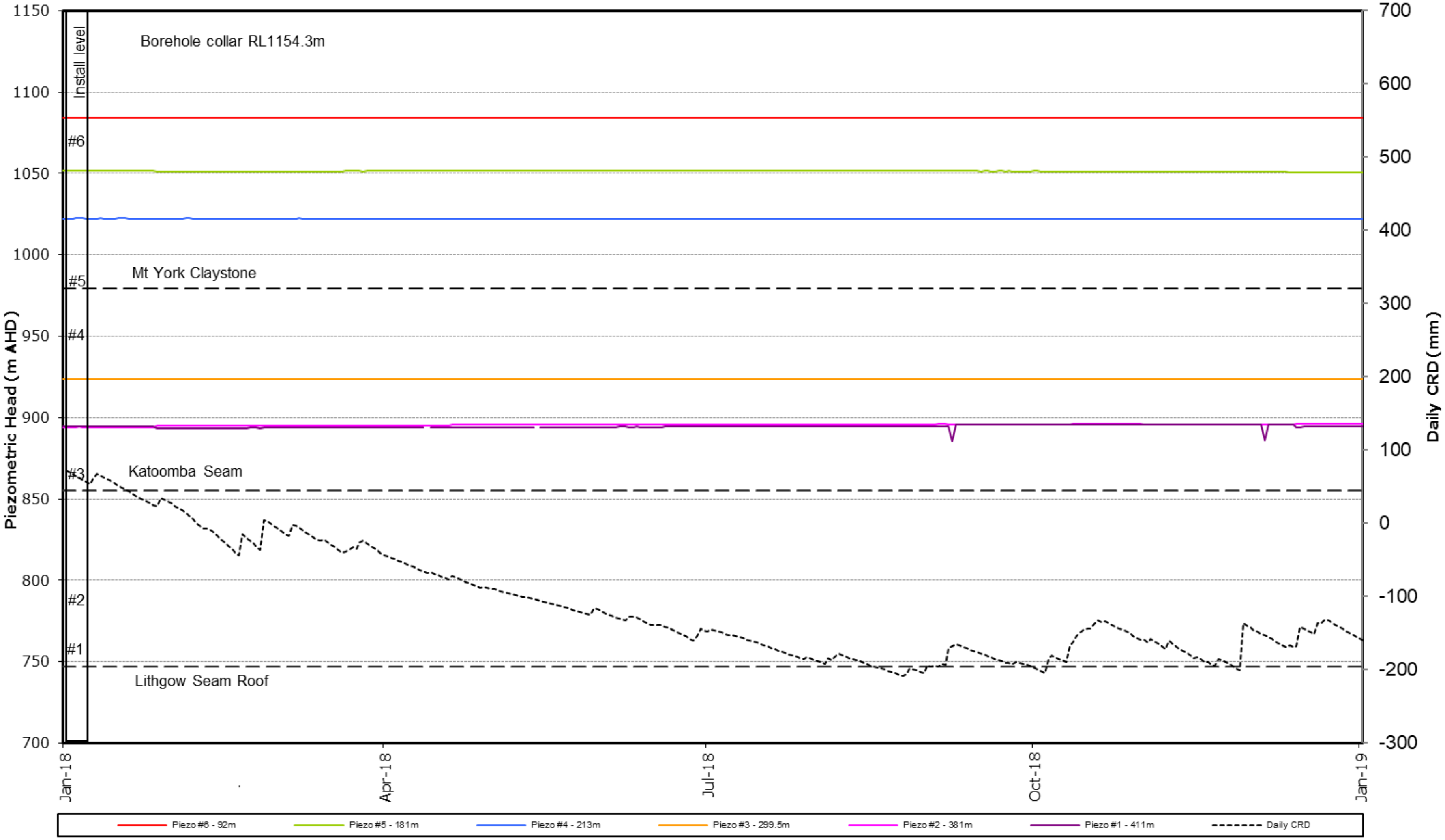


East Wolgan Swamp

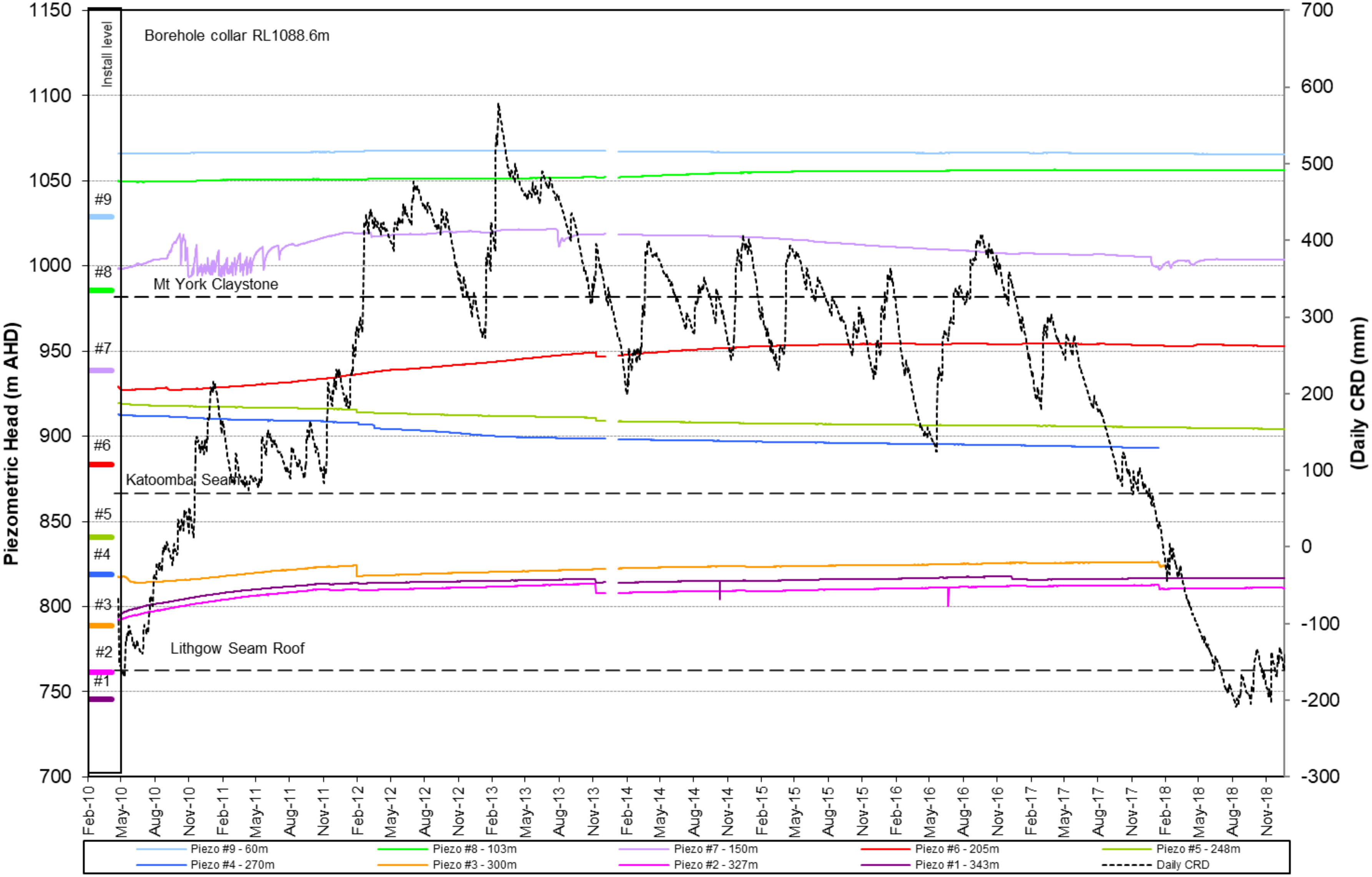


D.2.3 Vibrating wire piezometer monitoring

AP2PR

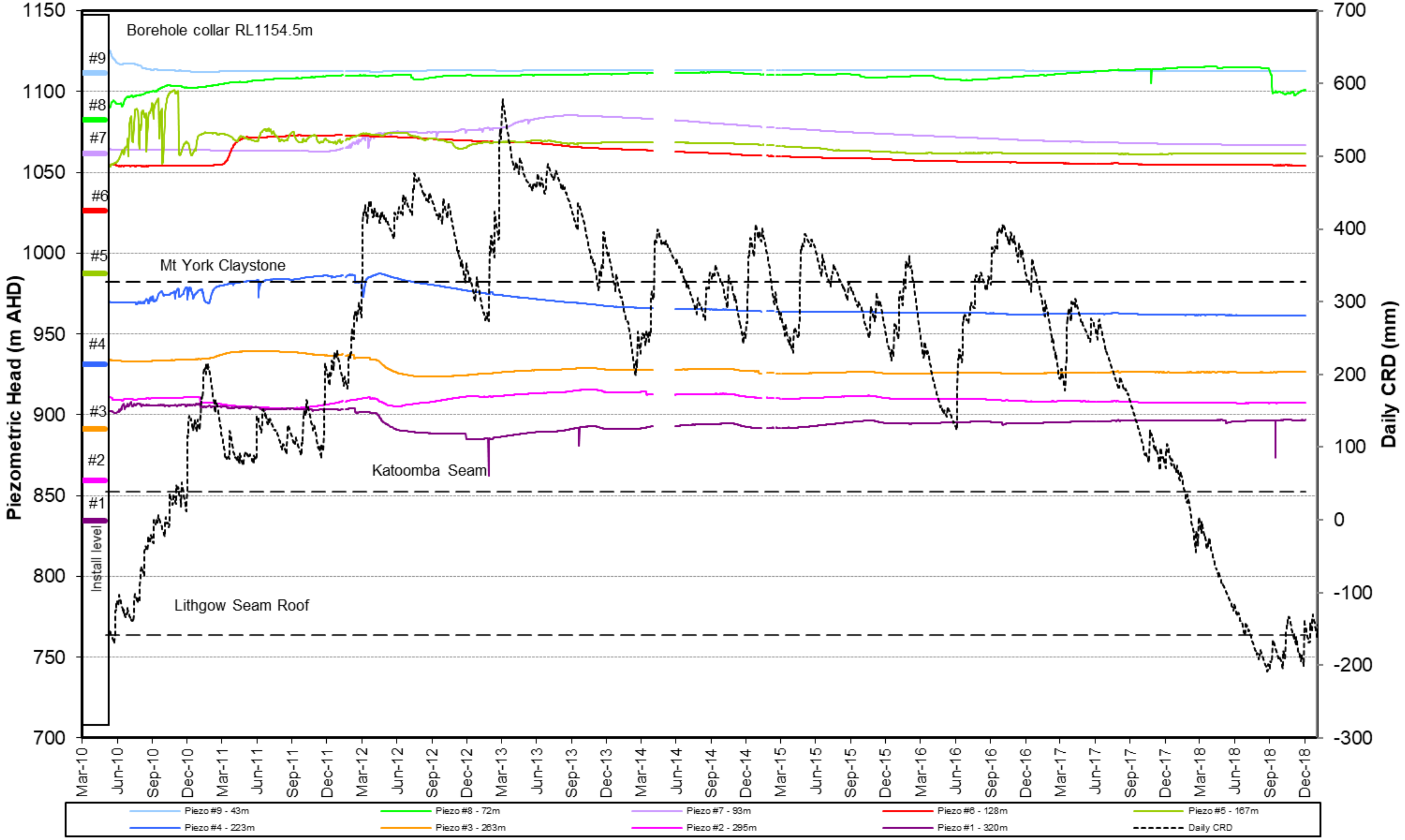


AP10PR



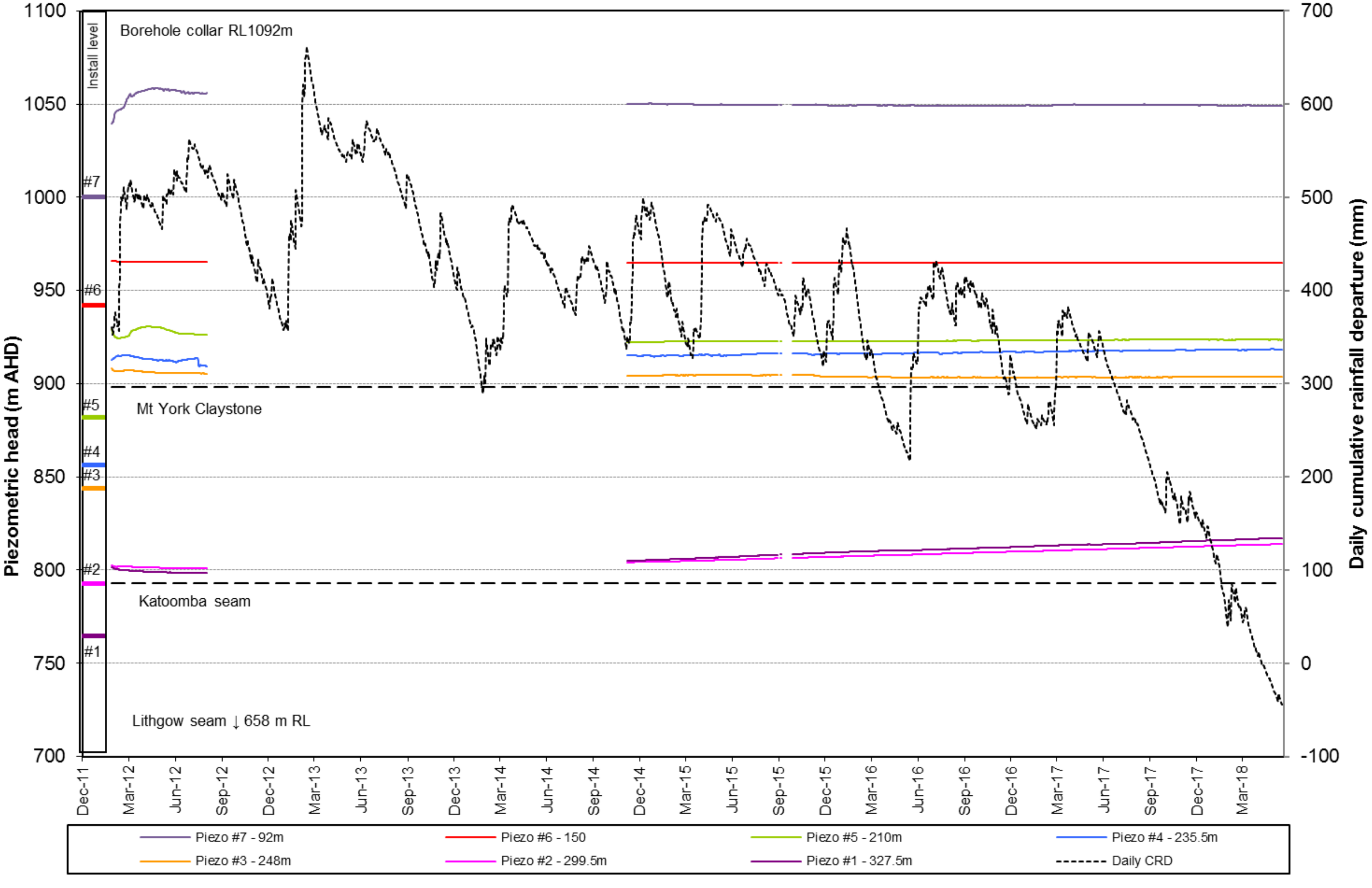
Borehole collar RL1088.6m
Install level
Mt York Claystone
Katoomba Seam
Lithgow Seam Roof
#9
#8
#7
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
(Daily CRD (mm)
1150
1100
1050
1000
950
900
850
800
750
700
700
600
500
400
300
200
100
0
-100
-200
-300
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Piezo #9 - 60m
Piezo #8 - 103m
Piezo #7 - 150m
Piezo #6 - 205m
Piezo #5 - 248m
Piezo #4 - 270m
Piezo #3 - 300m
Piezo #2 - 327m
Piezo #1 - 343m
Daily CRD

AP11PR



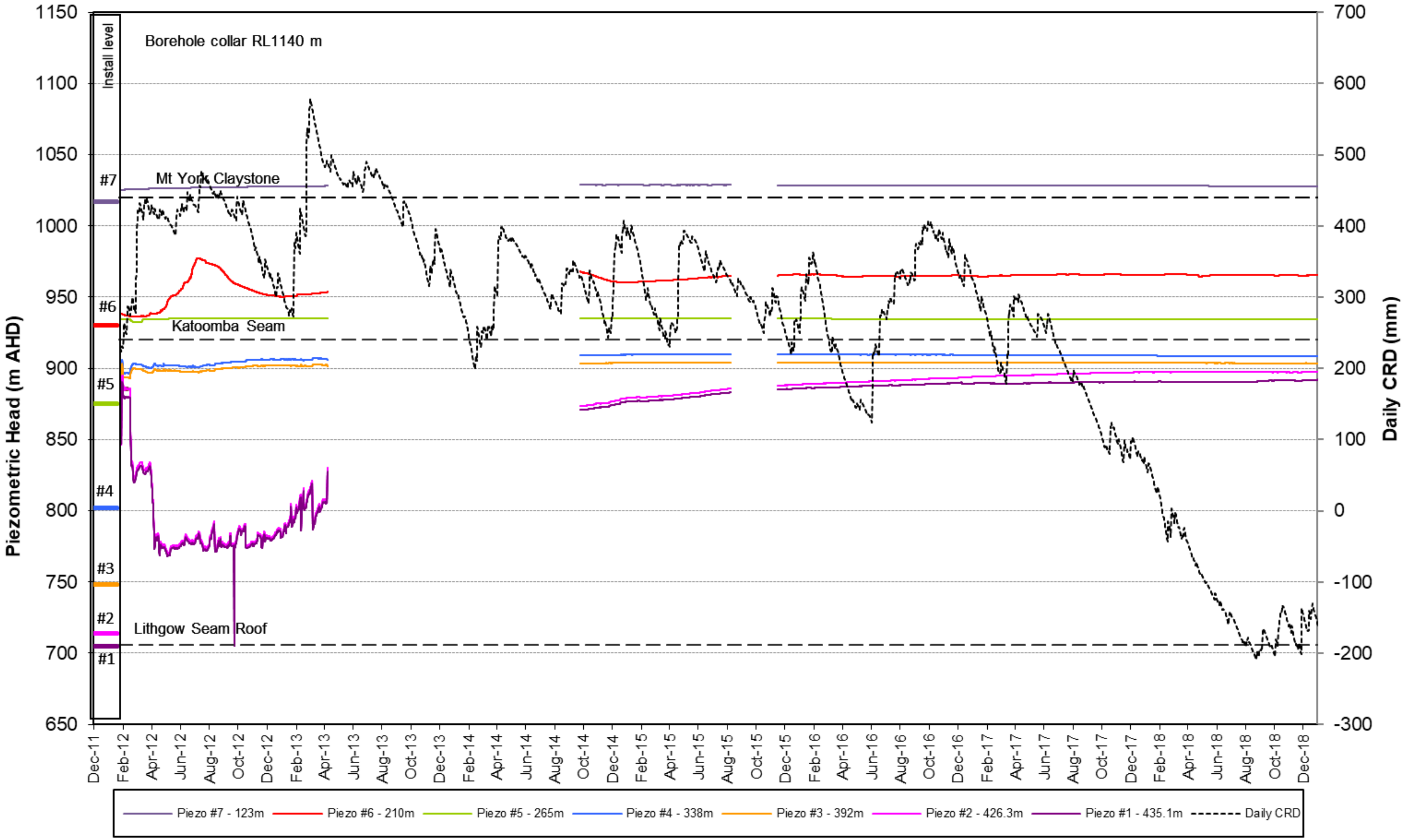
Borehole collar RL1154.5m
Mt York Claystone
Katoomba Seam
Lithgow Seam Roof
Install level
#9
#8
#7
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Daily CRD (mm)
1150
1100
1050
1000
950
900
850
800
750
700
700
600
500
400
300
200
100
0
-100
-200
-300
Mar-10
Jun-10
Sep-10
Dec-10
Mar-11
Jun-11
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Sep-15
Dec-15
Mar-16
Jun-16
Sep-16
Dec-16
Mar-17
Jun-17
Sep-17
Dec-17
Mar-18
Jun-18
Sep-18
Dec-18
Piezo #9 - 43m
Piezo #8 - 72m
Piezo #7 - 93m
Piezo #6 - 128m
Piezo #5 - 167m
Piezo #4 - 223m
Piezo #3 - 263m
Piezo #2 - 295m
Piezo #1 - 320m
Daily CRD

AP1101



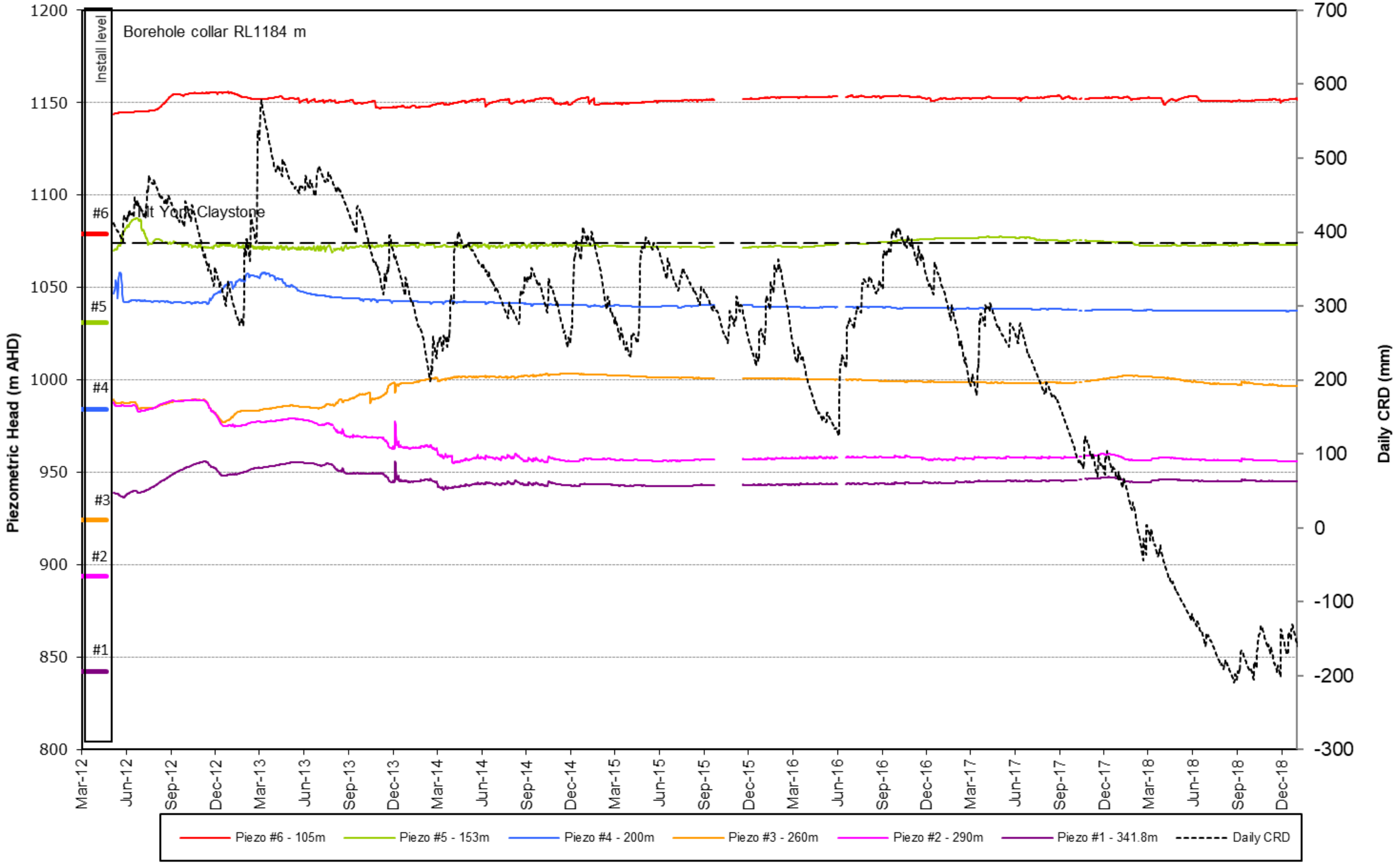
Borehole collar RL1092m
Install level
#7
#6
#5
#4
#3
#2
#1
Mt York Claystone
Katoomba seam
Lithgow seam ↓ 658 m RL
Piezometric head (m AHD)
Daily cumulative rainfall departure (mm)
1100
1050
1000
950
900
850
800
750
700
700
600
500
400
300
200
100
0
-100
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Sep-15
Dec-15
Mar-16
Jun-16
Sep-16
Dec-16
Mar-17
Jun-17
Sep-17
Dec-17
Mar-18
Piezo #7 - 92m
Piezo #6 - 150
Piezo #5 - 210m
Piezo #4 - 235.5m
Piezo #3 - 248m
Piezo #2 - 299.5m
Piezo #1 - 327.5m
Daily CRD

AP1102



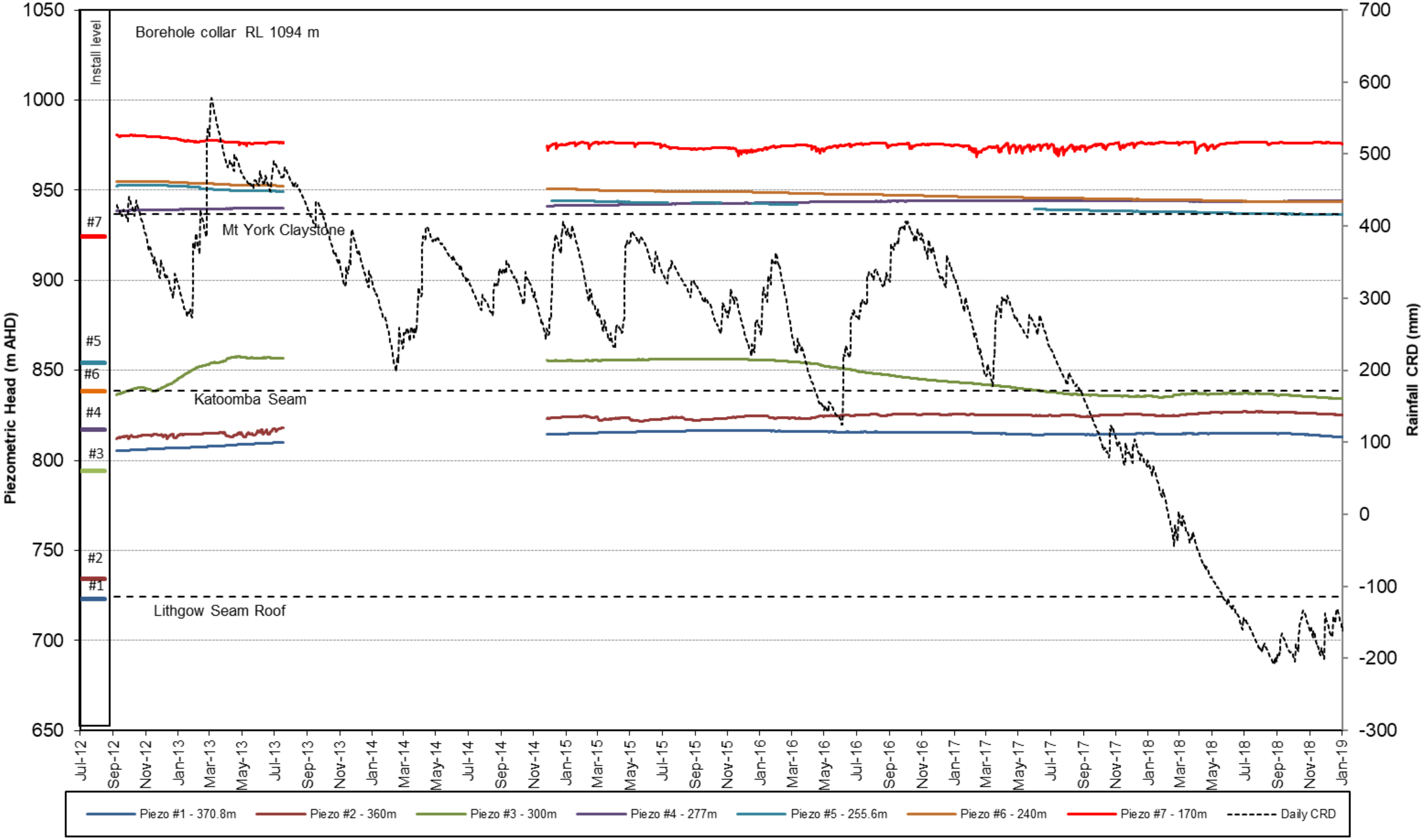
Piezometric Head (m AHD)
Daily CRD (mm)
Install level
Borehole collar RL1140 m
Mt York Claystone
Katoomba Seam
Lithgow Seam Roof
#7
#6
#5
#4
#3
#2
#1
Piezo #7 - 123m
Piezo #6 - 210m
Piezo #5 - 265m
Piezo #4 - 338m
Piezo #3 - 392m
Piezo #2 - 426.3m
Piezo #1 - 435.1m
Daily CRD

AP1103



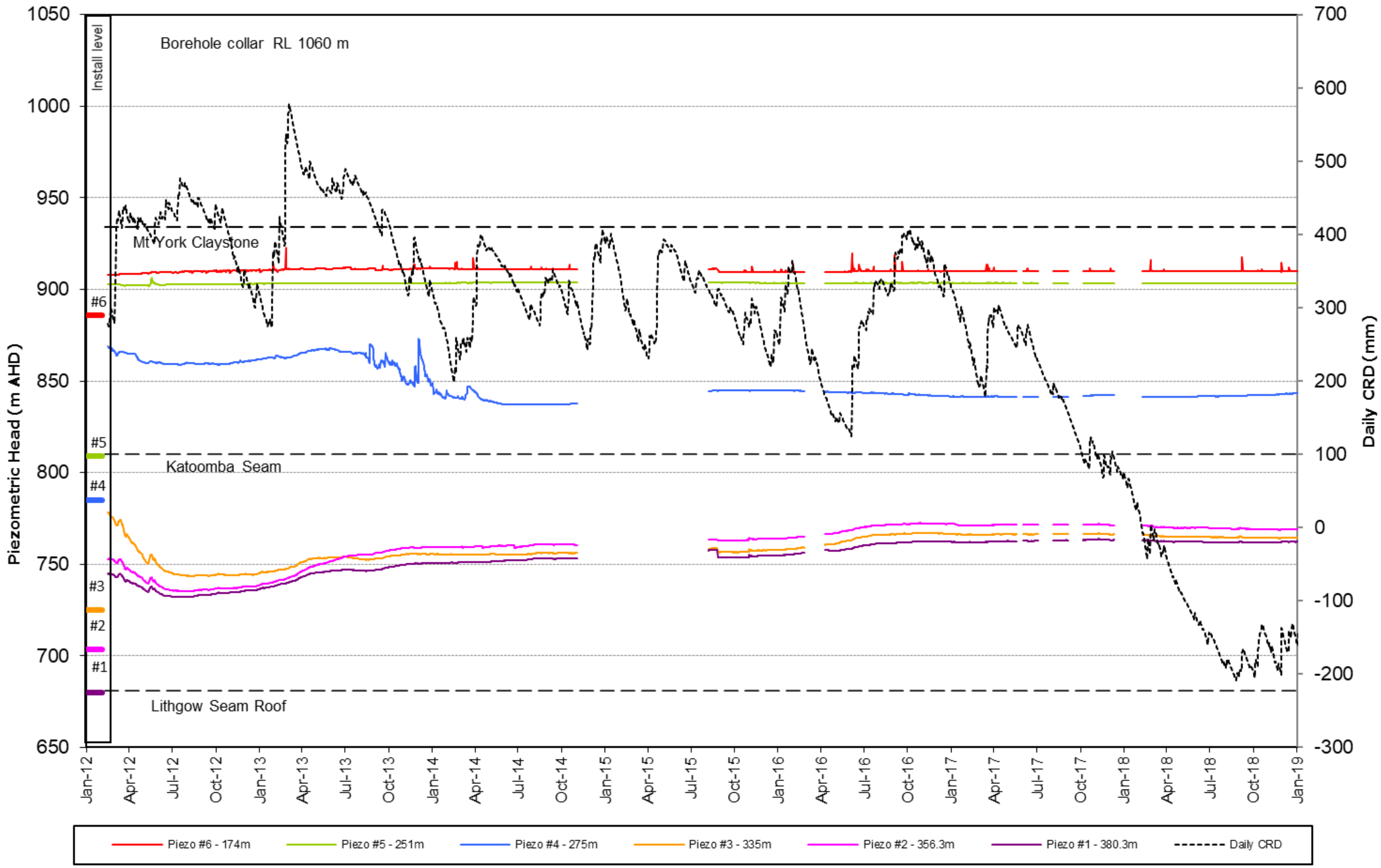
Borehole collar RL1184 m
Install level
Mt York Claystone
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Daily CRD (mm)
1200
1150
1100
1050
1000
950
900
850
800
700
600
500
400
300
200
100
0
-100
-200
-300
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Sep-15
Dec-15
Mar-16
Jun-16
Sep-16
Dec-16
Mar-17
Jun-17
Sep-17
Dec-17
Mar-18
Jun-18
Sep-18
Dec-18
Piezo #6 - 105m
Piezo #5 - 153m
Piezo #4 - 200m
Piezo #3 - 260m
Piezo #2 - 290m
Piezo #1 - 341.8m
Daily CRD

AP1104



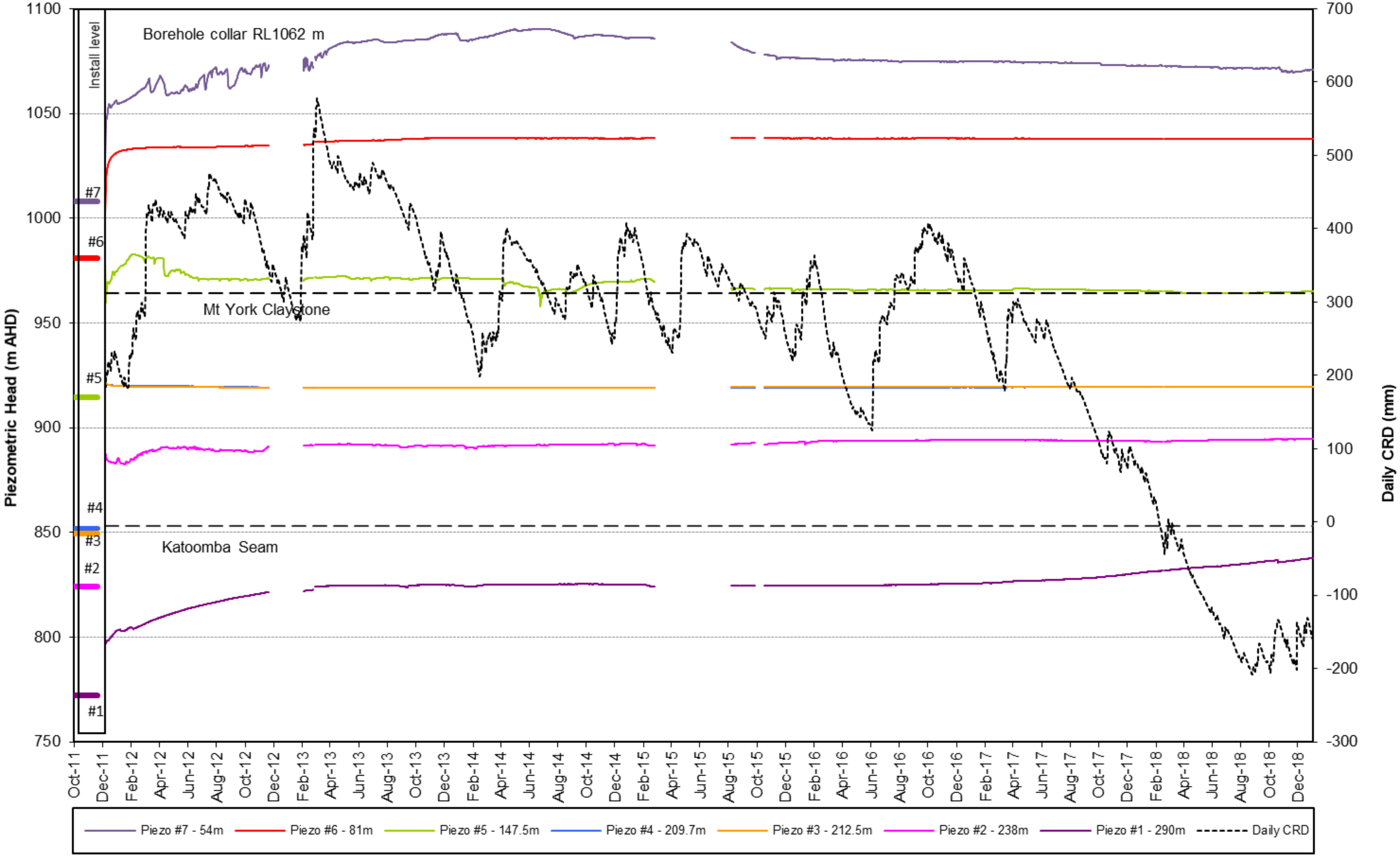
Borehole collar RL 1094 m
Install level
Mt York Claystone
Katoomba Seam
Lithgow Seam Roof
#7
#5
#6
#4
#3
#2
#1
Piezometric Head (m AHD)
Rainfall CRD (mm)
1050
1000
950
900
850
800
750
700
650
700
600
500
400
300
200
100
0
-100
-200
-300
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Jan-15
Mar-15
May-15
Jul-15
Sep-15
Nov-15
Jan-16
Mar-16
May-16
Jul-16
Sep-16
Nov-16
Jan-17
Mar-17
May-17
Jul-17
Sep-17
Nov-17
Jan-18
Mar-18
May-18
Jul-18
Sep-18
Nov-18
Jan-19
Piezo #1 - 370.8m
Piezo #2 - 360m
Piezo #3 - 300m
Piezo #4 - 277m
Piezo #5 - 255.6m
Piezo #6 - 240m
Piezo #7 - 170m
Daily CRD

AP1106



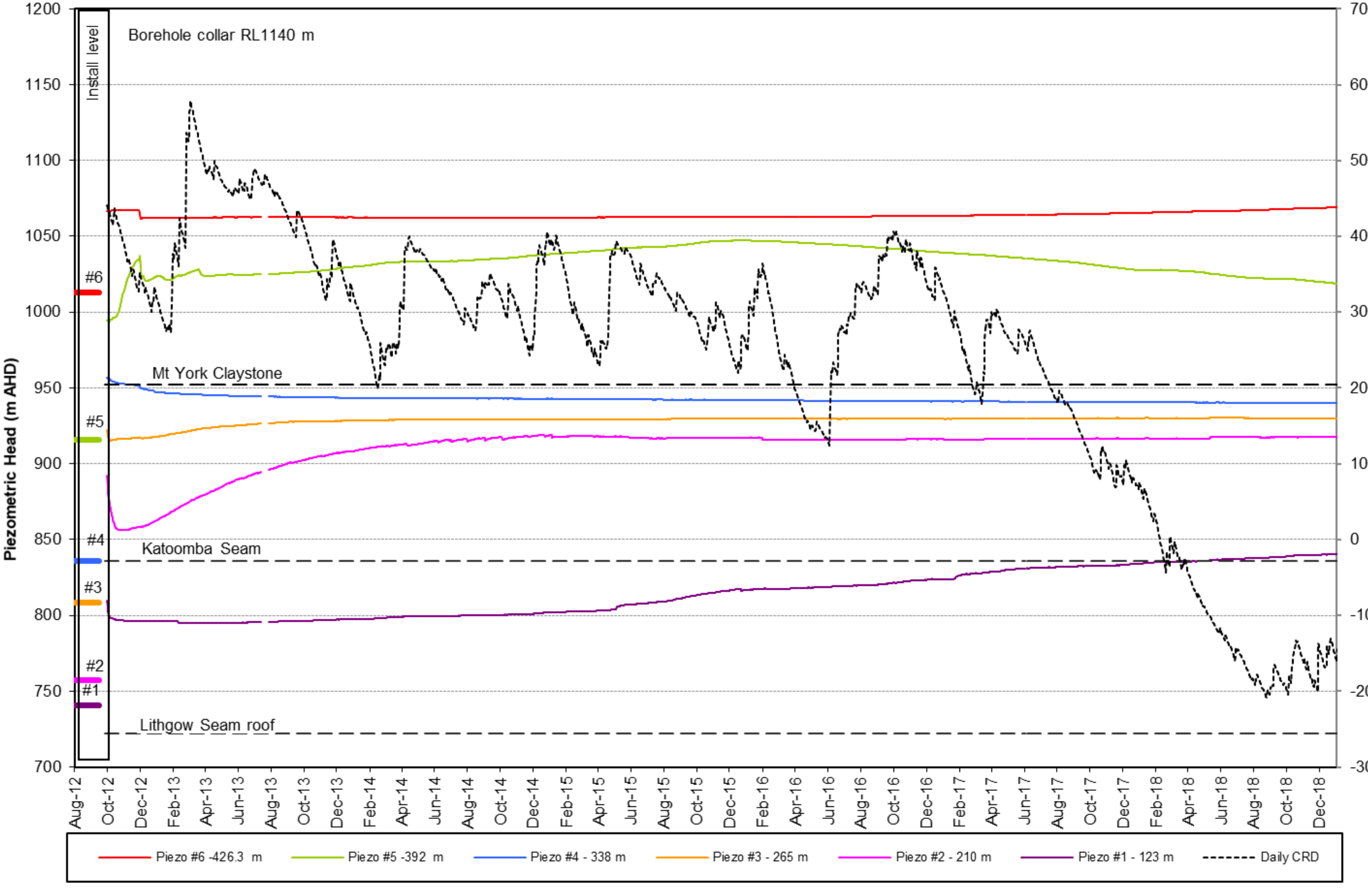
Install level
Borehole collar RL 1060 m
Mt York Claystone
Katoomba Seam
Lithgow Seam Roof
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Daily CRD (mm)
1050
1000
950
900
850
800
750
700
650
700
600
500
400
300
200
100
0
-100
-200
-300
Jan-12
Apr-12
Jul-12
Oct-12
Jan-13
Apr-13
Jul-13
Oct-13
Jan-14
Apr-14
Jul-14
Oct-14
Jan-15
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Piezo #6 - 174m
Piezo #5 - 251m
Piezo #4 - 275m
Piezo #3 - 335m
Piezo #2 - 356.3m
Piezo #1 - 380.3m
Daily CRD

AP1107



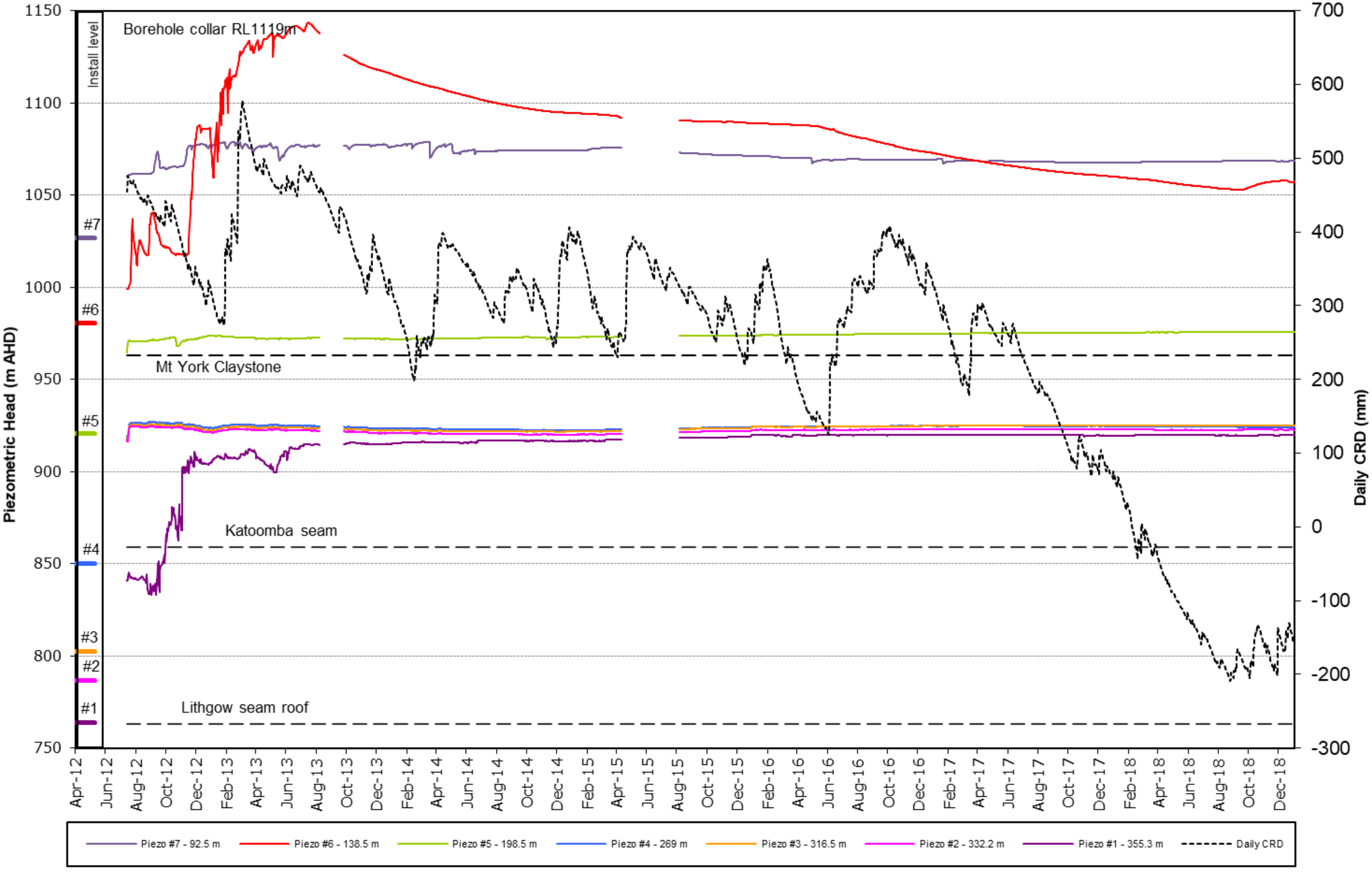
Borehole collar RL1062 m
Install level
Mt York Claystone
Katoomba Seam
#7
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Daily CRD (mm)
1100
1050
1000
950
900
850
800
750
700
600
500
400
300
200
100
0
-100
-200
-300
Oct-11
Dec-11
Feb-12
Apr-12
Jun-12
Aug-12
Oct-12
Dec-12
Feb-13
Apr-13
Jun-13
Aug-13
Oct-13
Dec-13
Feb-14
Apr-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Jun-16
Aug-16
Oct-16
Dec-16
Feb-17
Apr-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Oct-18
Dec-18
Piezo #7 - 54m
Piezo #6 - 81m
Piezo #5 - 147.5m
Piezo #4 - 209.7m
Piezo #3 - 212.5m
Piezo #2 - 238m
Piezo #1 - 290m
Daily CRD

AP1110

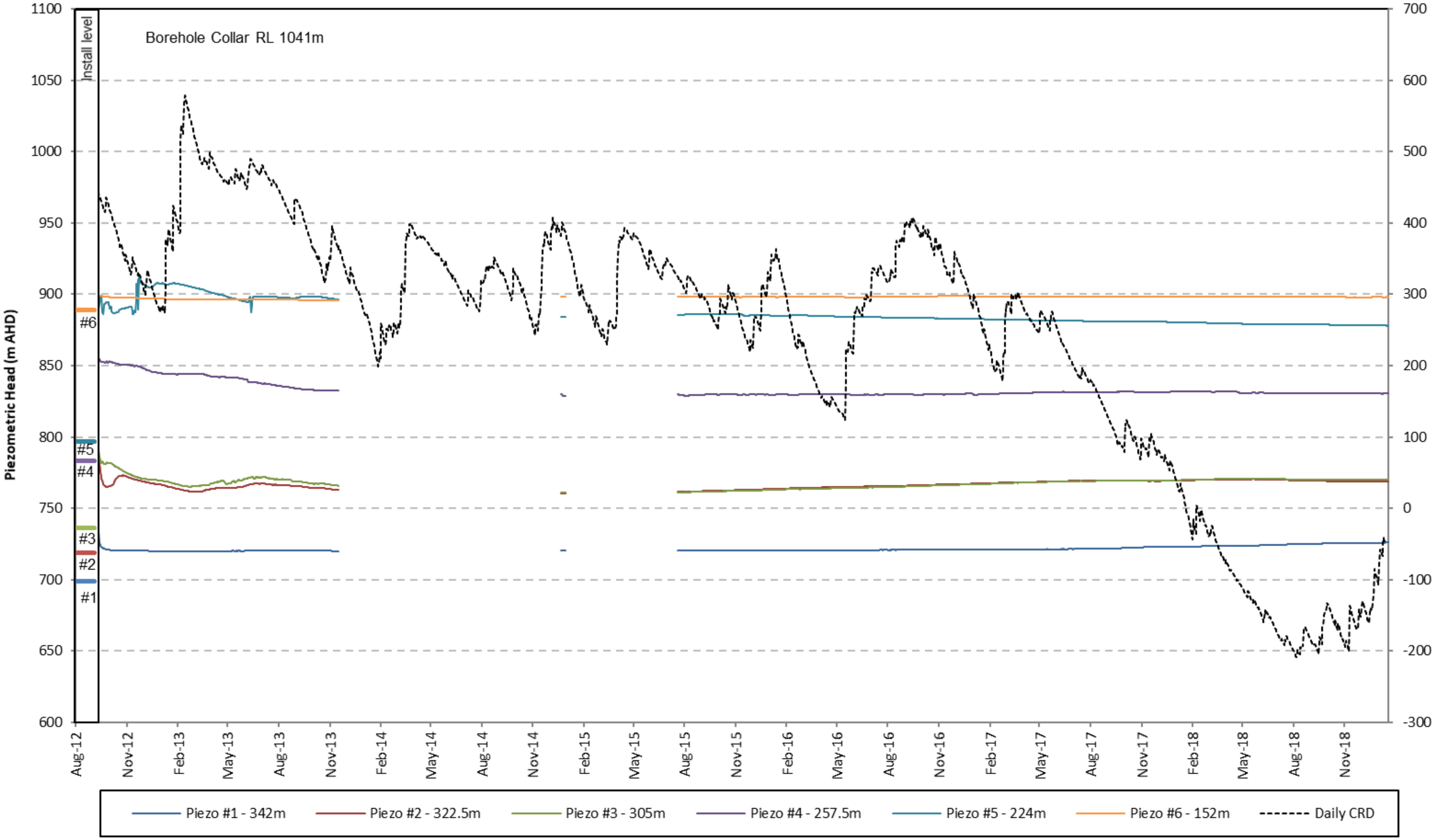


Borehole collar RL1140 m
Install level
Piezometric Head (m AHD)
Daily CRD (mm)
1200
1150
1100
1050
1000
950
900
850
800
750
700
700
600
500
400
300
200
100
0
-100
-200
-300
#6
#5
#4
#3
#2
#1
Mt York Claystone
Katoomba Seam
Lithgow Seam roof
Aug-12
Oct-12
Dec-12
Feb-13
Apr-13
Jun-13
Aug-13
Oct-13
Dec-13
Feb-14
Apr-14
Jun-14
Aug-14
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Jun-16
Aug-16
Oct-16
Dec-16
Feb-17
Apr-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Oct-18
Dec-18
Piezo #6 -426.3 m
Piezo #5 -392 m
Piezo #4 - 338 m
Piezo #3 - 265 m
Piezo #2 - 210 m
Piezo #1 - 123 m
Daily CRD

AP1204

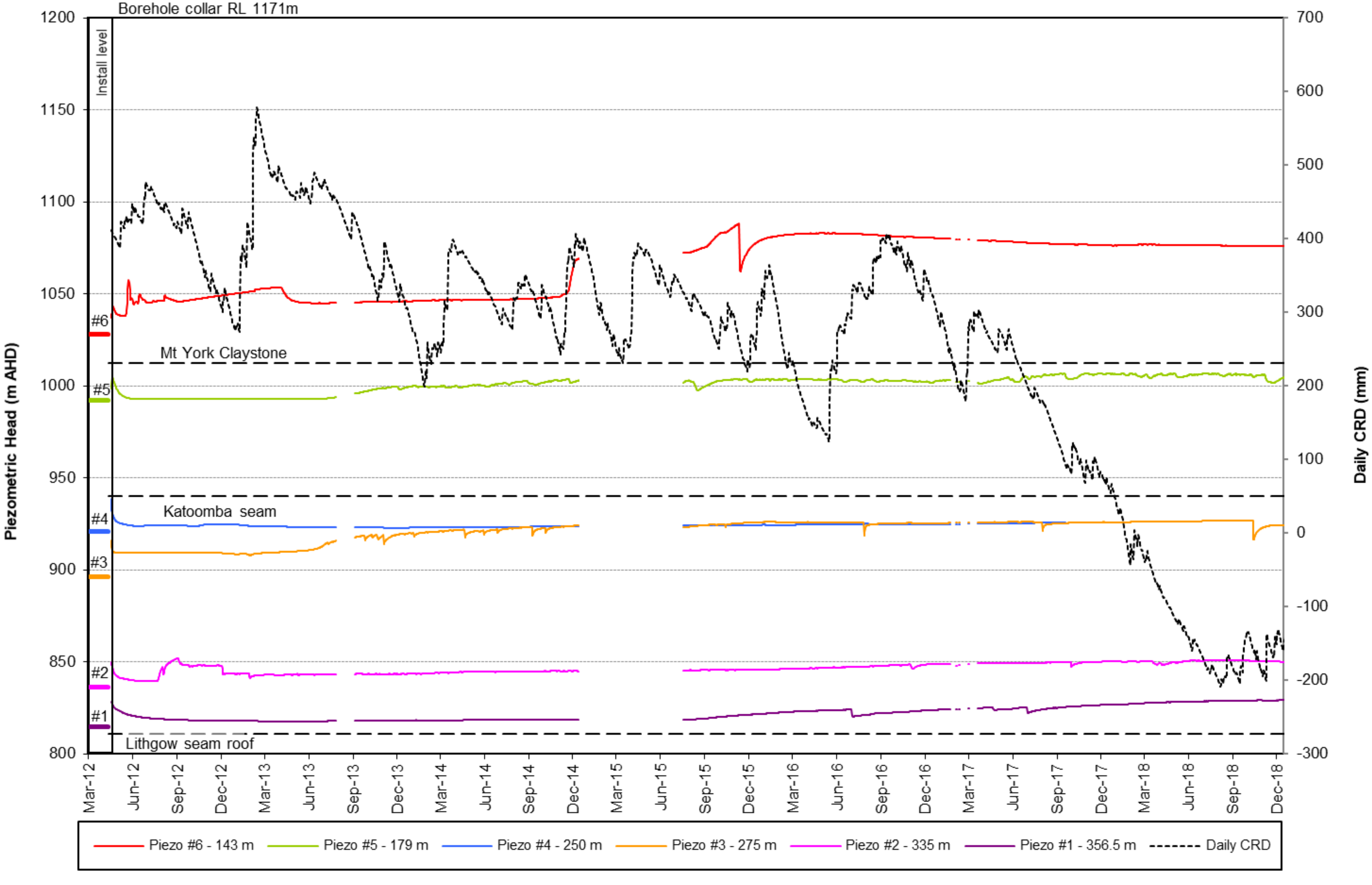

Borehole collar RL1119m
Install level
Mt York Claystone
Katoomba seam
Lithgow seam roof
#7
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Daily CRD (mm)
1150
1100
1050
1000
950
900
850
800
750
700
600
500
400
300
200
100
0
-100
-200
-300
Apr-12 Jun-12 Aug-12 Oct-12 Dec-12 Feb-13 Apr-13 Jun-13 Aug-13 Oct-13 Dec-13 Feb-14 Apr-14 Jun-14 Aug-14 Oct-14 Dec-14 Feb-15 Apr-15 Jun-15 Aug-15 Oct-15 Dec-15 Feb-16 Apr-16 Jun-16 Aug-16 Oct-16 Dec-16 Feb-17 Apr-17 Jun-17 Aug-17 Oct-17 Dec-17 Feb-18 Apr-18 Jun-18 Aug-18 Oct-18 Dec-18
Piezo #7 - 92.5 m
Piezo #6 - 138.5 m
Piezo #5 - 198.5 m
Piezo #4 - 269 m
Piezo #3 - 316.5 m
Piezo #2 - 332.2 m
Piezo #1 - 355.3 m
Daily CRD

AP1206



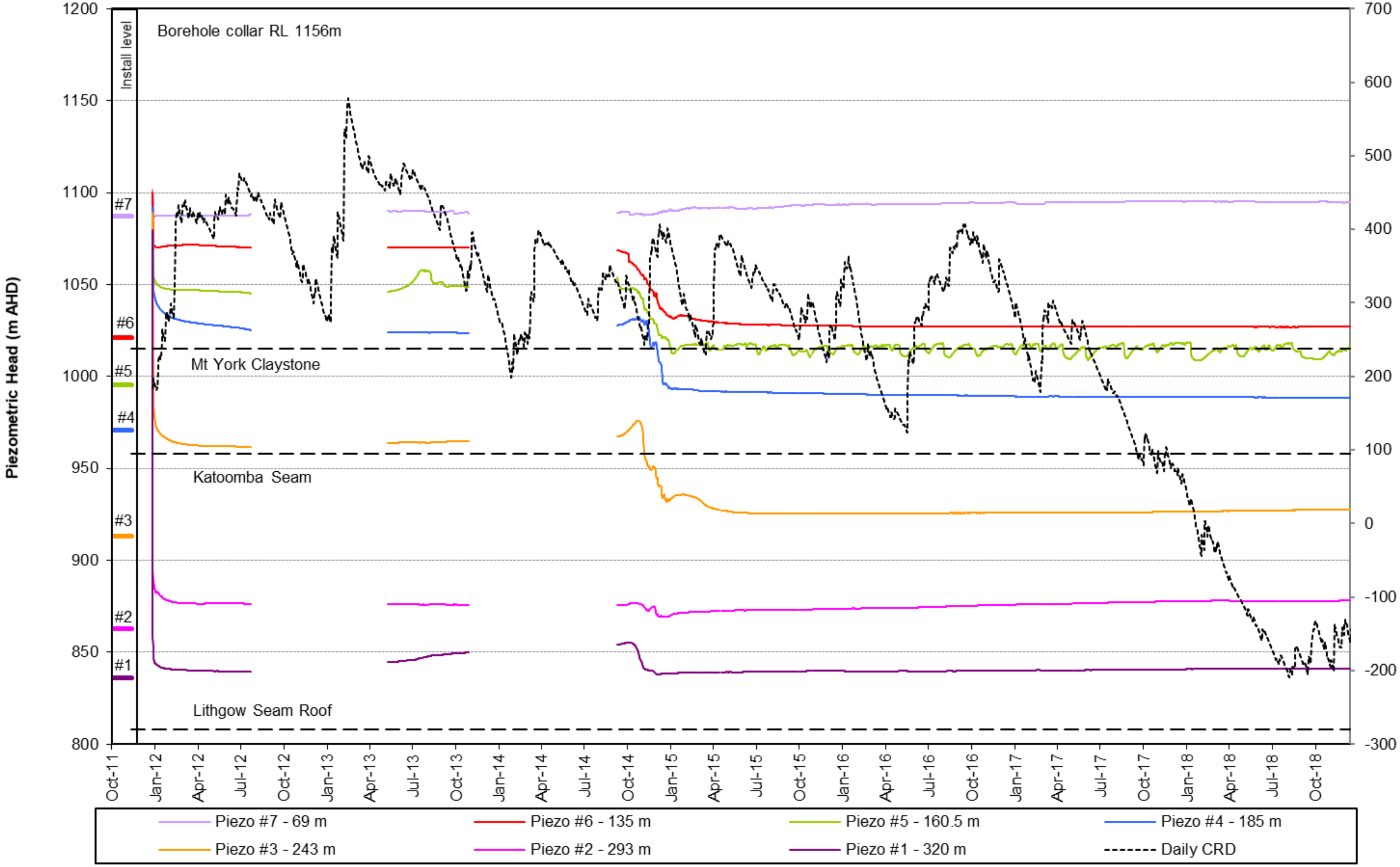
Borehole Collar RL 1041m
Install level
Piezometric Head (m AHD)
Daily CRD (mm)
#6
#5
#4
#3
#2
#1
1100
1050
1000
950
900
850
800
750
700
650
600
700
600
500
400
300
200
100
0
-100
-200
-300
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Piezo #1 - 342m
Piezo #2 - 322.5m
Piezo #3 - 305m
Piezo #4 - 257.5m
Piezo #5 - 224m
Piezo #6 - 152m
Daily CRD

APXXB1



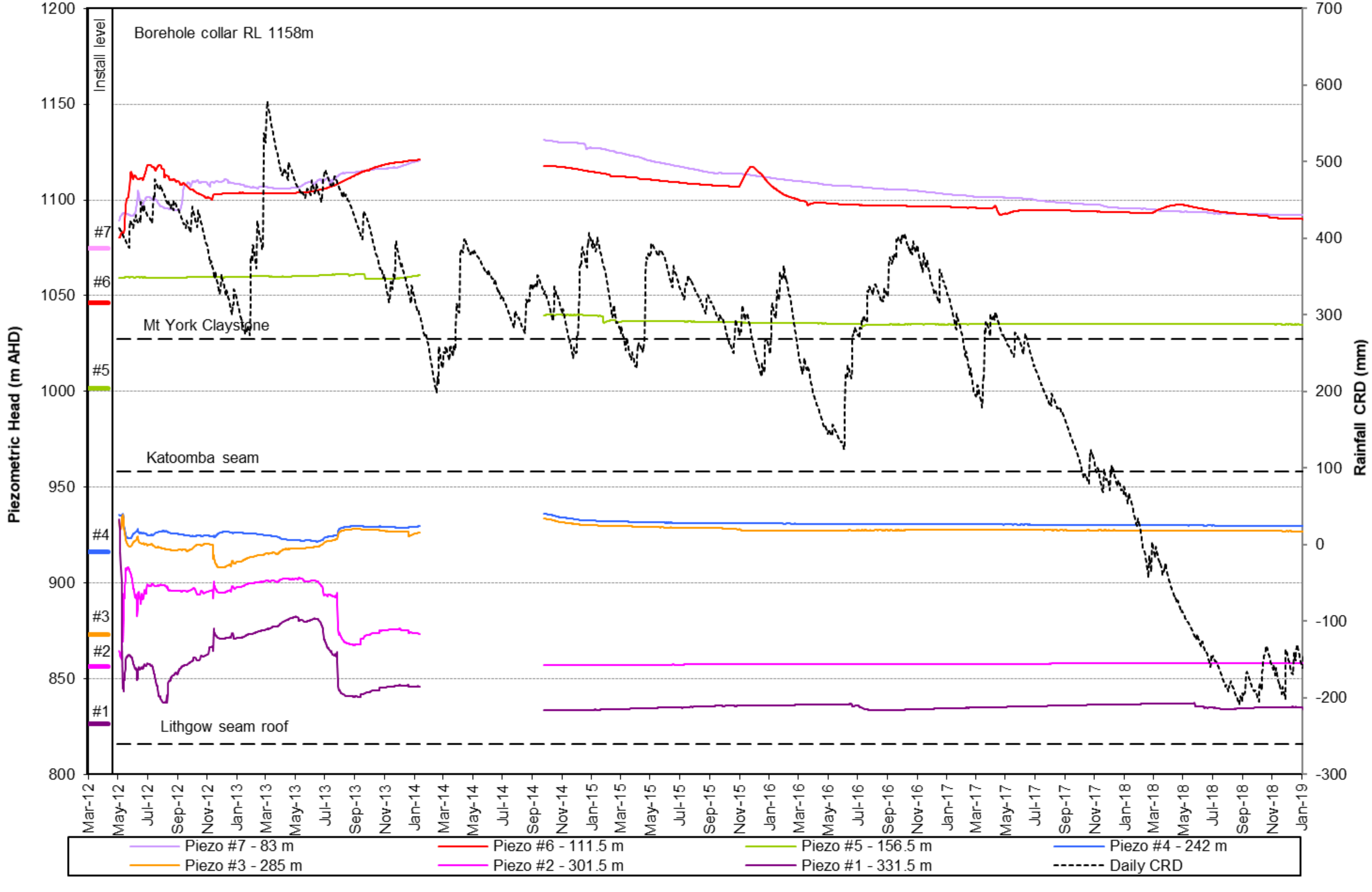
Borehole collar RL 1171m
Install level
Mt York Claystone
Katoomba seam
Lithgow seam roof
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Daily CRD (mm)
1200
1150
1100
1050
1000
950
900
850
800
700
600
500
400
300
200
100
0
-100
-200
-300
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Sep-15
Dec-15
Mar-16
Jun-16
Sep-16
Dec-16
Mar-17
Jun-17
Sep-17
Dec-17
Mar-18
Jun-18
Sep-18
Dec-18
Piezo #6 - 143 m
Piezo #5 - 179 m
Piezo #4 - 250 m
Piezo #3 - 275 m
Piezo #2 - 335 m
Piezo #1 - 356.5 m
Daily CRD

APXXB2



Borehole collar RL 1156m
Install level
Mt York Claystone
Katoomba Seam
Lithgow Seam Roof
#7
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Rainfall CRD (mm)
1200
1150
1100
1050
1000
950
900
850
800
700
600
500
400
300
200
100
0
-100
-200
-300
Oct-11
Jan-12
Apr-12
Jul-12
Oct-12
Jan-13
Apr-13
Jul-13
Oct-13
Jan-14
Apr-14
Jul-14
Oct-14
Jan-15
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Piezo #7 - 69 m
Piezo #6 - 135 m
Piezo #5 - 160.5 m
Piezo #4 - 185 m
Piezo #3 - 243 m
Piezo #2 - 293 m
Piezo #1 - 320 m
Daily CRD

APXXB3



Borehole collar RL 1158m
Install level
Mt York Claystone
Katoomba seam
Lithgow seam roof
#7
#6
#5
#4
#3
#2
#1
Piezometric Head (m AHD)
Rainfall CRD (mm)
1200
1150
1100
1050
1000
950
900
850
800
700
600
500
400
300
200
100
0
-100
-200
-300
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Jan-15
Mar-15
May-15
Jul-15
Sep-15
Nov-15
Jan-16
Mar-16
May-16
Jul-16
Sep-16
Nov-16
Jan-17
Mar-17
May-17
Jul-17
Sep-17
Nov-17
Jan-18
Mar-18
May-18
Jul-18
Sep-18
Nov-18
Jan-19
Piezo #7 - 83 m
Piezo #6 - 111.5 m
Piezo #5 - 156.5 m
Piezo #4 - 242 m
Piezo #3 - 285 m
Piezo #2 - 301.5 m
Piezo #1 - 331.5 m
Daily CRD

D.2.4 Underground water transfers

Statistical summary of water quality results

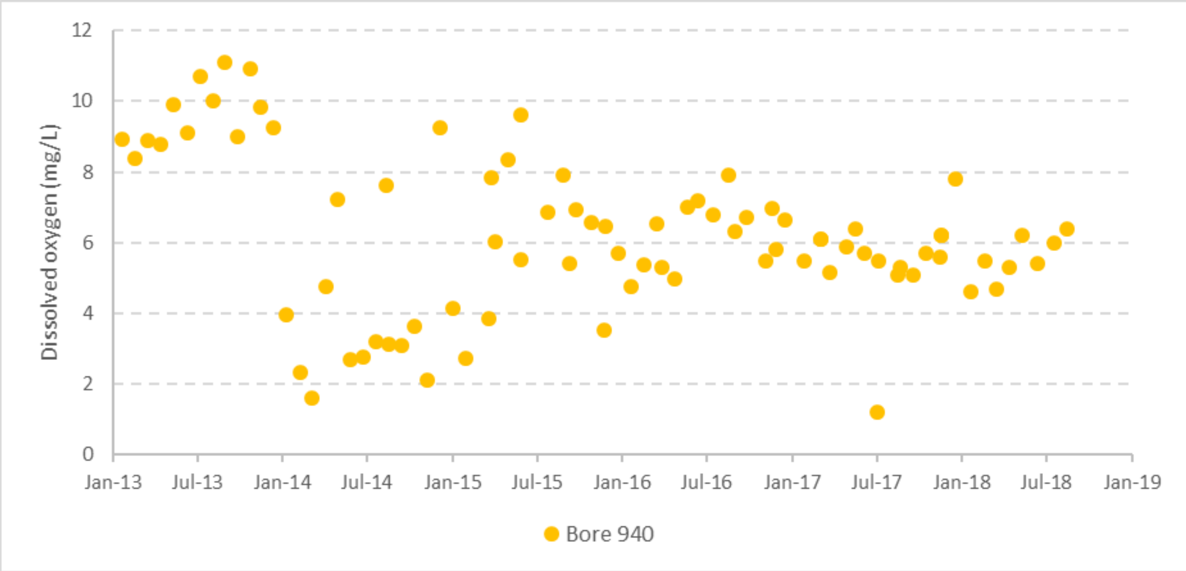
Parameters	Units	Raw Bore 940		Bore 940		800D Goaf	
		Count	Median	Count	Median	Count	Median
Physicochemical							
DO	mg/L	–	–	83	6.0	–	–
EC	µS/cm	187	1214	306	1207	20	1087
pH	pH units	188	7.4	309	7.6	20	7.2
TDS	mg/L	–	–	80	722	25	631
TSS	mg/L	179	5	303	5	23	5
Turbidity	NTU	185	2.0	305	2.0	20	11.5
Major ions							
Bicarbonate alkalinity	mg/L	13	607	96	610	25	607
Carbonate alkalinity	mg/L	13	1	96	1	25	1
Hydroxide alkalinity	mg/L	13	1	96	1	25	1
Total alkalinity	mg/L	13	607	96	612	25	607
Calcium	mg/L	13	7	95	7	17	17
Chloride	mg/L	13	6	96	6	18	7
Magnesium	mg/L	13	7	95	7	17	14
Potassium	mg/L	13	19	95	19	17	33
Sodium	mg/L	13	243	95	256	17	212
Sulfate	mg/L	13	6	96	27	18	9
Total hardness	mg/L	–	–	80	46	–	–
Nutrients							
Ammonia	mg/L	–	–	120	1.36	–	–
Nitrate	mg/L	–	–	80	0.01	–	–
Nitrite	mg/L	–	–	80	0.01	–	–
Nitrate + nitrite	mg/L	–	–	81	0.01	–	–
Total fluoride	mg/L	–	–	287	1.2	–	–
TKN	mg/L	–	–	81	1.4	–	–
Total nitrogen	mg/L	–	–	81	1.4	–	–

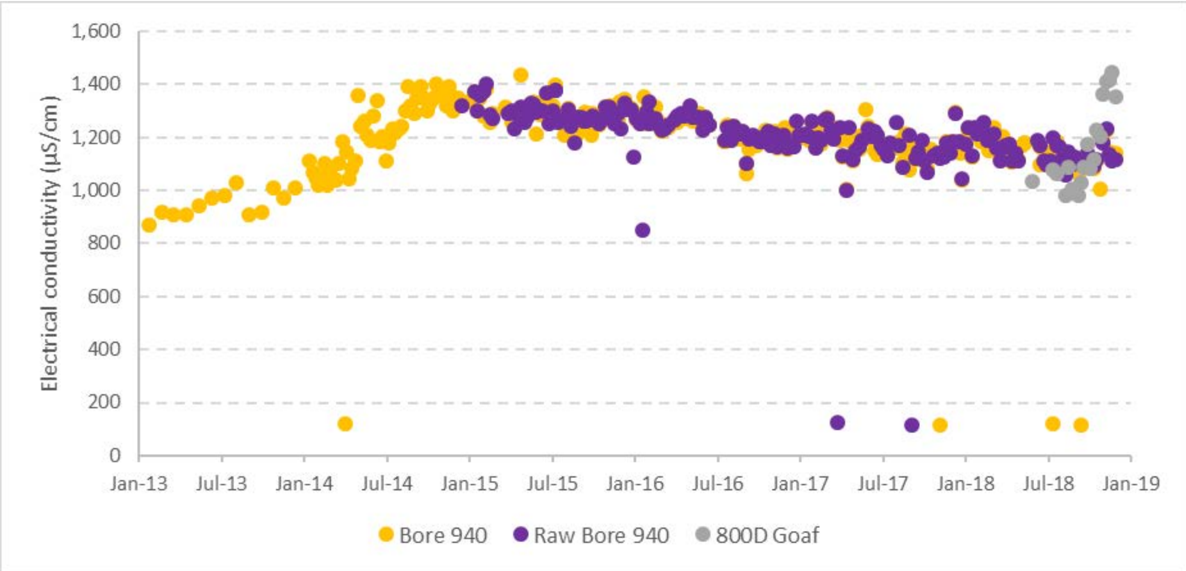
Parameters	Units	Raw Bore 940		Bore 940		800D Goaf	
		Count	Median	Count	Median	Count	Median
Total phosphorus	mg/L	–	–	81	0.03	–	–
Dissolved metals							
Aluminium	mg/L	183	0.01	301	0.01	25	0.01
Antimony	mg/L	–	–	80	0.001	–	–
Arsenic	mg/L	182	0.071	301	0.051	13	0.009
Barium	mg/L	–	–	81	0.065	22	0.132
Boron	mg/L	183	0.06	301	0.06	25	0.06
Cadmium	mg/L	–	–	81	0.0001	–	–
Chromium (III)	mg/L	–	–	22	0.01	–	–
Chromium (VI)	mg/L	–	–	23	0.01	–	–
Copper	mg/L	183	0.001	301	0.001	25	0.001
Iron	mg/L	183	0.21	301	0.22	25	0.07
Lead	mg/L	–	–	81	0.001	–	–
Lithium	mg/L	–	–	80	0.185	–	–
Manganese	mg/L	183	0.011	301	0.014	25	0.032
Mercury	mg/L	–	–	14	0.0001	–	–
Molybdenum	mg/L	–	–	82	0.073	–	–
Nickel	mg/L	182	0.006	299	0.006	25	0.004
Rubidium	mg/L	–	–	81	0.015	–	–
Strontium	mg/L	–	–	81	0.044	–	–
Uranium	mg/L	–	–	80	0.001	–	–
Zinc	mg/L	182	0.005	300	0.005	25	0.037
Total metals							
Aluminium	mg/L	–	–	79	0.01	15	0.01
Antimony	mg/L	–	–	65	0.001	–	–
Arsenic	mg/L	–	–	80	0.080	24	0.018
Barium	mg/L	–	–	80	0.079	15	0.173
Boron	mg/L	–	–	22	0.07	15	0.06
Cadmium	mg/L	–	–	23	0.0001	–	–
Cobalt	mg/L	–	–	19	0.002	–	–

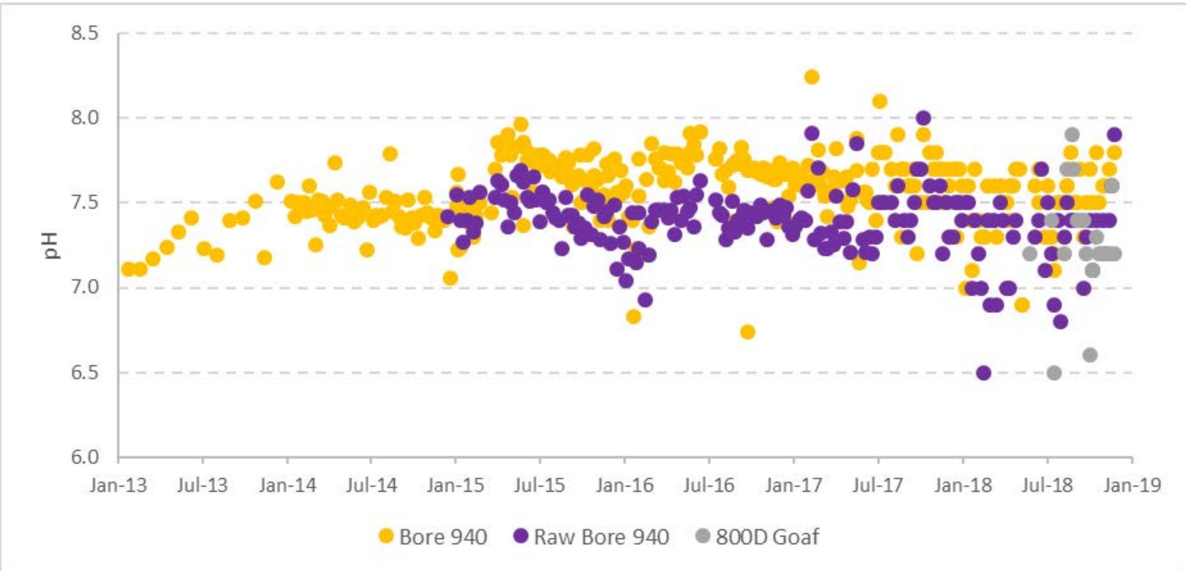
Parameters	Units	Raw Bore 940		Bore 940		800D Goaf	
		Count	Median	Count	Median	Count	Median
Copper	mg/L	–	–	23	0.002	15	0.001
Iron	mg/L	–	–	77	0.720	15	1.42
Lead	mg/L	–	–	79	0.001	–	–
Manganese	mg/L	–	–	78	0.016	15	0.034
Mercury	mg/L	–	–	24	0.0001	–	–
Nickel	mg/L	–	–	78	0.008	15	0.004
Selenium	mg/L	–	–	23	0.01	–	–
Silver	mg/L	–	–	22	0.001	–	–
Uranium	mg/L	–	–	22	0.002	–	–
Zinc	mg/L	–	–	78	0.013	15	0.062
Other							
Anionic surfactants	mg/L	–	–	23	0.1	15	0.1
Free chlorine	mg/L	–	–	81	0.02	–	–
Total chlorine	mg/L	–	–	81	0.05	–	–
Total cyanide	mg/L	–	–	81	0.004	–	–
Oil and grease	mg/L	–	–	300	5	25	5
Phenols	mg/L	–	–	79	0.05	–	–
Silica	mg/L	13	9.8	93	9.4	22	9.8
Silicon	mg/L	–	–	80	4.39	13	4.56
Total organic carbon	mg/L	–	–	80	1	–	–

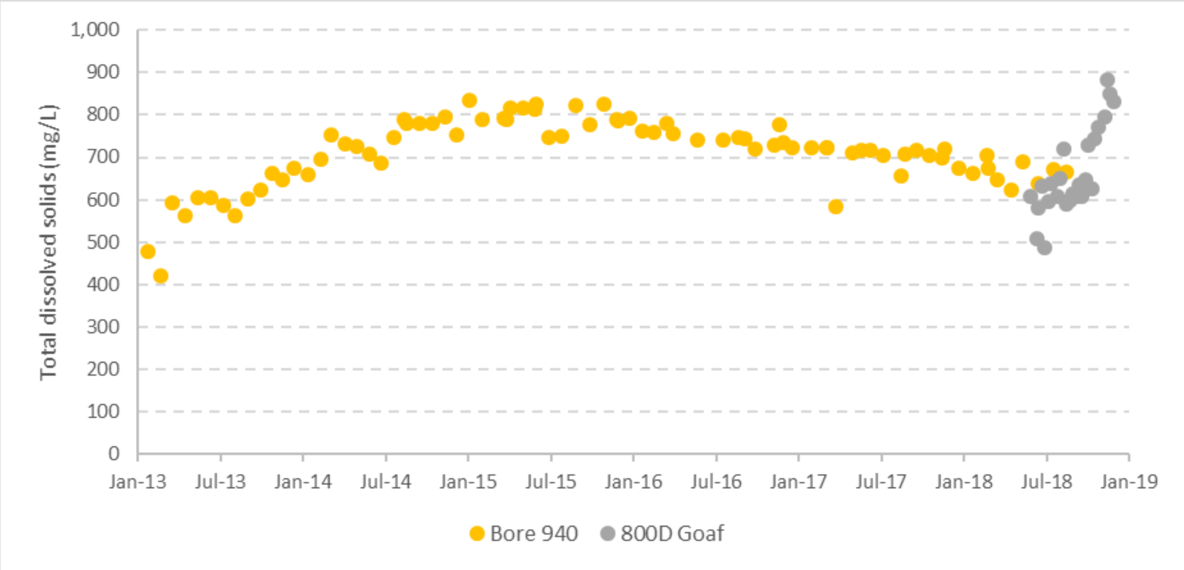
Time series graphs of water quality results

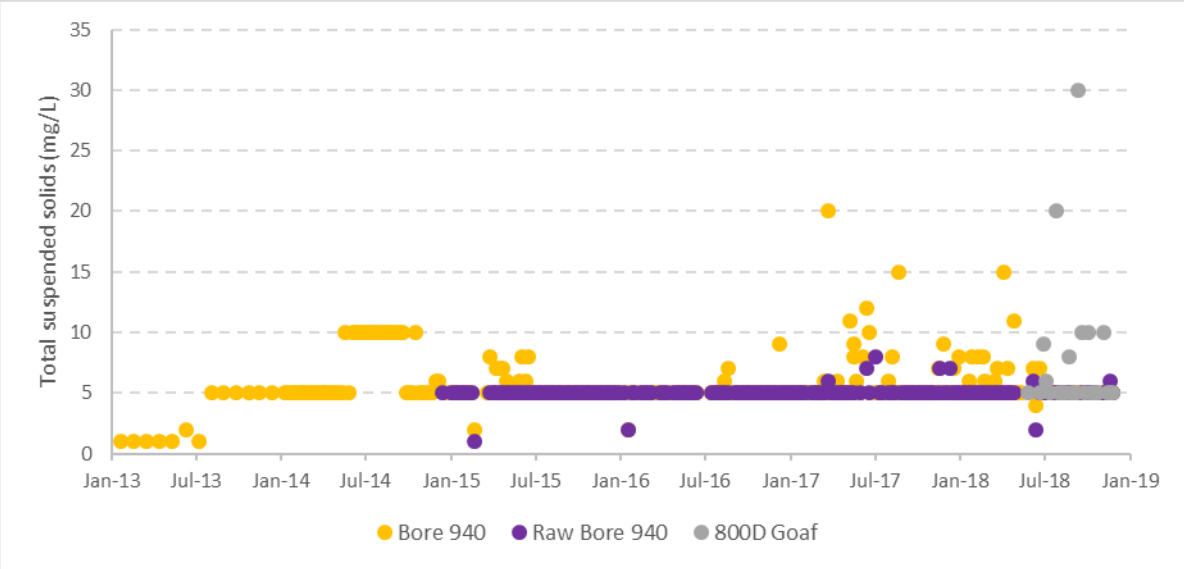
<u>Physicochemical</u>

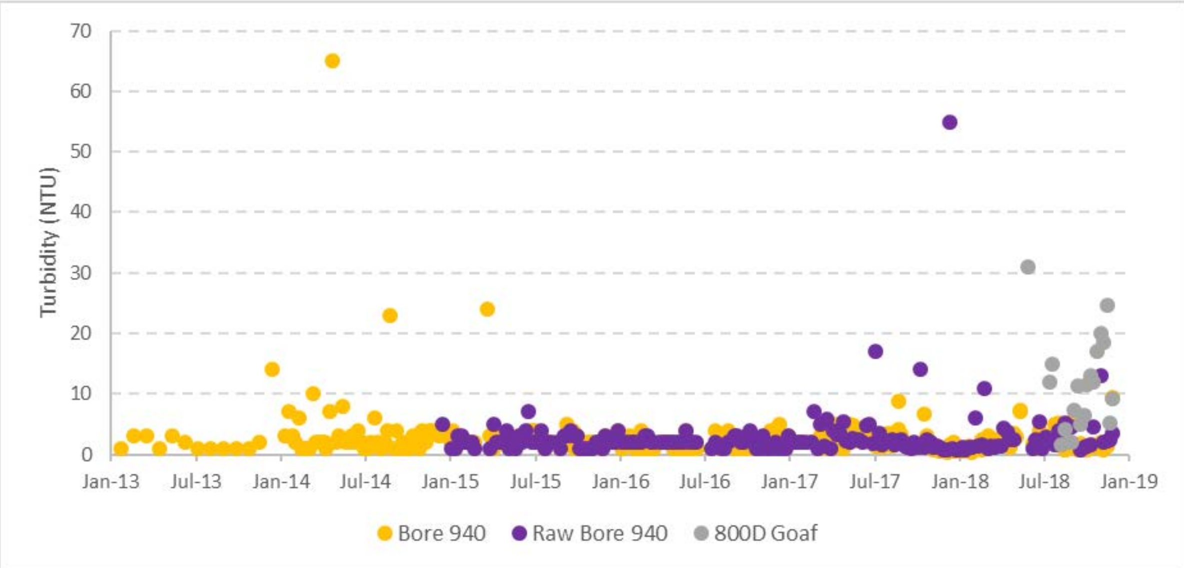




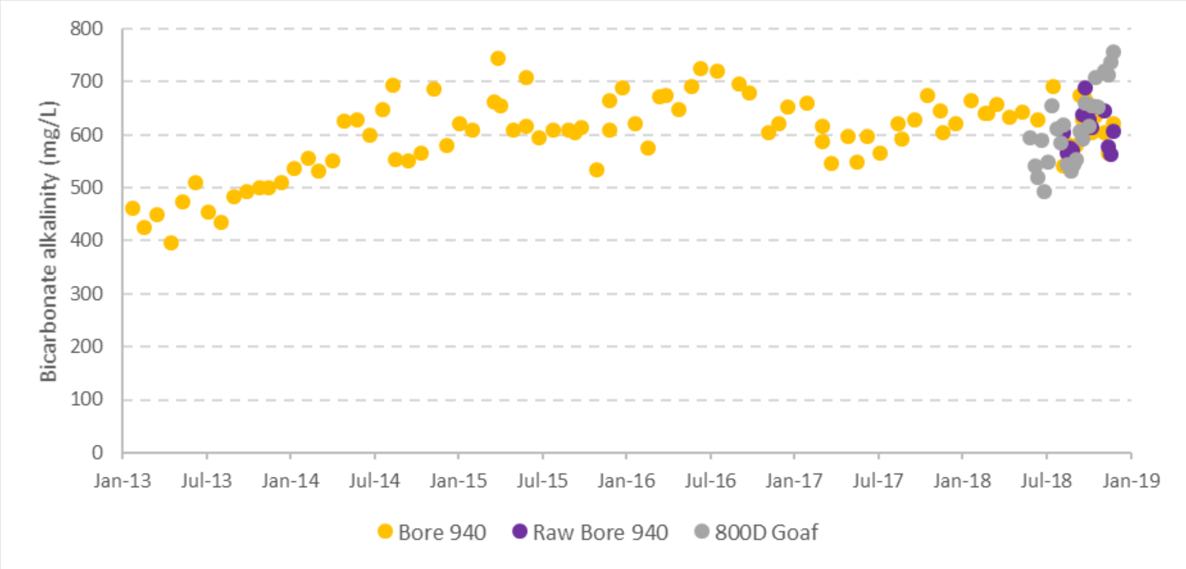



Total dissolved solids (mg/L)
1,000
900
800
700
600
500
400
300
200
100
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

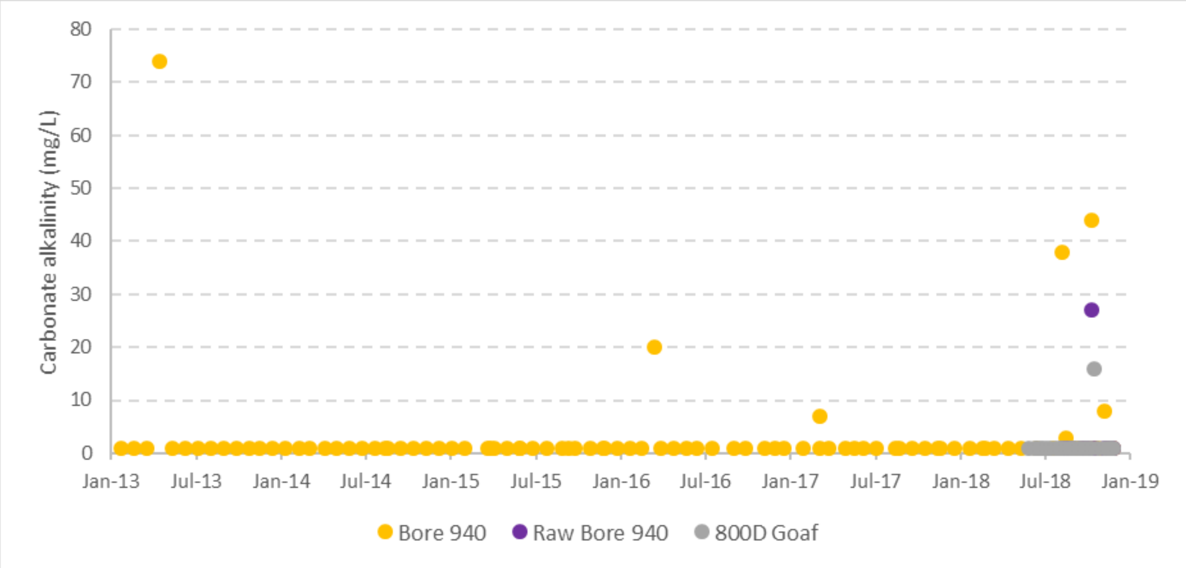

Total suspended solids (mg/L)
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf


Turbidity (NTU)
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

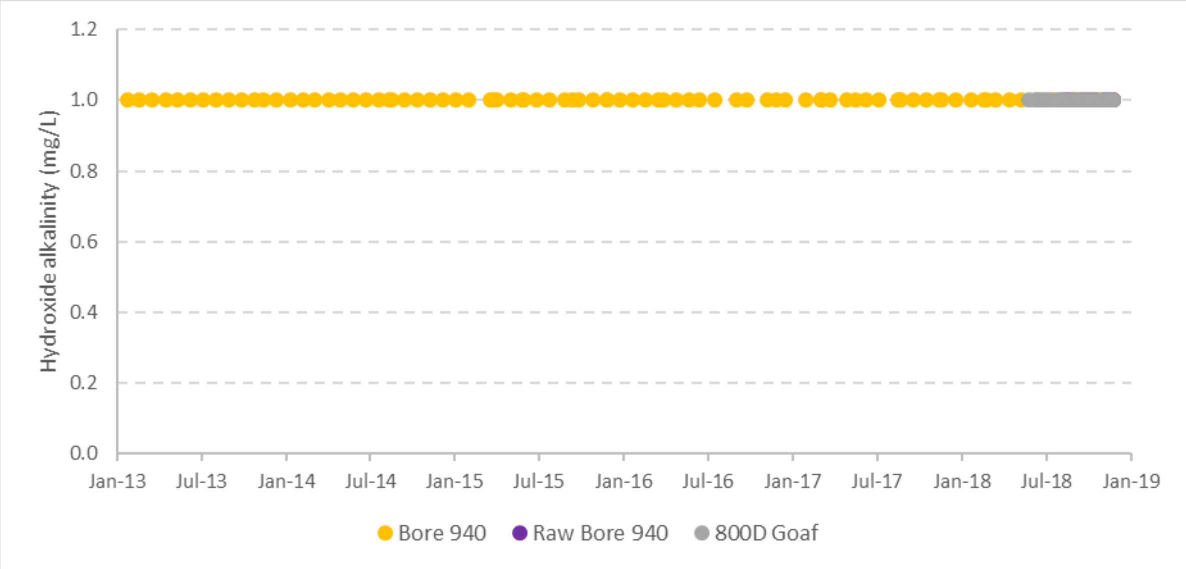
Major ions



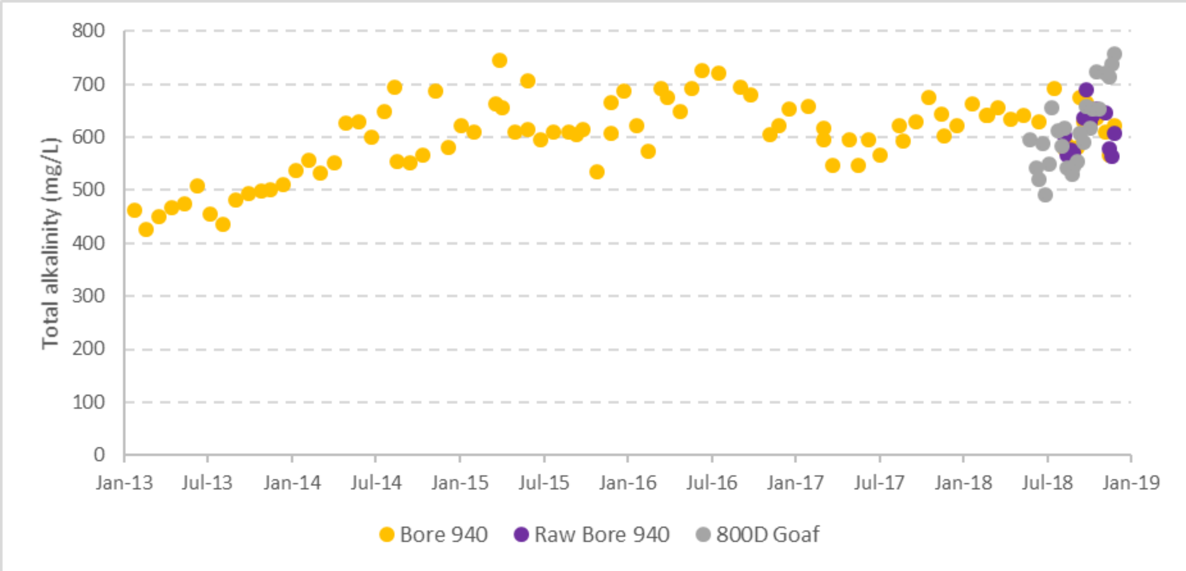
800
700
600
500
400
300
200
100
0
Bicarbonate alkalinity (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf



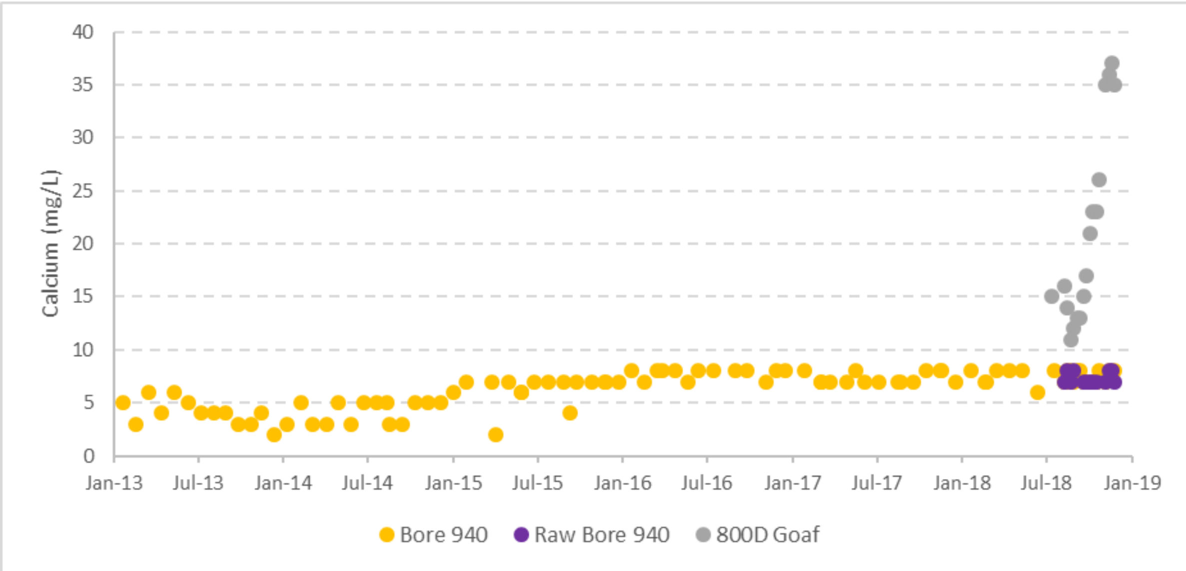
80
70
60
50
40
30
20
10
0
Carbonate alkalinity (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf



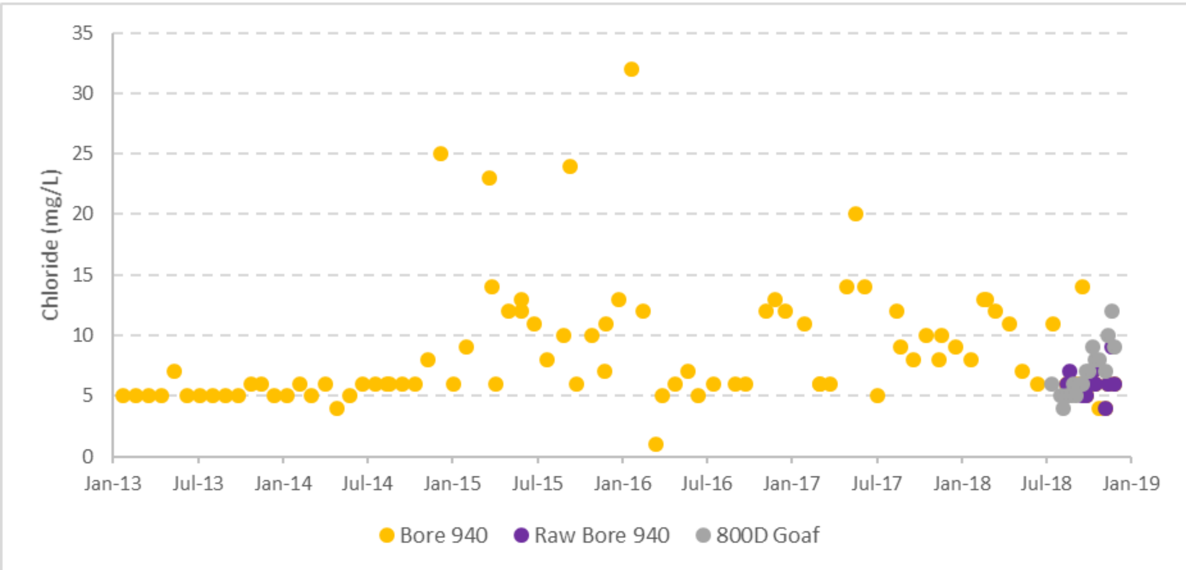
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Hydroxide alkalinity (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf



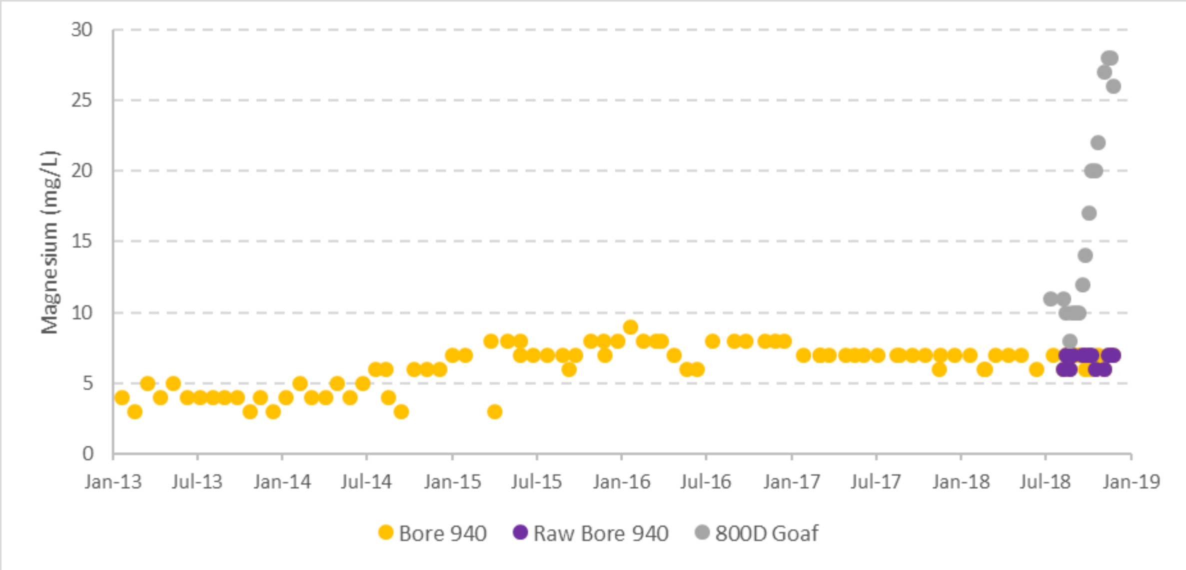
Total alkalinity (mg/L)
0
100
200
300
400
500
600
700
800
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

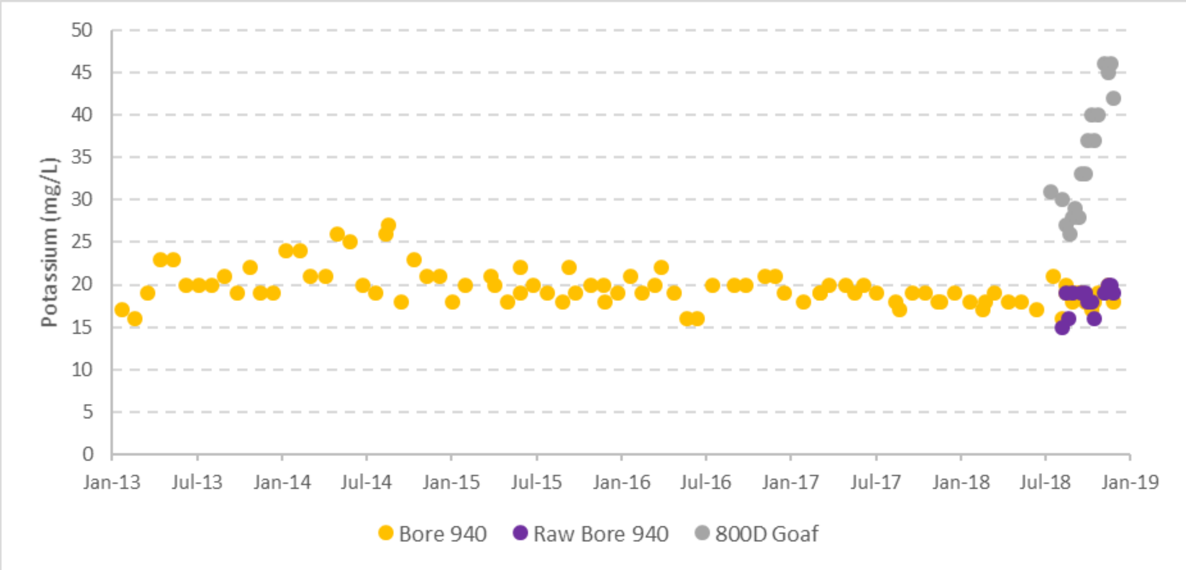


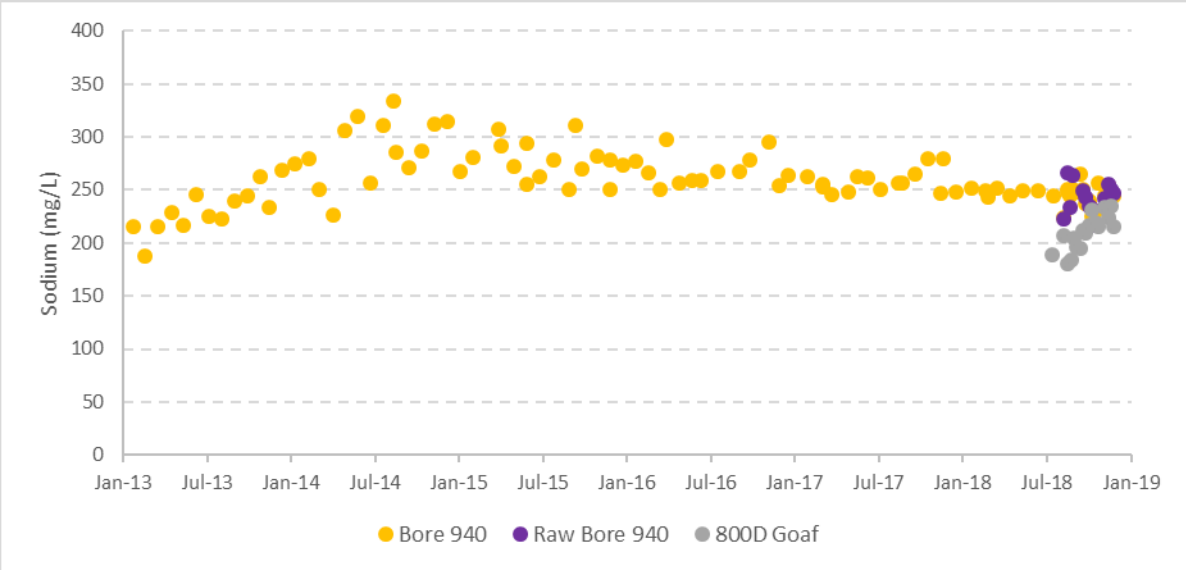
Calcium (mg/L)
0
5
10
15
20
25
30
35
40
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

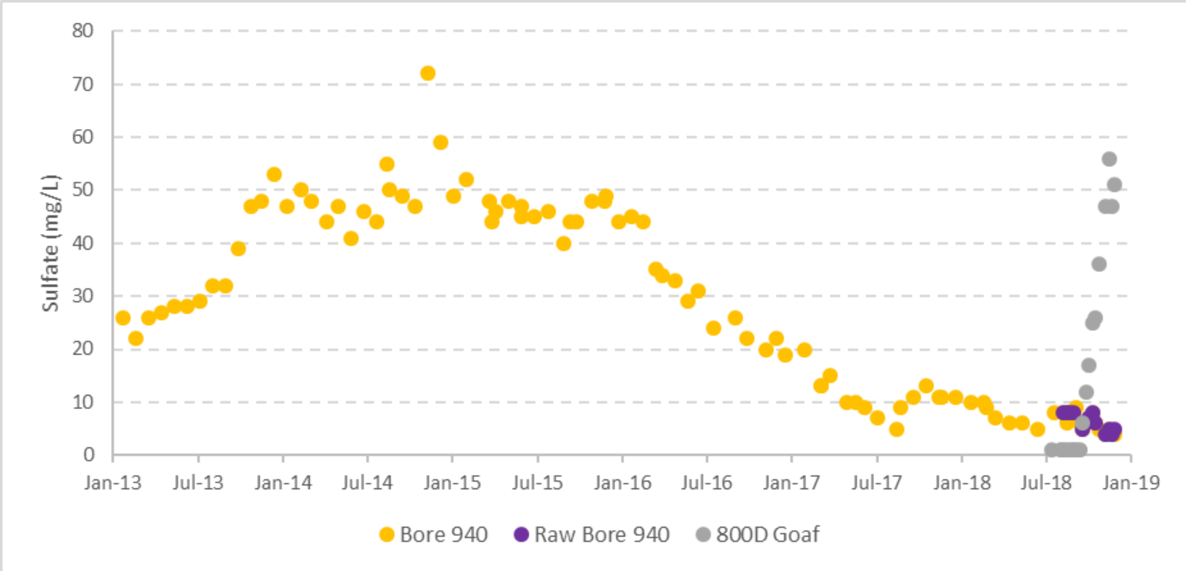


Chloride (mg/L)
0
5
10
15
20
25
30
35
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

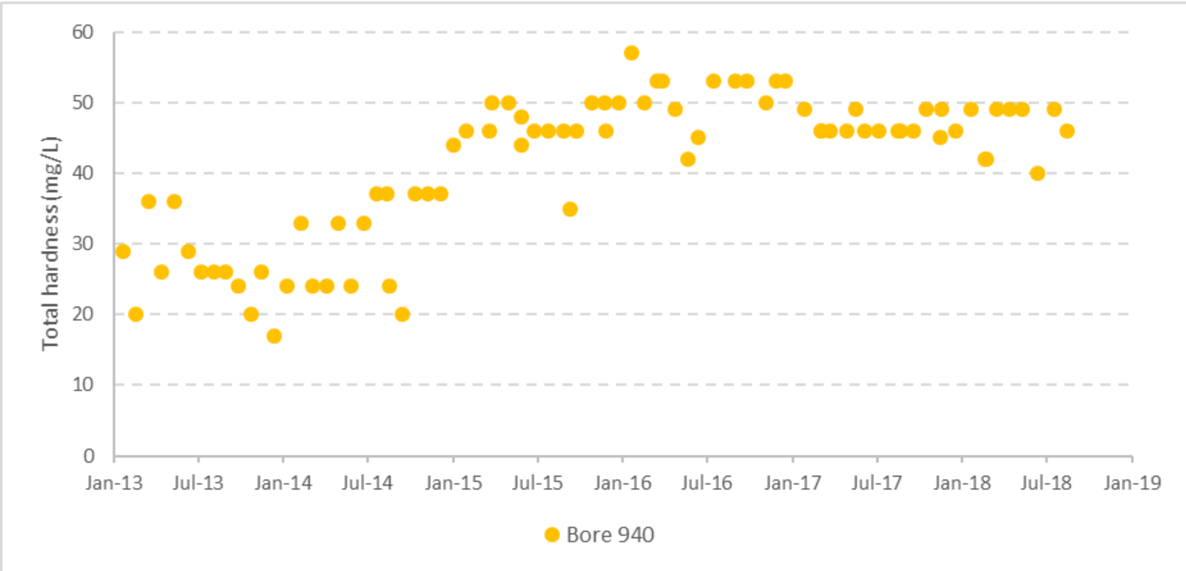

Magnesium (mg/L)
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf


Potassium (mg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf


Sodium (mg/L)
400
350
300
250
200
150
100
50
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

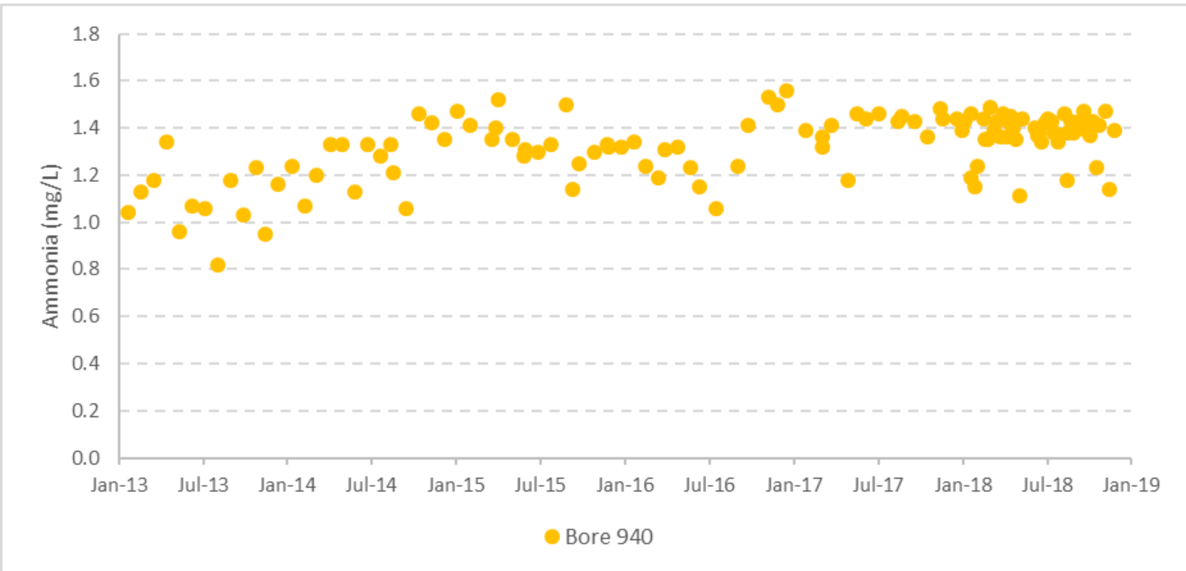


Sulfate (mg/L)
80
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

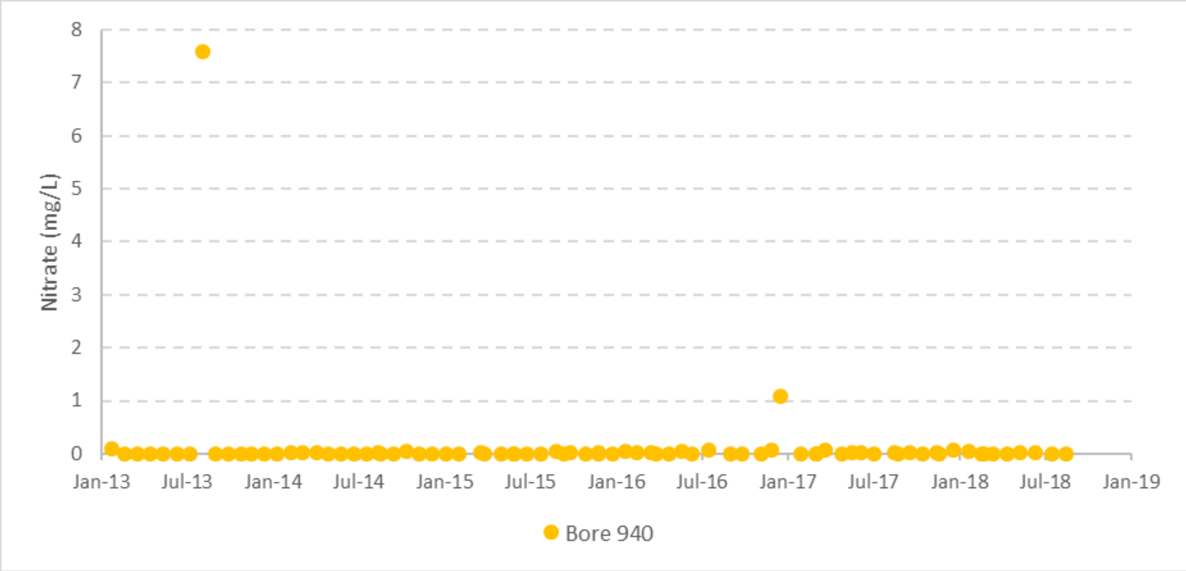


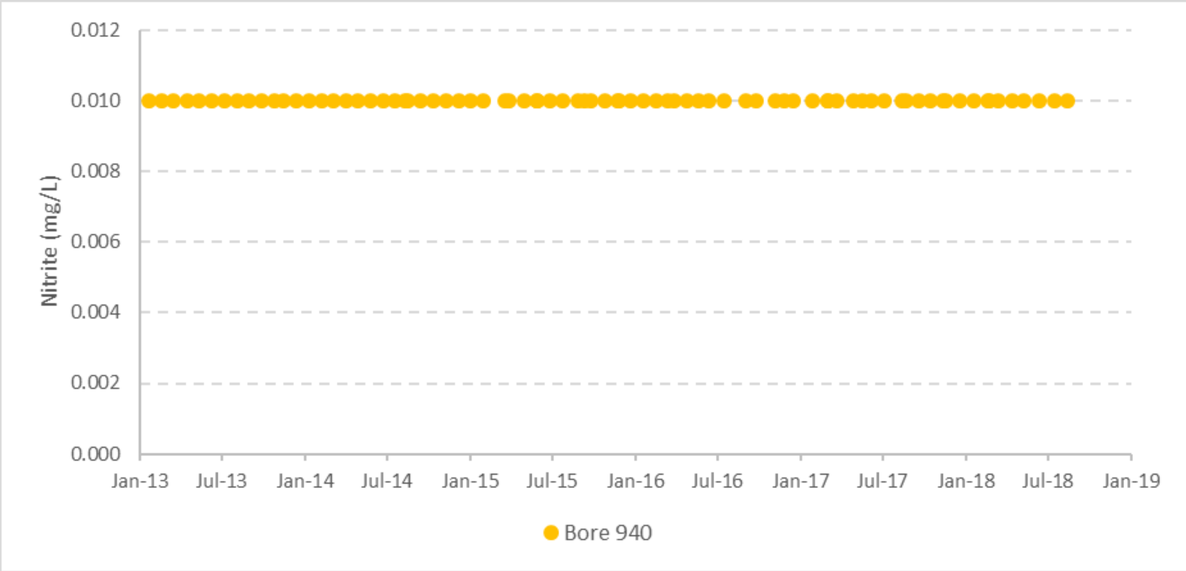
Total hardness (mg/L)
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

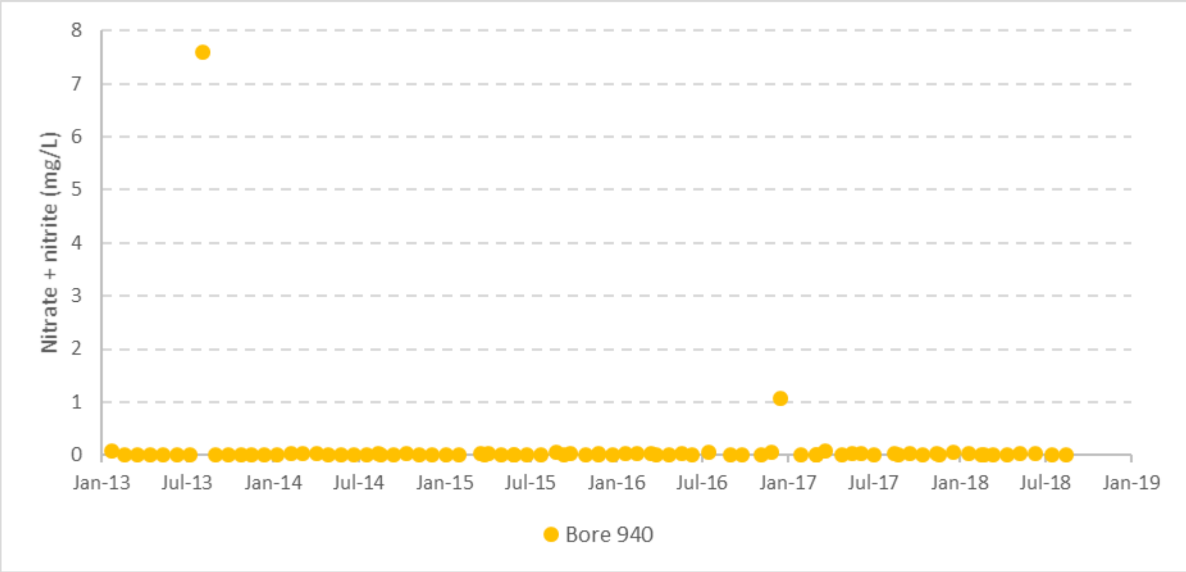
Nutrients

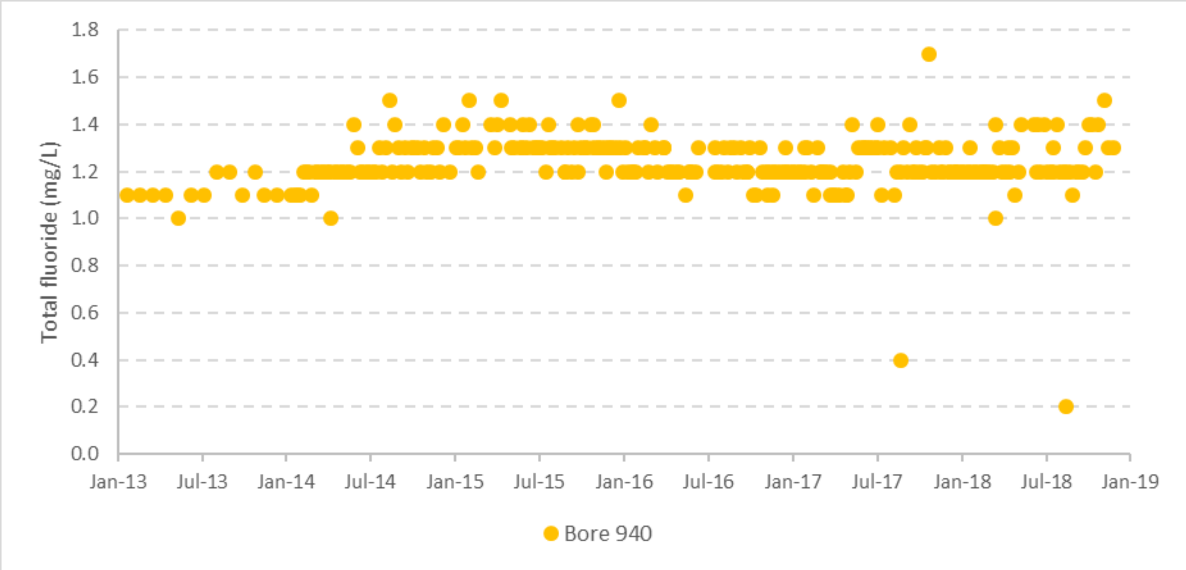


Ammonia (mg/L)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

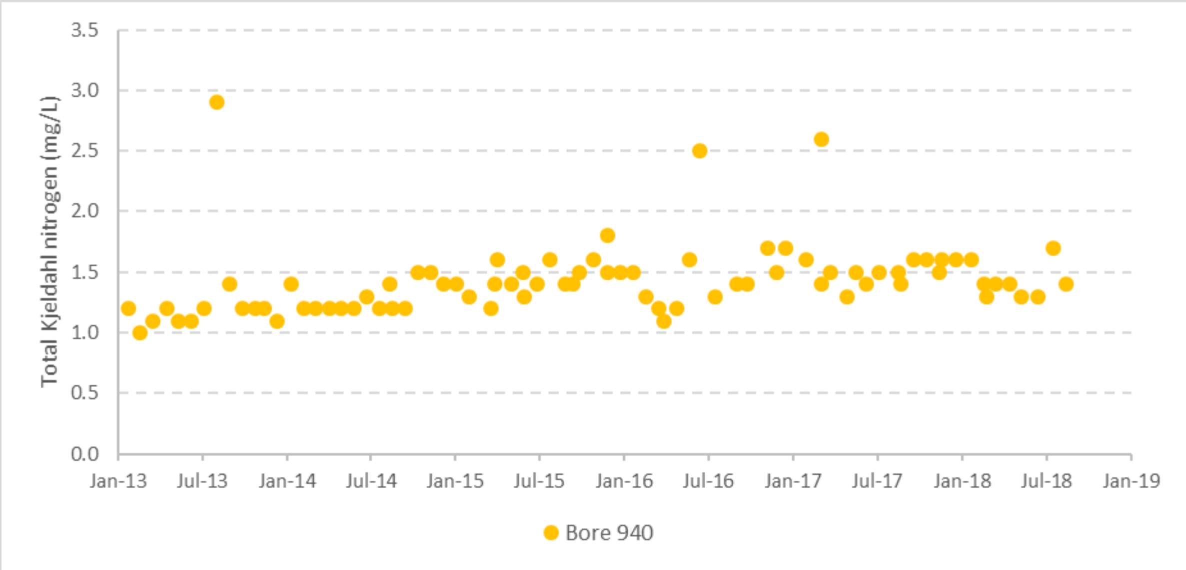

Nitrate (mg/L)
8
7
6
5
4
3
2
1
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bore 940


Nitrite (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bore 940

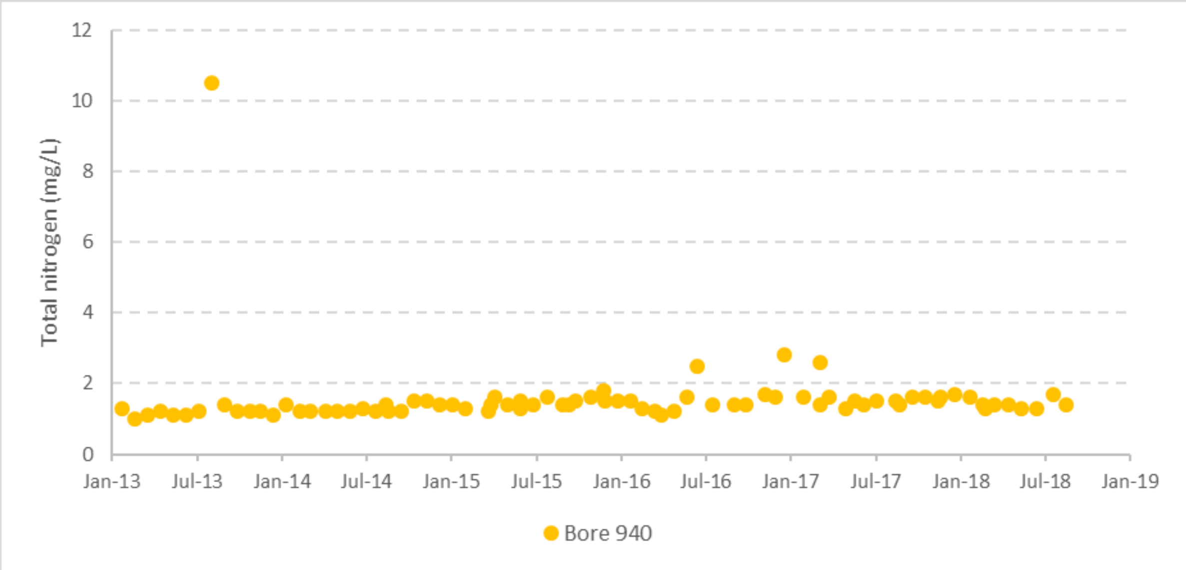

Nitrate + nitrite (mg/L)
8
7
6
5
4
3
2
1
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bore 940



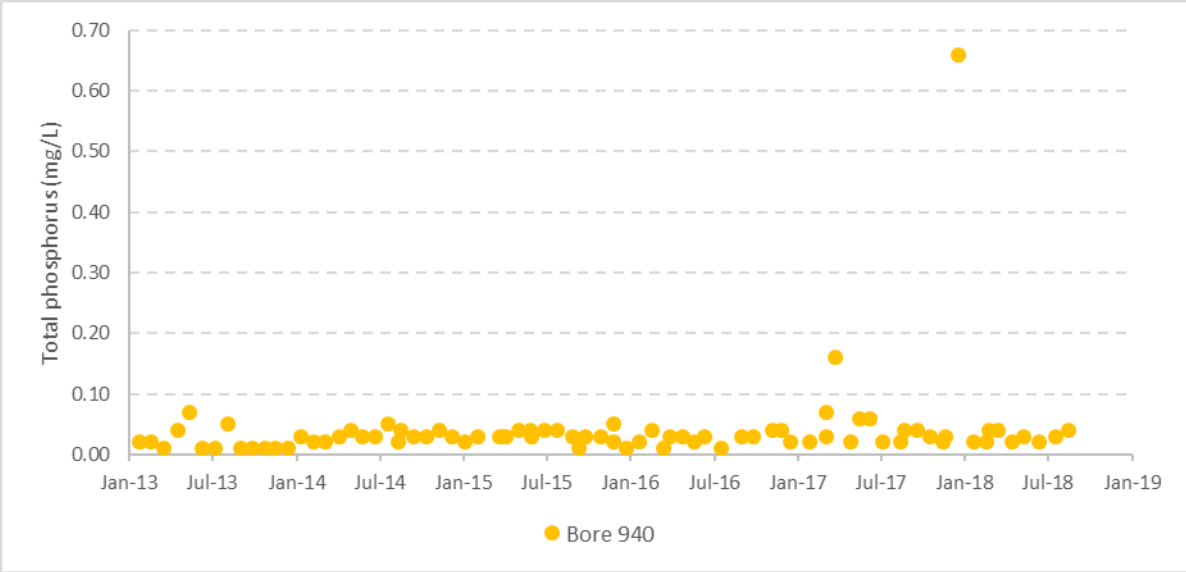
Total fluoride (mg/L)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



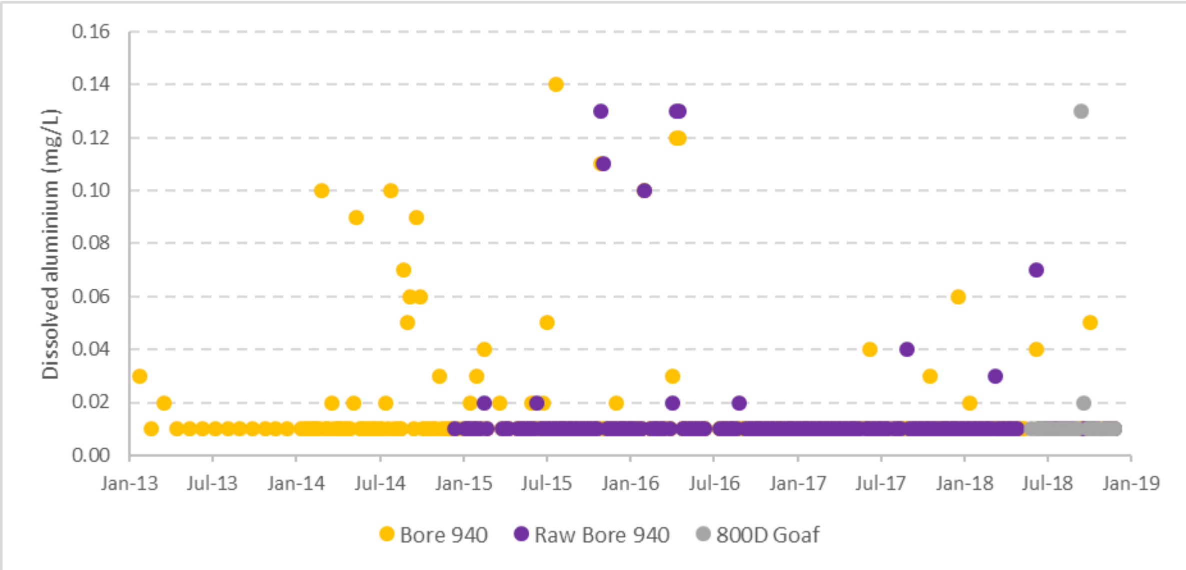
Total Kjeldahl nitrogen (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

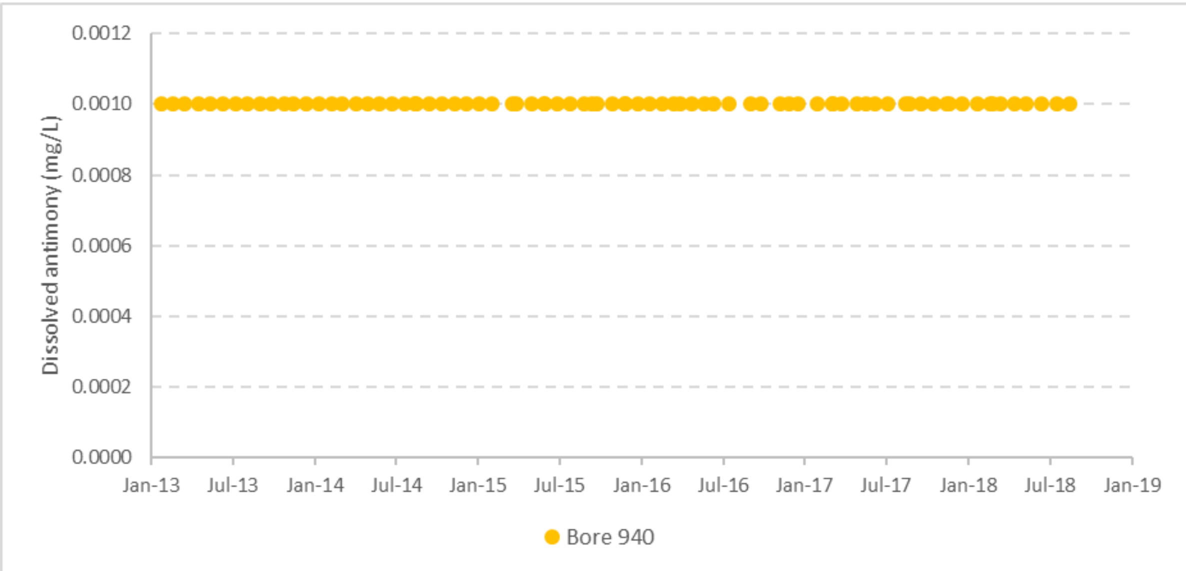


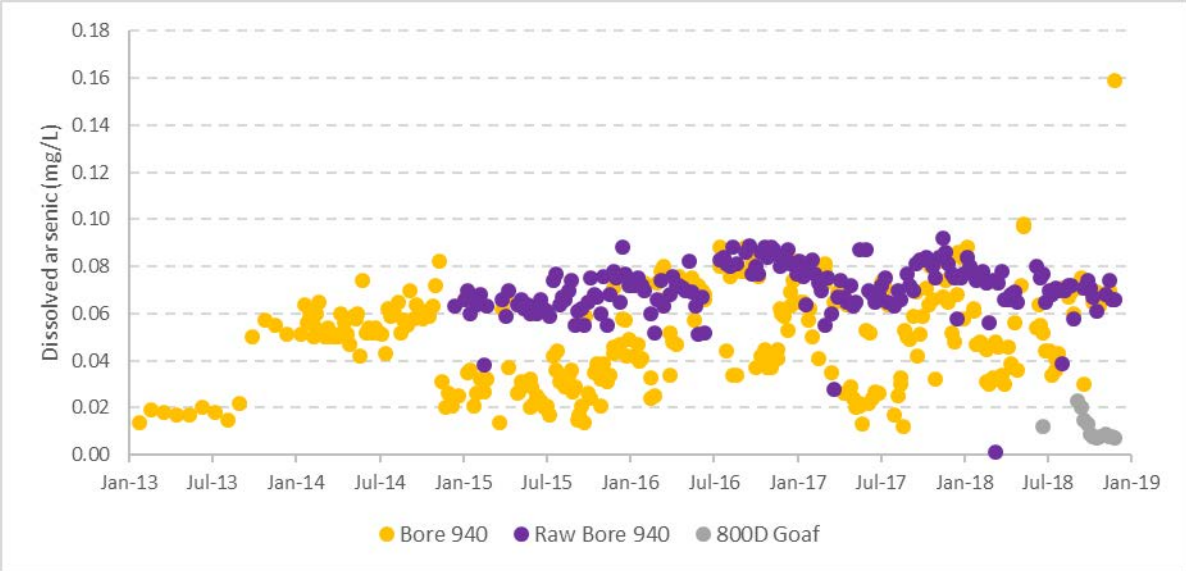
Total nitrogen (mg/L)
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



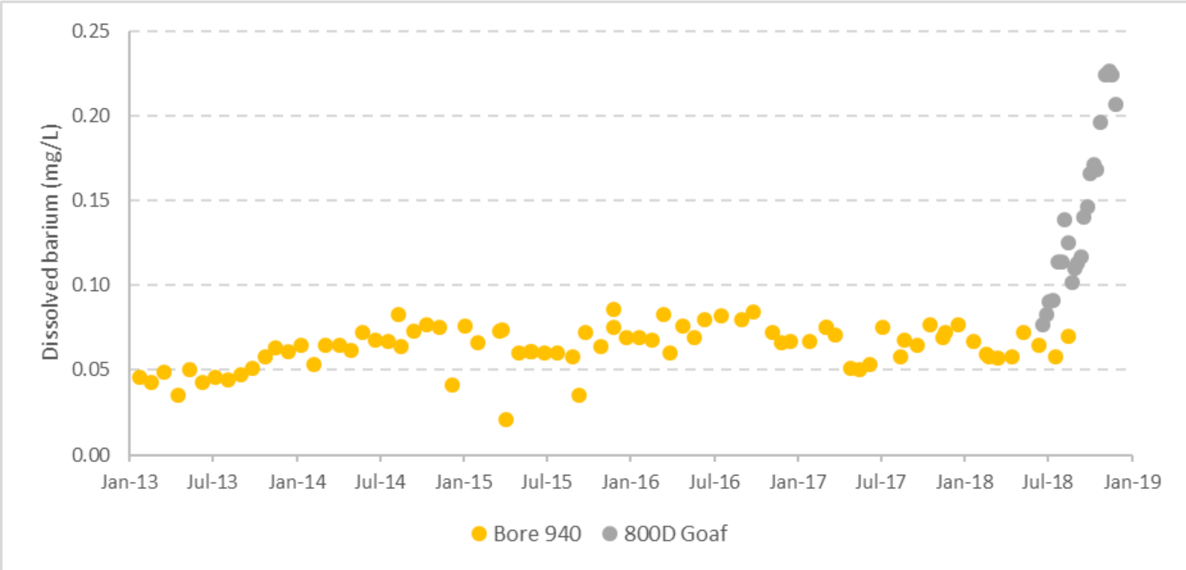
Dissolved metals



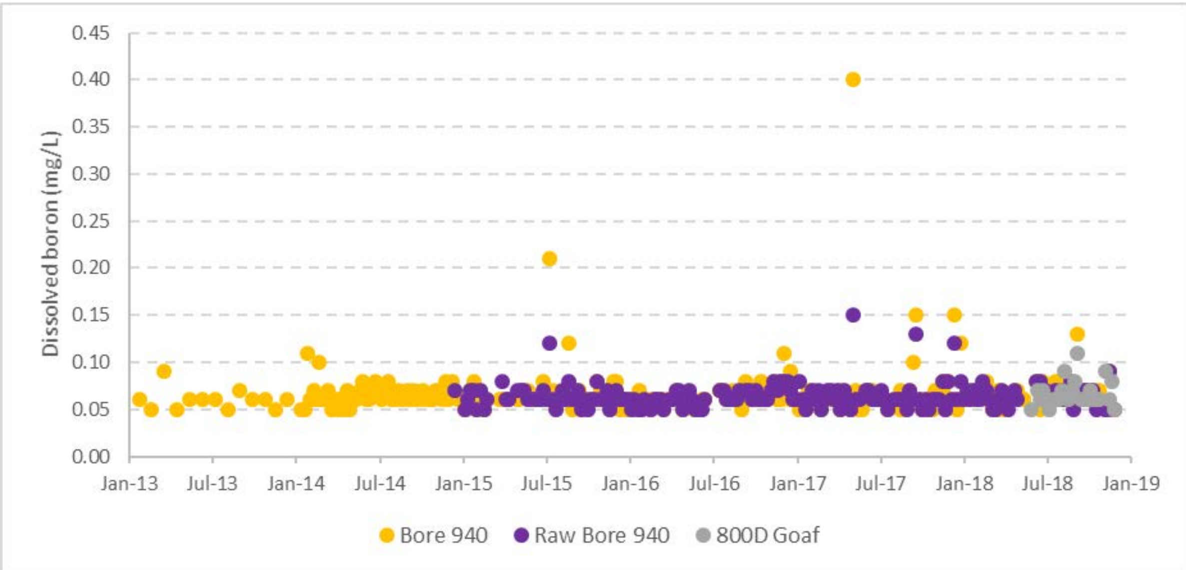




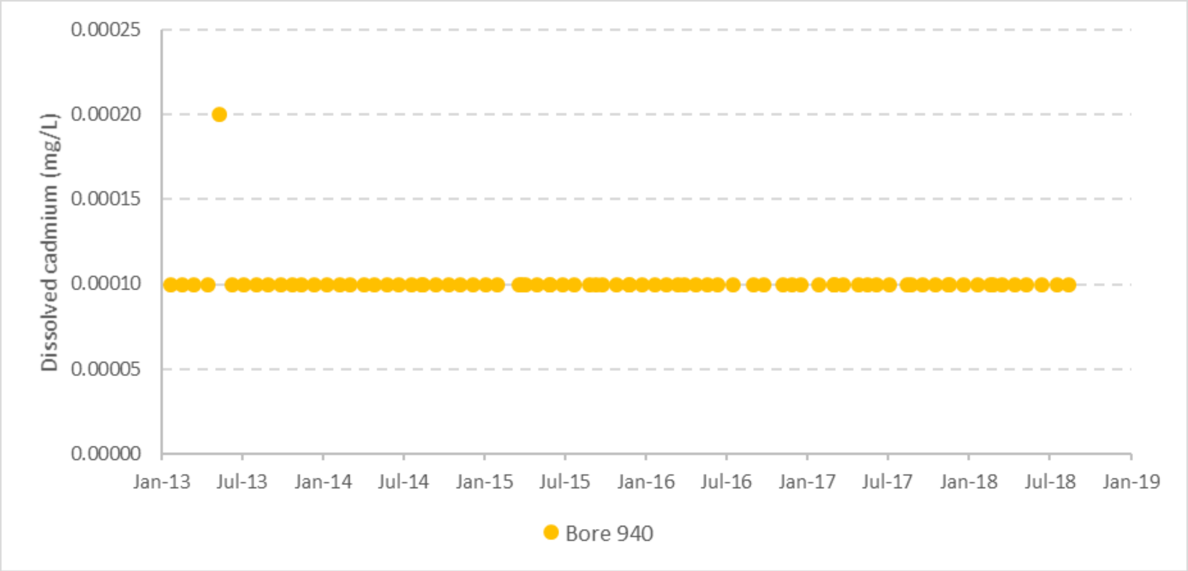
Dissolved arsenic (mg/L)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

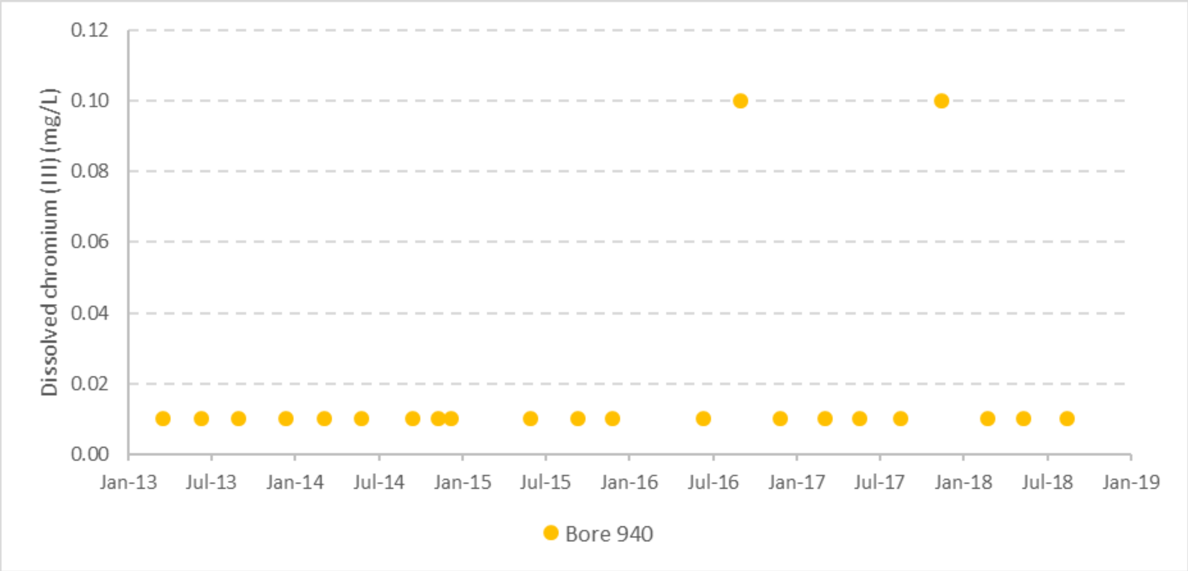


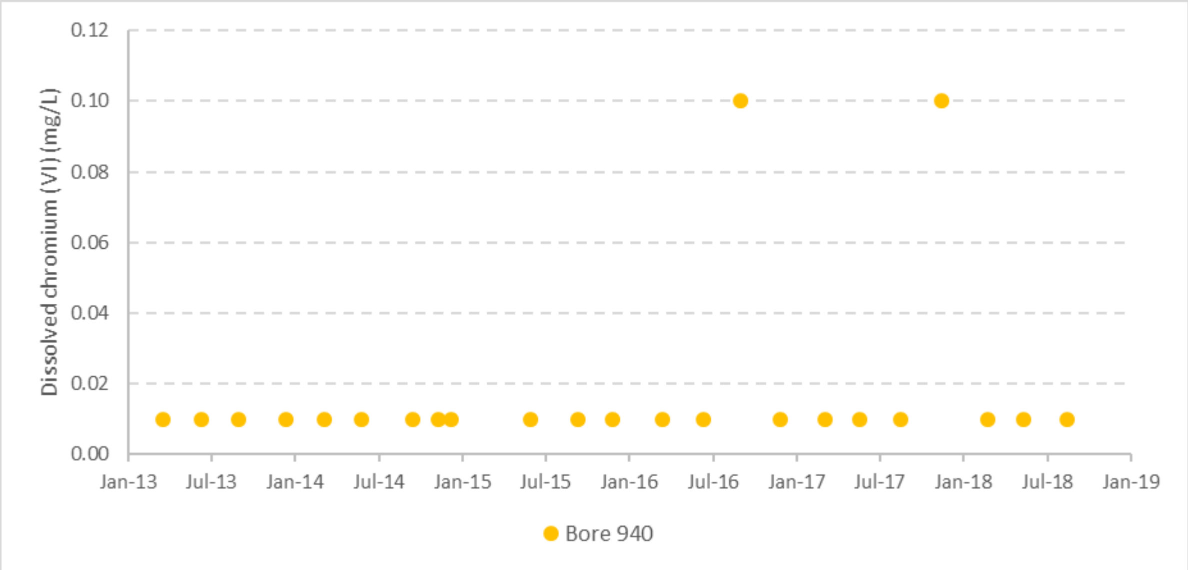
Dissolved barium (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

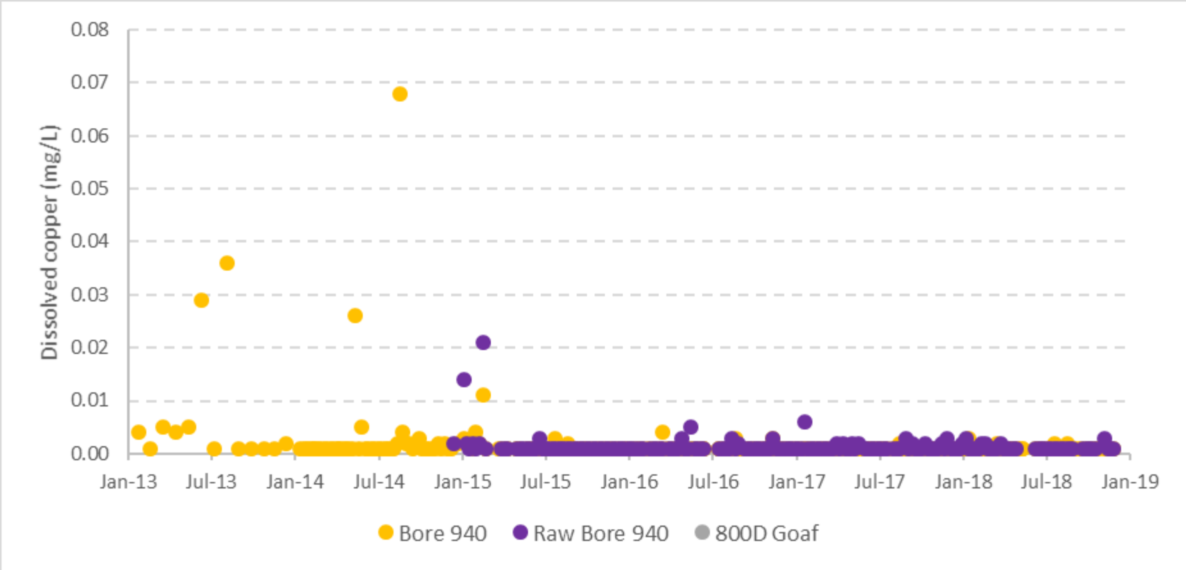


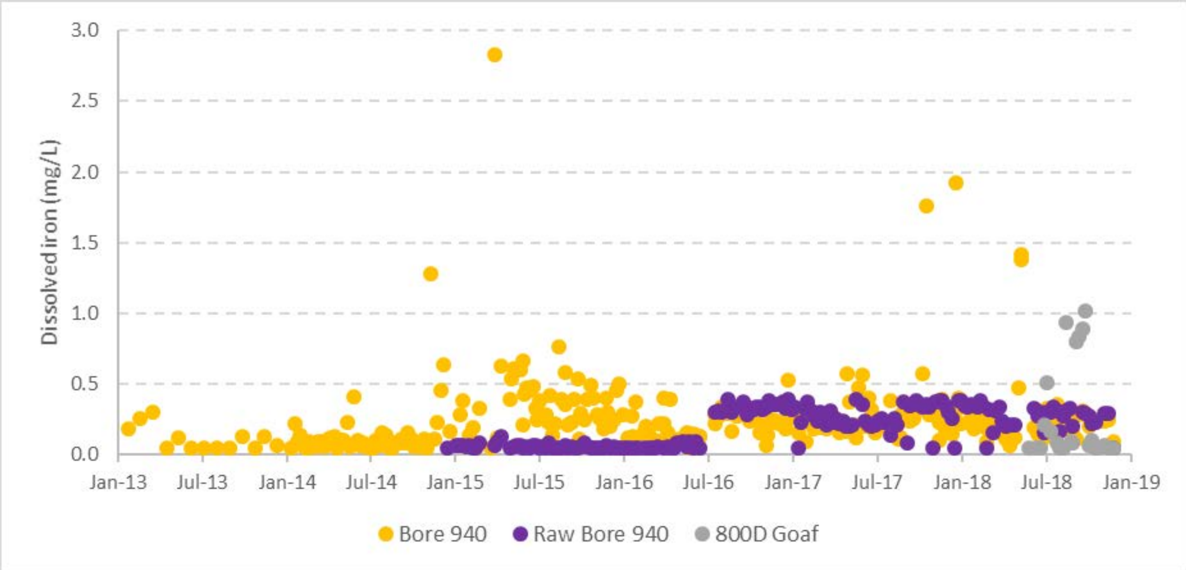
Dissolved boron (mg/L)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

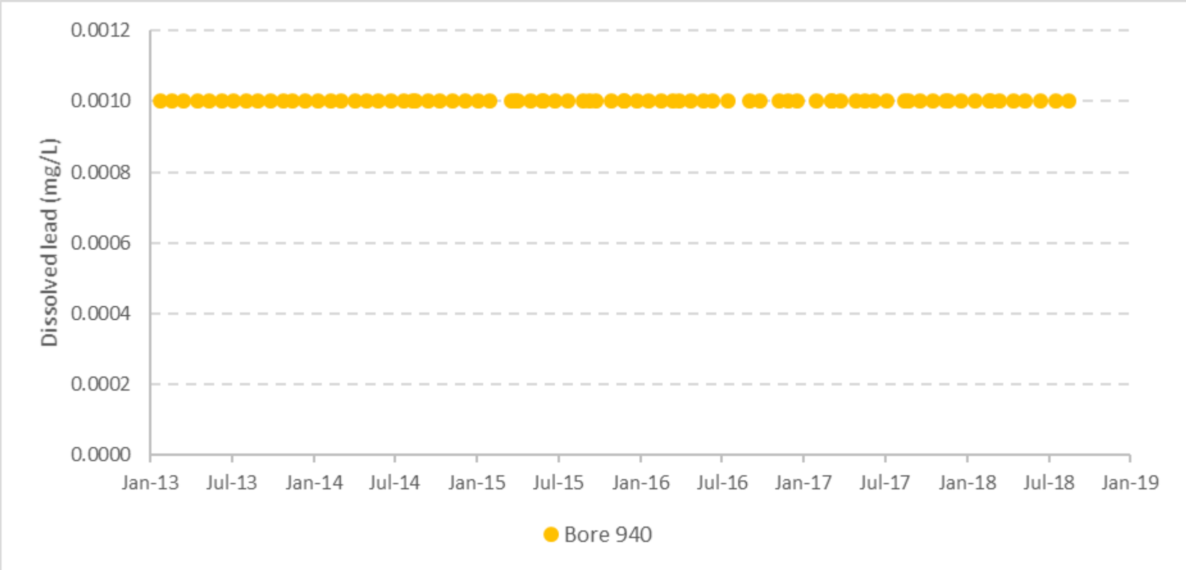

0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Dissolved cadmium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

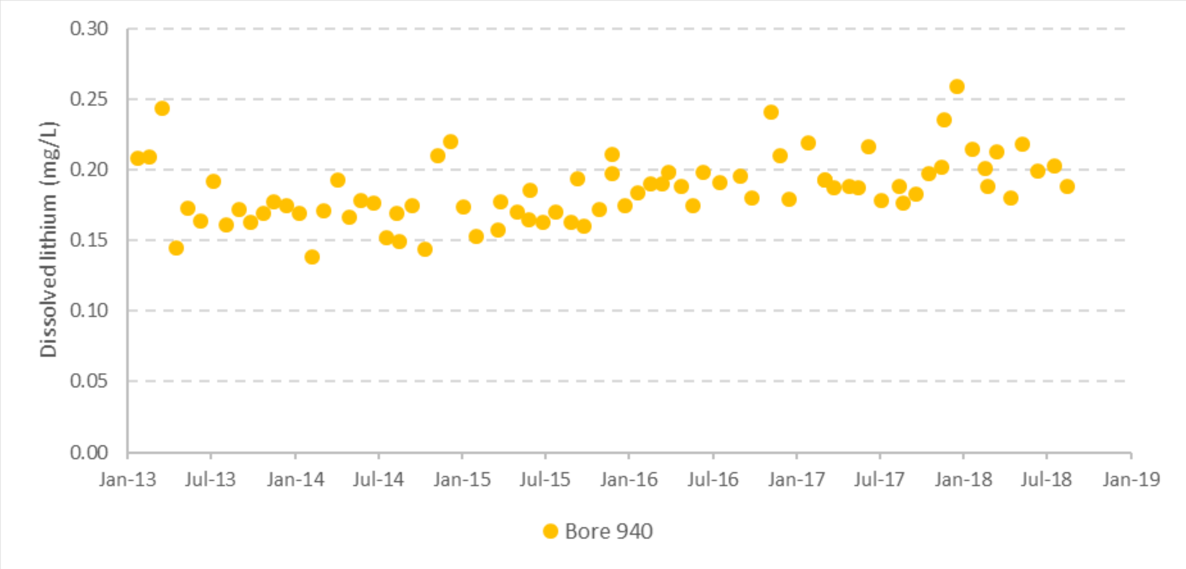

0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved chromium (III) (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940


0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved chromium (VI) (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

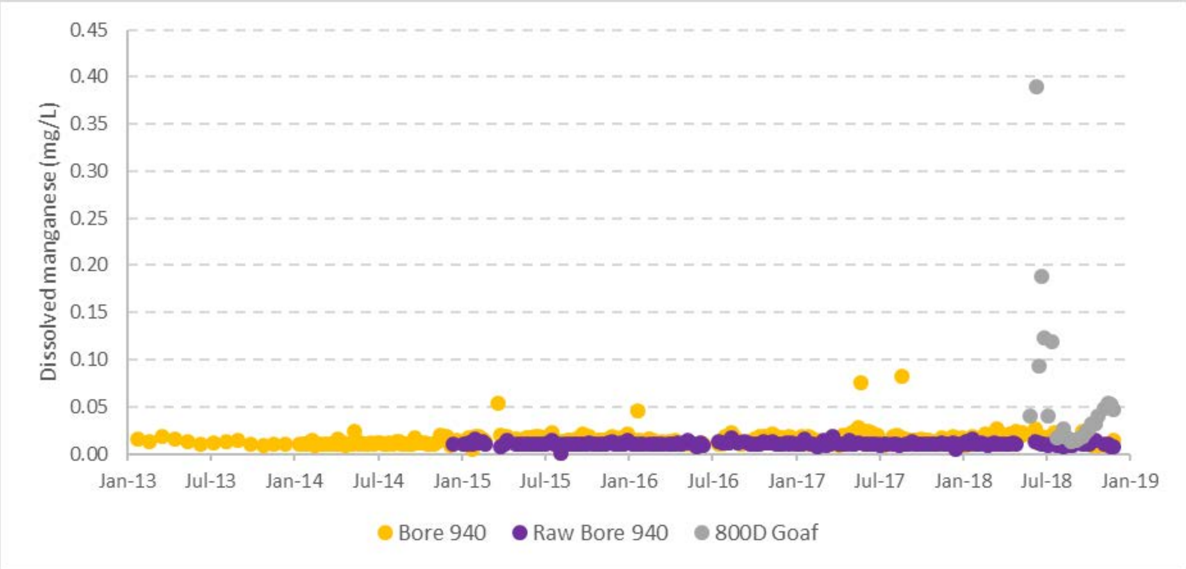

Dissolved copper (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bore 940
Raw Bore 940
800D Goaf


Dissolved iron (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bore 940
Raw Bore 940
800D Goaf

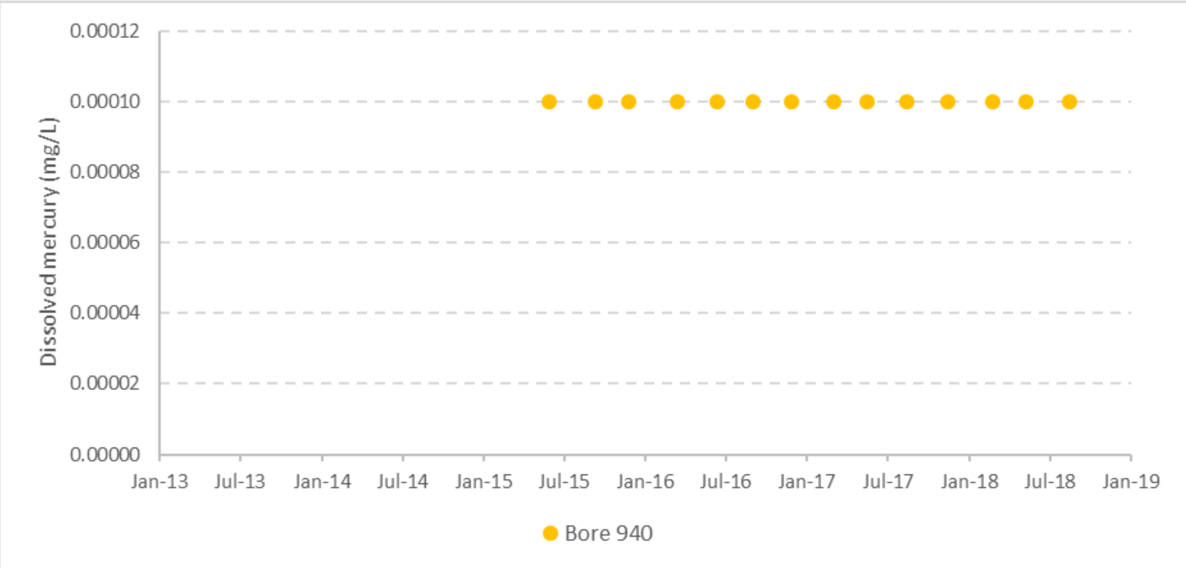

Dissolved lead (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bore 940



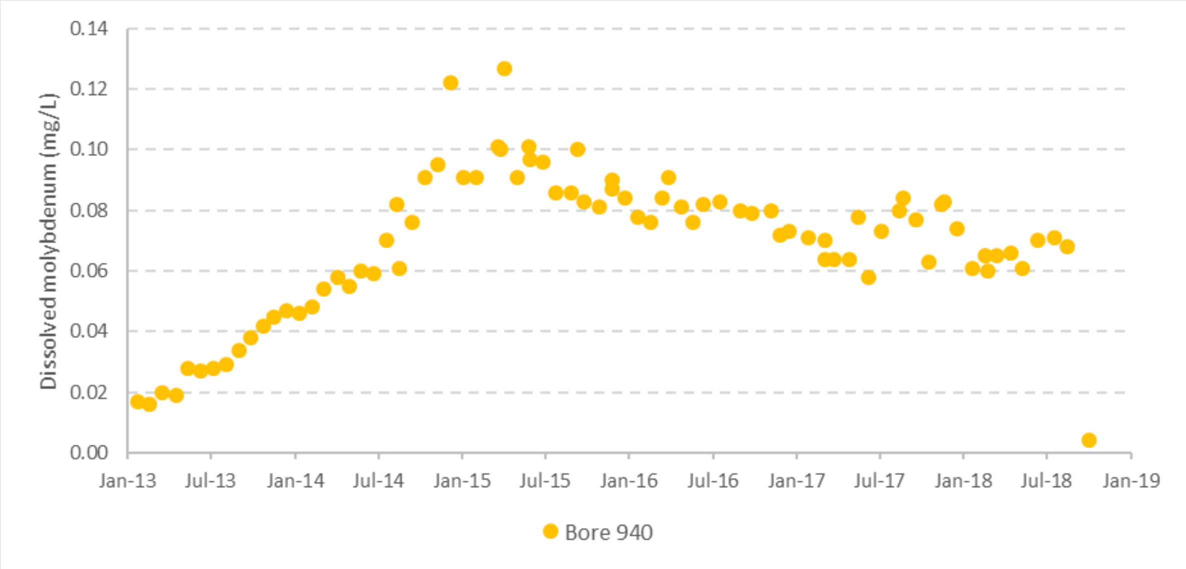
Dissolved lithium (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



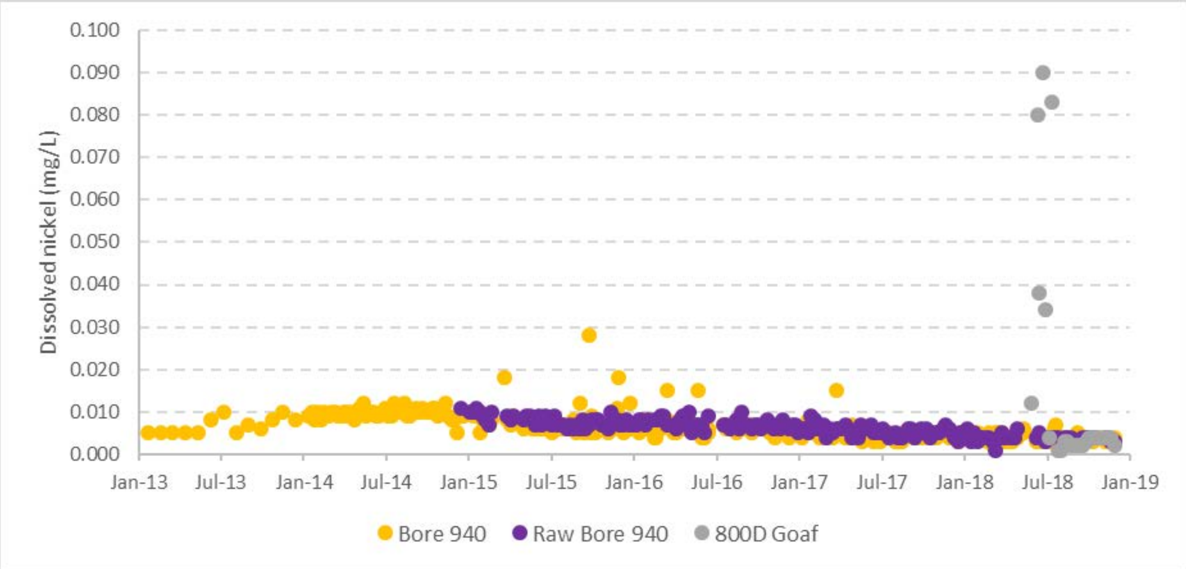
Dissolved manganese (mg/L)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf



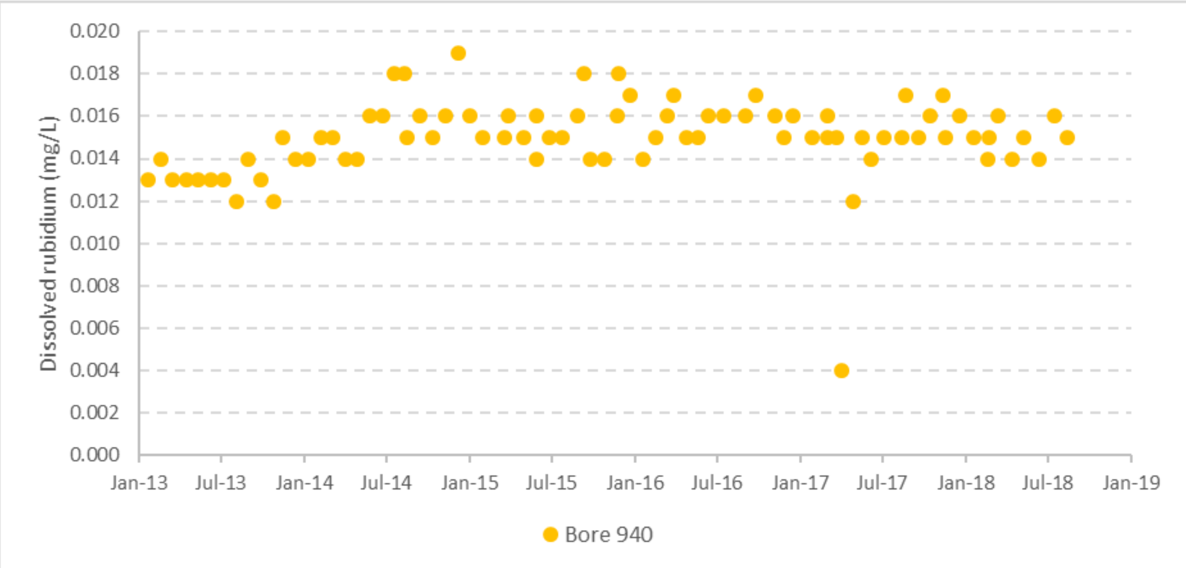
Dissolved mercury (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



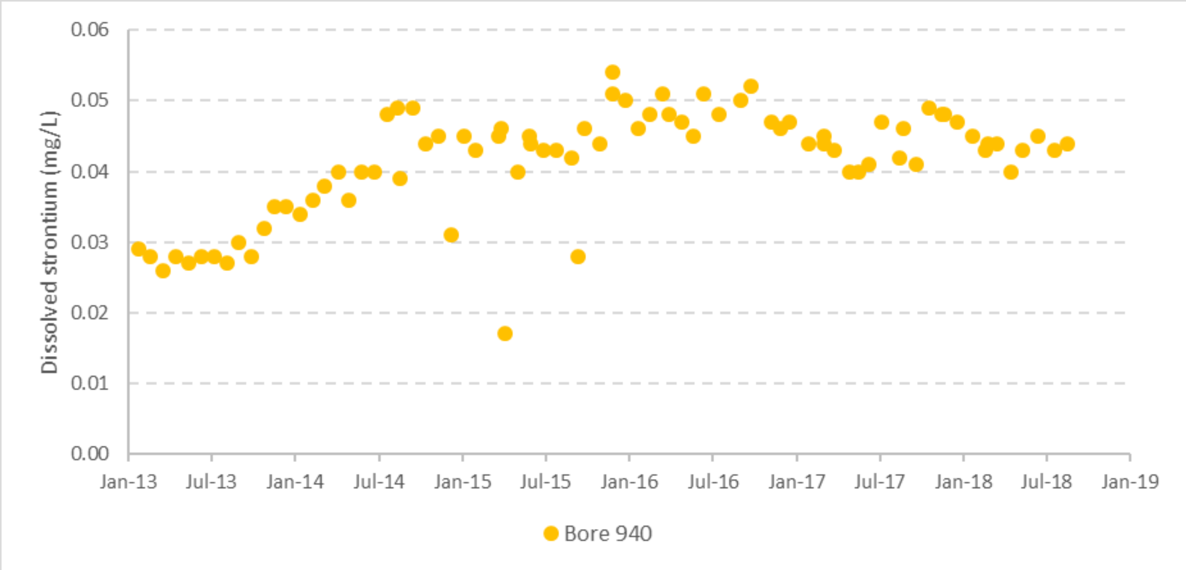
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved molybdenum (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



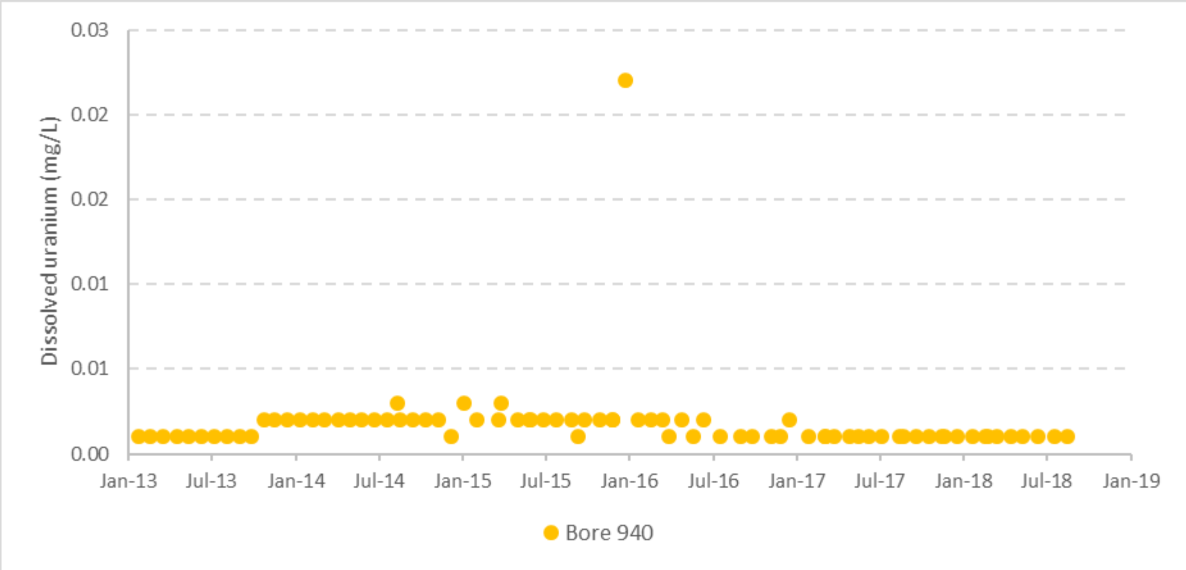
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Dissolved nickel (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf



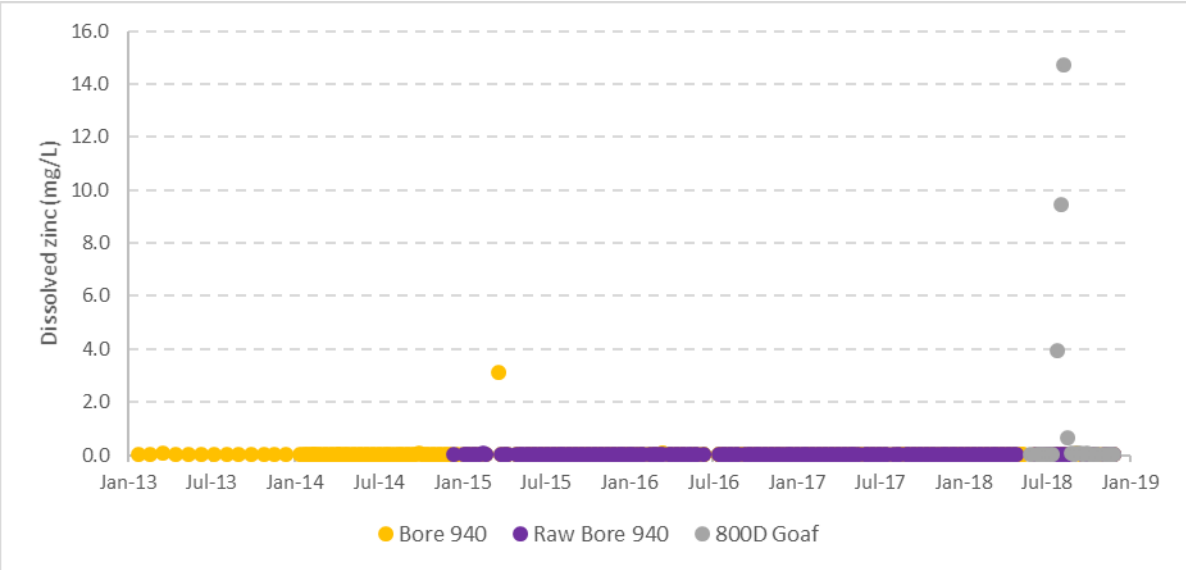
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved rubidium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



Dissolved strontium (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

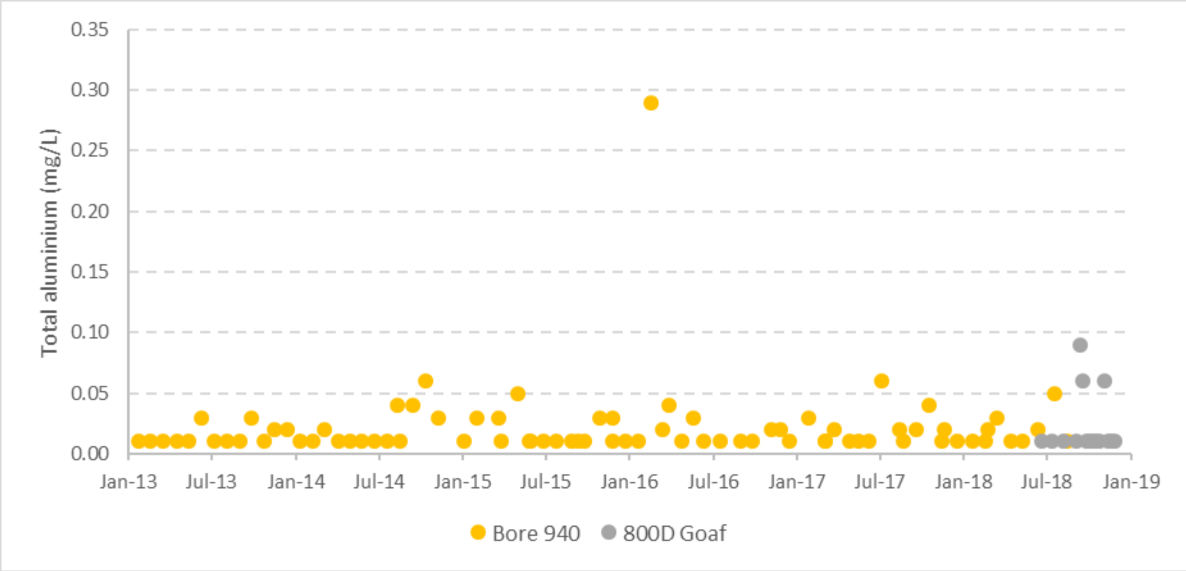


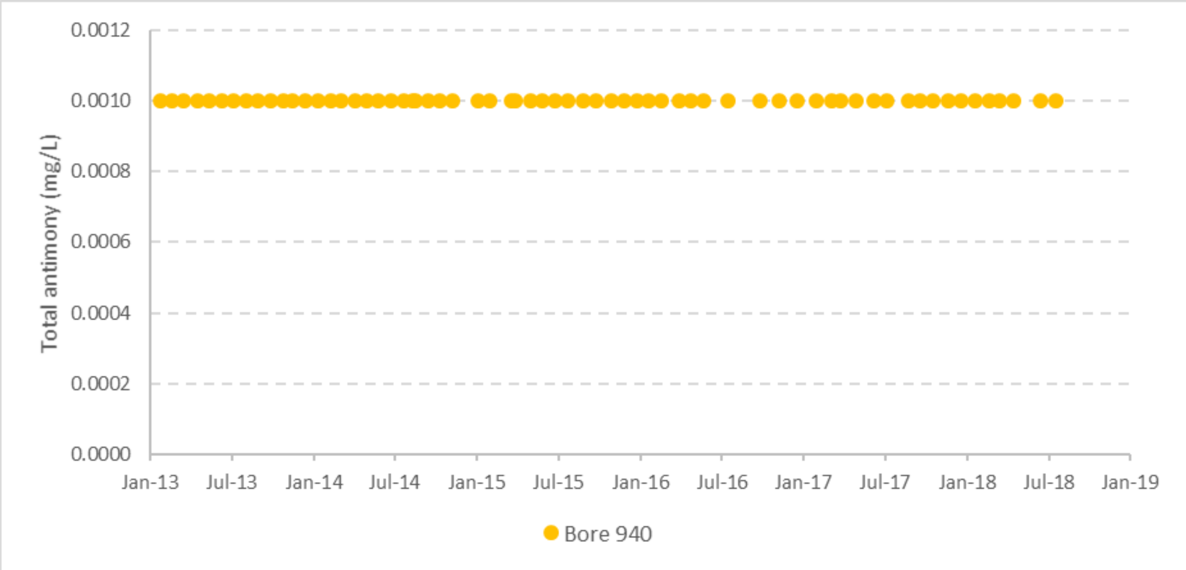
Dissolved uranium (mg/L)
0.03
0.02
0.02
0.01
0.01
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

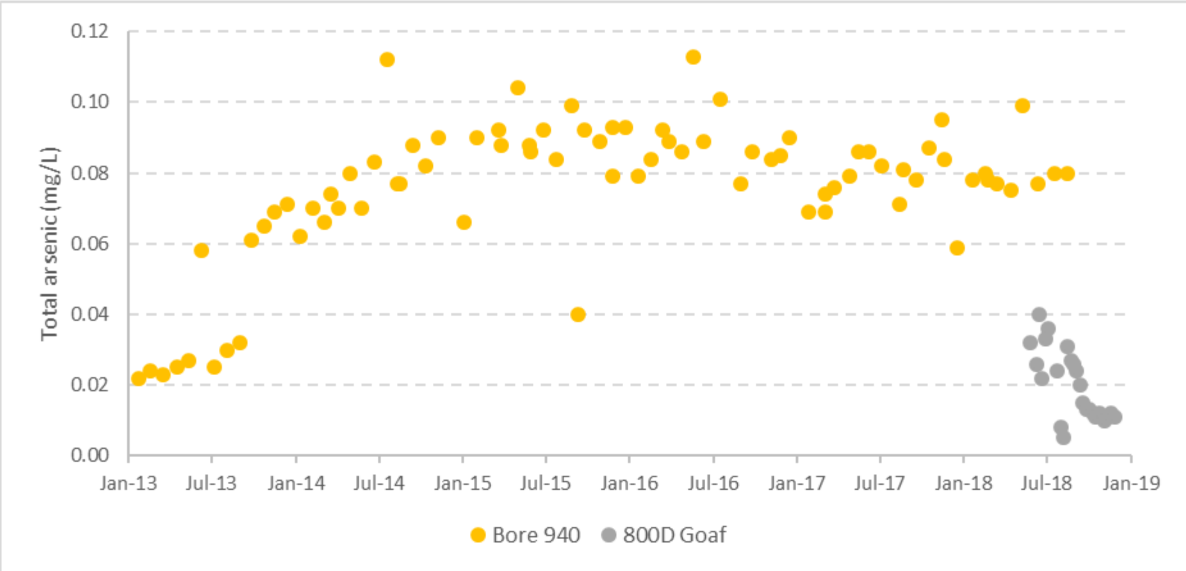


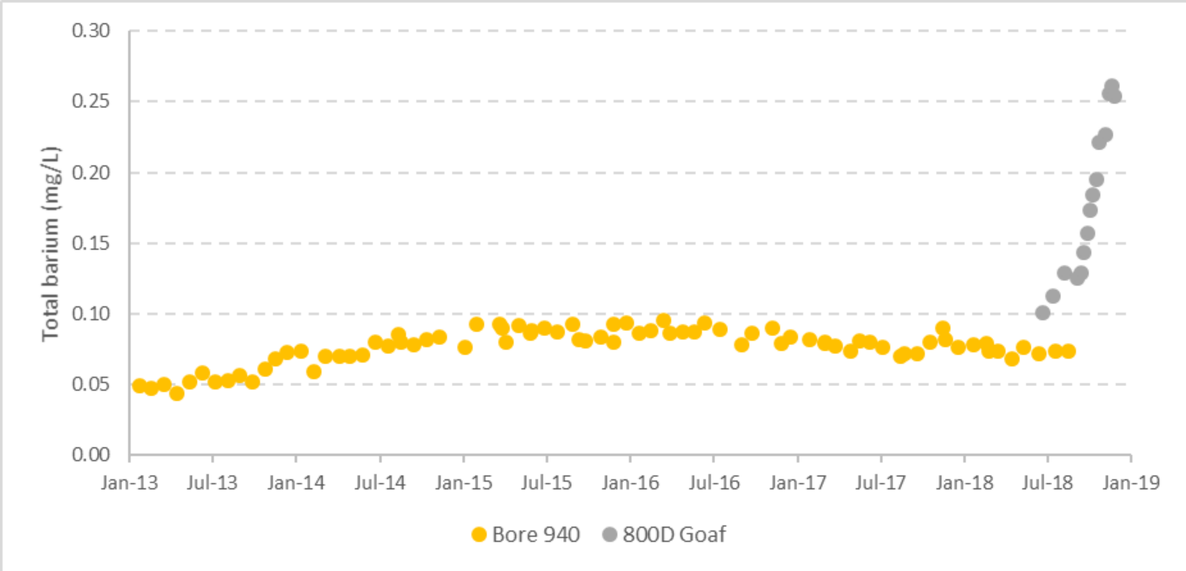
Dissolved zinc (mg/L)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
Raw Bore 940
800D Goaf

Total metals

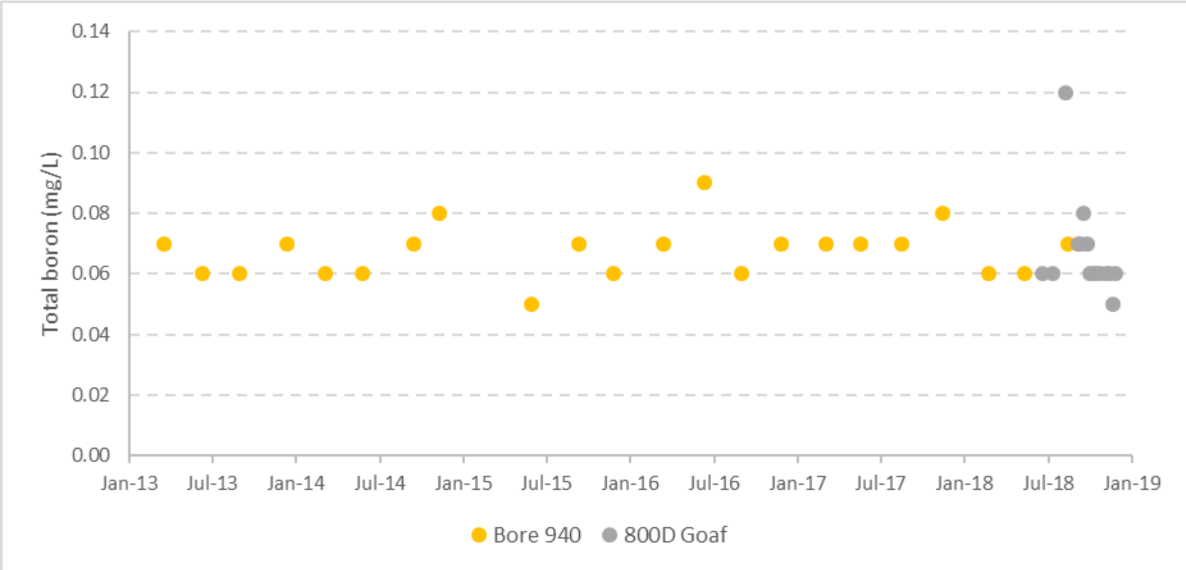




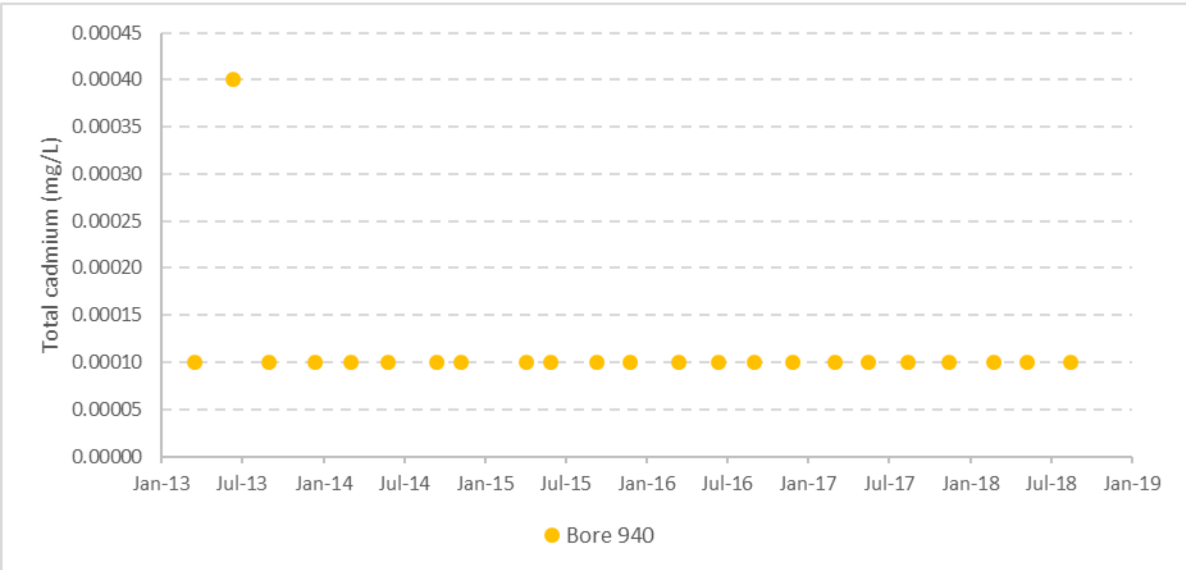




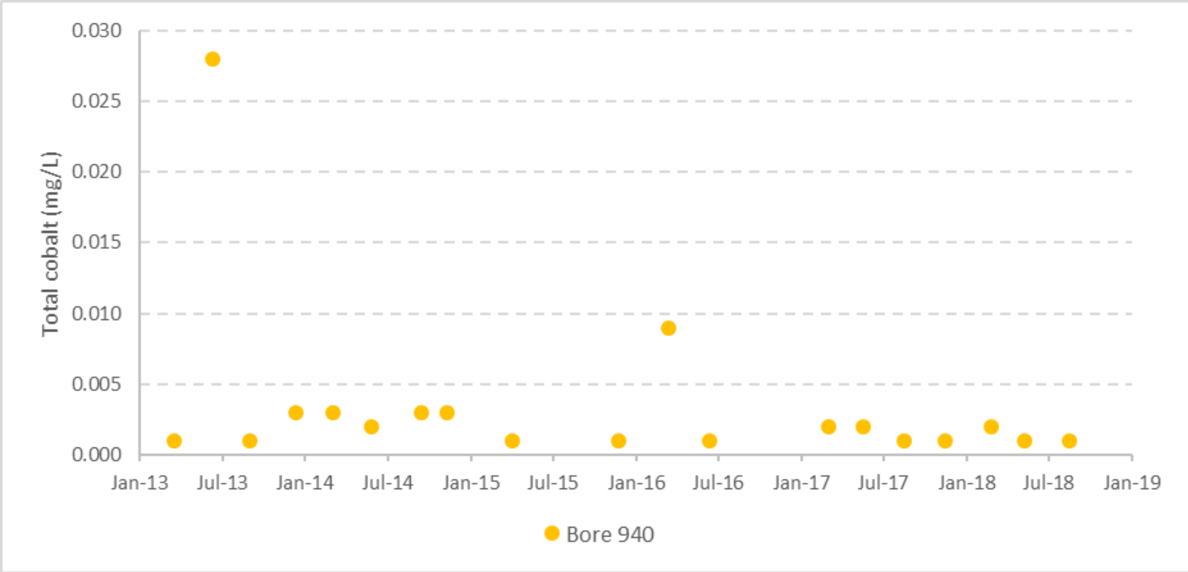
Total barium (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

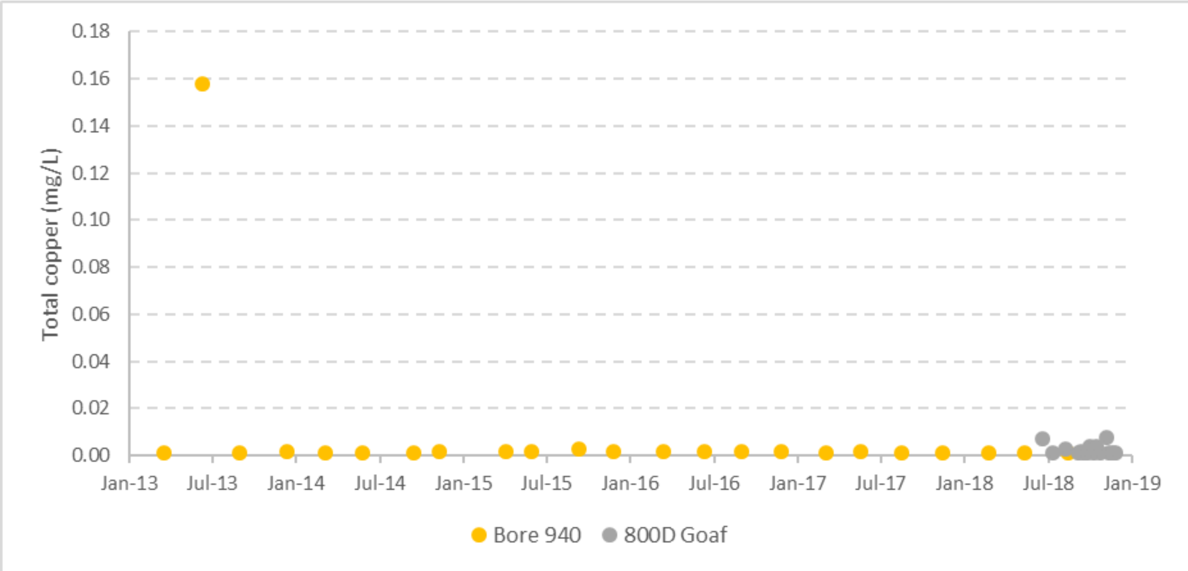


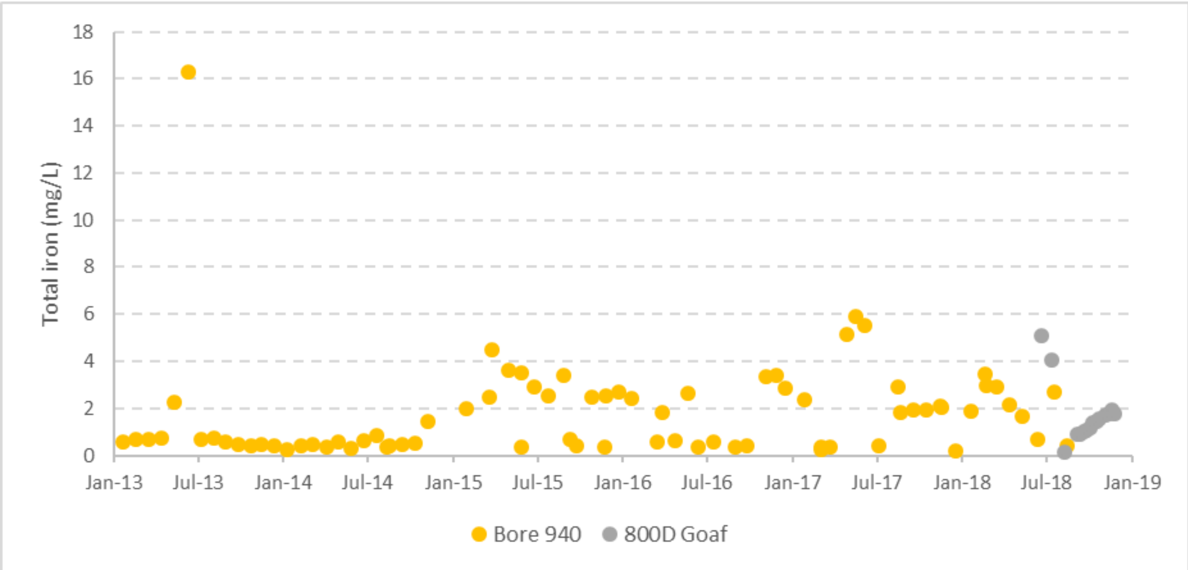
Total boron (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

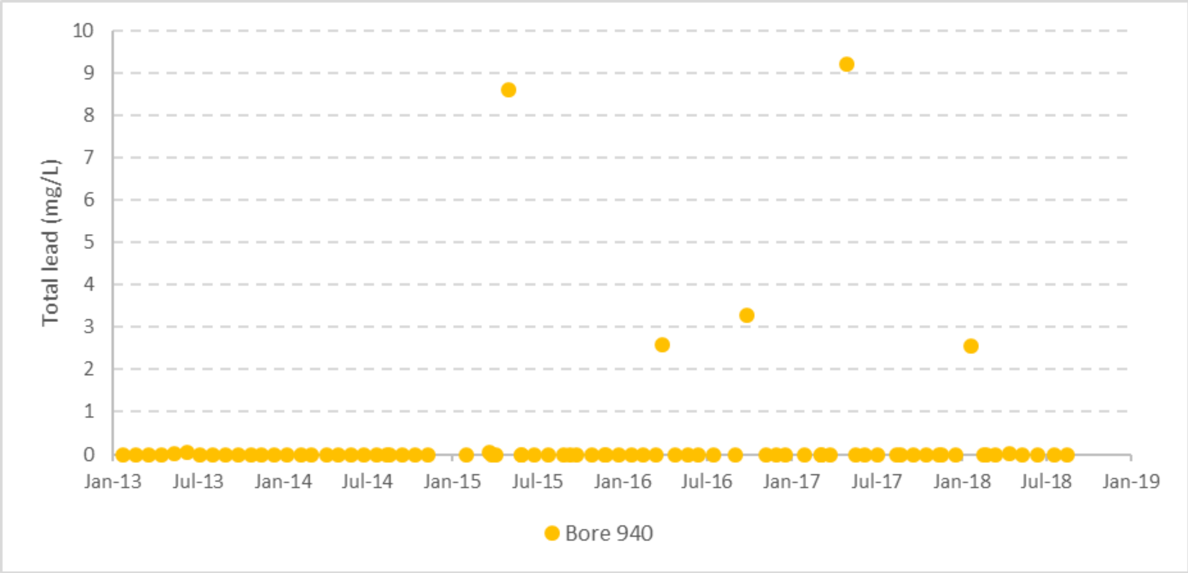


Total cadmium (mg/L)
0.00045
0.00040
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

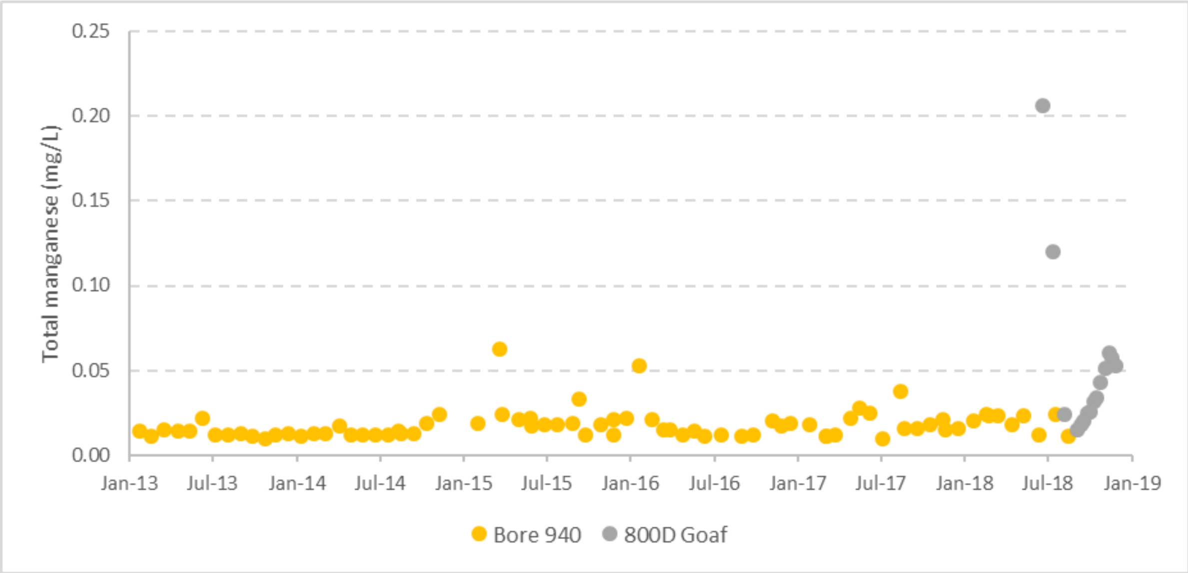

Total cobalt (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940


Total copper (mg/L)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

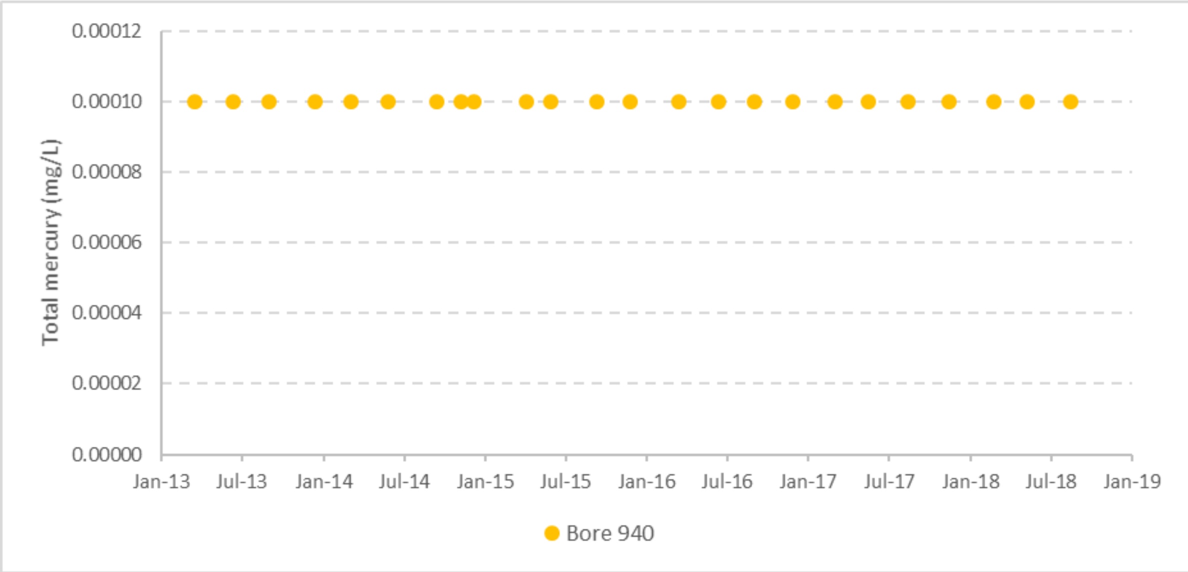

Total iron (mg/L)
18
16
14
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf



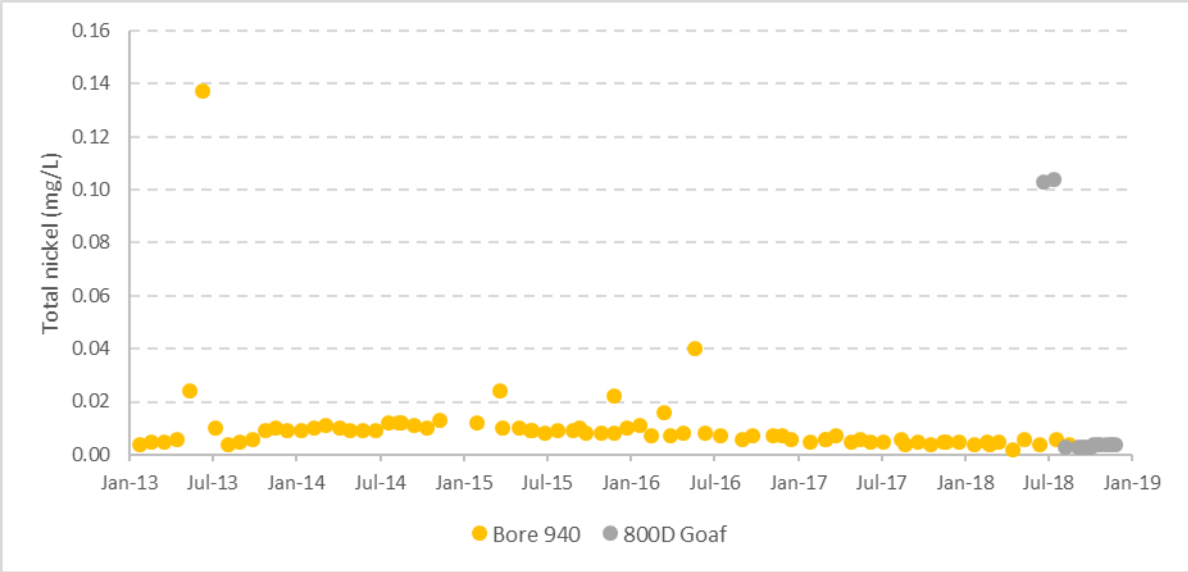
Total lead (mg/L)
10
9
8
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

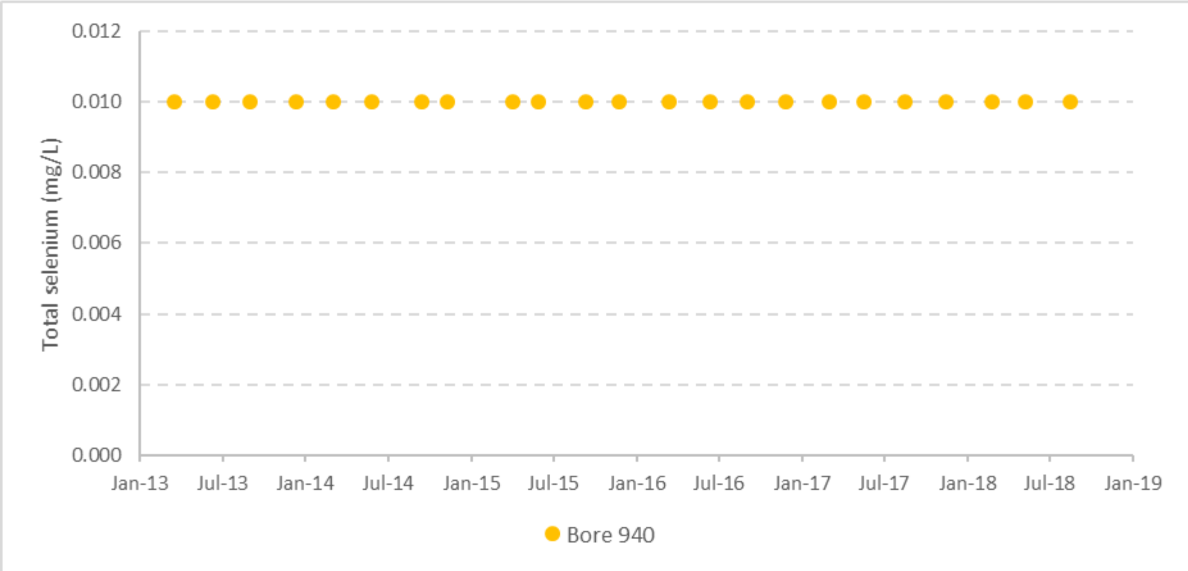


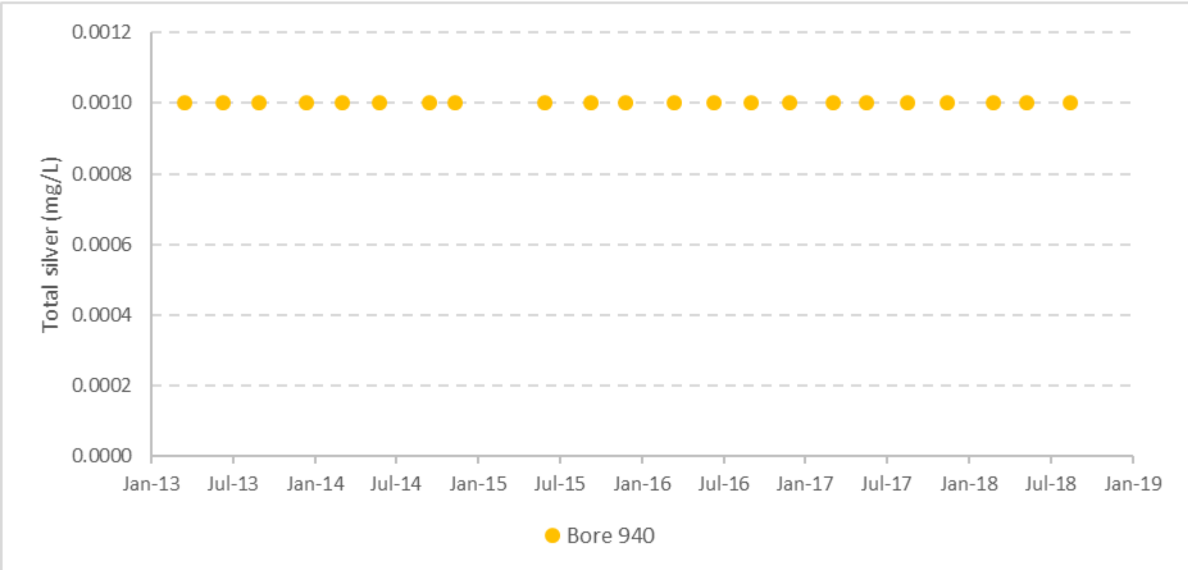
Total manganese (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

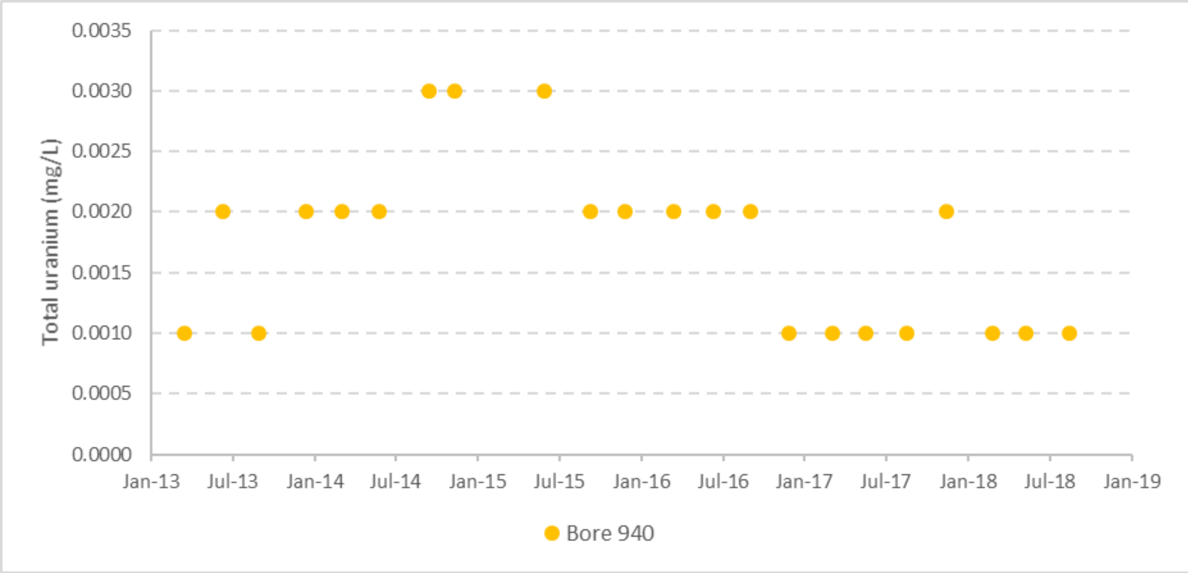


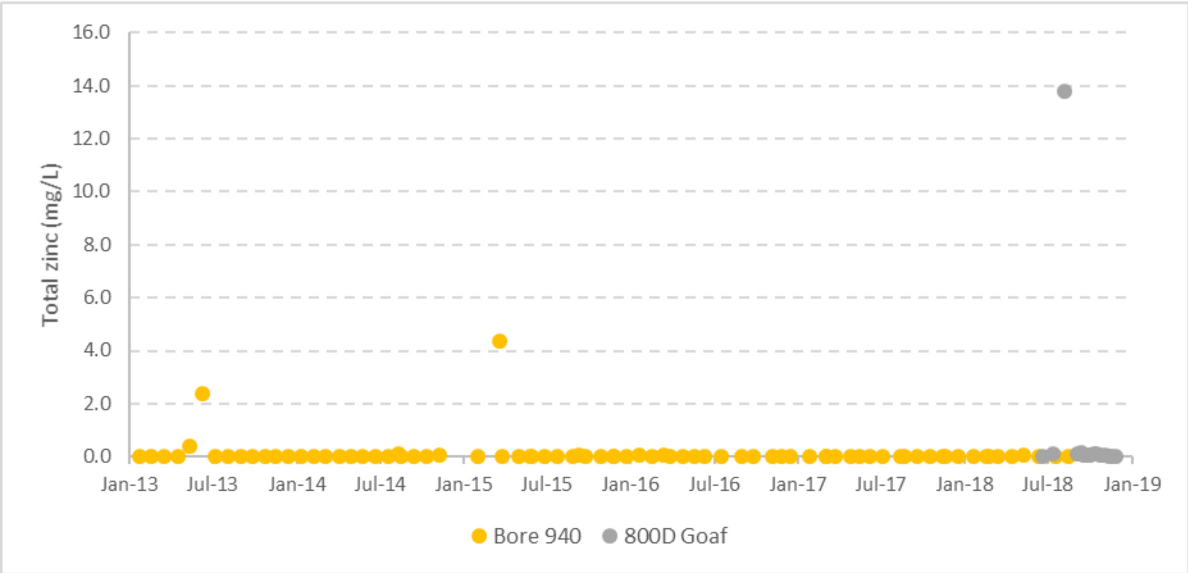
Total mercury (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940


Total nickel (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

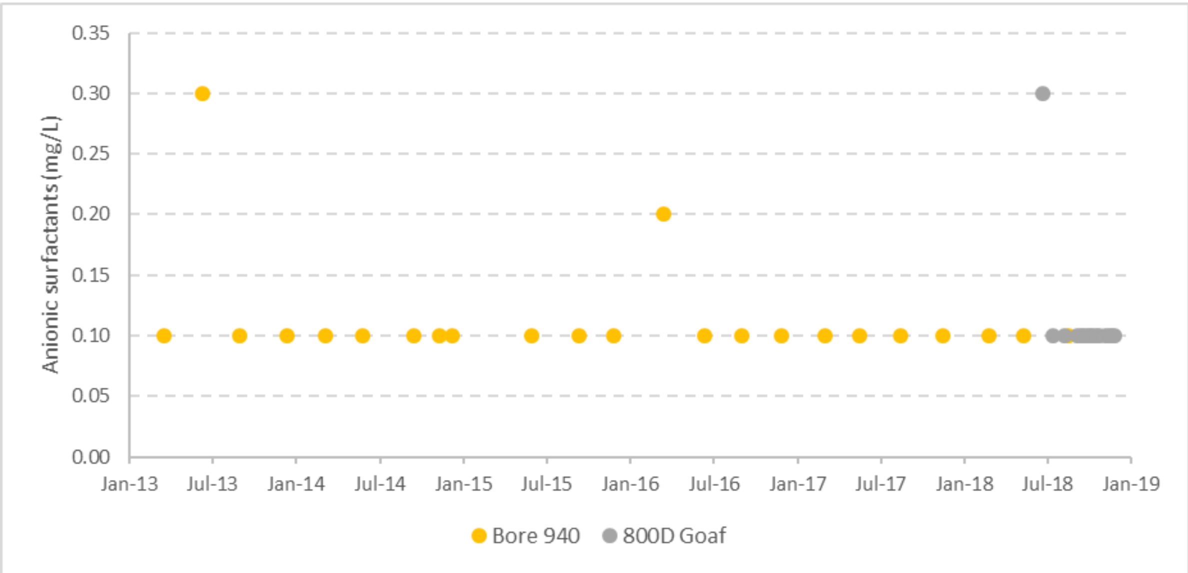

Total selenium (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

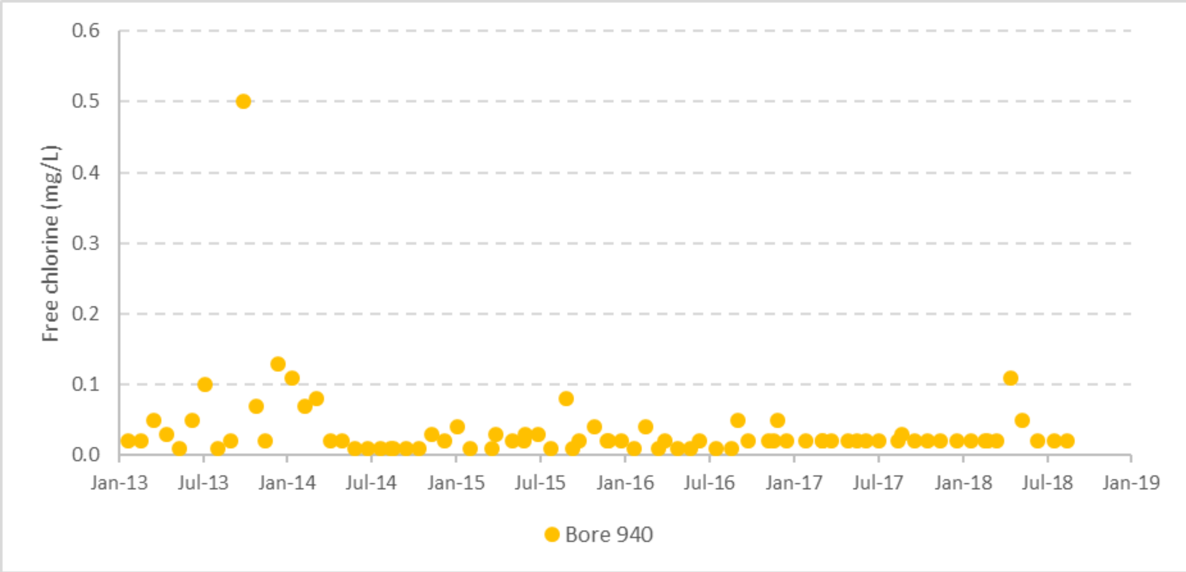

Total silver (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940


Total uranium (mg/L)
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

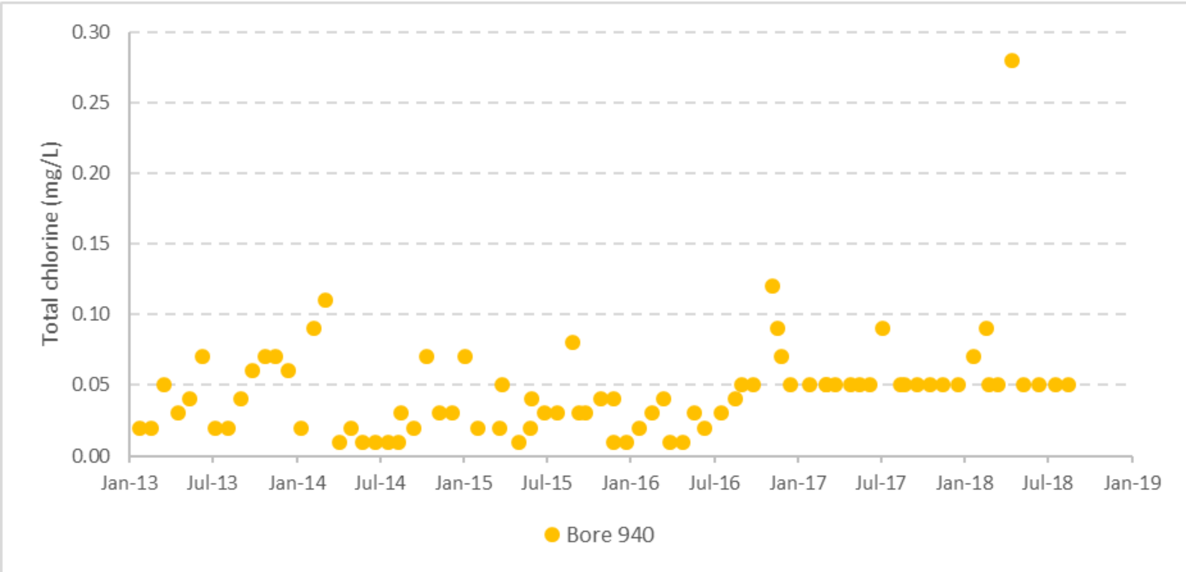

Total zinc (mg/L)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

Other

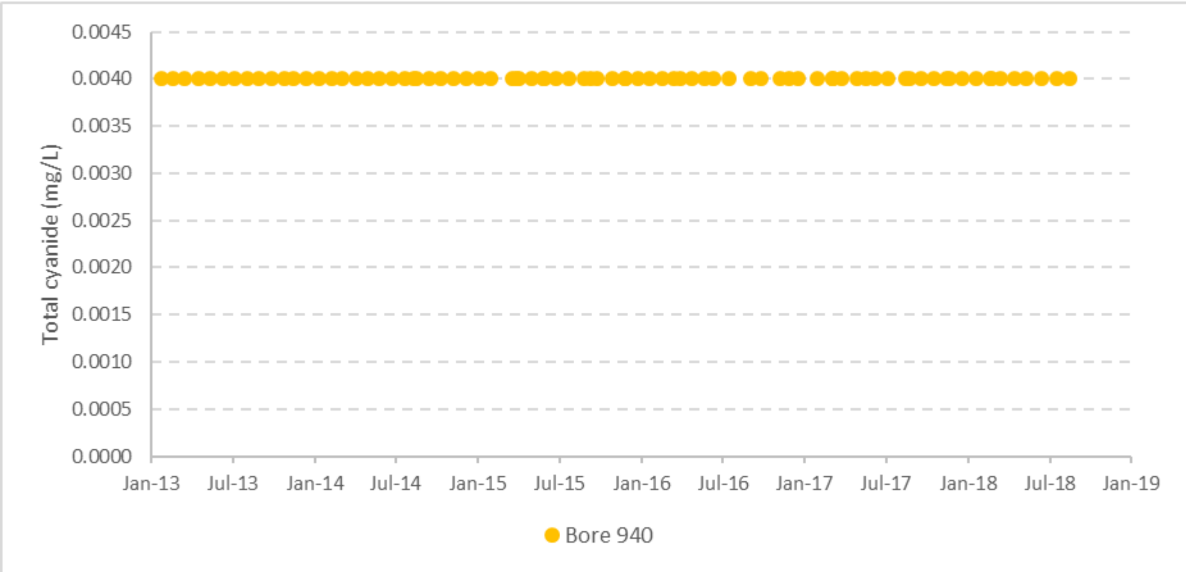

Anionic surfactants (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf



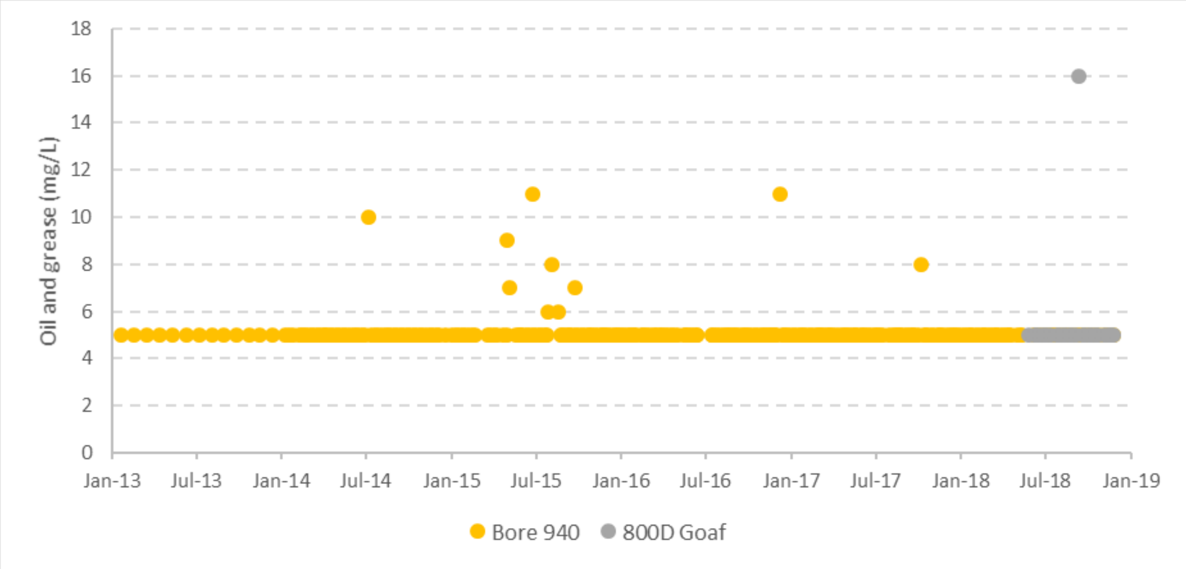
Free chlorine (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



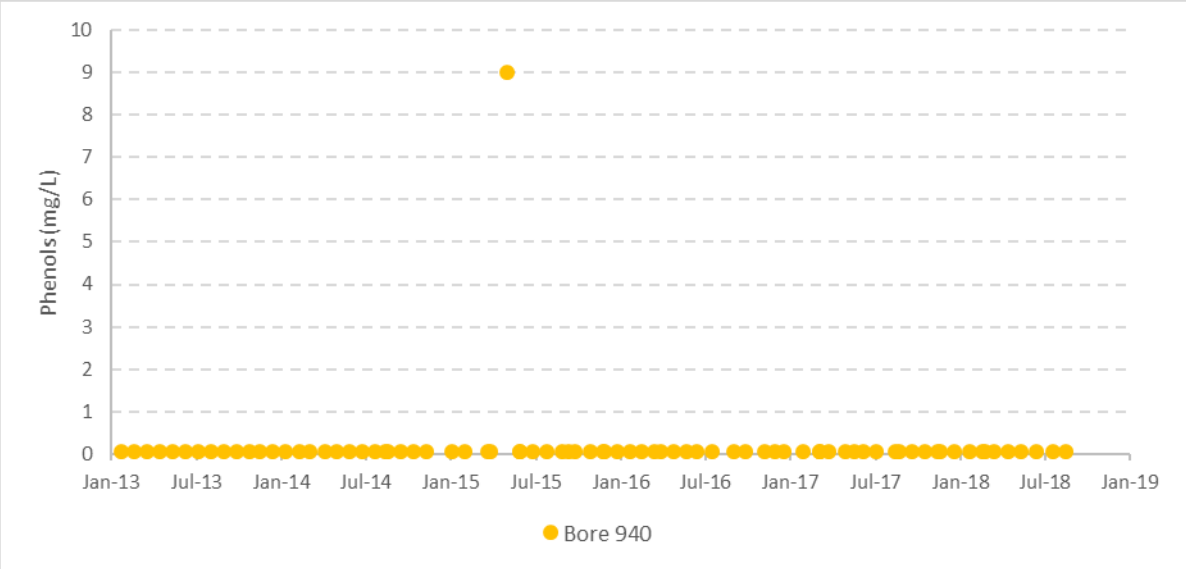
Total chlorine (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



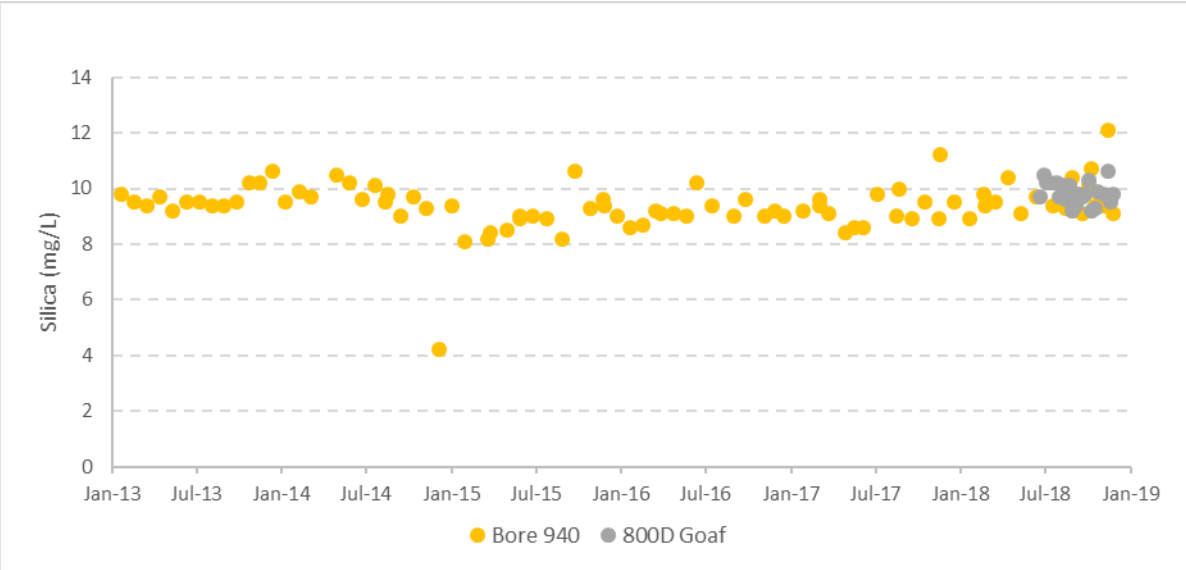
Total cyanide (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



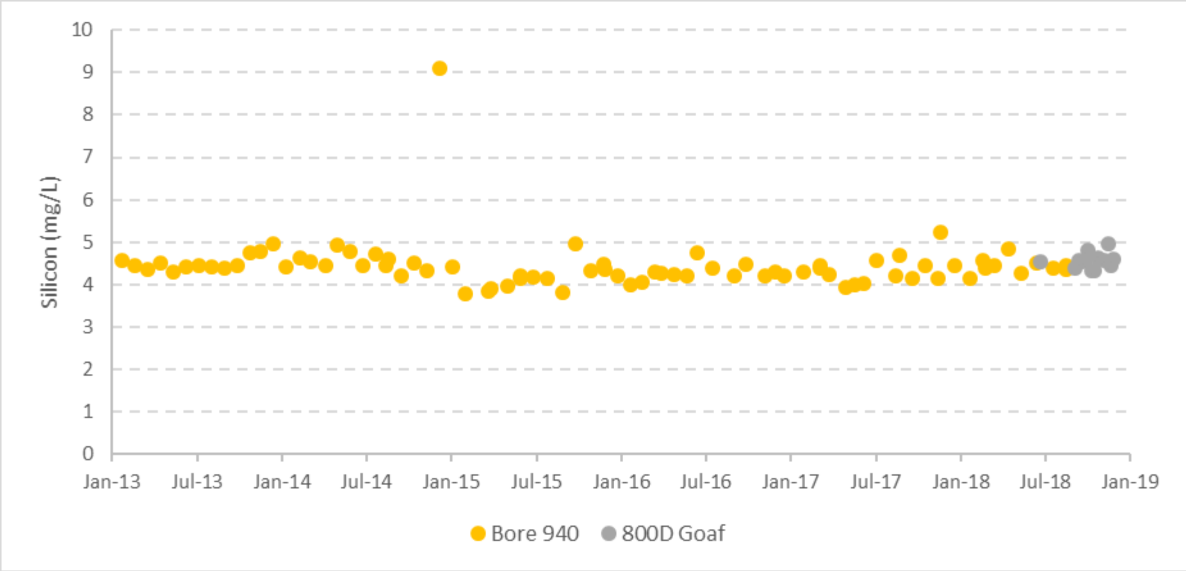
Oil and grease (mg/L)
18
16
14
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf

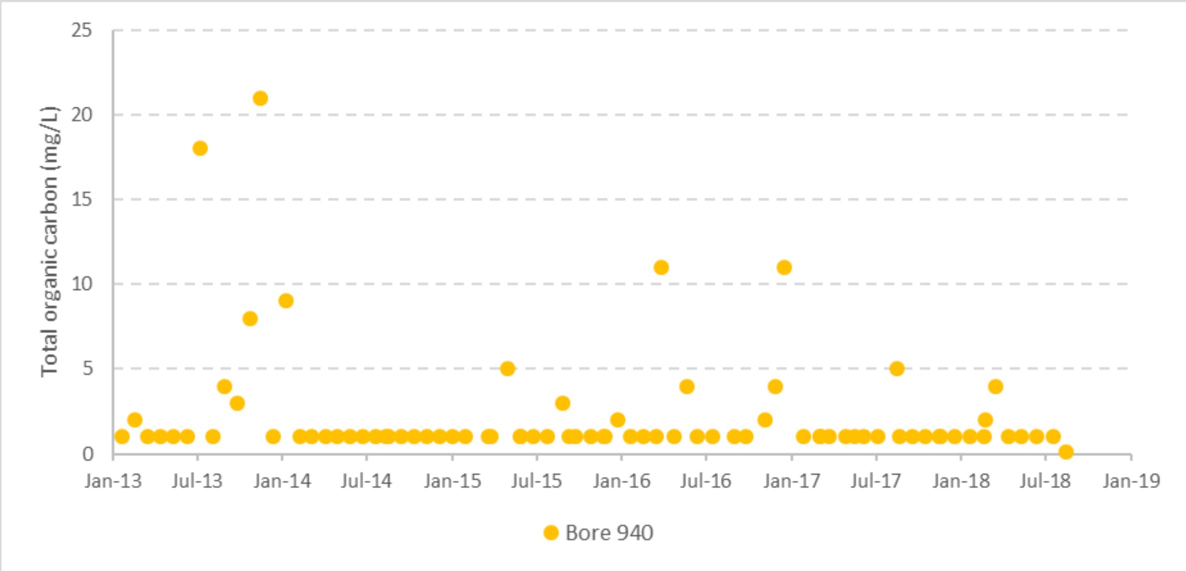


Phenols (mg/L)
10
9
8
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940



Silica (mg/L)
14
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf


Silicon (mg/L)
10
9
8
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940
800D Goaf


Total organic carbon (mg/L)
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bore 940

Appendix E – Additional surface water data

E.1 Surface water quality monitoring

E.1.1 Mining operations

Statistical summary of water quality results

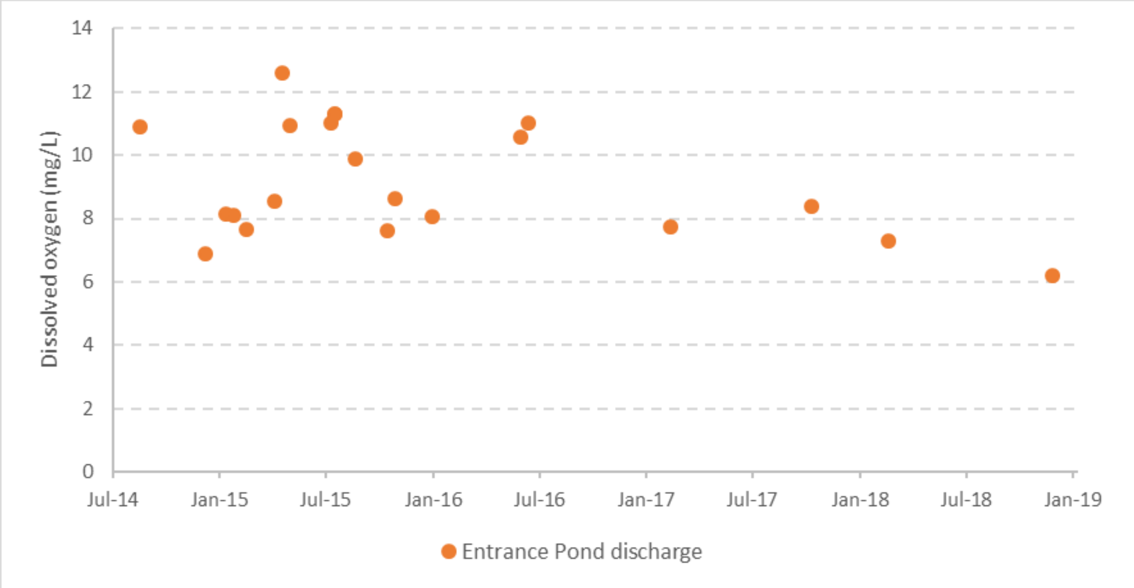
Parameter	Units	Carpark culvert		South Sediment Dam (Entrance Pond)		South Sediment Dam (Entrance Pond) discharge	
		Count	Median	Count	Median	Count	Median
Physicochemical							
DO	mg/L	–	–	–	–	21	8.6
EC	µS/cm	–	–	241	199	24	162
pH	pH units	72	7.8	244	8.1	26	7.9
TDS	mg/L	–	–	–	–	20	302
TSS	mg/L	70	41	232	226	25	362
Turbidity	NTU	–	–	234	725	25	810
Major ions							
Bicarbonate alkalinity	mg/L	–	–	–	–	23	42
Carbonate alkalinity	mg/L	–	–	–	–	23	1
Hydroxide alkalinity	mg/L	–	–	–	–	23	1
Total alkalinity	mg/L	–	–	–	–	23	42
Calcium	mg/L	–	–	–	–	23	7
Chloride	mg/L	–	–	–	–	23	3
Magnesium	mg/L	–	–	–	–	23	1
Potassium	mg/L	–	–	–	–	23	2
Sodium	mg/L	–	–	–	–	23	17
Sulfate	mg/L	–	–	–	–	23	26
Total hardness	mg/L	–	–	–	–	23	22
Nutrients							
Ammonia	mg/L	–	–	–	–	23	0.06
Nitrate	mg/L	–	–	–	–	23	0.26
Nitrite	mg/L	–	–	–	–	23	0.01
Nitrate + nitrite	mg/L	–	–	–	–	23	0.26
Total fluoride	mg/L	–	–	–	–	22	0.1

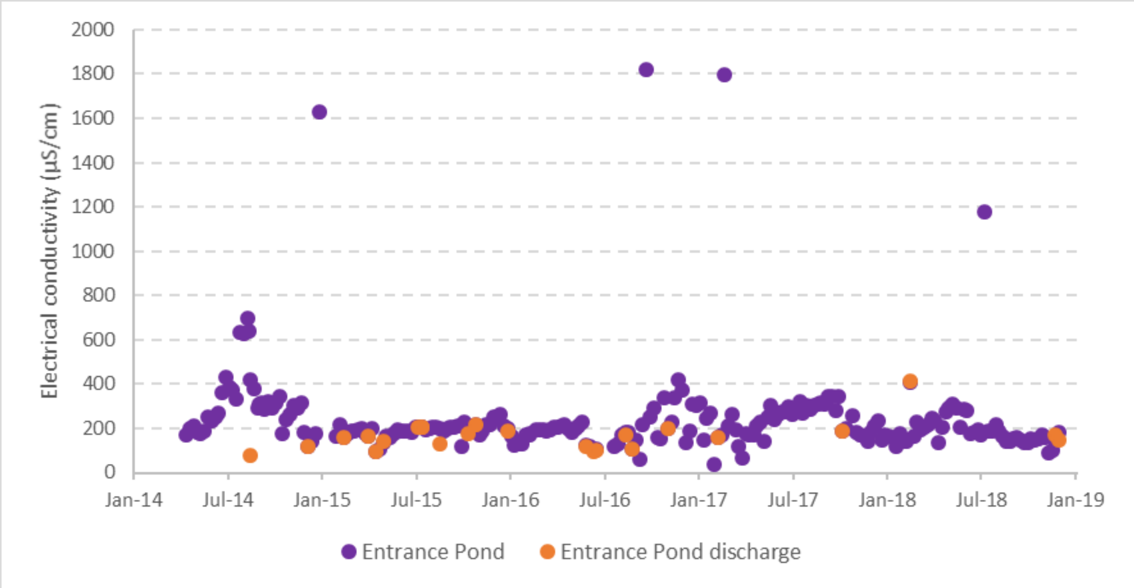
Parameter	Units	Carpark culvert		South Sediment Dam (Entrance Pond)		South Sediment Dam (Entrance Pond) discharge	
		Count	Median	Count	Median	Count	Median
TKN	mg/L	–	–	–	–	23	0.9
Total nitrogen	mg/L	–	–	–	–	23	1.4
Total phosphorus	mg/L	–	–	–	–	23	0.48
Dissolved metals							
Aluminium	mg/L	–	–	–	–	24	0.15
Antimony	mg/L	–	–	–	–	24	0.001
Arsenic	mg/L	–	–	–	–	24	0.001
Barium	mg/L	–	–	–	–	24	0.011
Boron	mg/L	–	–	–	–	24	0.05
Cadmium	mg/L	–	–	–	–	24	0.0001
Copper	mg/L	–	–	–	–	24	0.002
Iron	mg/L	–	–	–	–	24	0.16
Lead	mg/L	–	–	–	–	24	0.001
Lithium	mg/L	–	–	–	–	24	0.001
Manganese	mg/L	–	–	–	–	24	0.007
Molybdenum	mg/L	–	–	–	–	24	0.007
Nickel	mg/L	–	–	–	–	24	0.001
Rubidium	mg/L	–	–	–	–	24	0.002
Strontium	mg/L	–	–	–	–	24	0.022
Uranium	mg/L	–	–	–	–	24	0.001
Zinc	mg/L	–	–	–	–	24	0.008
Total metals							
Aluminium	mg/L	–	–	–	–	23	13.2
Antimony	mg/L	–	–	–	–	21	0.001
Arsenic	mg/L	–	–	–	–	23	0.005
Barium	mg/L	–	–	–	–	23	0.090
Iron	mg/L	–	–	–	–	23	12.7
Lead	mg/L	–	–	–	–	23	0.020
Manganese	mg/L	–	–	–	–	23	0.100

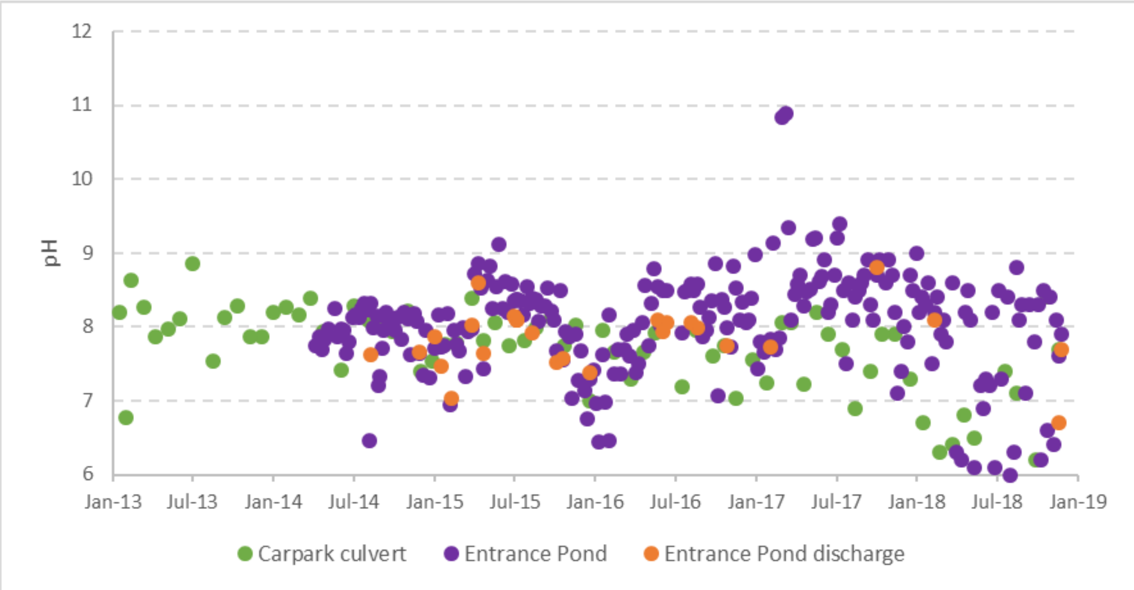
Parameter	Units	Carpark culvert		South Sediment Dam (Entrance Pond)		South Sediment Dam (Entrance Pond) discharge	
		Count	Median	Count	Median	Count	Median
Nickel	mg/L	–	–	–	–	23	0.017
Zinc	mg/L	–	–	–	–	23	0.047
Other							
Free chlorine	mg/L	–	–	–	–	24	0.02
Total chlorine	mg/L	–	–	–	–	24	0.05
Total cyanide	mg/L	–	–	–	–	24	0.004
Oil and grease	mg/L	68	5	234	5	26	5
Phenols	mg/L	–	–	–	–	20	0.05
Silica	mg/L	–	–	–	–	22	5.0
Silicon	mg/L	–	–	–	–	23	2.47
Total organic carbon	mg/L	–	–	–	–	23	7

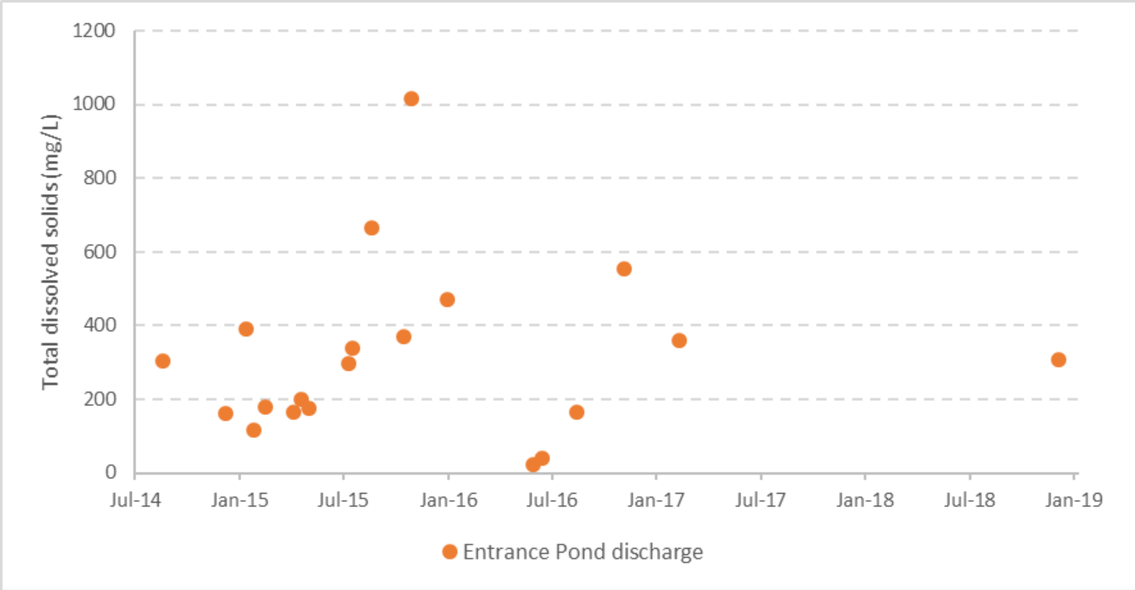
Time series graphs of water quality results

Physicochemical

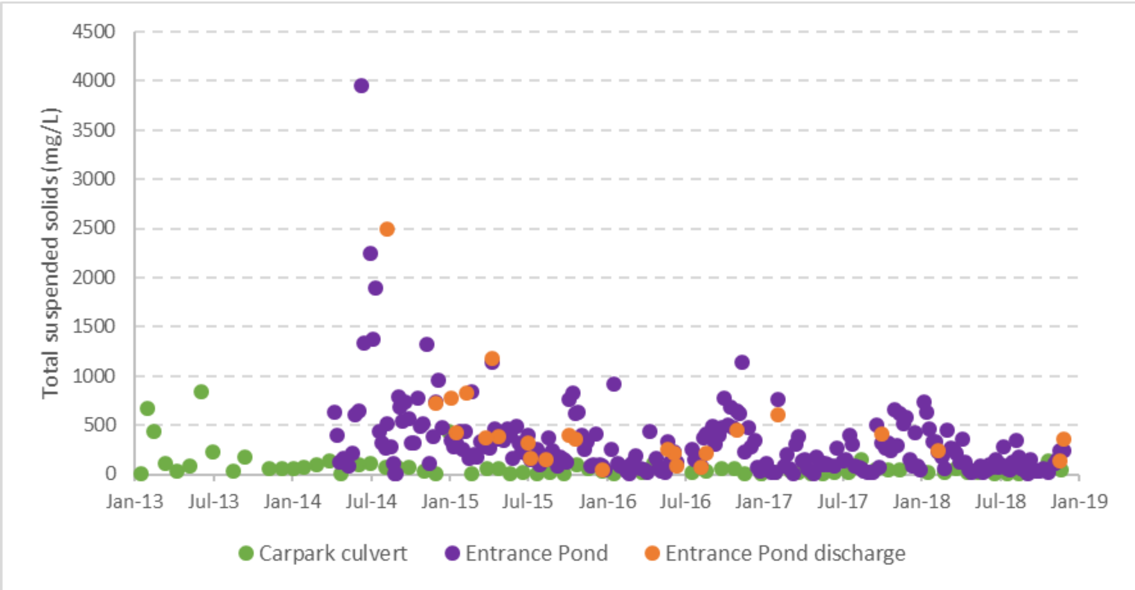




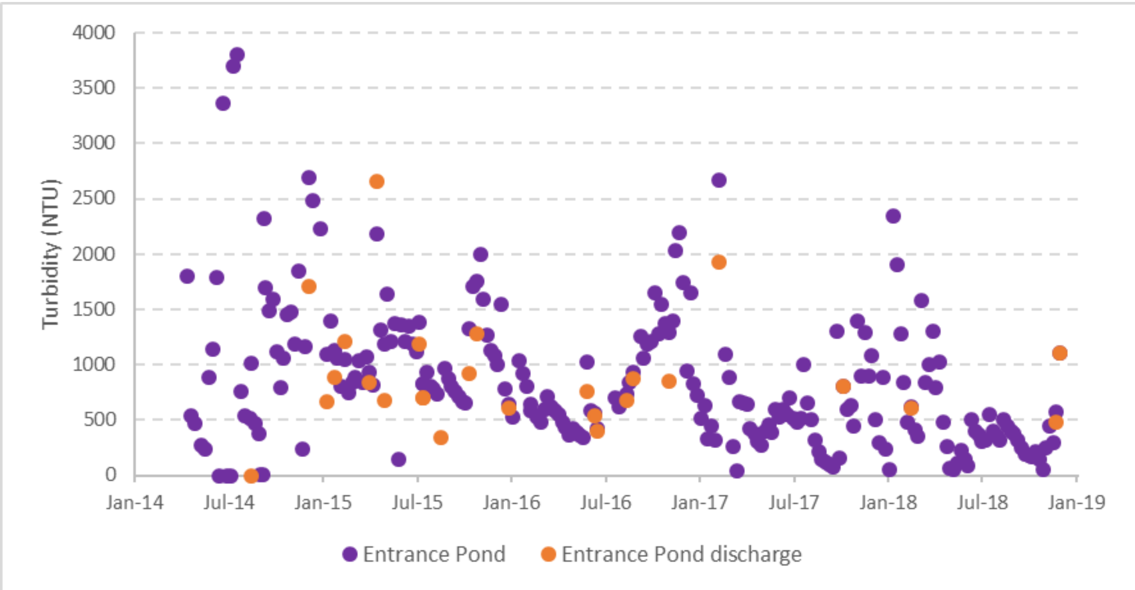




Total dissolved solids (mg/L)
1200
1000
800
600
400
200
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

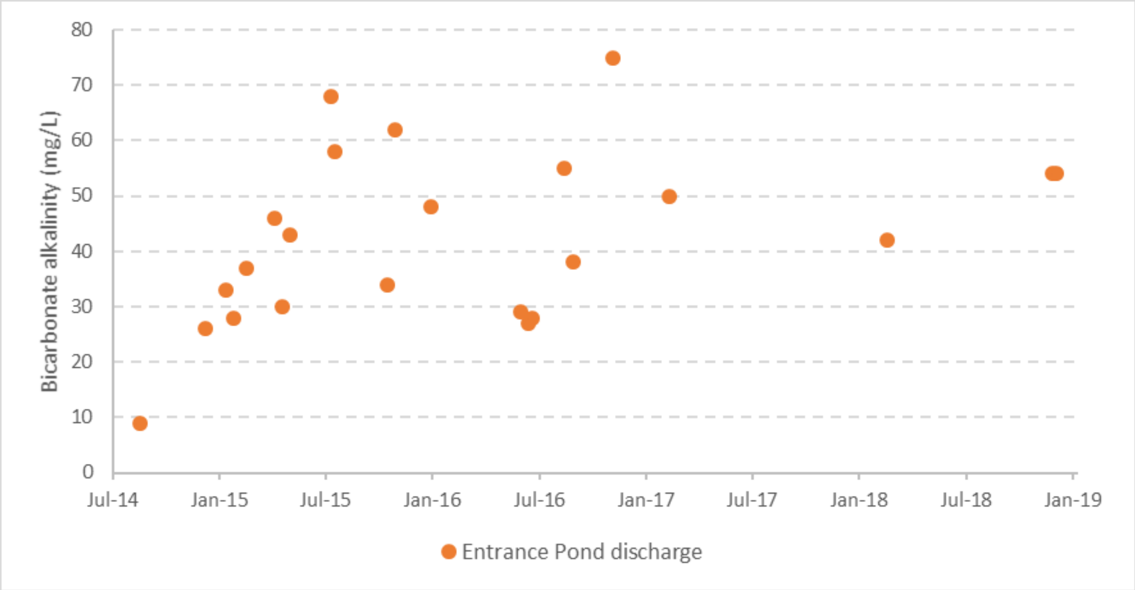


Total suspended solids (mg/L)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Carpark culvert
Entrance Pond
Entrance Pond discharge

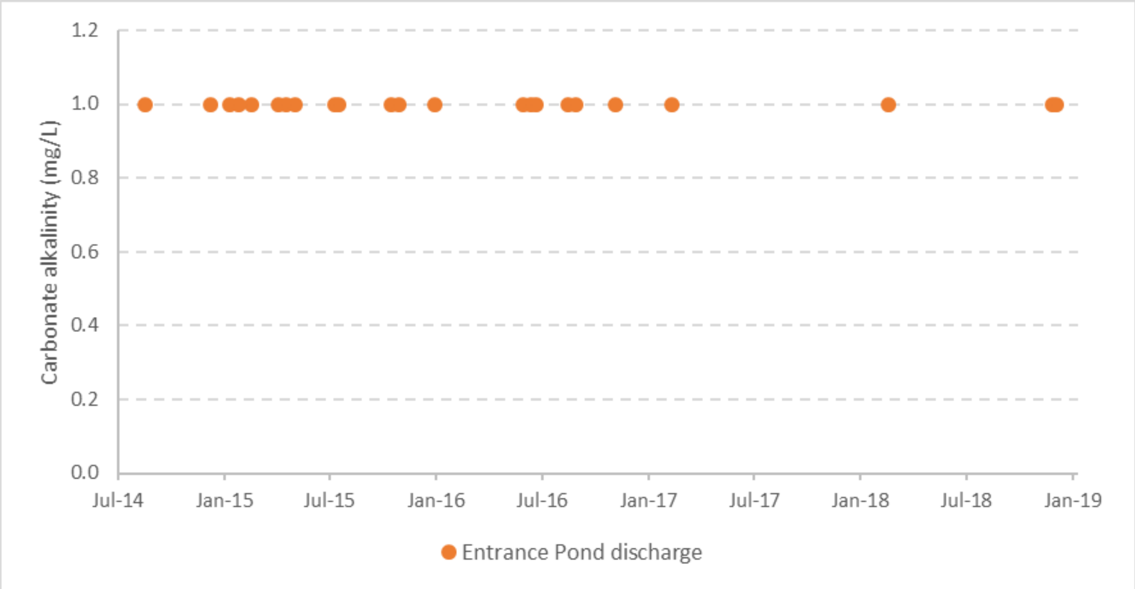


Turbidity (NTU)
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond
Entrance Pond discharge

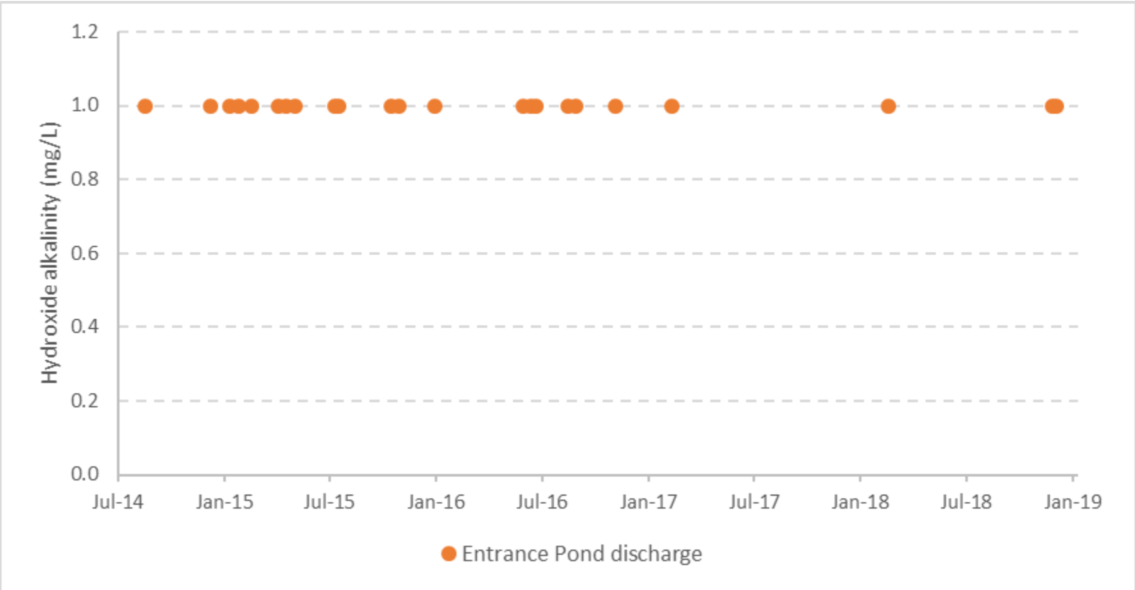
Major ions



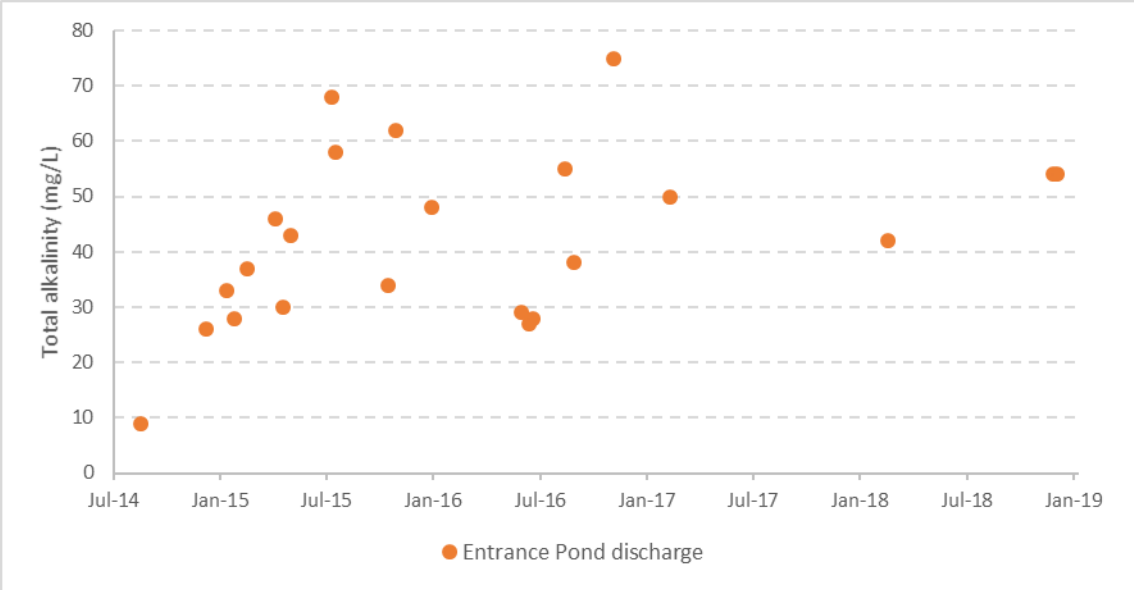
Bicarbonate alkalinity (mg/L)
0
10
20
30
40
50
60
70
80
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



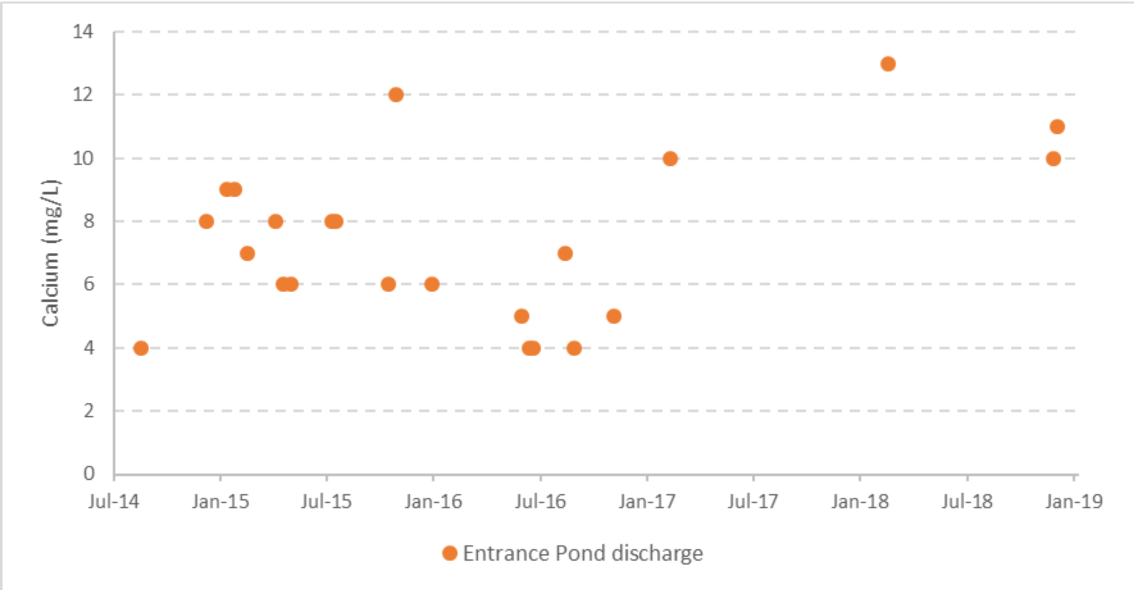
Carbonate alkalinity (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



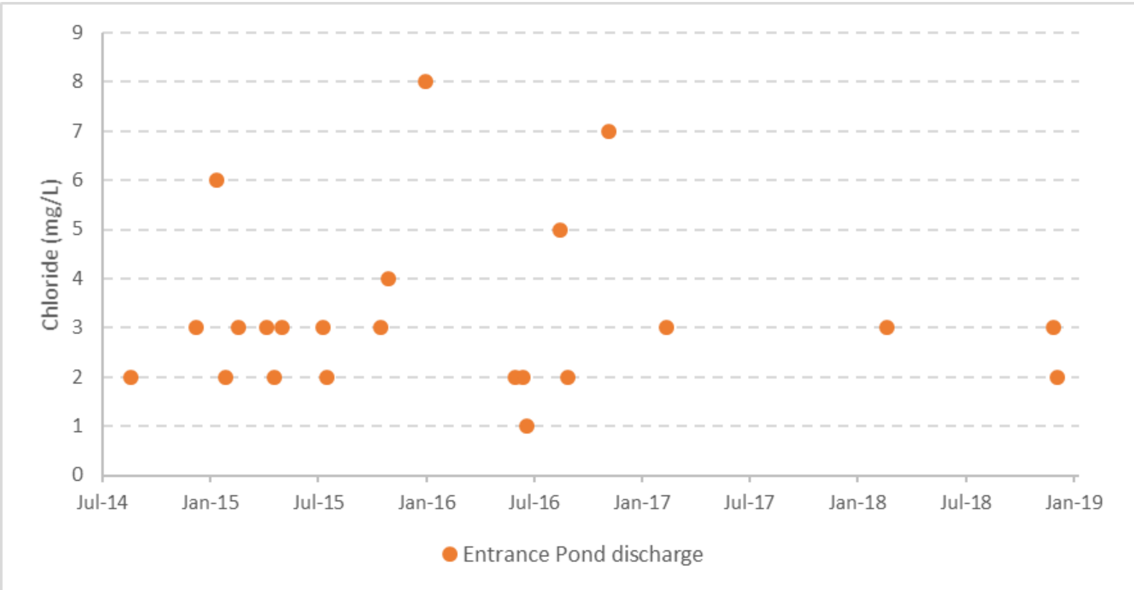
Hydroxide alkalinity (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



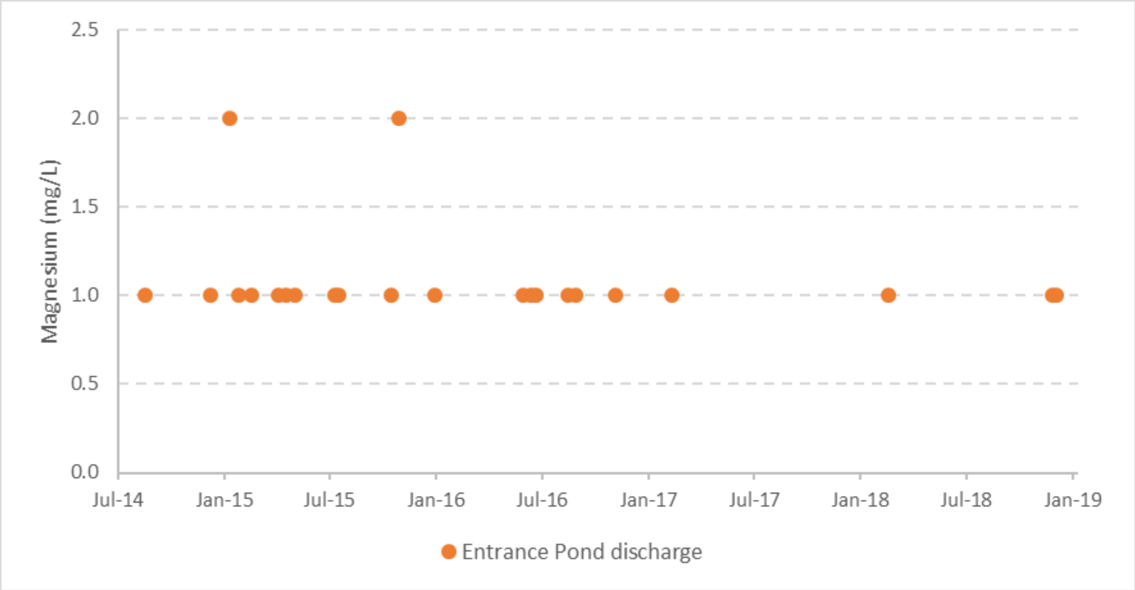
Total alkalinity (mg/L)
80
70
60
50
40
30
20
10
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

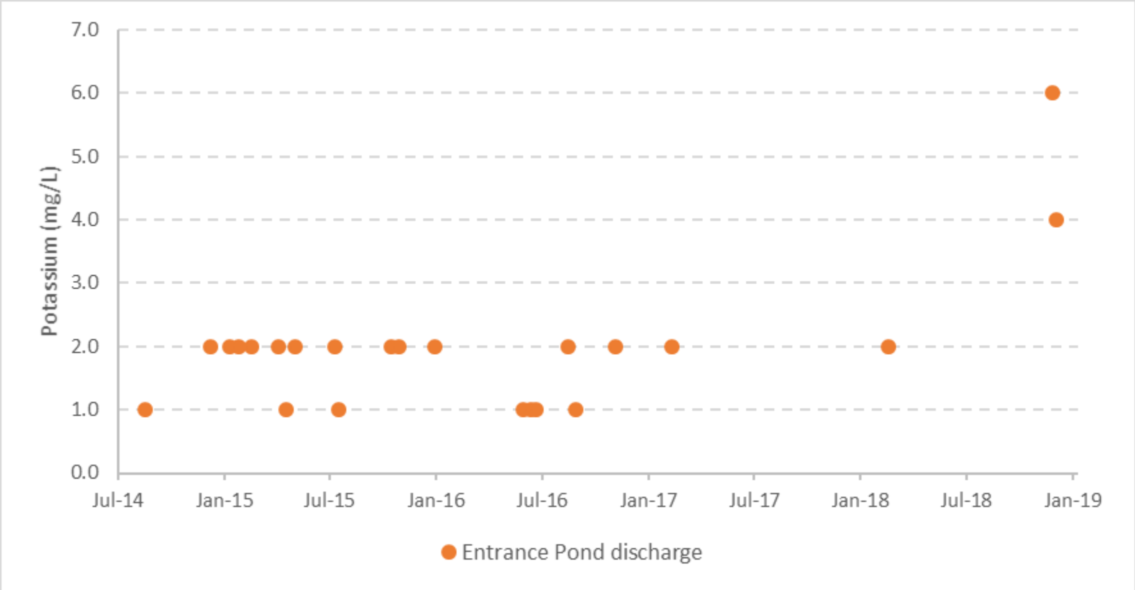


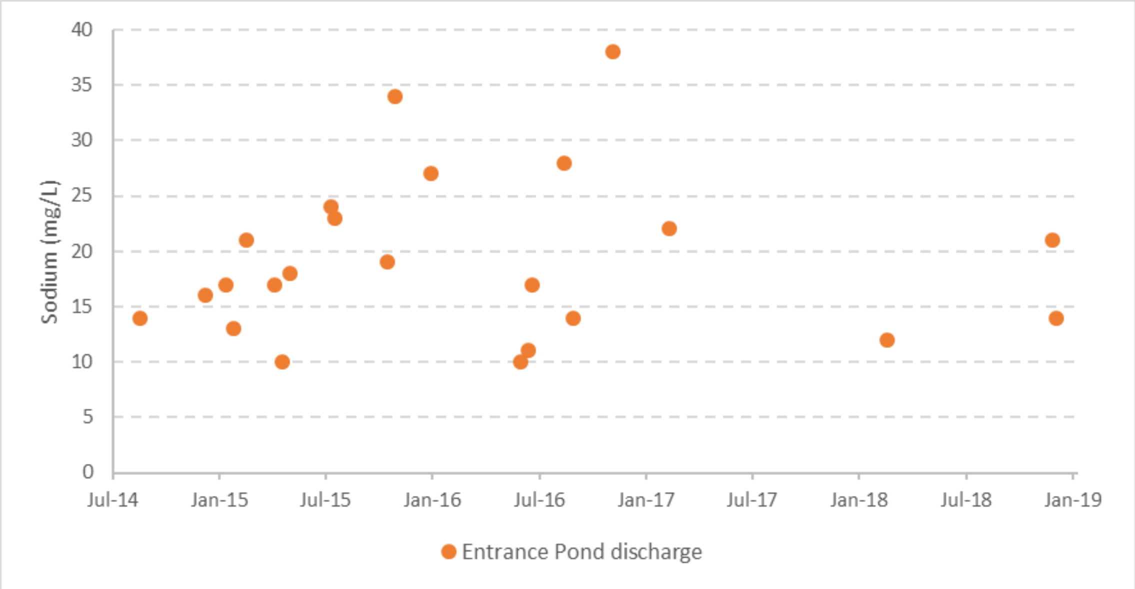
Calcium (mg/L)
14
12
10
8
6
4
2
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

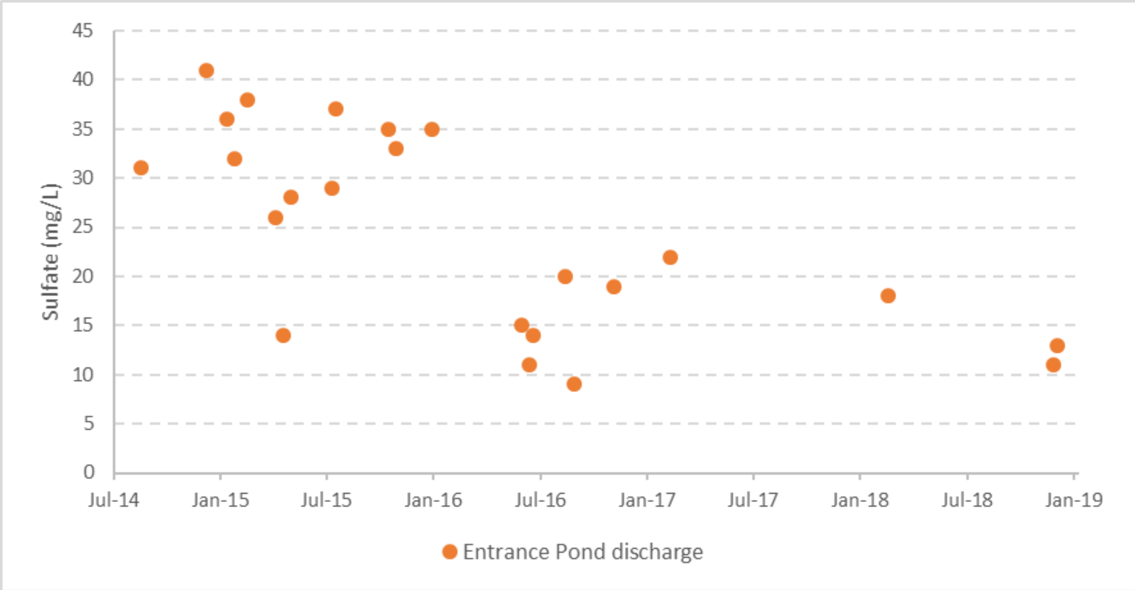


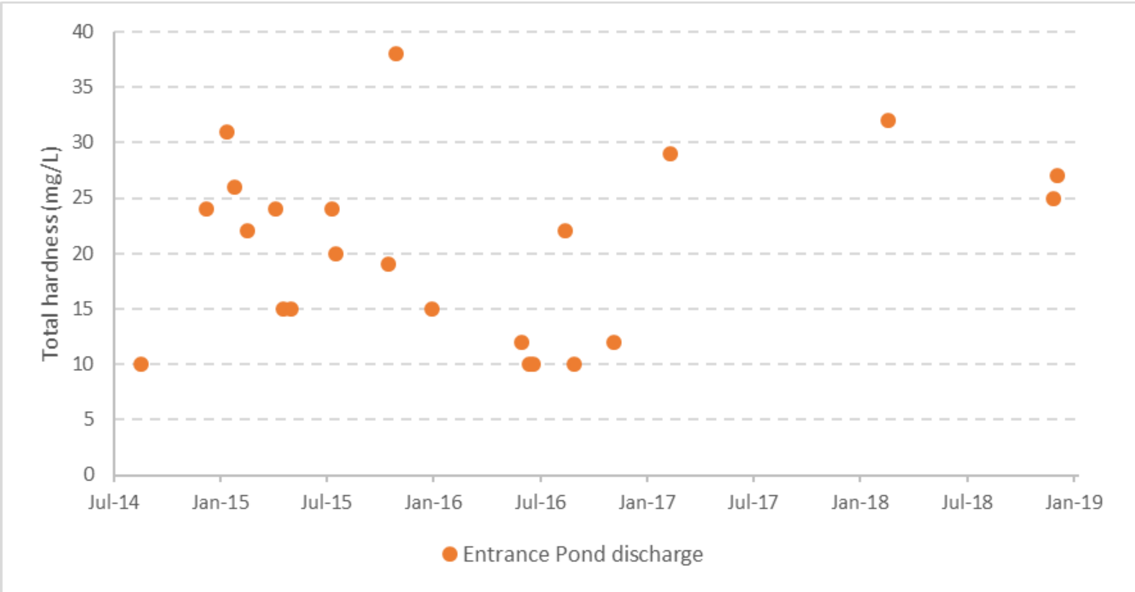
Chloride (mg/L)
9
8
7
6
5
4
3
2
1
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge


Magnesium (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

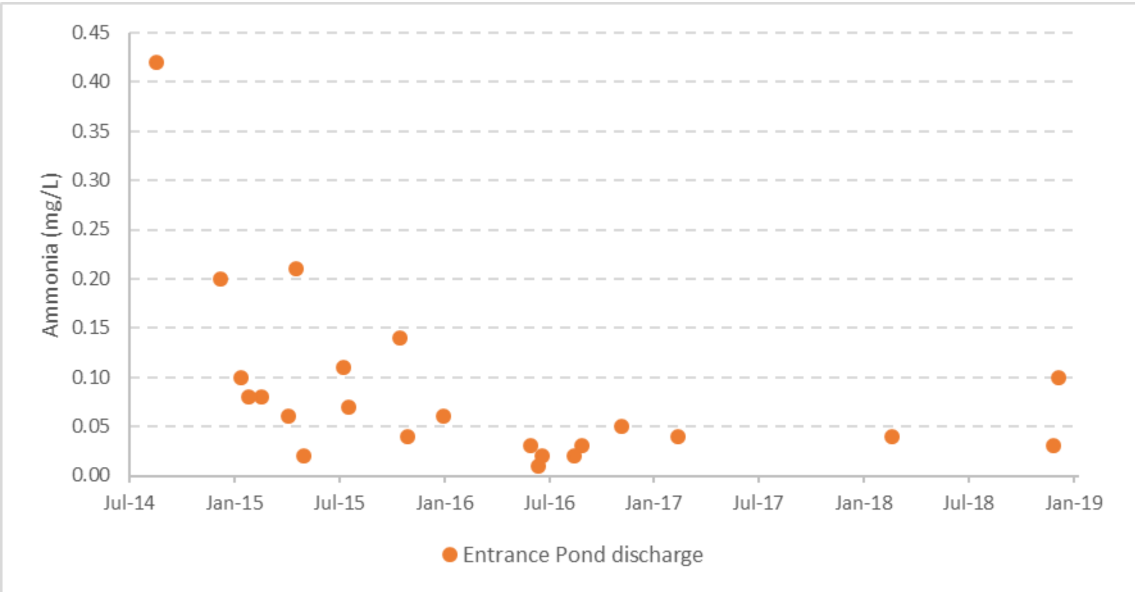

Potassium (mg/L)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

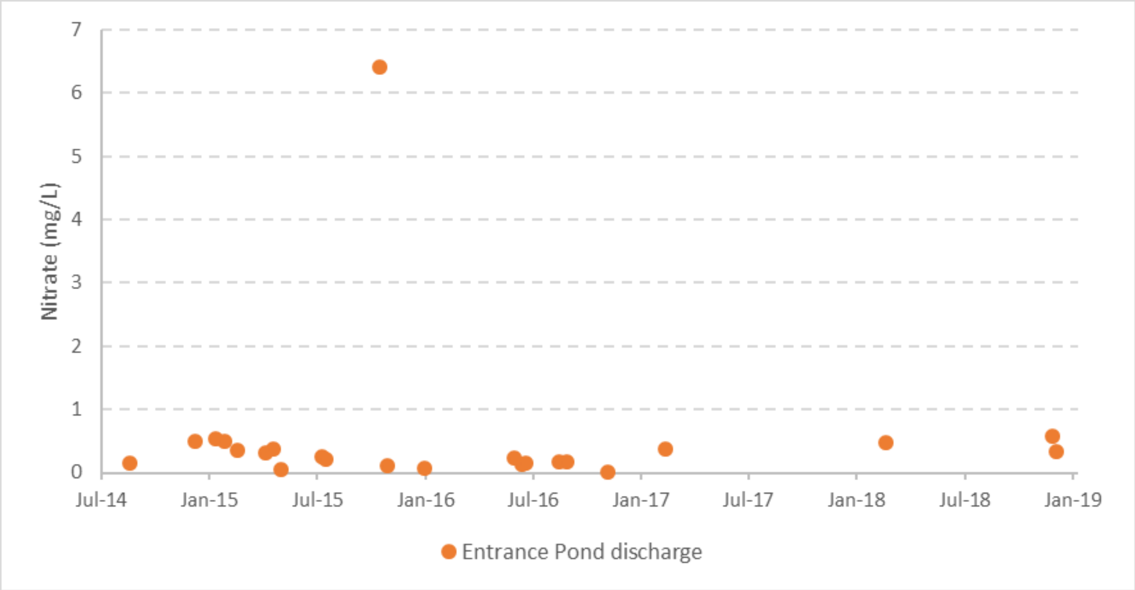

Sodium (mg/L)
40
35
30
25
20
15
10
5
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

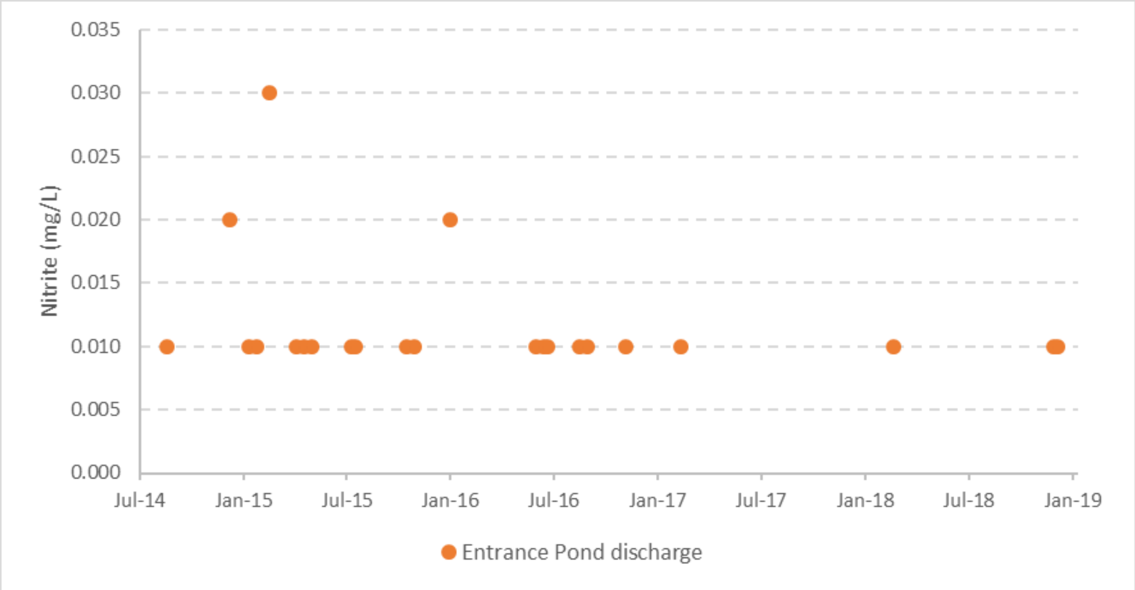


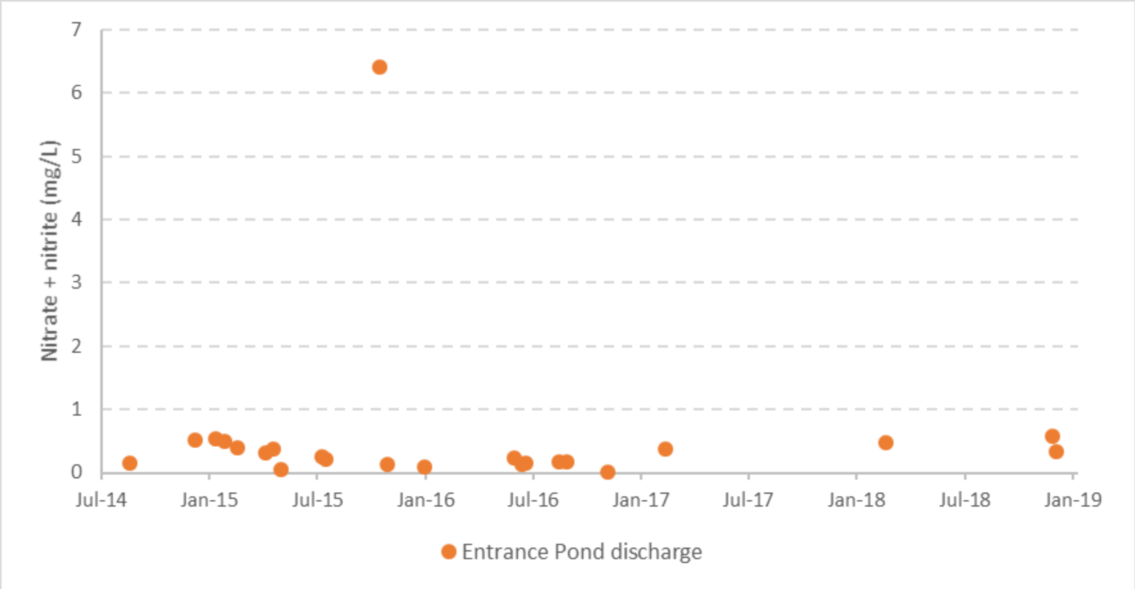


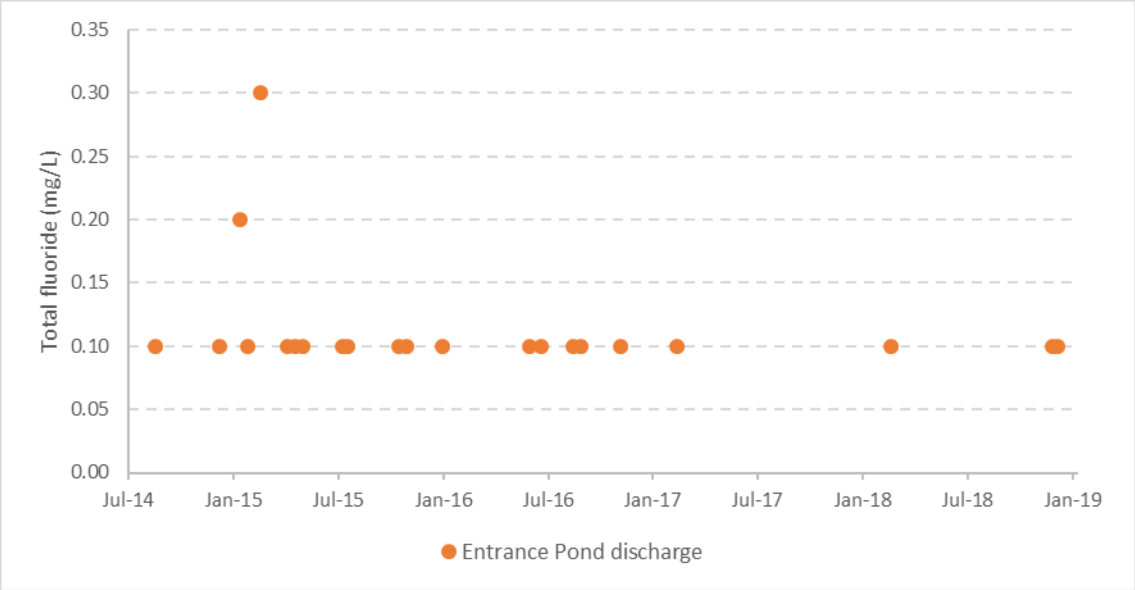
<u>Nutrients</u>

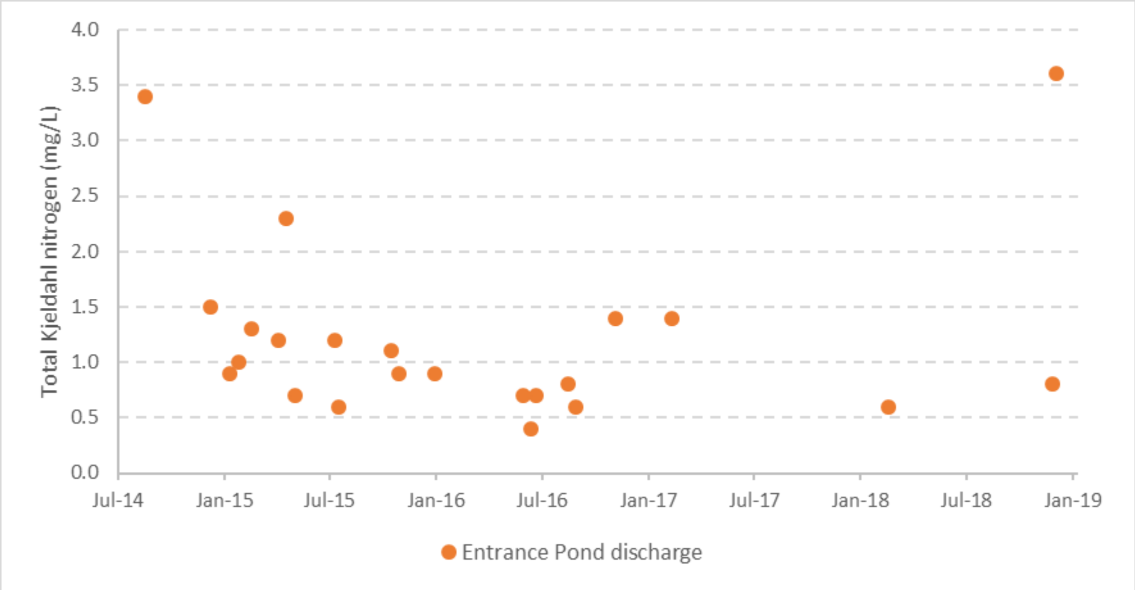


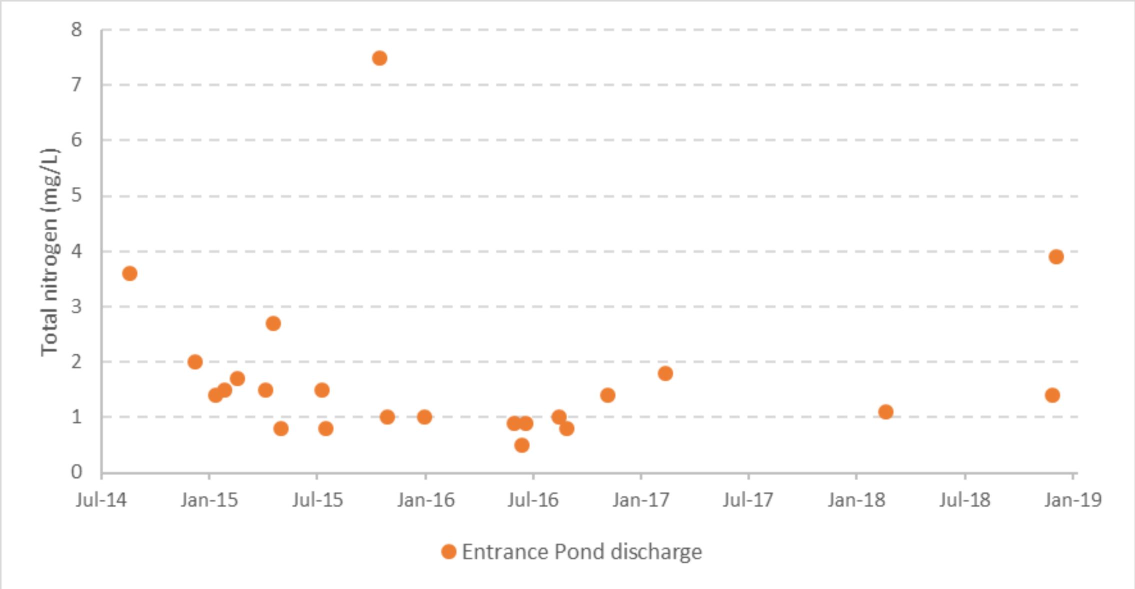

Nitrate (mg/L)
7
6
5
4
3
2
1
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

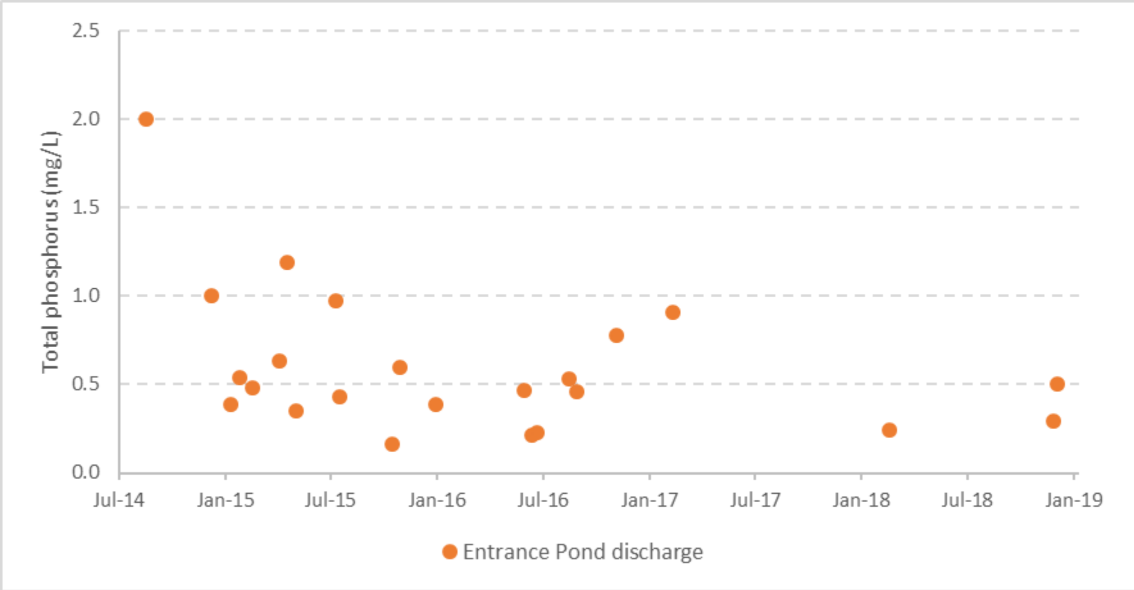

Nitrite (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge


Nitrate + nitrite (mg/L)
7
6
5
4
3
2
1
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

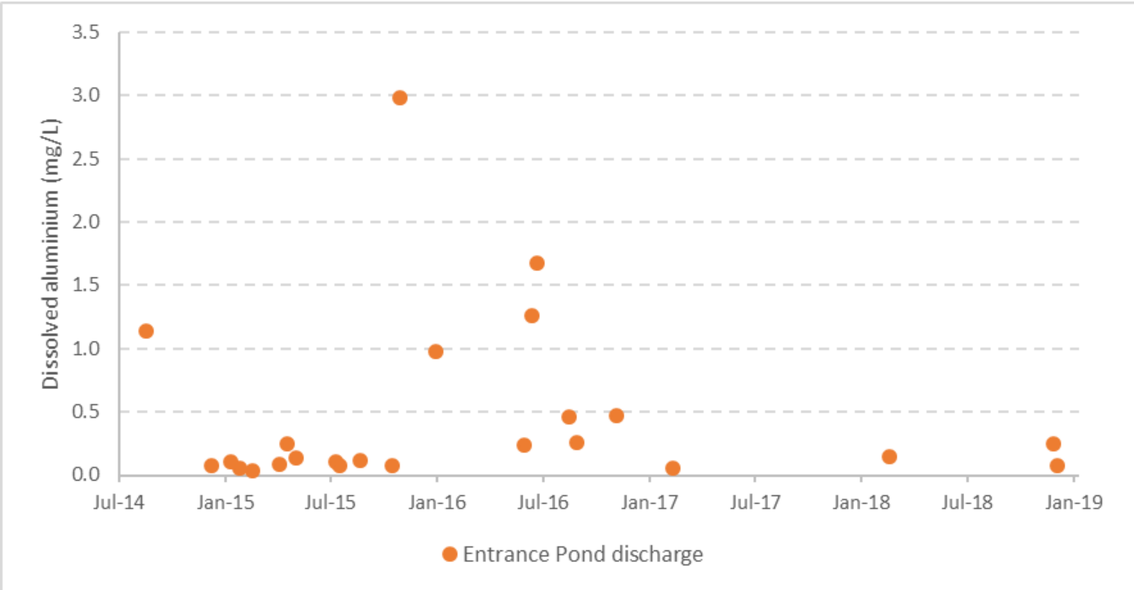

Total fluoride (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

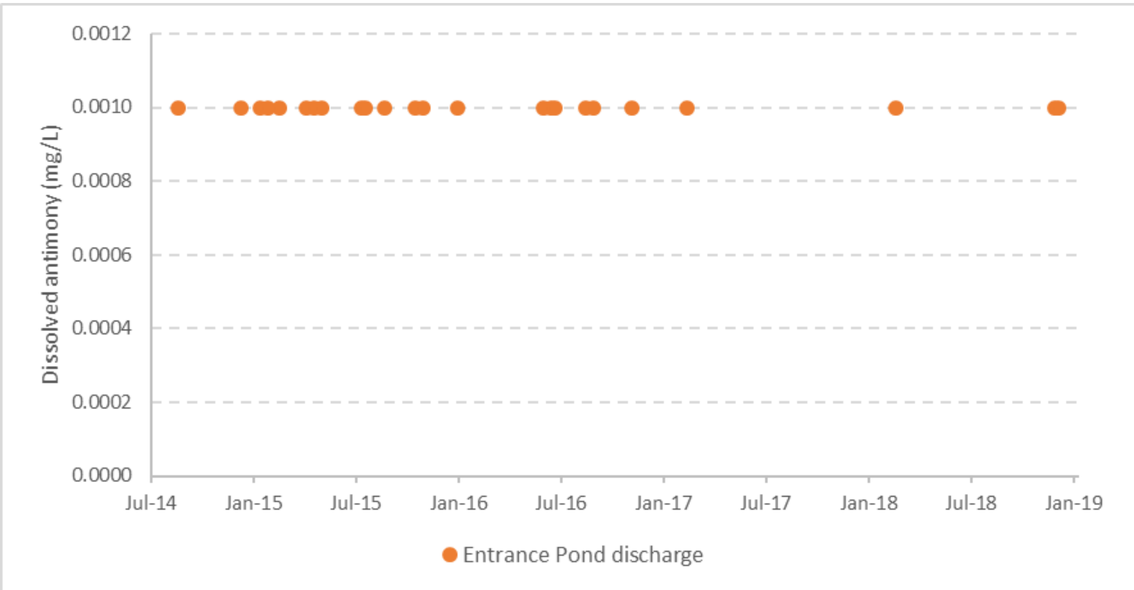

Total Kjeldahl nitrogen (mg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

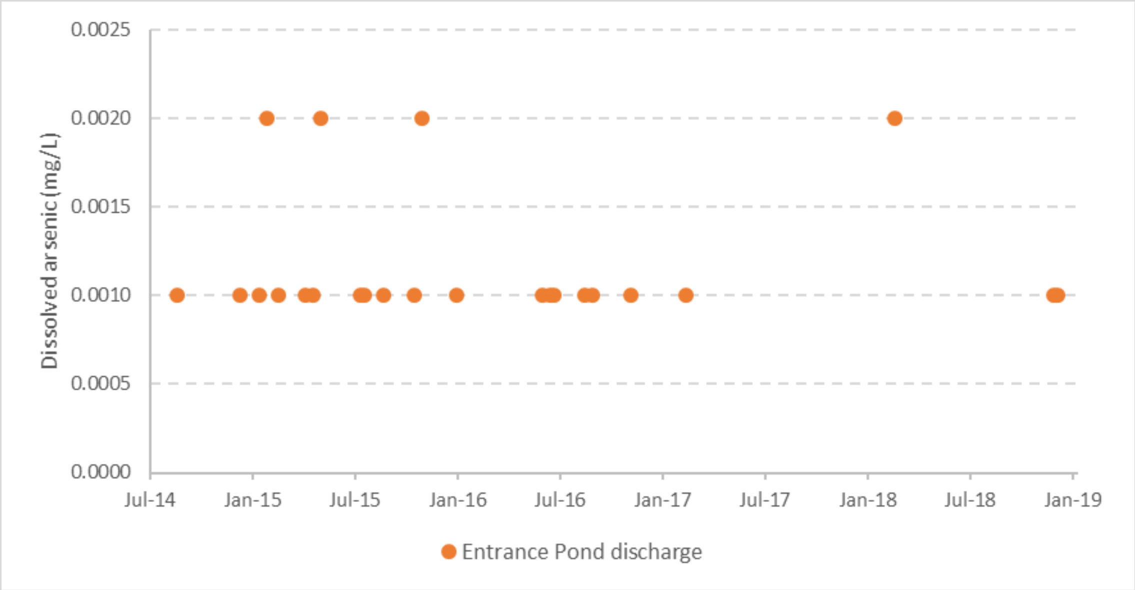

Total nitrogen (mg/L)
8
7
6
5
4
3
2
1
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



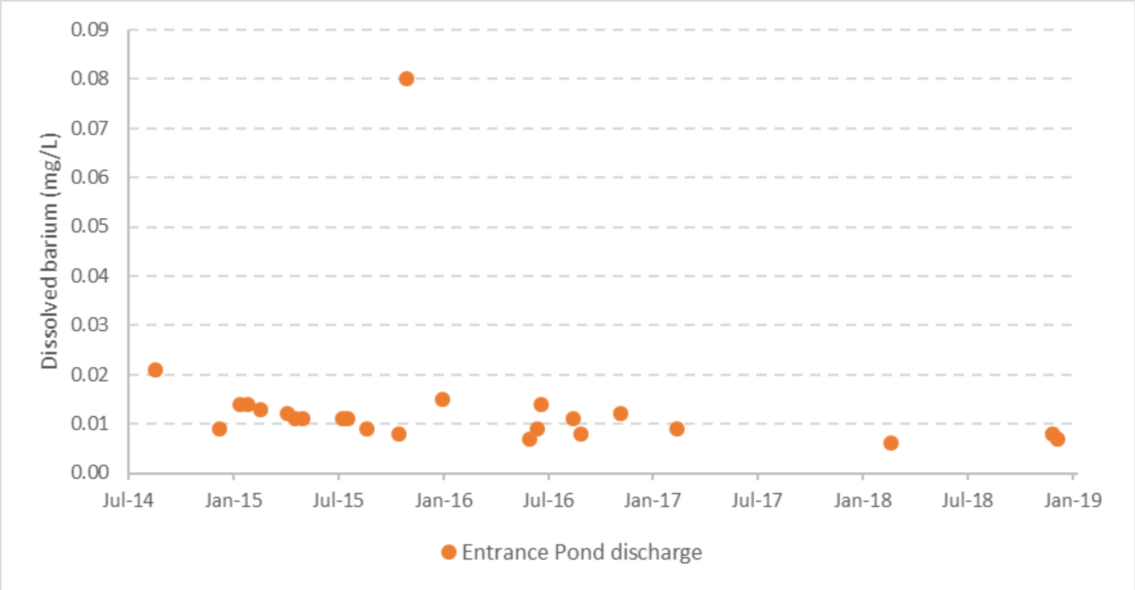
Dissolved metals



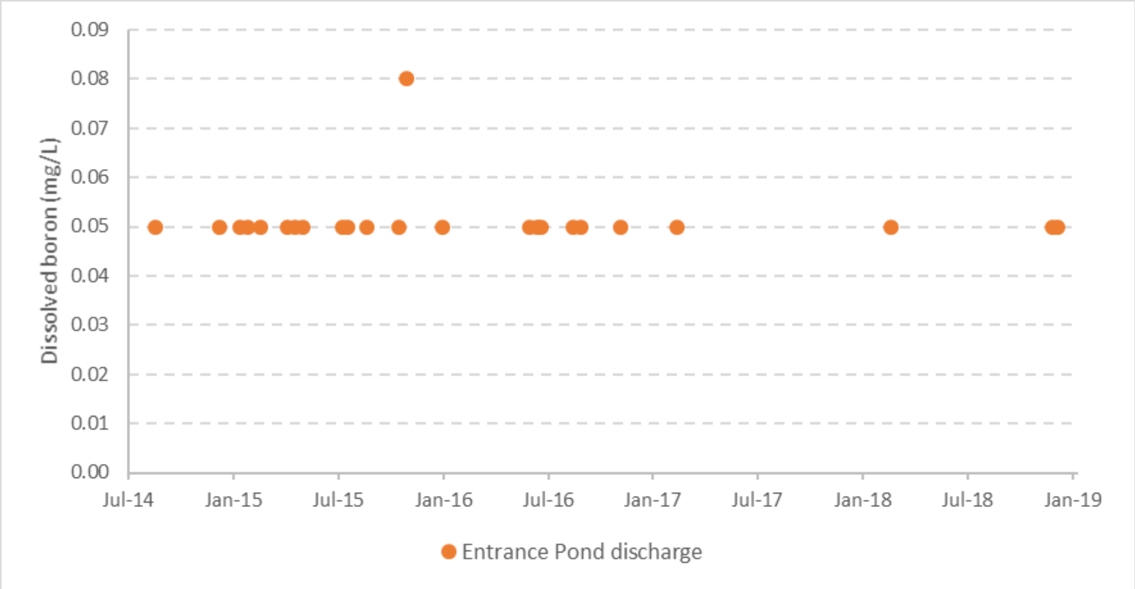




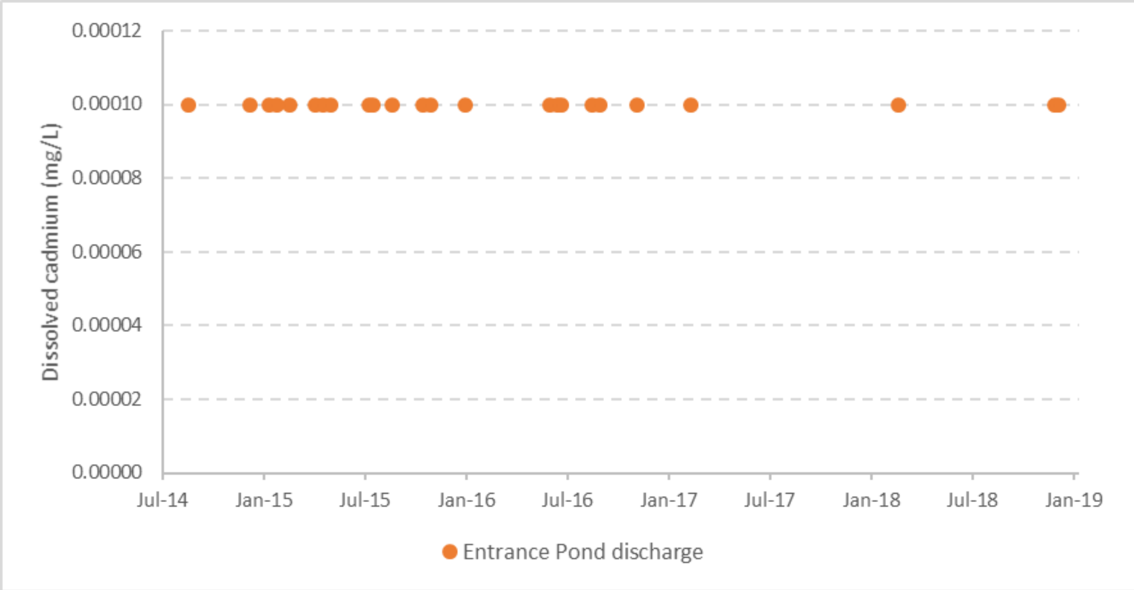
Dissolved arsenic (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



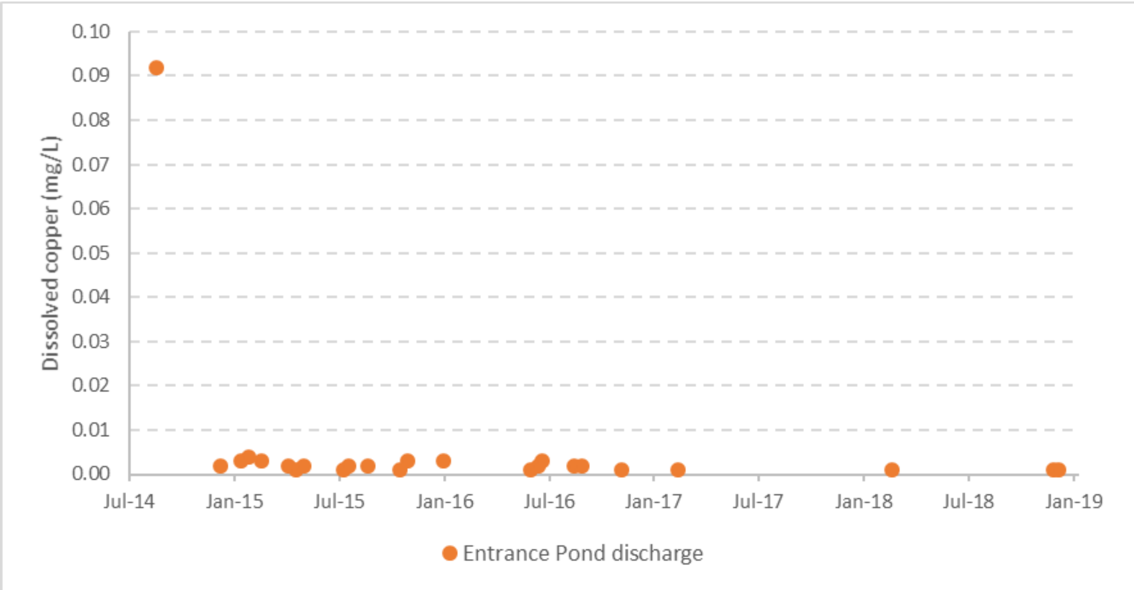
Dissolved barium (mg/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



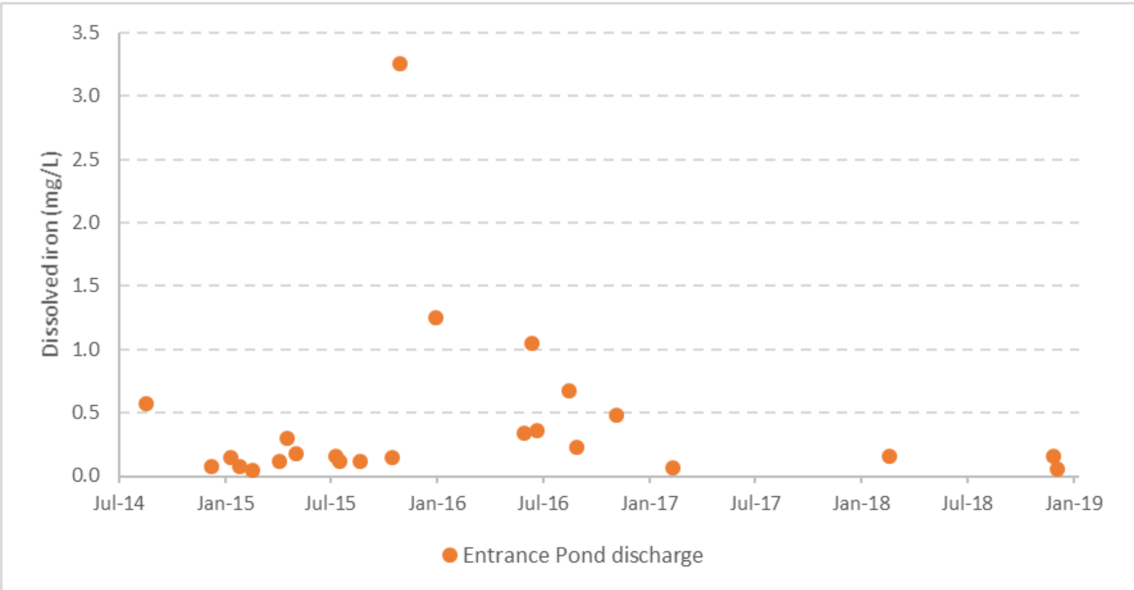
Dissolved boron (mg/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



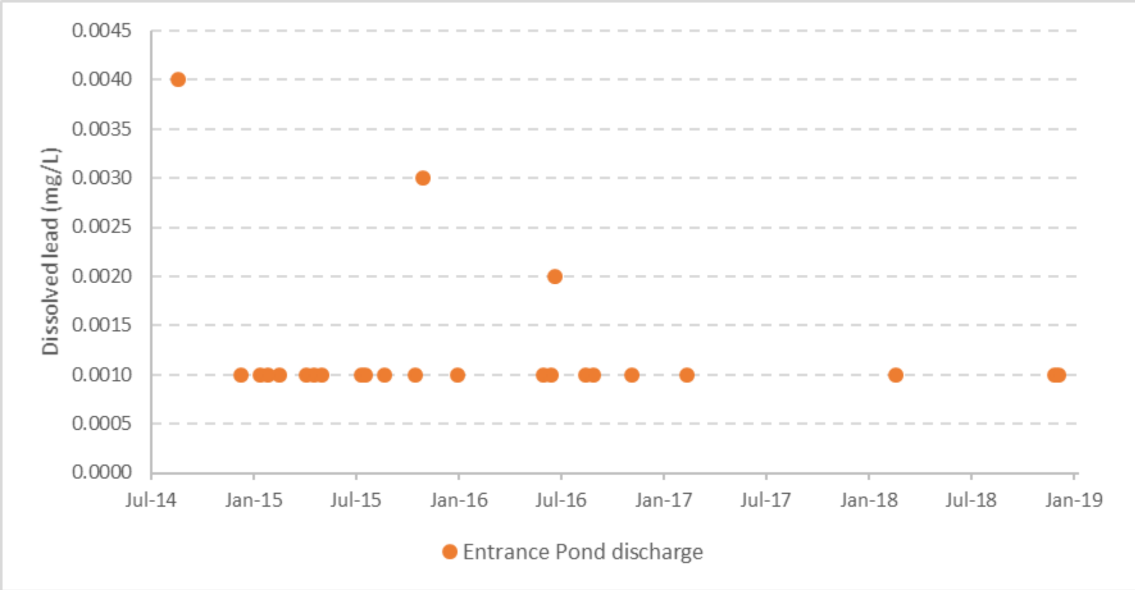
Dissolved cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Entrance Pond discharge

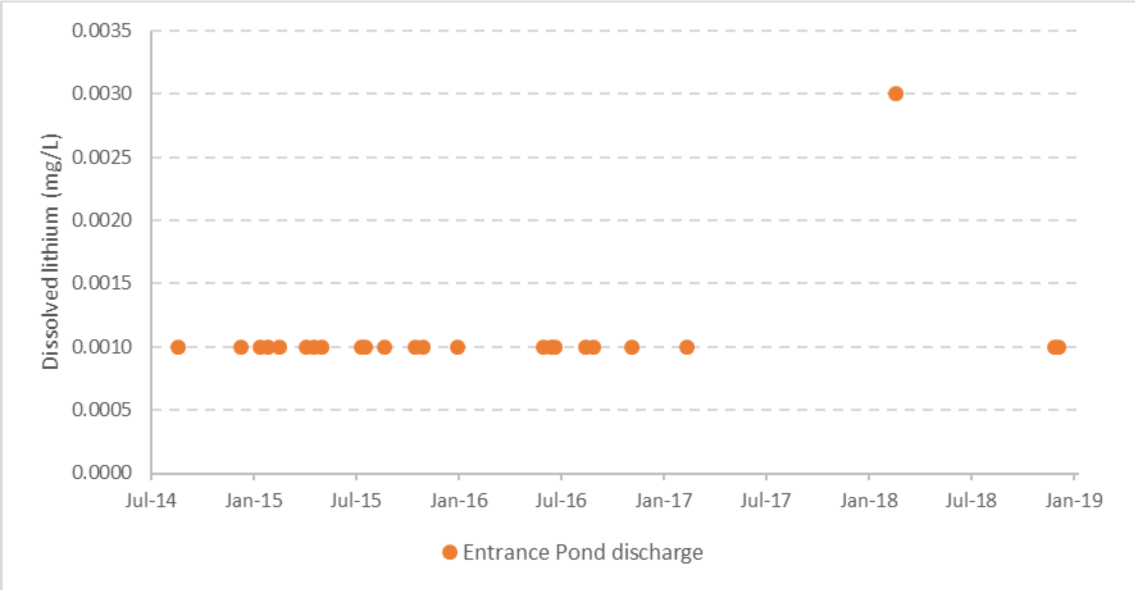


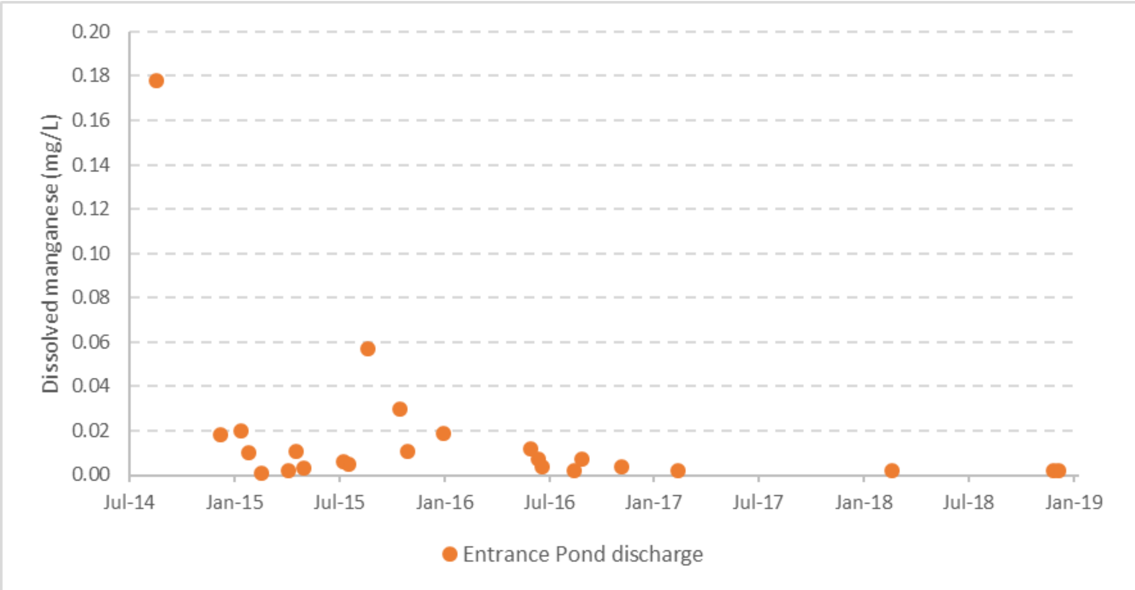
Dissolved copper (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Entrance Pond discharge

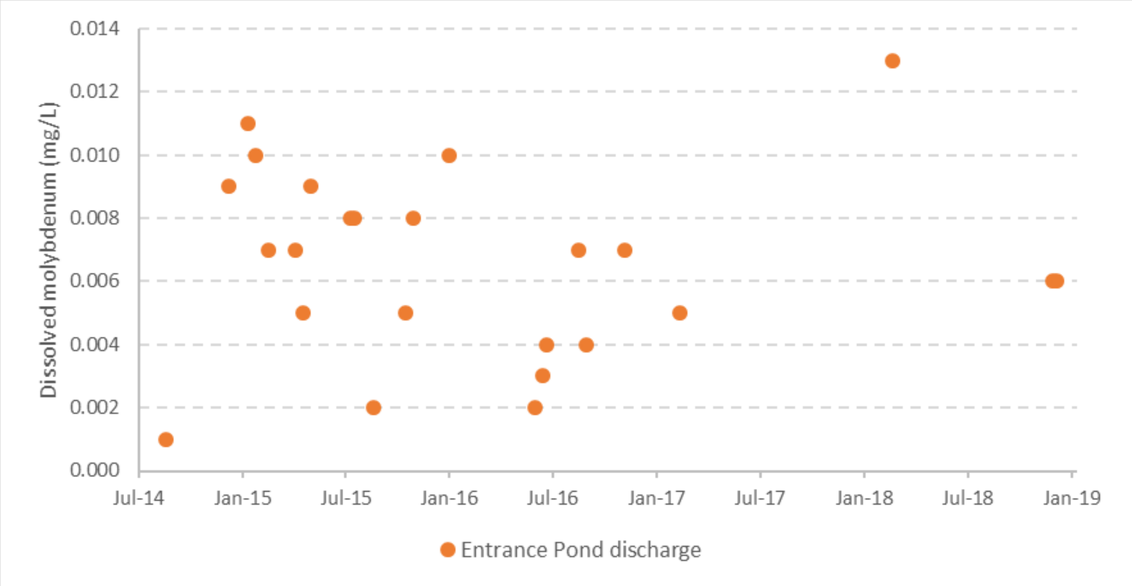


Dissolved iron (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Entrance Pond discharge

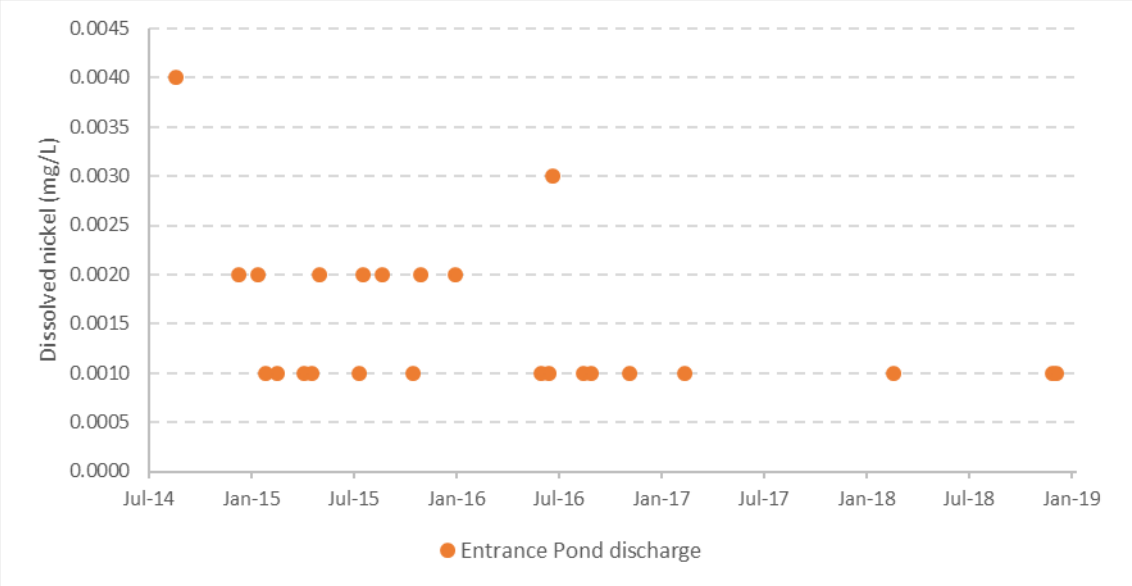

0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved lead (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge


0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved lithium (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

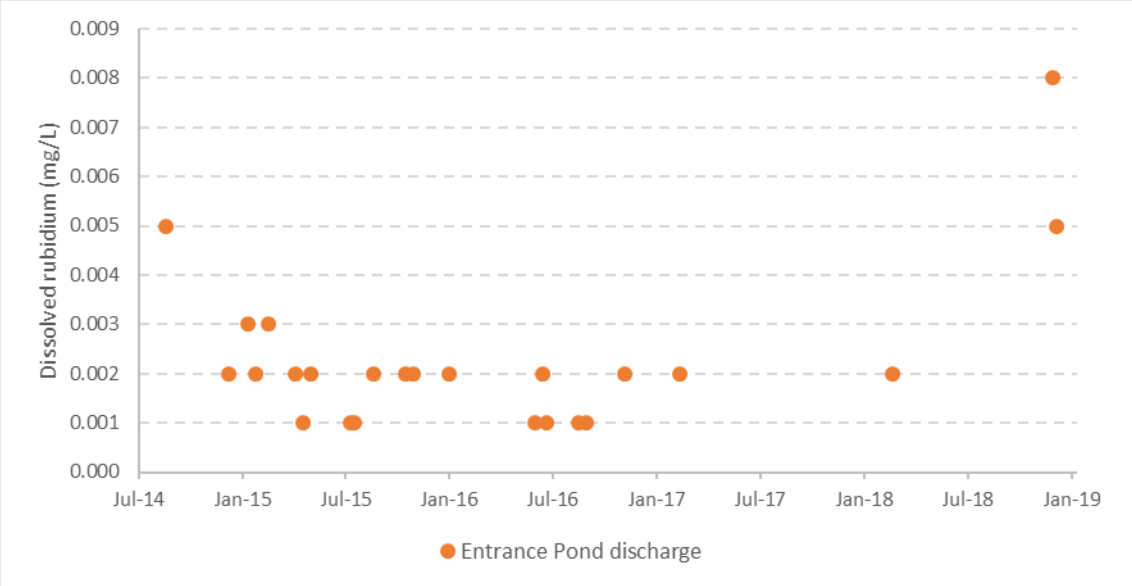

0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dissolved manganese (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



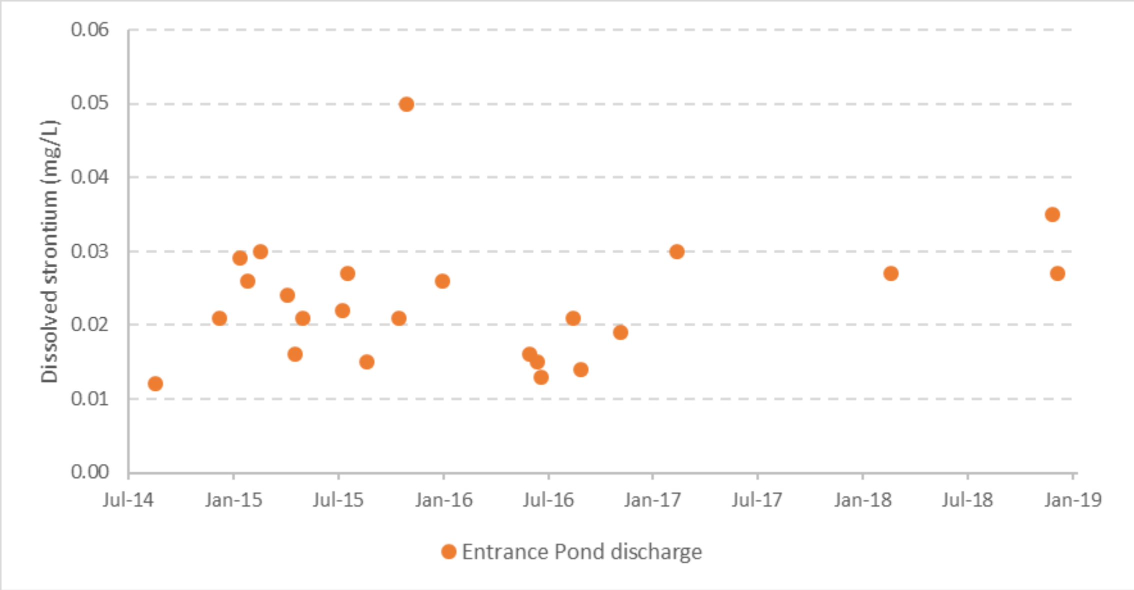
Dissolved molybdenum (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

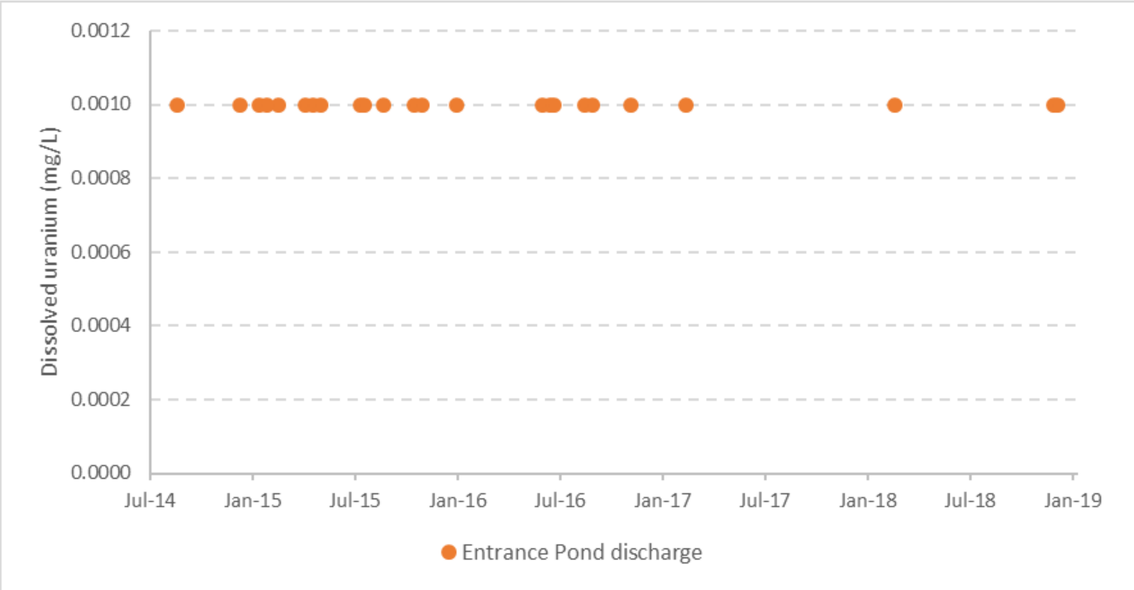


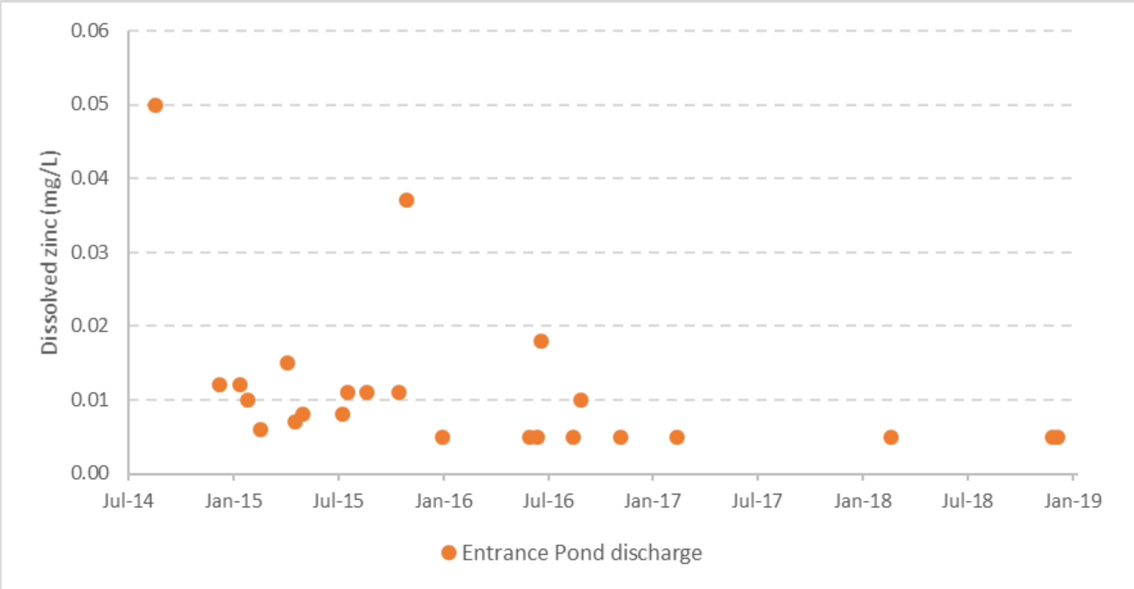
Dissolved nickel (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



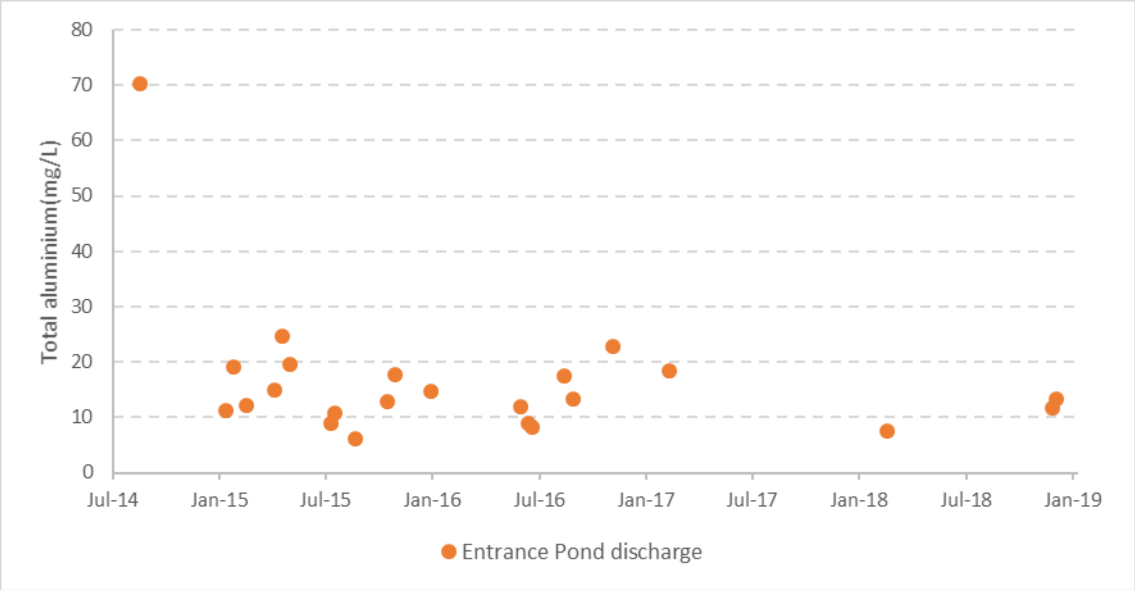
Dissolved rubidium (mg/L)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

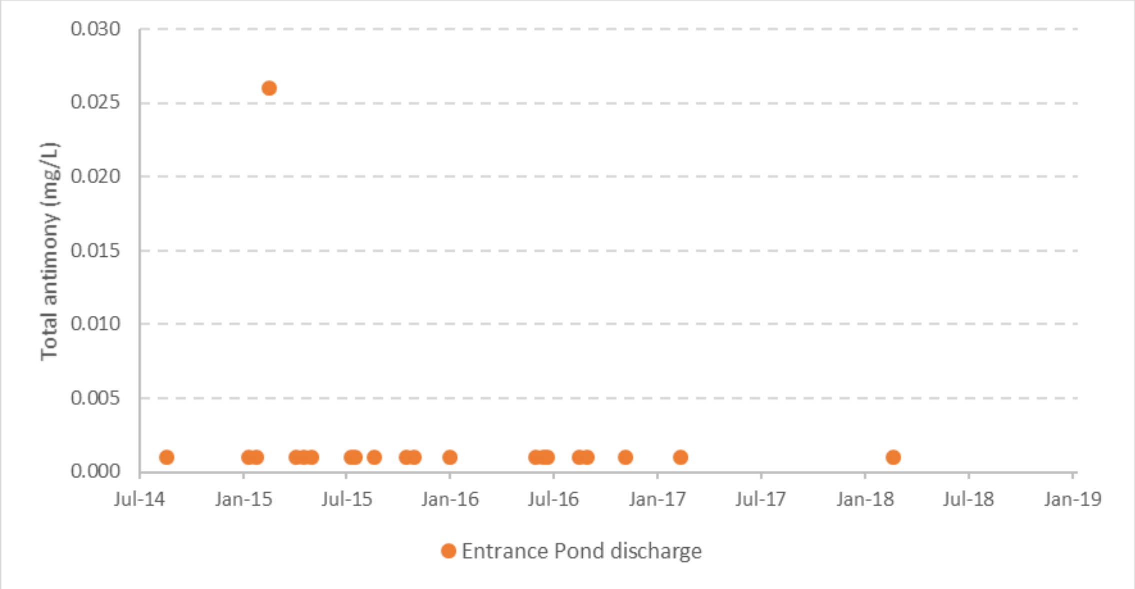

0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved strontium (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

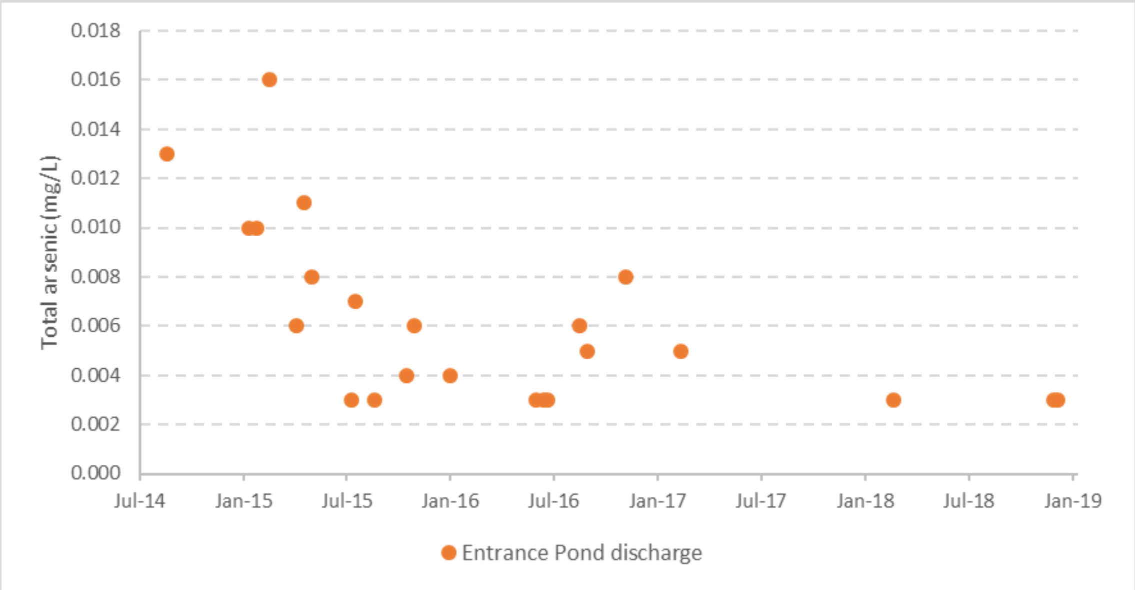

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved uranium (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

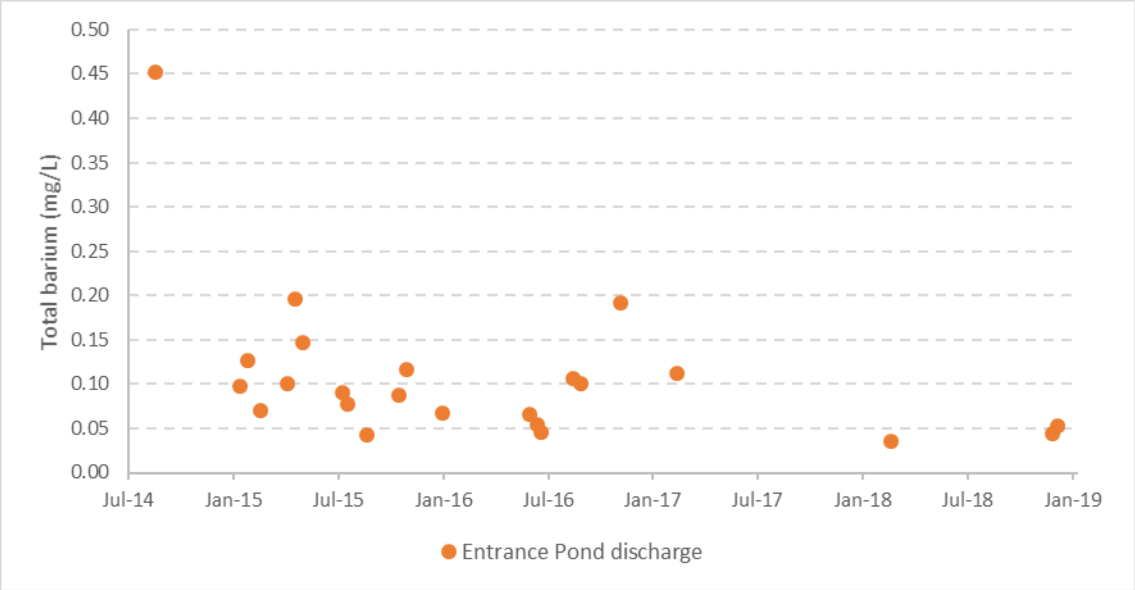

0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved zinc (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

Total metals

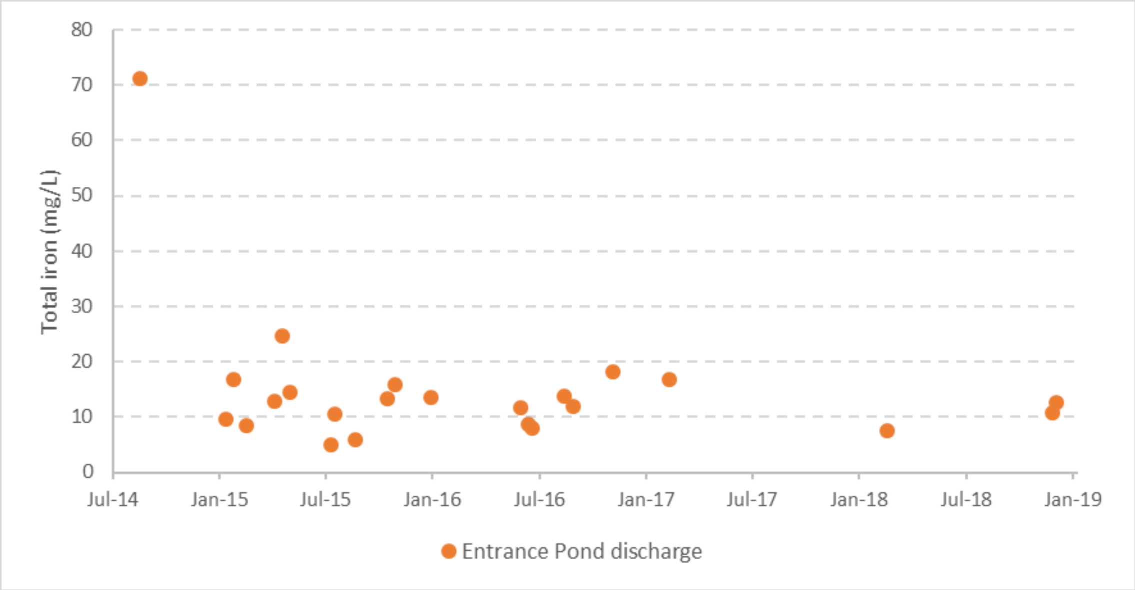




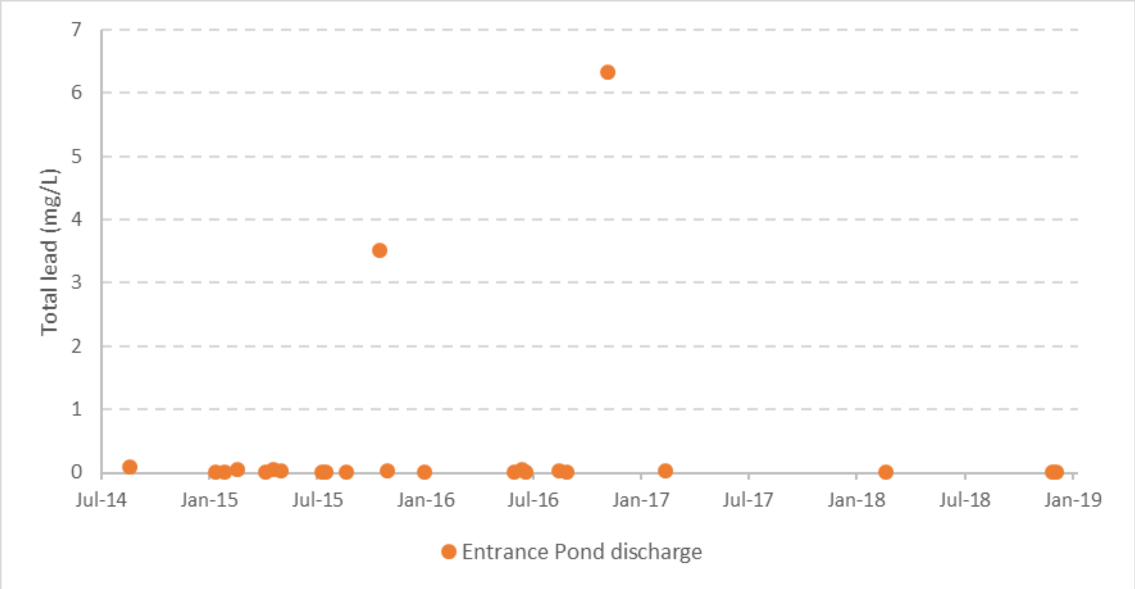




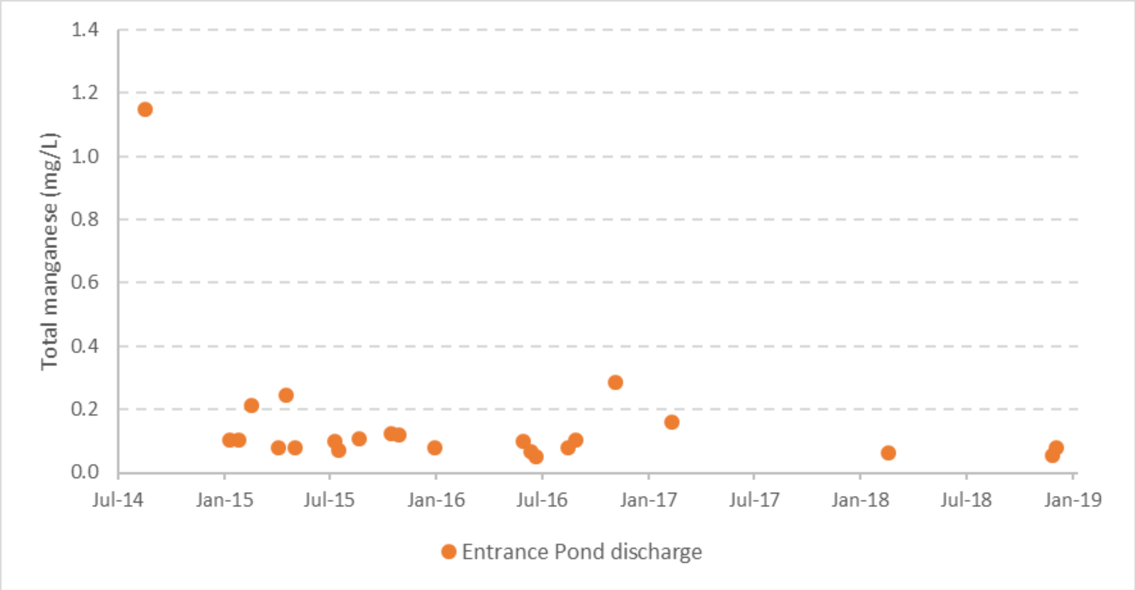
Total barium (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

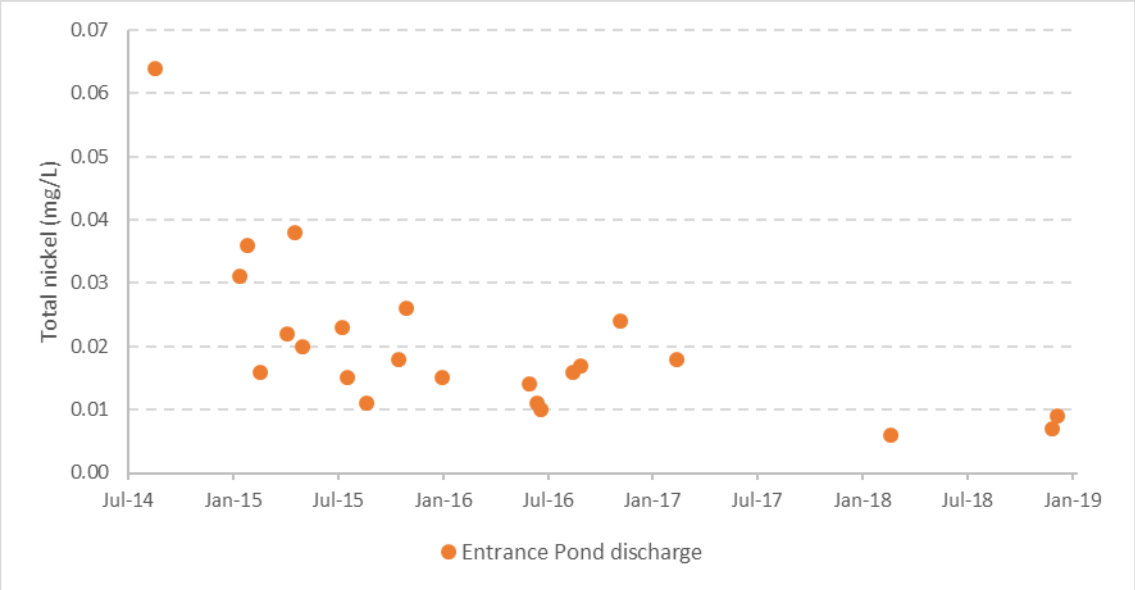


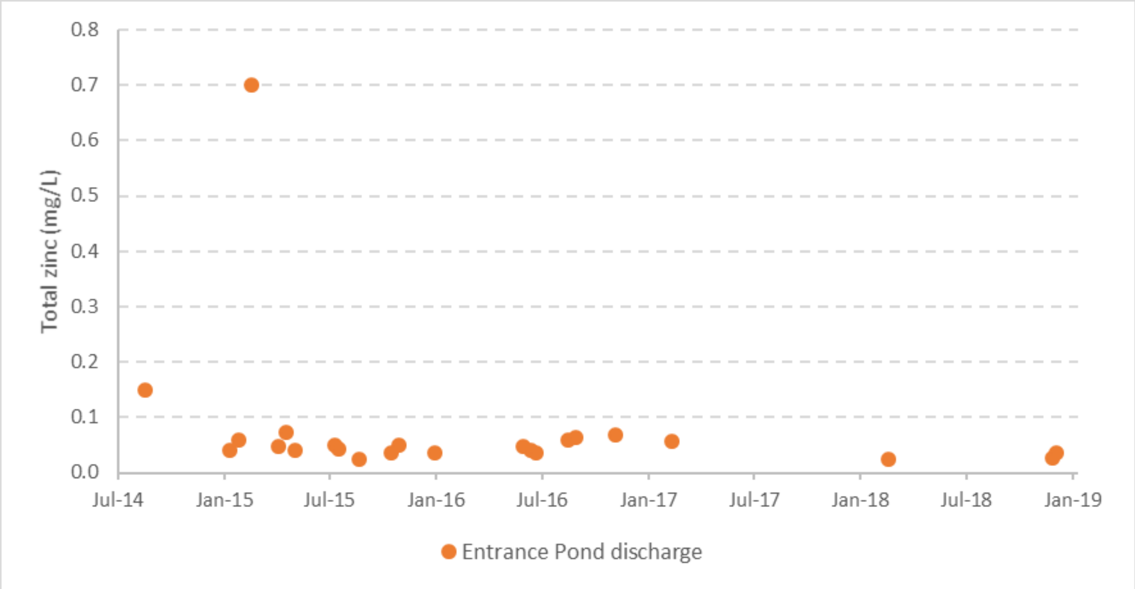
Total iron (mg/L)
80
70
60
50
40
30
20
10
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



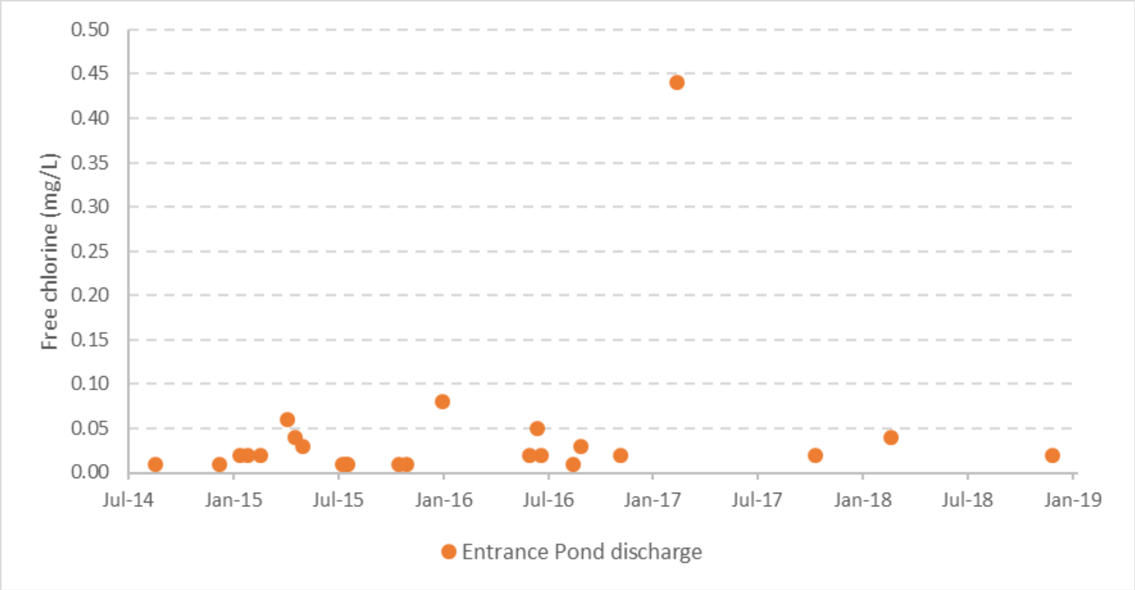
Total lead (mg/L)
7
6
5
4
3
2
1
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

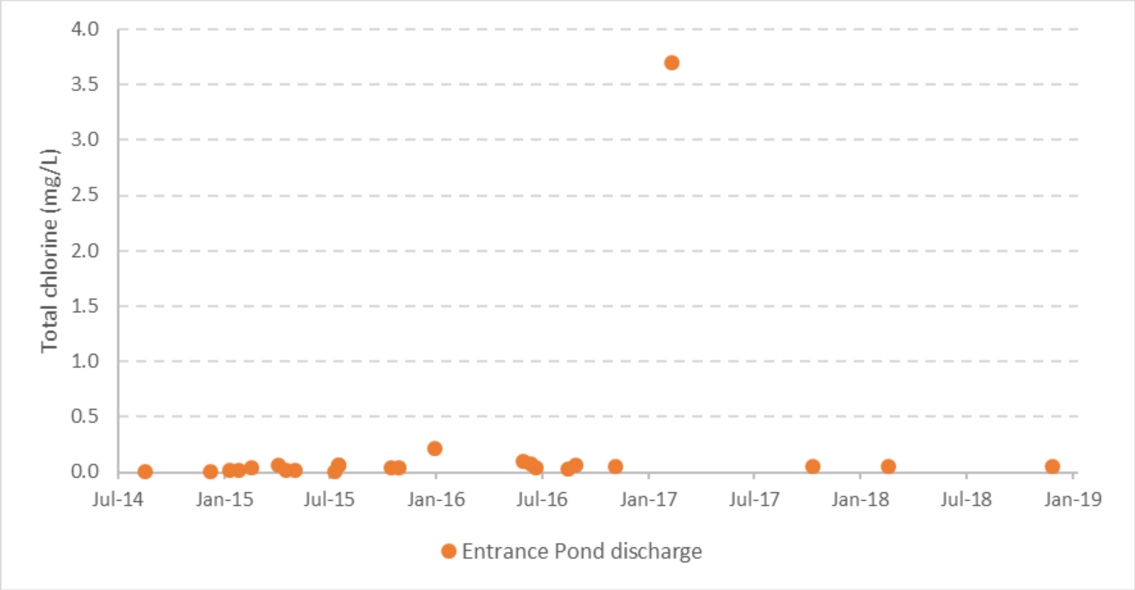

Total manganese (mg/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

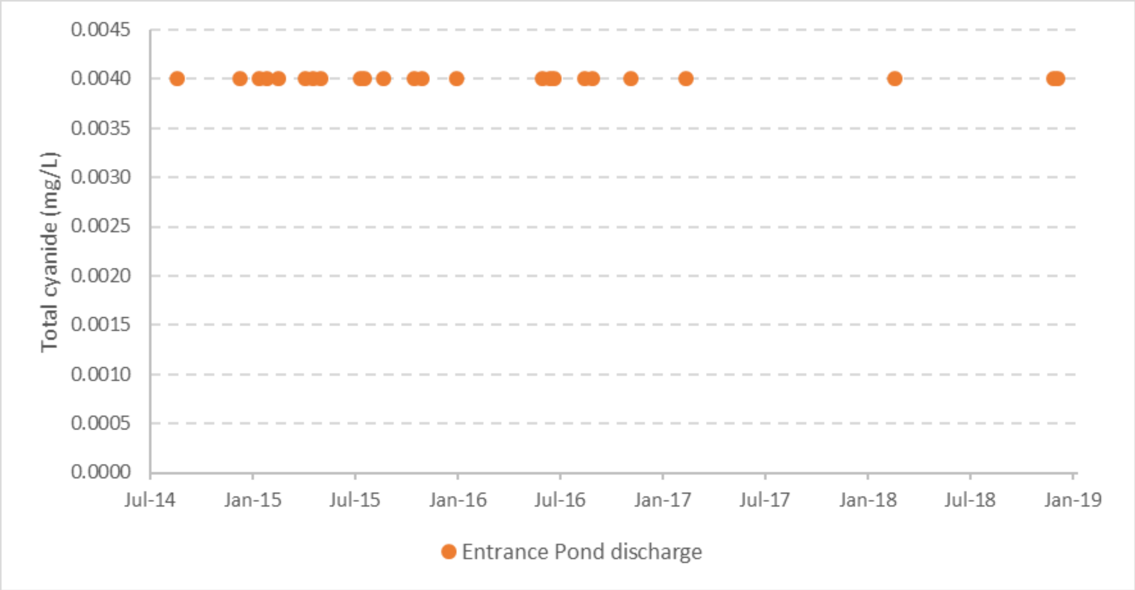

Total nickel (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

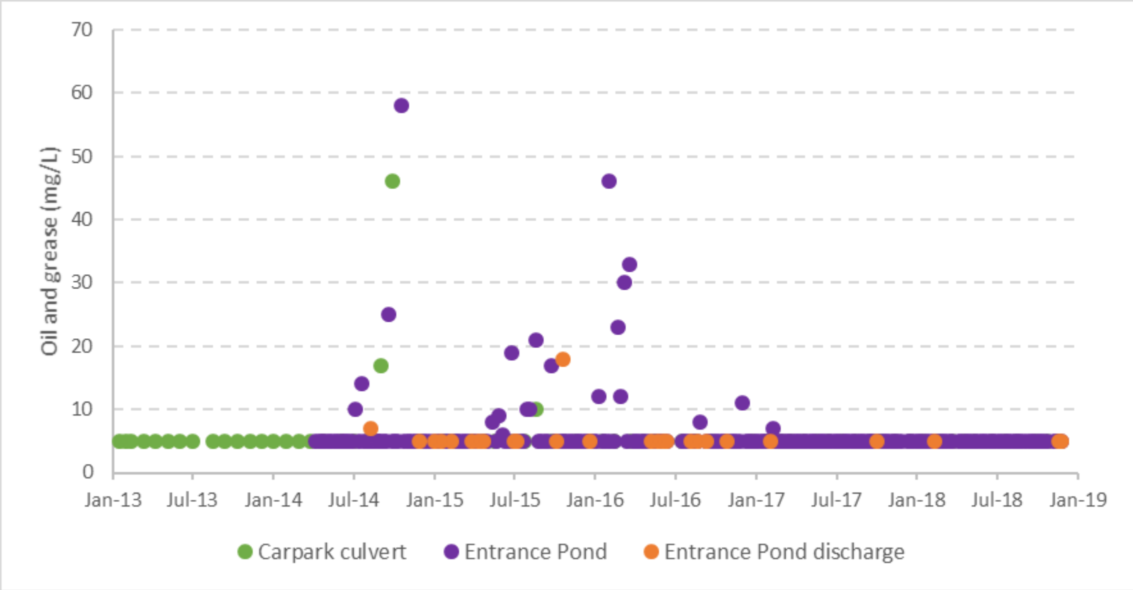

Total zinc (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

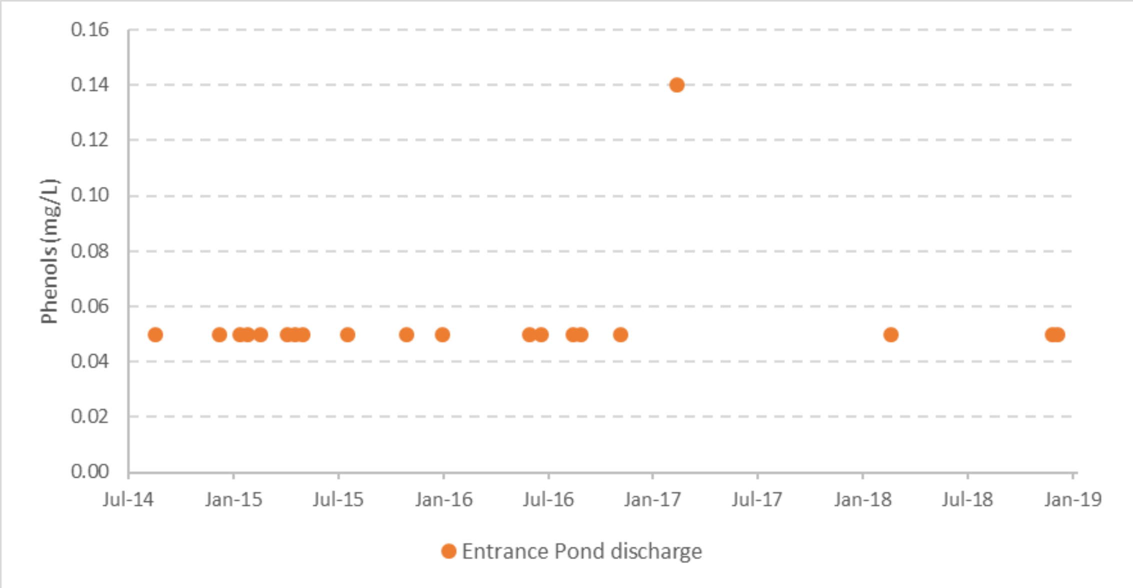
Other

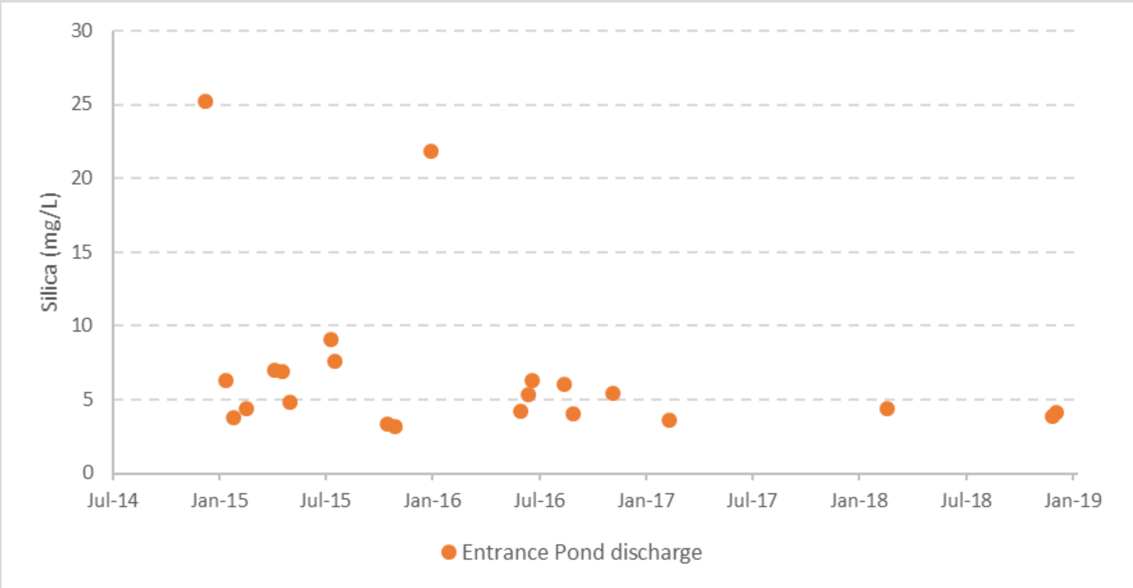

0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Free chlorine (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

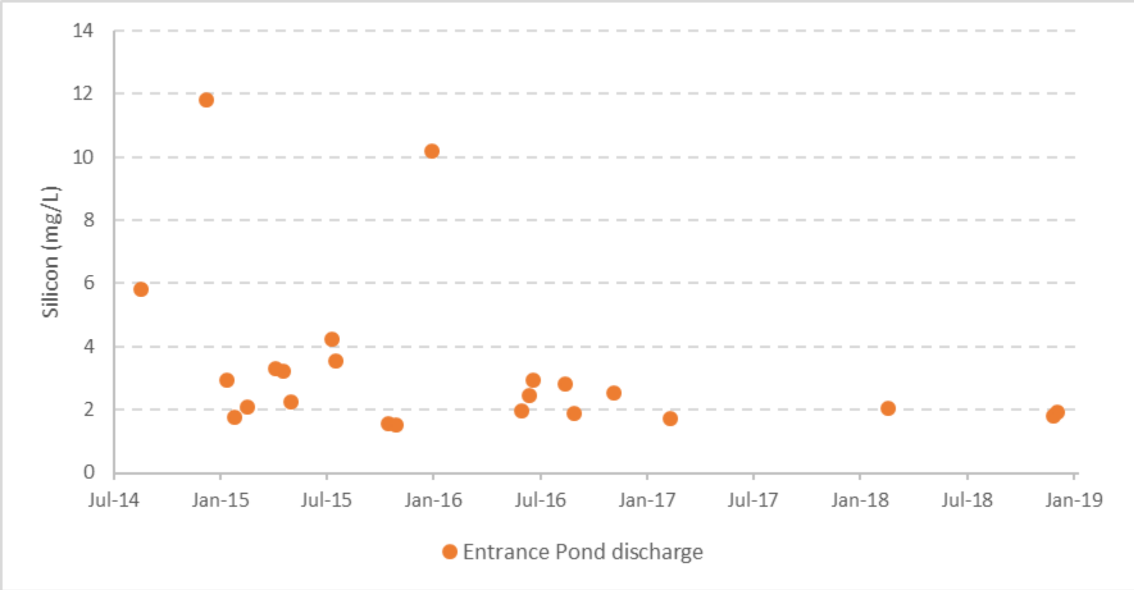

4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Total chlorine (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge


0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Total cyanide (mg/L)
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

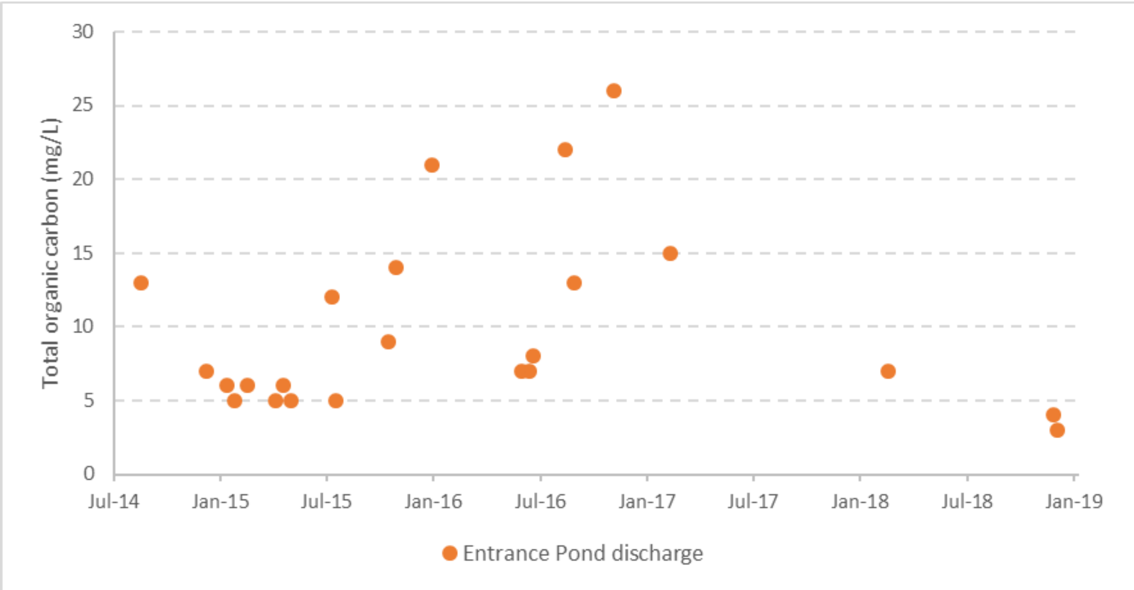

Oil and grease (mg/L)
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Carpark culvert
Entrance Pond
Entrance Pond discharge


Phenols (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge


Silica (mg/L)
30
25
20
15
10
5
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



Silicon (mg/L)
14
12
10
8
6
4
2
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge



Total organic carbon (mg/L)
30
25
20
15
10
5
0
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Entrance Pond discharge

E.1.2 Watercourses – upstream of operations

Statistical summary of water quality results

Parameter	Units	Coxs River Far U/S		Coxs River U/S		Lambs Creek		Kangaroo Creek U/S (AP)		Kangaroo Creek U/S (NP)		Kangaroo Creek D/S (NP)	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Physicochemical													
DO	mg/L	70	4.1	67	7.9	68	3.1	69	6.1	–	–	–	–
EC	µS/cm	71	150	66	108	68	121	70	92	8	51	111	44
pH	pH units	72	6.6	67	6.8	69	5.8	71	6.6	8	5.8	112	6.0
TDS	mg/L	70	92	64	88	68	76	68	81	–	–	–	–
TSS	mg/L	71	9	66	6	68	8	70	5	8	44	105	5
Turbidity	NTU	70	10	65	10	67	15	69	5	–	–	–	–
Major ions													
Bicarbonate alkalinity	mg/L	72	18	65	13	69	27	70	14	–	–	–	–
Carbonate alkalinity	mg/L	72	1	65	1	69	1	70	1	–	–	–	–
Hydroxide alkalinity	mg/L	72	1	65	1	69	1	70	1	–	–	–	–
Total alkalinity	mg/L	72	18	65	13	69	27	70	14	–	–	–	–
Calcium	mg/L	72	8	65	5	69	1	70	2	–	–	–	–
Chloride	mg/L	72	6	65	6	69	6	70	7	–	–	–	–
Magnesium	mg/L	72	4	65	3	69	4	70	2	–	–	–	–
Potassium	mg/L	72	3	65	4	69	7	70	2	–	–	–	–
Sodium	mg/L	72	6	65	6	69	5	70	8	–	–	–	–
Sulfate	mg/L	71	22	65	17	69	13	70	5	–	–	–	–

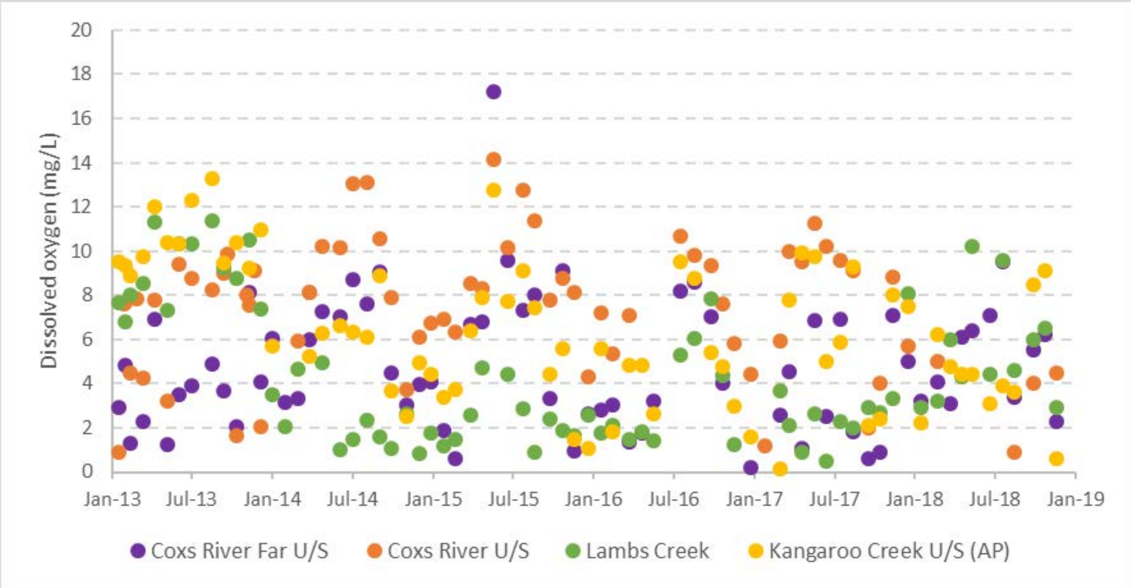
Parameter	Units	Coxs River Far U/S		Coxs River U/S		Lambs Creek		Kangaroo Creek U/S (AP)		Kangaroo Creek U/S (NP)		Kangaroo Creek D/S (NP)	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Total hardness	mg/L	72	36	65	29	69	19	70	12	–	–	–	–
Nutrients													
Ammonia	mg/L	72	0.02	65	0.02	69	0.02	70	0.02	–	–	–	–
Nitrate	mg/L	72	0.01	65	0.01	69	0.01	70	0.01	–	–	–	–
Nitrite	mg/L	72	0.01	65	0.01	69	0.01	70	0.01	–	–	–	–
Nitrate + nitrite	mg/L	72	0.01	65	0.01	69	0.01	70	0.01	–	–	–	–
Total fluoride	mg/L	72	0.1	65	0.1	69	0.1	70	0.1	–	–	–	–
TKN	mg/L	72	0.3	65	0.4	69	0.1	70	0.3	–	–	–	–
Total nitrogen	mg/L	72	0.4	65	0.4	69	0.2	70	0.4	–	–	–	–
Total phosphorus	mg/L	72	0.01	65	0.02	69	0.01	70	0.01	–	–	–	–
Dissolved metals													
Aluminium	mg/L	72	0.03	65	0.03	69	0.01	70	0.07	–	–	–	–
Antimony	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Arsenic	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Barium	mg/L	72	0.055	65	0.032	69	0.083	70	0.030	–	–	–	–
Boron	mg/L	72	0.05	65	0.05	69	0.05	70	0.05	–	–	–	–
Cadmium	mg/L	72	0.0001	65	0.0001	69	0.0001	70	0.0001	–	–	–	–
Copper	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Iron	mg/L	72	1.44	65	0.28	69	7.0	70	0.93	9	0.70	107	0.88
Lead	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Lithium	mg/L	72	0.002	65	0.002	69	0.004	70	0.003	–	–	–	–

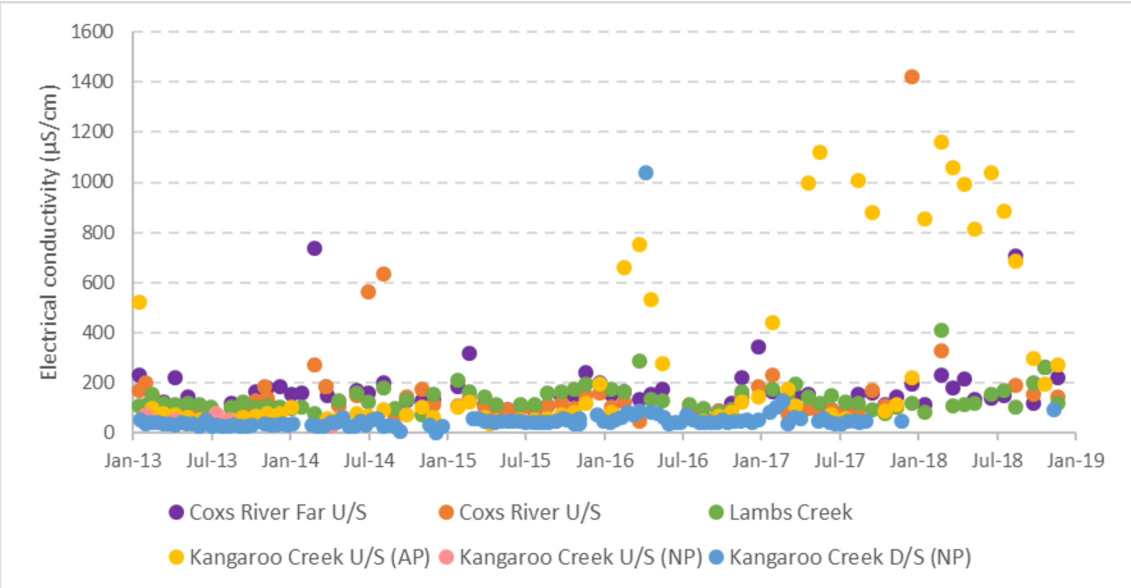
Parameter	Units	Coxs River Far U/S		Coxs River U/S		Lambs Creek		Kangaroo Creek U/S (AP)		Kangaroo Creek U/S (NP)		Kangaroo Creek D/S (NP)	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Manganese	mg/L	72	0.958	65	0.111	69	0.786	70	0.100	9	0.383	107	0.066
Molybdenum	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Nickel	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Rubidium	mg/L	72	0.007	65	0.009	69	0.015	70	0.005	–	–	–	–
Strontium	mg/L	72	0.038	65	0.032	69	0.031	70	0.015	–	–	–	–
Uranium	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Zinc	mg/L	72	0.010	65	0.008	69	0.010	70	0.006	–	–	–	–
Total metals													
Aluminium	mg/L	72	0.06	65	0.22	69	0.02	70	0.22	–	–	–	–
Antimony	mg/L	69	0.001	63	0.001	66	0.001	67	0.001	–	–	–	–
Arsenic	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Barium	mg/L	72	0.060	65	0.036	69	0.088	70	0.037	–	–	–	–
Iron	mg/L	69	5.72	63	0.78	66	9.65	67	2.27	9	1.80	108	1.74
Lead	mg/L	72	0.001	65	0.001	69	0.001	70	0.001	–	–	–	–
Manganese	mg/L	72	1.03	65	0.144	69	0.870	70	0.113	9	0.443	108	0.077
Nickel	mg/L	71	0.001	65	0.001	68	0.001	69	0.001	–	–	–	–
Zinc	mg/L	71	0.007	65	0.008	68	0.007	69	0.006	–	–	–	–
Other													
Free chlorine	mg/L	72	0.02	66	0.03	69	0.02	69	0.02	–	–	–	–
Total chlorine	mg/L	72	0.05	66	0.05	69	0.05	69	0.05	–	–	–	–
Total cyanide	mg/L	71	0.004	64	0.004	68	0.004	69	0.004	–	–	–	–

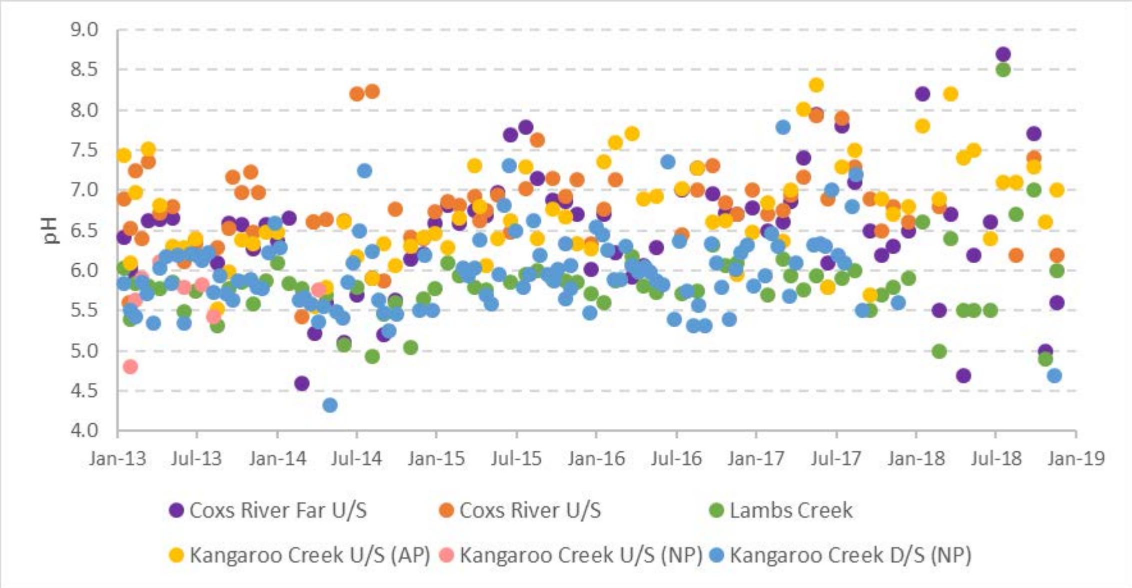
Parameter	Units	Coxs River Far U/S		Coxs River U/S		Lambs Creek		Kangaroo Creek U/S (AP)		Kangaroo Creek U/S (NP)		Kangaroo Creek D/S (NP)	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Oil and grease	mg/L	70	5	64	5	67	5	69	5	–	–	–	–
Phenols	mg/L	72	0.05	65	0.05	69	0.05	70	0.05	–	–	–	–
Silica	mg/L	69	8.8	63	7.3	67	9.7	67	9.5	–	–	–	–
Silicon	mg/L	72	4.15	65	3.44	69	4.54	70	4.46	–	–	–	–
Total organic carbon	mg/L	71	5	64	6	68	2	69	6	–	–	–	–

Time series graphs of water quality results

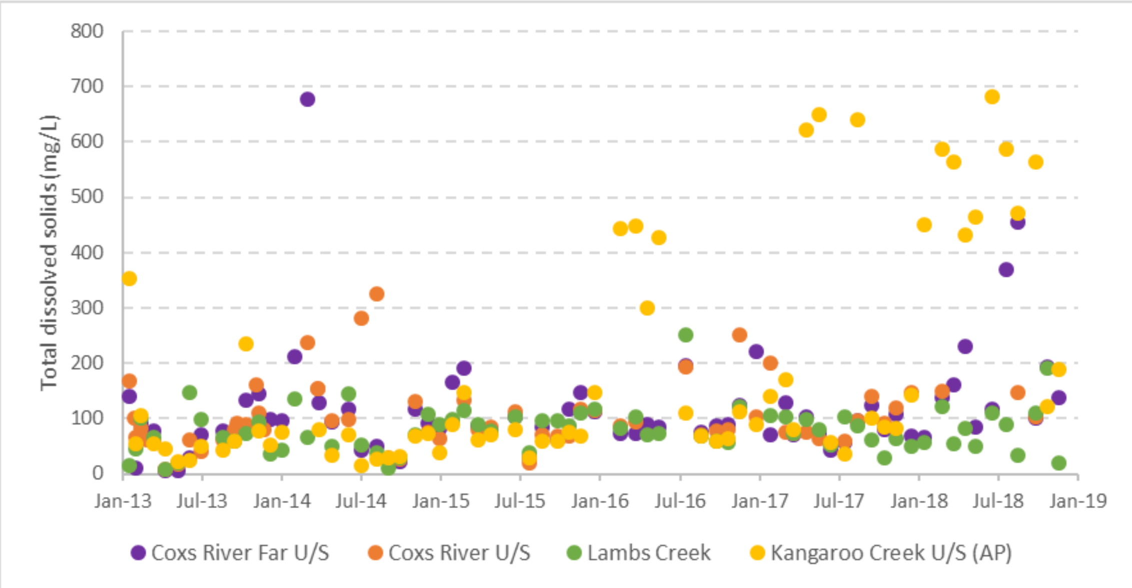
Physicochemical



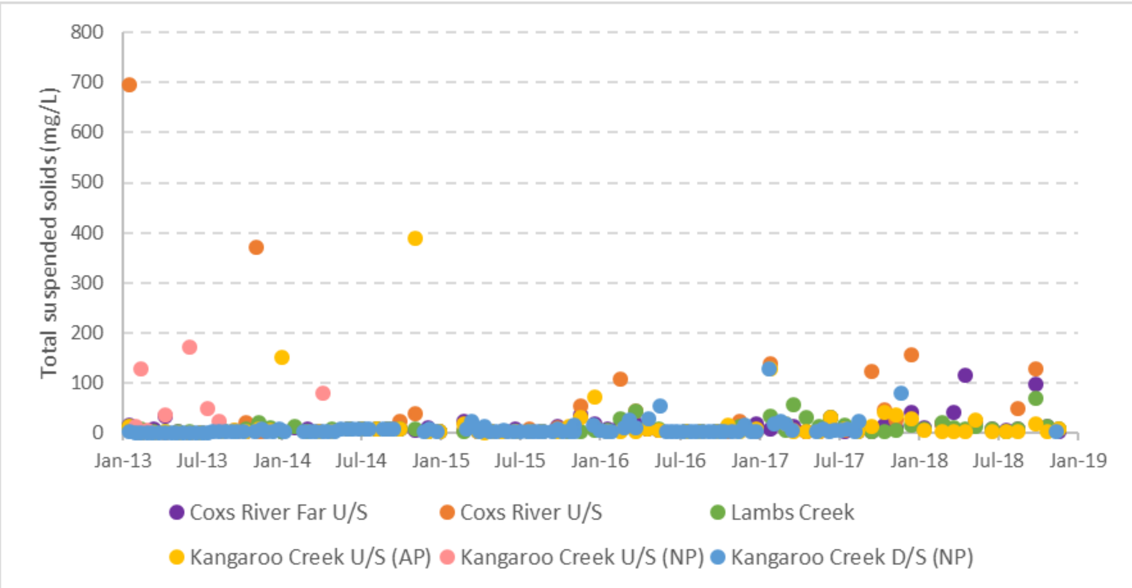




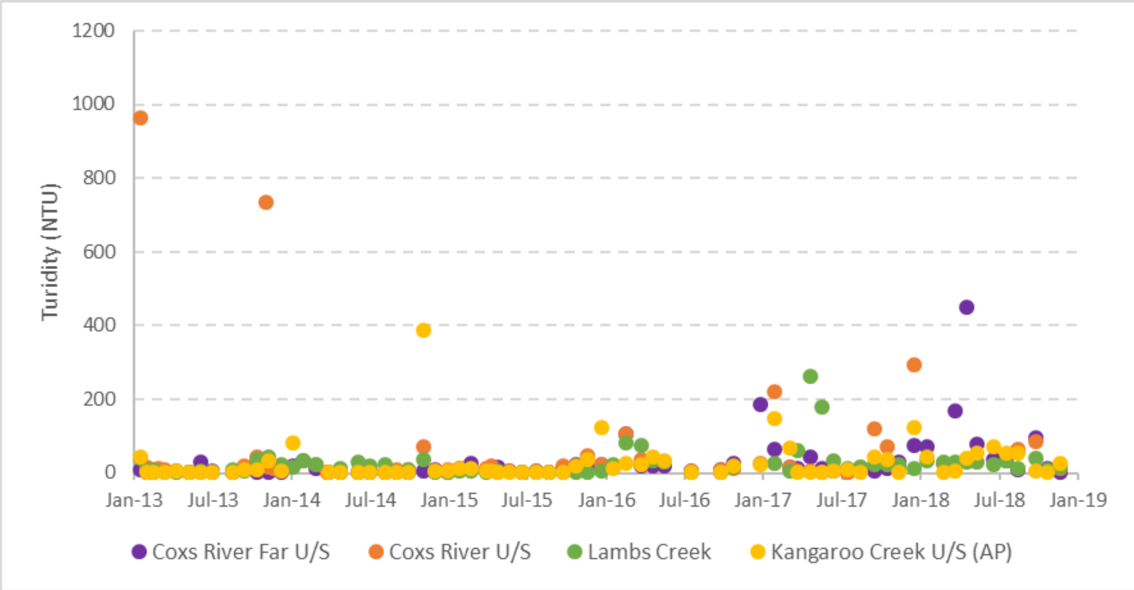
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
pH
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)
Kangaroo Creek U/S (NP)
Kangaroo Creek D/S (NP)



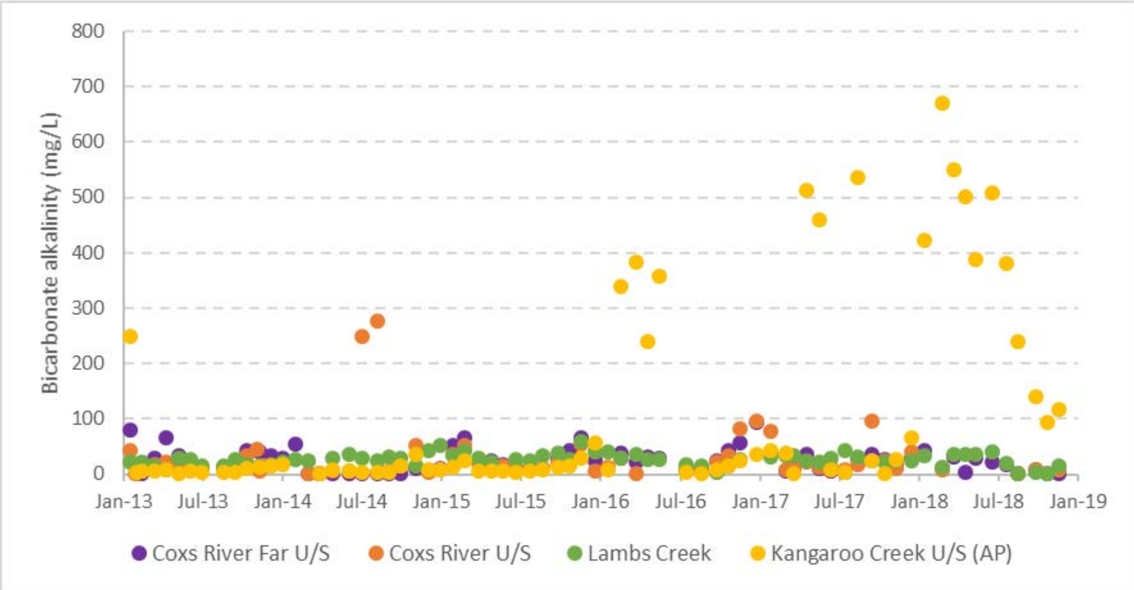
800
700
600
500
400
300
200
100
0
Total dissolved solids (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

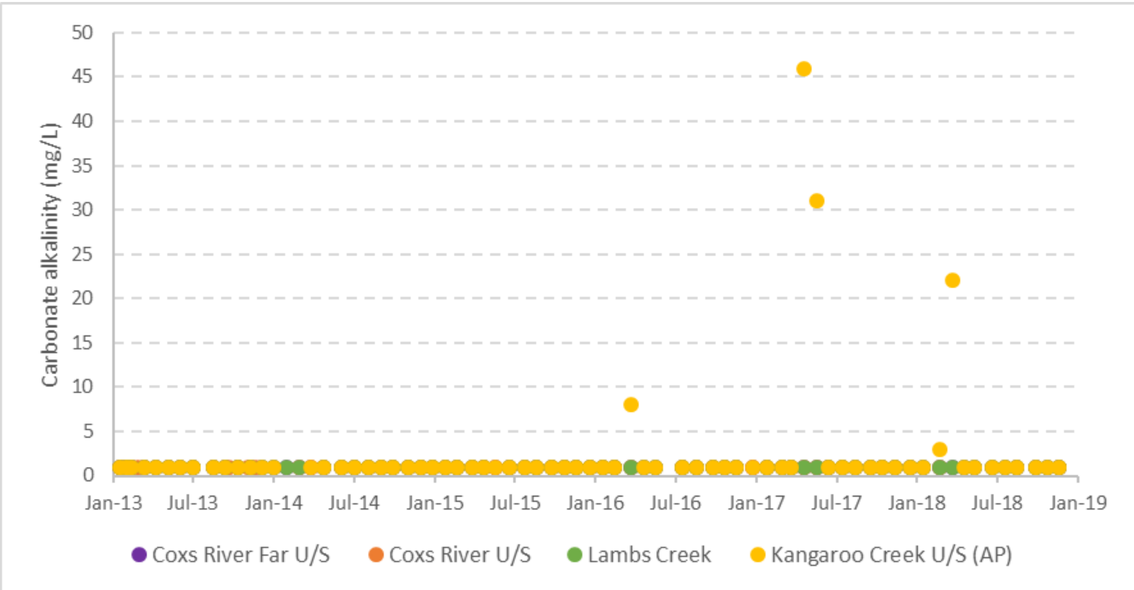


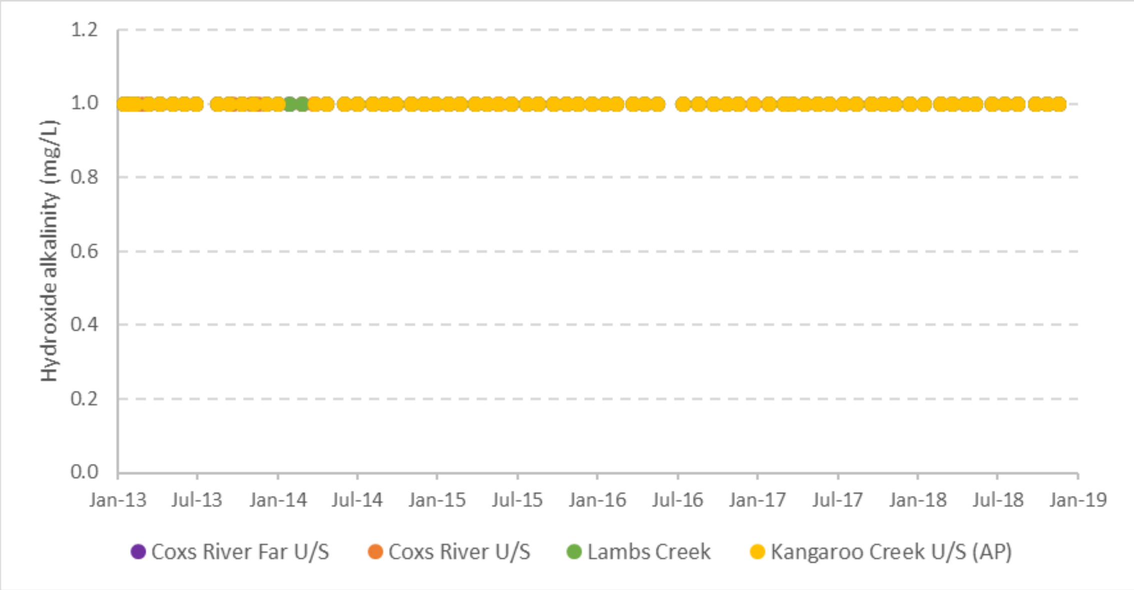
800
700
600
500
400
300
200
100
0
Total suspended solids (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)
Kangaroo Creek U/S (NP)
Kangaroo Creek D/S (NP)


Turidity (NTU)
1200
1000
800
600
400
200
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

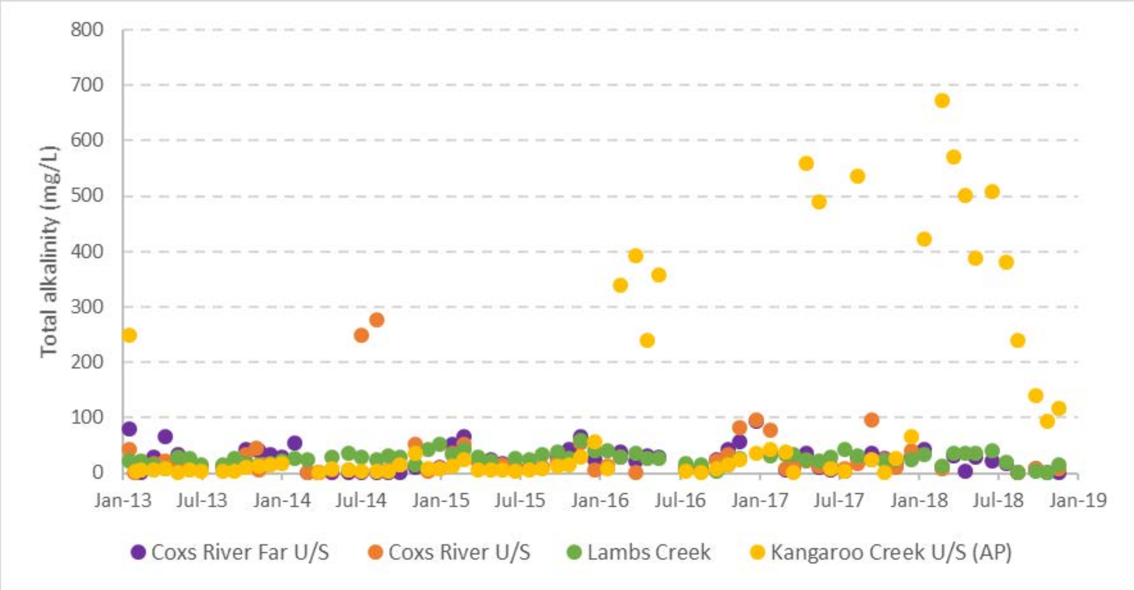
Major ions


Bicarbonate alkalinity (mg/L)
800
700
600
500
400
300
200
100
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

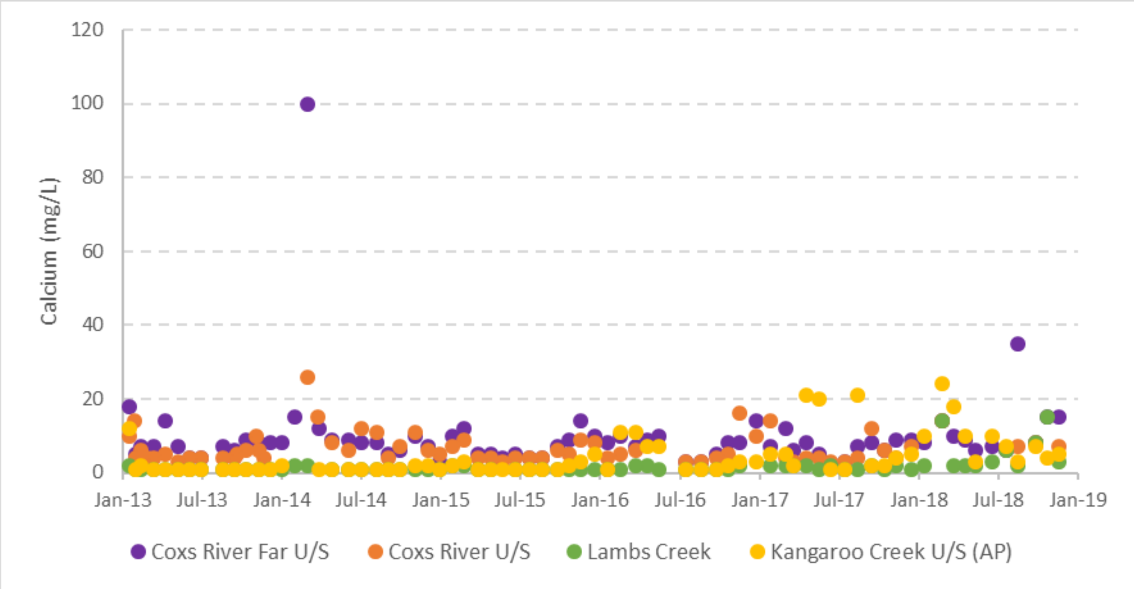

Carbonate alkalinity (mg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



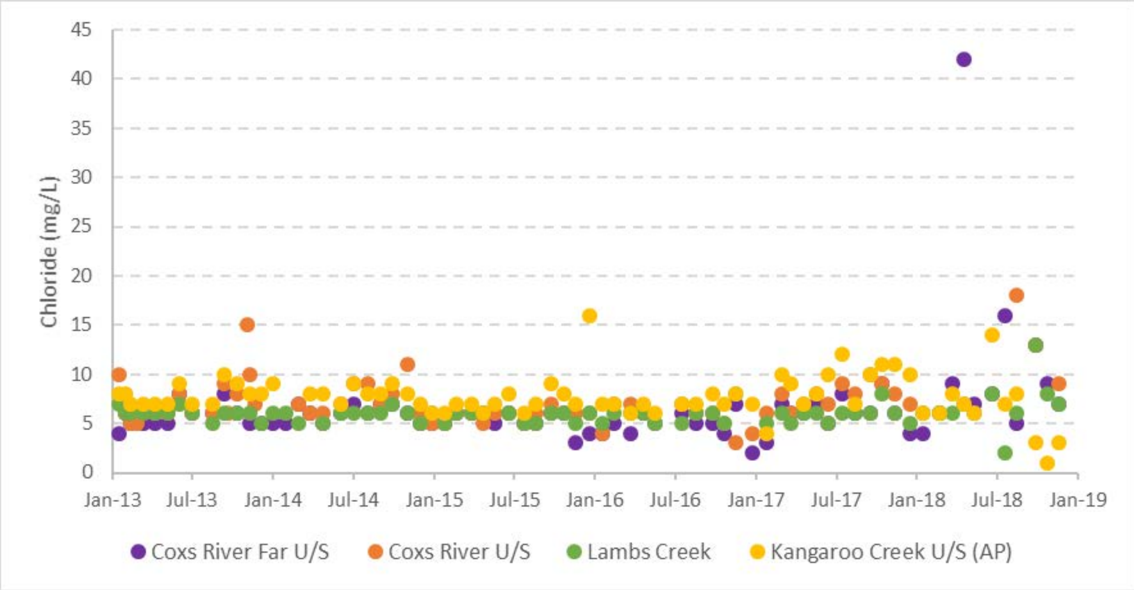
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Hydroxide alkalinity (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

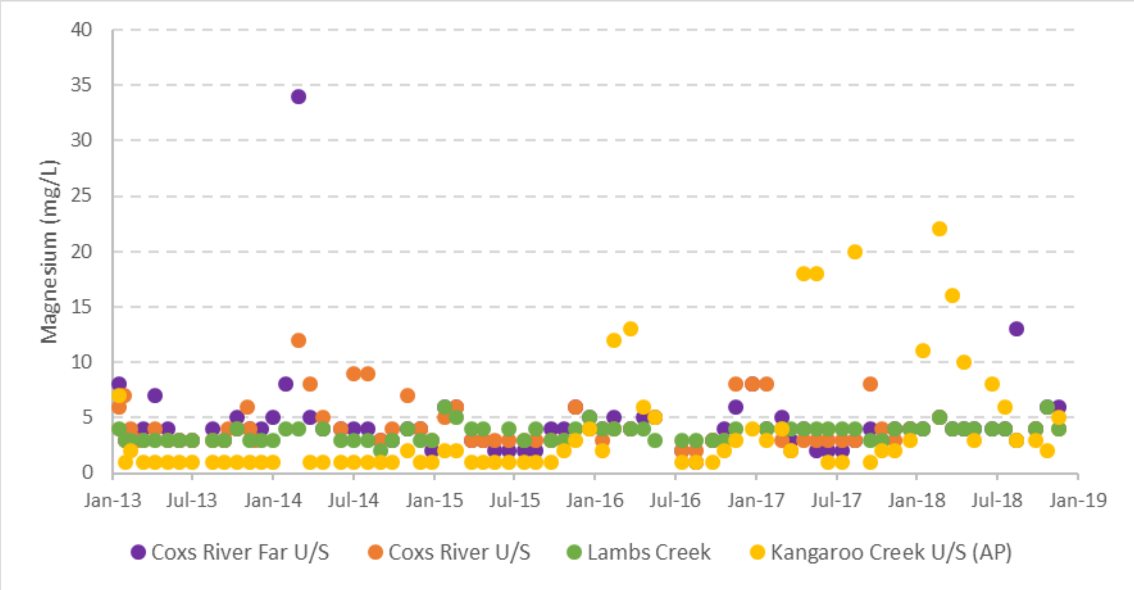


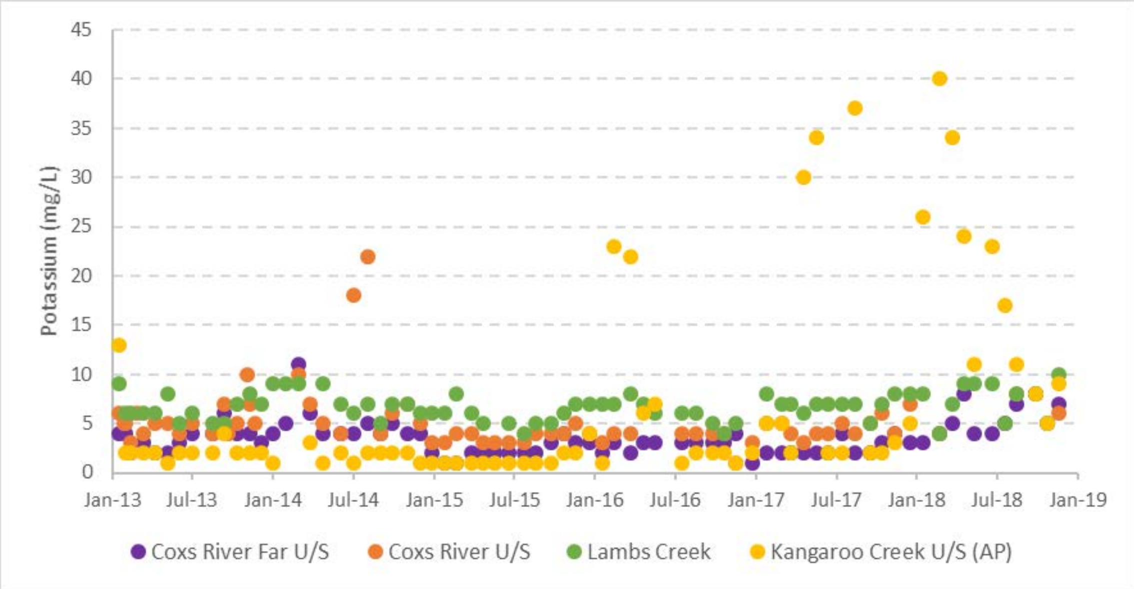
800
700
600
500
400
300
200
100
0
Total alkalinity (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

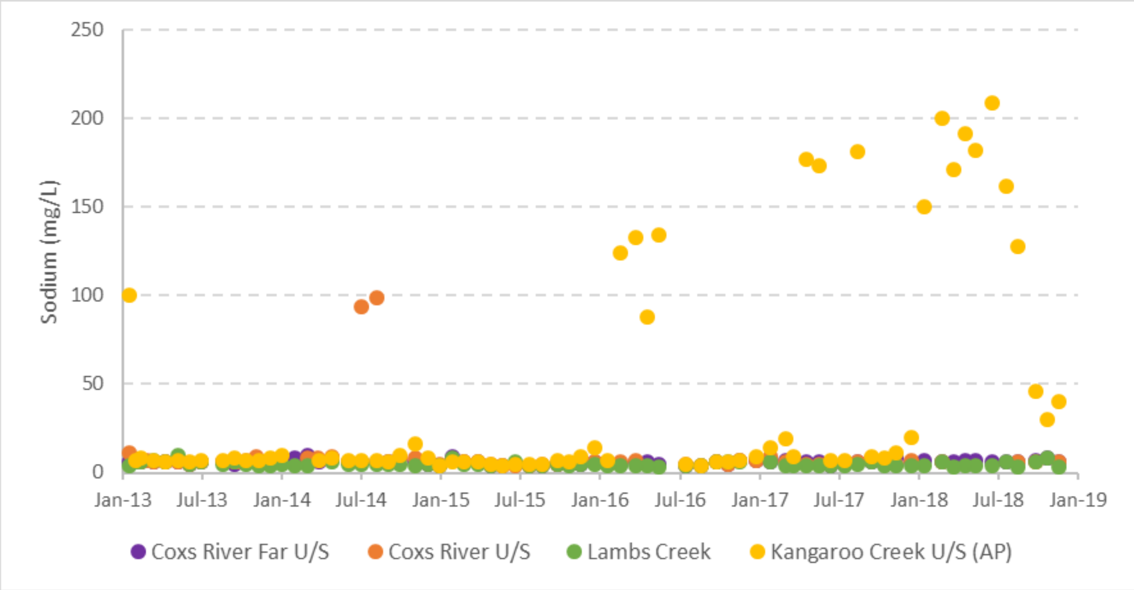


120
100
80
60
40
20
0
Calcium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

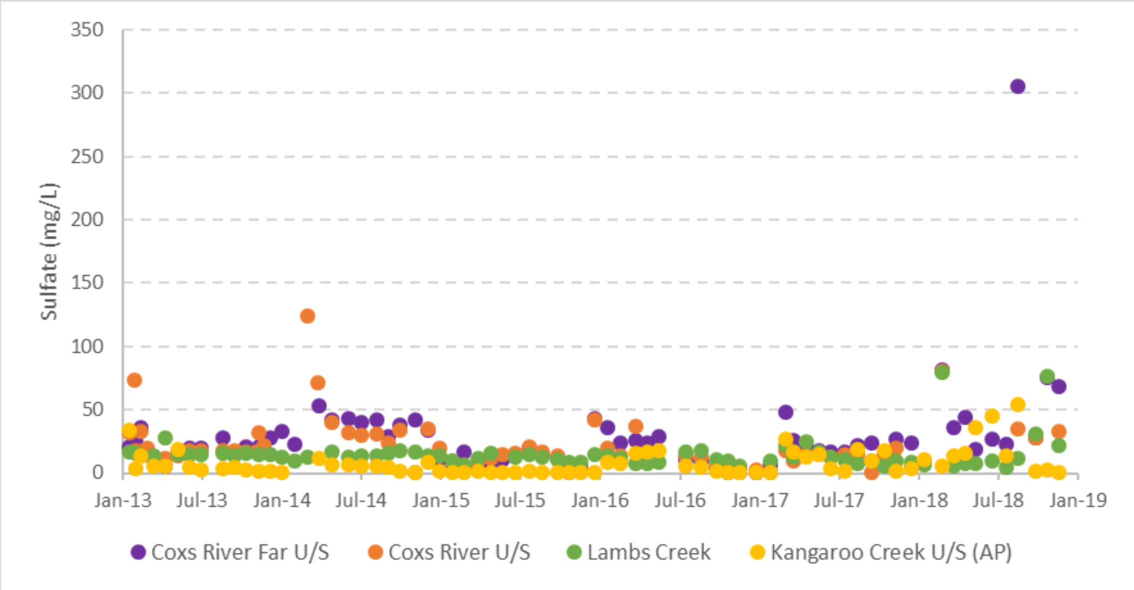

Chloride (mg/L)
45
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)


Magnesium (mg/L)
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

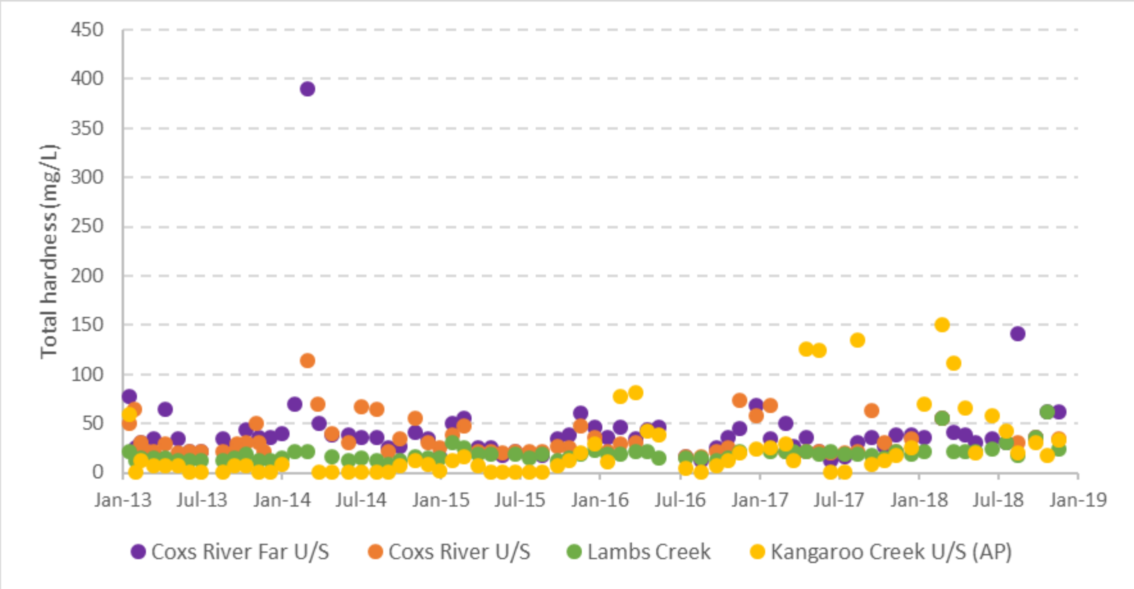

Potassium (mg/L)
45
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



Sodium (mg/L)
250
200
150
100
50
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

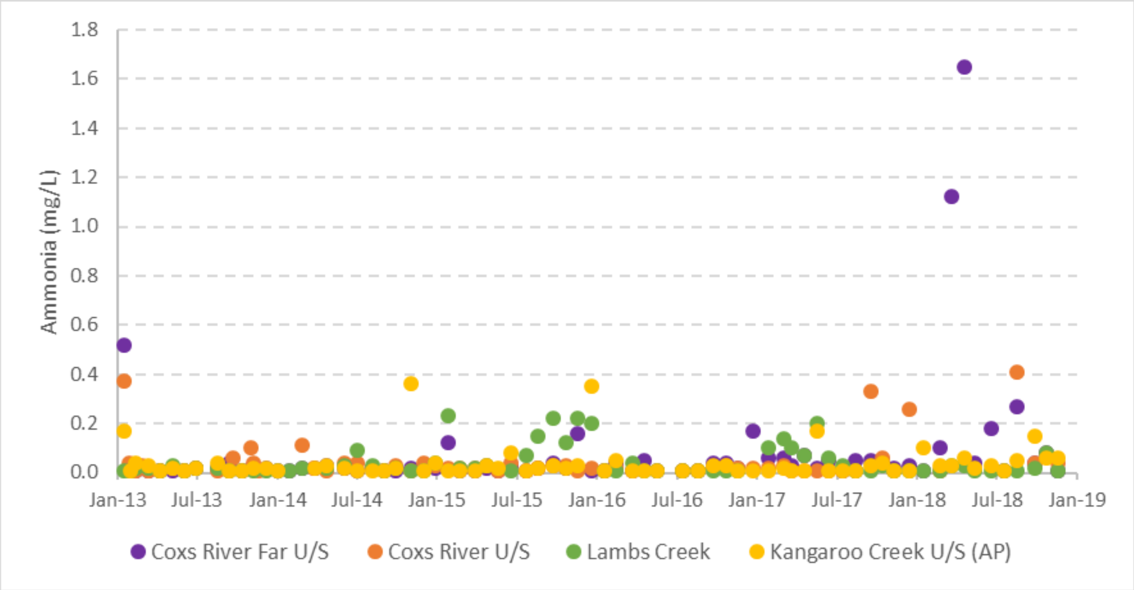


Sulfate (mg/L)
350
300
250
200
150
100
50
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

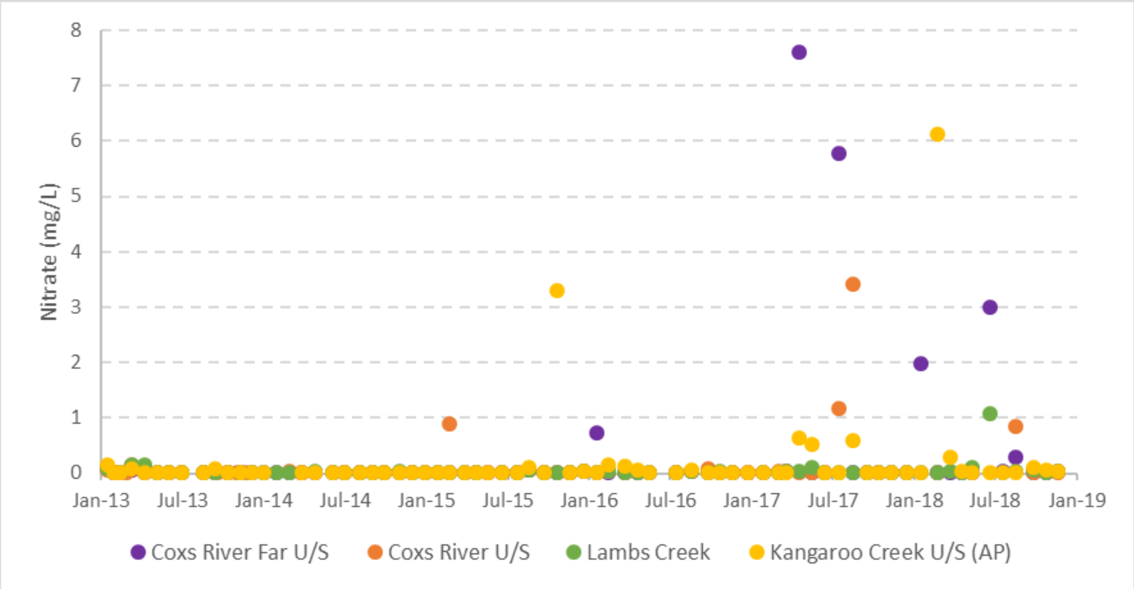


Total hardness (mg/L)
450
400
350
300
250
200
150
100
50
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

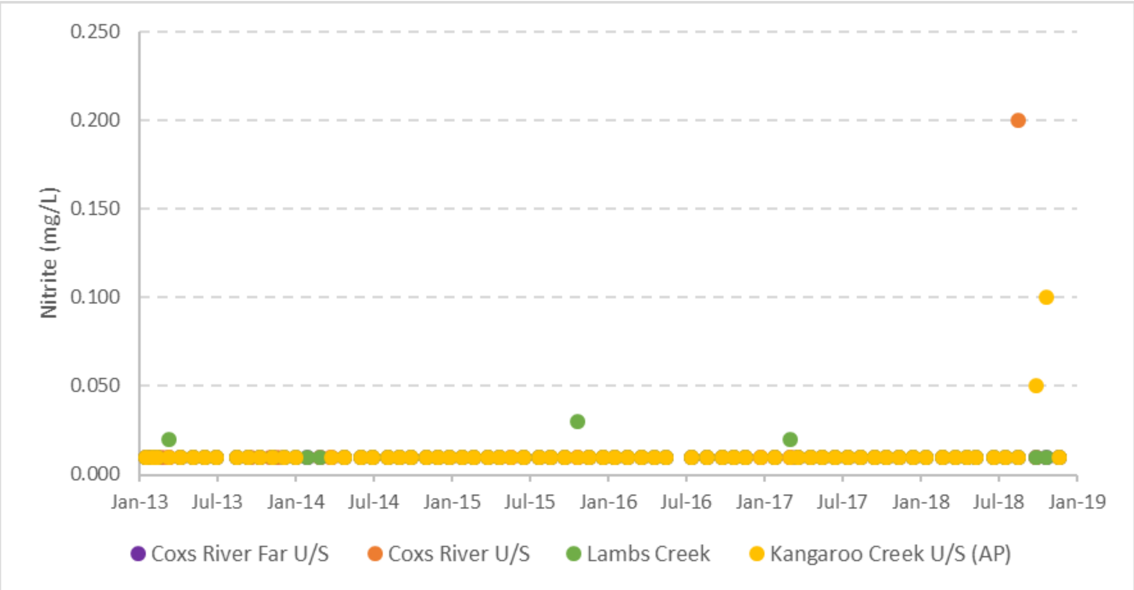
Nutrients



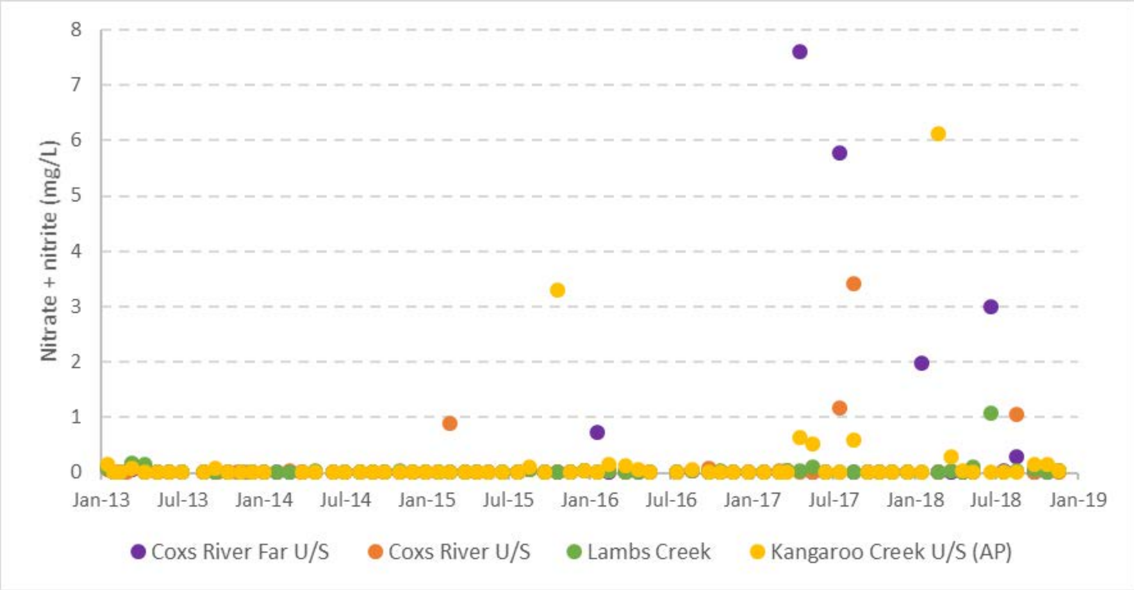
Ammonia (mg/L)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



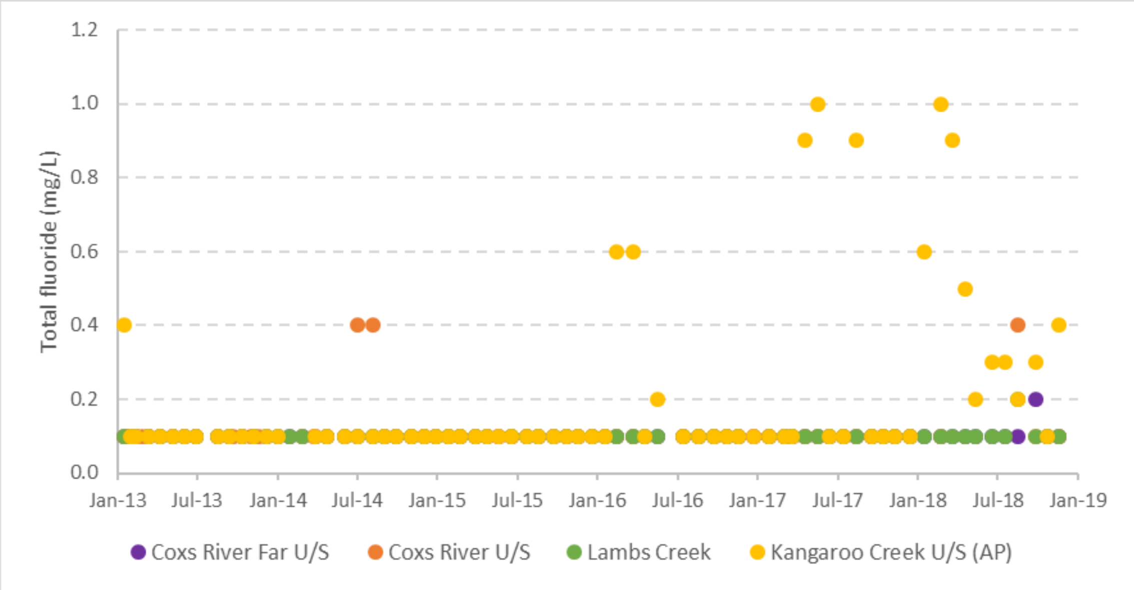
Nitrate (mg/L)
8
7
6
5
4
3
2
1
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



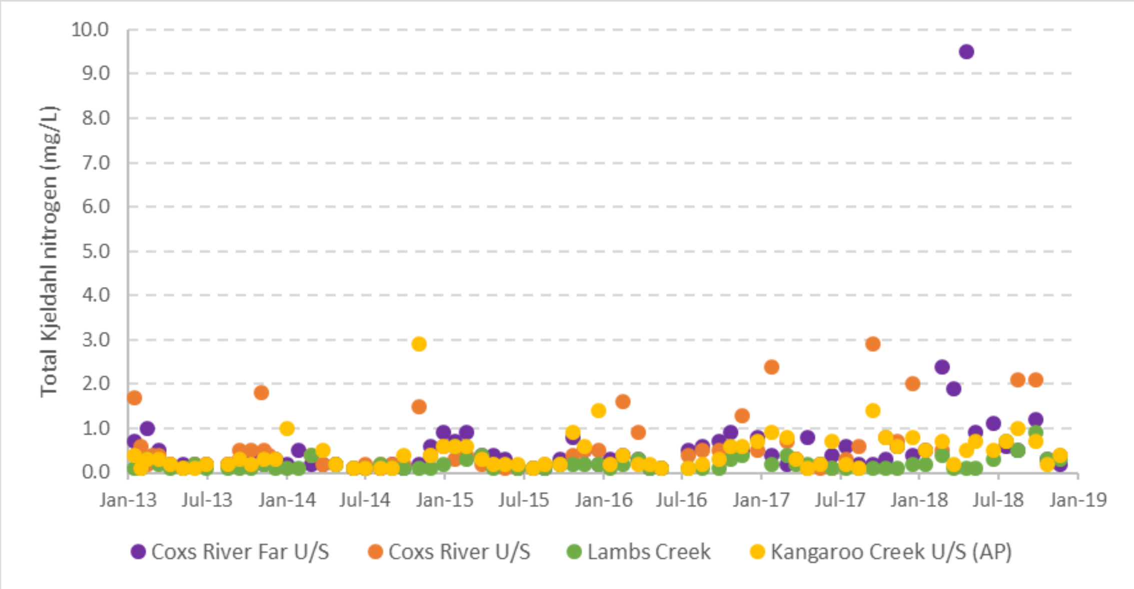
Nitrite (mg/L)
0.250
0.200
0.150
0.100
0.050
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



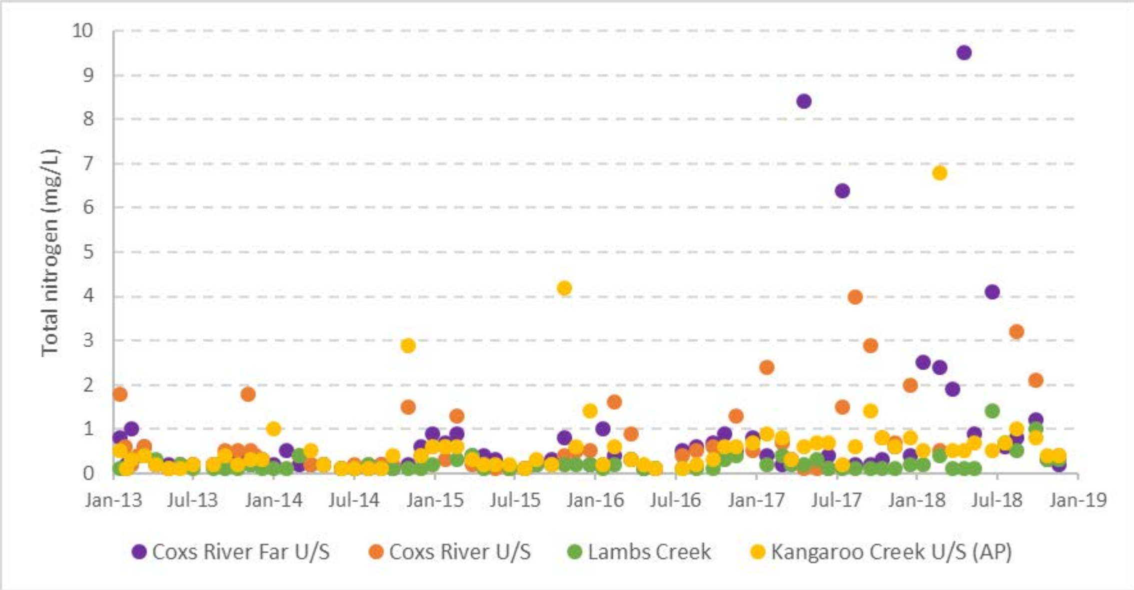
Nitrate + nitrite (mg/L)
8
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

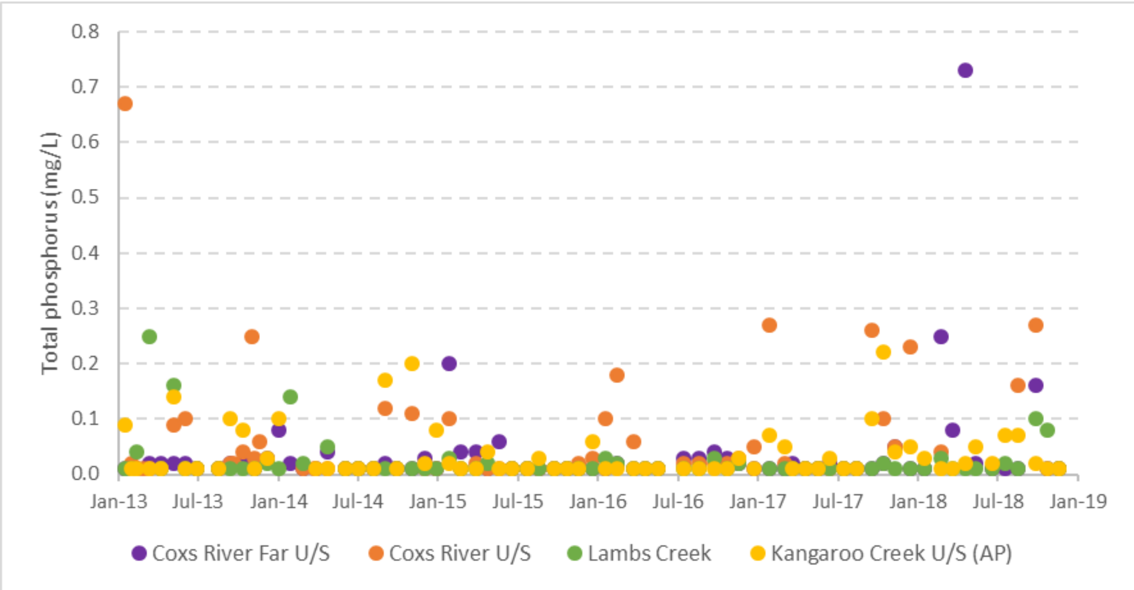


Total fluoride (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

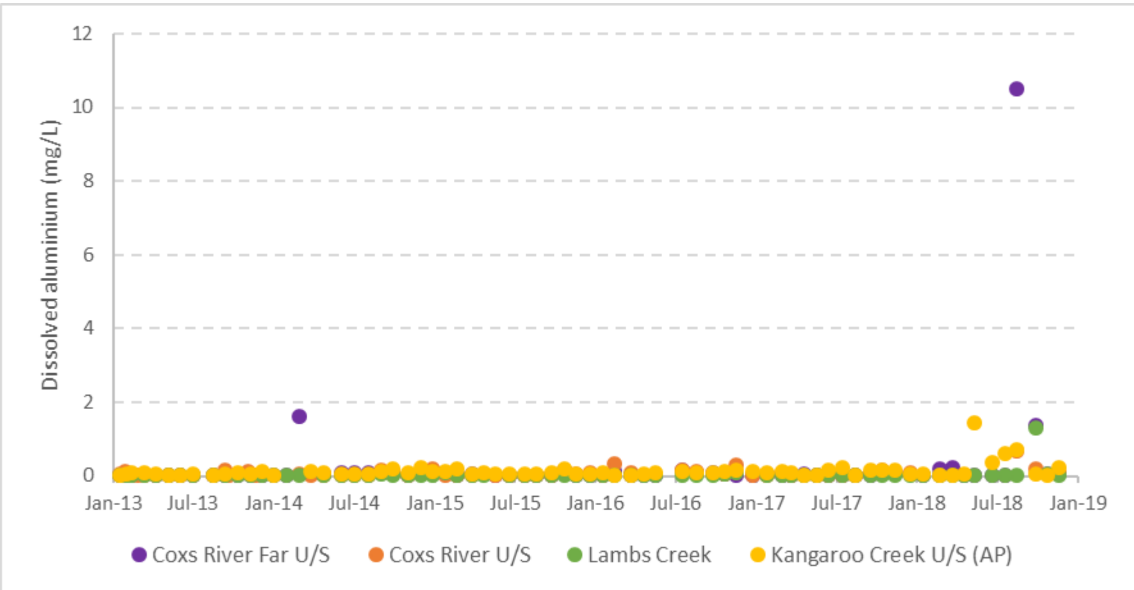


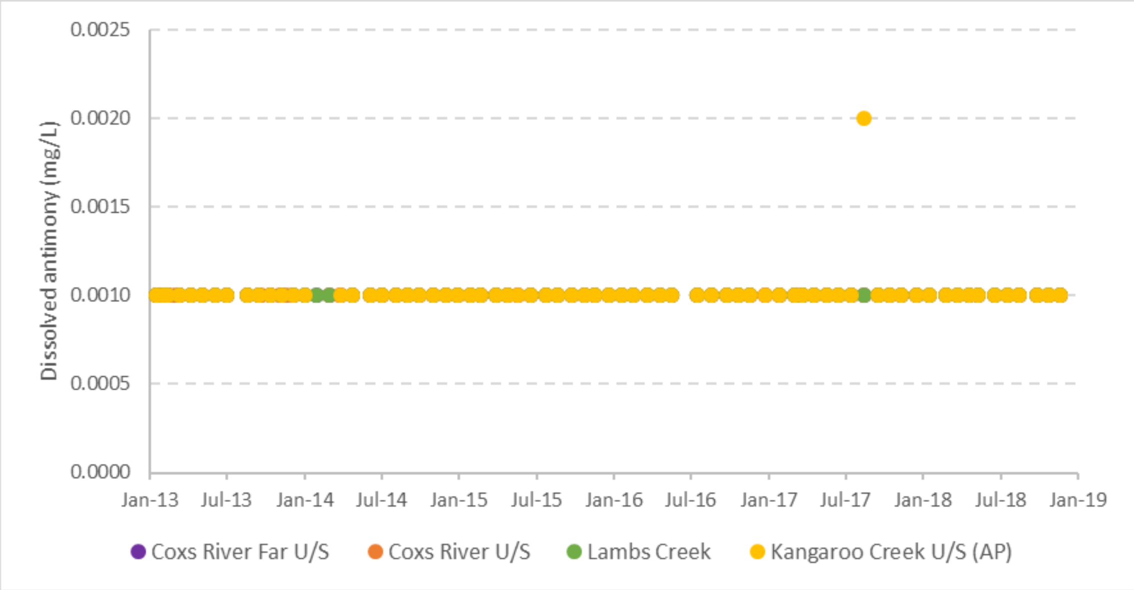
Total Kjeldahl nitrogen (mg/L)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

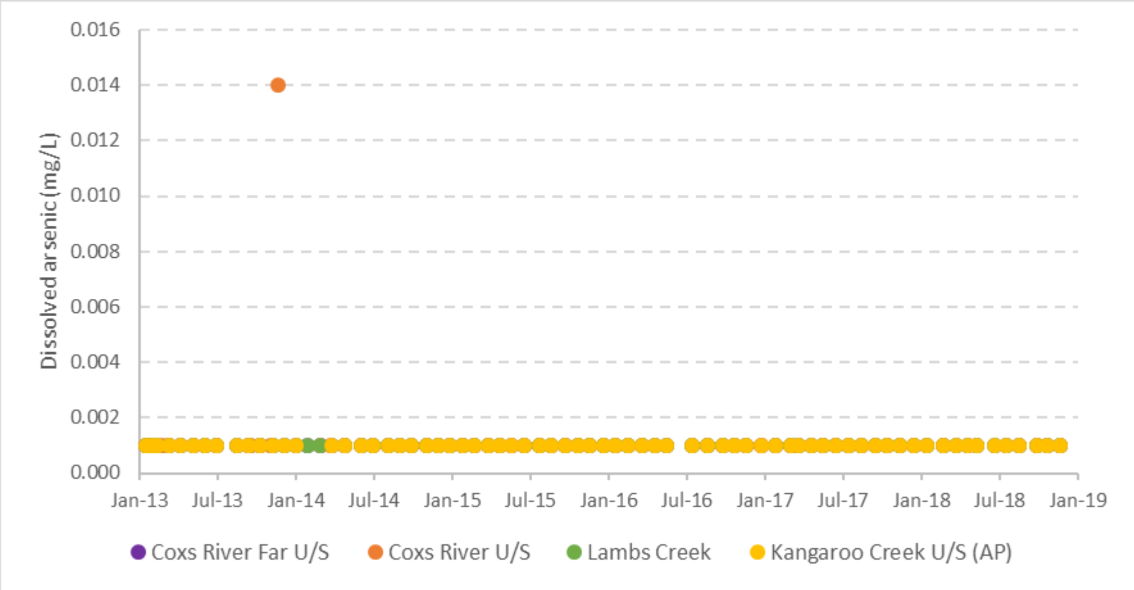


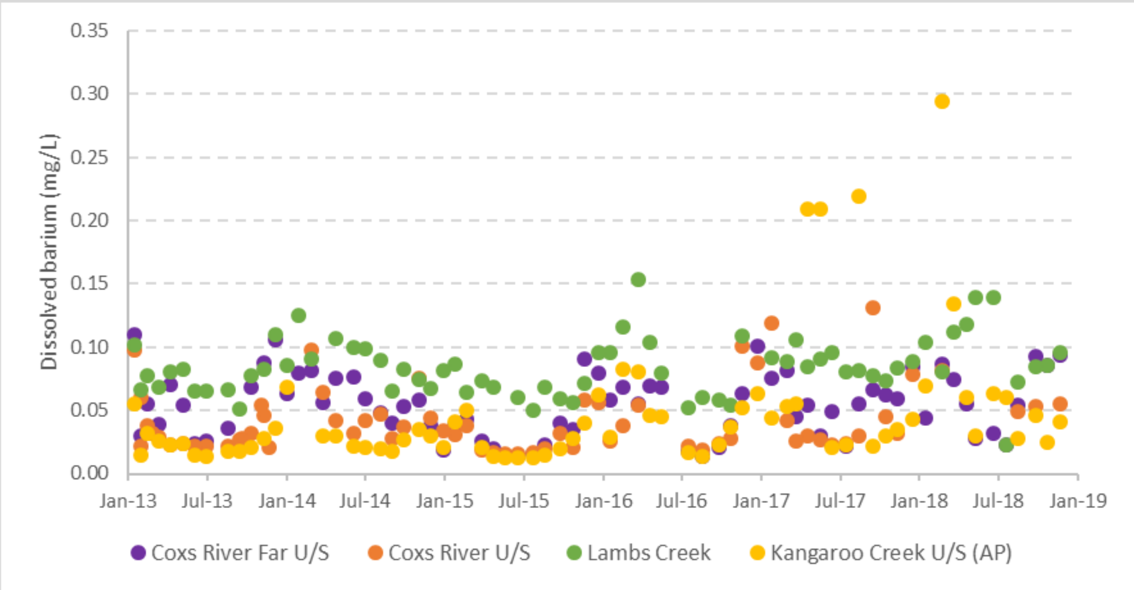


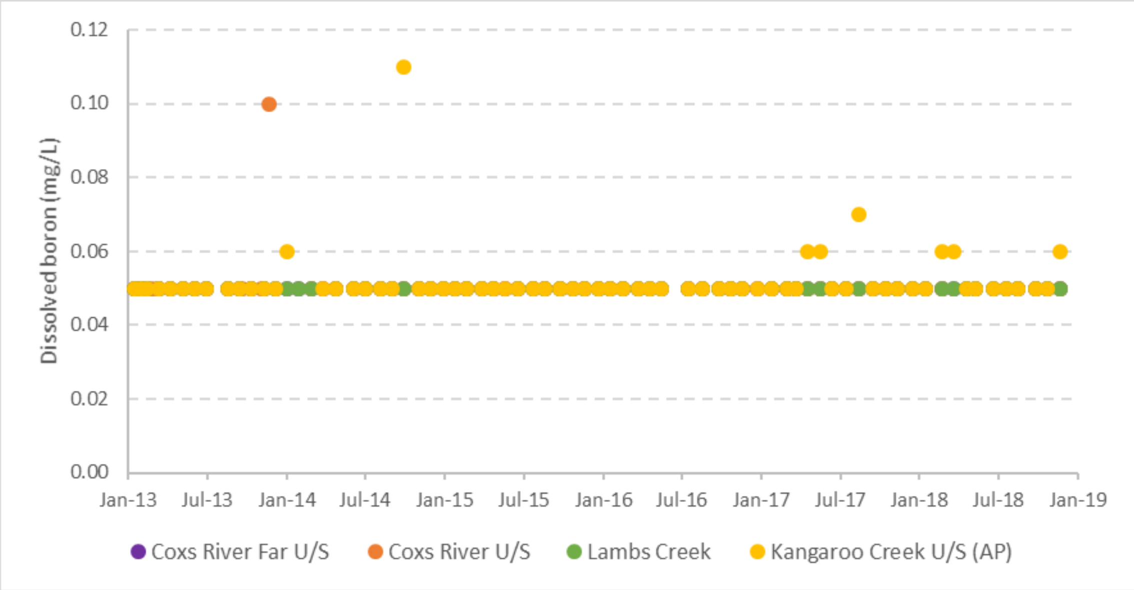
<u>Dissolved metals</u>

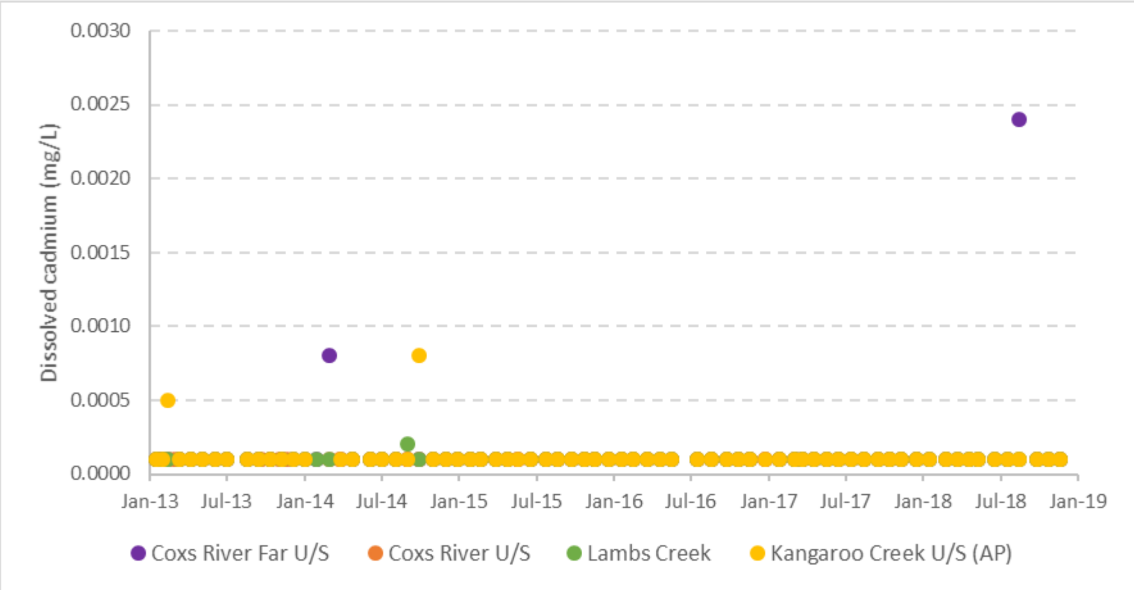


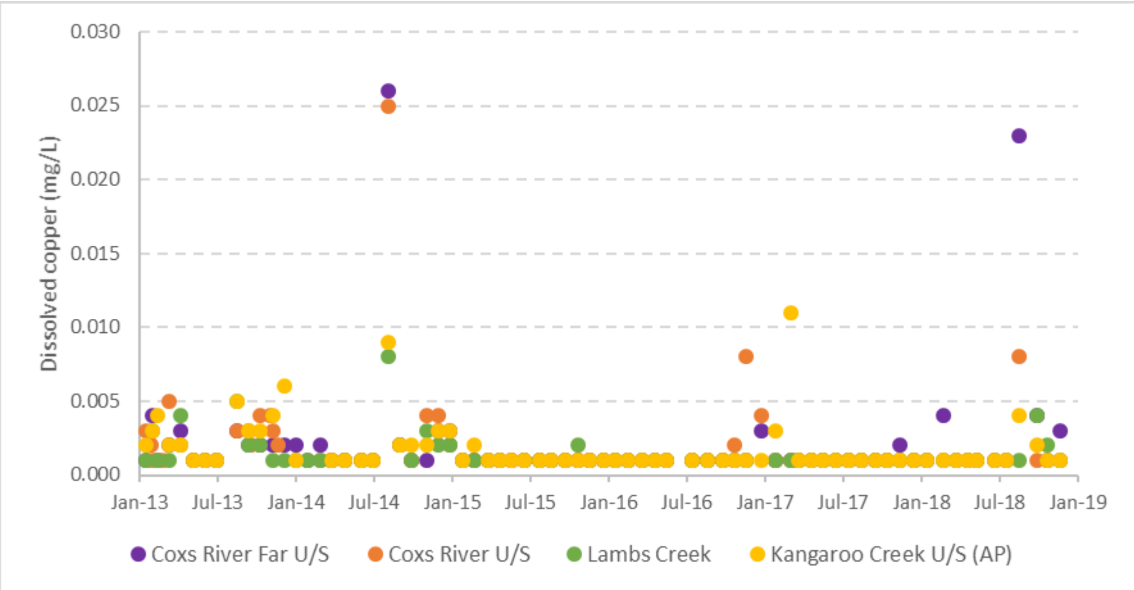

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved antimony (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

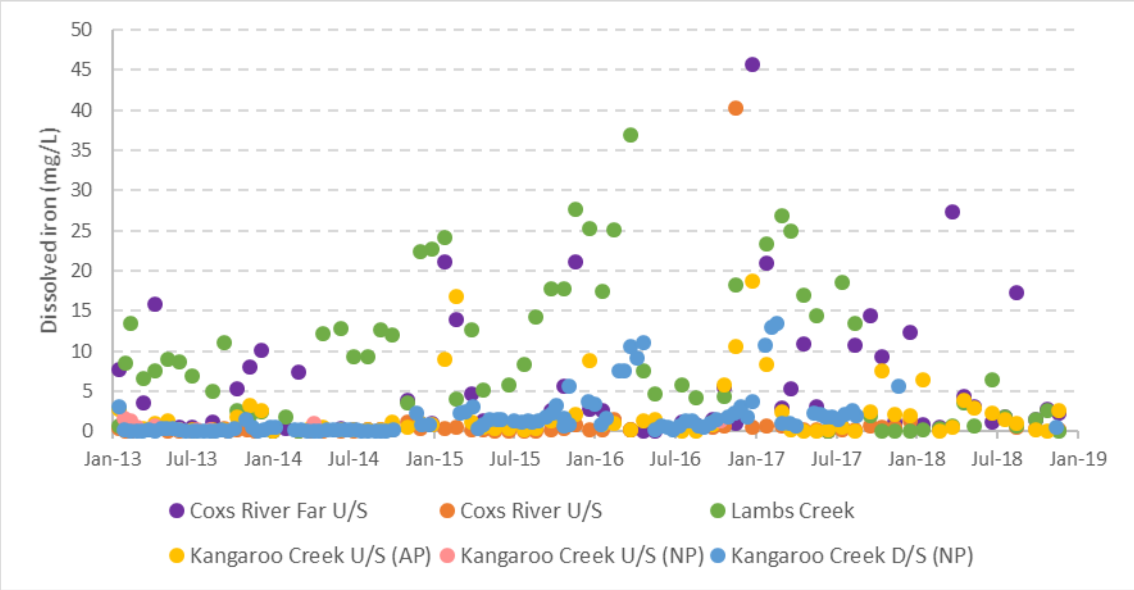

0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved arsenic (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)


0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dissolved barium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

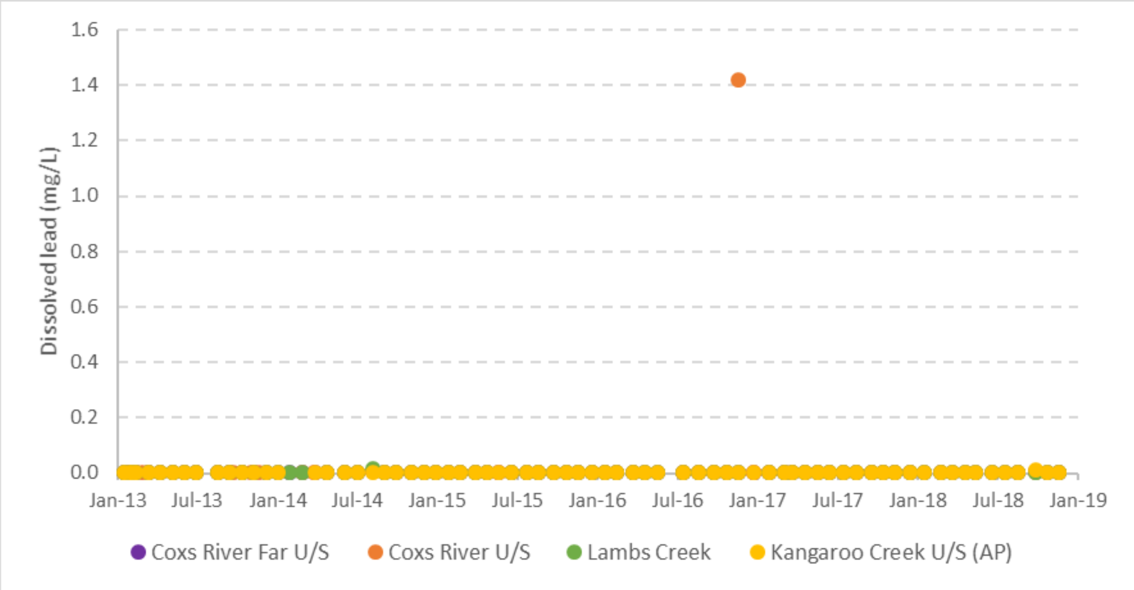

Dissolved boron (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)


Dissolved cadmium (mg/L)
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

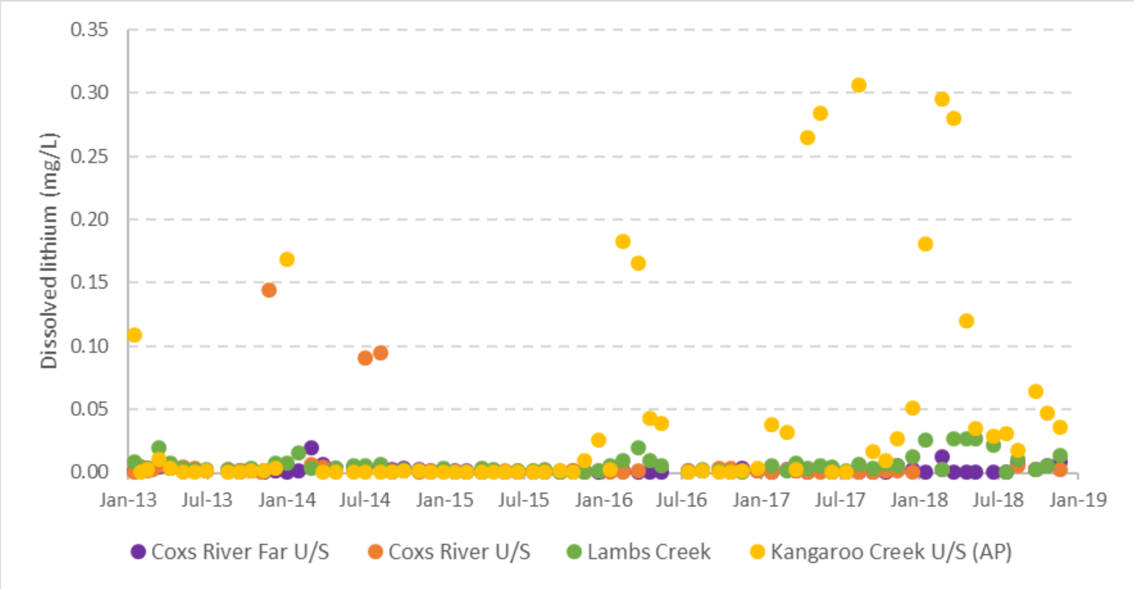

Dissolved copper (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



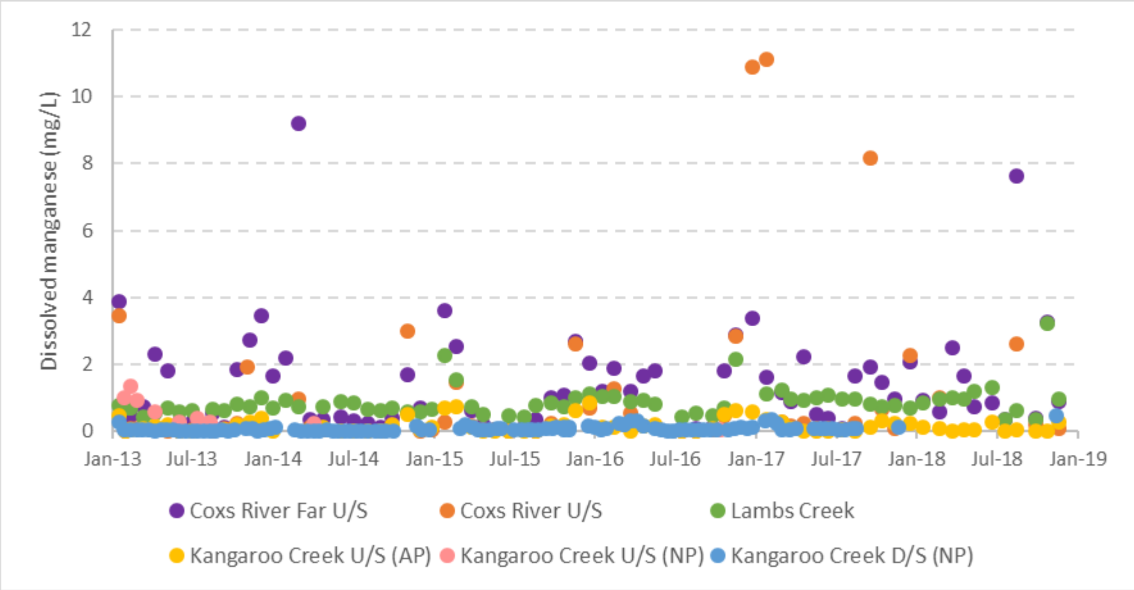
Dissolved iron (mg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)
Kangaroo Creek U/S (NP)
Kangaroo Creek D/S (NP)

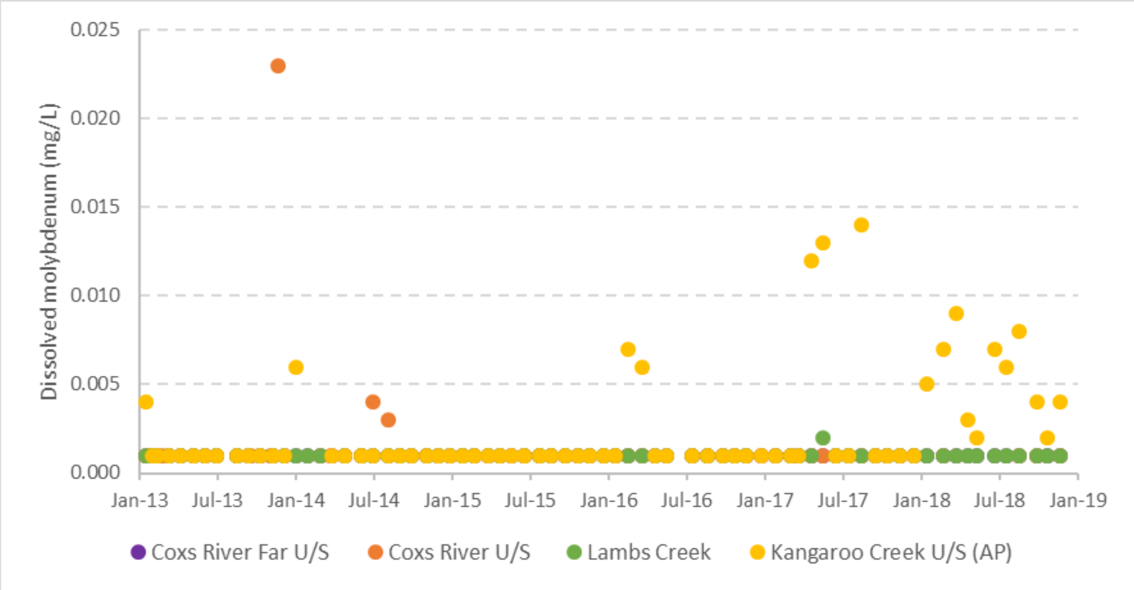


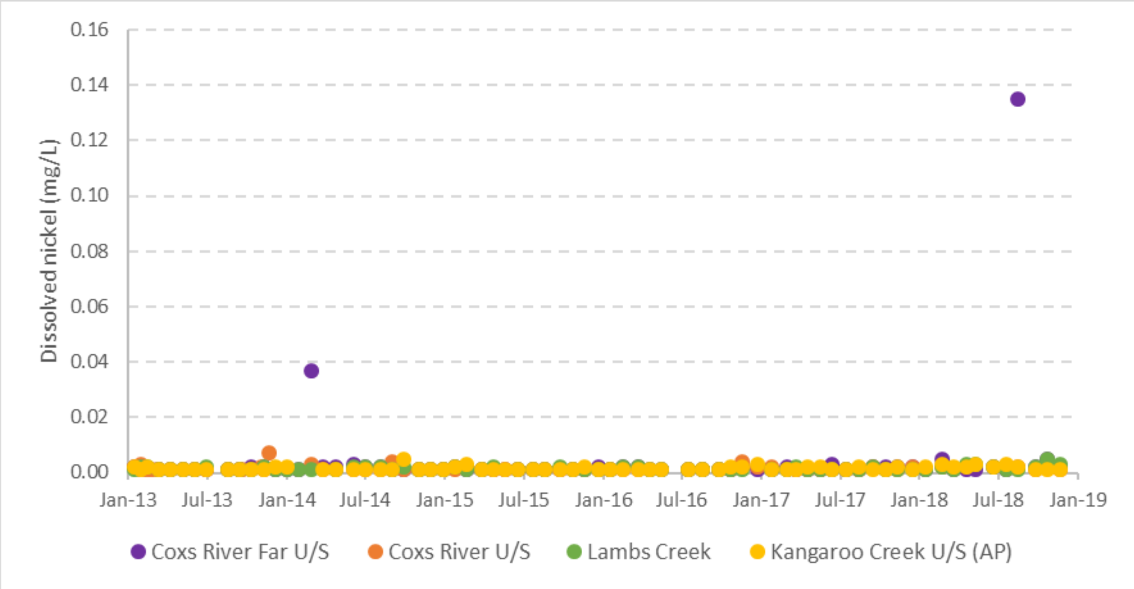
Dissolved lead (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

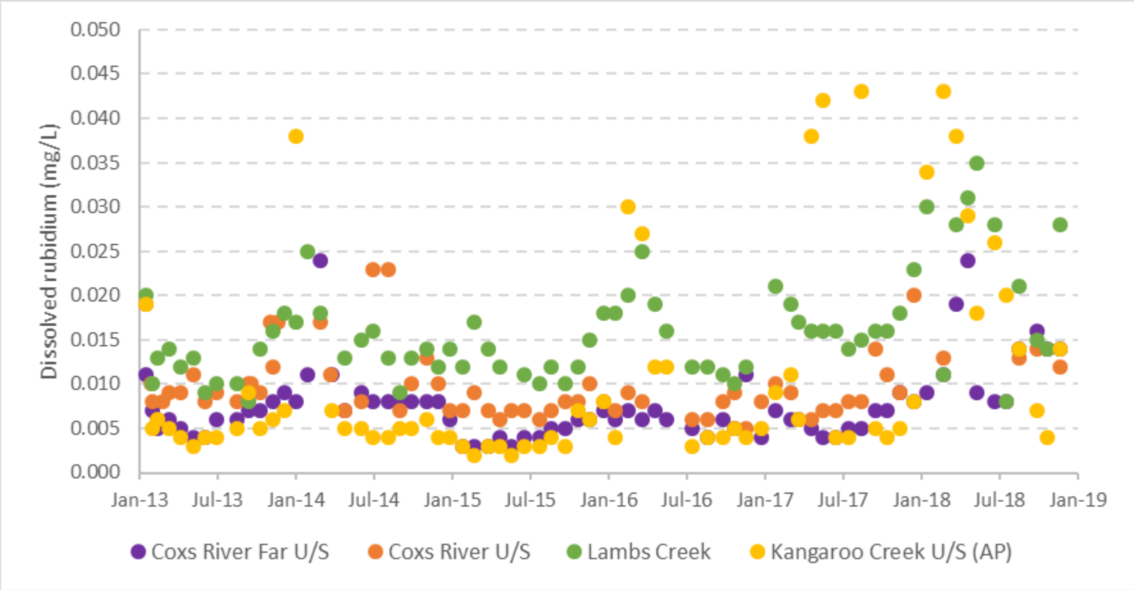


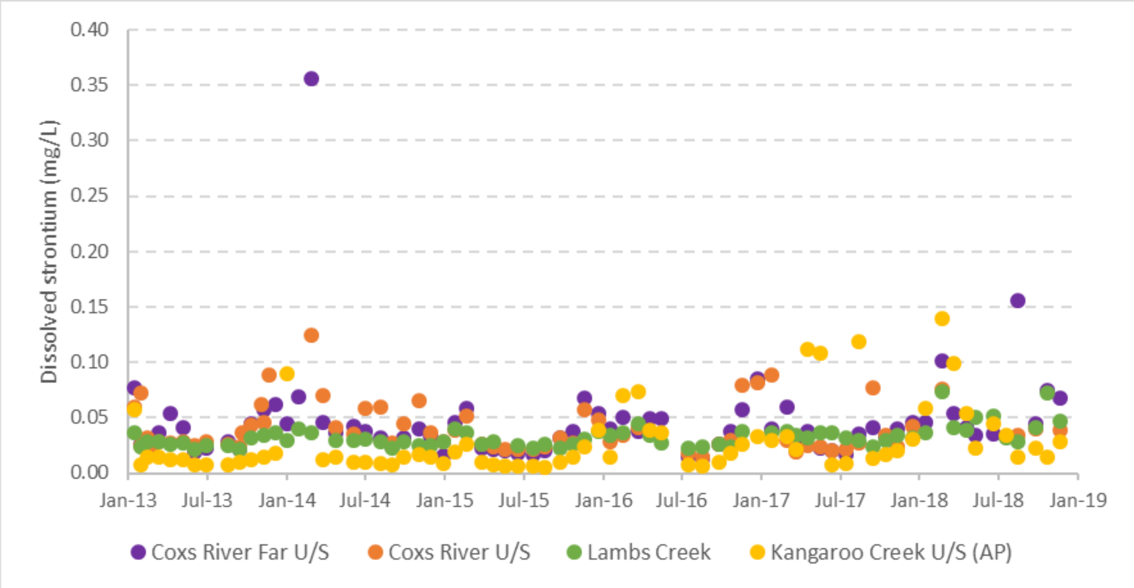
Dissolved lithium (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

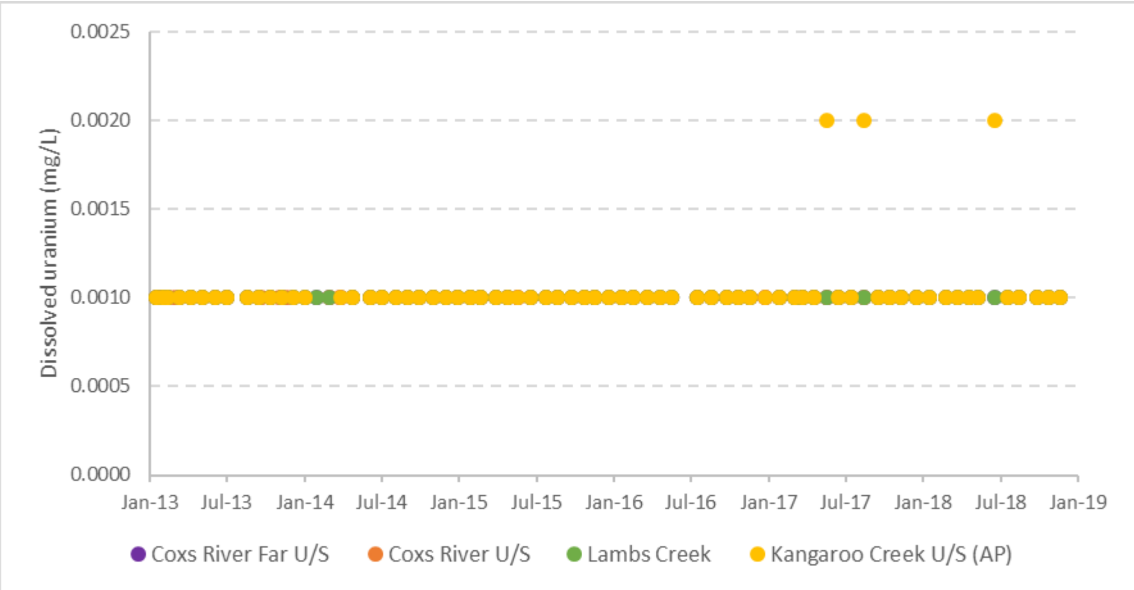

Dissolved manganese (mg/L)
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)
Kangaroo Creek U/S (NP)
Kangaroo Creek D/S (NP)

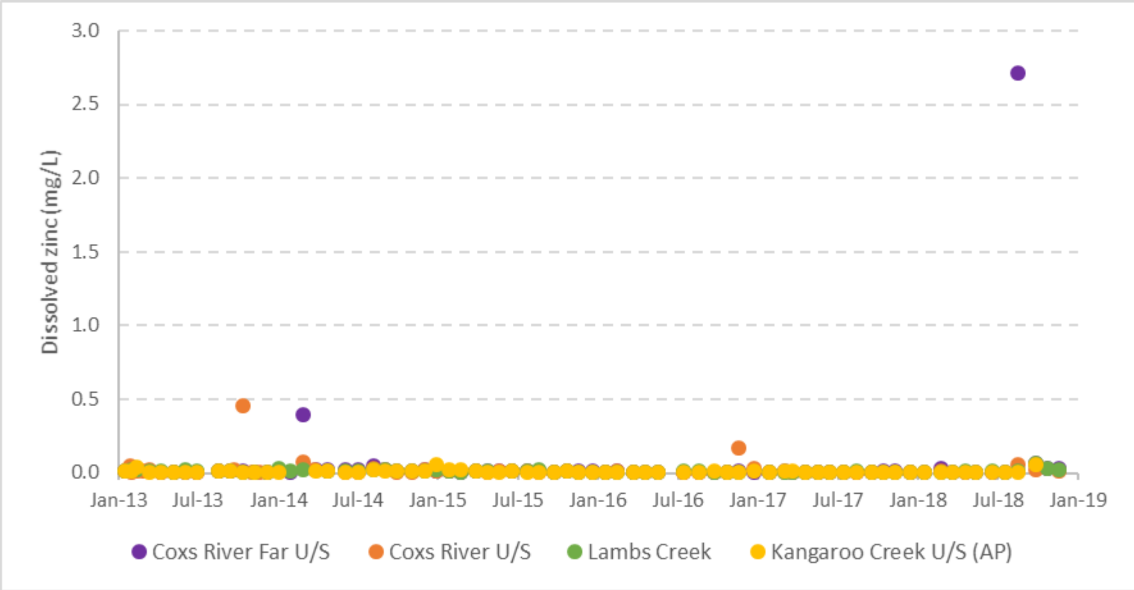

Dissolved molybdenum (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)


Dissolved nickel (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

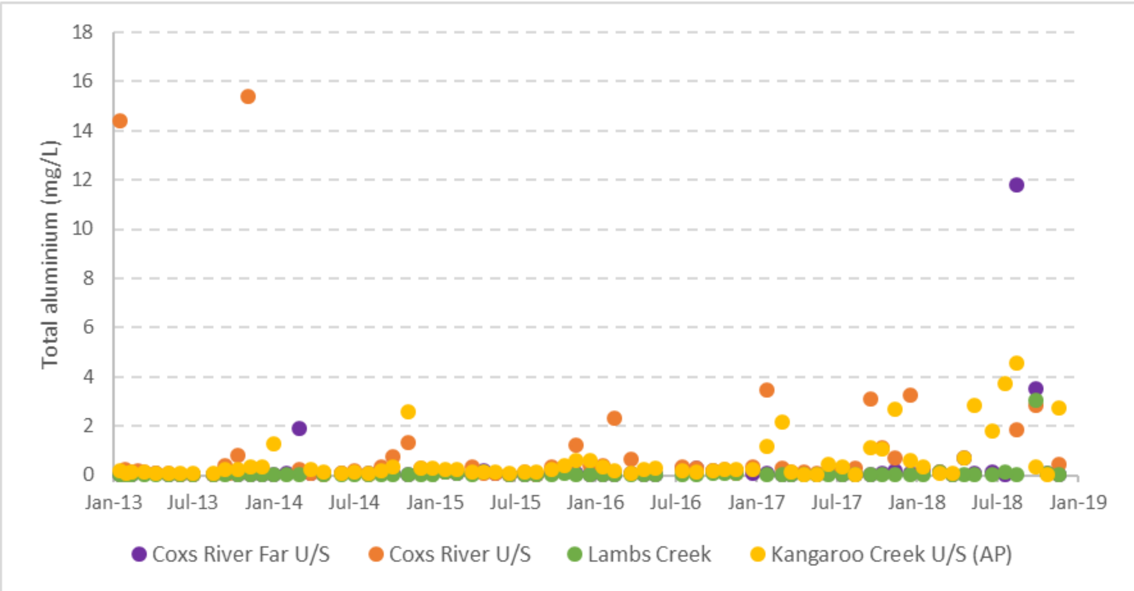

0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved rubidium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

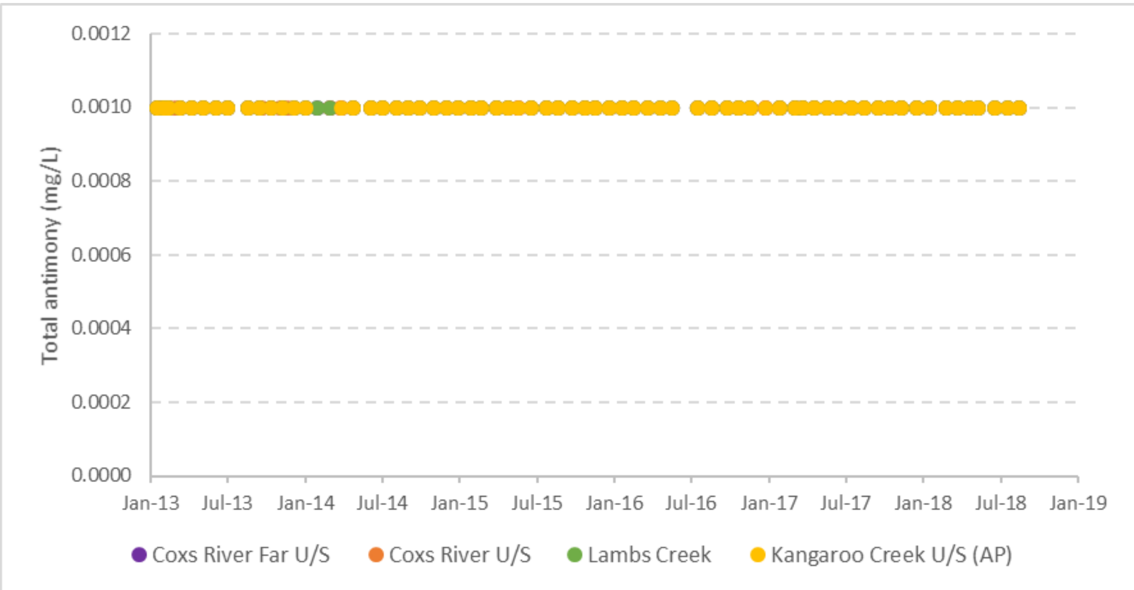

0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dissolved strontium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

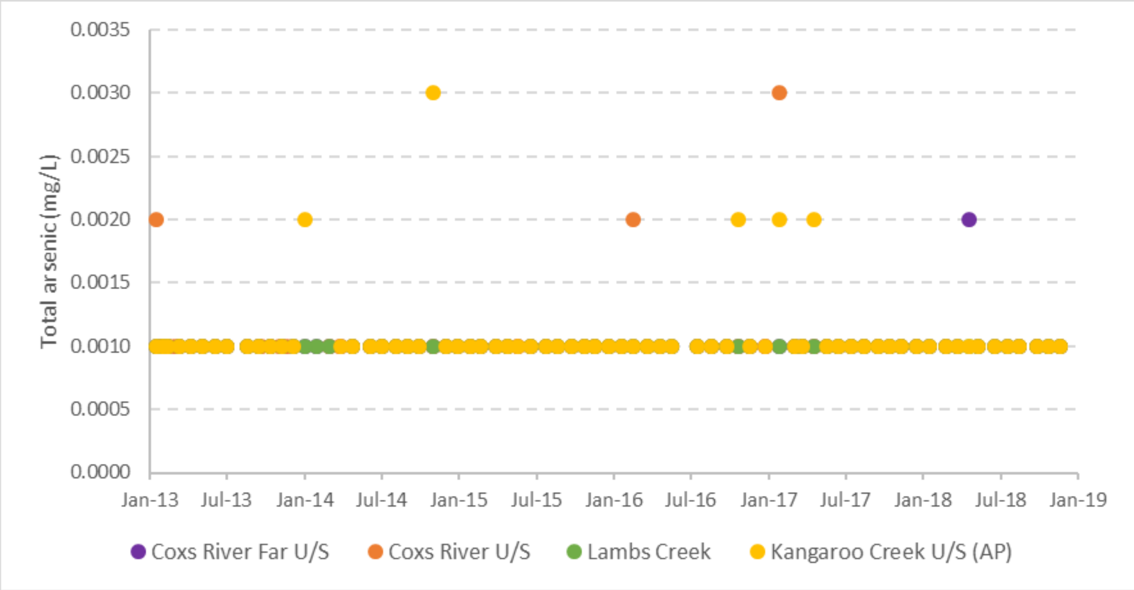

0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Dissolved uranium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



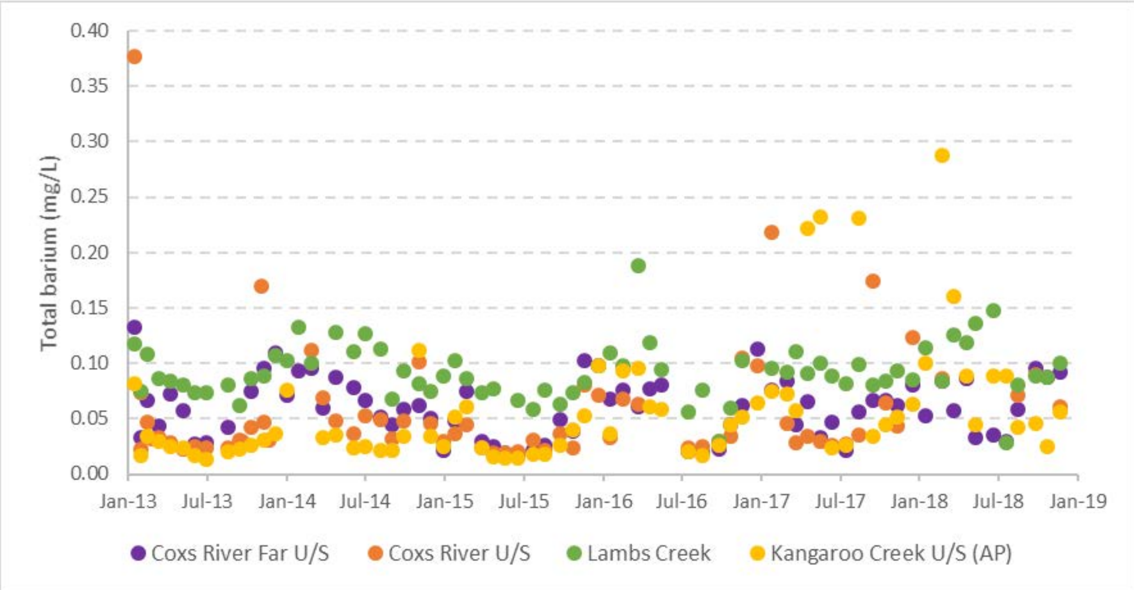
Total metals



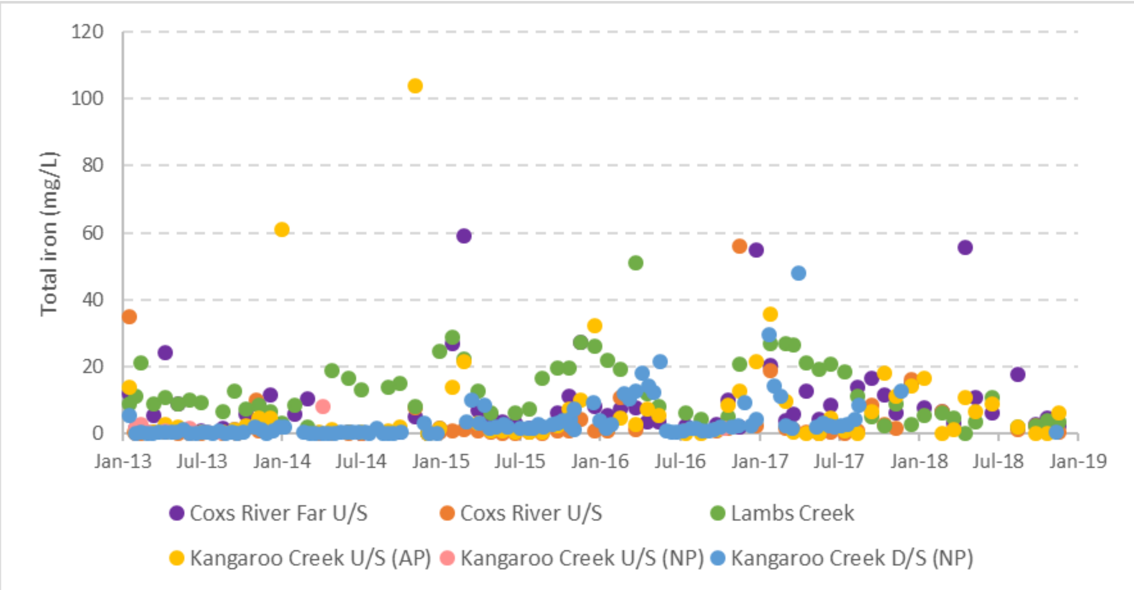




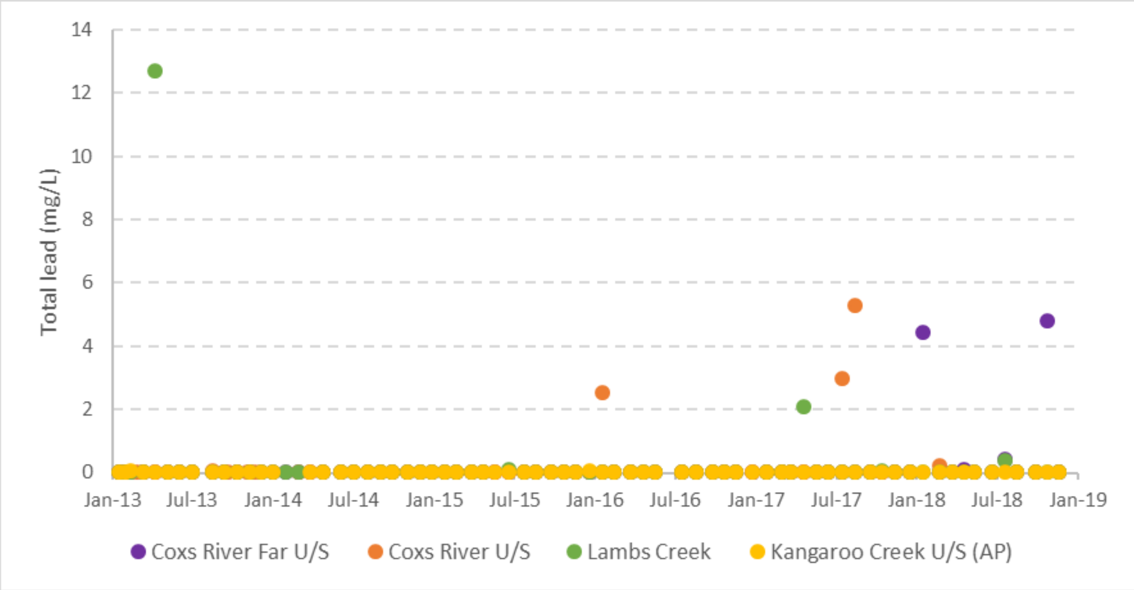
Total arsenic (mg/L)
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



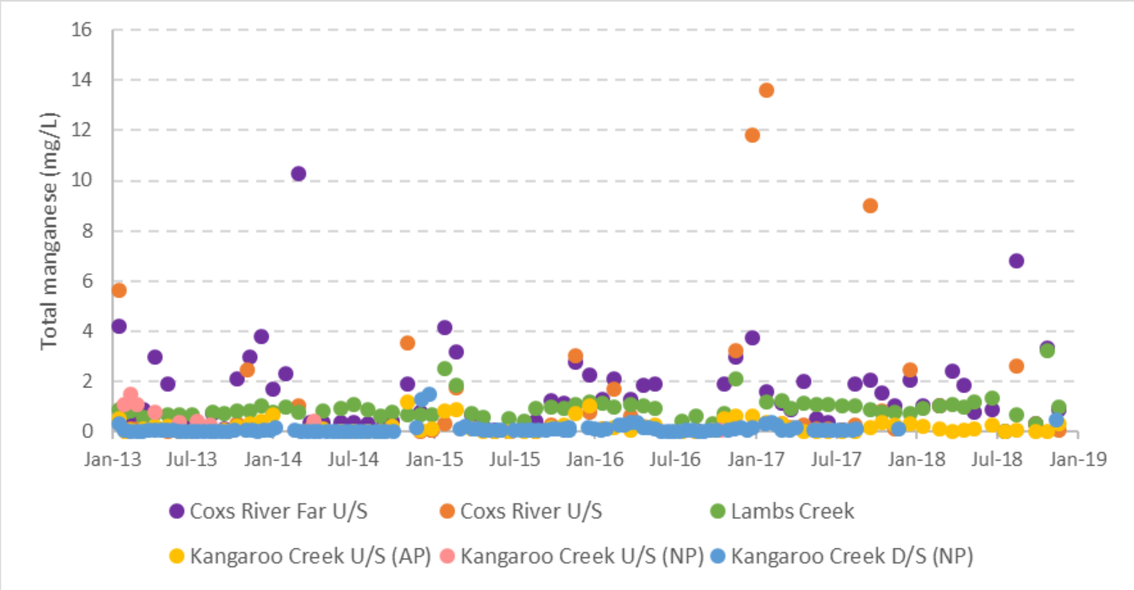
Total barium (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



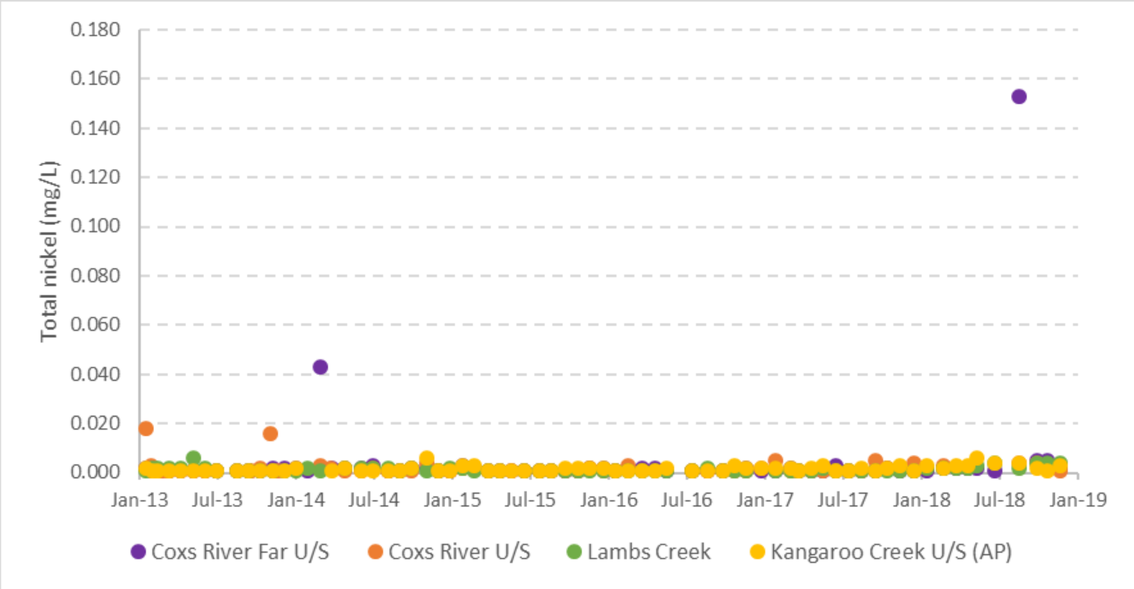
Total iron (mg/L)
120
100
80
60
40
20
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)
Kangaroo Creek U/S (NP)
Kangaroo Creek D/S (NP)



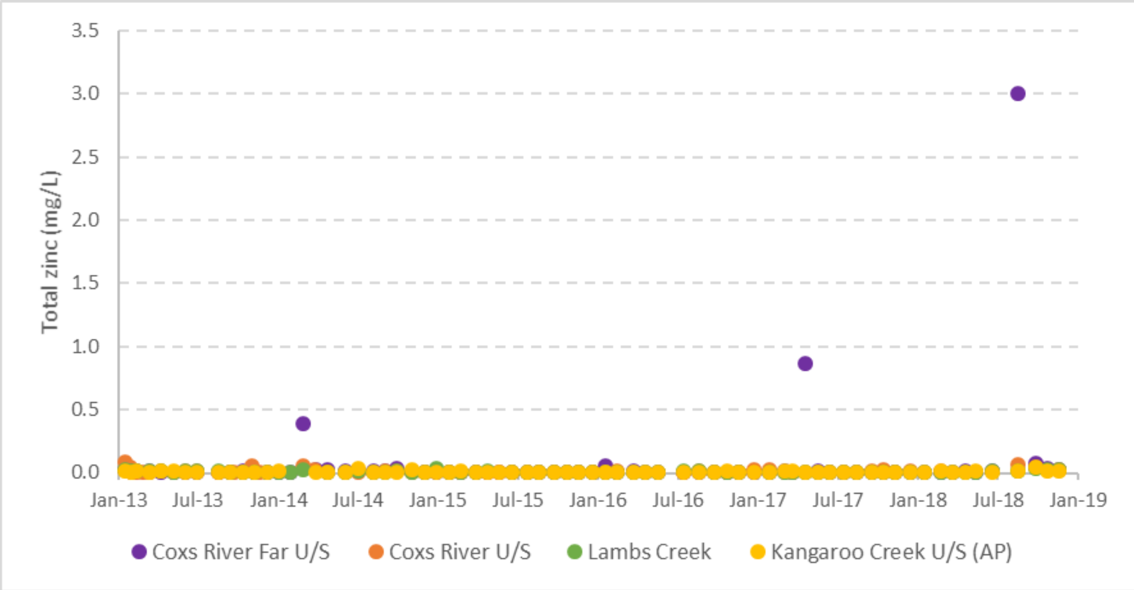
14
12
10
8
6
4
2
0
Total lead (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



16
14
12
10
8
6
4
2
0
Total manganese (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)
Kangaroo Creek U/S (NP)
Kangaroo Creek D/S (NP)

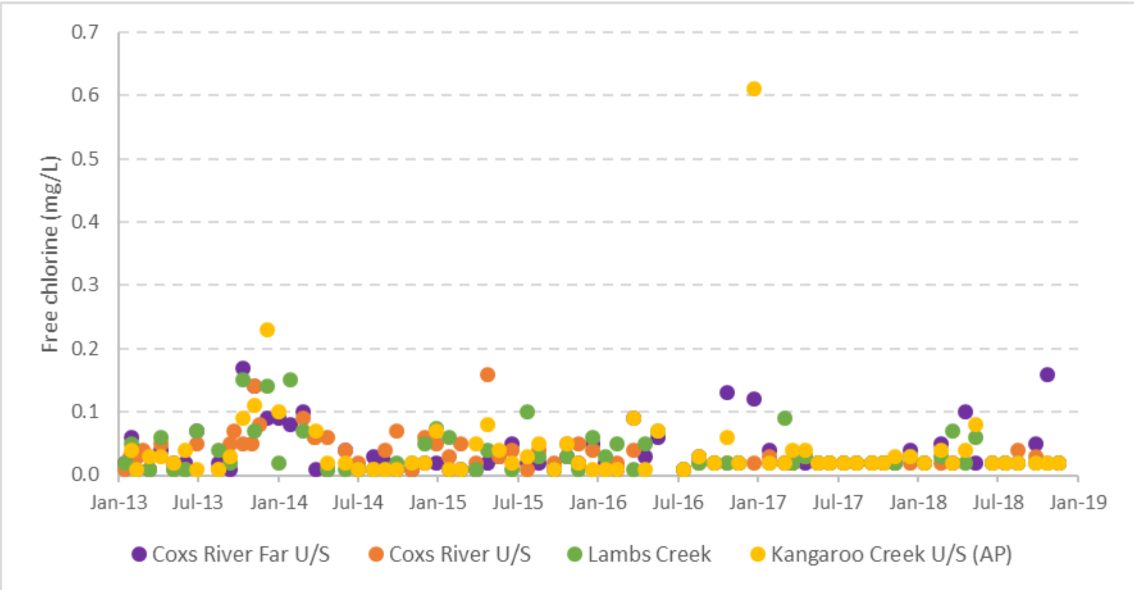


0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Total nickel (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

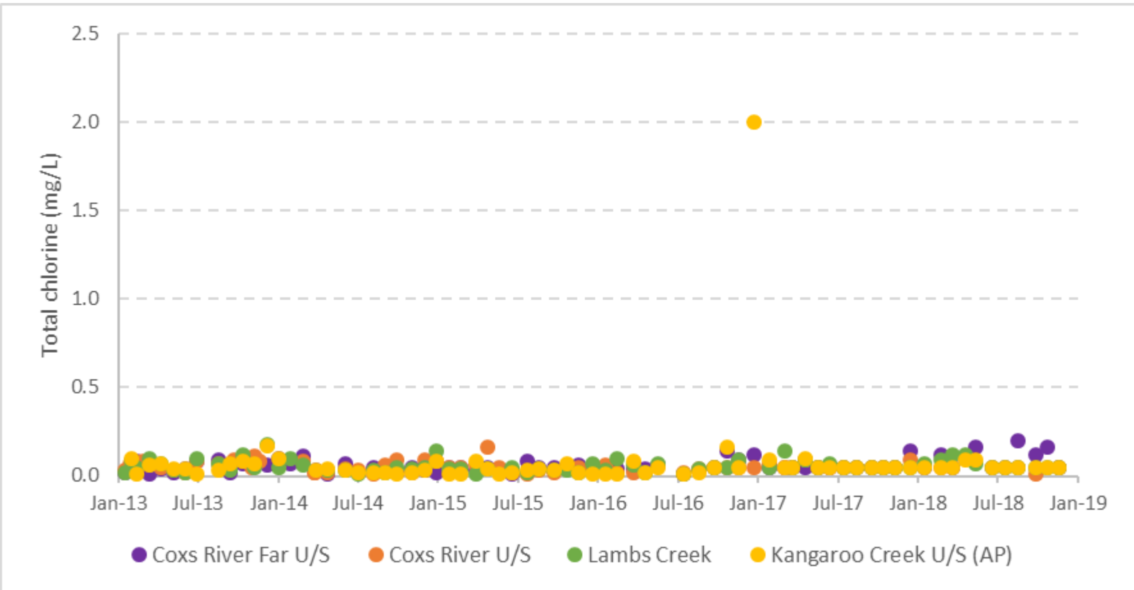


Total zinc (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

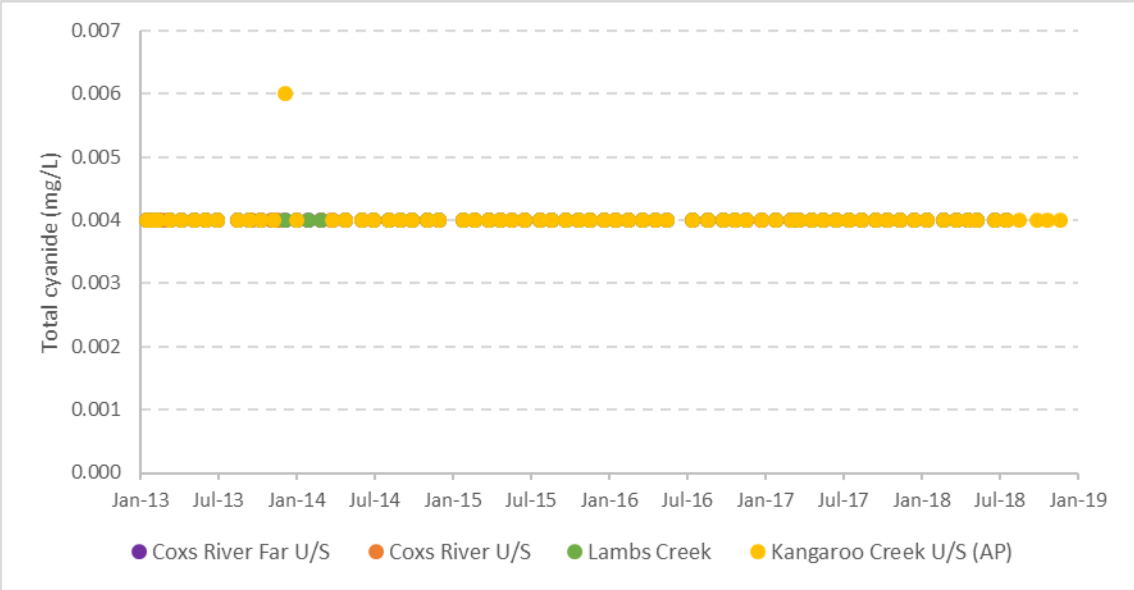
<u>Other</u>



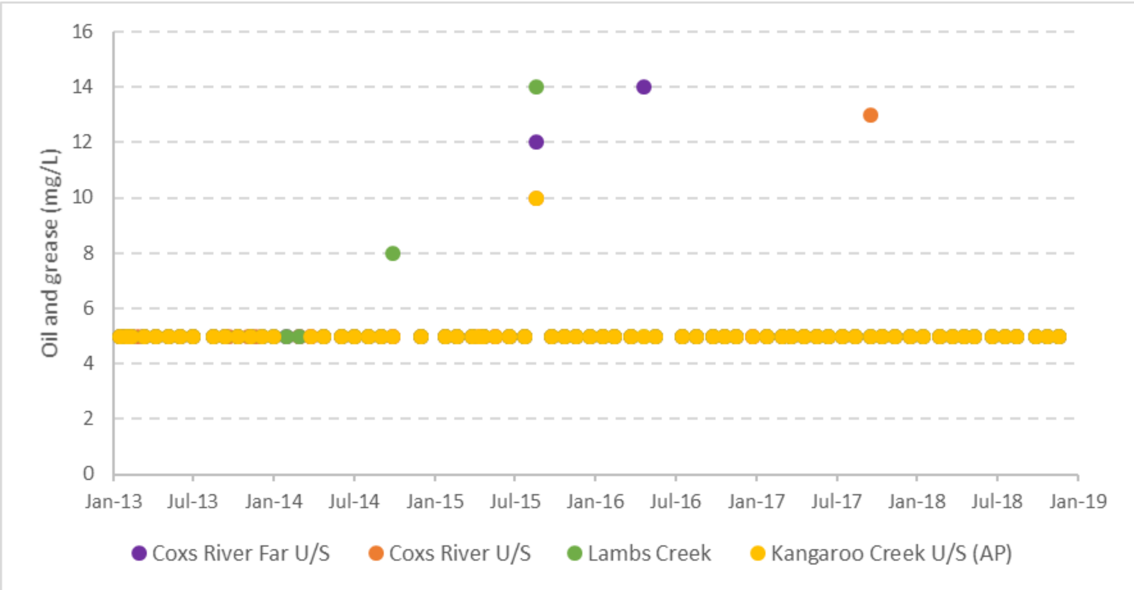
Free chlorine (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



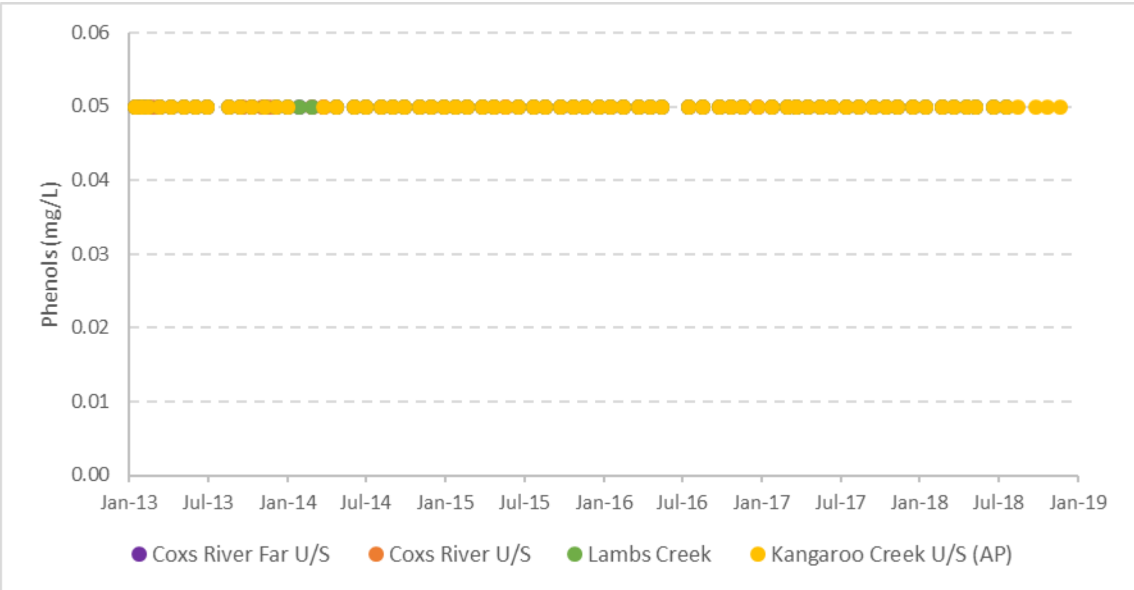
Total chlorine (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



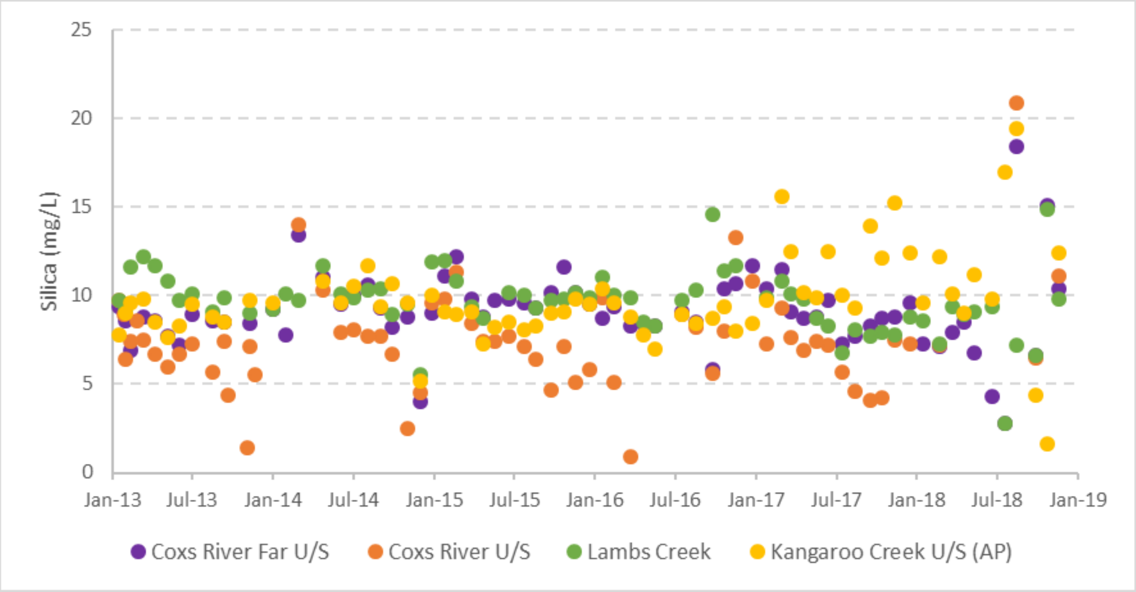
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Total cyanide (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



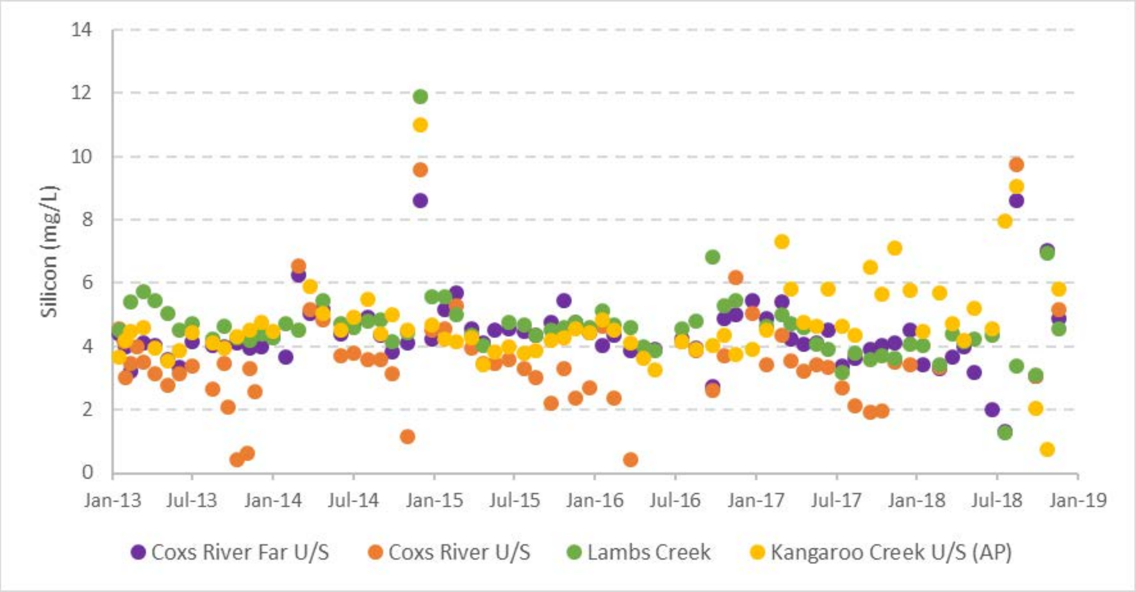
16
14
12
10
8
6
4
2
0
Oil and grease (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



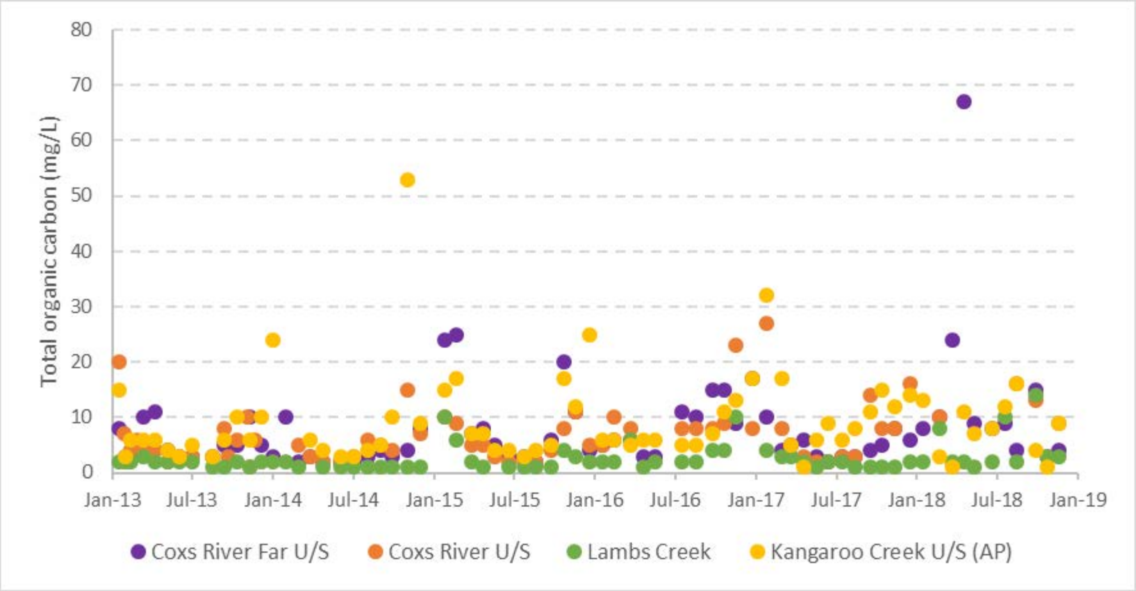
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Phenols (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



Silica (mg/L)
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



Silicon (mg/L)
14
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)



Total organic carbon (mg/L)
80
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Coxs River Far U/S
Coxs River U/S
Lambs Creek
Kangaroo Creek U/S (AP)

E.1.3 Watercourses – downstream of operations

Statistical summary of water quality results

Parameter	Units	Bungleboori		Kangaroo Creek D/S (AP)		KC/CR confluence		Coxs River D/S		LDP003 D/S	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Physicochemical											
DO	mg/L	5	9.8	71	7.8	62	8.5	81	9.6	15	8.2
EC	µS/cm	4	40	72	909	70	713	82	583	21	375
pH	pH units	5	7.9	73	8.1	71	8.2	83	8.0	21	7.4
TDS	mg/L	5	195	70	532	69	420	80	323	19	246
TSS	mg/L	5	550	72	5	70	5	82	5	21	5
Turbidity	NTU	5	1938	70	2.6	70	5	82	6	20	8.4
Major ions											
Bicarbonate alkalinity	mg/L	5	8	72	444	70	328	81	254	19	82
Carbonate alkalinity	mg/L	5	1	72	4	70	4	81	1	19	1
Hydroxide alkalinity	mg/L	5	1	72	1	70	1	81	1	19	1
Total alkalinity	mg/L	5	8	72	458	70	336	81	254	19	82
Calcium	mg/L	5	1	72	18	70	15	81	14	19	11
Chloride	mg/L	5	1	72	7	70	7	81	7	19	9
Magnesium	mg/L	5	2	72	15	70	13	81	9	19	8
Potassium	mg/L	5	1	72	30	70	24	81	19	19	11

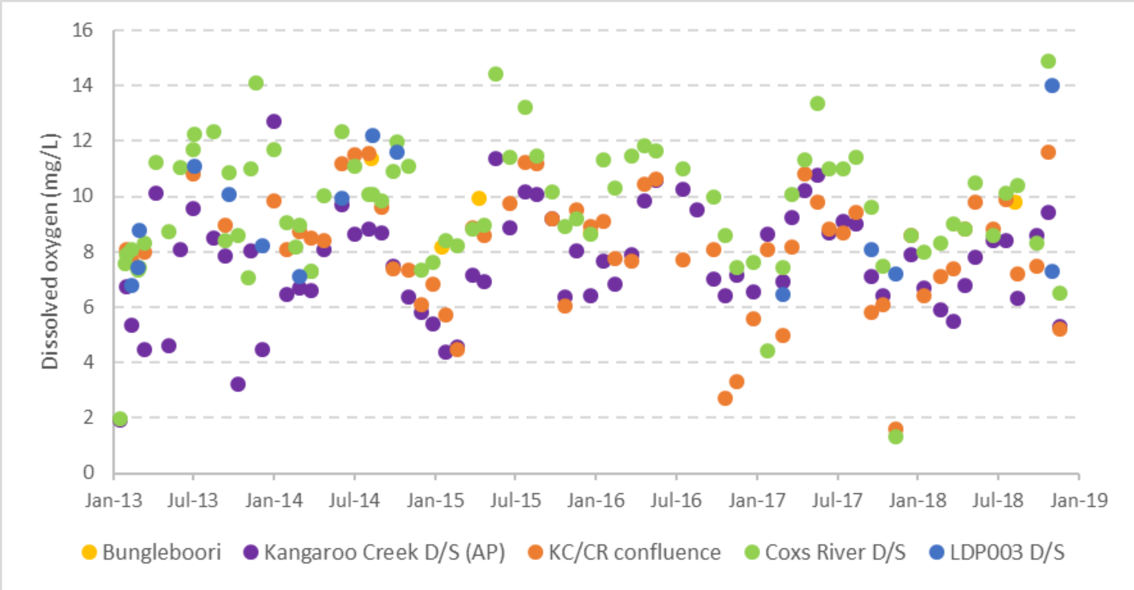
Parameter	Units	Bungleboori		Kangaroo Creek D/S (AP)		KC/CR confluence		Coxs River D/S		LDP003 D/S	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Sodium	mg/L	5	1	72	159	70	116	81	95	19	44
Sulfate	mg/L	5	4	72	14	70	17	81	19	19	76
Total hardness	mg/L	5	11	72	108	70	88	81	74	19	63
Nutrients											
Ammonia	mg/L	5	0.02	72	0.01	69	0.01	81	0.01	19	0.01
Nitrate	mg/L	5	0.04	72	0.22	70	0.13	81	0.02	19	0.02
Nitrite	mg/L	5	0.01	72	0.01	70	0.01	81	0.01	19	0.01
Nitrate + nitrite	mg/L	5	0.04	72	0.25	66	0.13	81	0.02	19	0.02
Total fluoride	mg/L	5	0.1	72	0.8	70	0.6	81	0.4	19	0.2
TKN	mg/L	5	1.4	72	0.2	69	0.2	81	0.4	19	0.2
Total nitrogen	mg/L	5	1.4	72	0.4	69	0.4	81	0.4	19	0.2
Total phosphorus	mg/L	5	0.83	72	0.01	69	0.01	81	0.01	19	0.01
Dissolved metals											
Aluminium	mg/L	5	0.36	72	0.01	70	0.02	81	0.02	19	0.01
Antimony	mg/L	5	0.001	72	0.001	70	0.001	81	0.001	19	0.001
Arsenic	mg/L	5	0.001	72	0.001	70	0.001	81	0.001	19	0.001
Barium	mg/L	5	0.004	72	0.138	70	0.105	81	0.053	19	0.015
Boron	mg/L	5	0.05	72	0.05	70	0.05	81	0.05	19	0.12
Cadmium	mg/L	5	0.0001	72	0.0001	70	0.0001	81	0.0001	19	0.0001
Copper	mg/L	5	0.003	72	0.001	70	0.001	81	0.001	19	0.001
Iron	mg/L	5	0.24	72	0.11	70	0.12	81	0.17	19	0.11

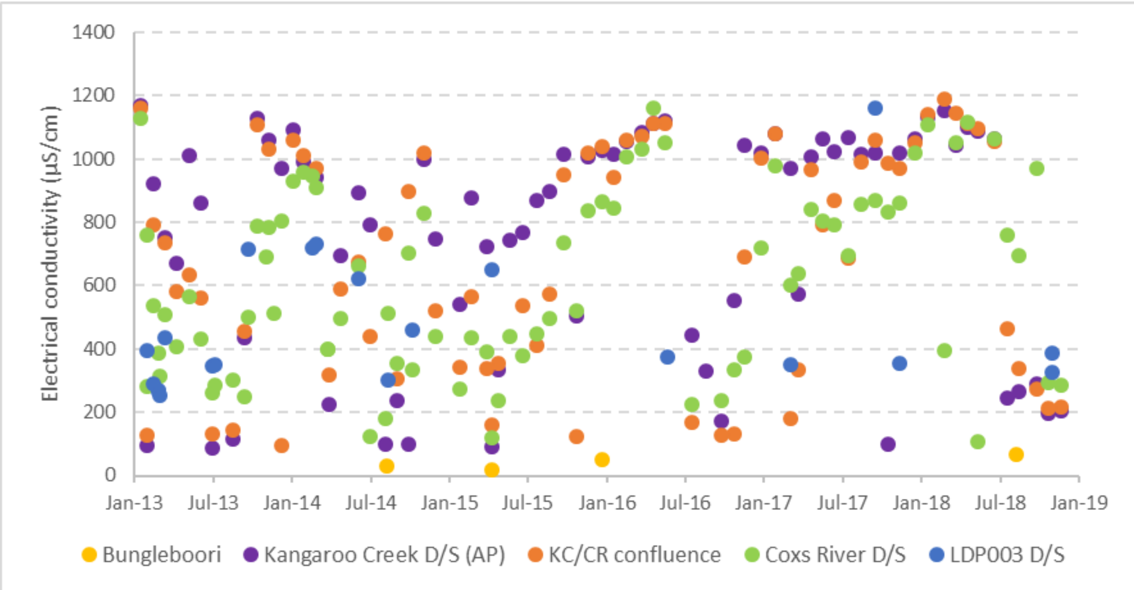
Parameter	Units	Bungleboori		Kangaroo Creek D/S (AP)		KC/CR confluence		Coxs River D/S		LDP003 D/S	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Lead	mg/L	5	0.001	72	0.001	70	0.001	81	0.001	19	0.001
Lithium	mg/L	5	0.001	72	0.222	70	0.158	81	0.094	19	0.079
Manganese	mg/L	5	0.065	72	0.022	70	0.019	81	0.018	19	0.050
Molybdenum	mg/L	5	0.001	72	0.010	70	0.008	81	0.003	19	0.001
Nickel	mg/L	5	0.001	72	0.002	70	0.001	81	0.001	19	0.004
Rubidium	mg/L	5	0.001	72	0.035	70	0.027	81	0.022	19	0.021
Strontium	mg/L	5	0.007	72	0.104	70	0.086	81	0.066	19	0.150
Uranium	mg/L	5	0.001	72	0.001	70	0.001	81	0.001	19	0.001
Zinc	mg/L	5	0.006	72	0.007	70	0.006	81	0.005	19	0.012
Total metals											
Aluminium	mg/L	5	32.2	72	0.05	70	0.08	81	0.15	19	0.02
Antimony	mg/L	5	0.001	69	0.001	67	0.001	78	0.001	17	0.001
Arsenic	mg/L	5	0.003	72	0.001	70	0.001	81	0.001	19	0.001
Barium	mg/L	5	0.133	72	0.165	70	0.129	81	0.061	19	0.015
Iron	mg/L	5	33.3	65	0.38	68	0.38	79	0.48	19	0.54
Lead	mg/L	5	0.030	72	0.001	69	0.001	81	0.001	18	0.001
Manganese	mg/L	5	0.605	72	0.032	70	0.027	81	0.029	18	0.079
Nickel	mg/L	5	0.025	72	0.002	70	0.002	81	0.001	18	0.005
Zinc	mg/L	5	0.082	72	0.009	70	0.009	81	0.005	19	0.009
Other											
Free chlorine	mg/L	5	0.02	71	0.02	70	0.02	82	0.03	18	0.03

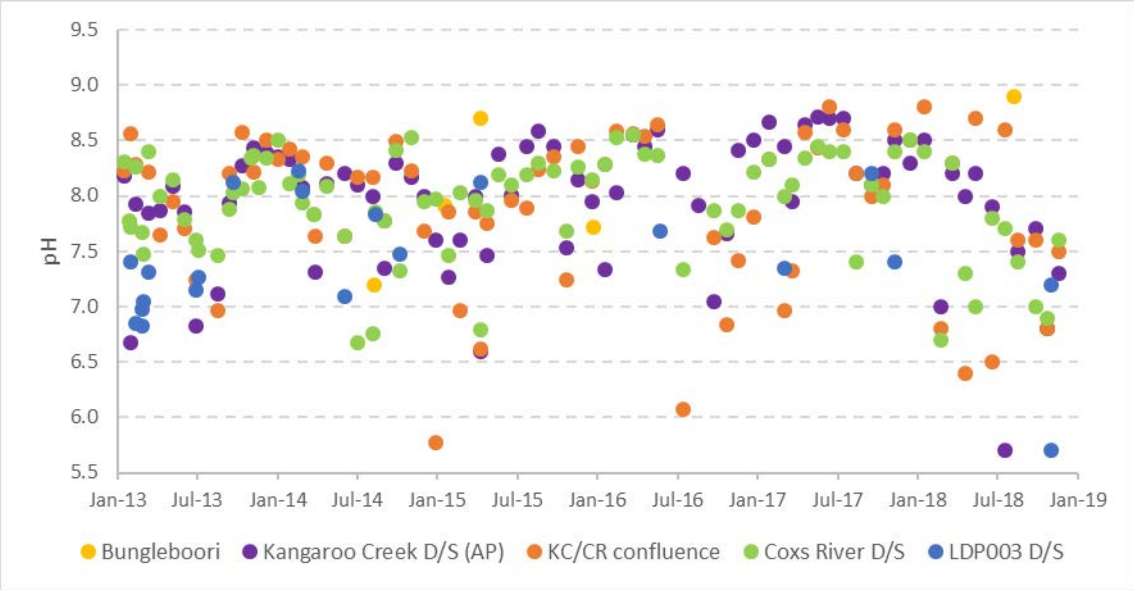
Parameter	Units	Bungleboori		Kangaroo Creek D/S (AP)		KC/CR confluence		Coxs River D/S		LDP003 D/S	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Total chlorine	mg/L	5	0.01	71	0.05	70	0.05	82	0.05	18	0.05
Total cyanide	mg/L	5	0.004	71	0.004	69	0.004	80	0.004	19	0.004
Oil and grease	mg/L	5	5	70	5	69	5	80	5	23	5
Phenols	mg/L	5	0.05	72	0.05	69	0.05	81	0.05	19	0.05
Silica	mg/L	5	7.6	69	9.4	67	8.9	78	8.4	19	16.0
Silicon	mg/L	5	2.98	72	4.44	70	4.19	81	3.91	19	7.49
Total organic carbon	mg/L	5	18	71	4	69	3	80	6	19	3

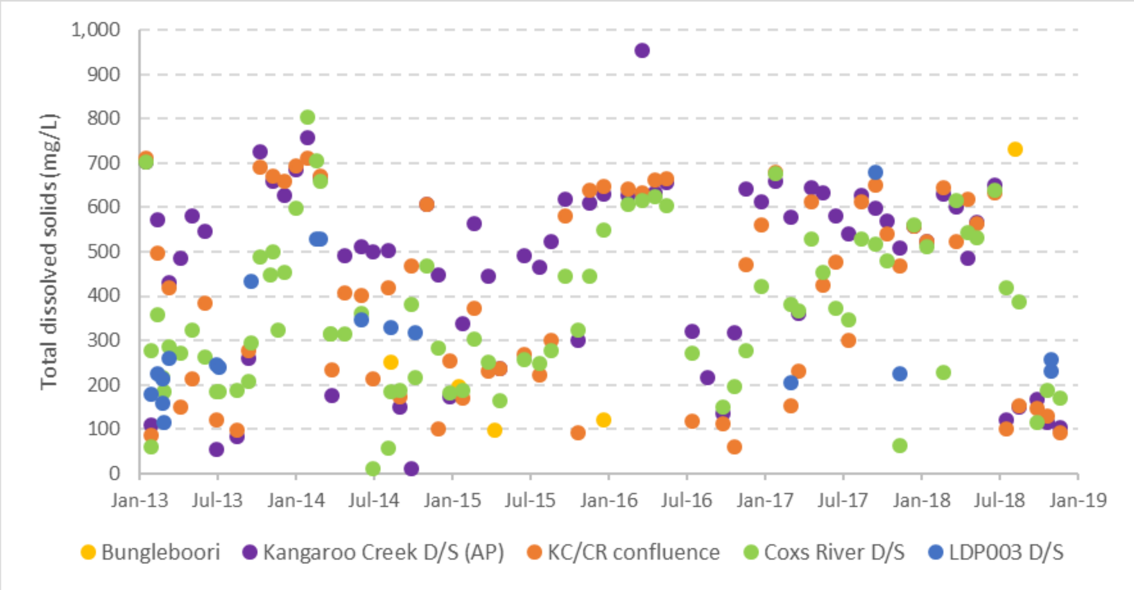
Time series graphs of water quality results

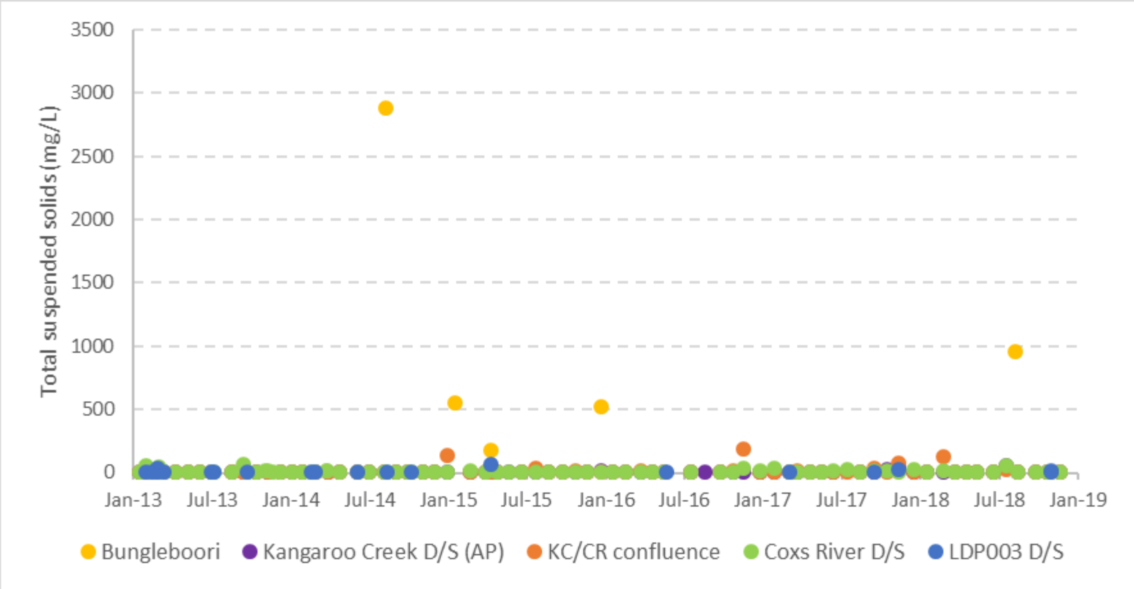
Physicochemical

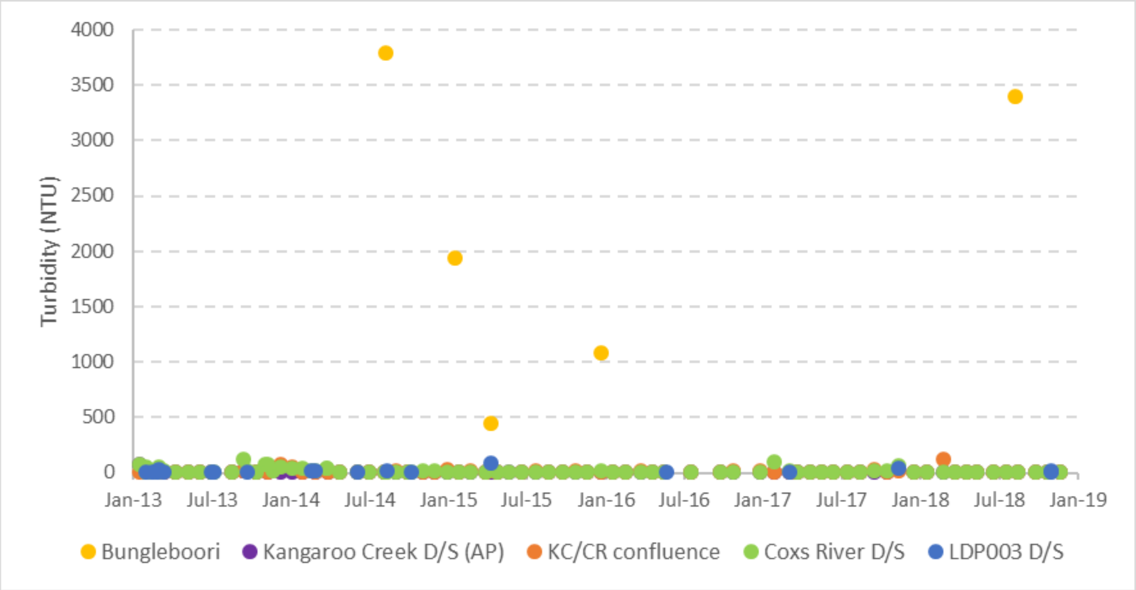





pH
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

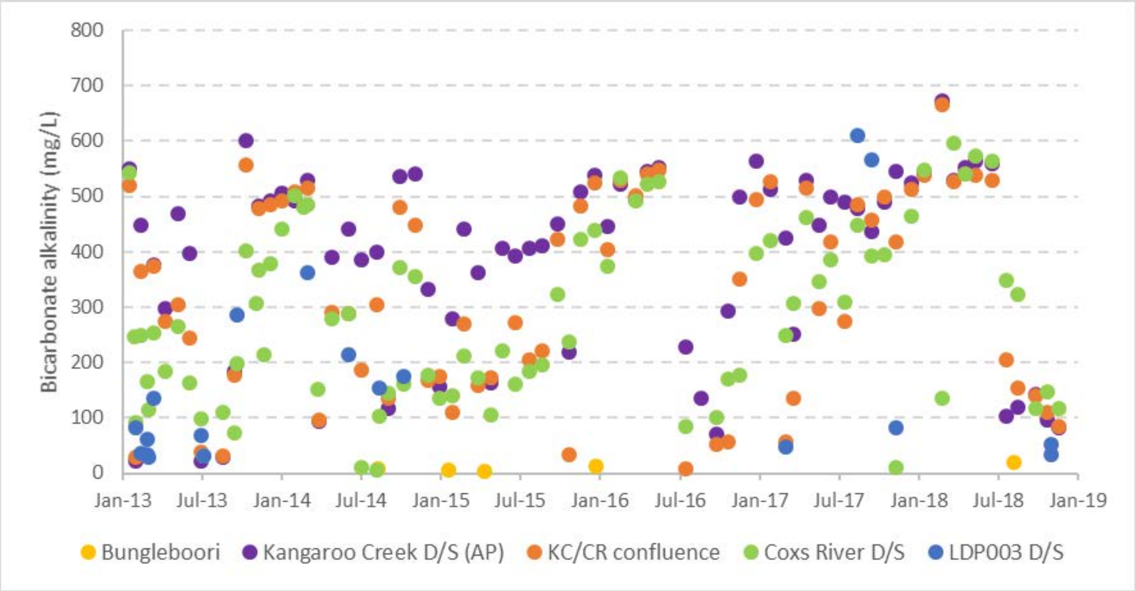

Total dissolved solids (mg/L)
1,000
900
800
700
600
500
400
300
200
100
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Total suspended solids (mg/L)
3500
3000
2500
2000
1500
1000
500
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

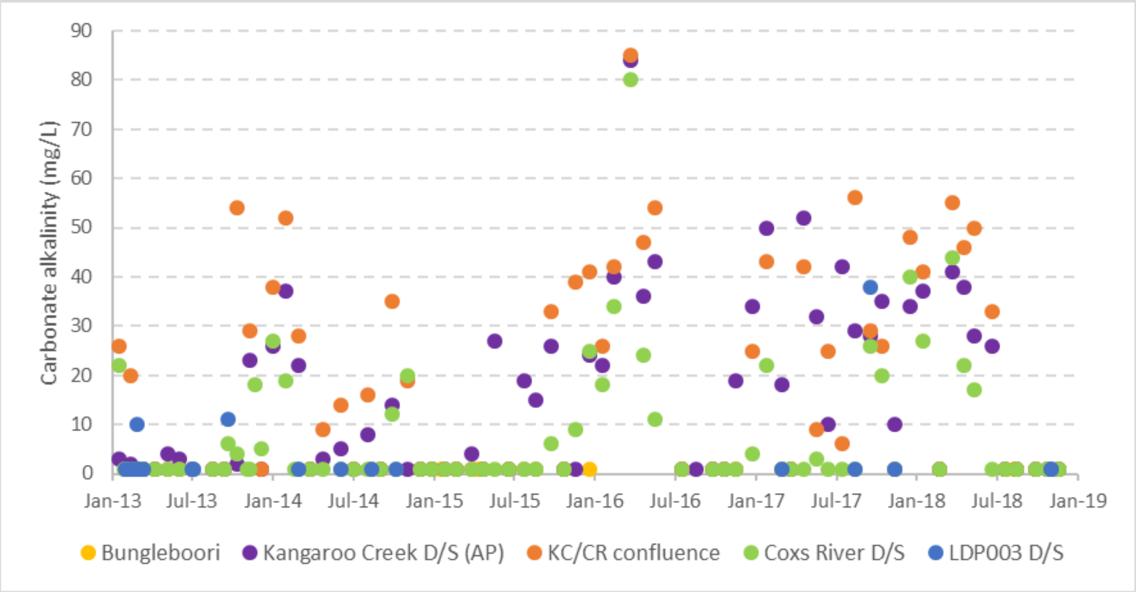


4000
3500
3000
2500
2000
1500
1000
500
0
Turbidity (NTU)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

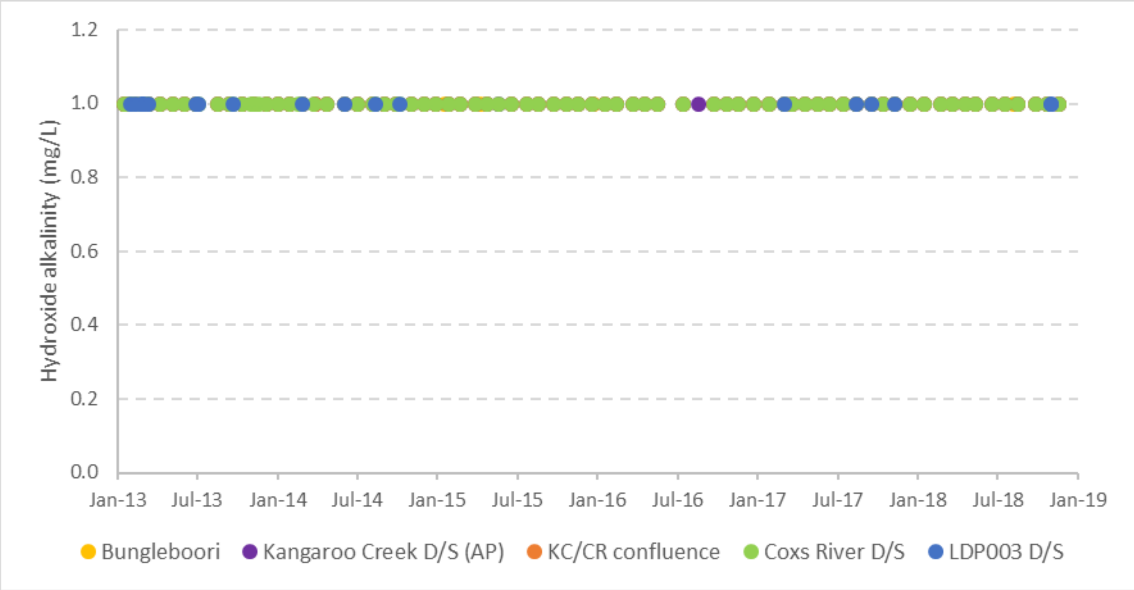
Major ions

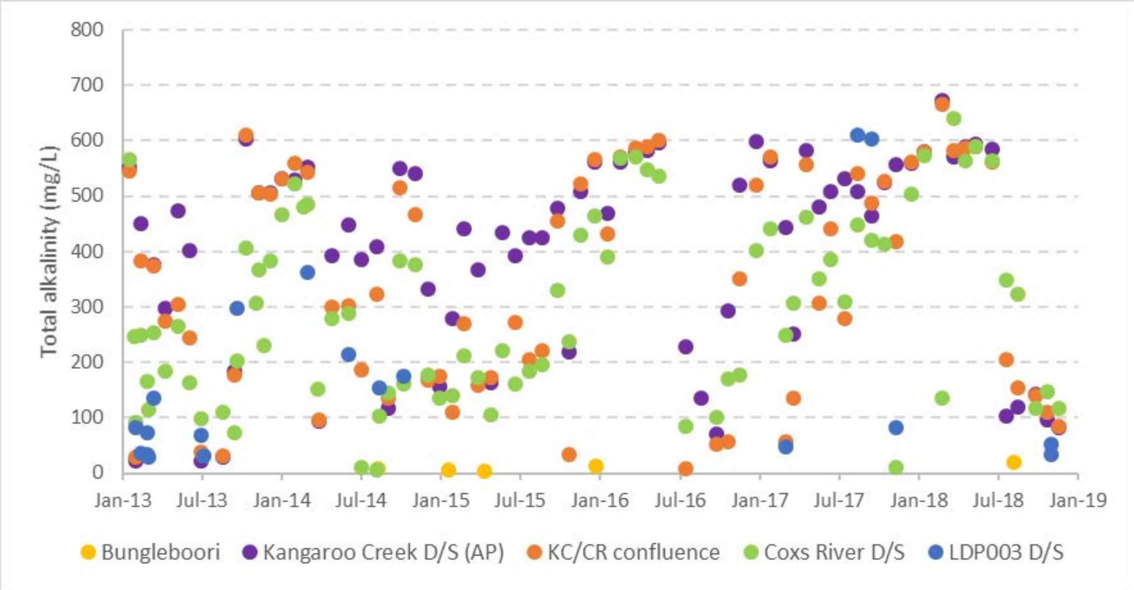


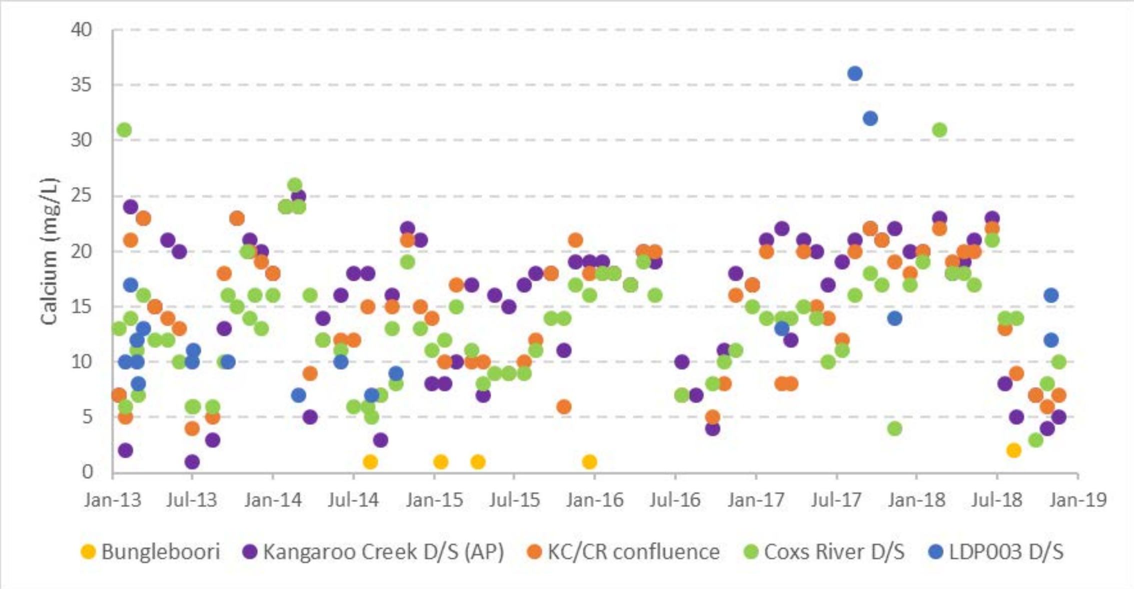
800
700
600
500
400
300
200
100
0
Bicarbonate alkalinity (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

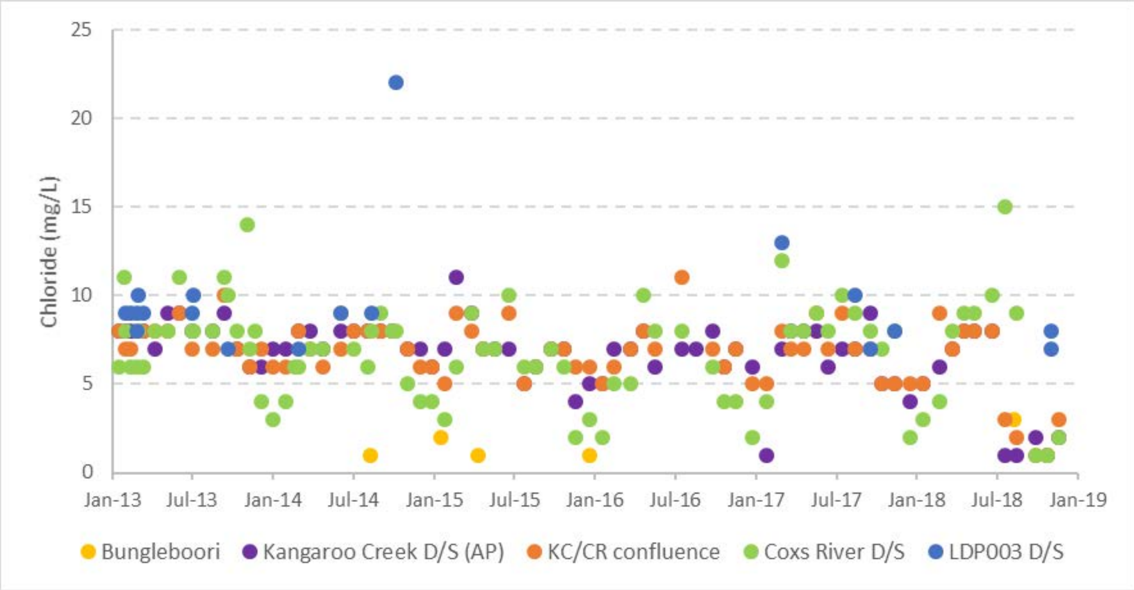


90
80
70
60
50
40
30
20
10
0
Carbonate alkalinity (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

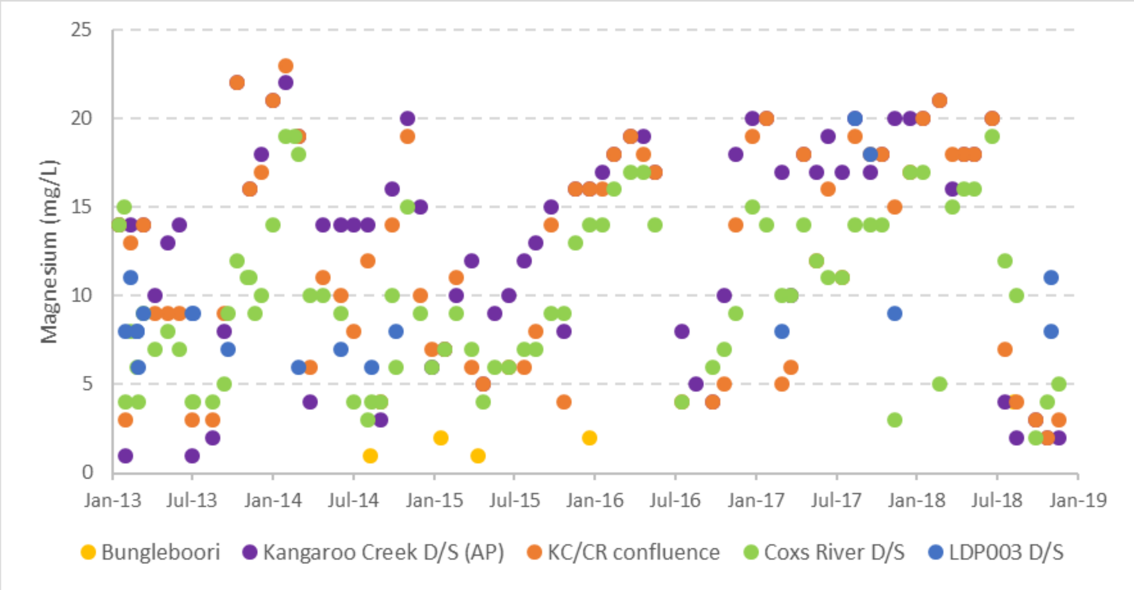

Hydroxide alkalinity (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Total alkalinity (mg/L)
800
700
600
500
400
300
200
100
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

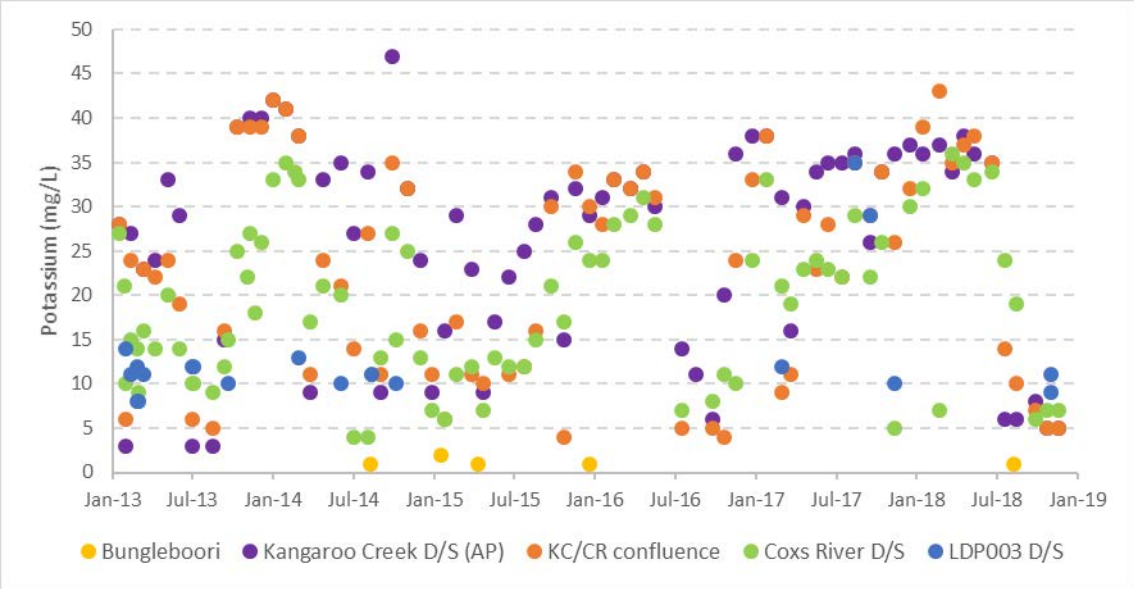

Calcium (mg/L)
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



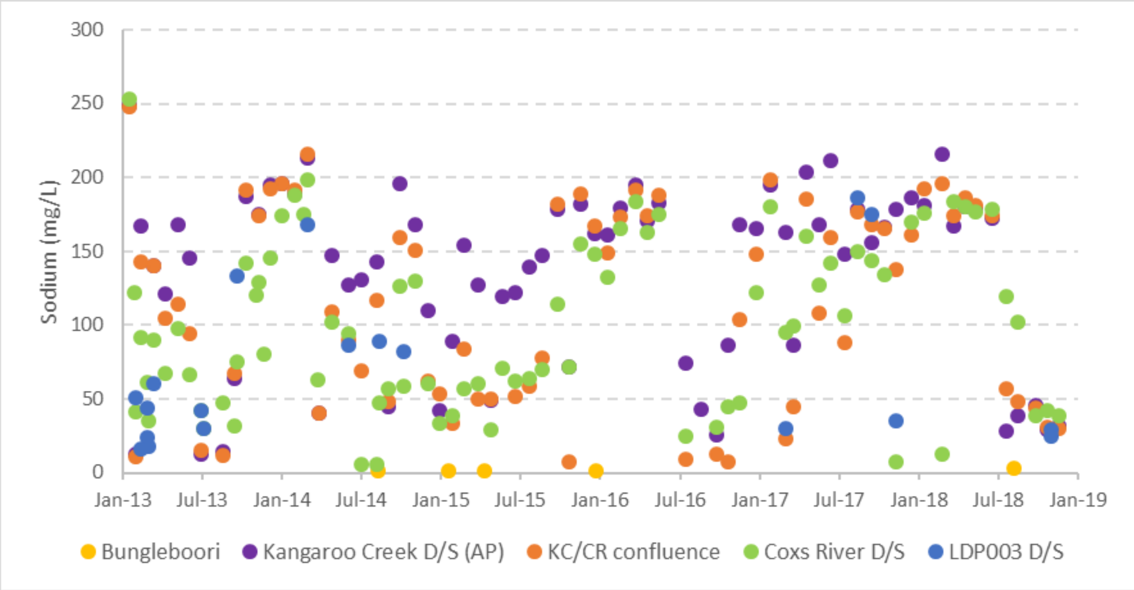
Chloride (mg/L)
0
5
10
15
20
25
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



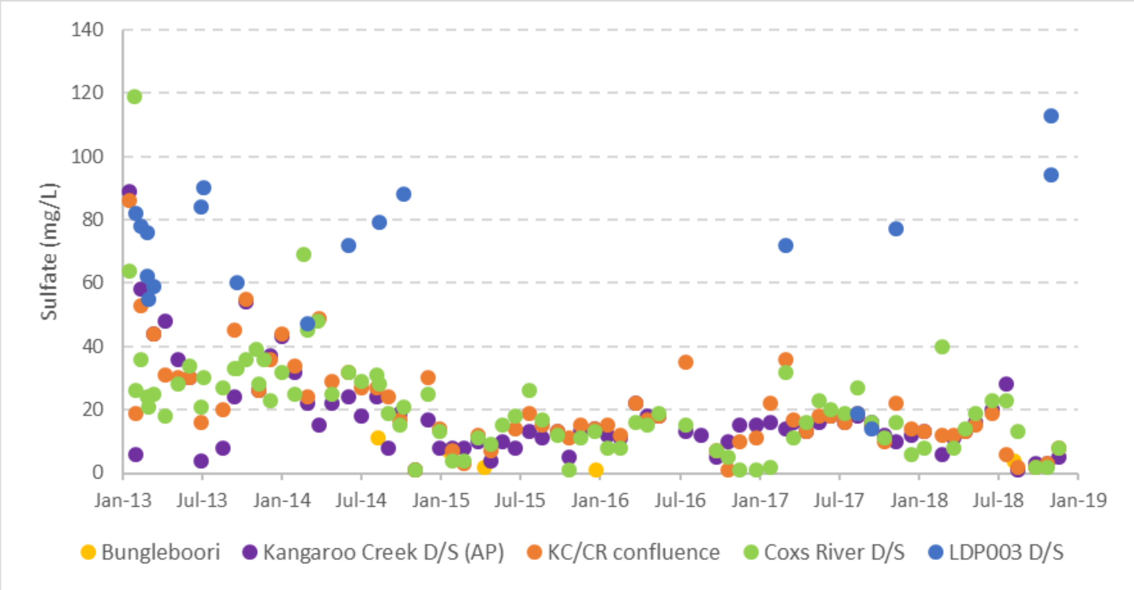
Magnesium (mg/L)
0
5
10
15
20
25
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



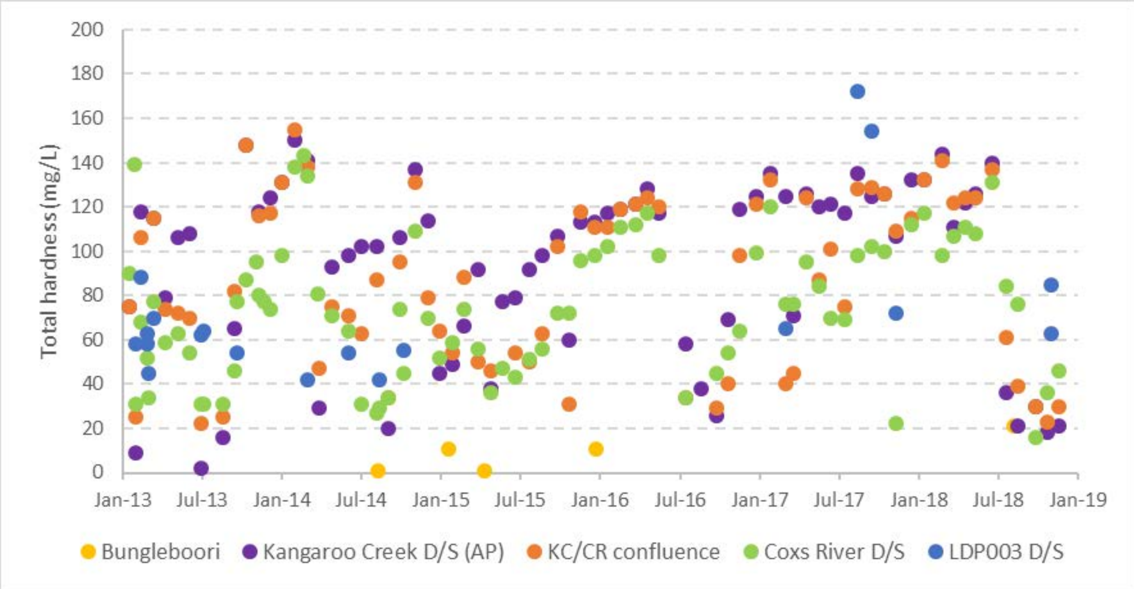
Potassium (mg/L)
0
5
10
15
20
25
30
35
40
45
50
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



Sodium (mg/L)
300
250
200
150
100
50
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

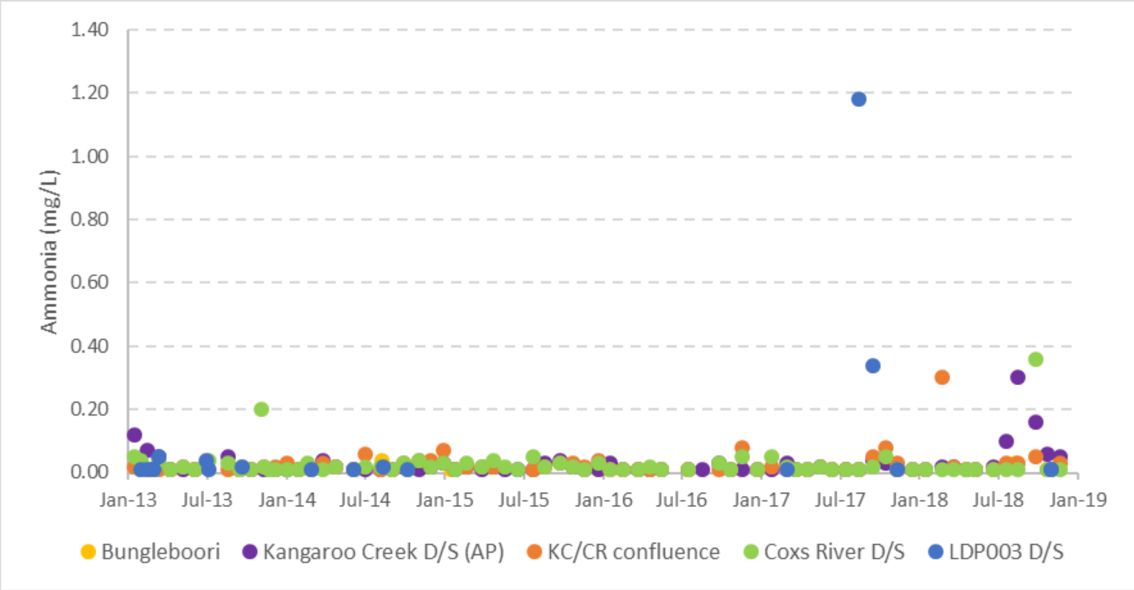


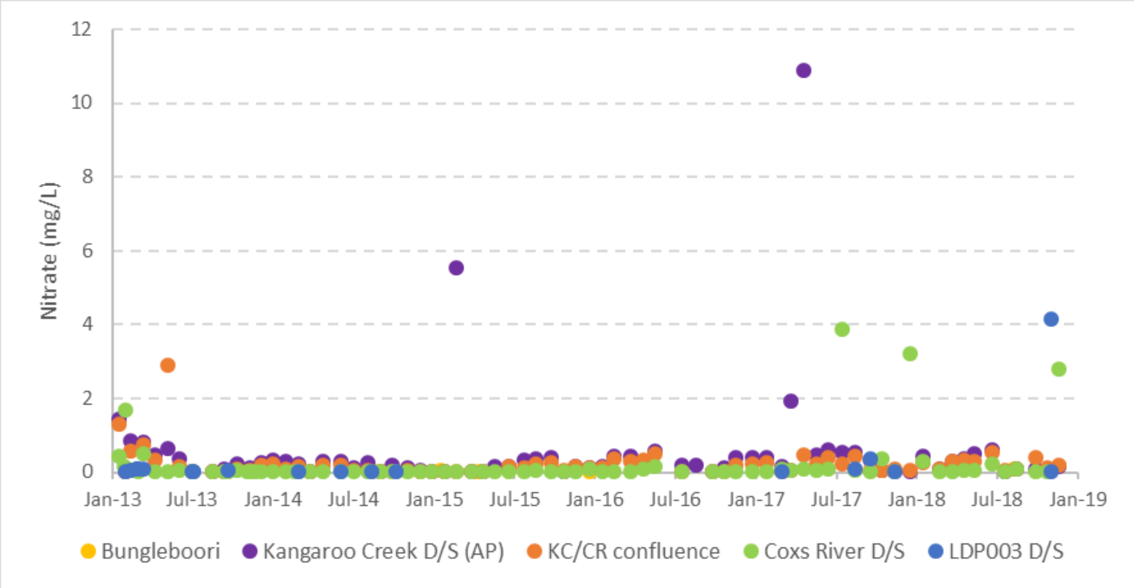
Sulfate (mg/L)
140
120
100
80
60
40
20
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

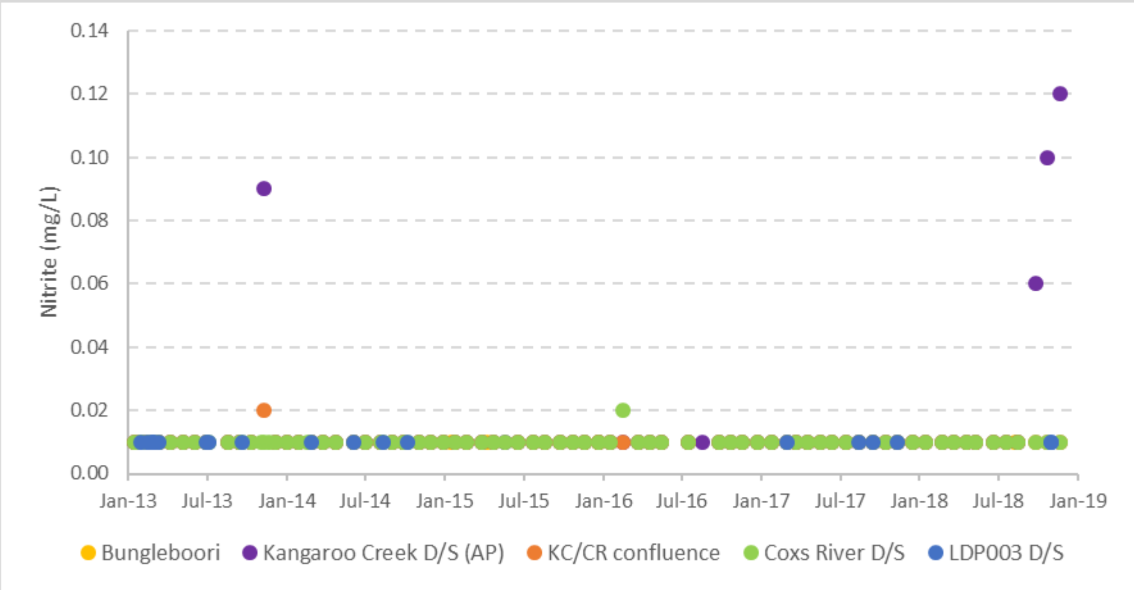


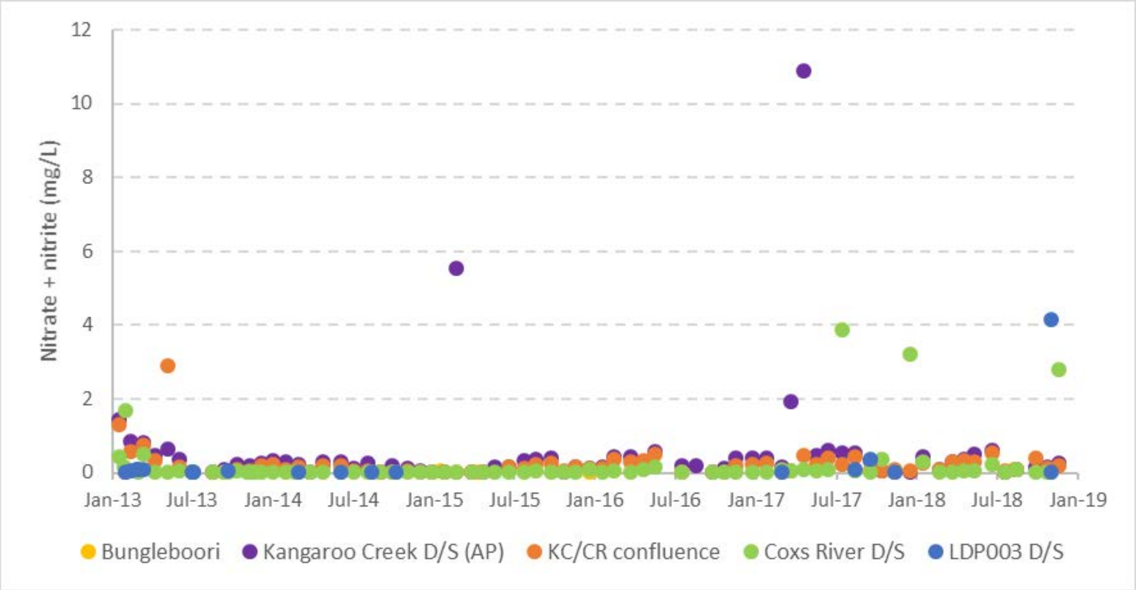
Total hardness (mg/L)
200
180
160
140
120
100
80
60
40
20
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

Nutrients

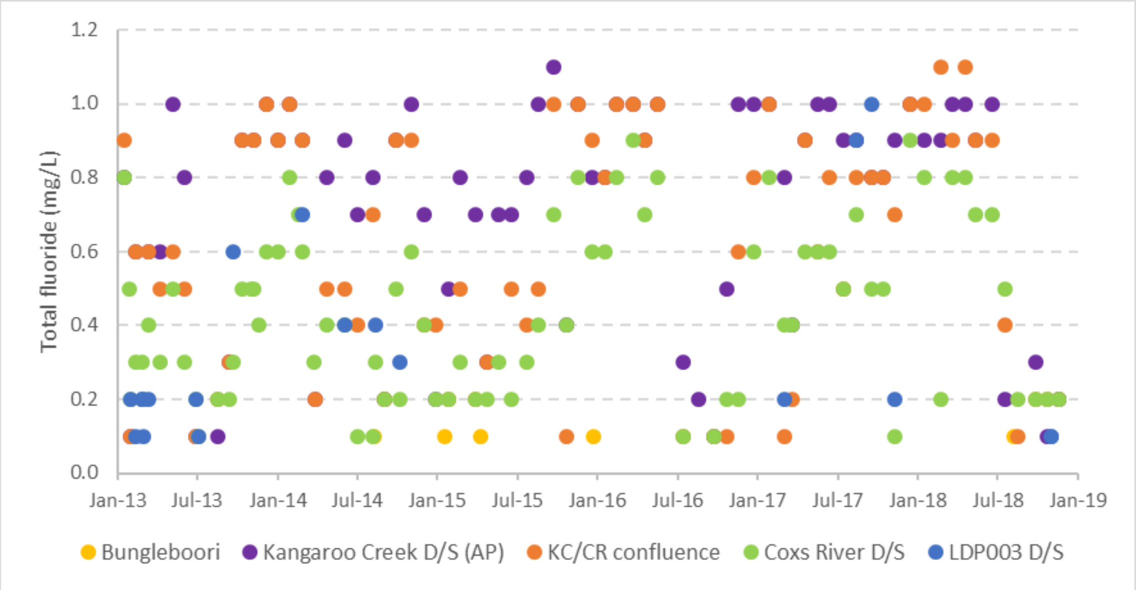

Ammonia (mg/L)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Nitrate (mg/L)
12
10
8
6
4
2
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

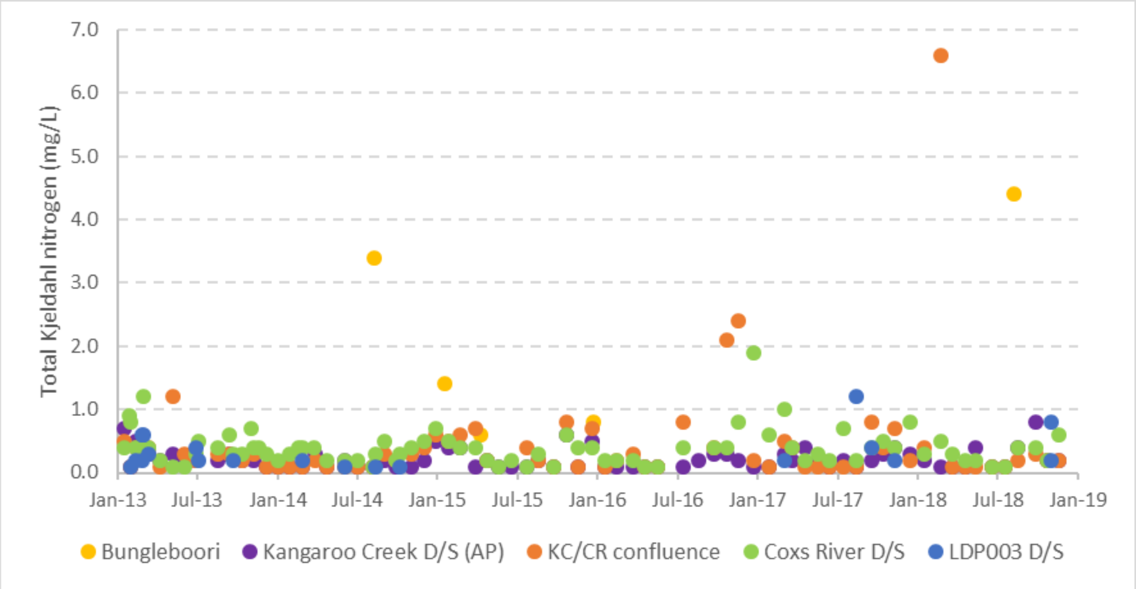

Nitrite (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



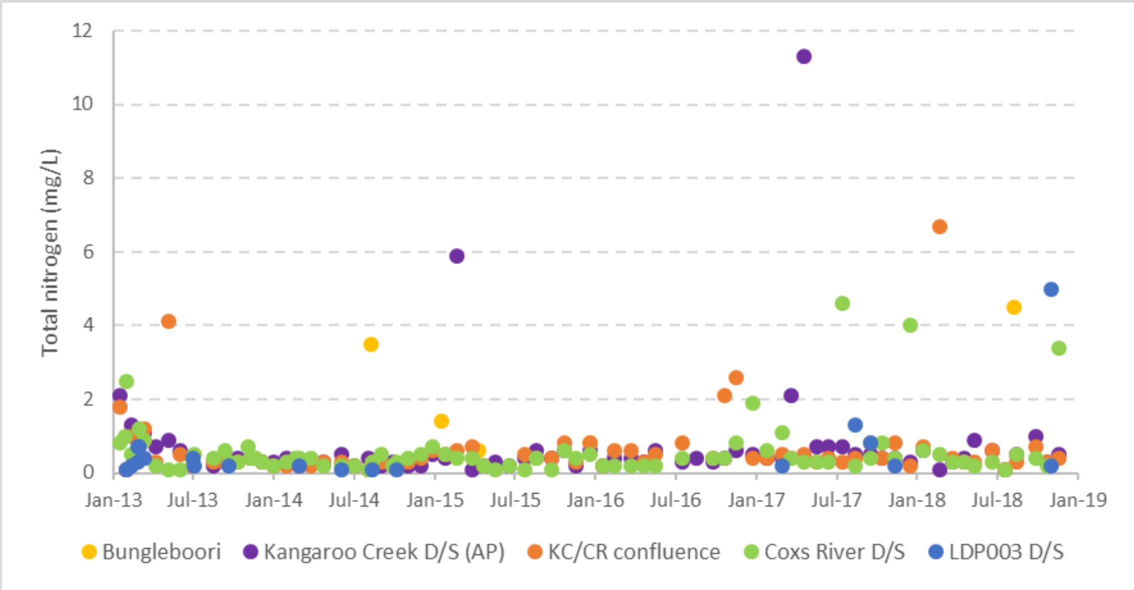
Nitrate + nitrite (mg/L)
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

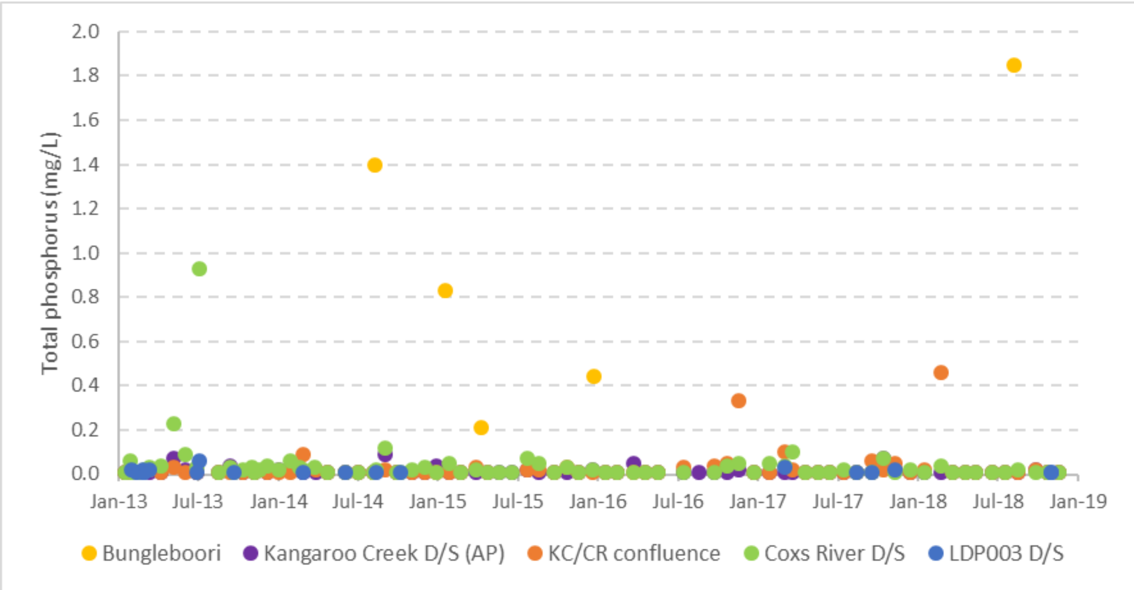


Total fluoride (mg/L)
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

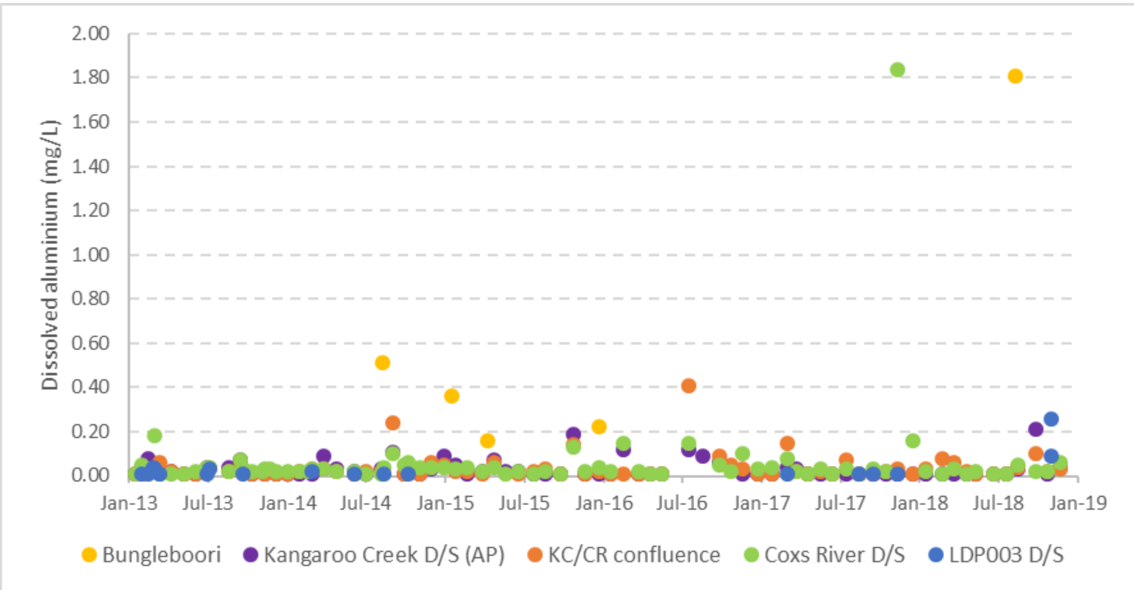


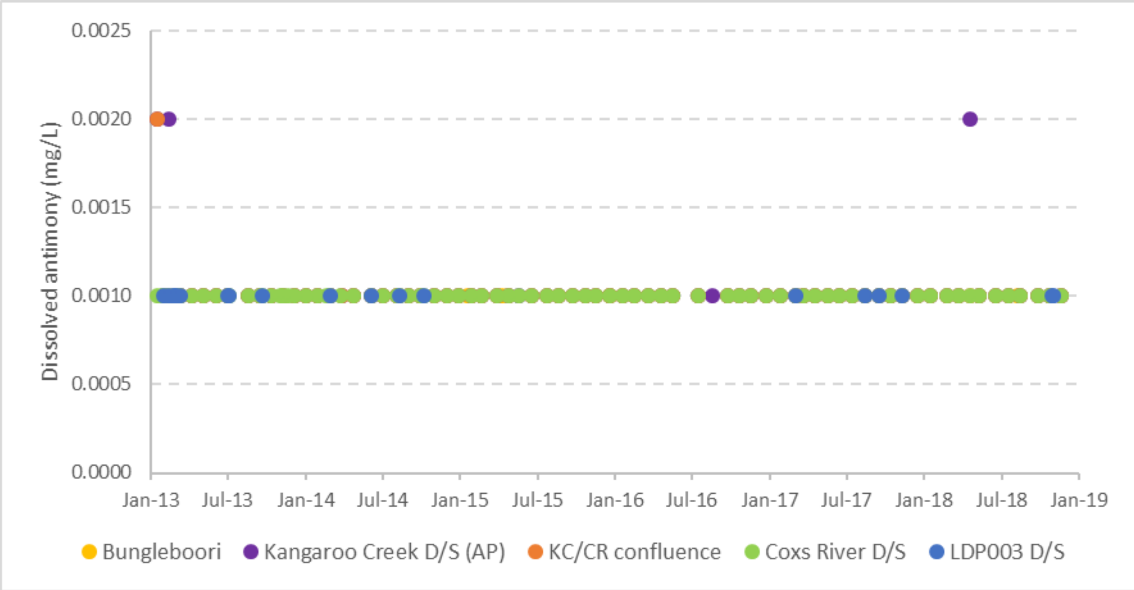
Total Kjeldahl nitrogen (mg/L)
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

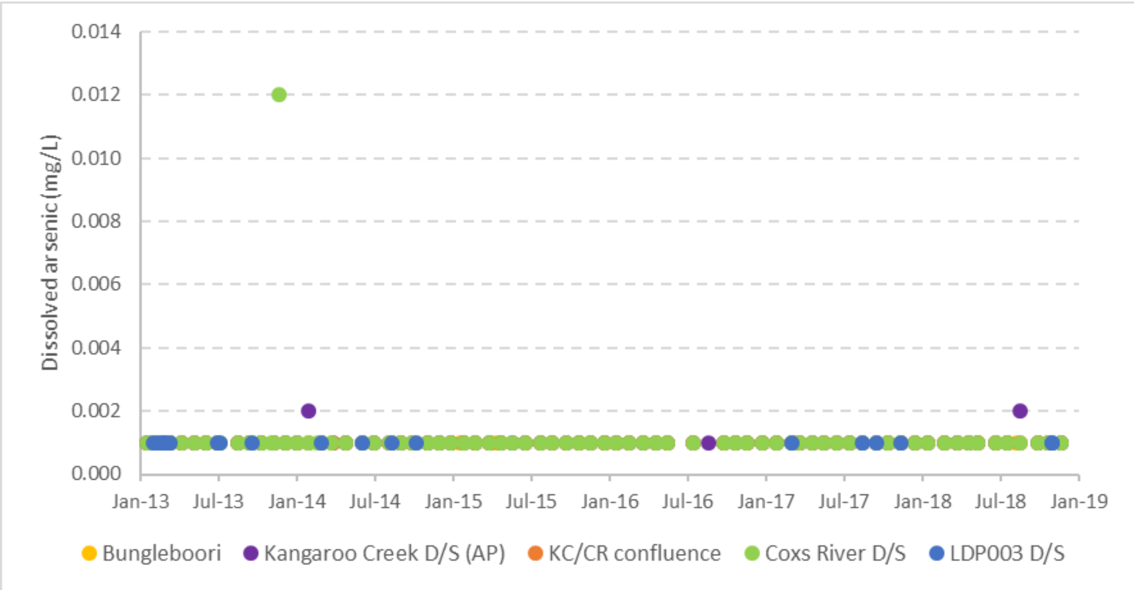


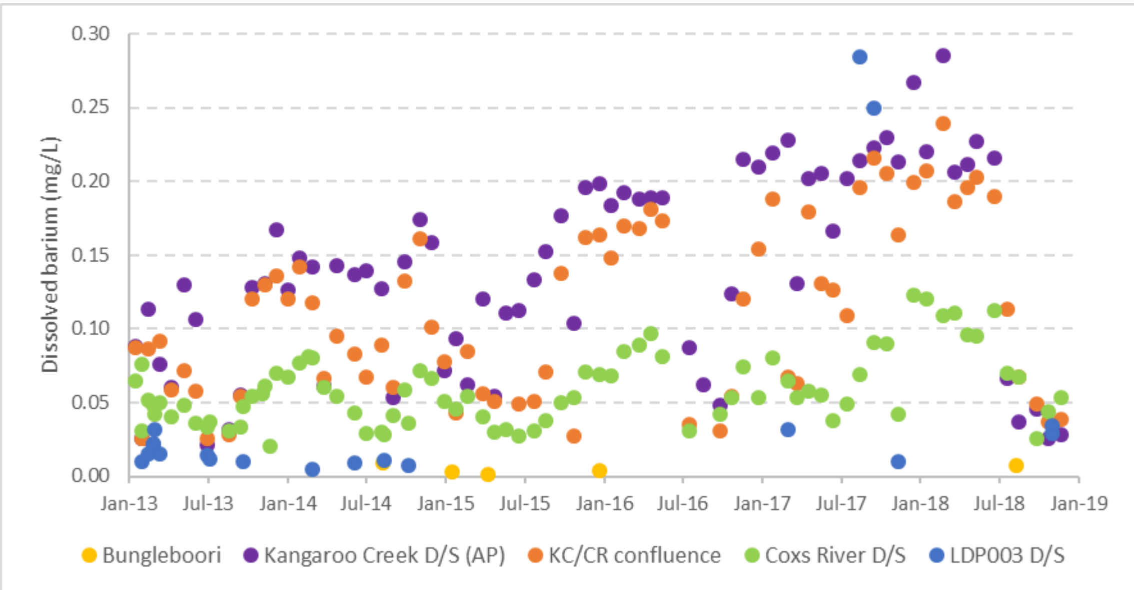


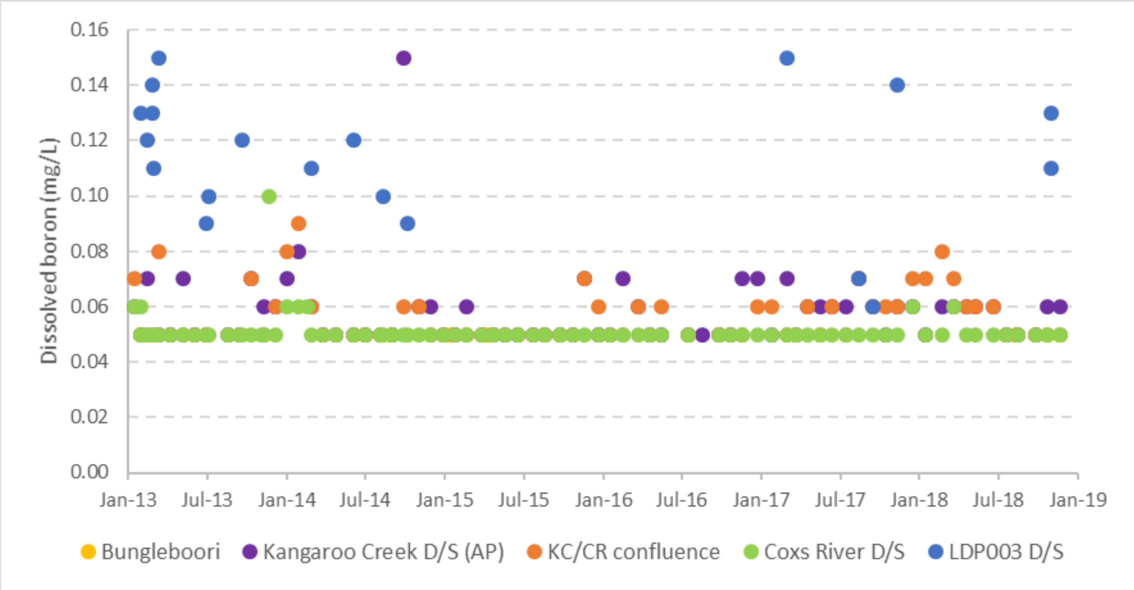
<u>Dissolved metals</u>

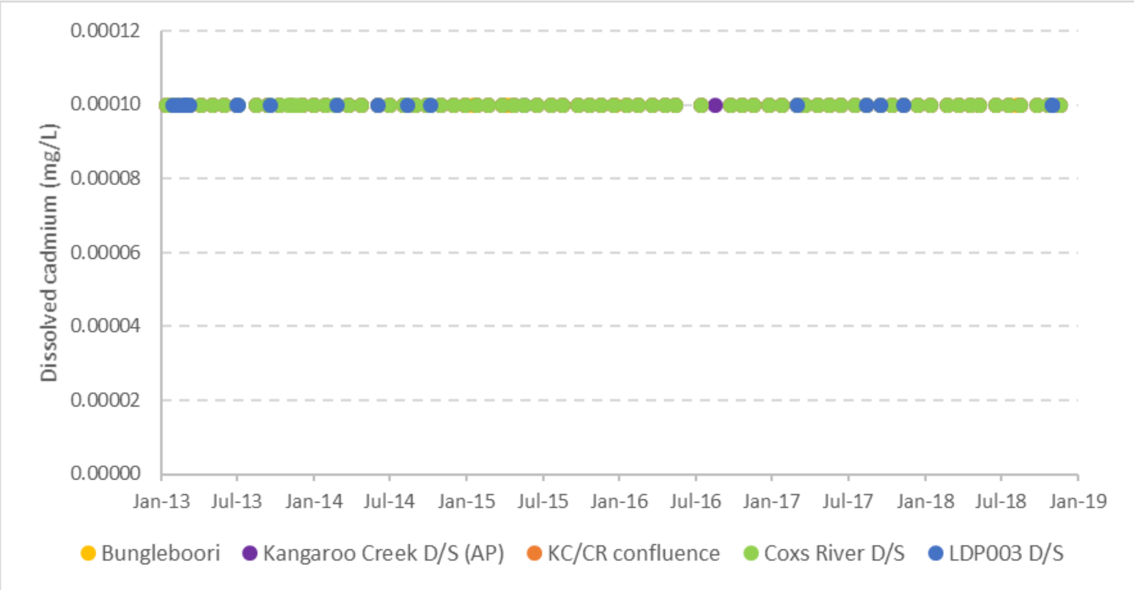


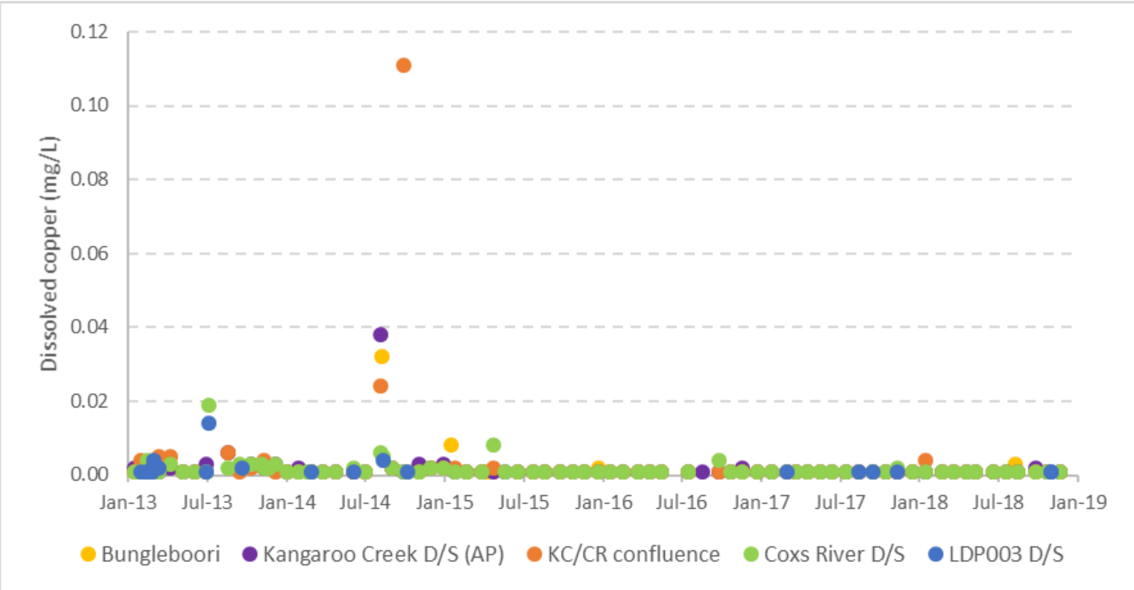

Dissolved antimony (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

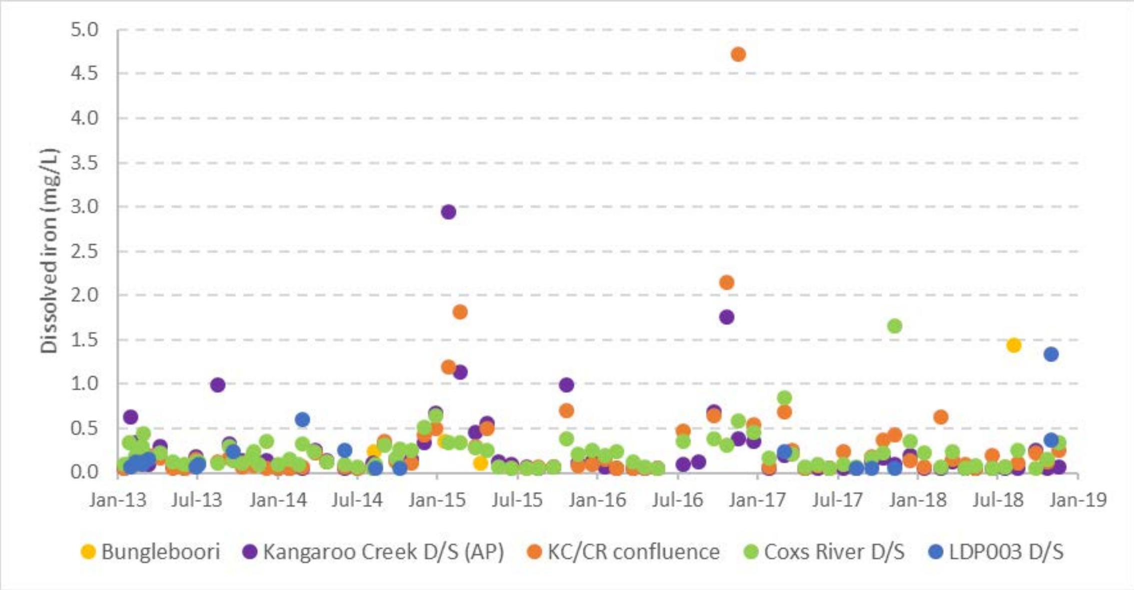

Dissolved arsenic (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Dissolved barium (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

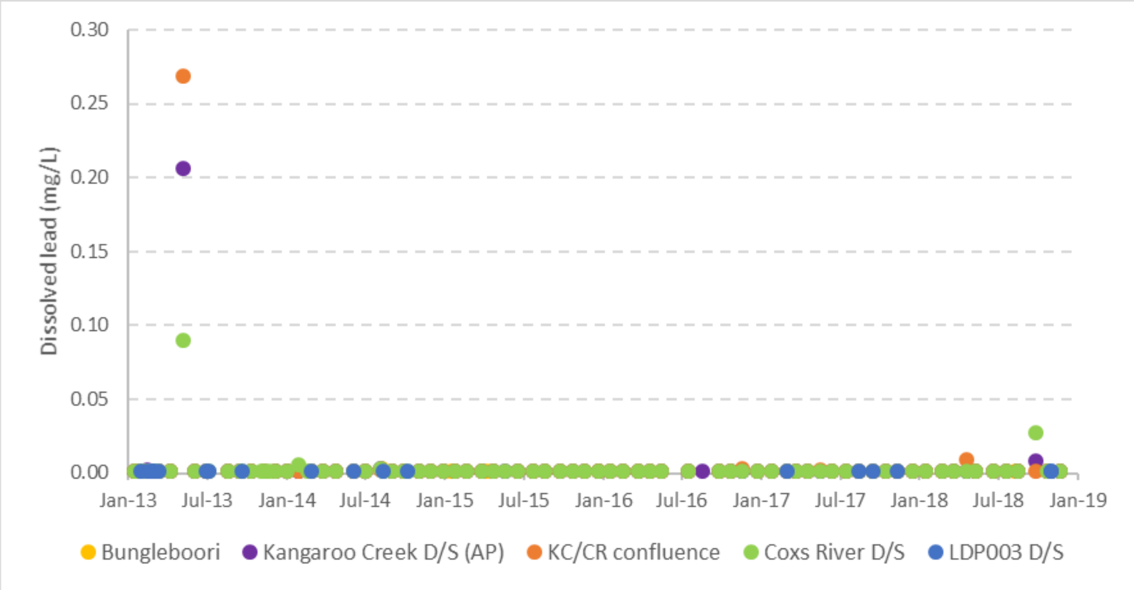

Dissolved boron (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Dissolved cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

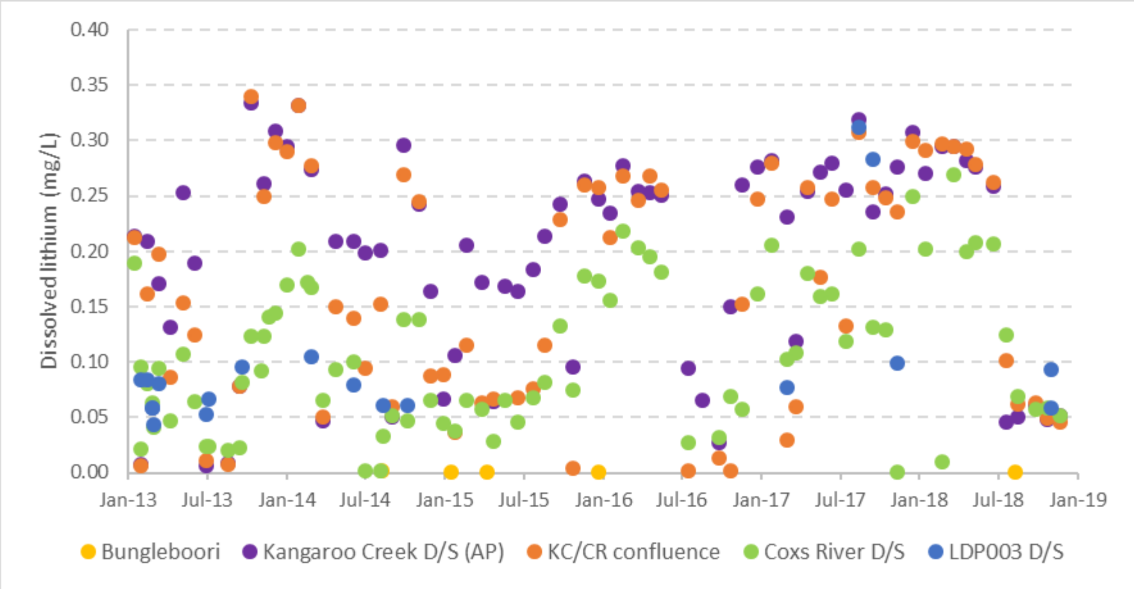

Dissolved copper (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



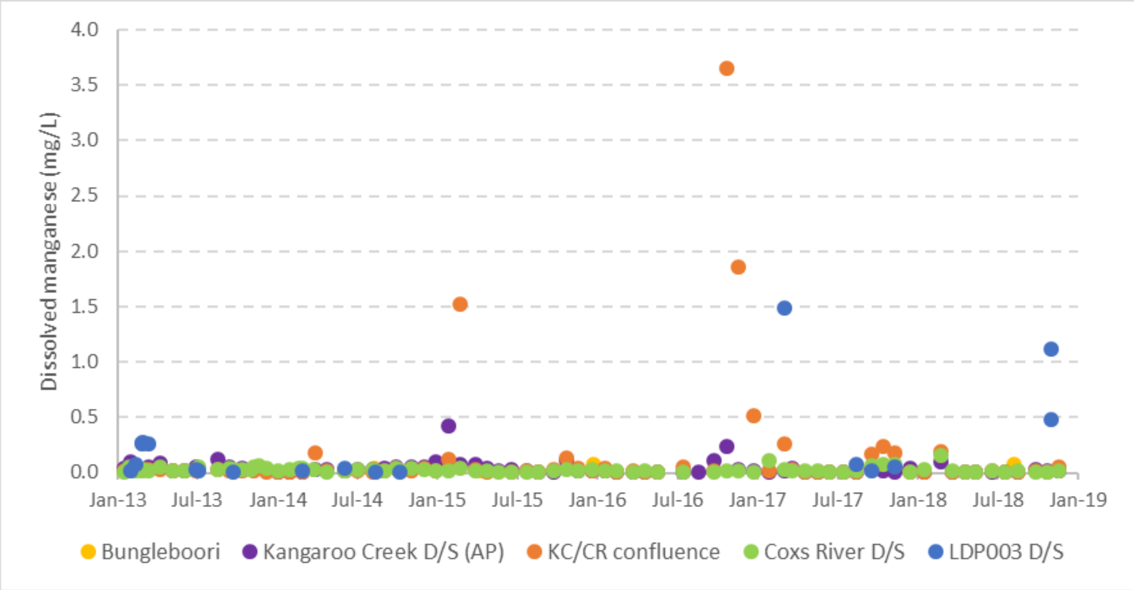
Dissolved iron (mg/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori Kangaroo Creek D/S (AP) KC/CR confluence Coxs River D/S LDP003 D/S



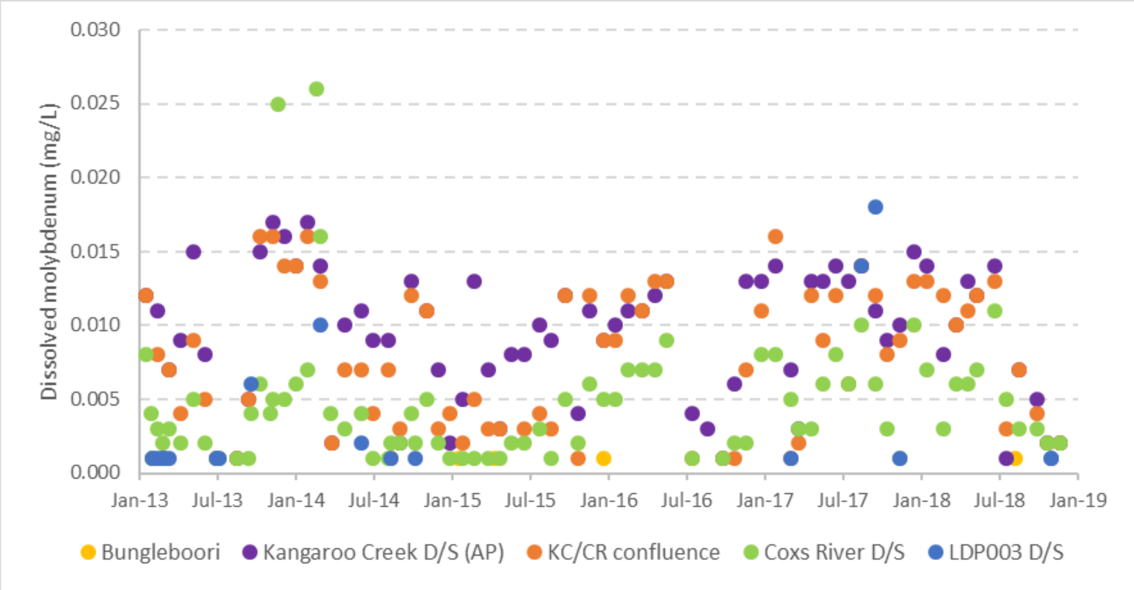
Dissolved lead (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori Kangaroo Creek D/S (AP) KC/CR confluence Coxs River D/S LDP003 D/S



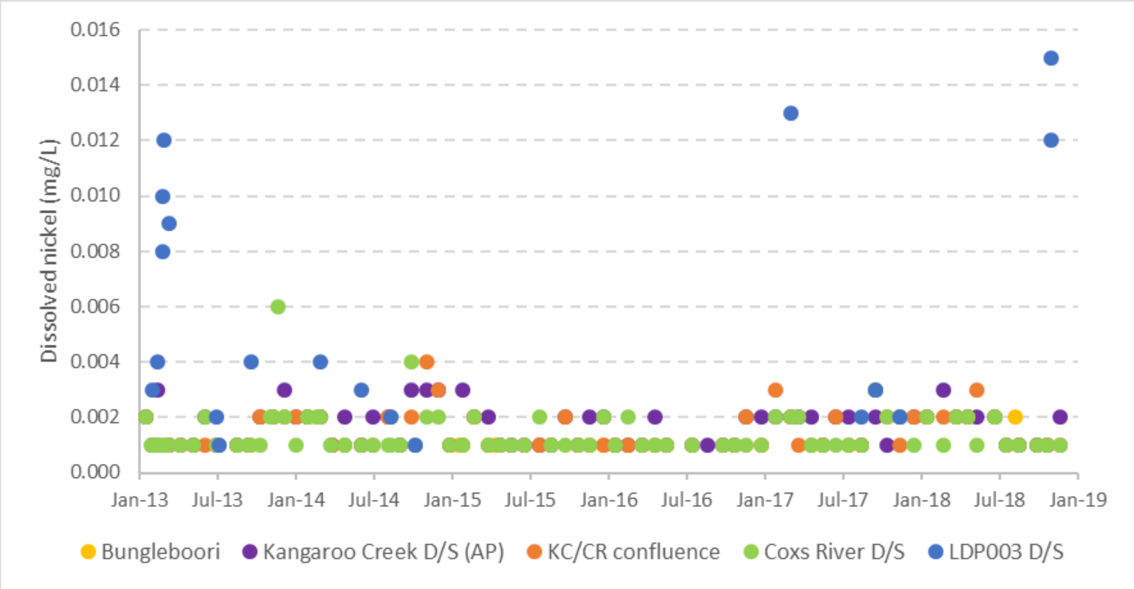
Dissolved lithium (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori Kangaroo Creek D/S (AP) KC/CR confluence Coxs River D/S LDP003 D/S



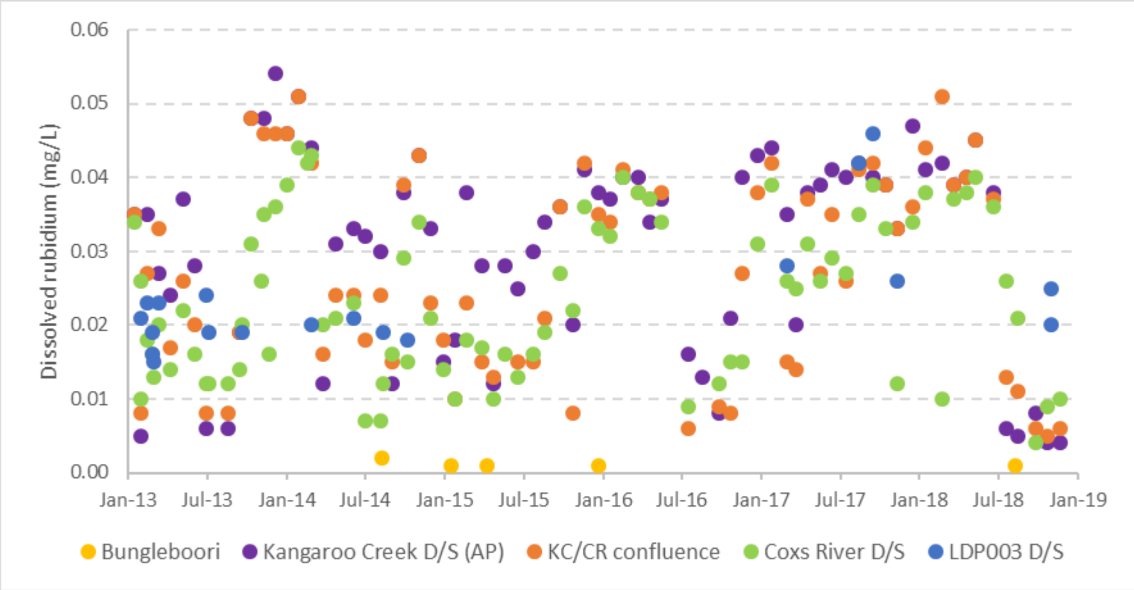
Dissolved manganese (mg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

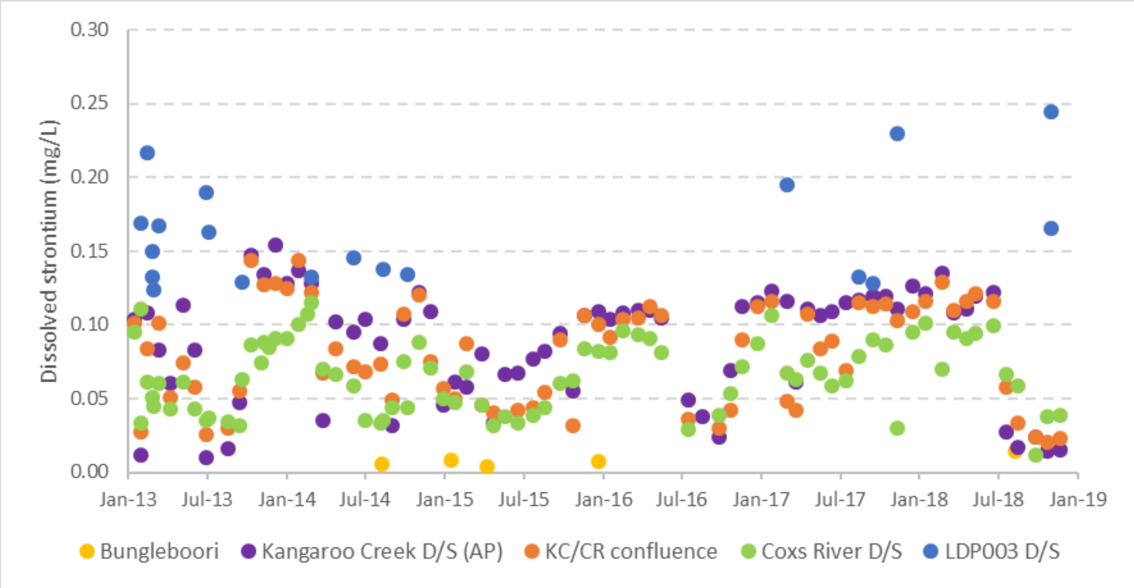


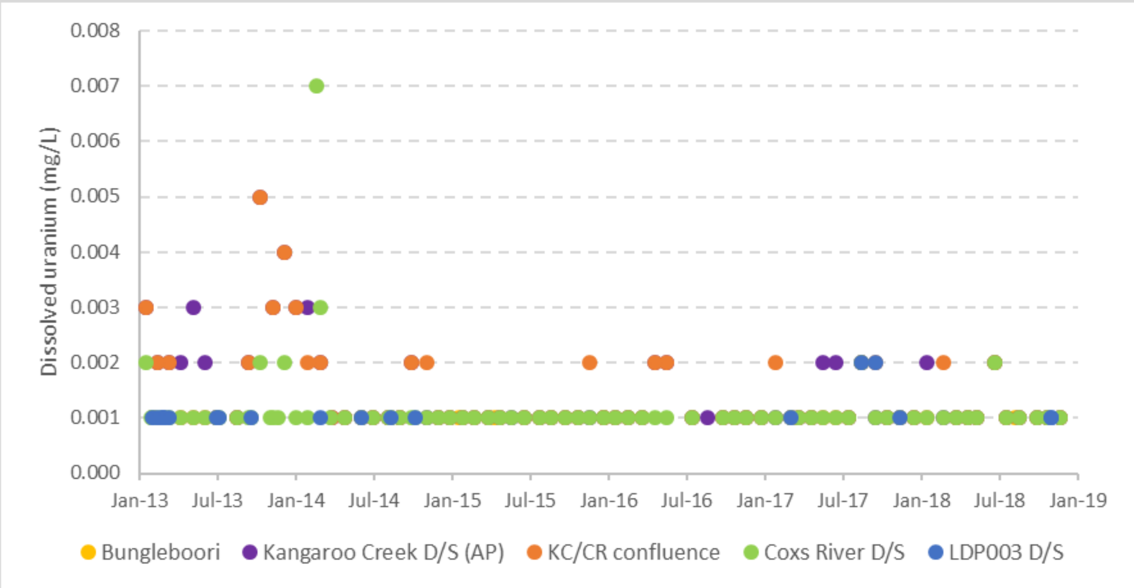
Dissolved molybdenum (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

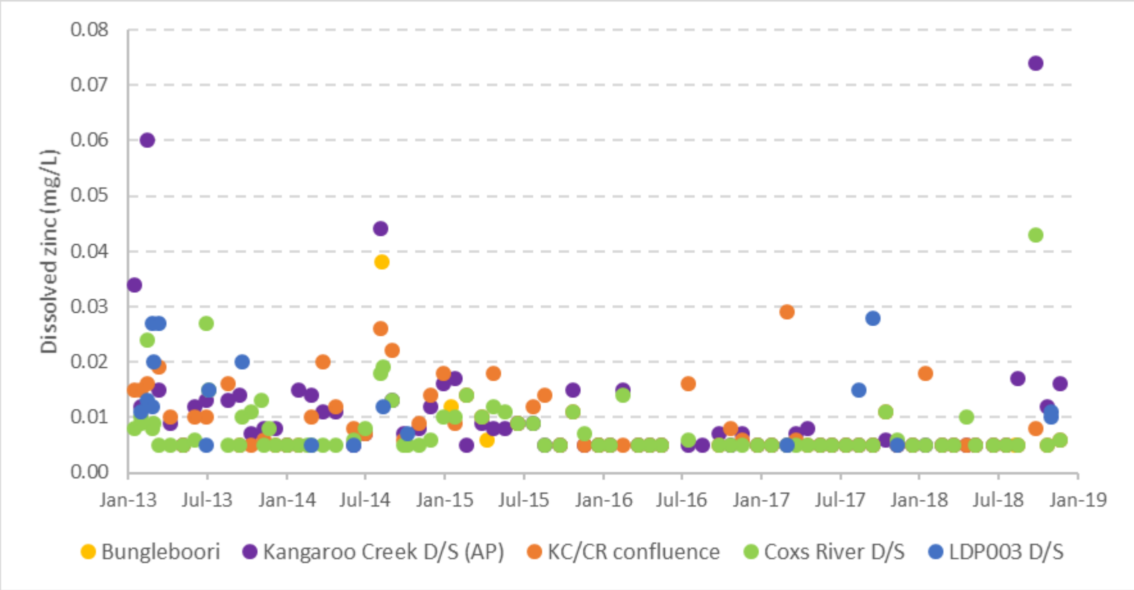


Dissolved nickel (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

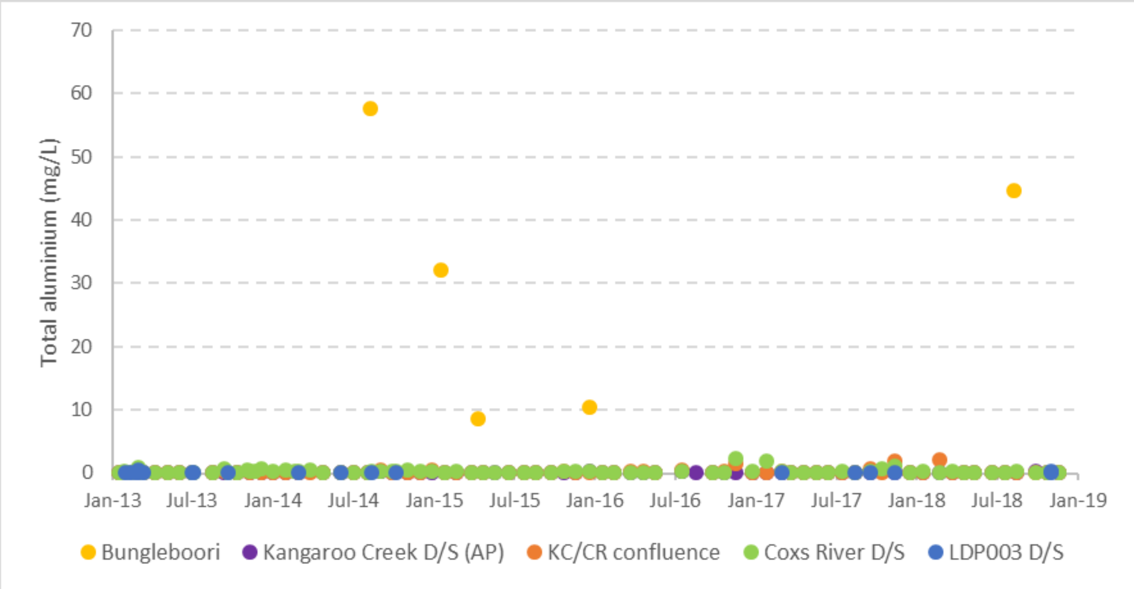

Dissolved rubidium (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

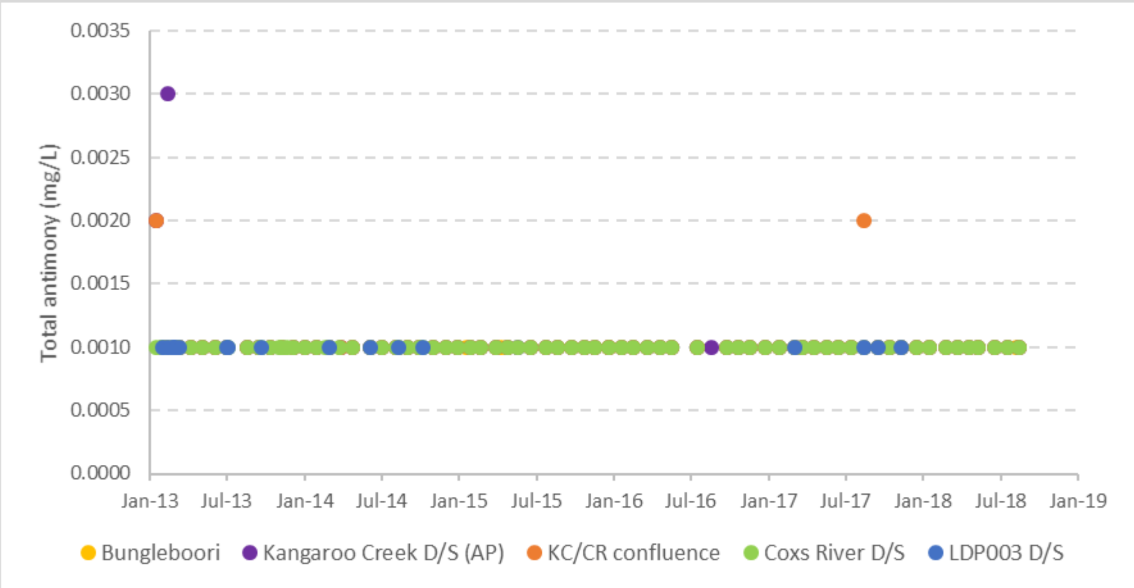

Dissolved strontium (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

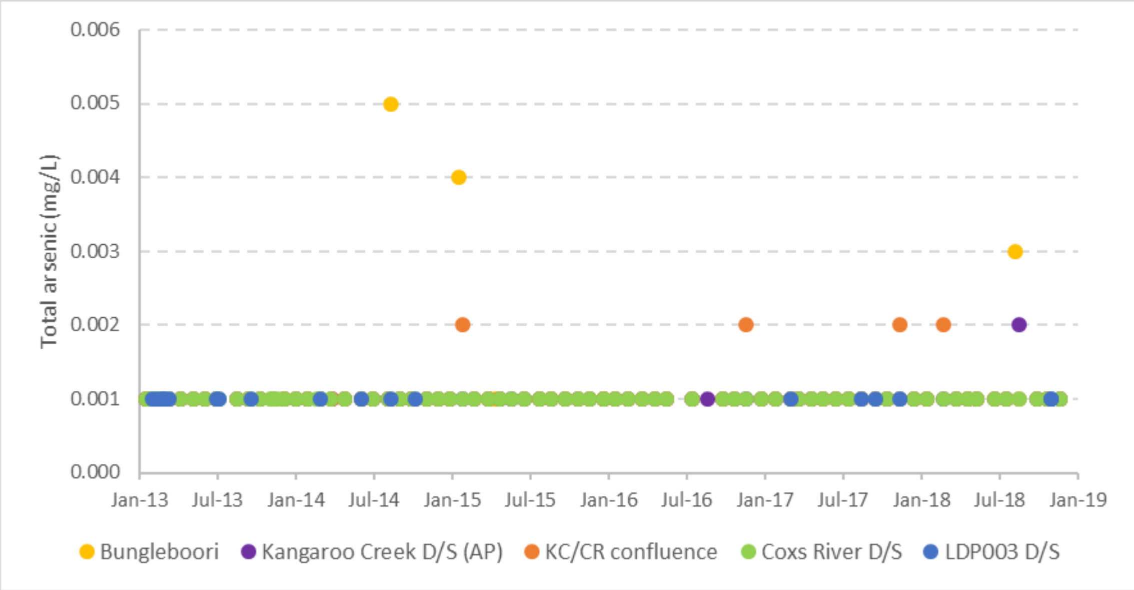

Dissolved uranium (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



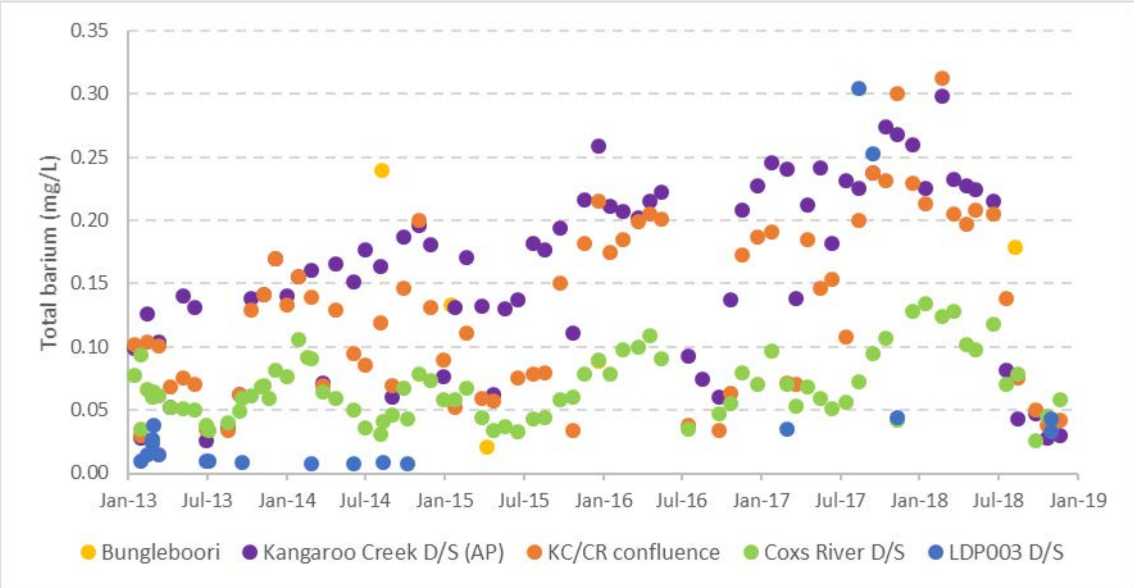
Total metals



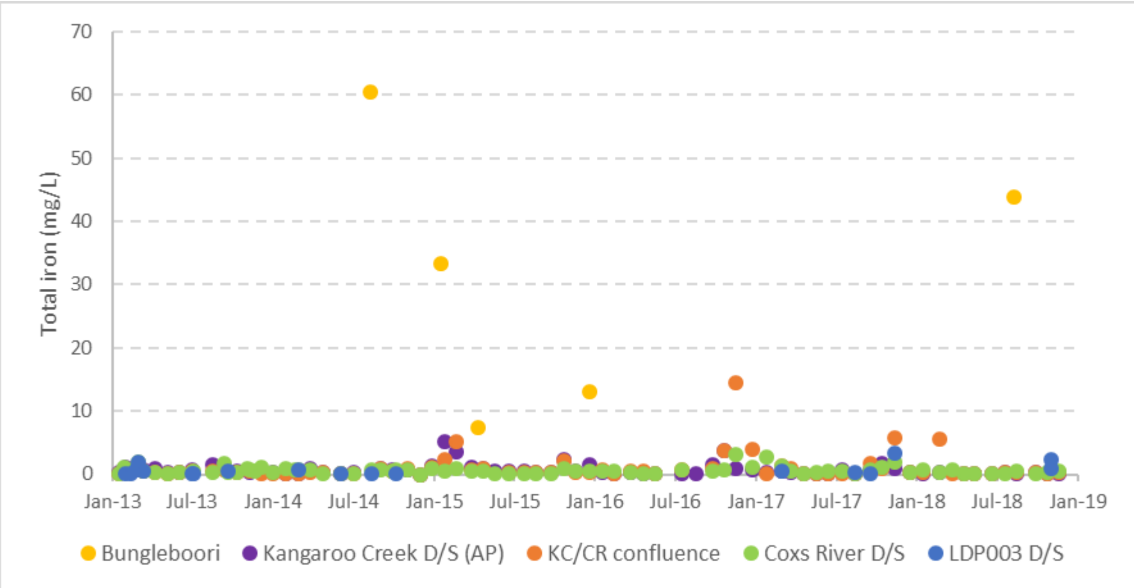




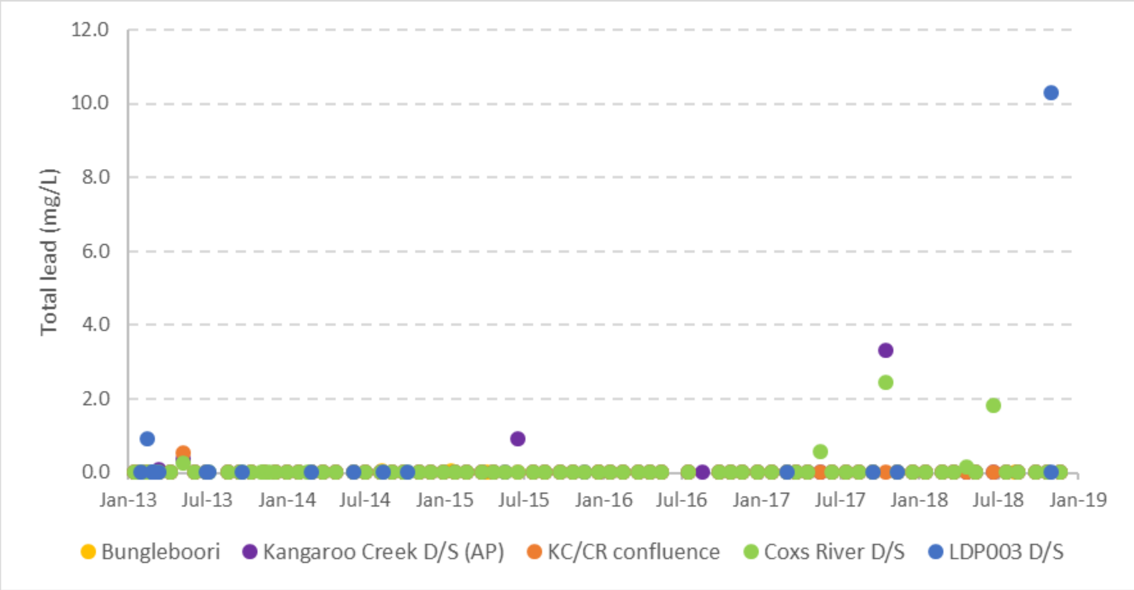
Total arsenic (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



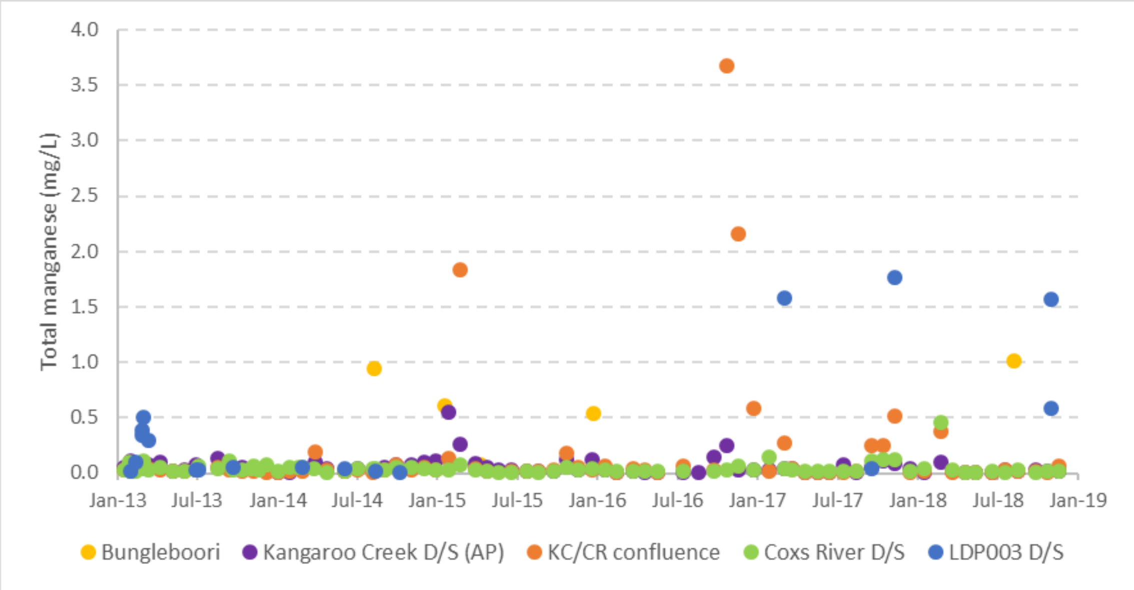
Total barium (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



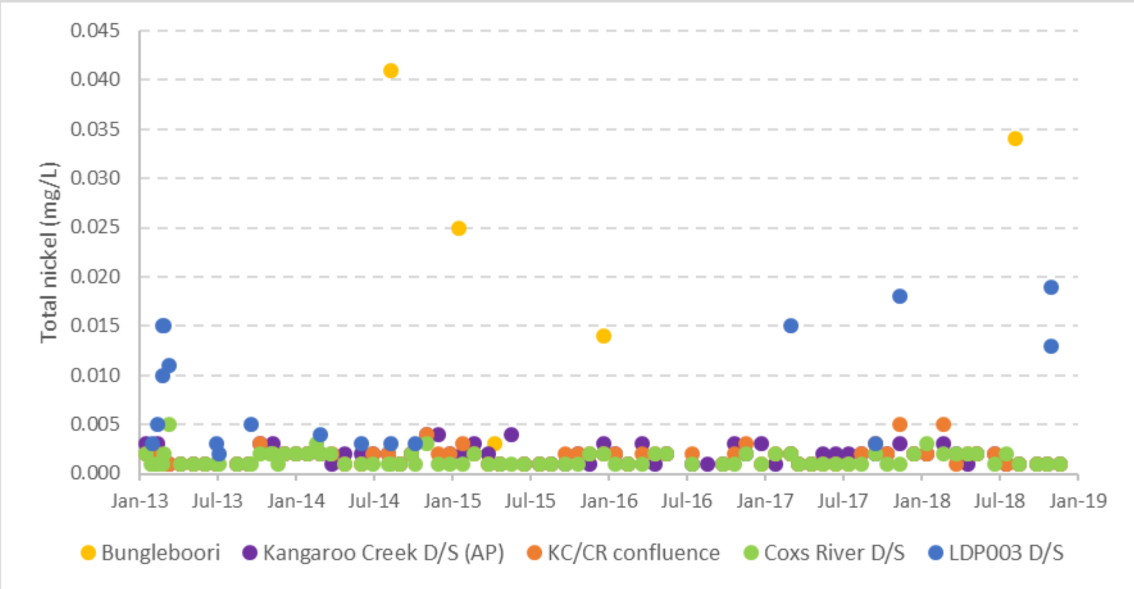
Total iron (mg/L)
70
60
50
40
30
20
10
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



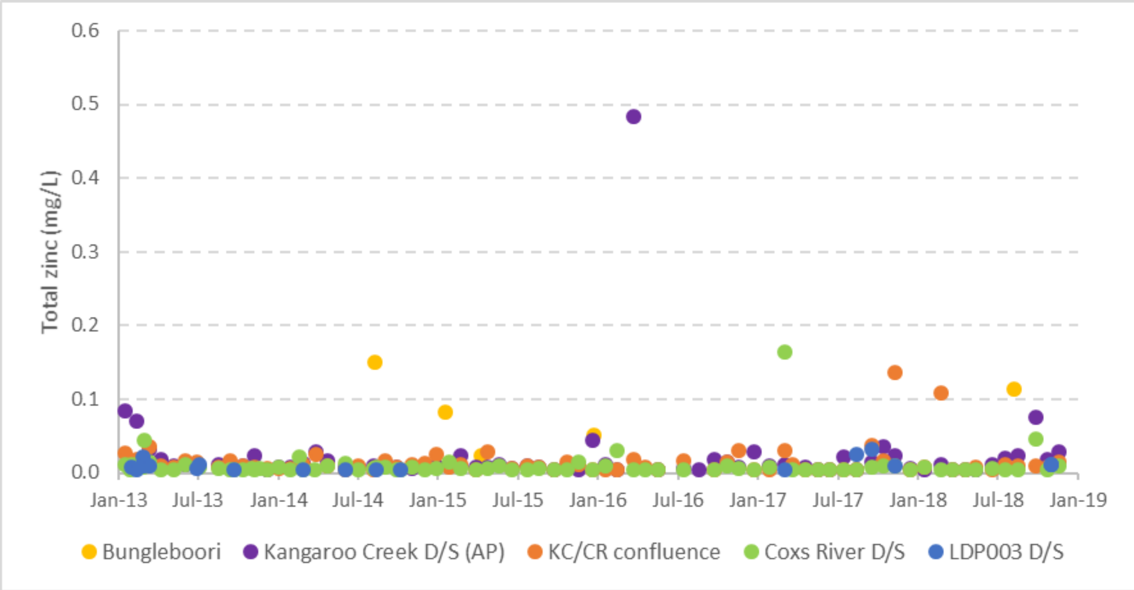
Total lead (mg/L)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S



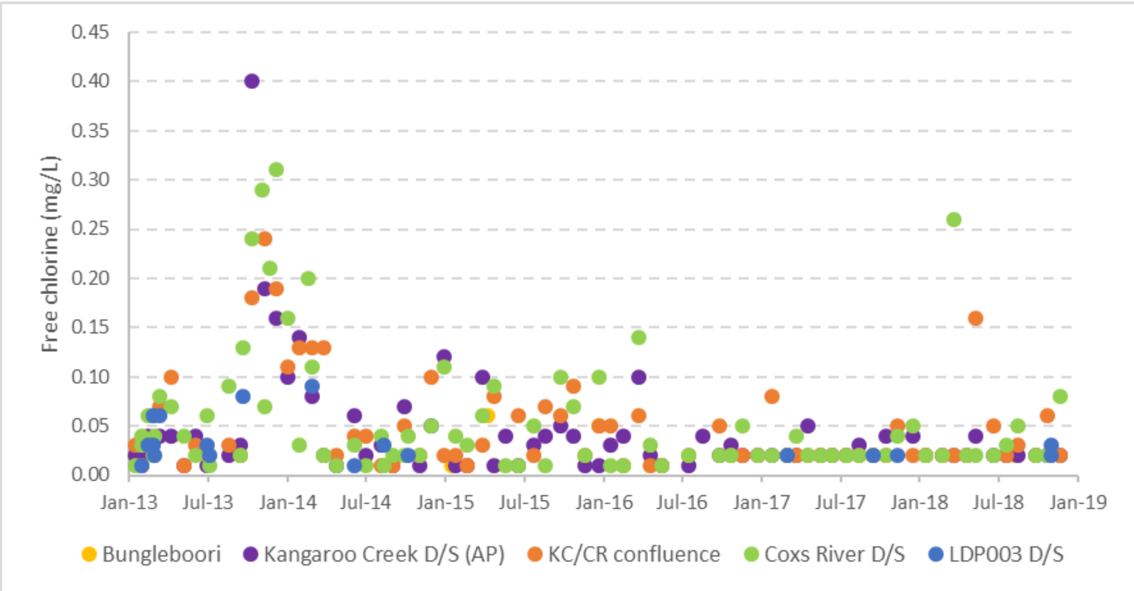
Total manganese (mg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

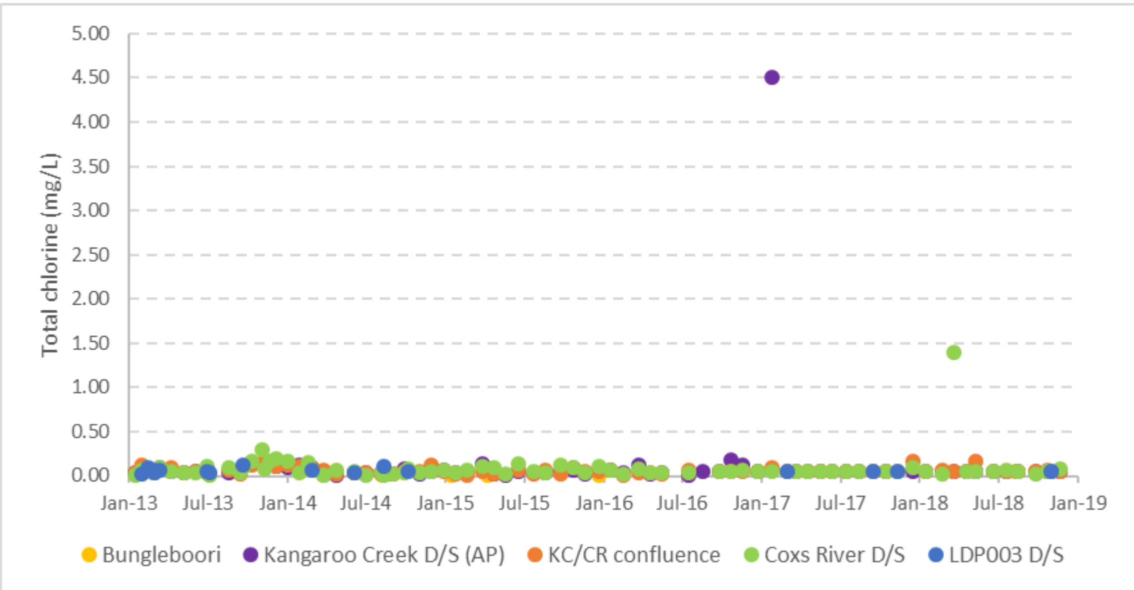


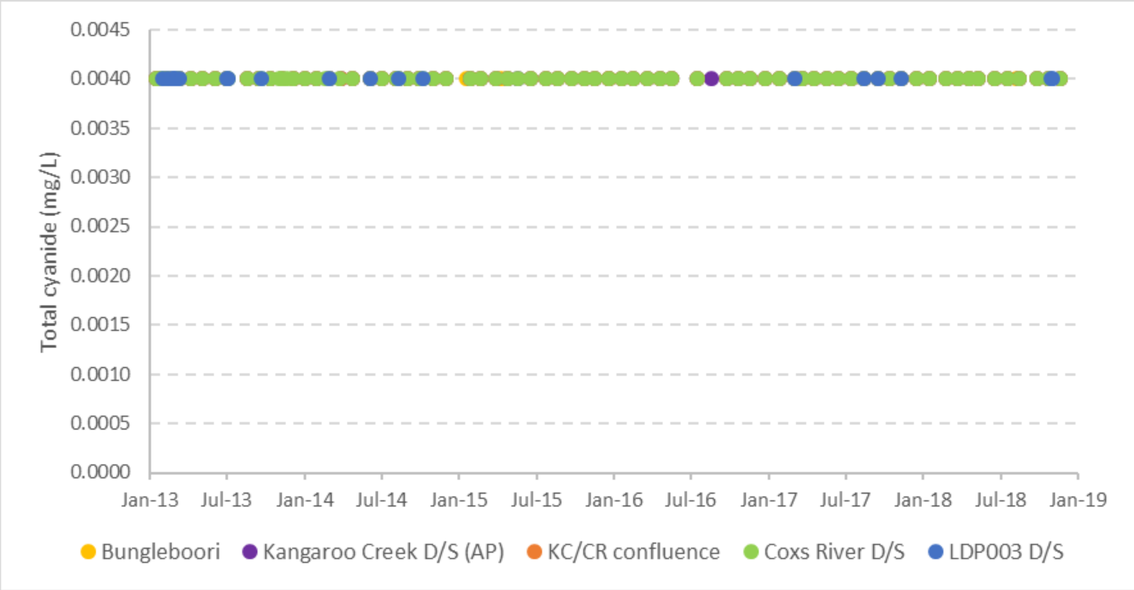
Total nickel (mg/L)
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

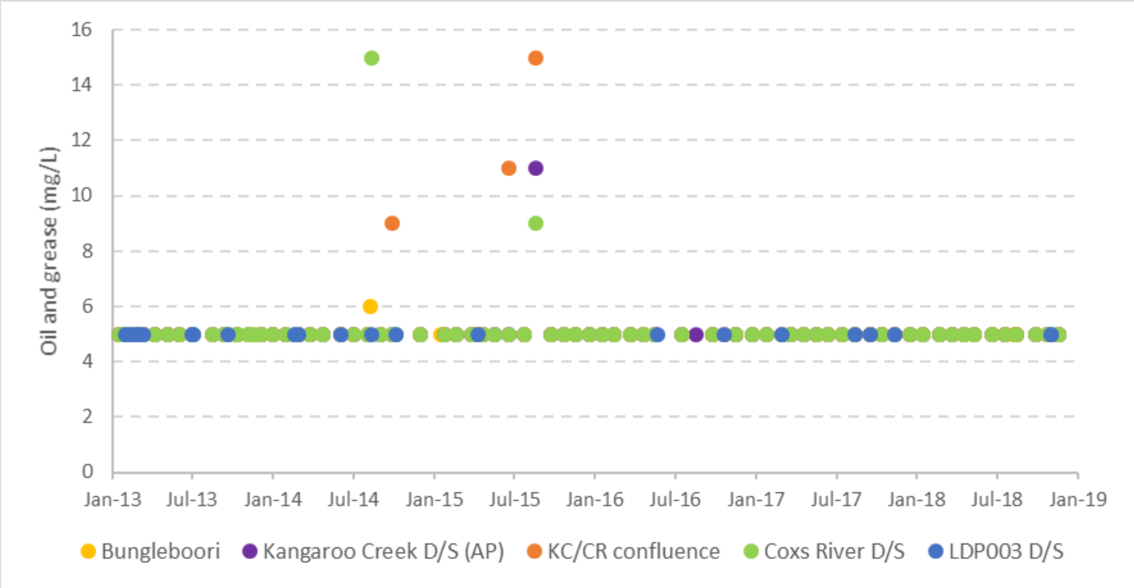

Total zinc (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori Kangaroo Creek D/S (AP) KC/CR confluence Coxs River D/S LDP003 D/S

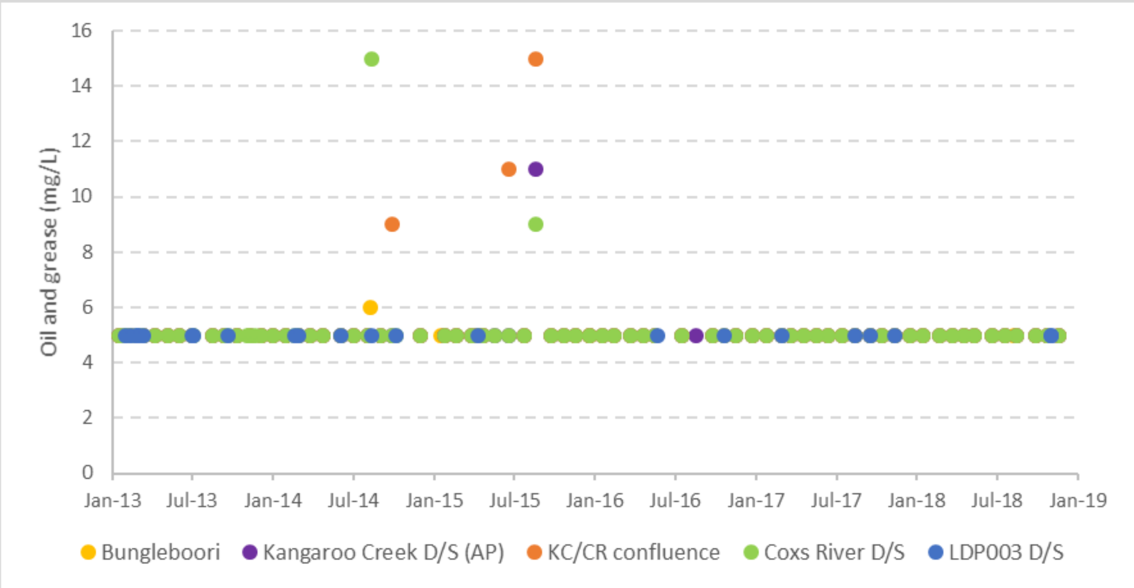
<u>Other</u>

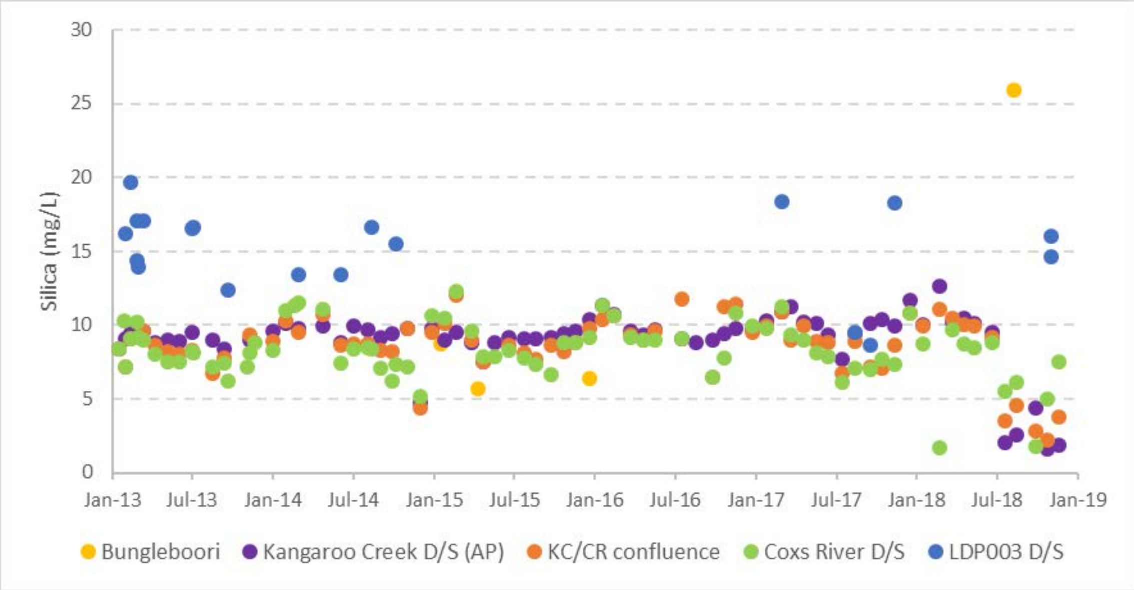

Free chlorine (mg/L)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori Kangaroo Creek D/S (AP) KC/CR confluence Coxs River D/S LDP003 D/S

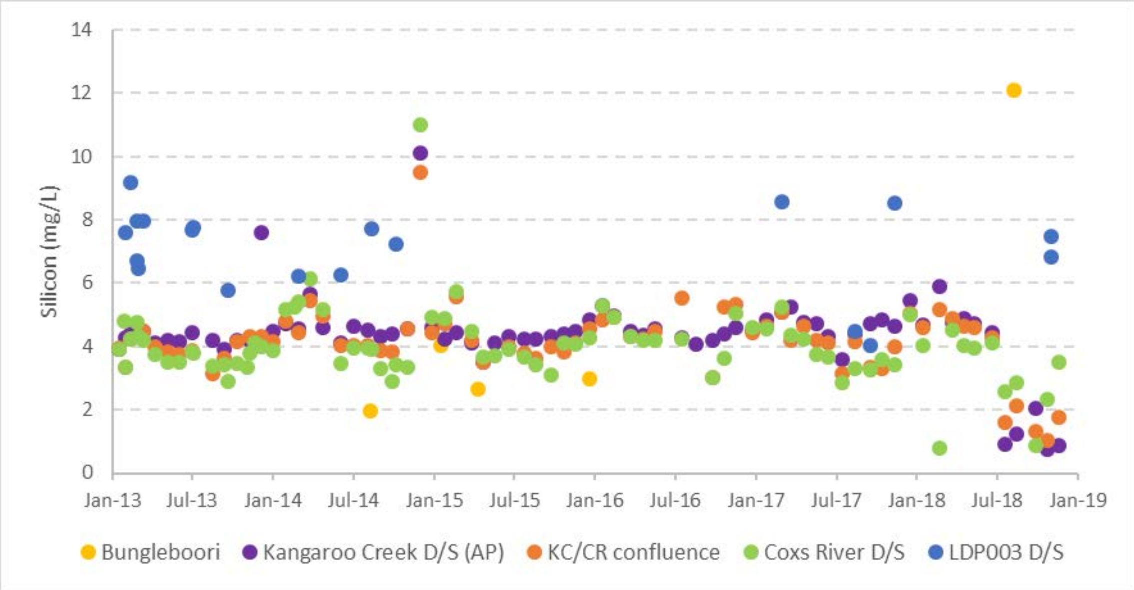

Total chlorine (mg/L)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori Kangaroo Creek D/S (AP) KC/CR confluence Coxs River D/S LDP003 D/S

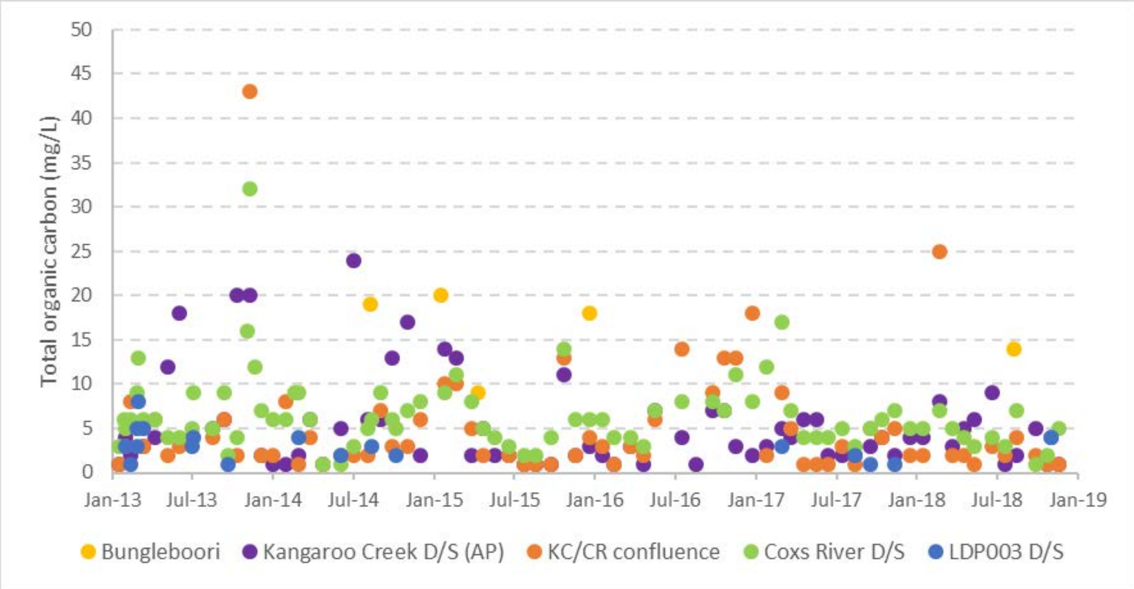

Total cyanide (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Oil and grease (mg/L)
16
14
12
10
8
6
4
2
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Oil and grease (mg/L)
16
14
12
10
8
6
4
2
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Silica (mg/L)
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Silicon (mg/L)
14
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S


Total organic carbon (mg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Bungleboori
Kangaroo Creek D/S (AP)
KC/CR confluence
Coxs River D/S
LDP003 D/S

E.1.4 Watercourses – Wolgan River catchment

Statistical summary of water quality results

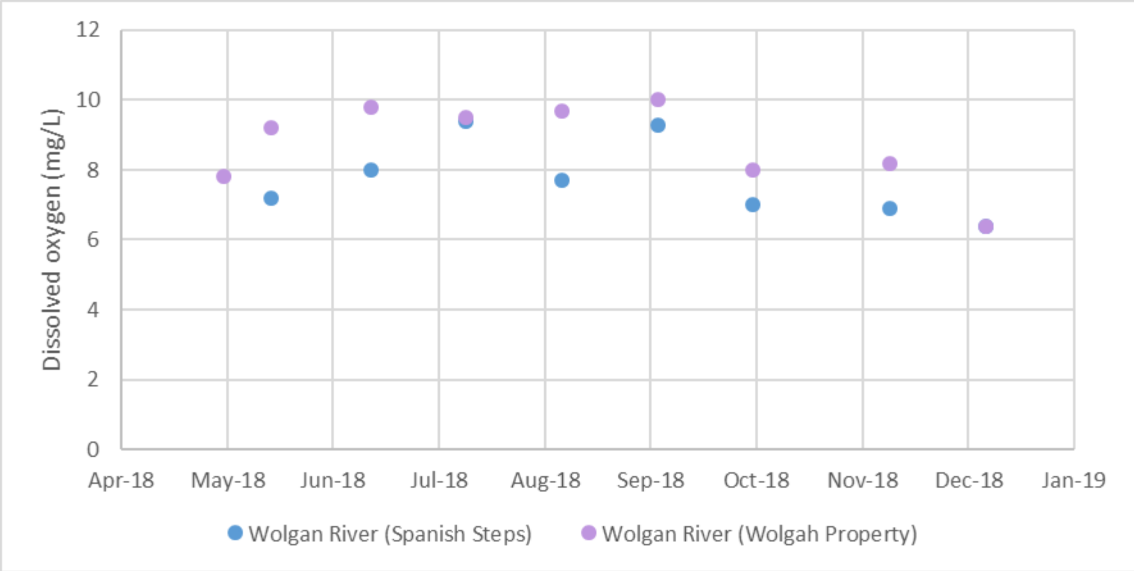
Parameters	Units	Wolgan River (Spanish Steps)		Wolgan River (Wolgah Property)	
		Count	Median	Count	Median
Physicochemical					
DO	mg/L	8	7.5	9	9.2
EC	µS/cm	8	45	9	57
pH	pH units	8	6.1	9	6.6
TDS	mg/L	8	37	9	44
TSS	mg/L	8	6	9	5
Turbidity	NTU	8	3.9	9	3.3
Major ions					
Bicarbonate alkalinity	mg/L	8	6	9	12
Carbonate alkalinity	mg/L	8	1	9	1
Hydroxide alkalinity	mg/L	8	1	9	1
Total alkalinity	mg/L	8	6	9	12
Calcium	mg/L	8	1	9	1
Chloride	mg/L	8	5	9	6
Magnesium	mg/L	8	1	9	1
Potassium	mg/L	8	1	9	1
Sodium	mg/L	8	7	9	6
Sulfate	mg/L	8	1	9	2
Total hardness	mg/L	7	1	8	5
Nutrients					
Ammonia	mg/L	8	0.01	9	0.01
Nitrate	mg/L	8	0.01	9	0.01
Nitrite	mg/L	8	0.01	9	0.01
Nitrate + nitrite	mg/L	8	0.01	9	0.01
TKN	mg/L	8	0.1	9	0.2
Total nitrogen	mg/L	8	0.1	9	0.2

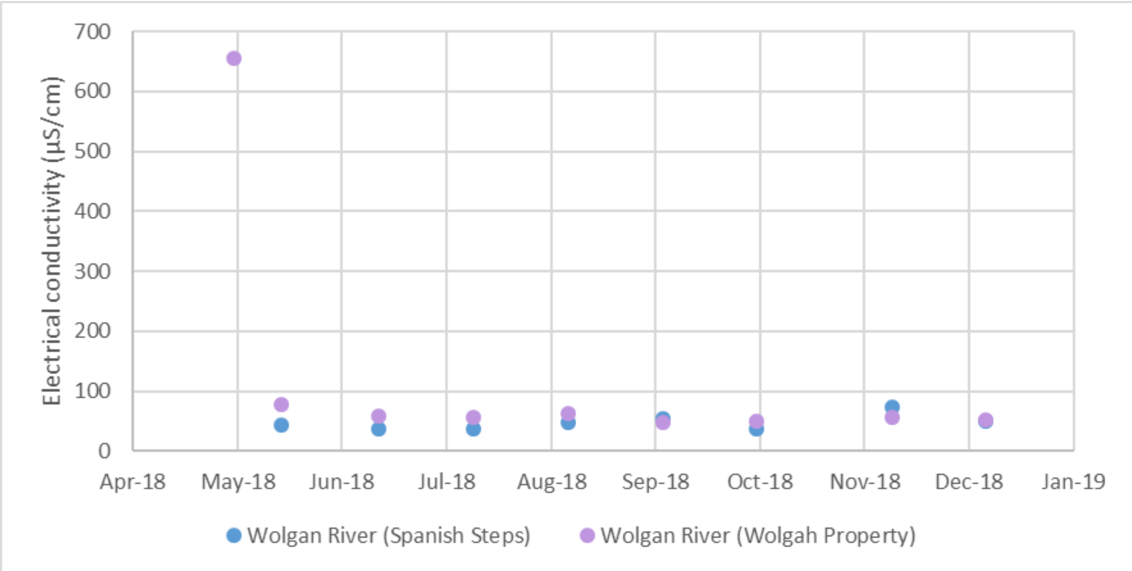
Parameters	Units	Wolgan River (Spanish Steps)		Wolgan River (Wolgah Property)	
		Count	Median	Count	Median
Total phosphorus	mg/L	8	0.01	9	0.01
Dissolved metals					
Aluminium	mg/L	8	0.05	9	0.03
Antimony	mg/L	8	0.001	9	0.001
Arsenic	mg/L	8	0.001	9	0.001
Barium	mg/L	8	0.004	9	0.004
Boron	mg/L	8	0.05	9	0.05
Cadmium	mg/L	8	0.0001	9	0.0001
Chromium (III)	mg/L	8	0.01	9	0.01
Chromium (VI)	mg/L	8	0.01	9	0.01
Copper	mg/L	8	0.001	9	0.001
Iron	mg/L	8	0.23	9	0.30
Lead	mg/L	8	0.001	9	0.001
Lithium	mg/L	8	0.002	9	0.007
Manganese	mg/L	8	0.008	9	0.004
Mercury	mg/L	8	0.0001	9	0.0001
Molybdenum	mg/L	8	0.001	9	0.001
Nickel	mg/L	8	0.001	9	0.001
Rubidium	mg/L	8	0.001	9	0.002
Strontium	mg/L	8	0.004	9	0.005
Uranium	mg/L	8	0.001	9	0.001
Zinc	mg/L	8	0.005	9	0.005
Total metals					
Aluminium	mg/L	8	0.11	9	0.12
Arsenic	mg/L	8	0.001	9	0.001
Barium	mg/L	8	0.007	9	0.006
Boron	mg/L	8	0.05	9	0.05
Cadmium	mg/L	8	0.0001	9	0.0001

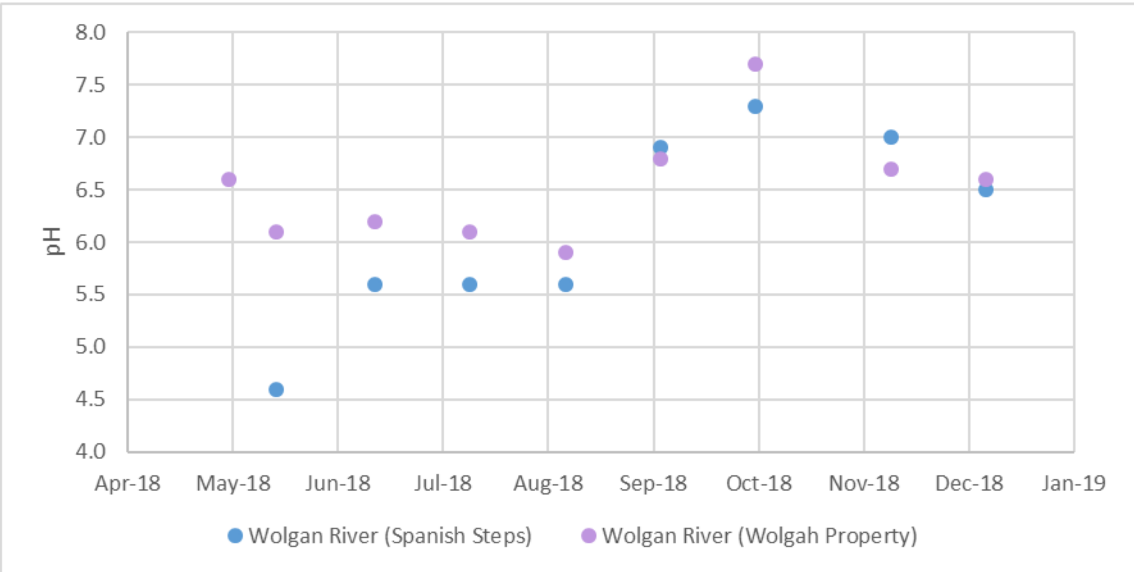
Parameters	Units	Wolgan River (Spanish Steps)		Wolgan River (Wolgah Property)	
		Count	Median	Count	Median
Cobalt	mg/L	8	0.001	9	0.001
Copper	mg/L	8	0.001	9	0.001
Iron	mg/L	8	0.59	9	0.66
Lead	mg/L	8	0.001	9	0.001
Manganese	mg/L	8	0.012	9	0.019
Mercury	mg/L	8	0.0001	9	0.0001
Nickel	mg/L	8	0.001	9	0.001
Selenium	mg/L	8	0.01	9	0.01
Silver	mg/L	8	0.001	9	0.001
Uranium	mg/L	8	0.001	9	0.001
Zinc	mg/L	8	0.005	9	0.005
Other					
Anionic surfactants	mg/L	8	0.1	8	0.1
Free chlorine	mg/L	8	0.02	9	0.02
Total chlorine	mg/L	8	0.05	9	0.05
Total cyanide	mg/L	8	0.004	9	0.004
Oil and grease	mg/L	8	5	9	5
Phenols	mg/L	8	0.05	9	0.05
Silica	mg/L	8	6.3	9	6.2
Silicon	mg/L	8	2.95	9	2.88
Total organic carbon	mg/L	8	4	9	3

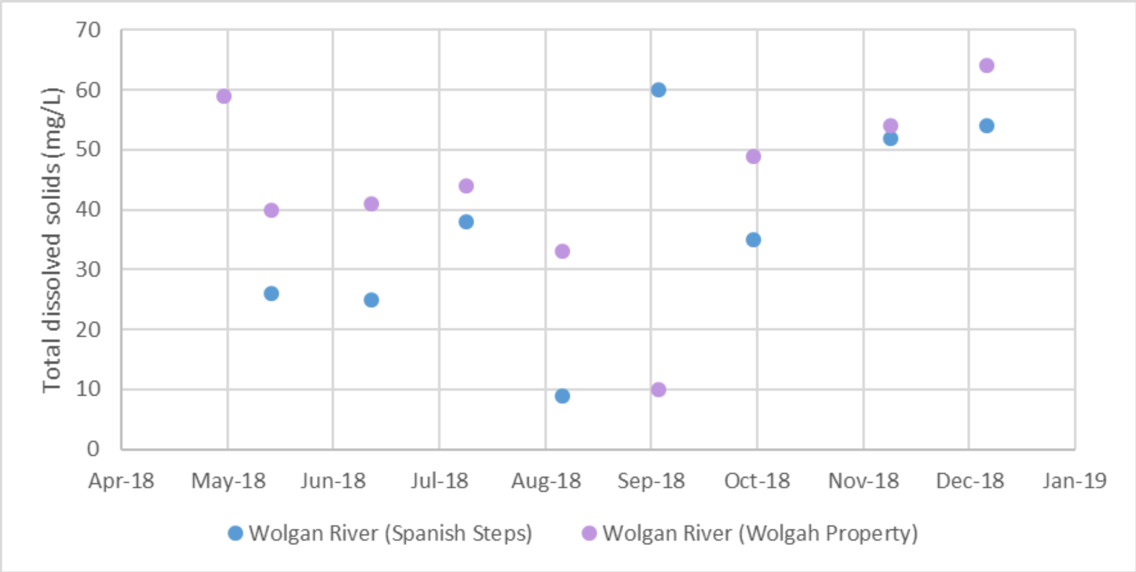
Time series graphs of water quality results

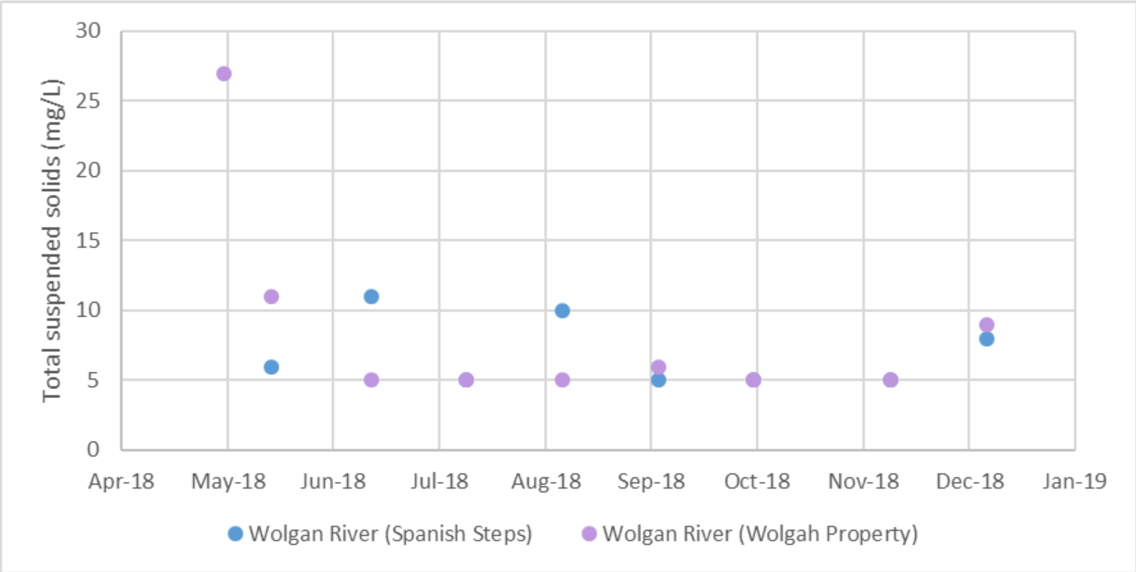
Physicochemical

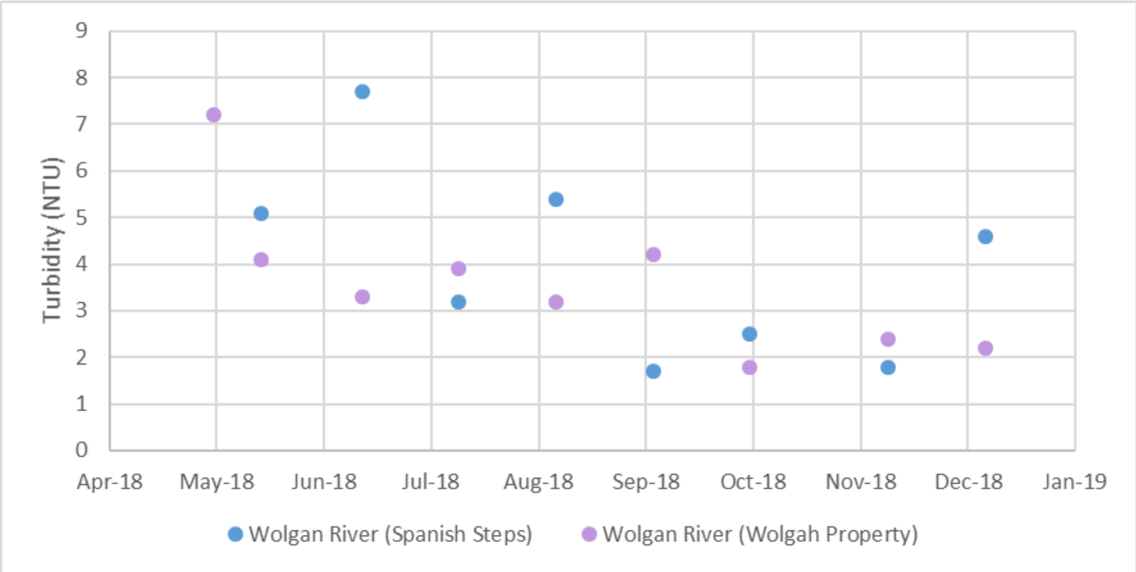




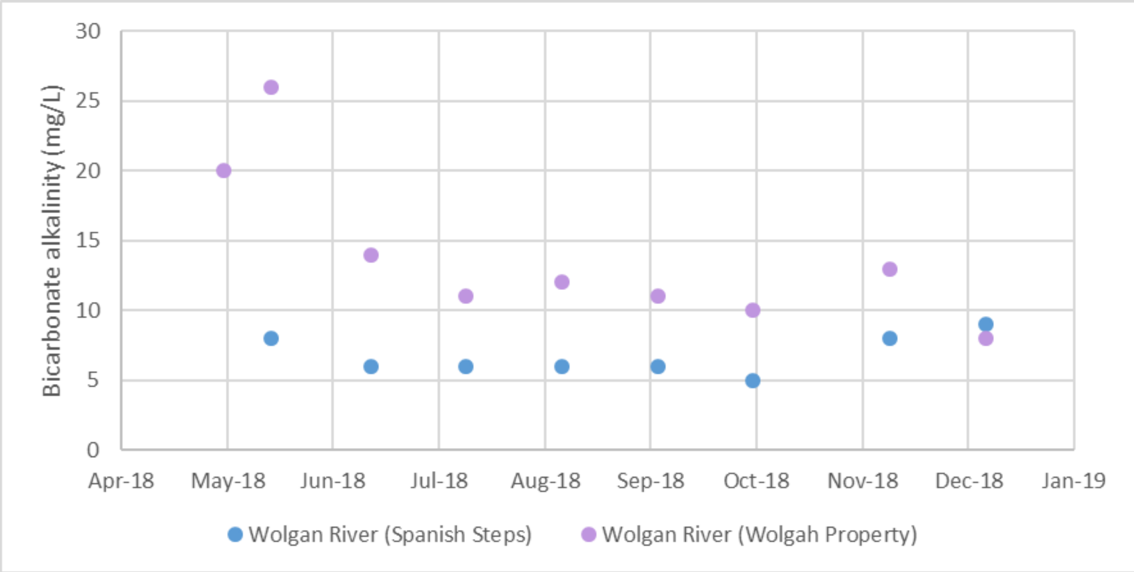



Total dissolved solids (mg/L)
0
10
20
30
40
50
60
70
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

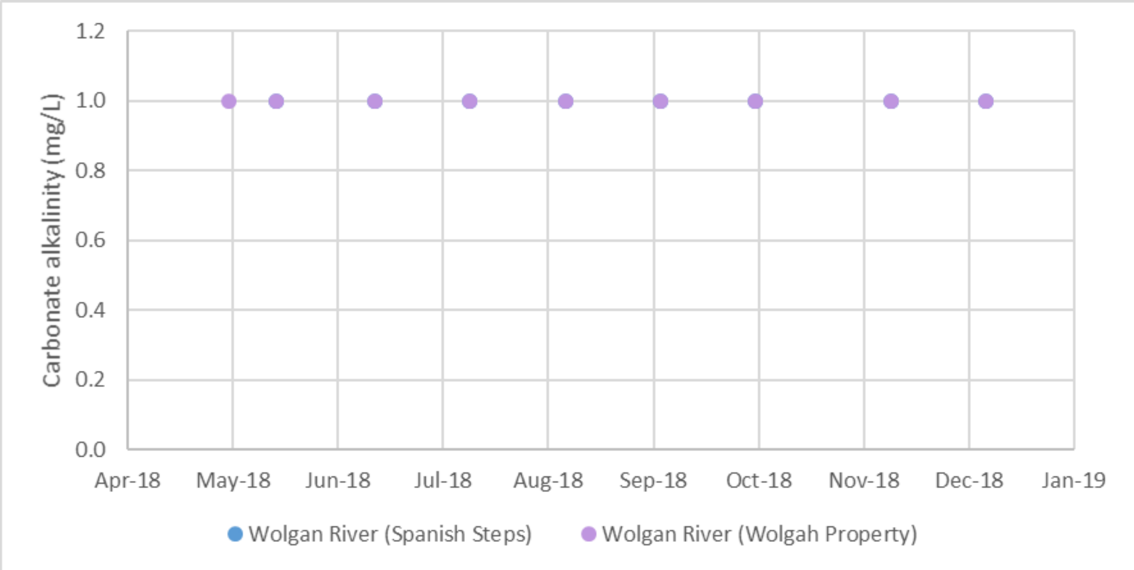

Total suspended solids (mg/L)
0
5
10
15
20
25
30
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


Turbidity (NTU)
0
1
2
3
4
5
6
7
8
9
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

Major ions



Bicarbonate alkalinity (mg/L)
30
25
20
15
10
5
0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)



Carbonate alkalinity (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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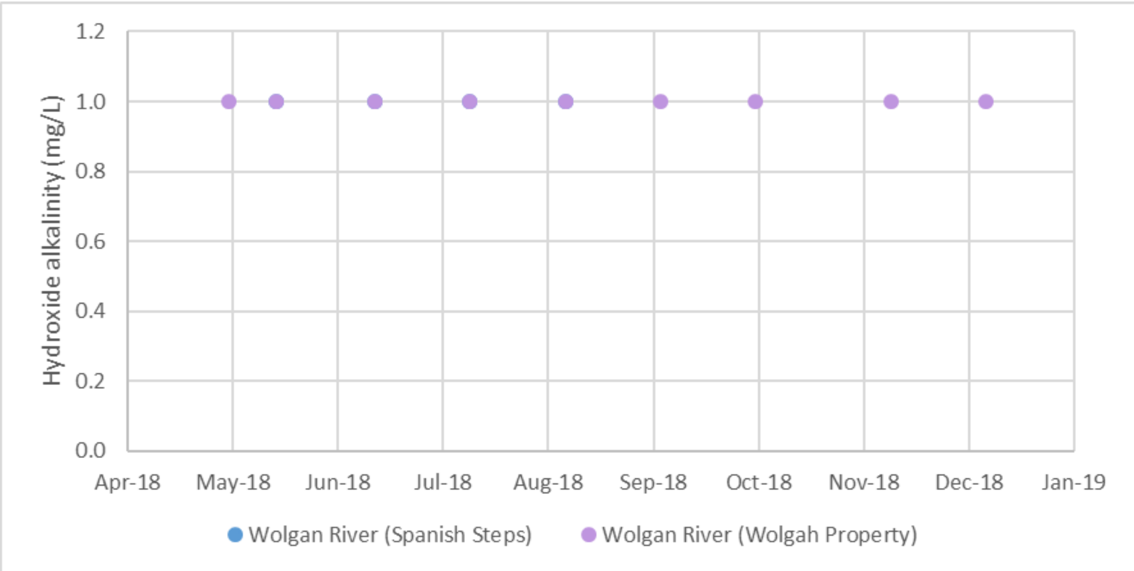

Hydroxide alkalinity (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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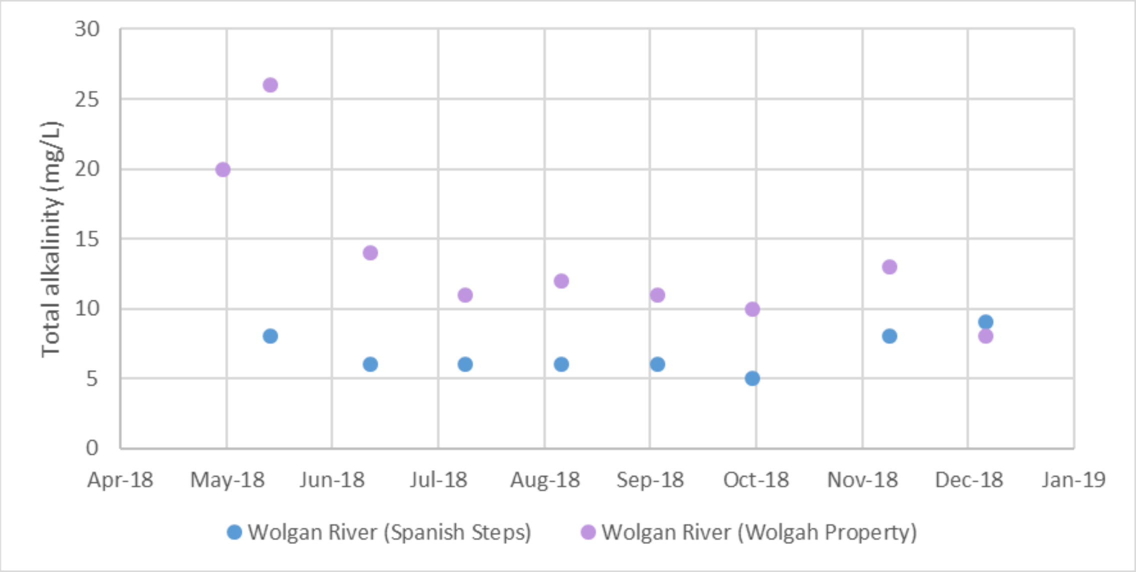
Total alkalinity (mg/L)
30
25
20
15
10
5
0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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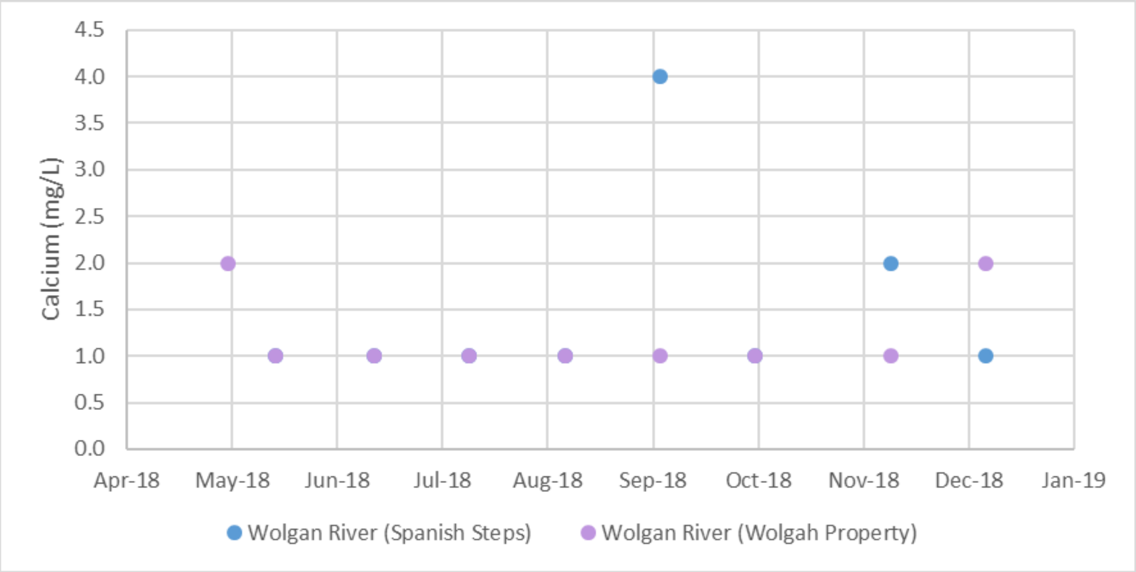
Calcium (mg/L)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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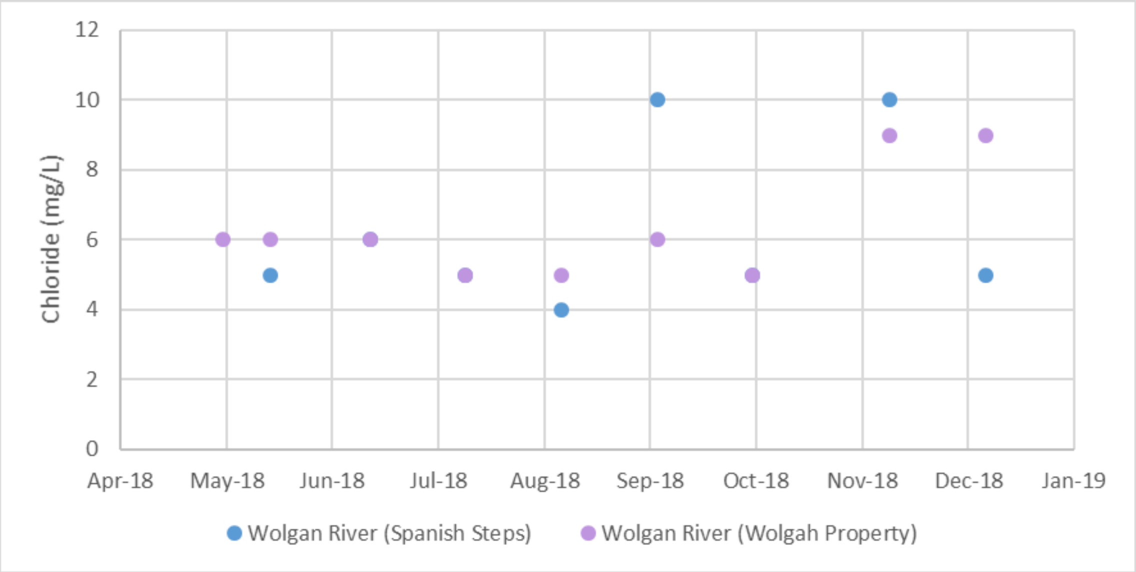
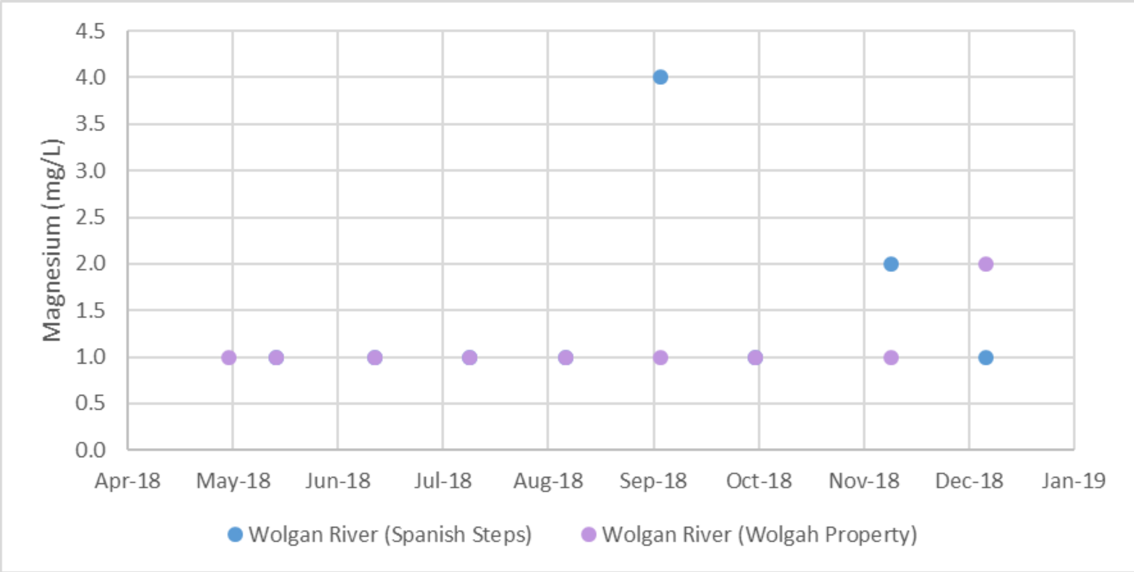

Chloride (mg/L)
12
10
8
6
4
2
0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


Magnesium (mg/L)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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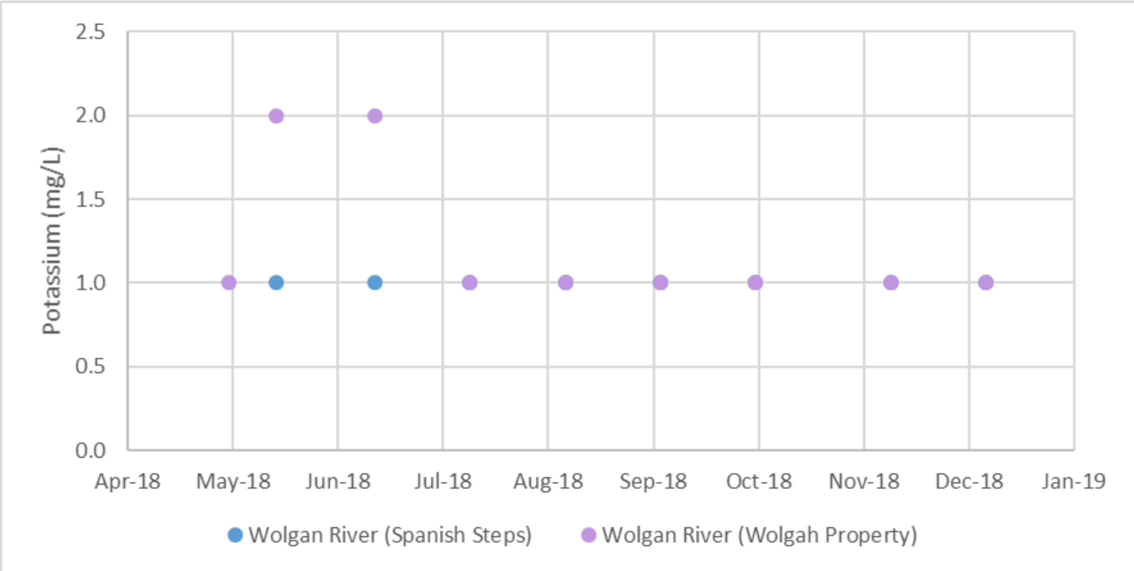
Potassium (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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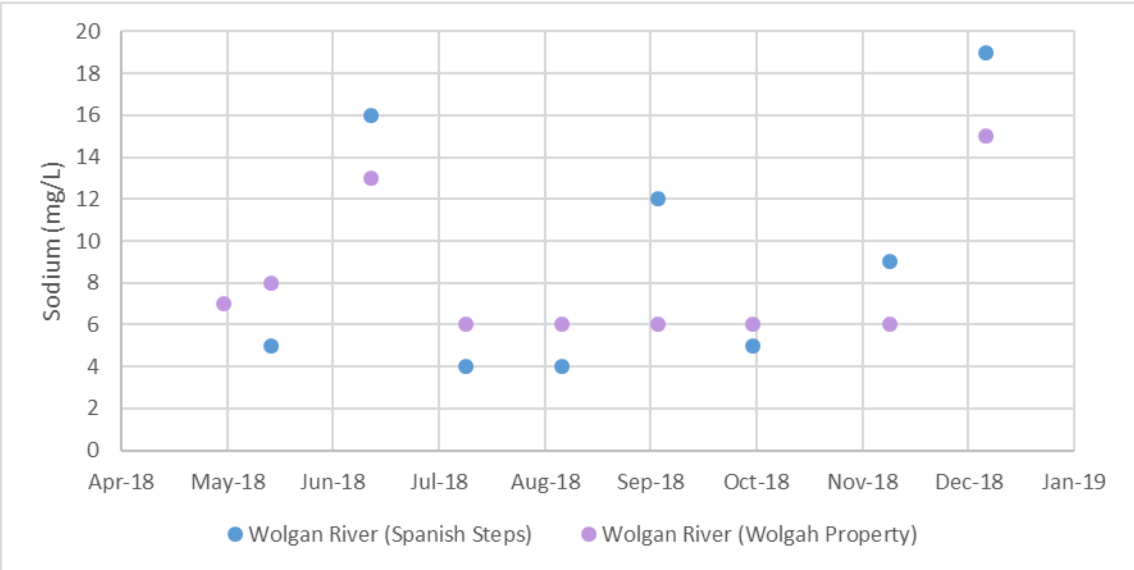
Sodium (mg/L)
20
18
16
14
12
10
8
6
4
2
0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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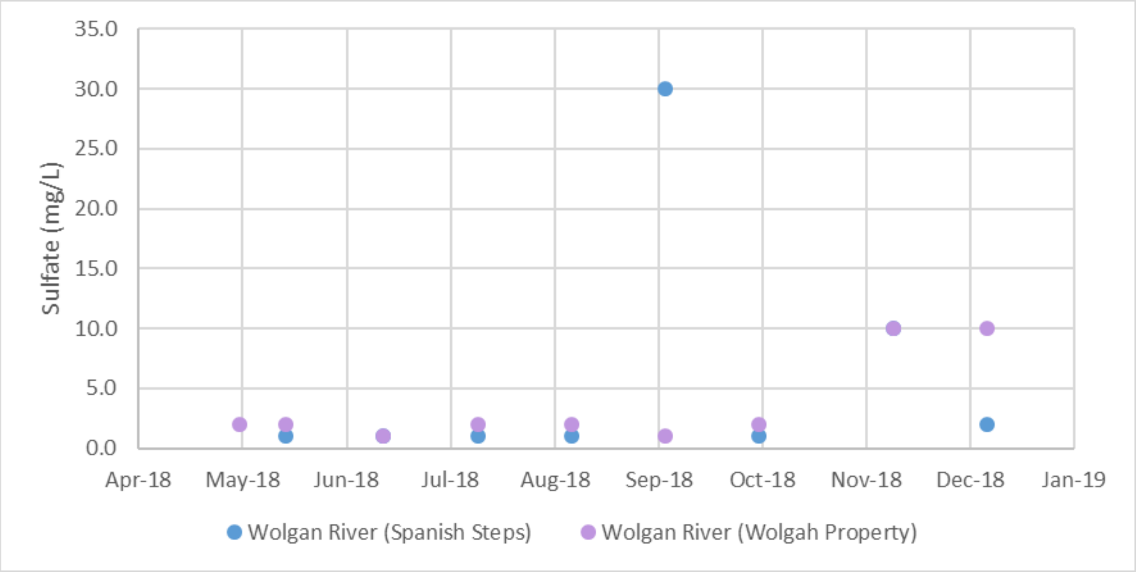
Sulfate (mg/L)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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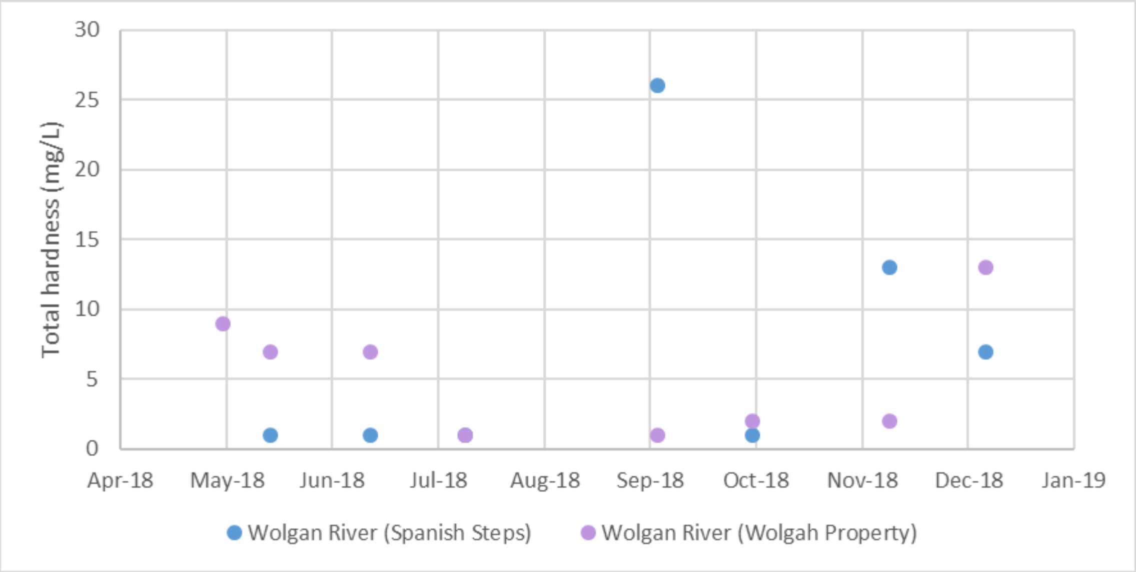
Total hardness (mg/L)
30
25
20
15
10
5
0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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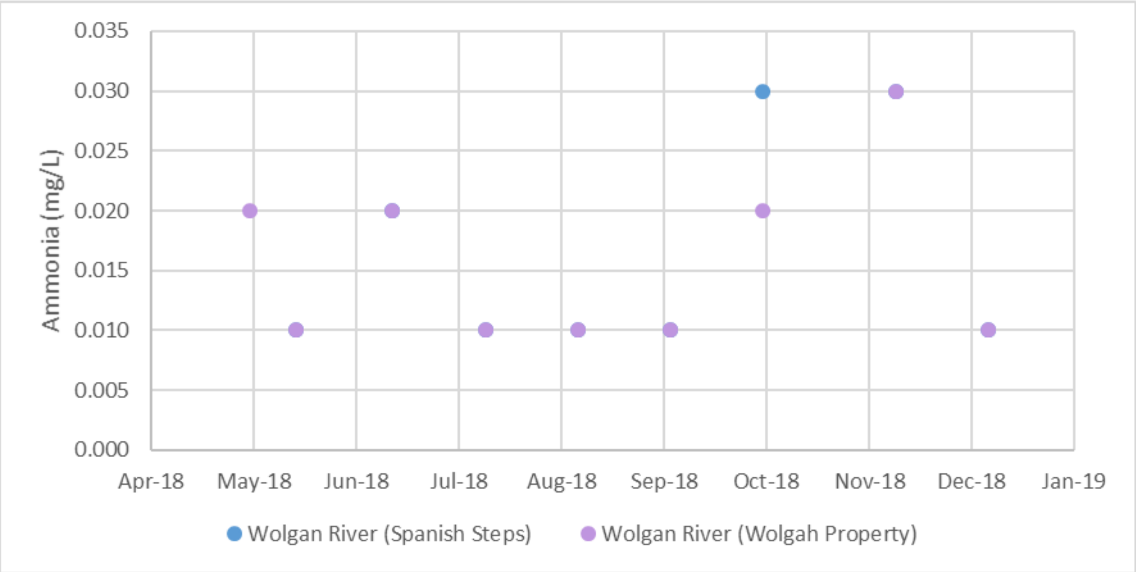
Nutrients


Ammonia (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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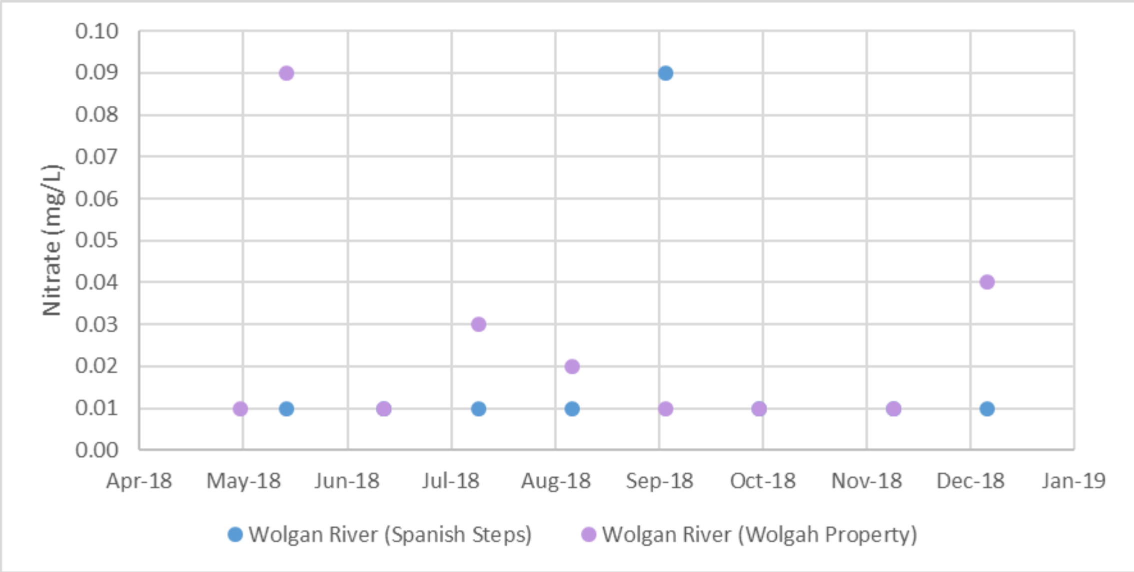

Nitrate (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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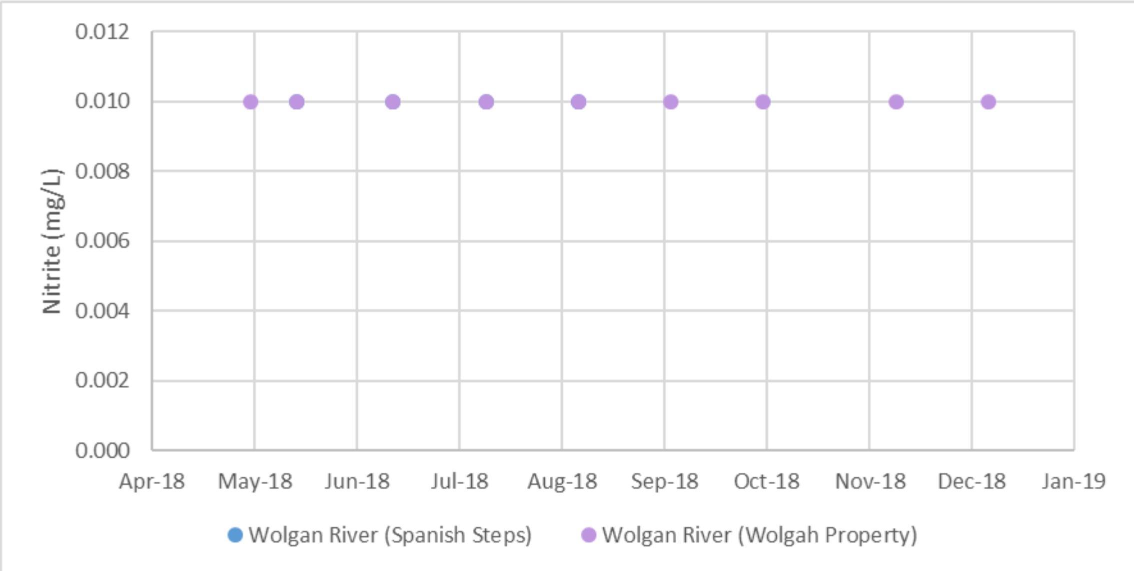

Nitrite (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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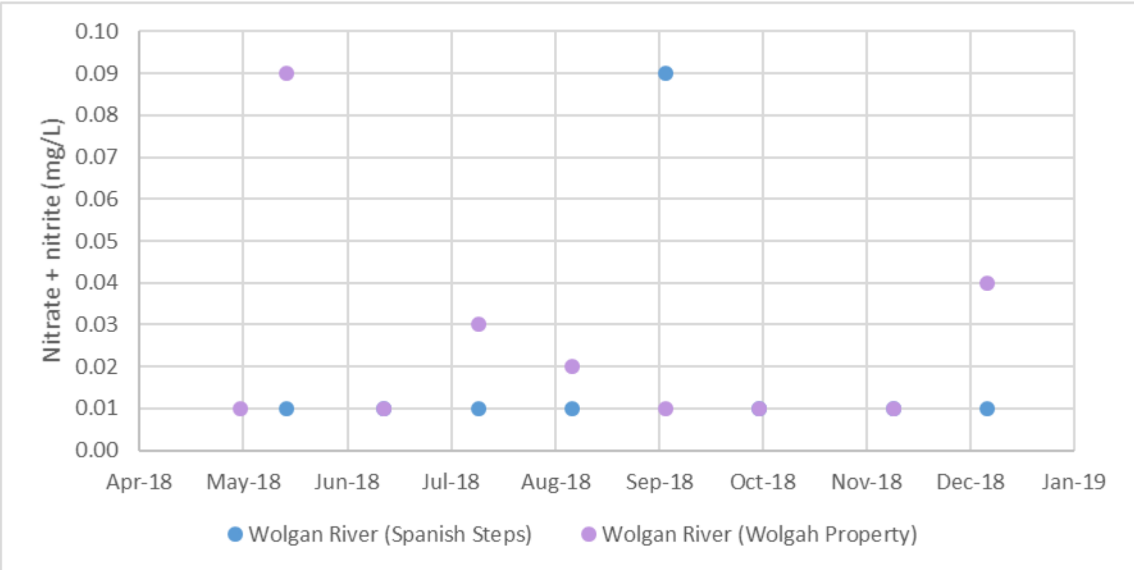

Nitrate + nitrite (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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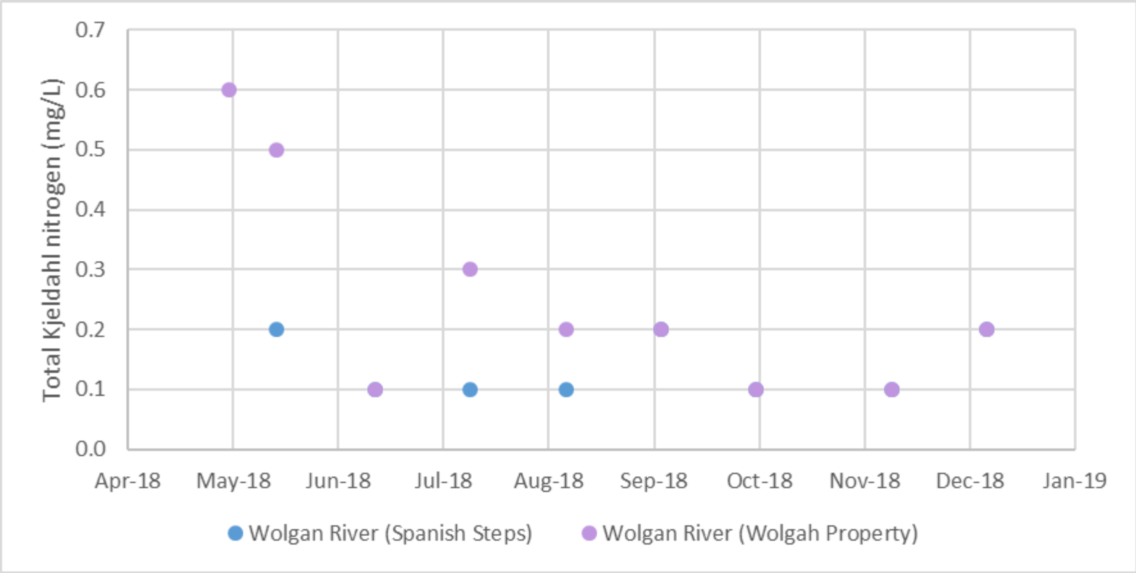
Total Kjeldahl nitrogen (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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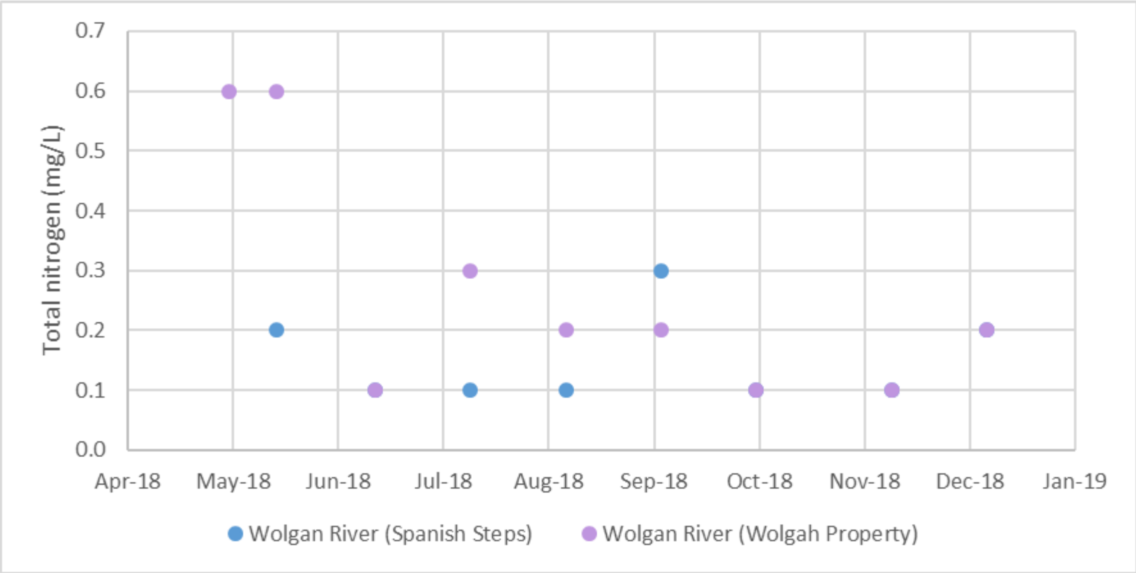
Total nitrogen (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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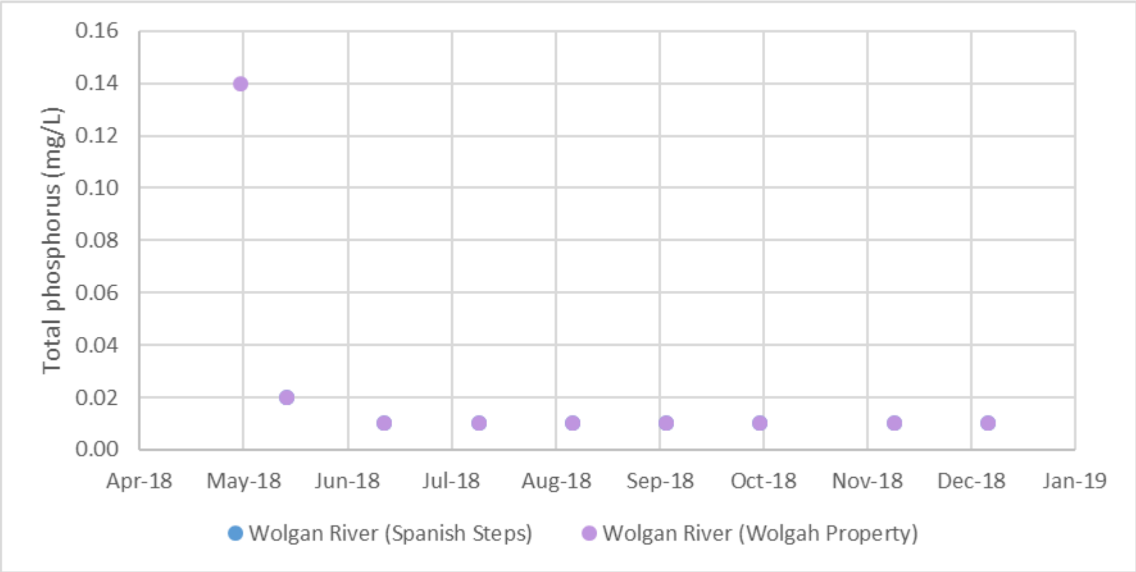
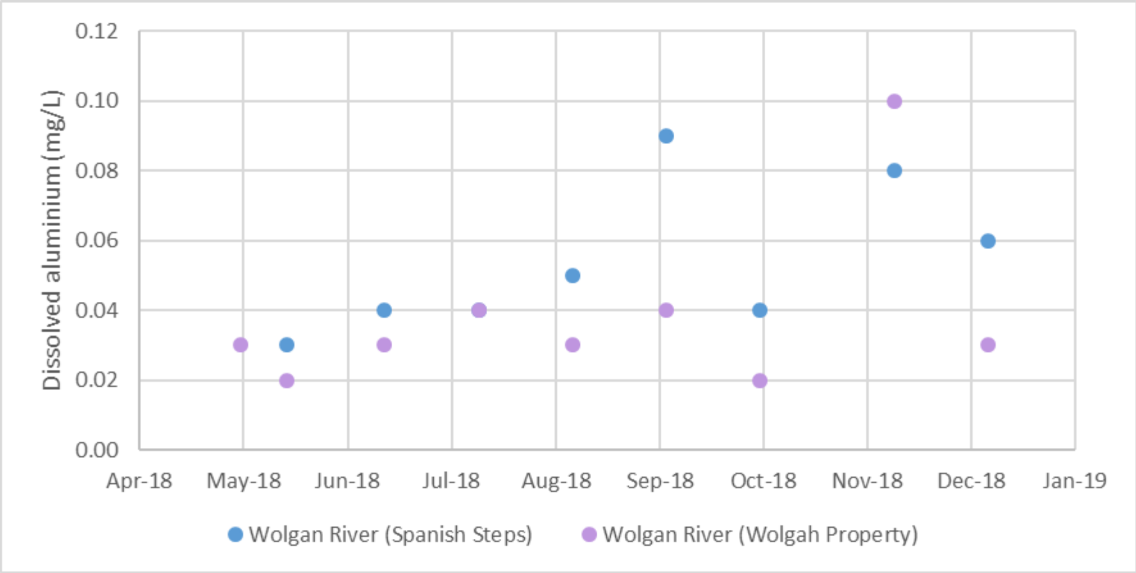
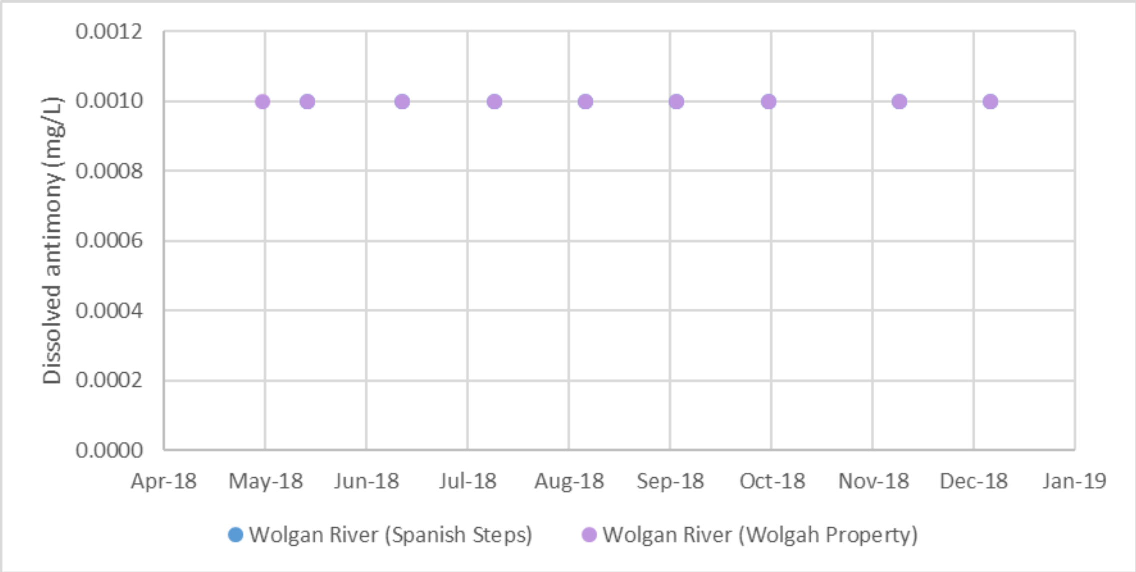
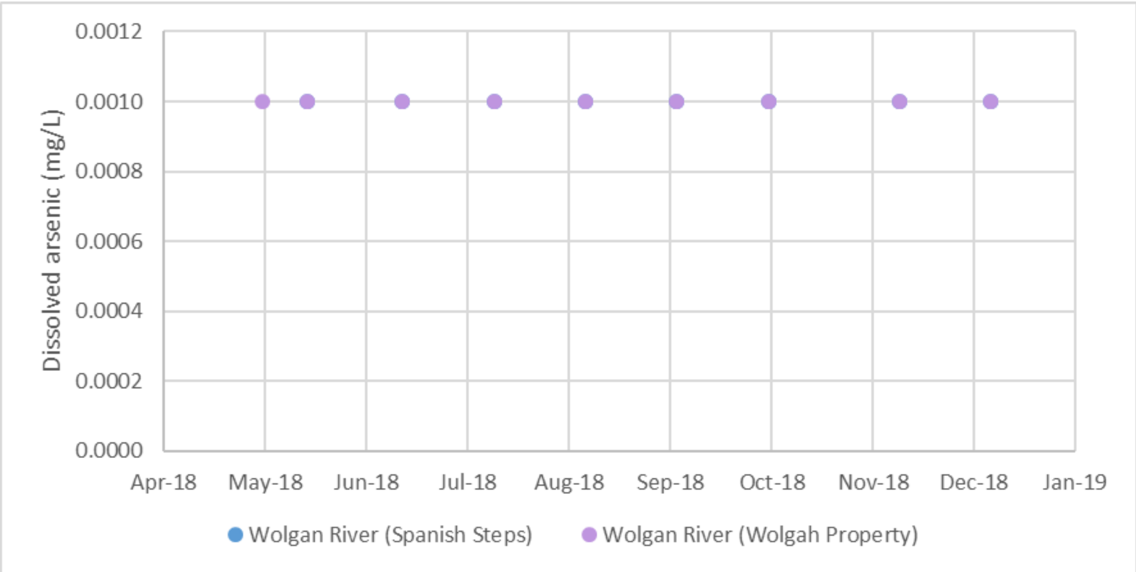
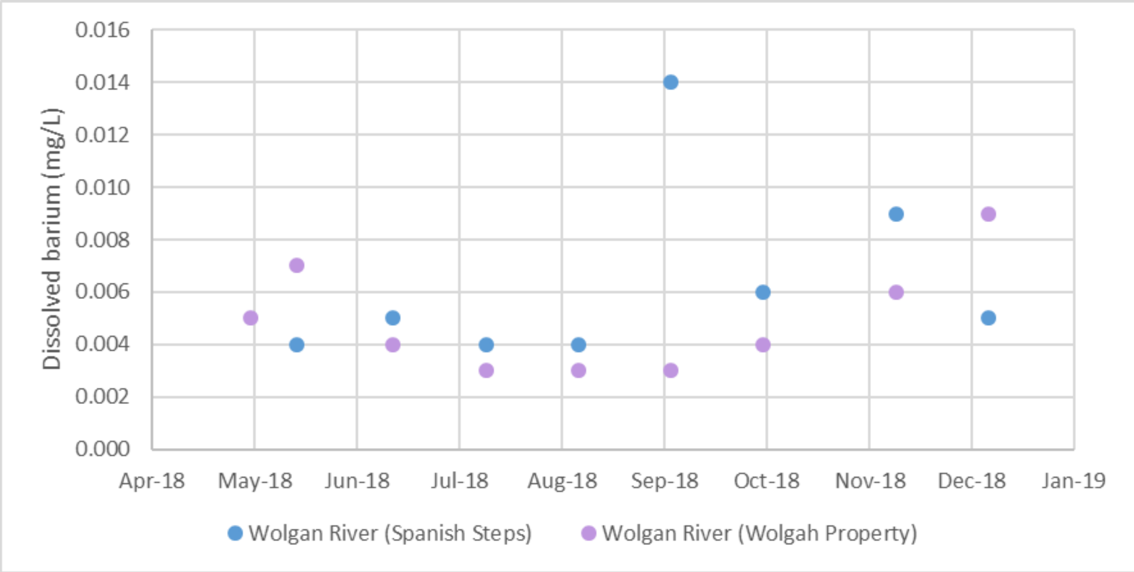

Total phosphorus (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

Dissolved metals








Dissolved barium (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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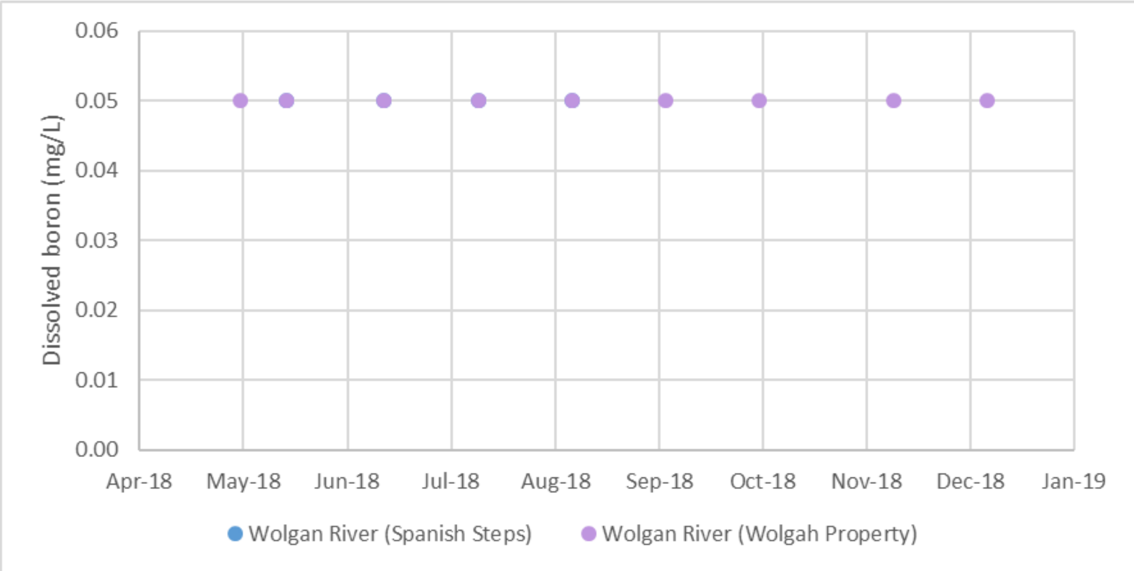
Dissolved boron (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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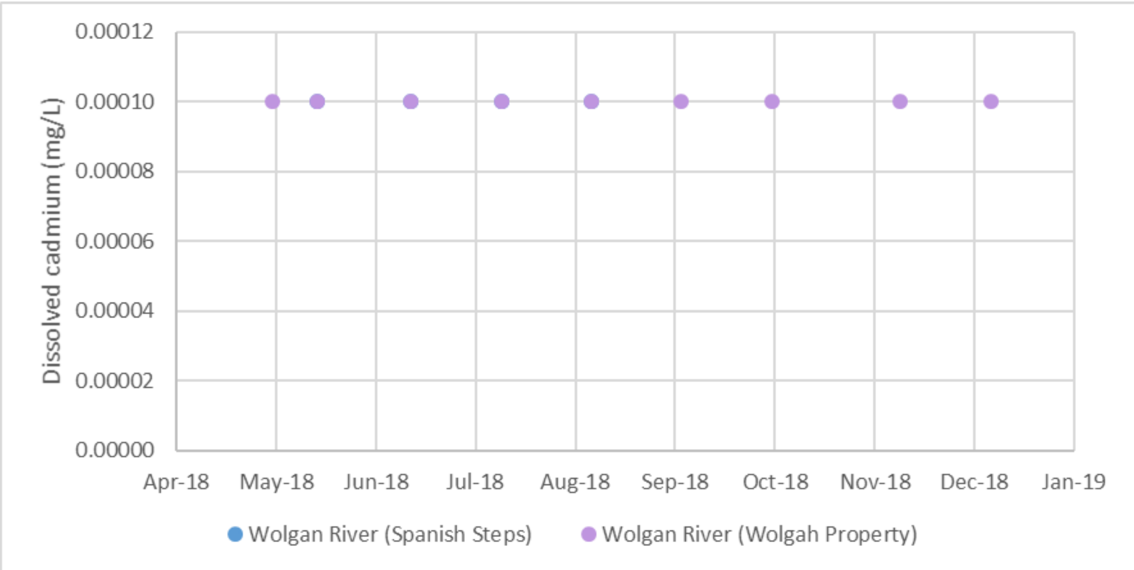
Dissolved cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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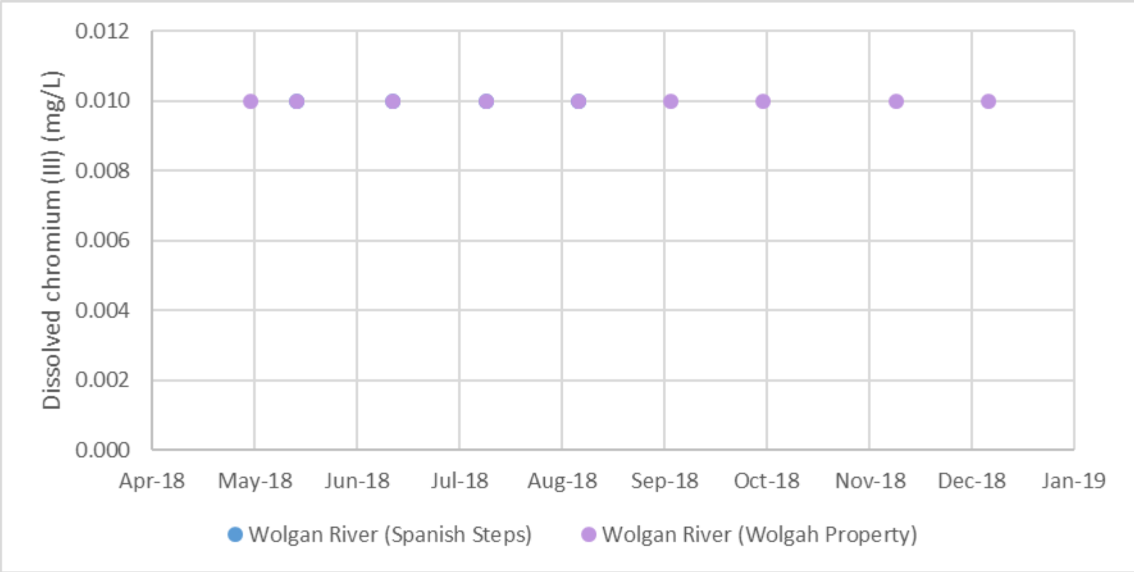
Dissolved chromium (III) (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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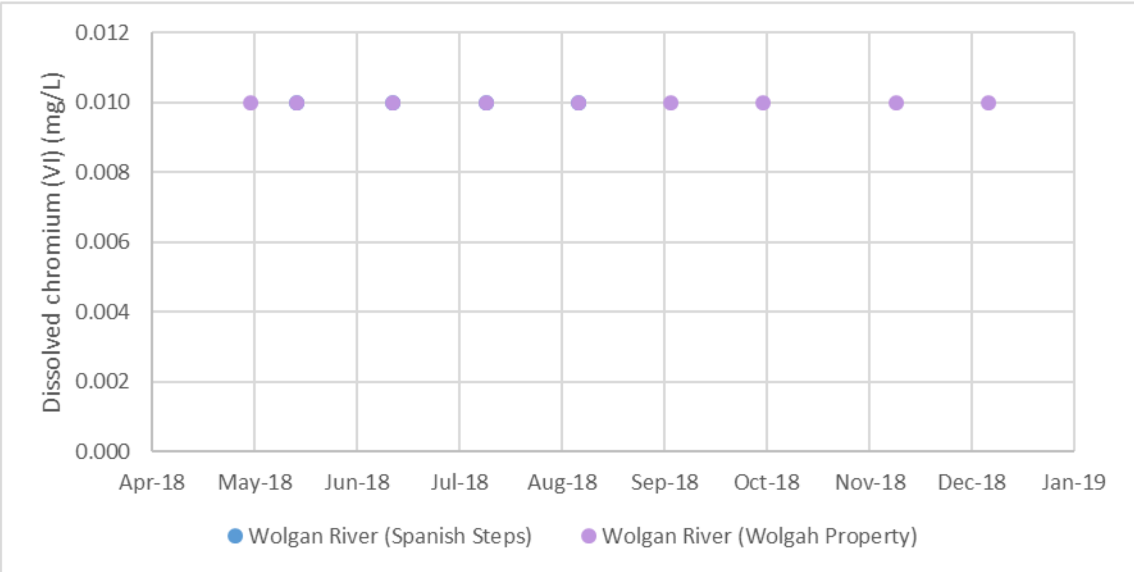
Dissolved chromium (VI) (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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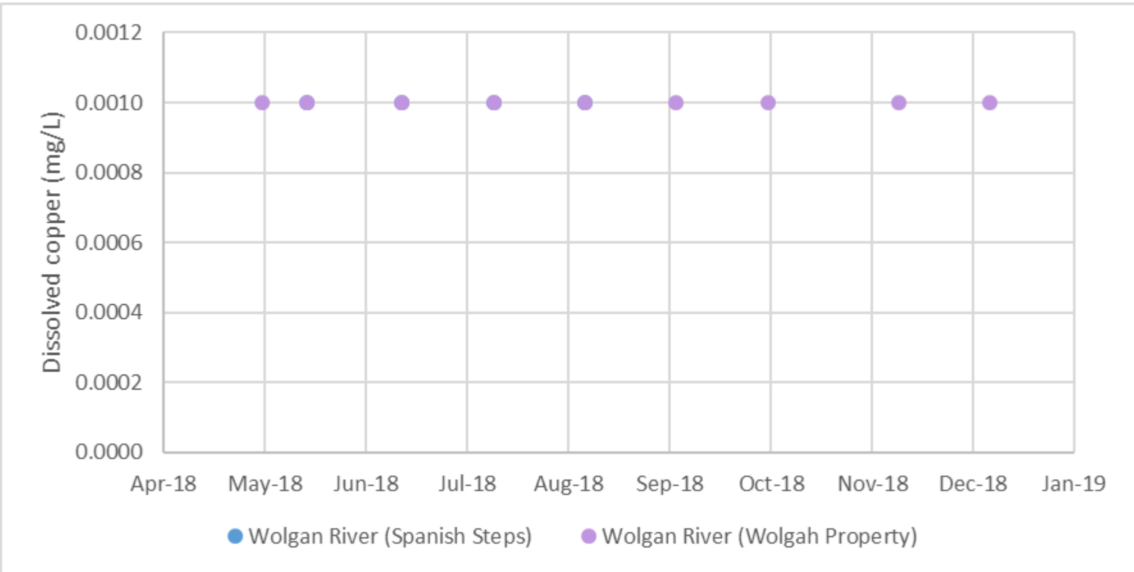
Dissolved copper (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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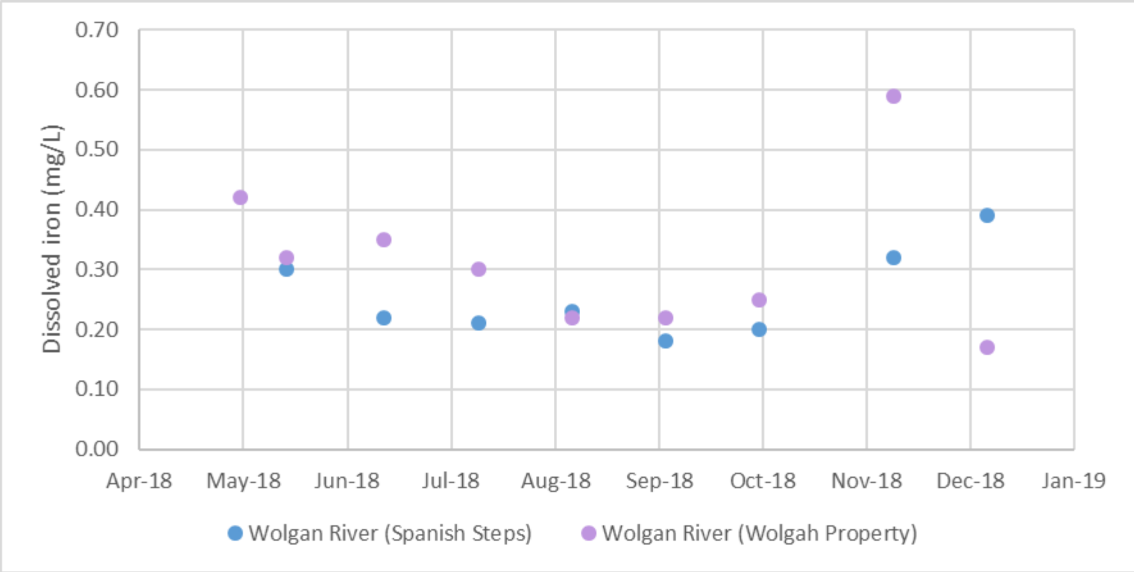

Dissolved iron (mg/L)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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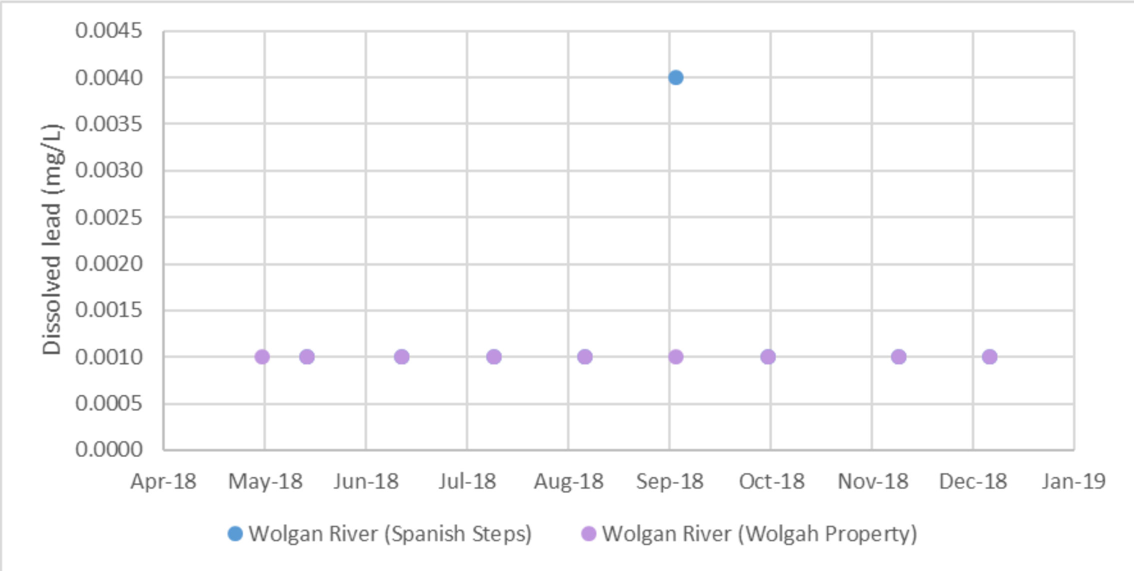

Dissolved lead (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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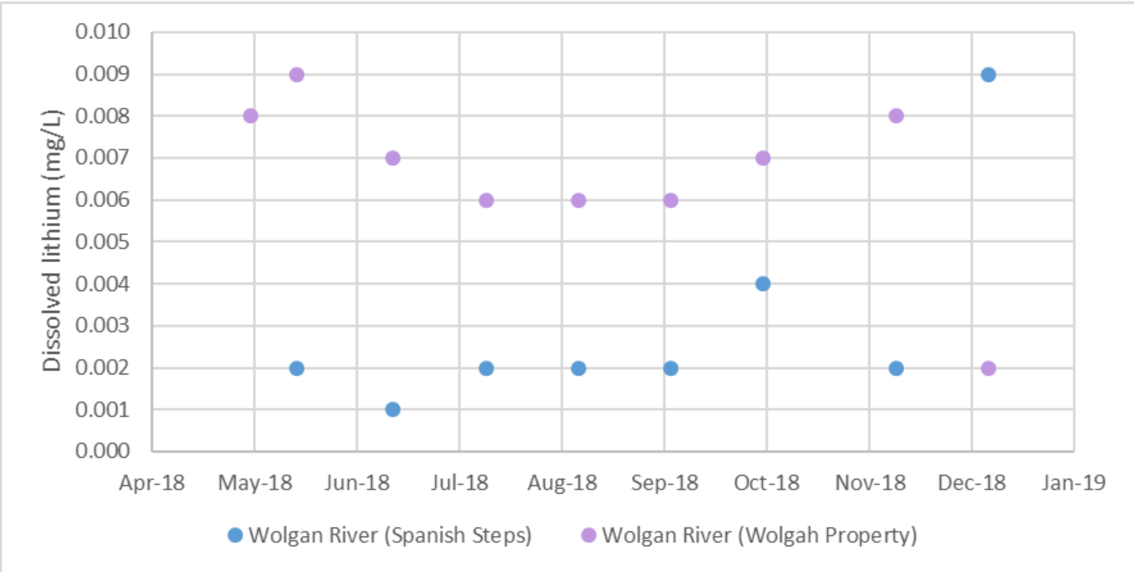

Dissolved lithium (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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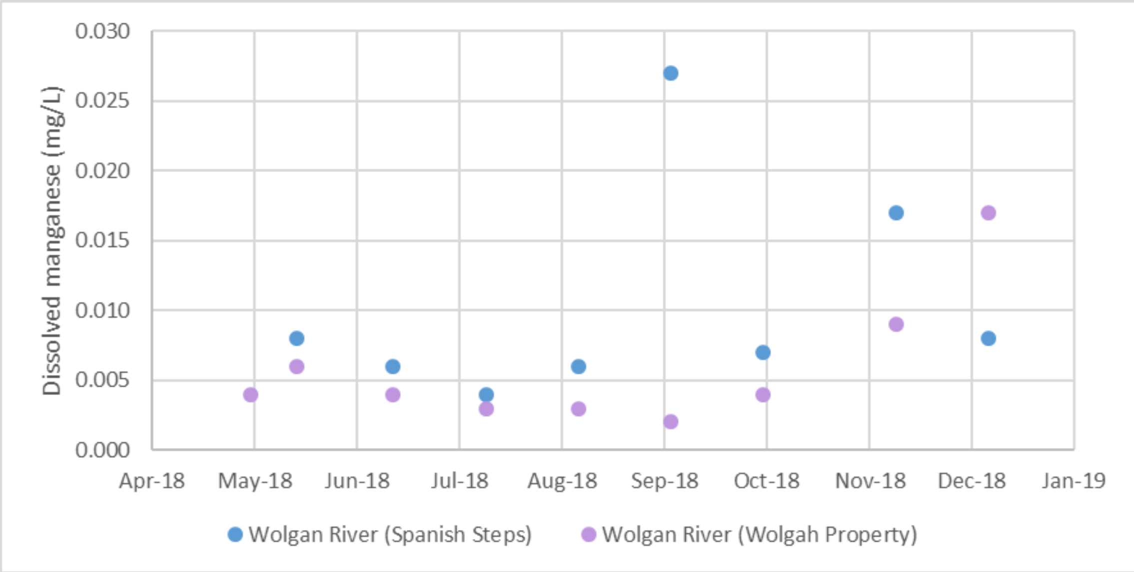
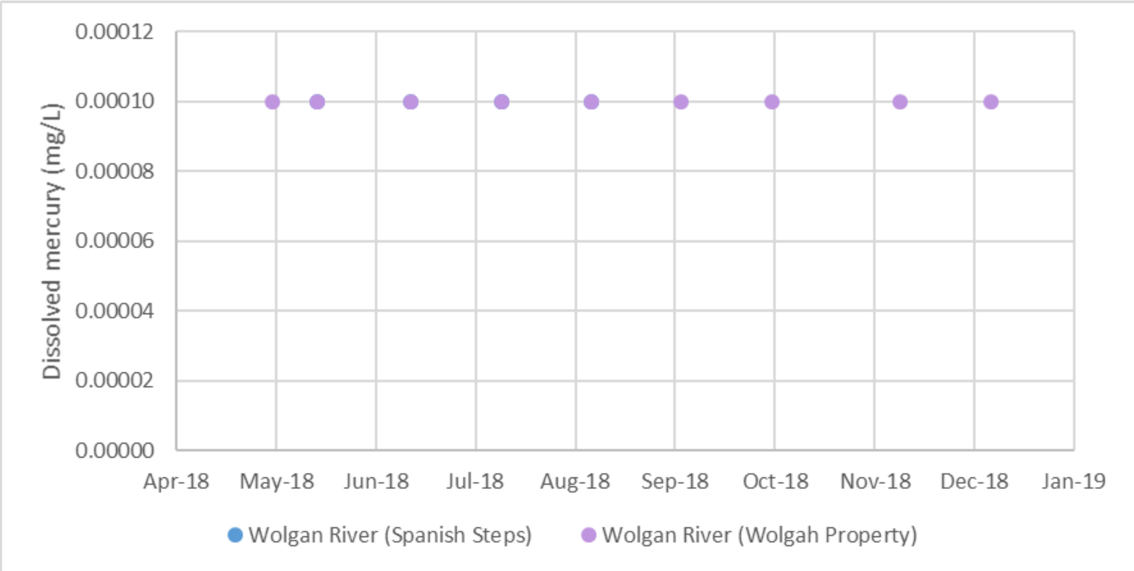

Dissolved manganese (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


Dissolved mercury (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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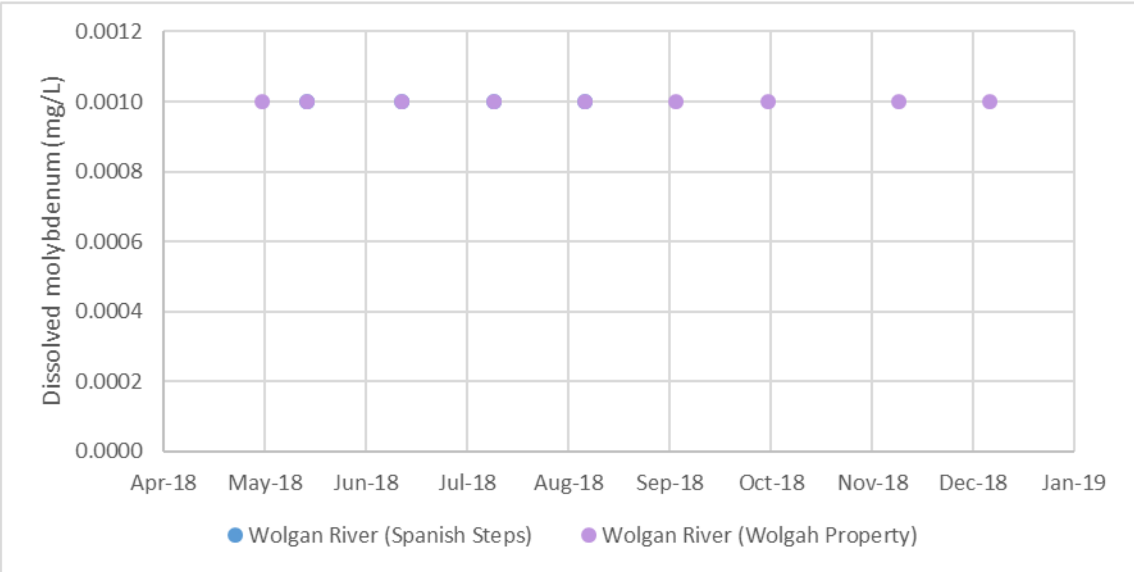
Dissolved molybdenum (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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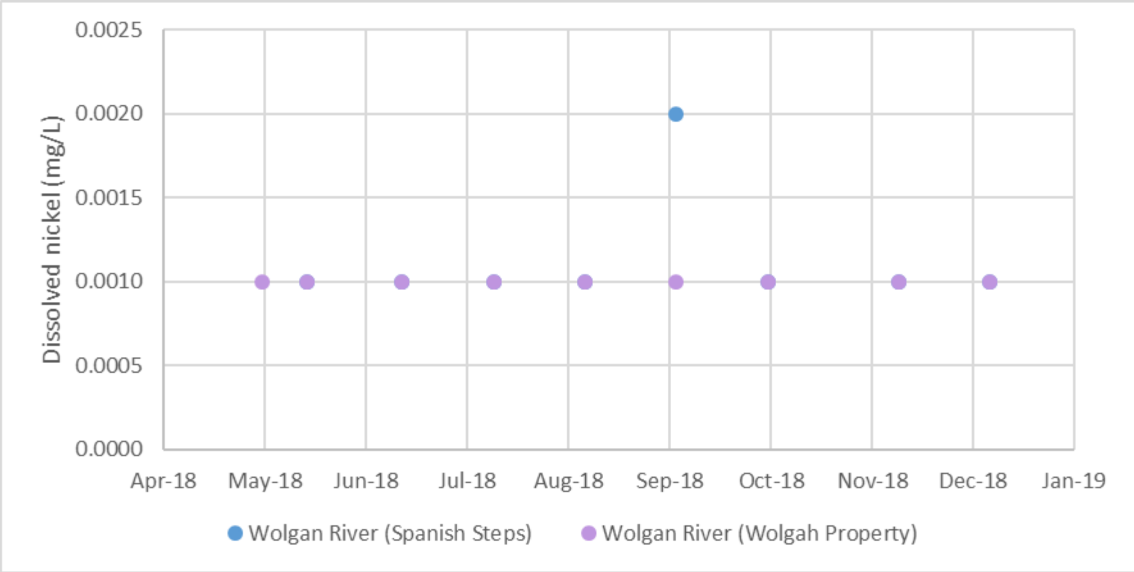
Dissolved nickel (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
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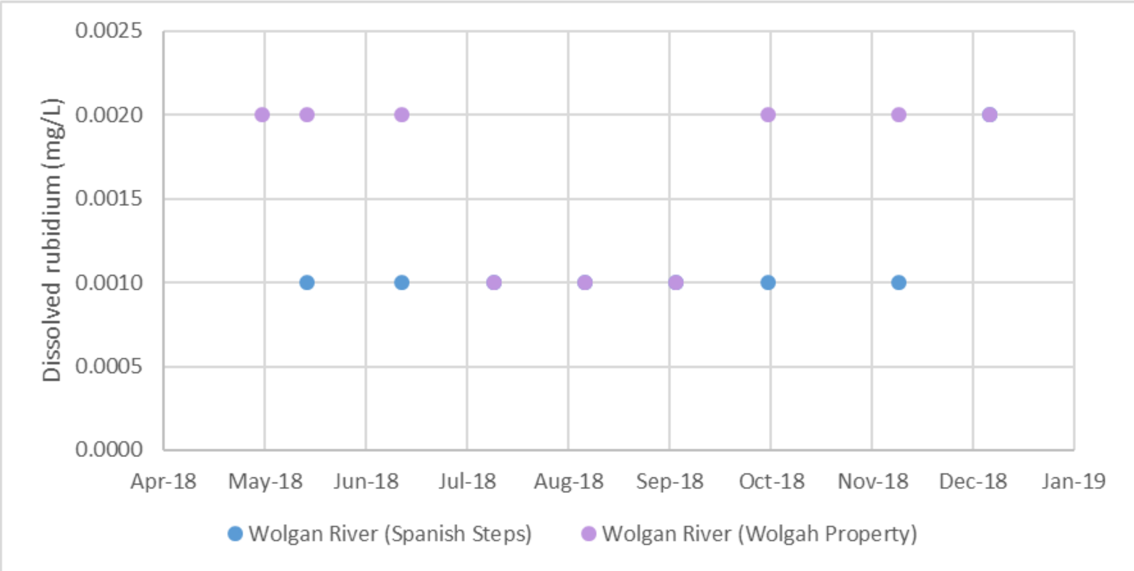
Dissolved rubidium (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
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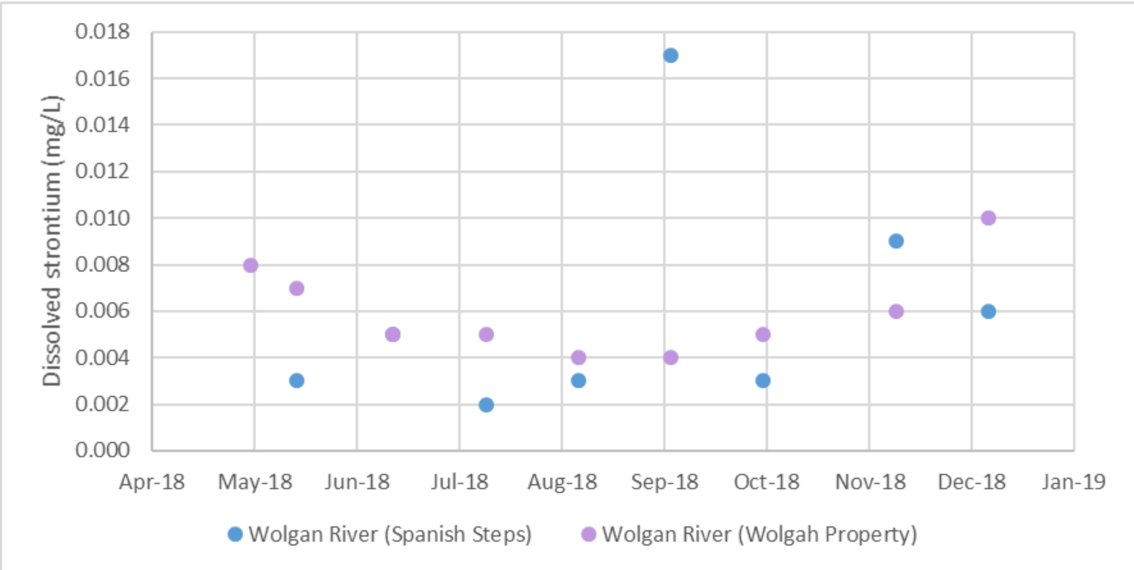
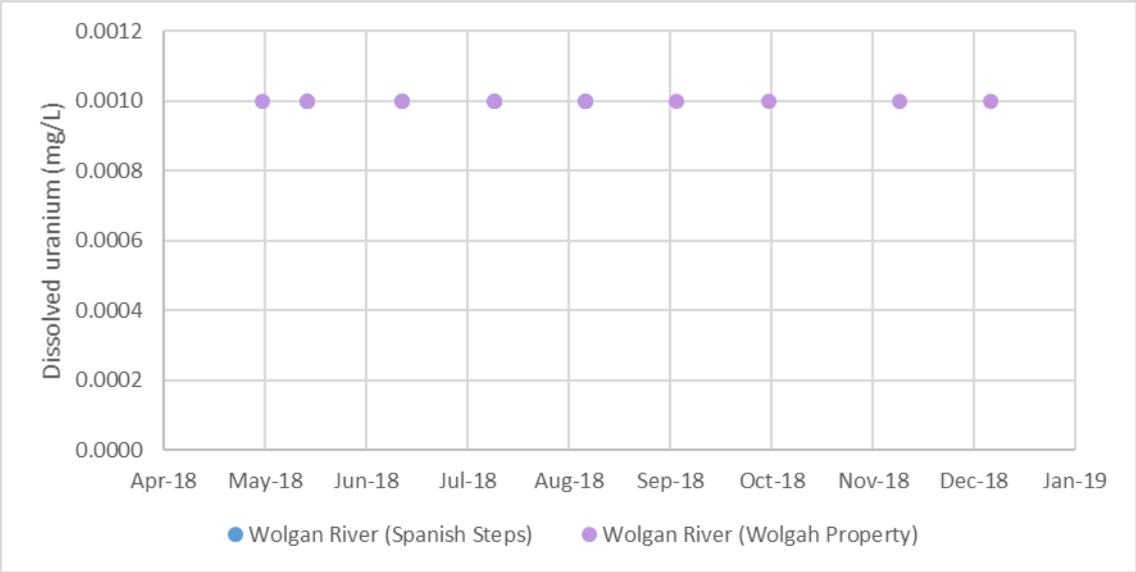
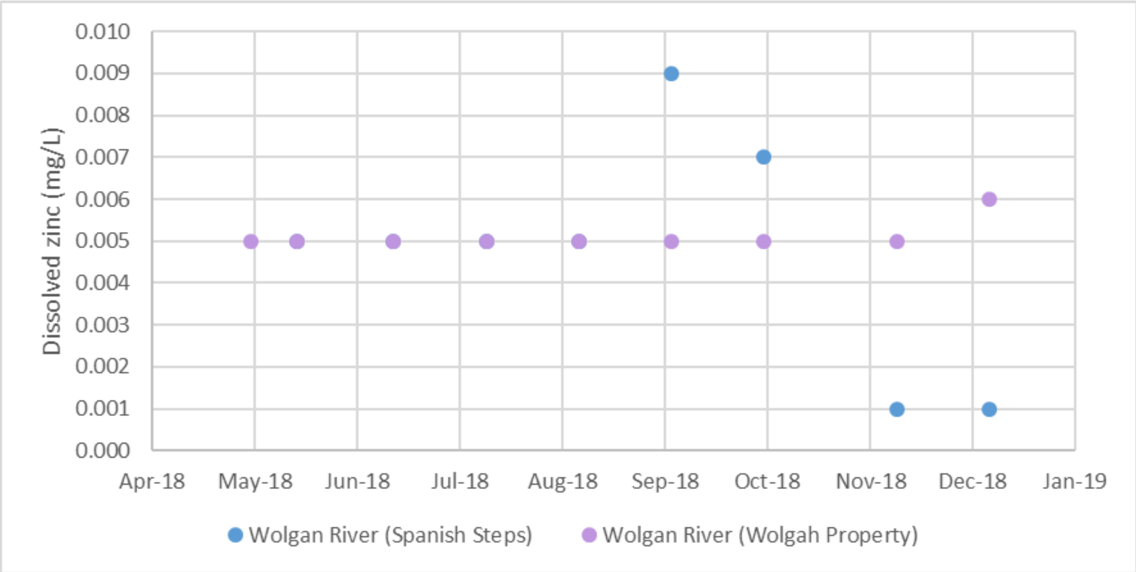
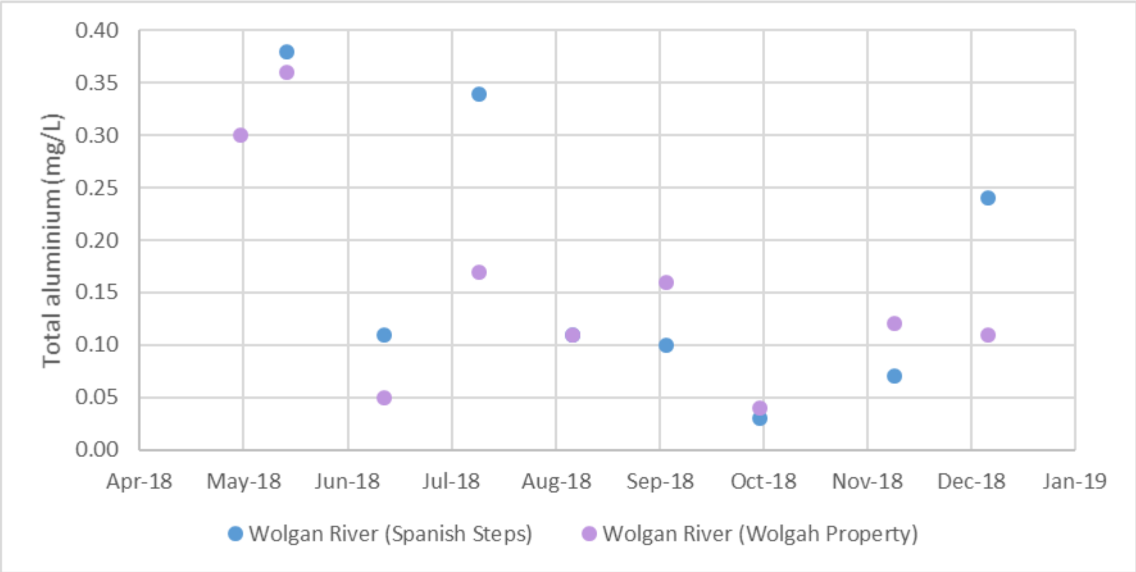
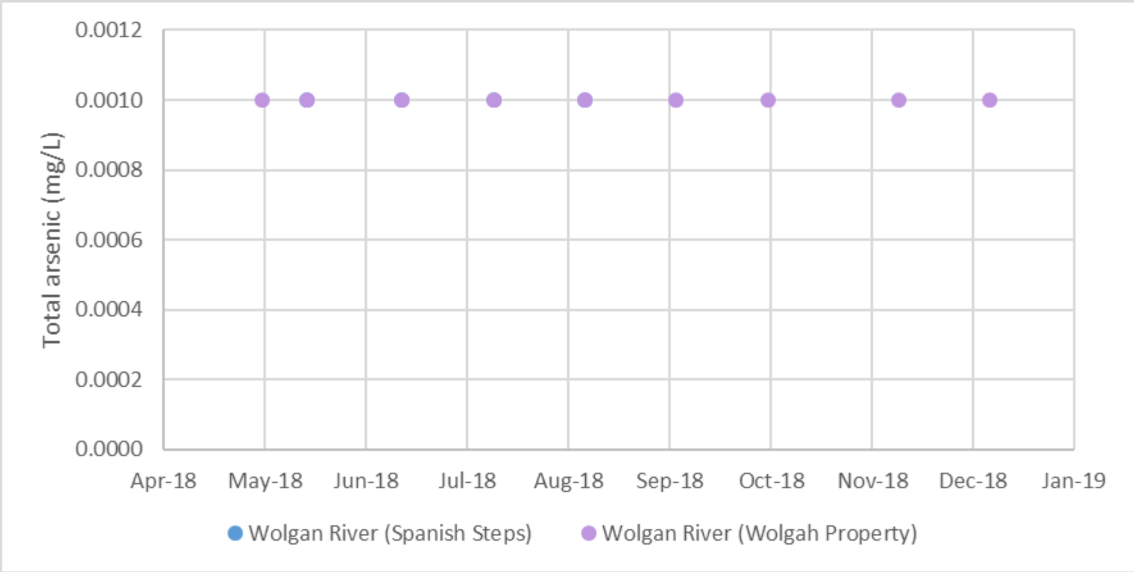

Dissolved strontium (mg/L)
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

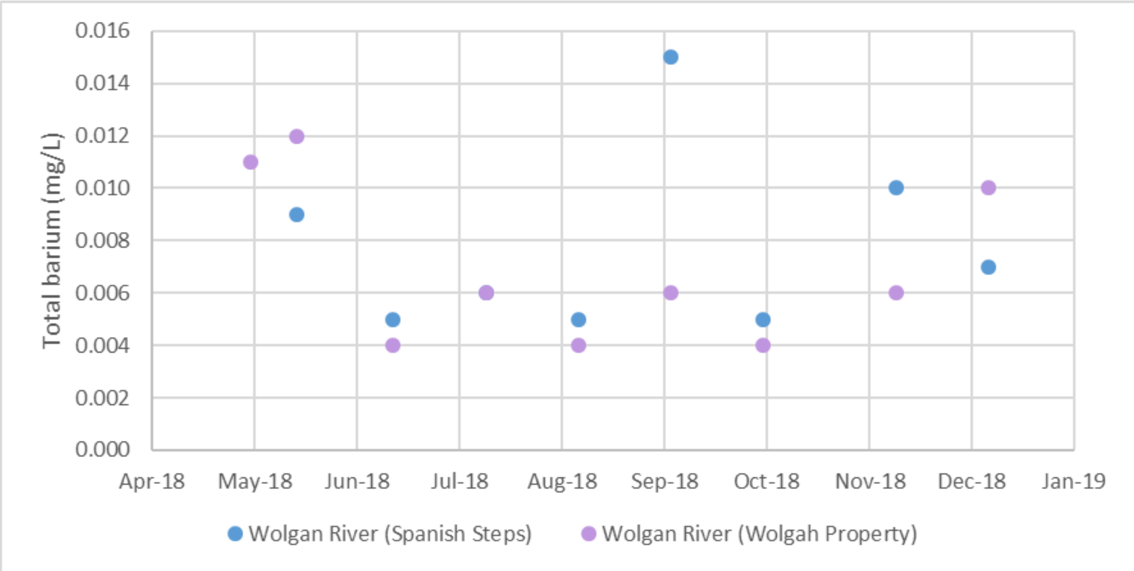


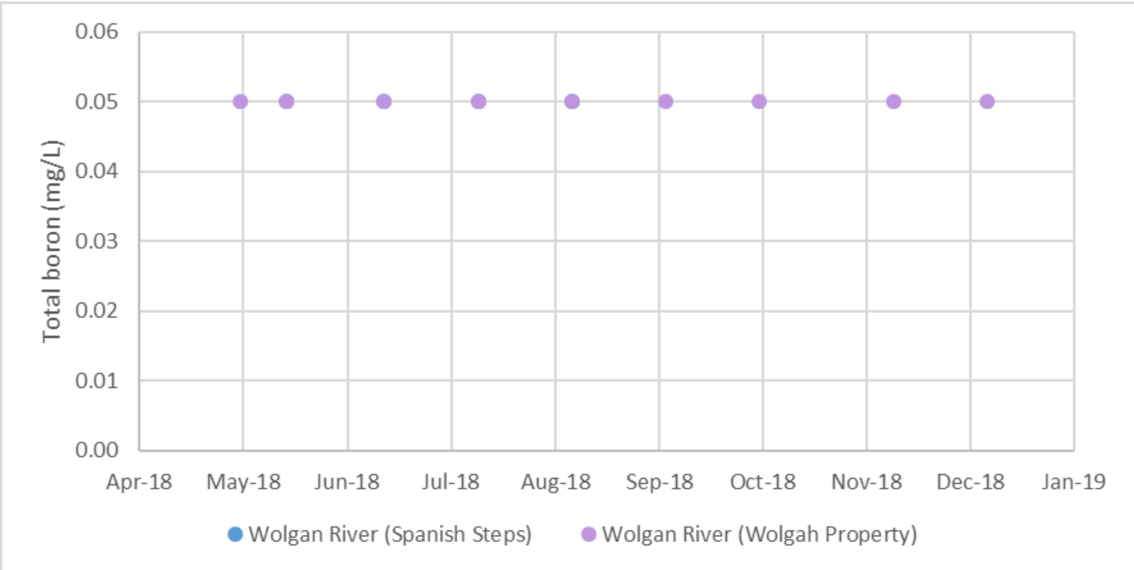


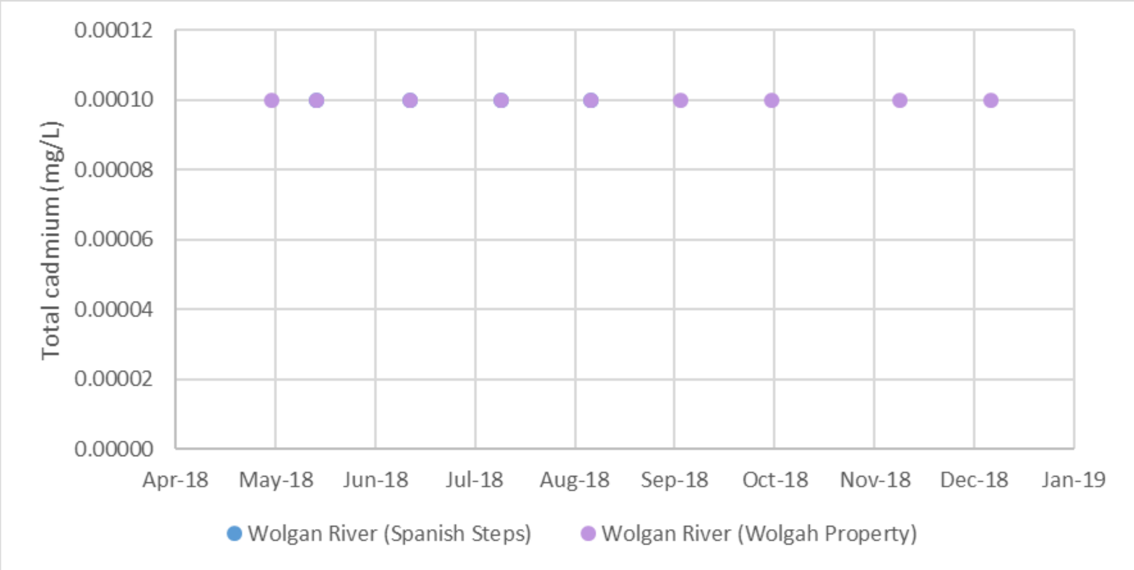
Total metals



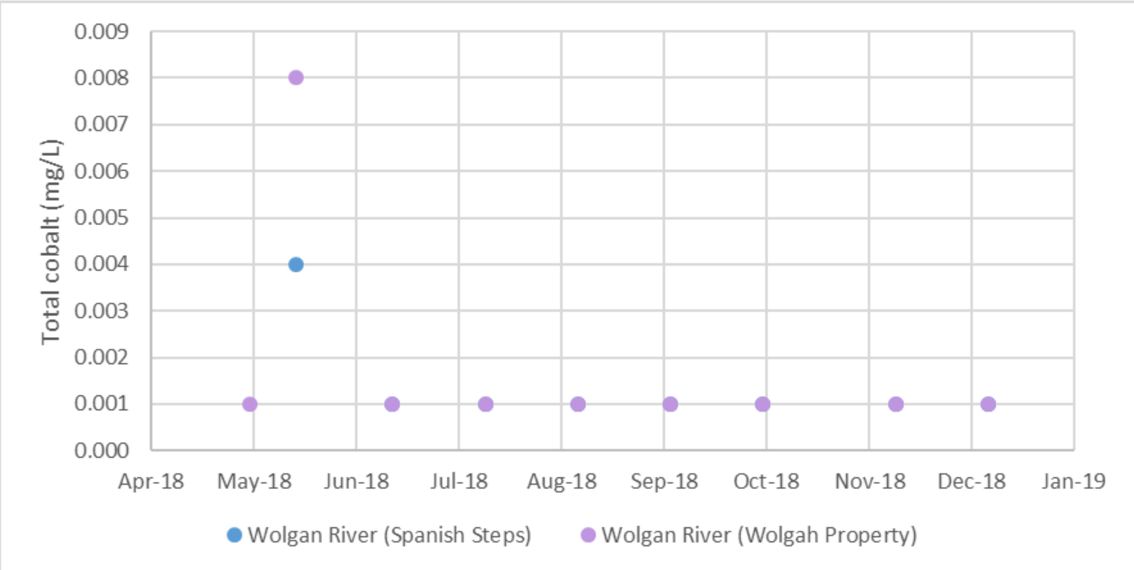

Total arsenic (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


Total barium (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

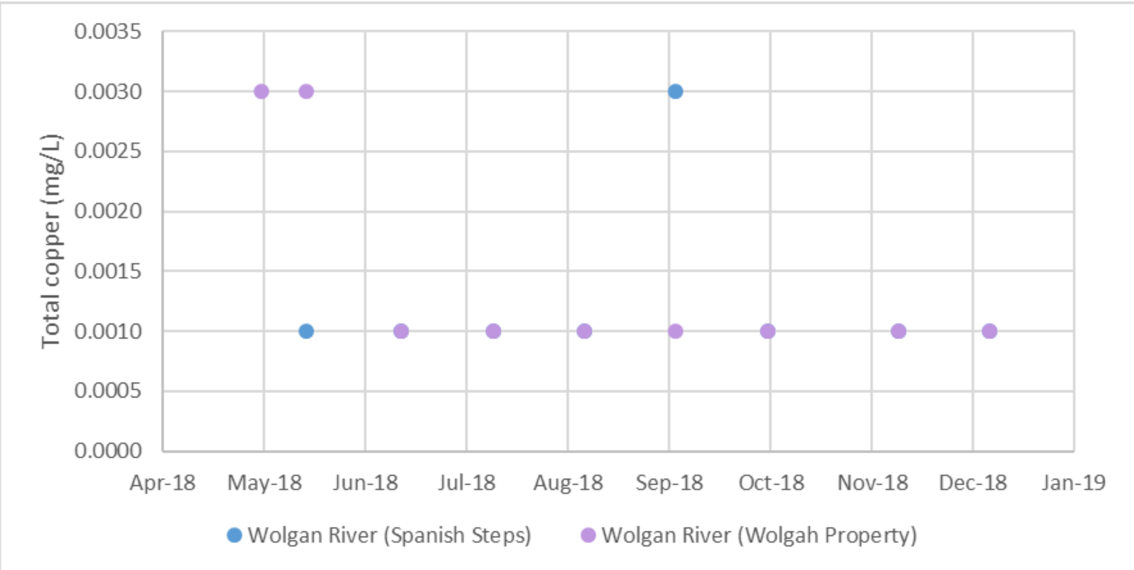

Total boron (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)



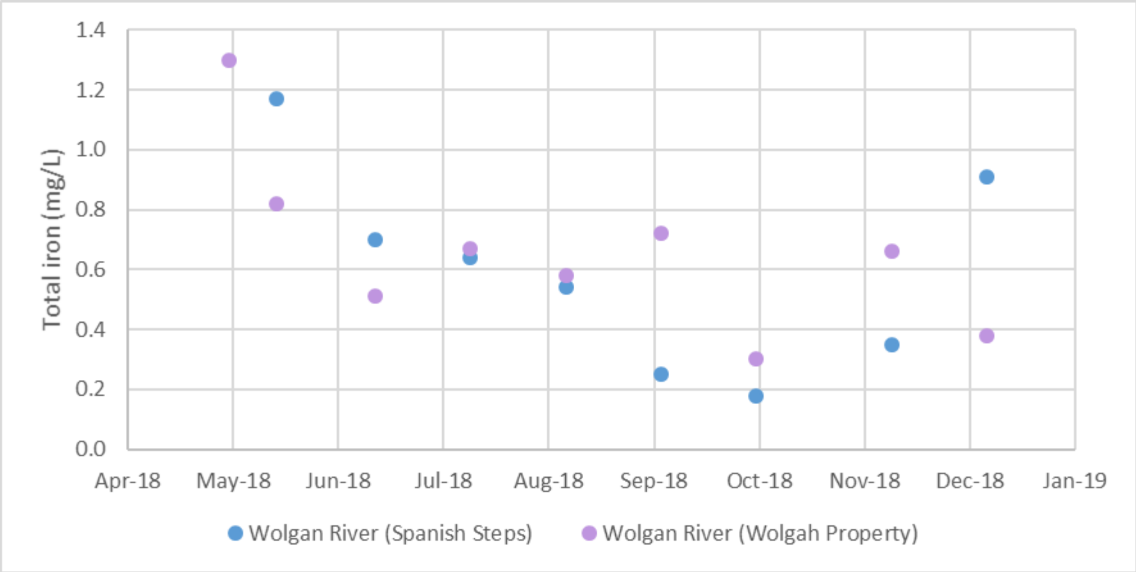
Total cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

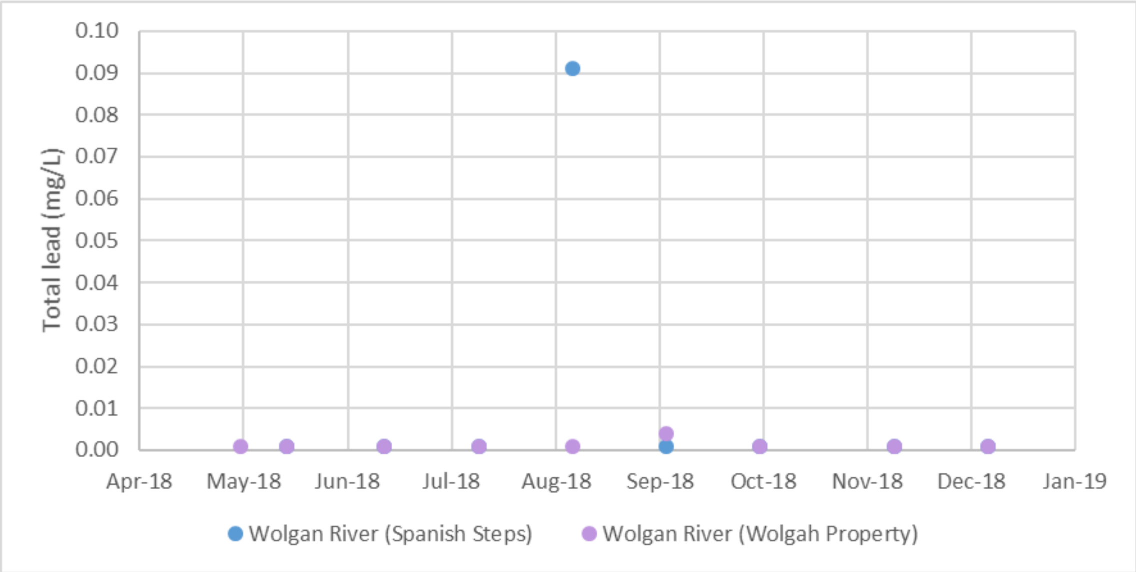


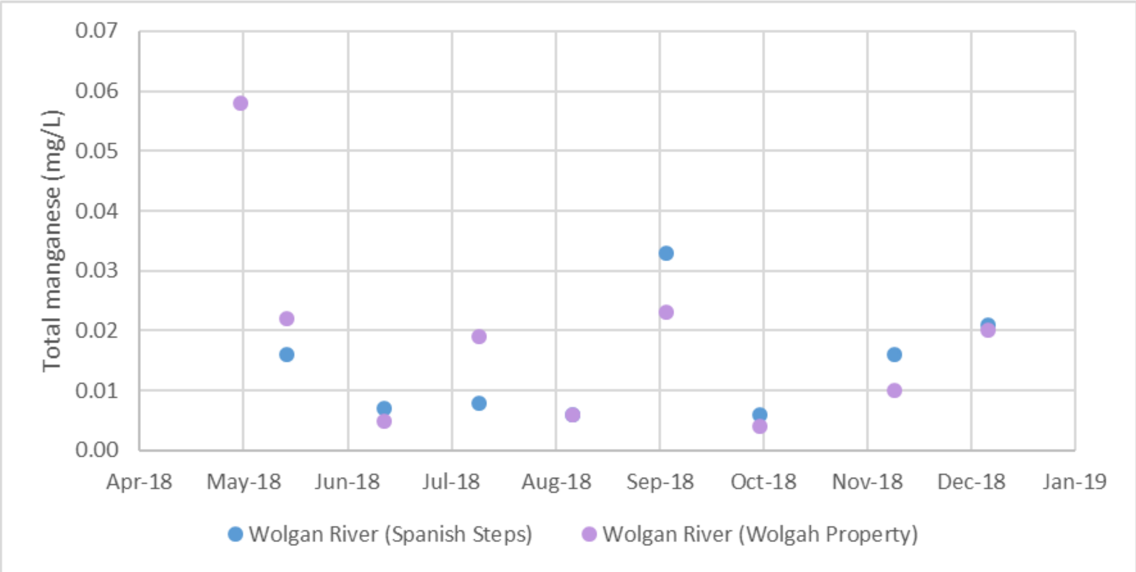
Total cobalt (mg/L)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

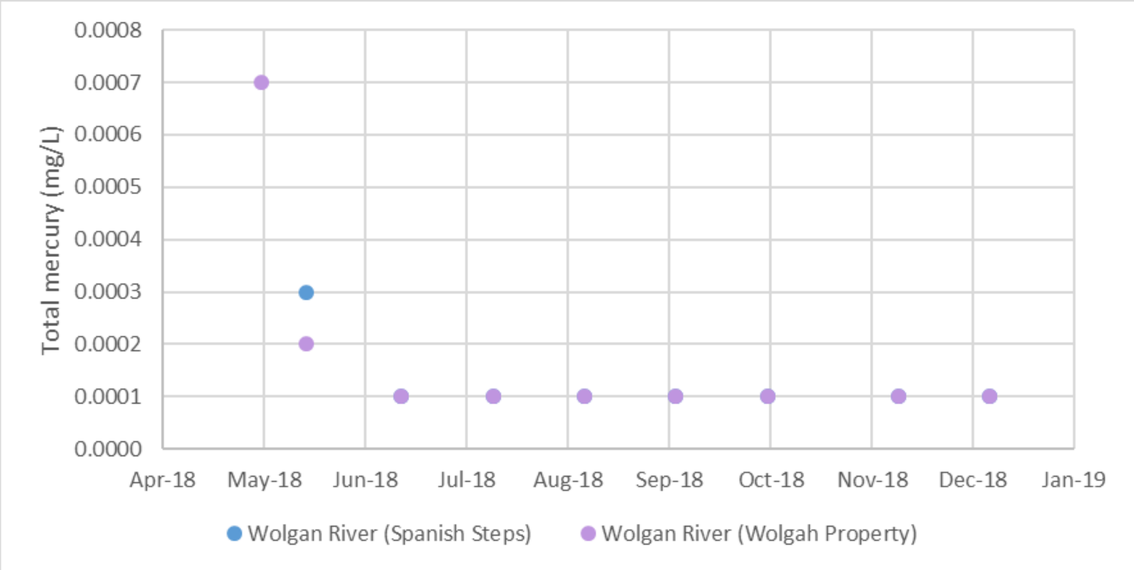


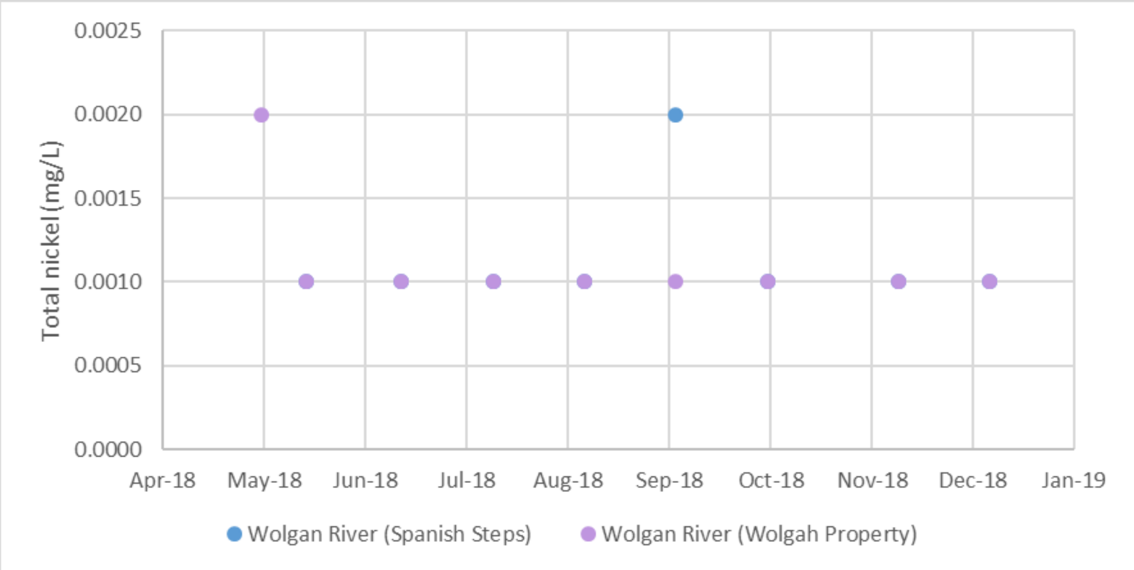
Total copper (mg/L)
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

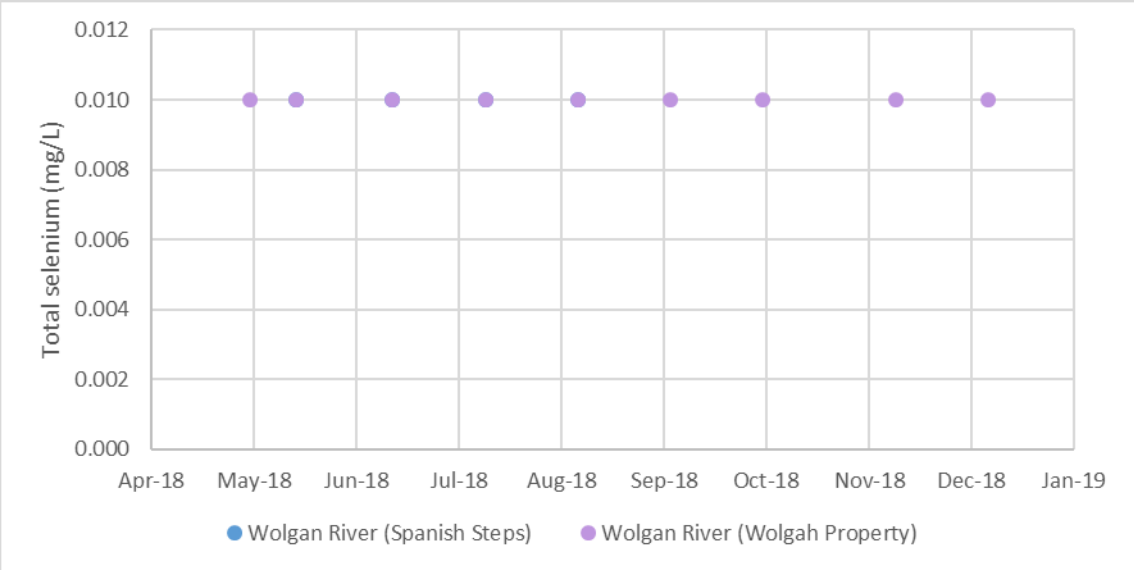

Total iron (mg/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

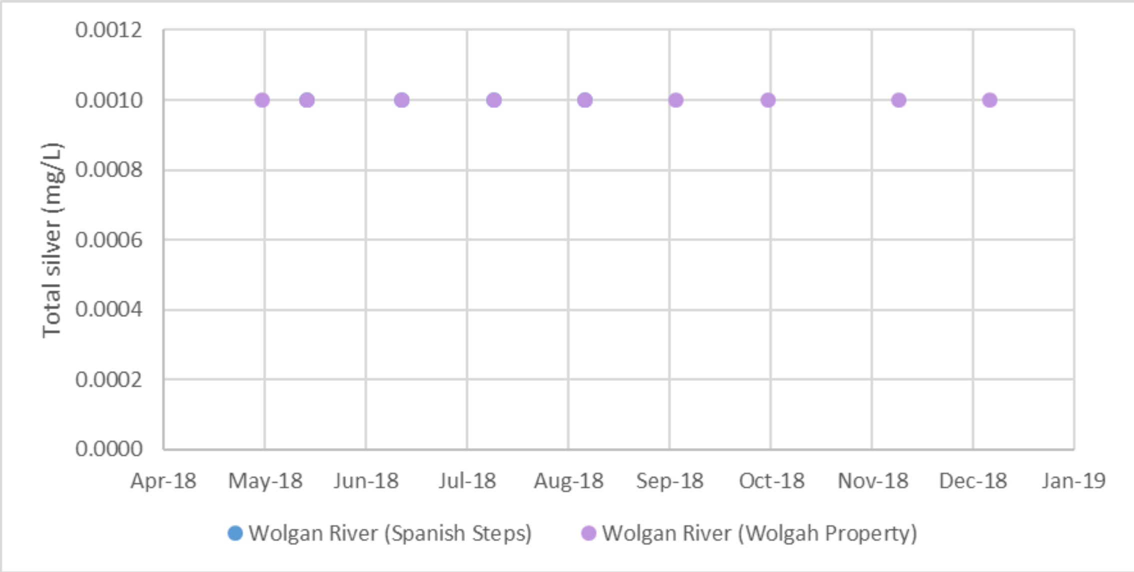

Total lead (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

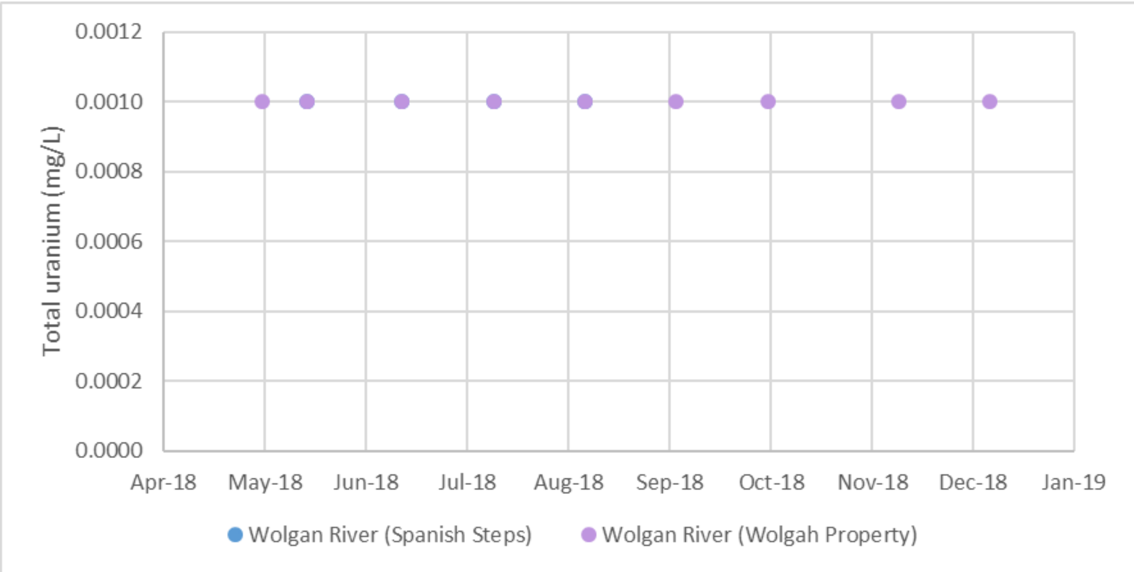

Total manganese (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

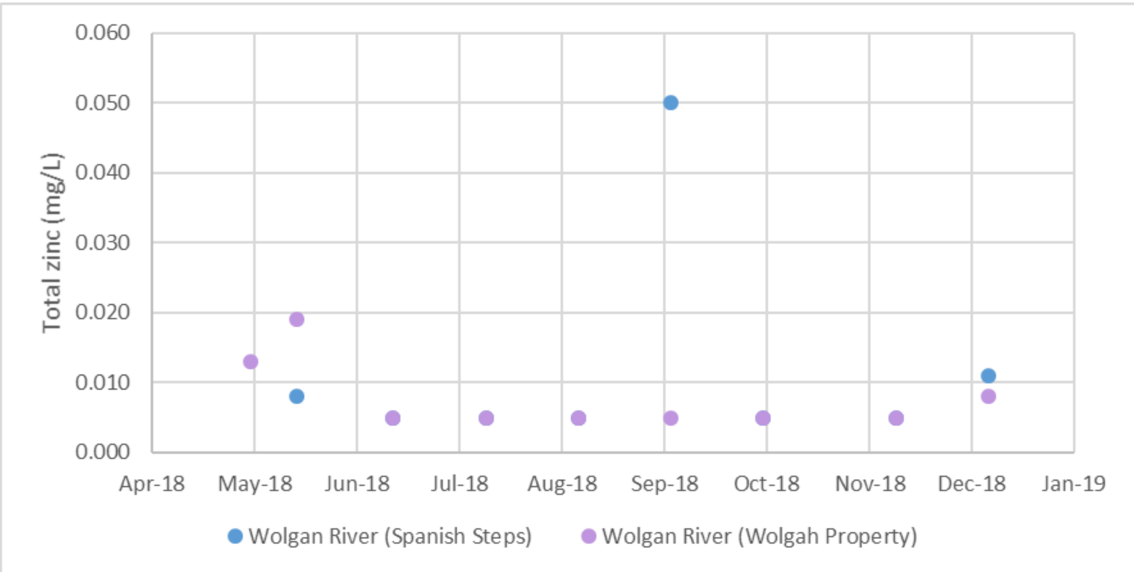

0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
Total mercury (mg/L)
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Total nickel (mg/L)
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

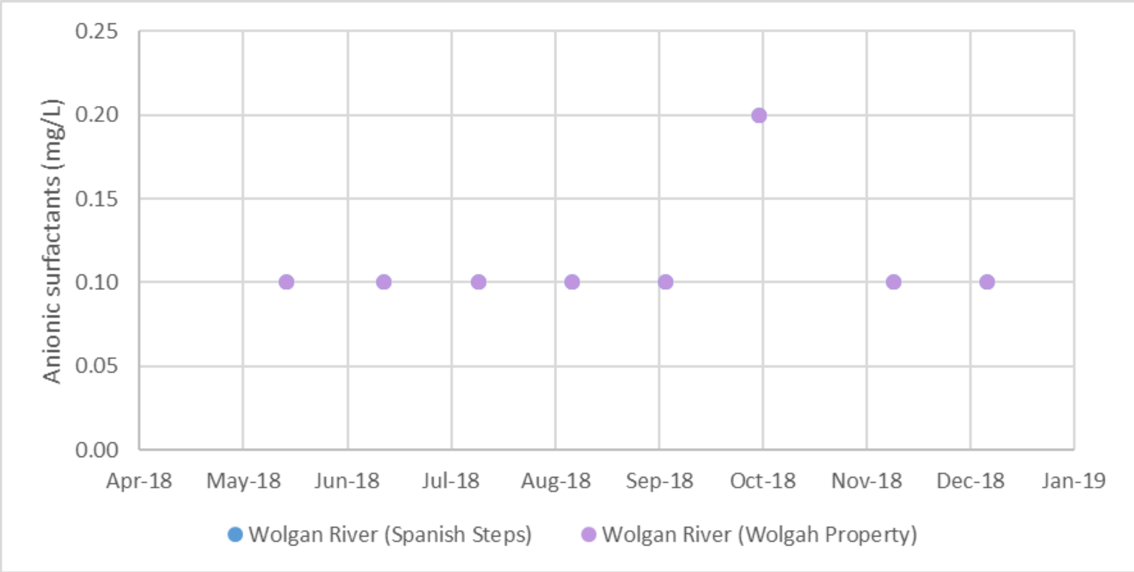

0.012
0.010
0.008
0.006
0.004
0.002
0.000
Total selenium (mg/L)
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


Total silver (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

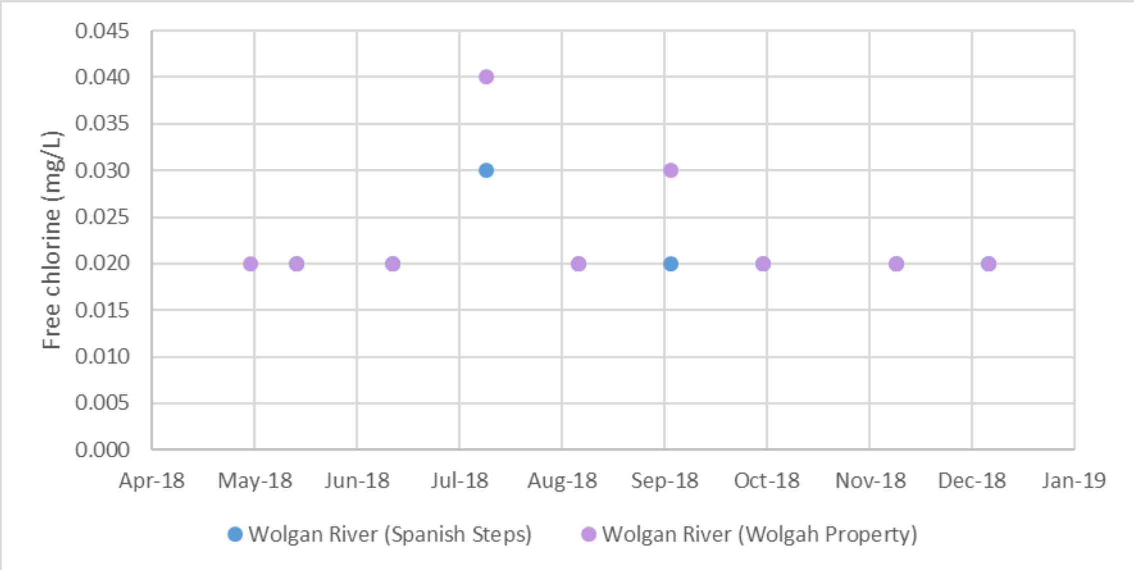

Total uranium (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


Total zinc (mg/L)
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

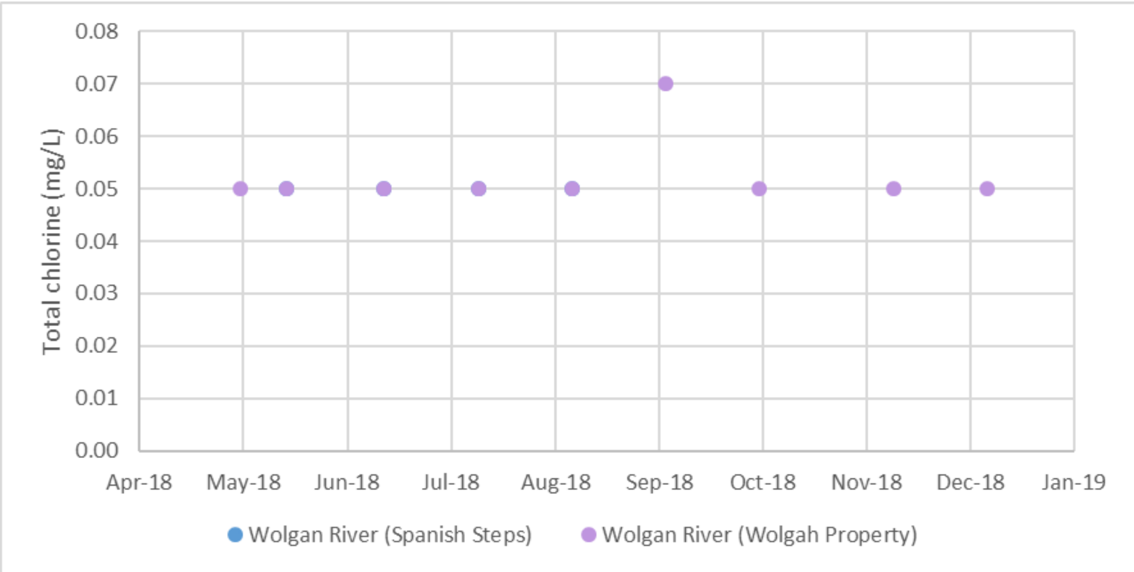
Other



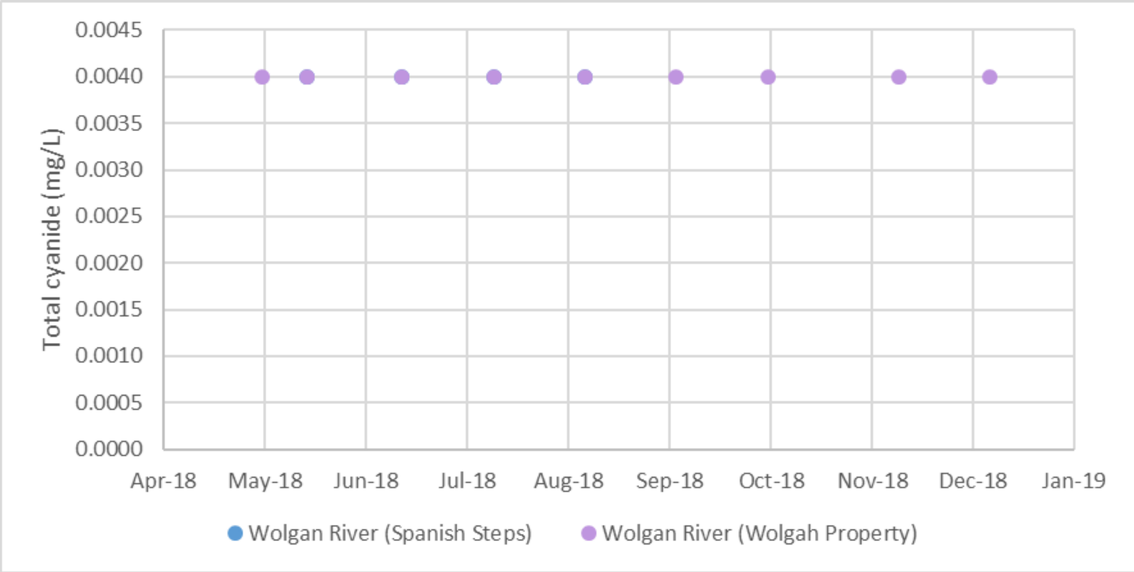
Anionic surfactants (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

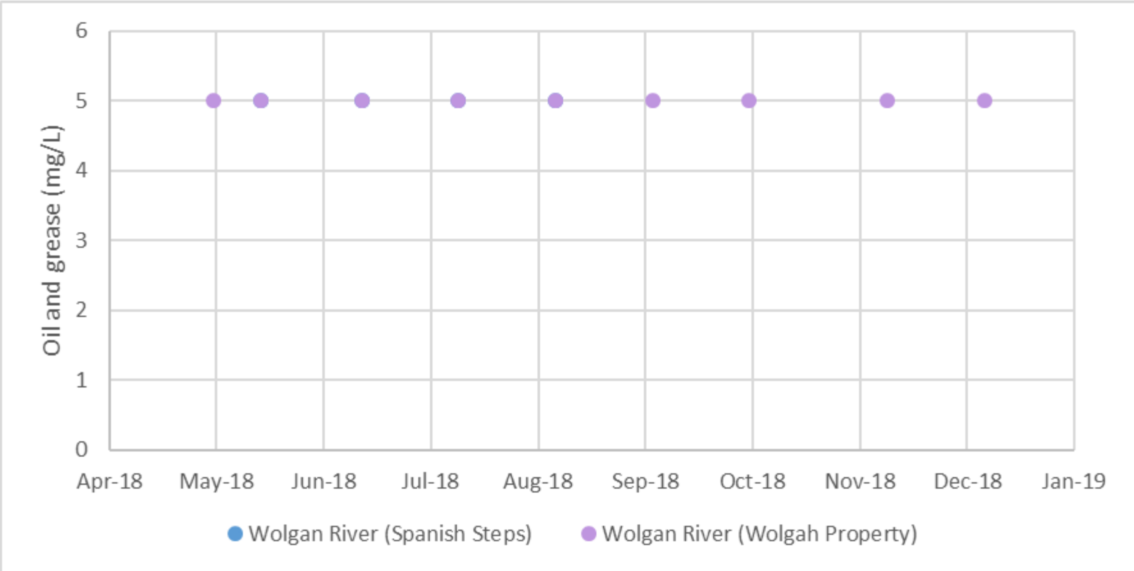


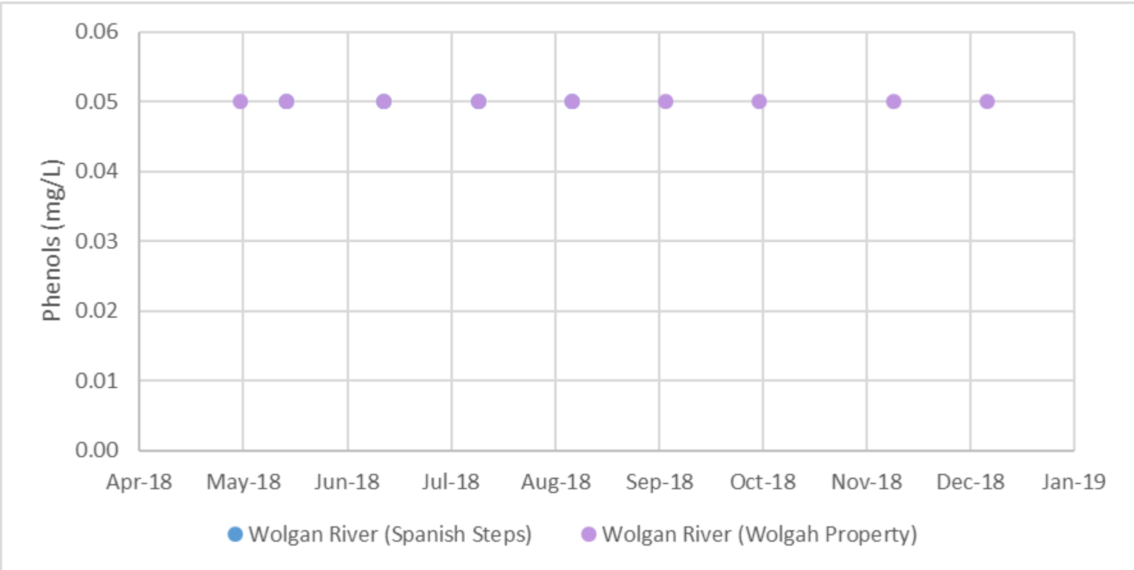
Free chlorine (mg/L)
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

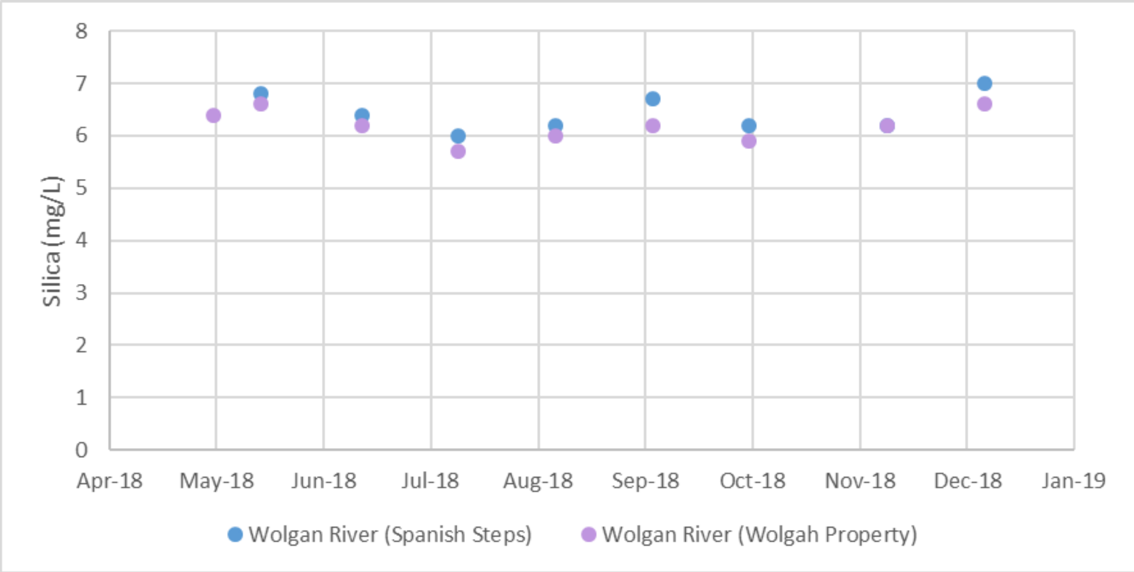


Total chlorine (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

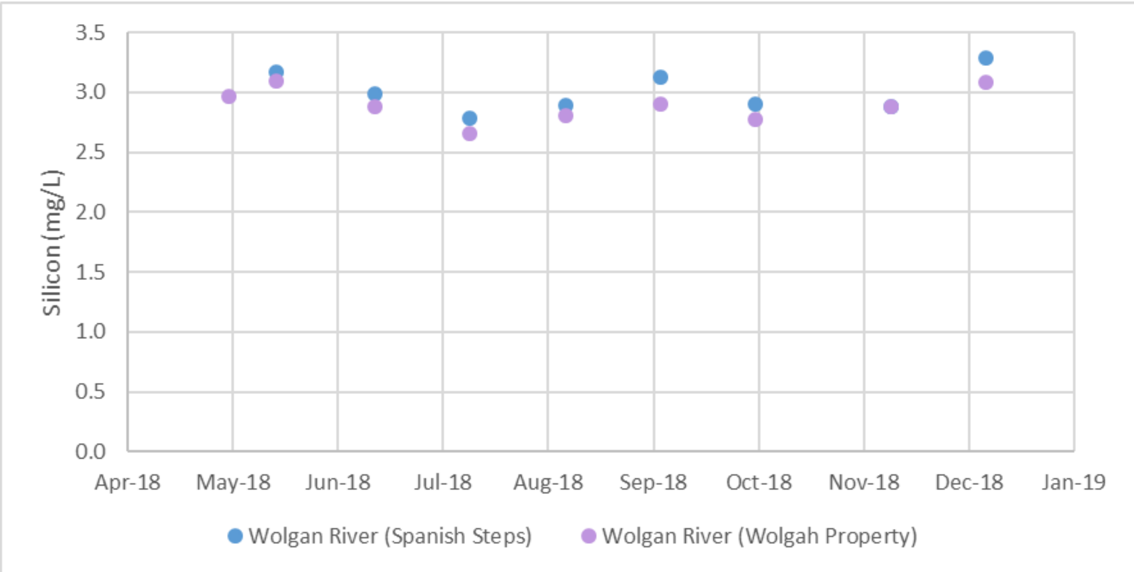

Total cyanide (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Apr-18 May-18 Jun-18 Jul-18 Aug-18 Sep-18 Oct-18 Nov-18 Dec-18 Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)


Oil and grease (mg/L)
6
5
4
3
2
1
0
Apr-18 May-18 Jun-18 Jul-18 Aug-18 Sep-18 Oct-18 Nov-18 Dec-18 Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

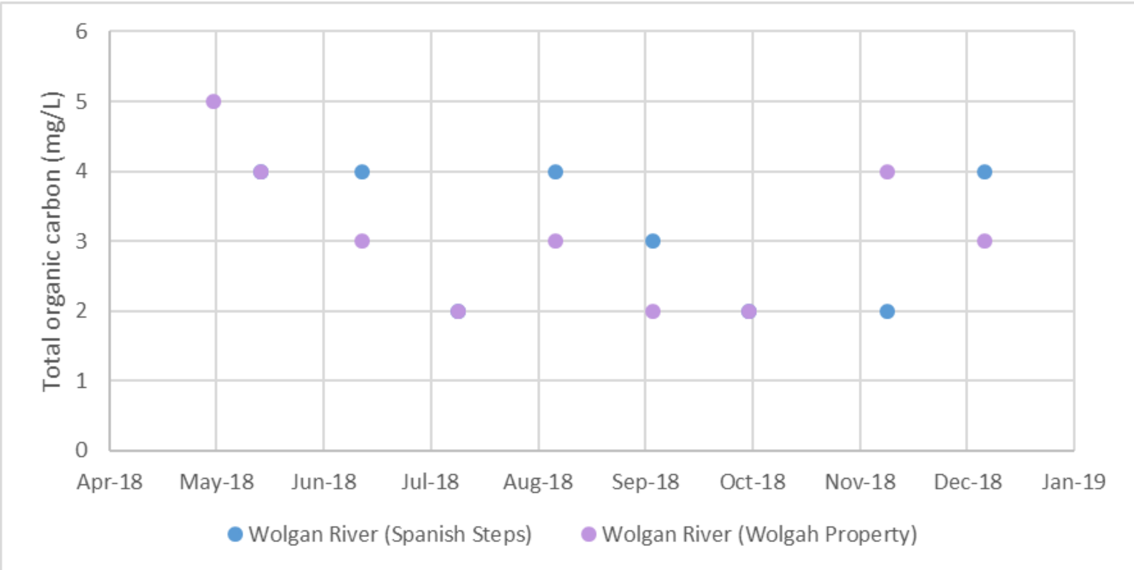

Phenols (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apr-18 May-18 Jun-18 Jul-18 Aug-18 Sep-18 Oct-18 Nov-18 Dec-18 Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)



Silica (mg/L)
8
7
6
5
4
3
2
1
0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)



Silicon (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)



Total organic carbon (mg/L)
6
5
4
3
2
1
0
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Wolgan River (Spanish Steps)
Wolgan River (Wolgah Property)

E.1.5 Swamps

Statistical summary of water quality results

Parameter	Units	Narrow Swamp U/S		Narrow Swamp D/S		Tri Star Swamp		Twin Gully Swamp	
		Count	Median	Count	Median	Count	Median	Count	Median
Physicochemical									
DO	mg/L	–	–	–	–	71	9.4	60	9.2
EC	µS/cm	8	66	10	111	70	23	68	25
pH	pH units	8	6.5	10	6.2	72	6.2	70	6.5
TDS	mg/L	–	–	–	–	71	23	69	25
TSS	mg/L	7	160	9	8	72	5	70	8
Turbidity	NTU	–	–	–	–	72	4	70	5
Major ions									
Bicarbonate alkalinity	mg/L	–	–	–	–	71	1	69	1
Carbonate alkalinity	mg/L	–	–	–	–	71	1	69	1
Hydroxide alkalinity	mg/L	–	–	–	–	71	1	69	1
Total alkalinity	mg/L	–	–	–	–	71	1	69	1
Calcium	mg/L	–	–	–	–	71	1	69	1
Chloride	mg/L	–	–	–	–	71	5	69	5
Magnesium	mg/L	–	–	–	–	71	1	69	1
Potassium	mg/L	–	–	–	–	71	1	69	1
Sodium	mg/L	–	–	–	–	71	3	69	3
Sulfate	mg/L	–	–	–	–	71	1	69	1
Total hardness	mg/L	–	–	–	–	71	1	69	1

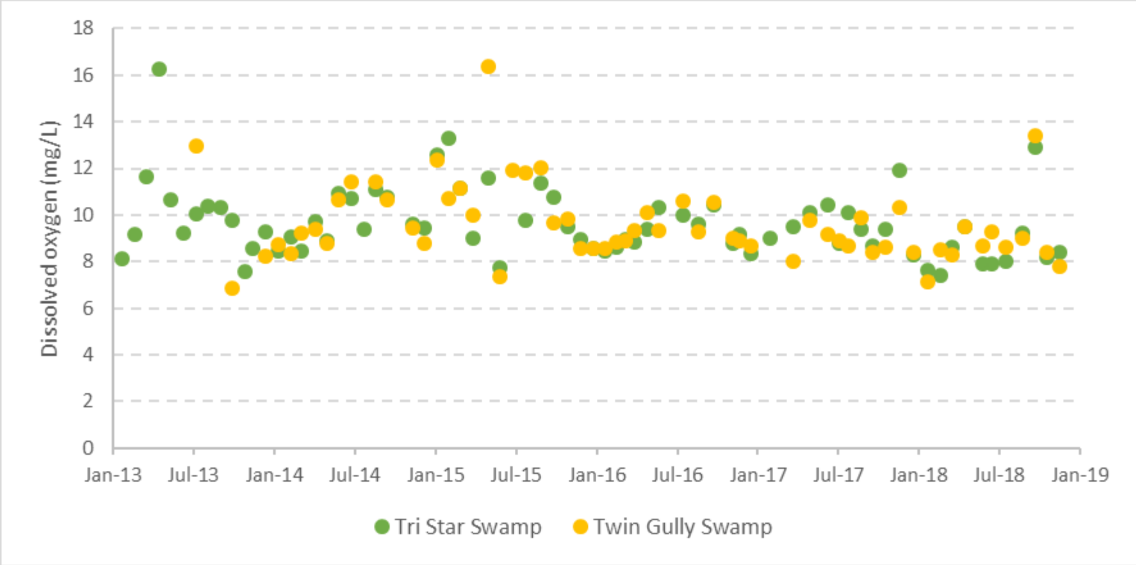
Parameter	Units	Narrow Swamp U/S		Narrow Swamp D/S		Tri Star Swamp		Twin Gully Swamp	
		Count	Median	Count	Median	Count	Median	Count	Median
Nutrients									
Ammonia	mg/L	–	–	–	–	71	0.01	69	0.01
Nitrate	mg/L	–	–	–	–	71	0.01	69	0.01
Nitrite	mg/L	–	–	–	–	71	0.01	69	0.01
Nitrate + nitrite	mg/L	–	–	–	–	71	0.01	69	0.01
Total fluoride	mg/L	–	–	–	–	71	0.1	69	0.1
TKN	mg/L	–	–	–	–	71	0.1	69	0.2
Total nitrogen	mg/L	–	–	–	–	71	0.1	69	0.2
Total phosphorus	mg/L	–	–	–	–	71	0.01	69	0.01
Dissolved metals									
Aluminium	mg/L	–	–	–	–	71	0.05	69	0.09
Antimony	mg/L	–	–	–	–	71	0.001	69	0.001
Arsenic	mg/L	–	–	–	–	71	0.001	69	0.001
Barium	mg/L	–	–	–	–	71	0.006	69	0.004
Boron	mg/L	–	–	–	–	71	0.05	69	0.05
Cadmium	mg/L	–	–	–	–	71	0.0001	69	0.0001
Copper	mg/L	–	–	–	–	71	0.001	69	0.001
Iron	mg/L	8	0.605	10	1.20	71	0.19	69	0.21
Lead	mg/L	–	–	–	–	71	0.001	69	0.001
Lithium	mg/L	–	–	–	–	71	0.001	69	0.001
Manganese	mg/L	8	0.118	10	0.089	71	0.010	69	0.005

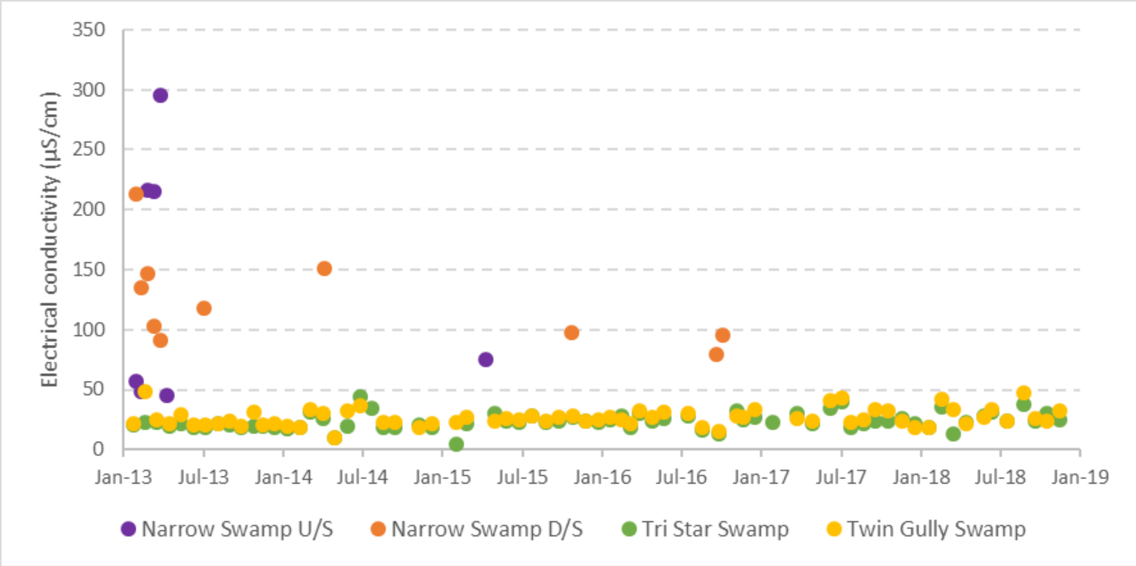
Parameter	Units	Narrow Swamp U/S		Narrow Swamp D/S		Tri Star Swamp		Twin Gully Swamp	
		Count	Median	Count	Median	Count	Median	Count	Median
Molybdenum	mg/L	–	–	–	–	71	0.001	69	0.001
Nickel	mg/L	–	–	–	–	71	0.001	69	0.001
Rubidium	mg/L	–	–	–	–	71	0.001	69	0.001
Strontium	mg/L	–	–	–	–	71	0.002	69	0.002
Uranium	mg/L	–	–	–	–	71	0.001	69	0.001
Zinc	mg/L	–	–	–	–	71	0.005	69	0.005
Total metals									
Aluminium	mg/L	–	–	–	–	71	0.14	69	0.21
Antimony	mg/L	–	–	–	–	68	0.001	66	0.001
Arsenic	mg/L	–	–	–	–	71	0.001	69	0.001
Barium	mg/L	–	–	–	–	71	0.007	69	0.006
Iron	mg/L	8	7.69	10	2.88	70	0.55	68	0.59
Lead	mg/L	–	–	–	–	71	0.001	69	0.001
Manganese	mg/L	8	0.208	10	0.172	71	0.013	69	0.007
Nickel	mg/L	–	–	–	–	71	0.001	68	0.001
Zinc	mg/L	–	–	–	–	71	0.005	68	0.005
Other									
Free chlorine	mg/L	–	–	–	–	72	0.02	70	0.02
Total chlorine	mg/L	–	–	–	–	72	0.05	70	0.05
Total cyanide	mg/L	–	–	–	–	71	0.004	69	0.004
Oil and grease	mg/L	–	–	–	–	72	5	70	5

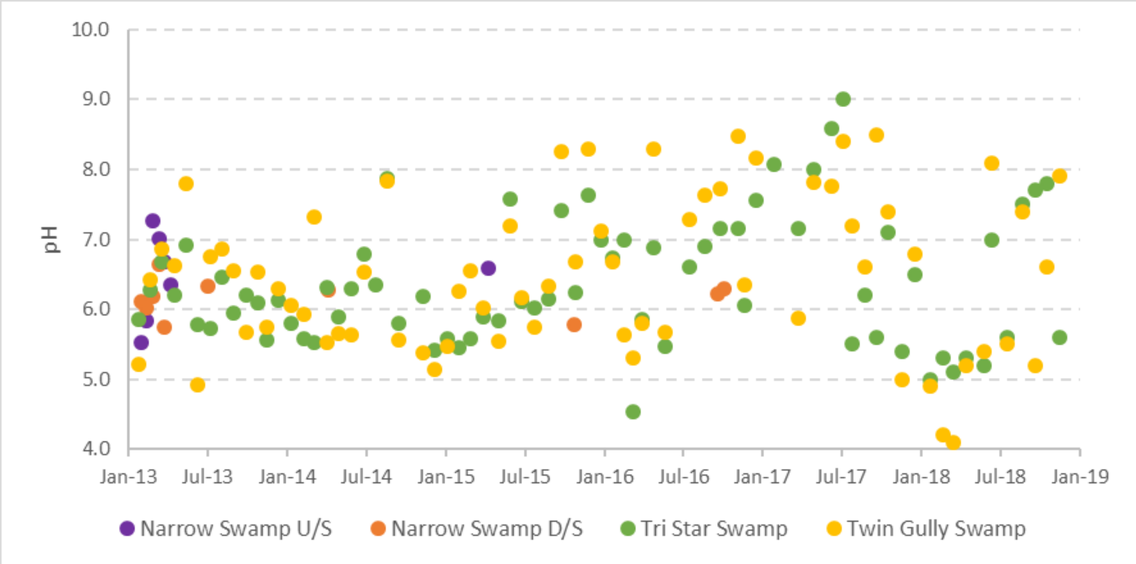
Parameter	Units	Narrow Swamp U/S		Narrow Swamp D/S		Tri Star Swamp		Twin Gully Swamp	
		Count	Median	Count	Median	Count	Median	Count	Median
Phenols	mg/L	–	–	–	–	71	0.05	69	0.05
Silica	mg/L	–	–	–	–	70	6.1	68	6.3
Silicon	mg/L	–	–	–	–	71	2.86	69	2.95
Total organic carbon	mg/L	–	–	–	–	71	2	69	4

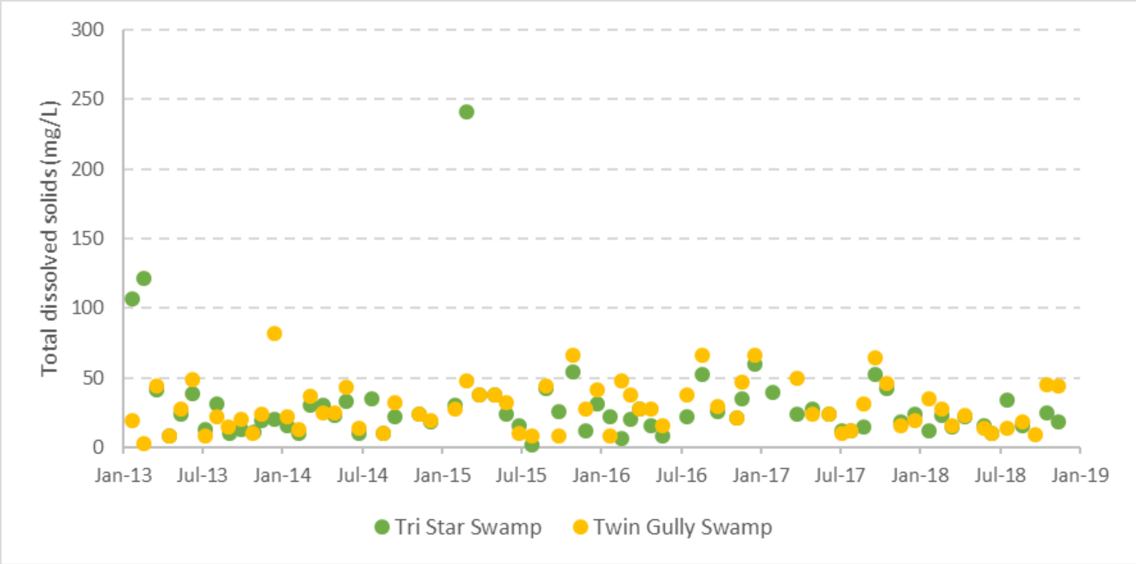
Time series graphs of water quality results

Physicochemical

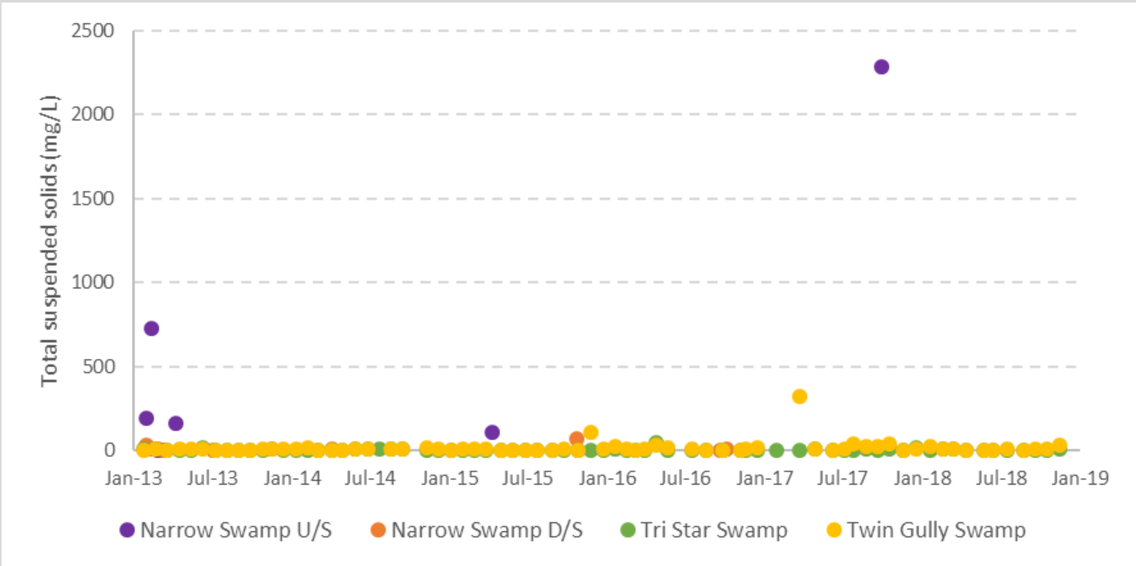




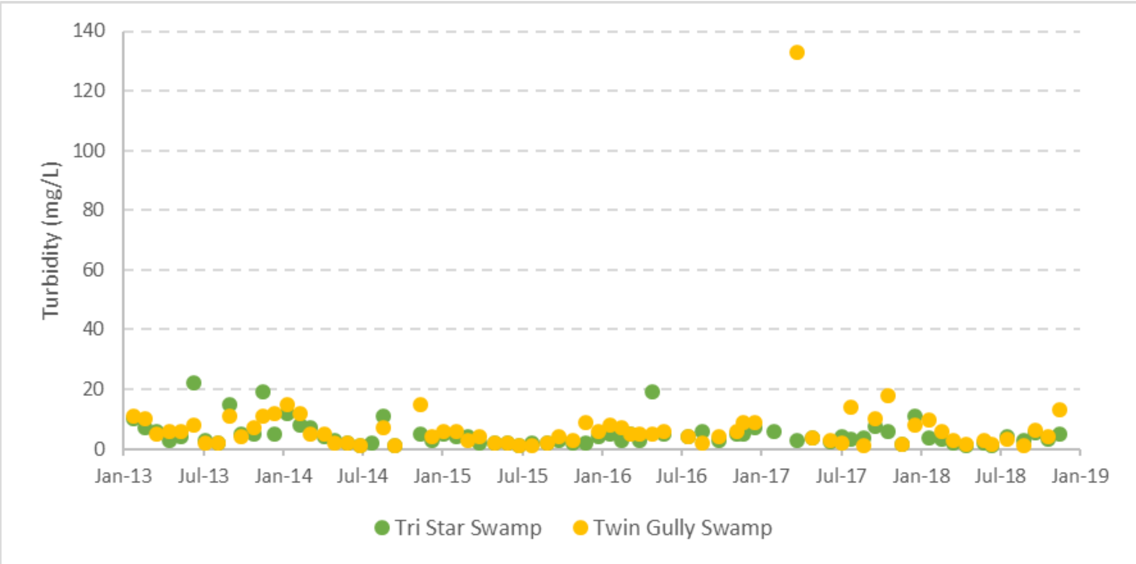




Total dissolved solids (mg/L)
300
250
200
150
100
50
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

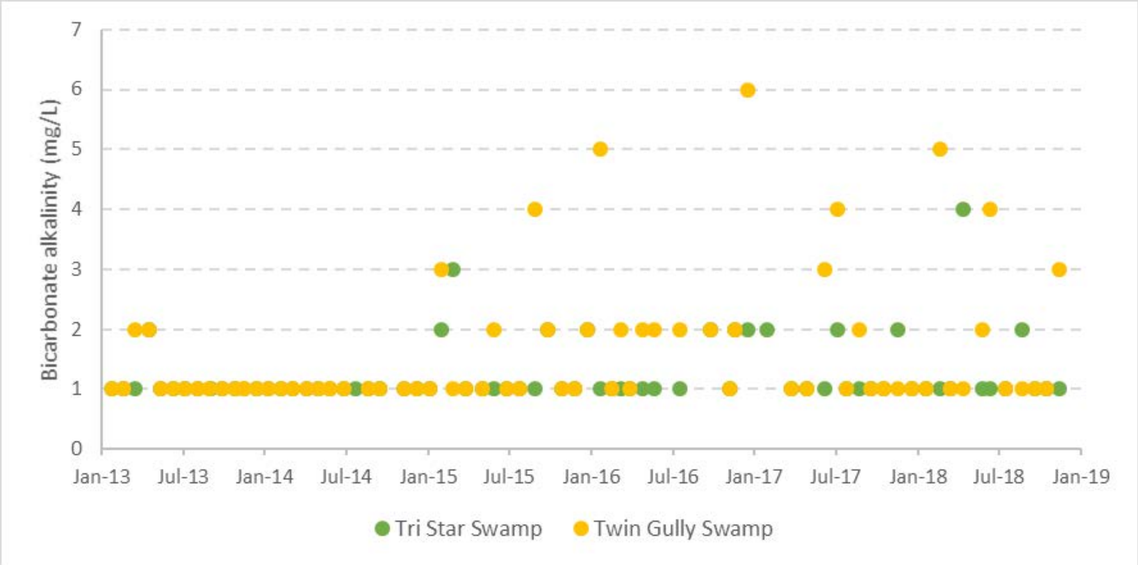


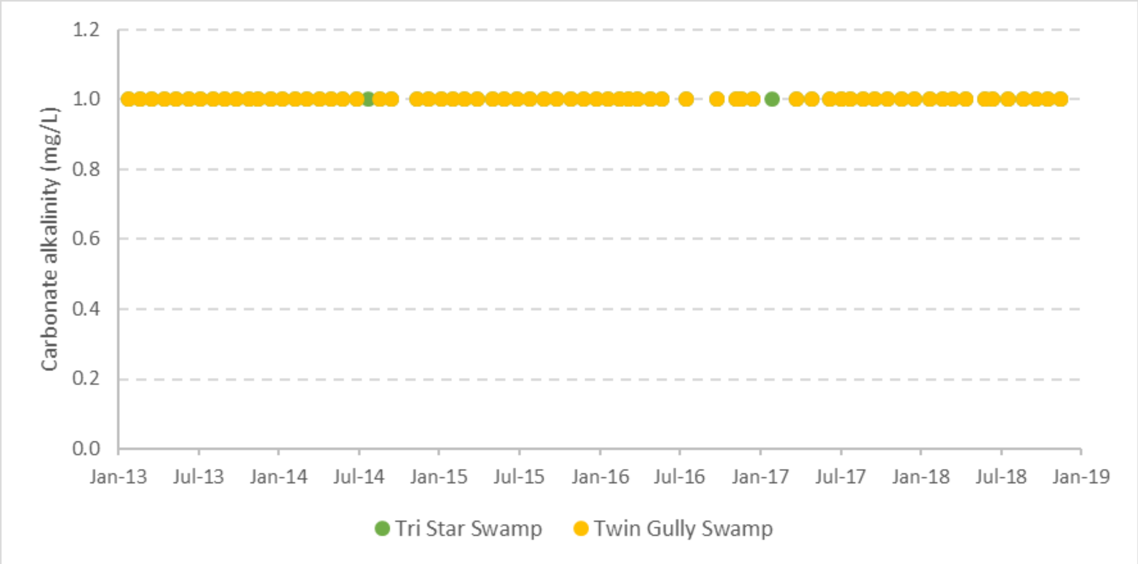
Total suspended solids (mg/L)
2500
2000
1500
1000
500
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Narrow Swamp U/S
Narrow Swamp D/S
Tri Star Swamp
Twin Gully Swamp

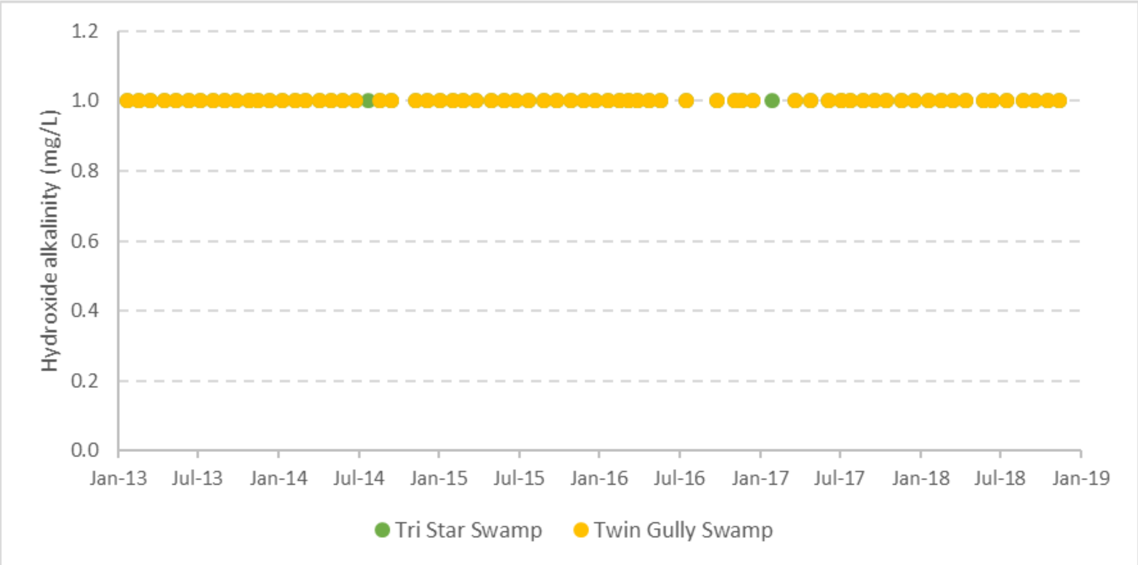


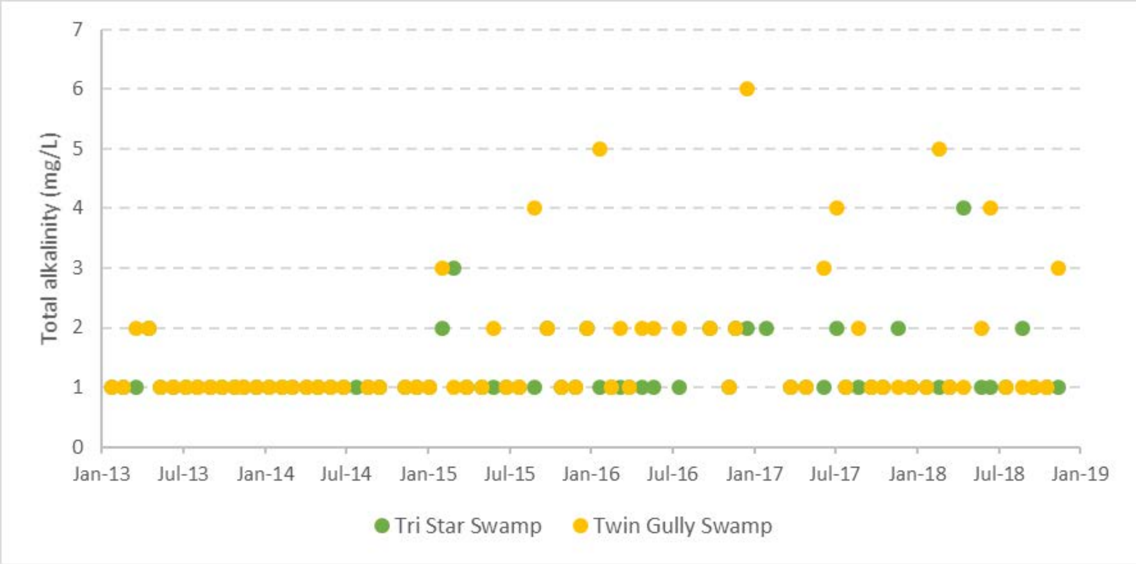
Turbidity (mg/L)
140
120
100
80
60
40
20
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

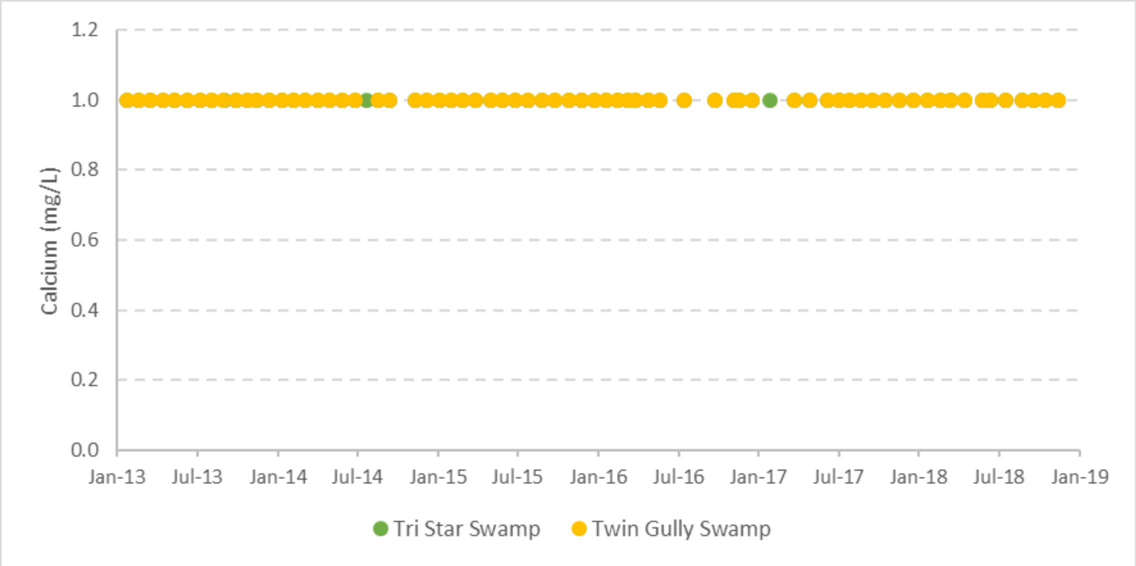
Major ions

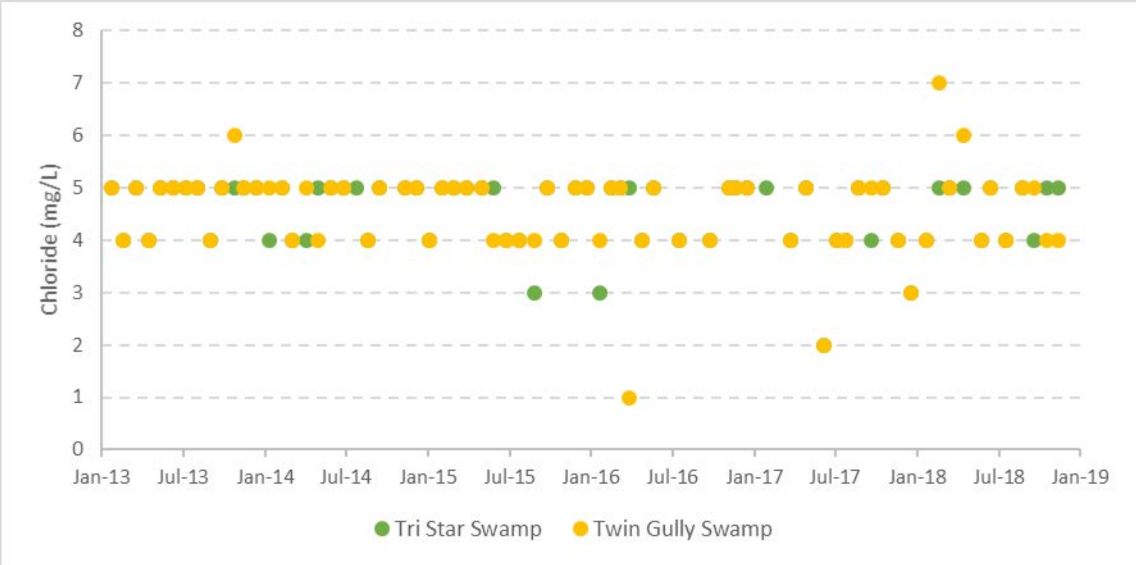

Bicarbonate alkalinity (mg/L)
0
1
2
3
4
5
6
7
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

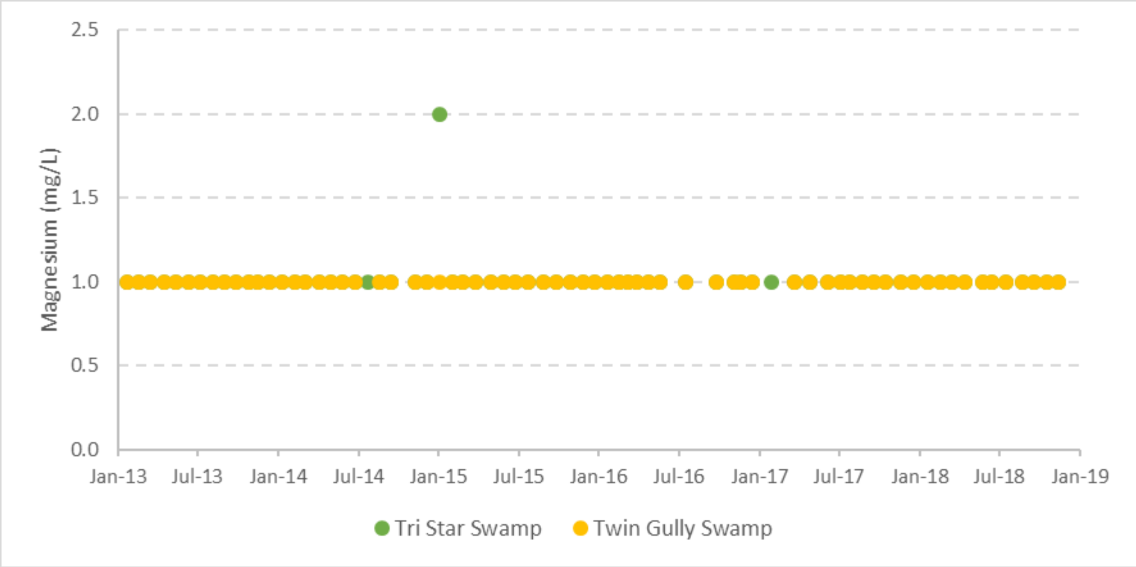

Carbonate alkalinity (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp


Hydroxide alkalinity (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

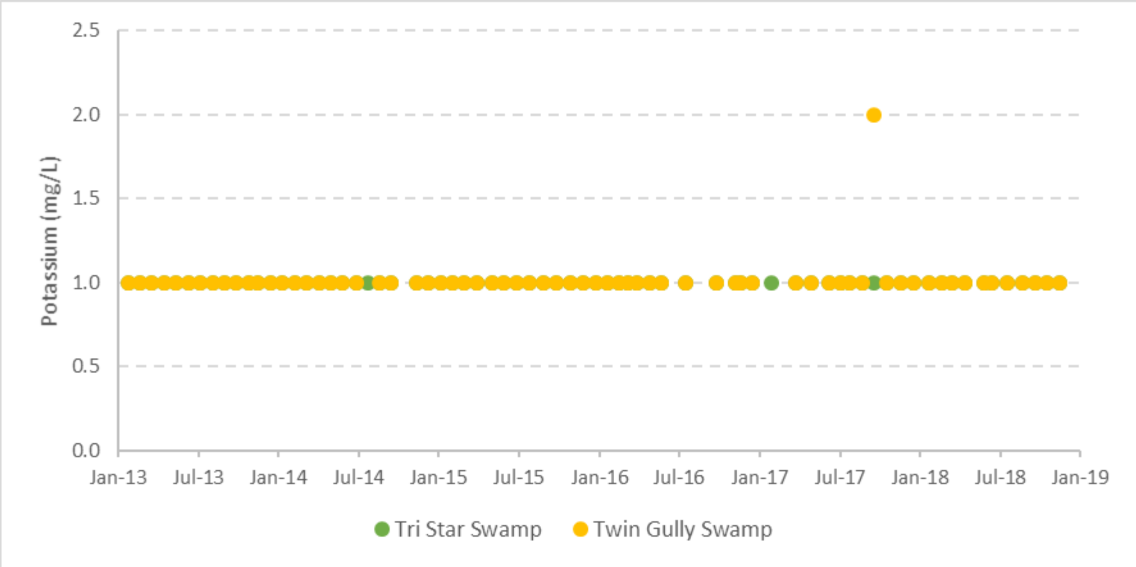

Total alkalinity (mg/L)
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp


Calcium (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

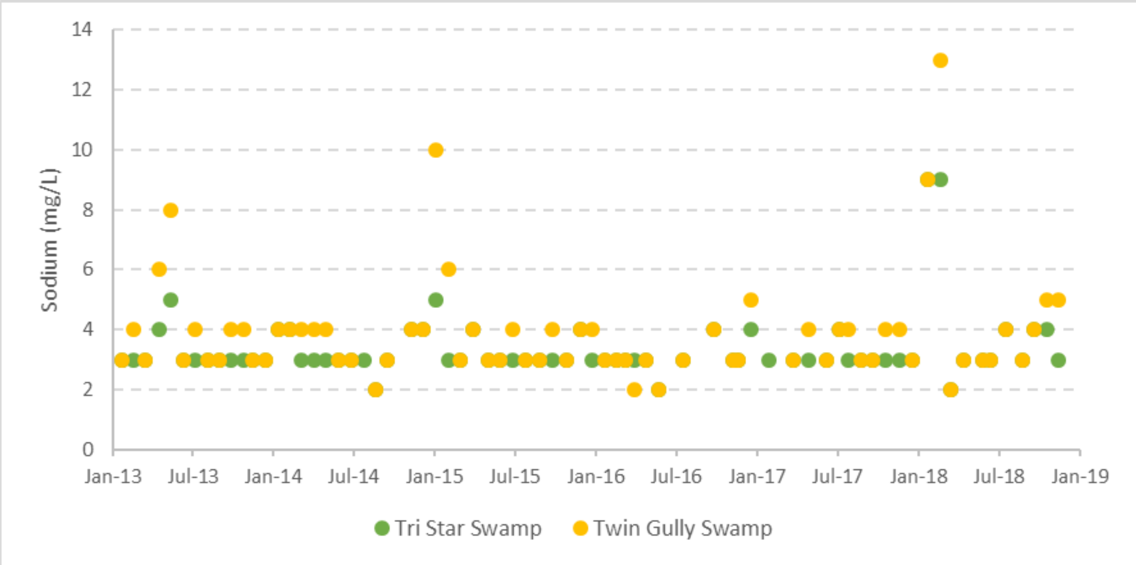

Chloride (mg/L)
8
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp



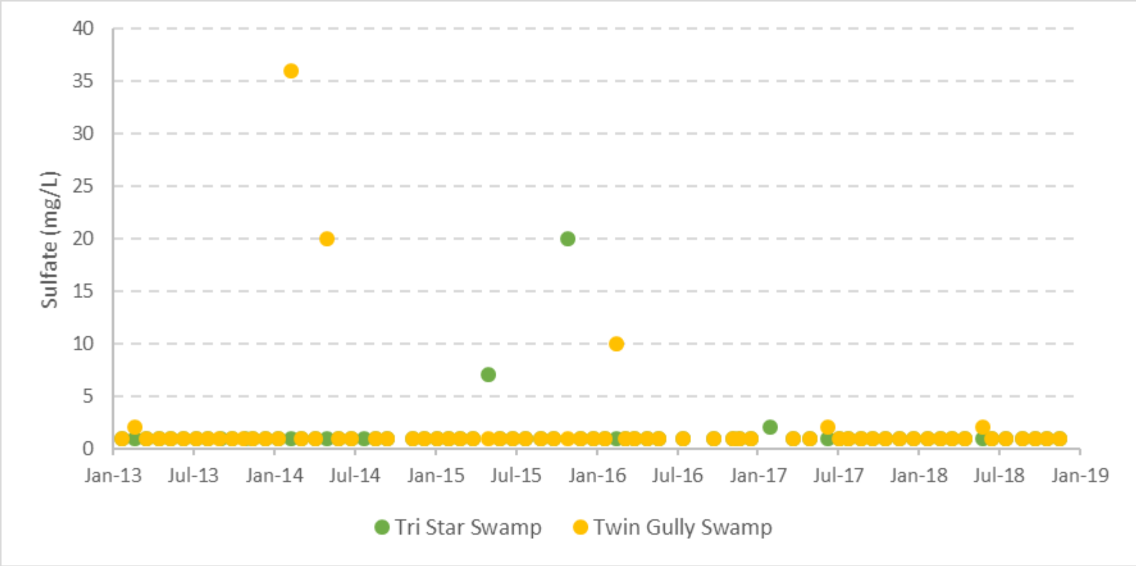
2.5
2.0
1.5
1.0
0.5
0.0
Magnesium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

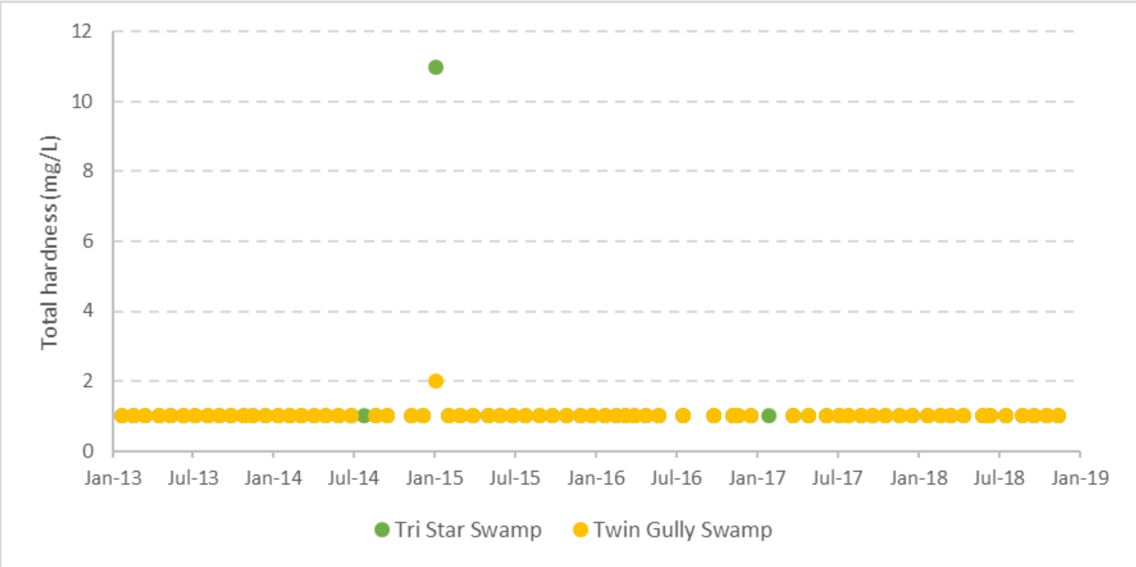


2.5
2.0
1.5
1.0
0.5
0.0
Potassium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

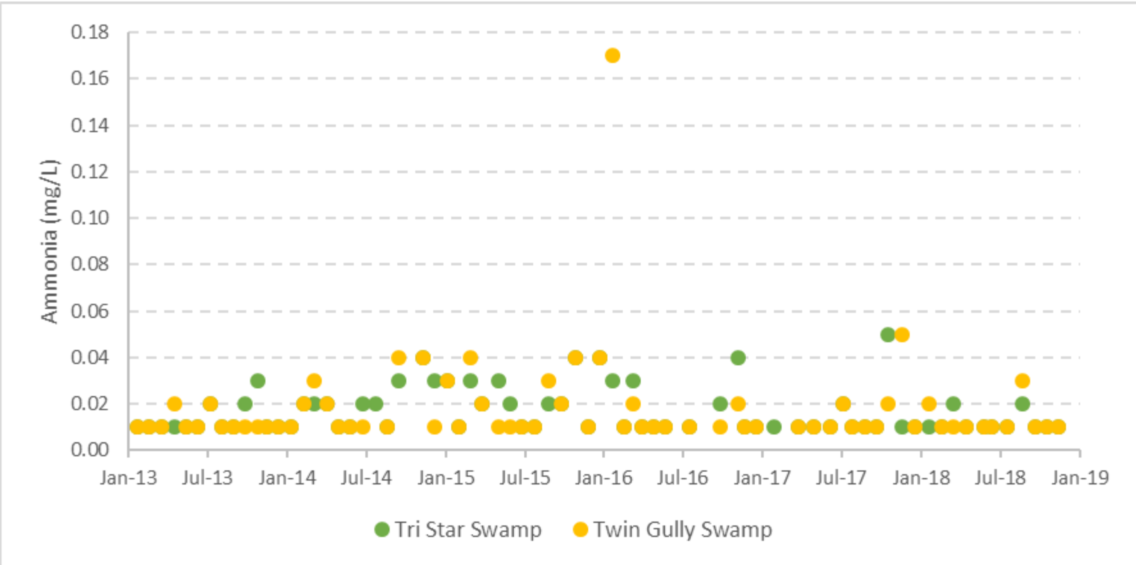


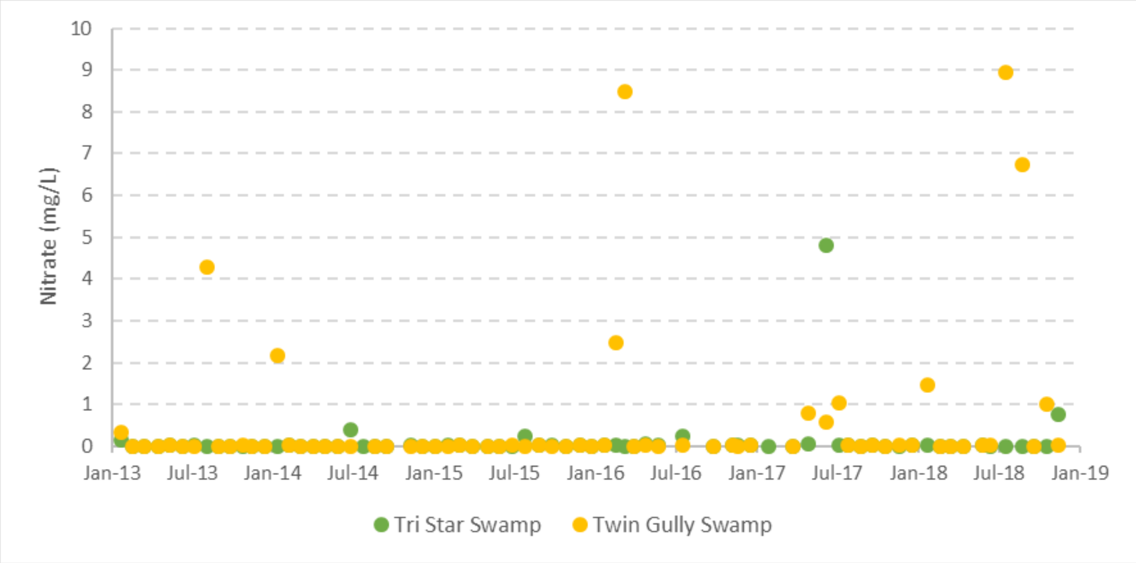
14
12
10
8
6
4
2
0
Sodium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp


Sulfate (mg/L)
40
35
30
25
20
15
10
5
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

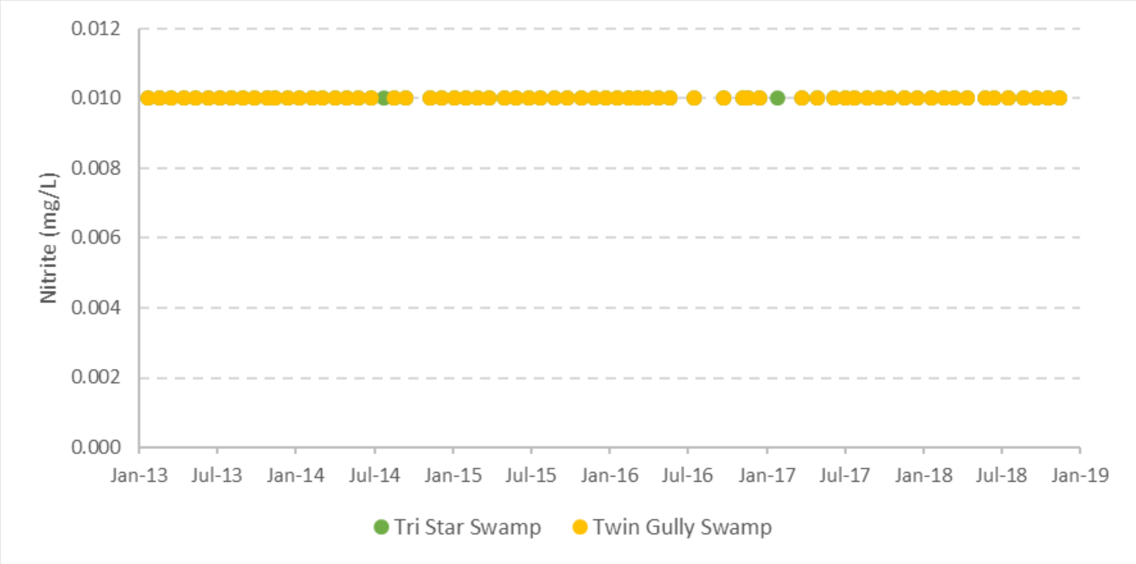

Total hardness (mg/L)
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

Nutrients

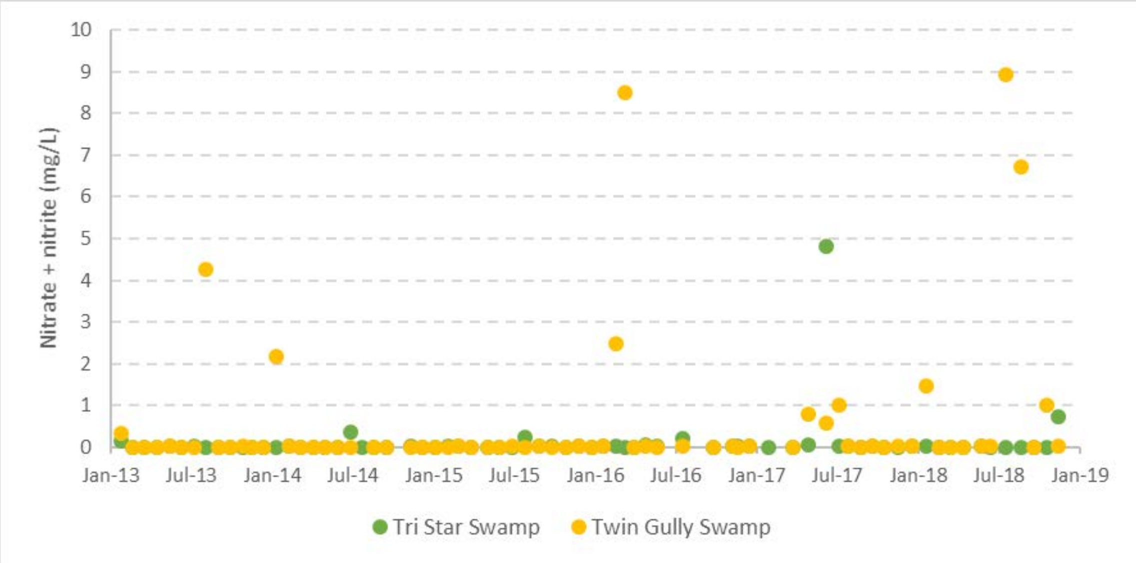

Ammonia (mg/L)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp



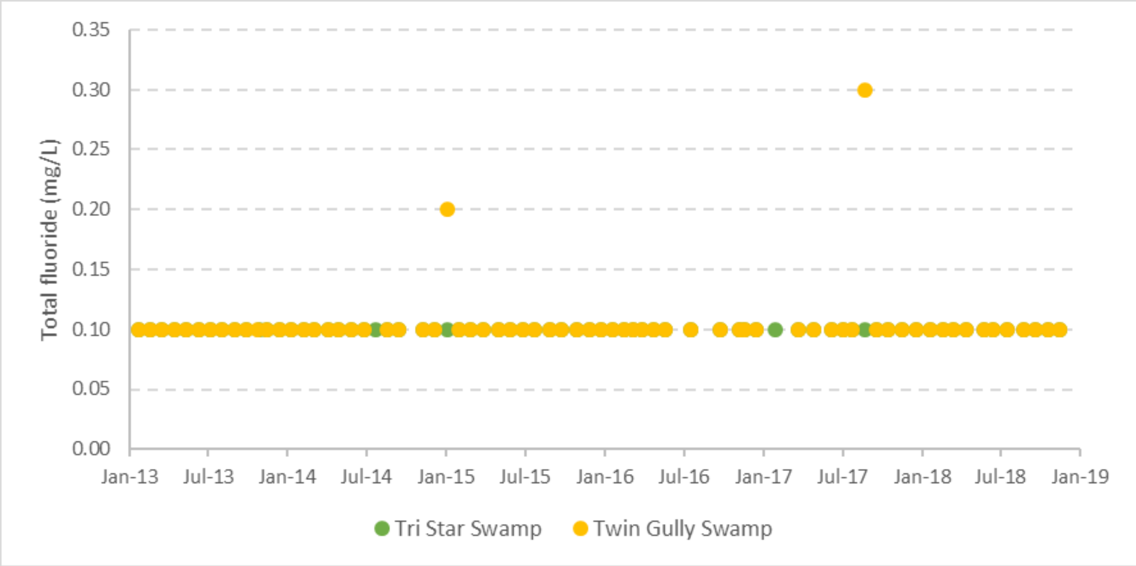
Nitrate (mg/L)
10
9
8
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

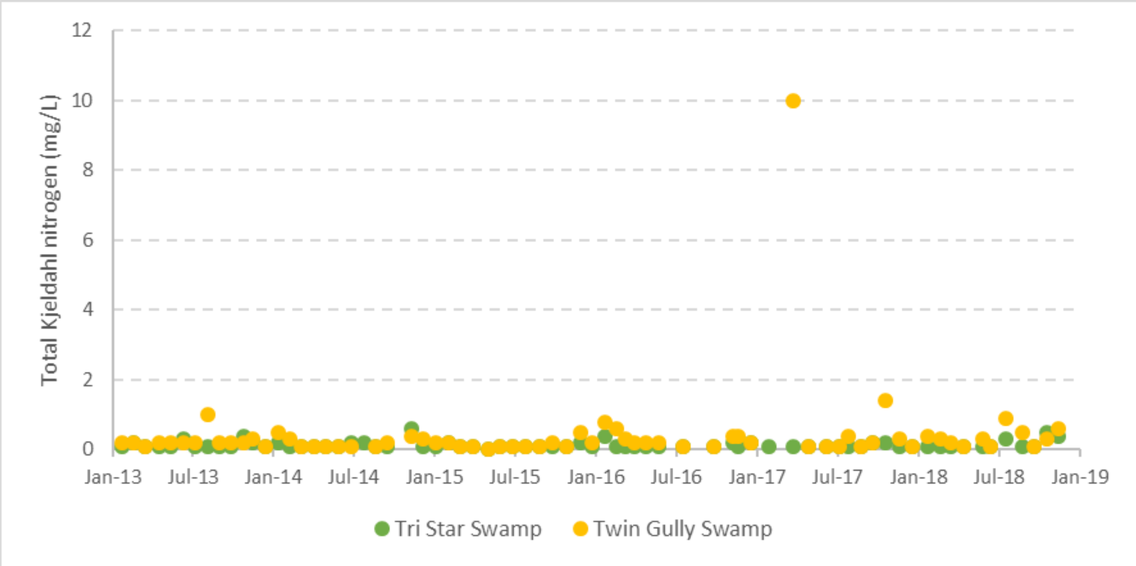


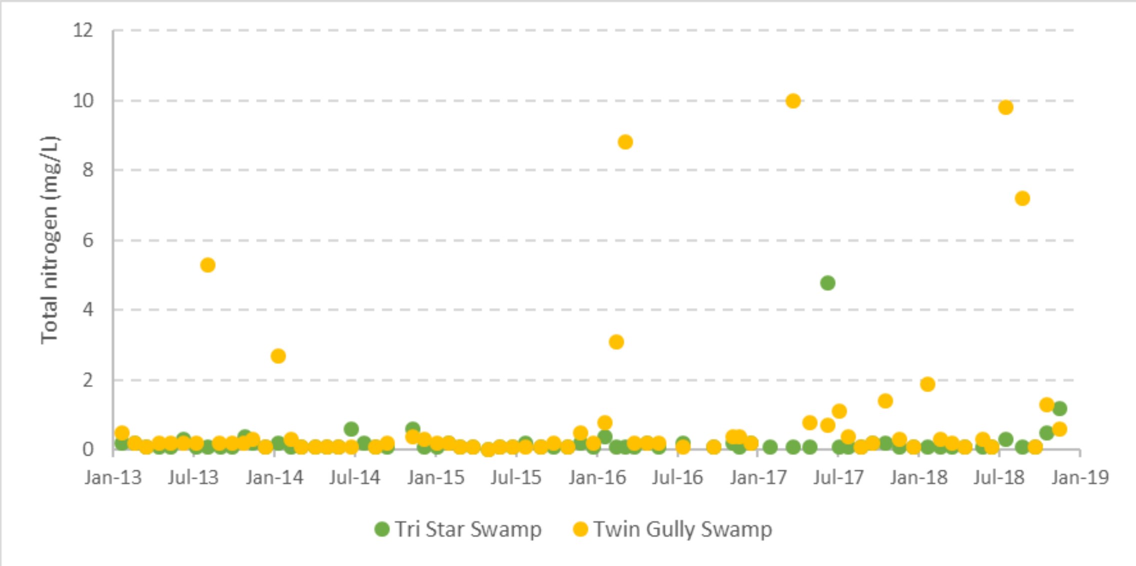
Nitrite (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

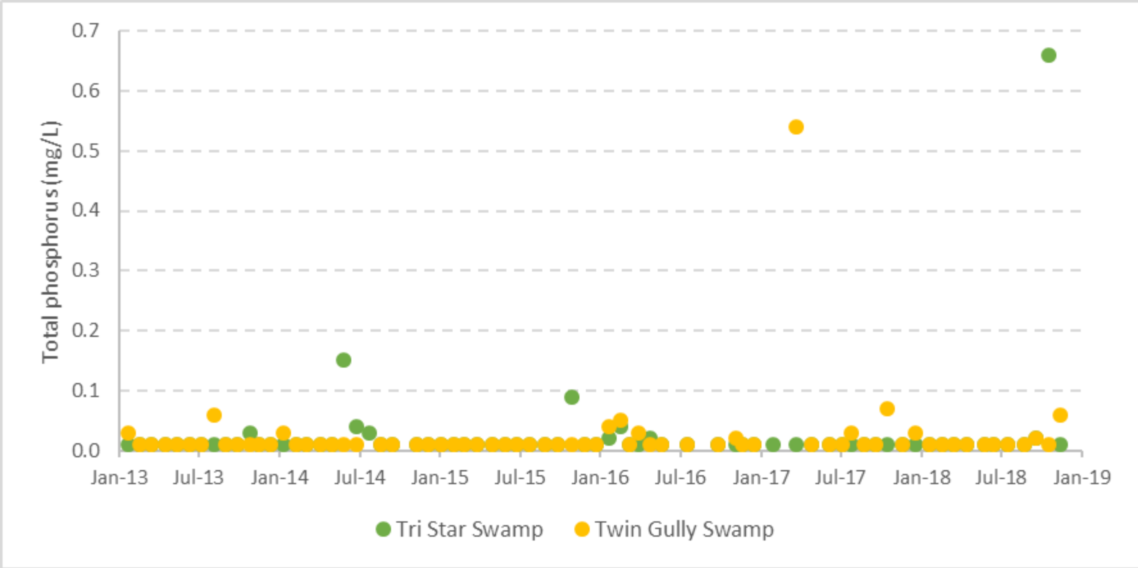


Nitrate + nitrite (mg/L)
10
9
8
7
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

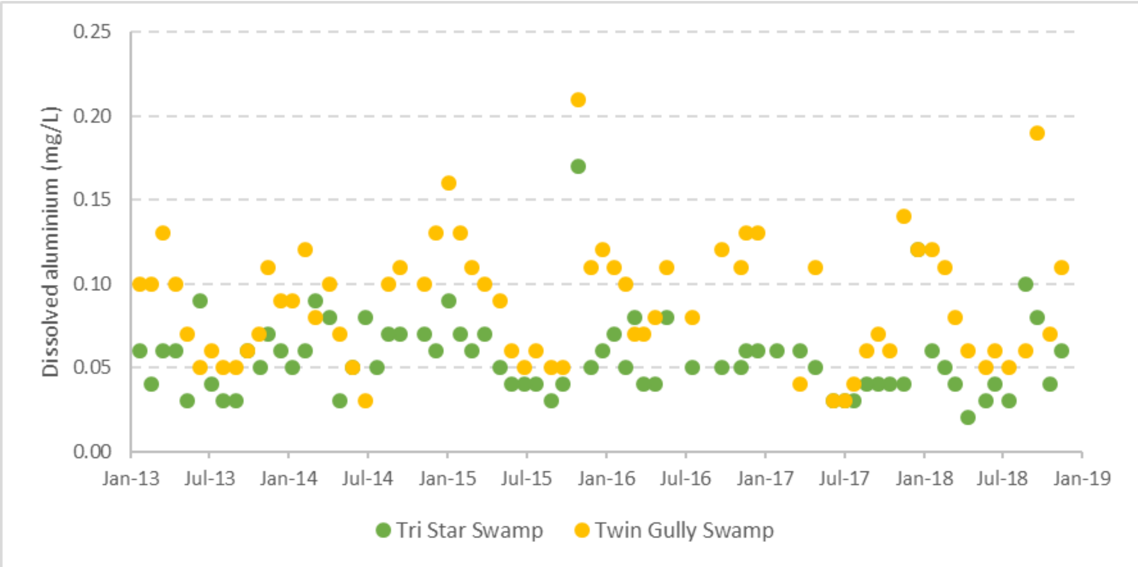

0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Total fluoride (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

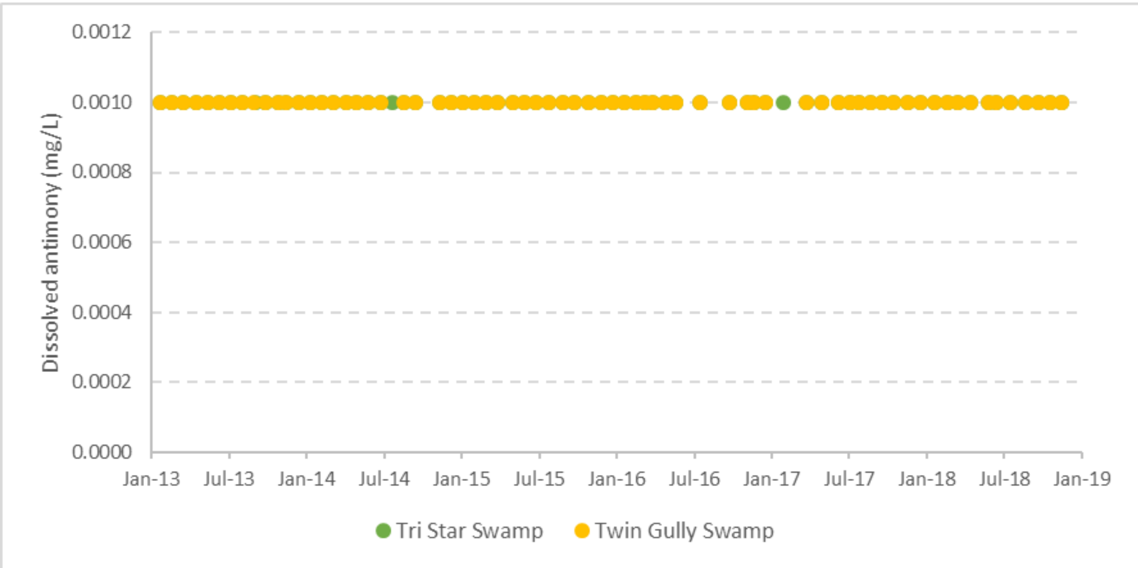

12
10
8
6
4
2
0
Total Kjeldahl nitrogen (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

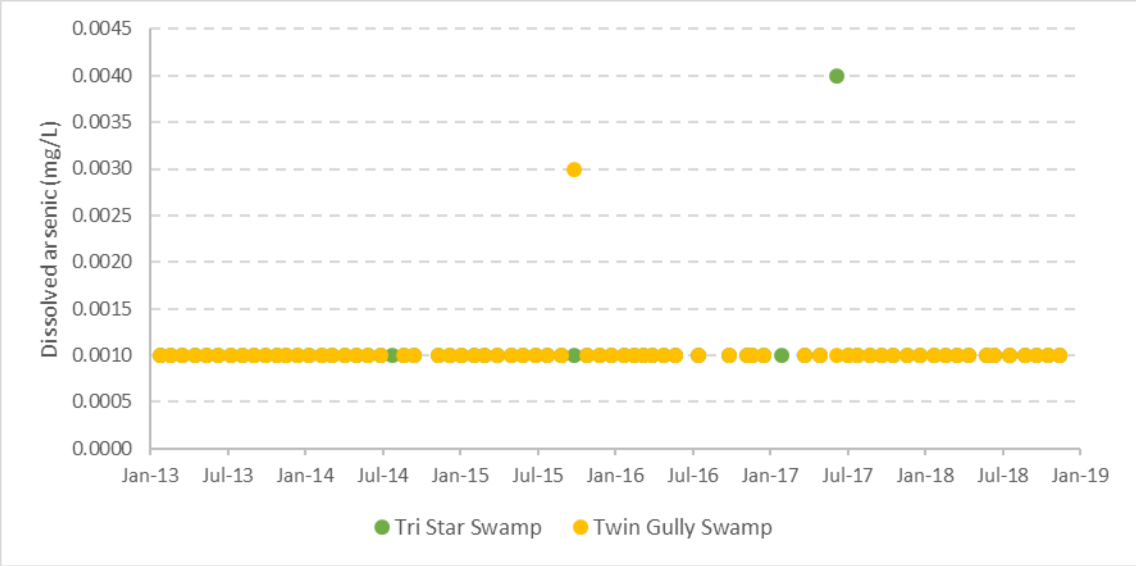

12
10
8
6
4
2
0
Total nitrogen (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp



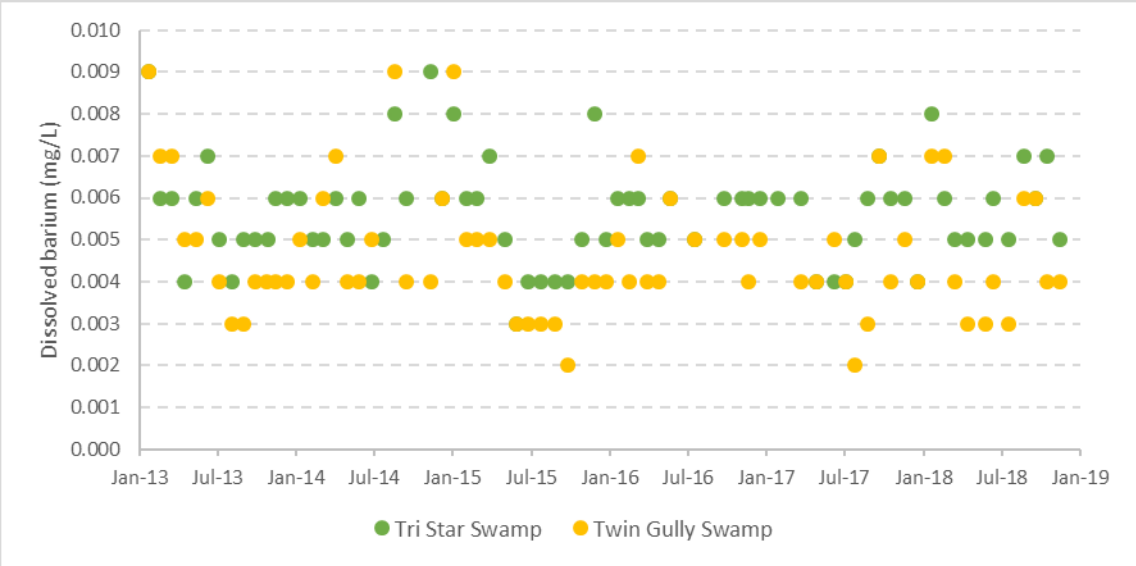
Dissolved metals



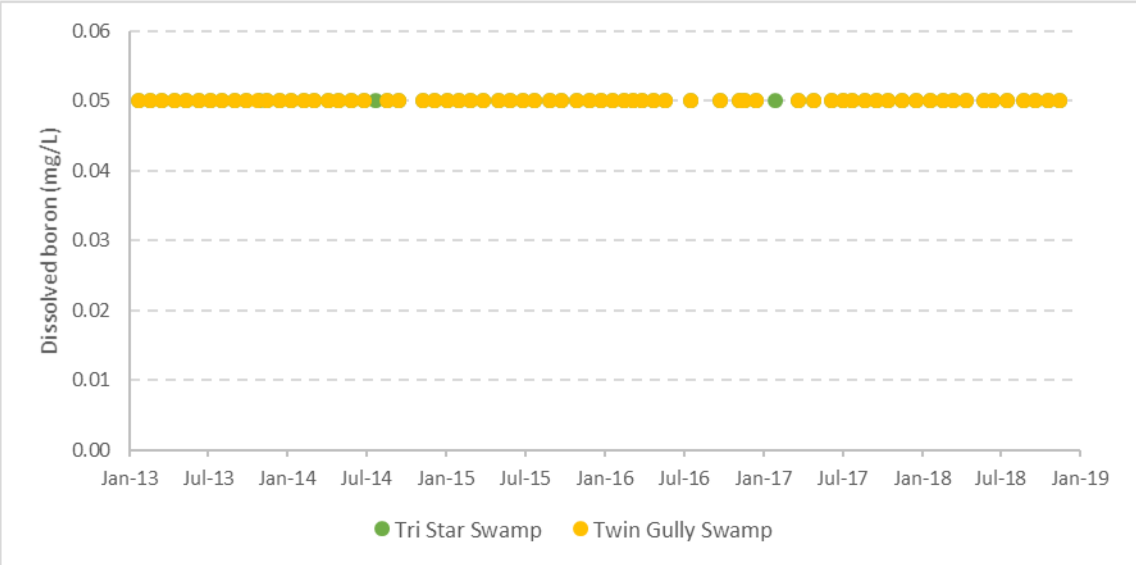




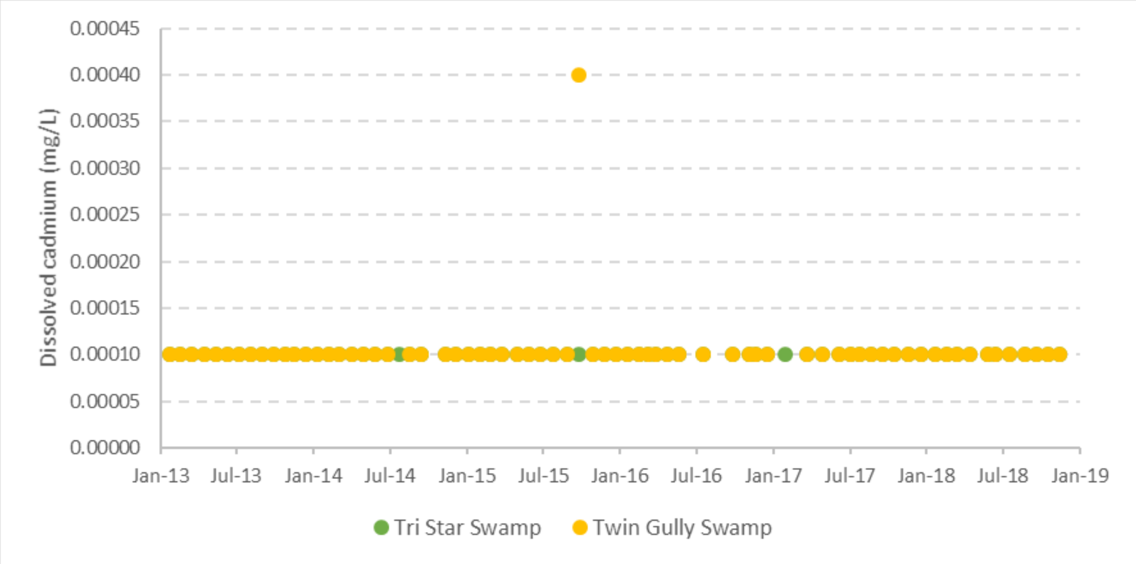
Dissolved arsenic (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp



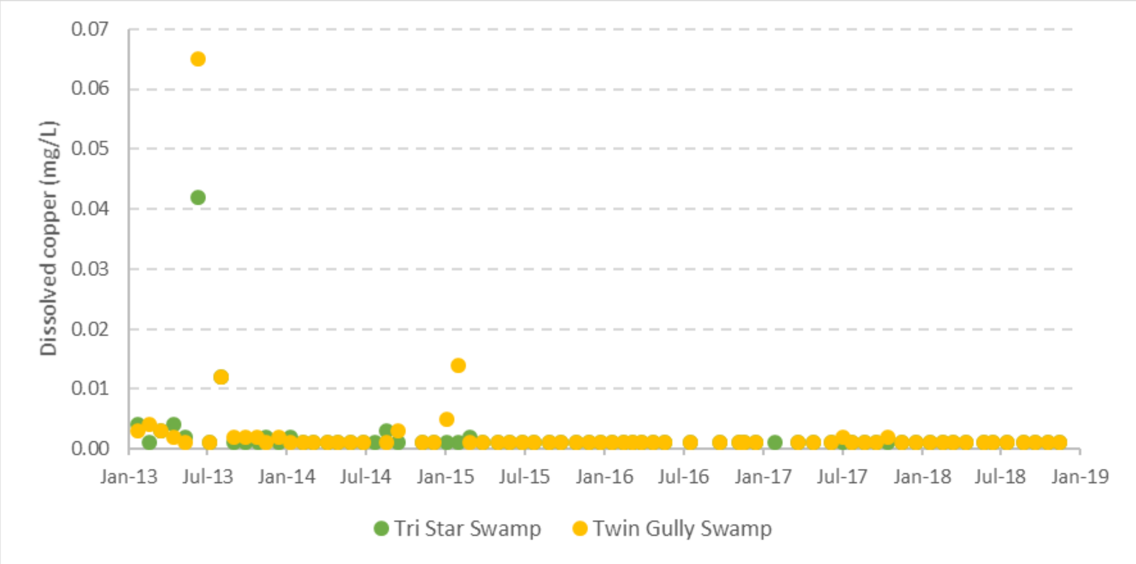
Dissolved barium (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp



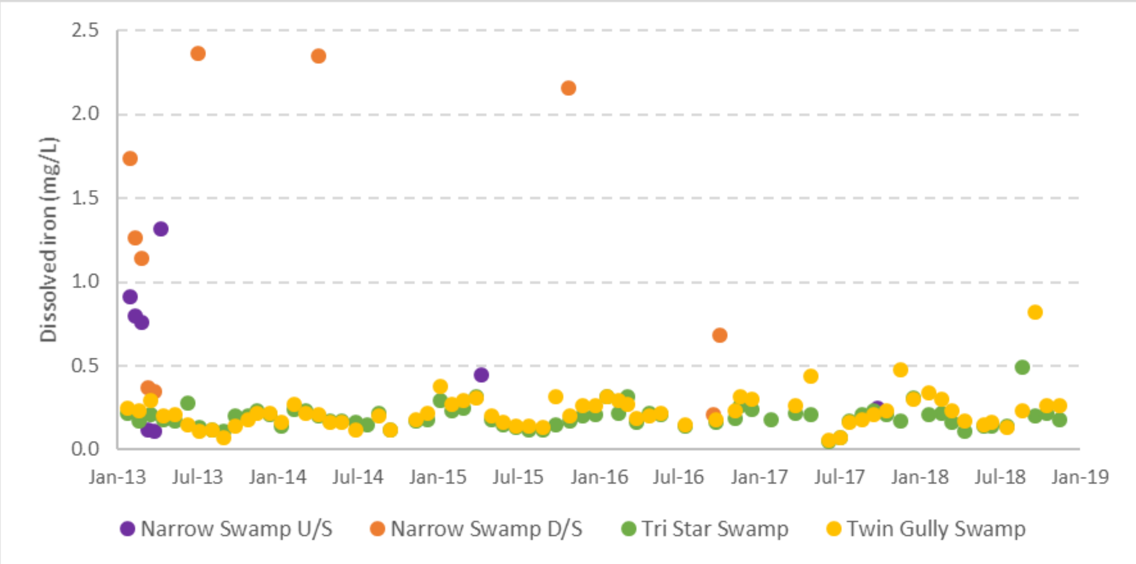
Dissolved boron (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp



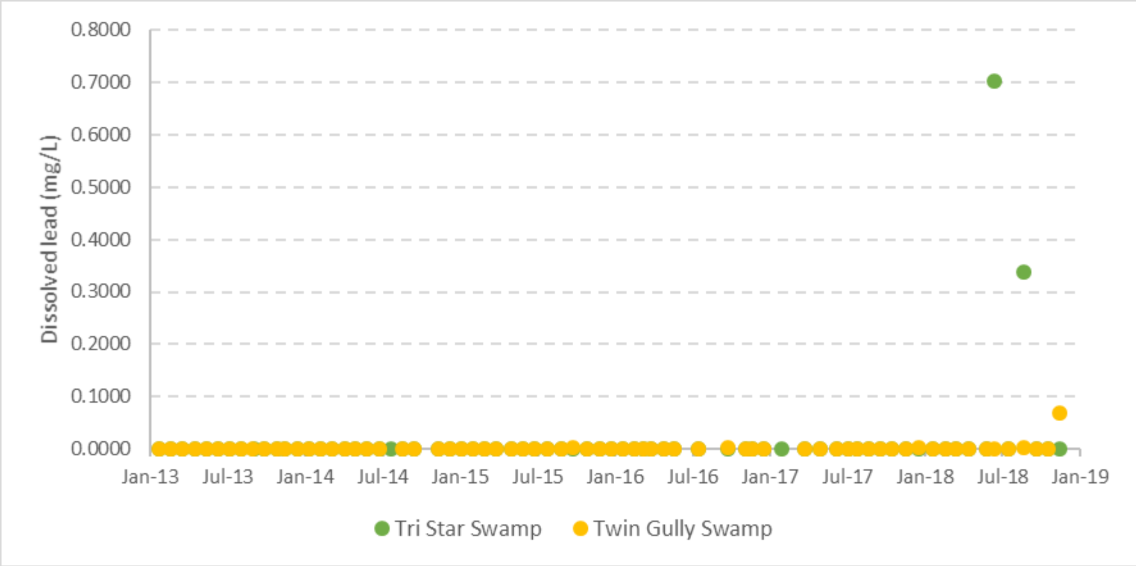
Dissolved cadmium (mg/L)
0.00045
0.00040
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

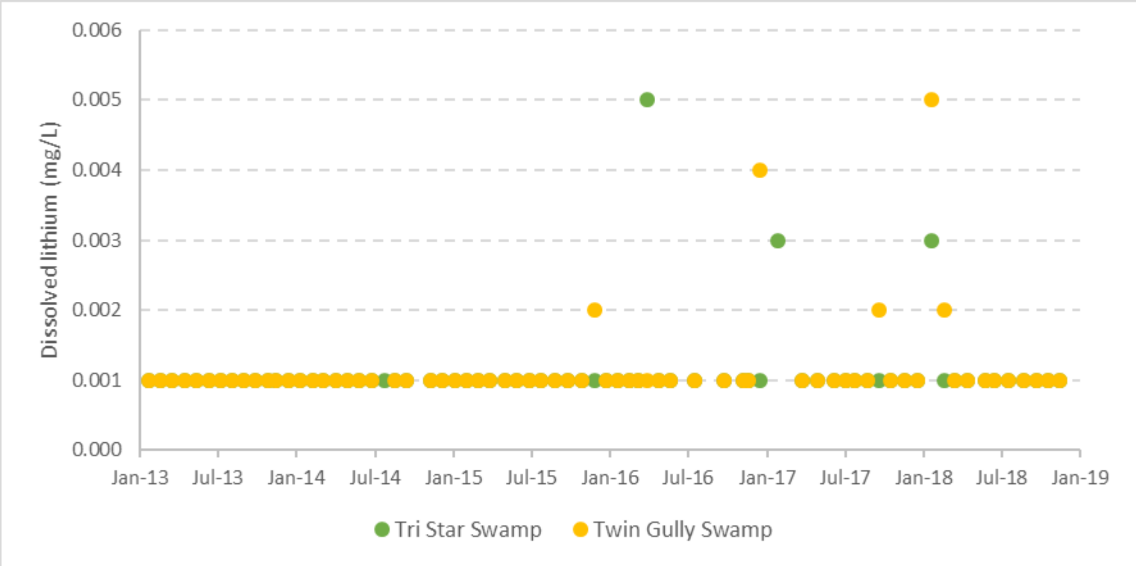


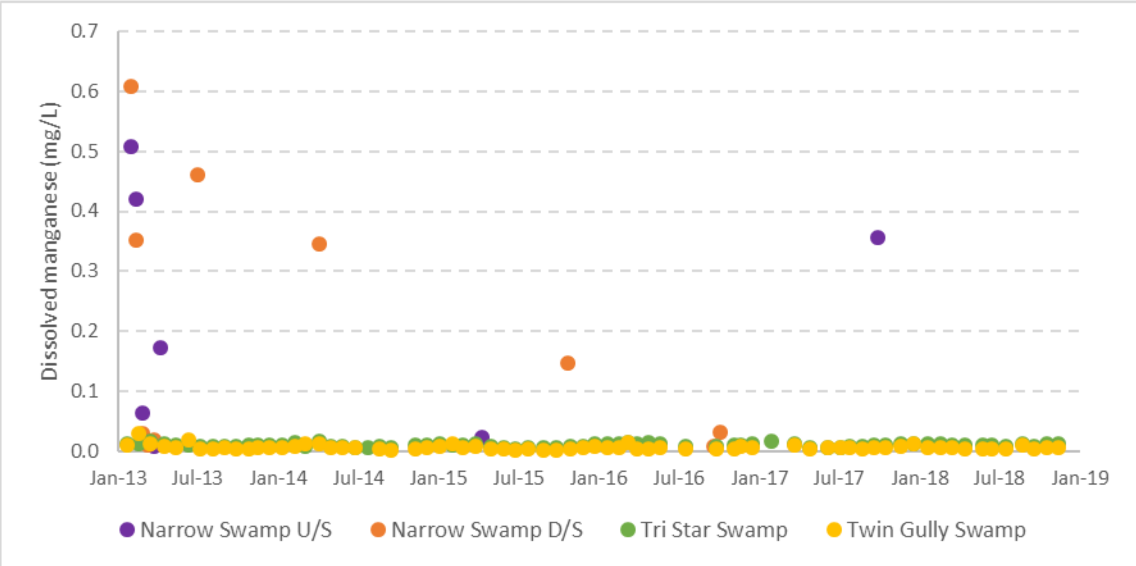
Dissolved copper (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

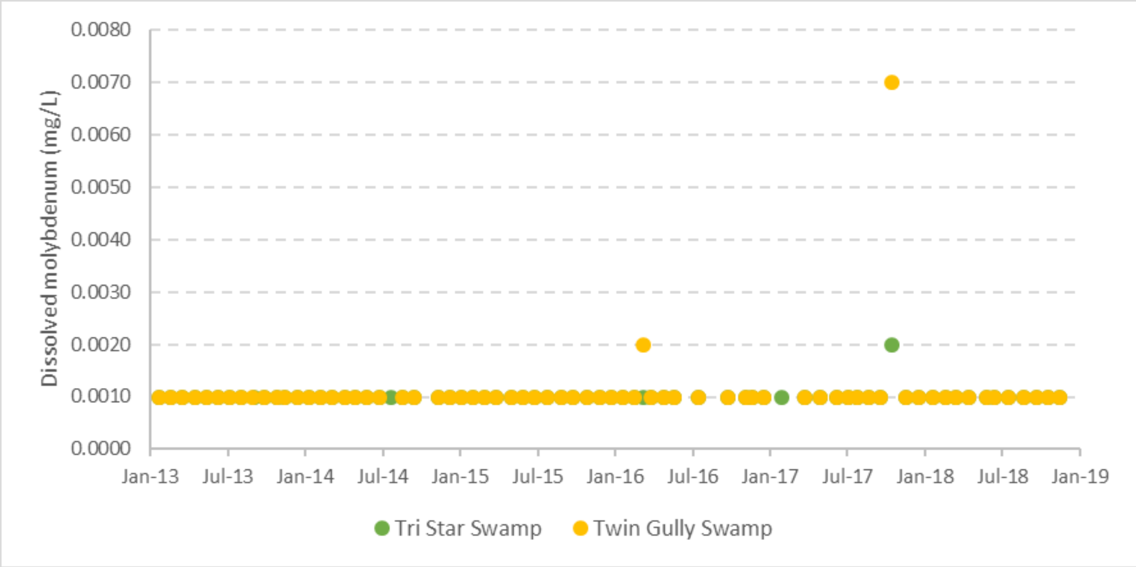


Dissolved iron (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Narrow Swamp U/S
Narrow Swamp D/S
Tri Star Swamp
Twin Gully Swamp

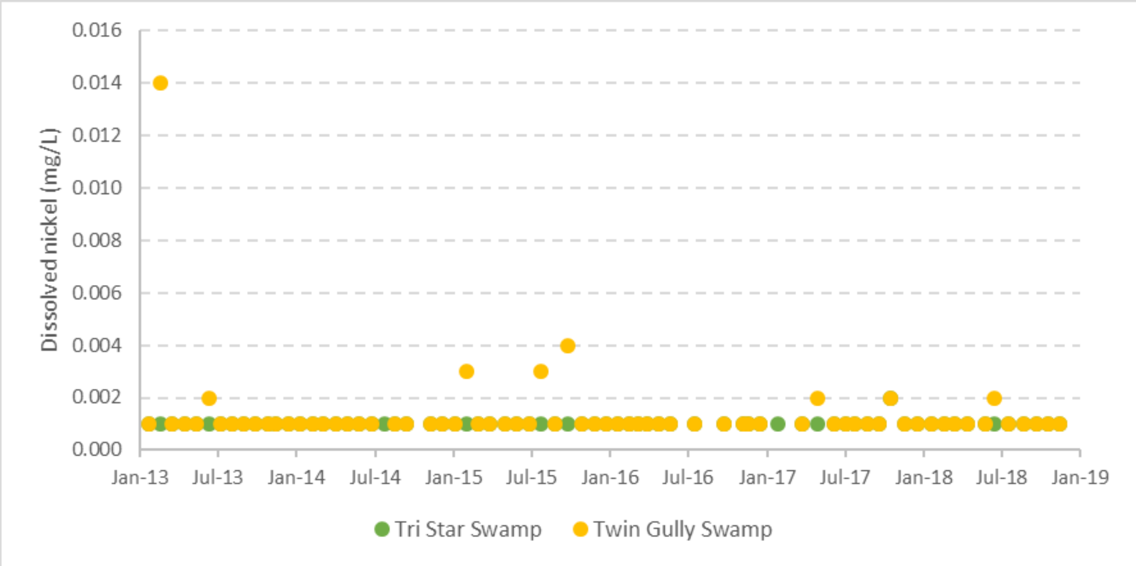

0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
Dissolved lead (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp


0.006
0.005
0.004
0.003
0.002
0.001
0.000
Dissolved lithium (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

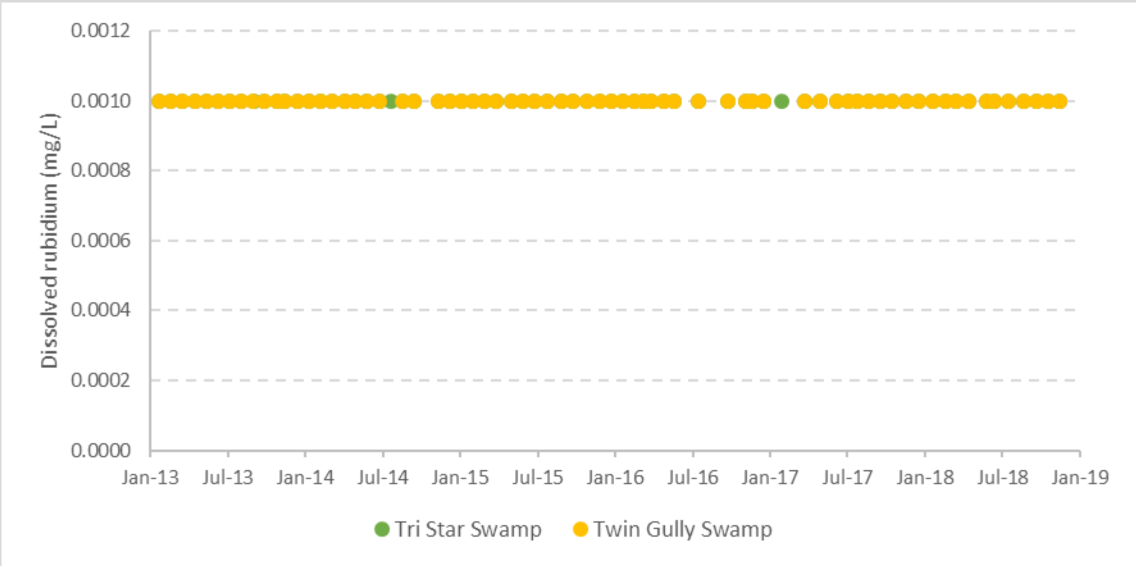

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Dissolved manganese (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Narrow Swamp U/S
Narrow Swamp D/S
Tri Star Swamp
Twin Gully Swamp



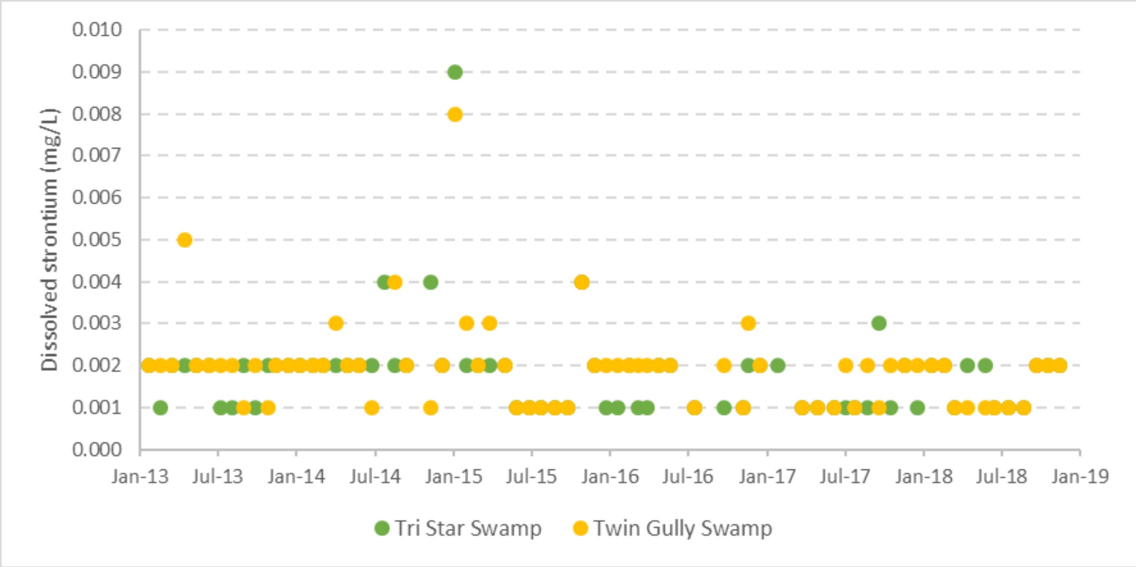
0.0080
0.0070
0.0060
0.0050
0.0040
0.0030
0.0020
0.0010
0.0000
Dissolved molybdenum (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

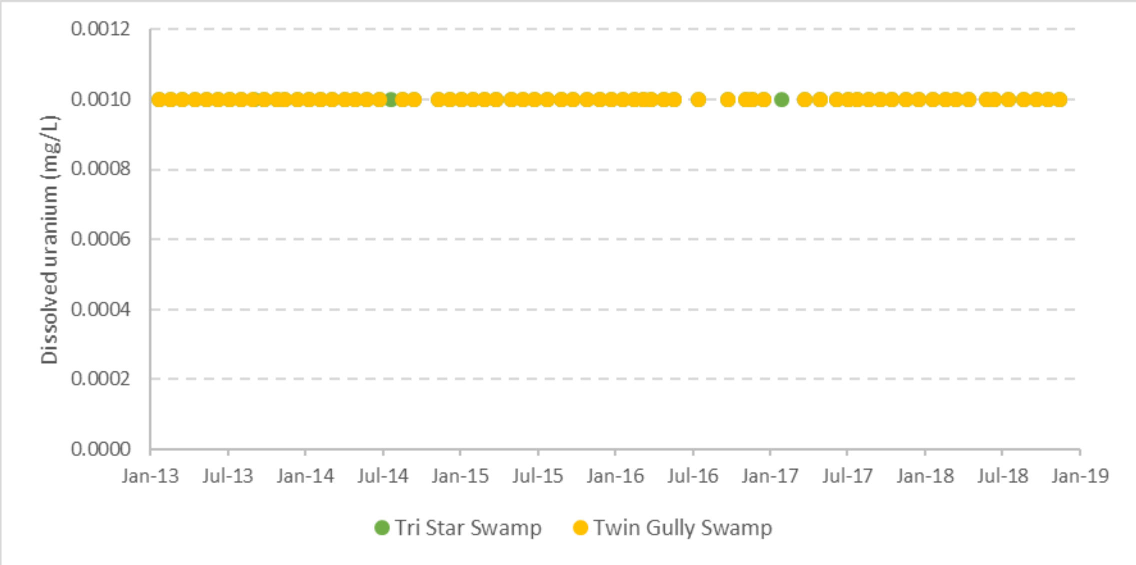


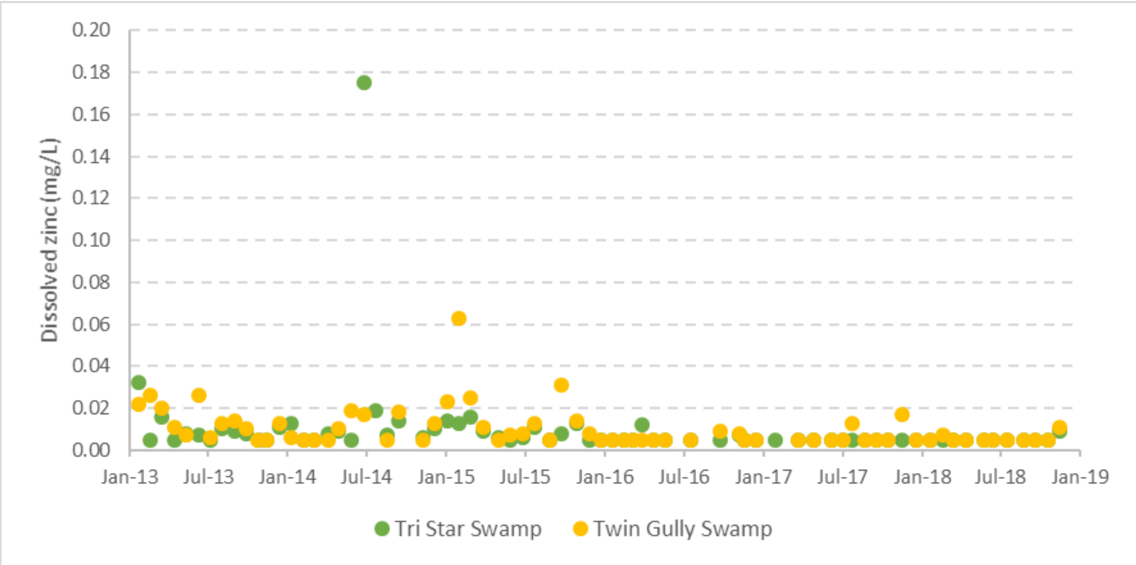
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Dissolved nickel (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp



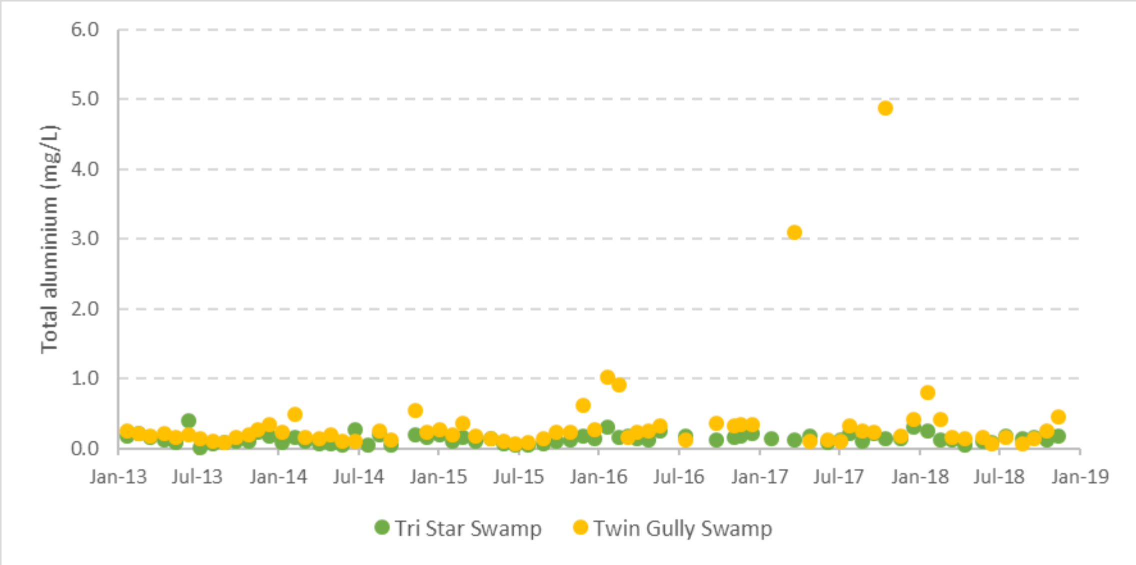
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Dissolved rubidium (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

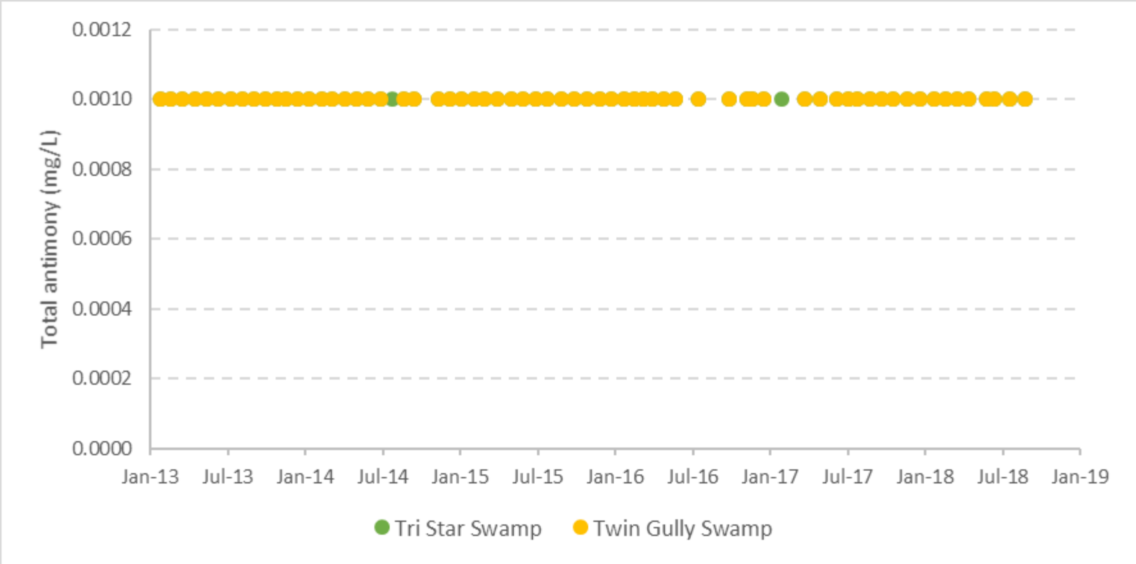

Dissolved strontium (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

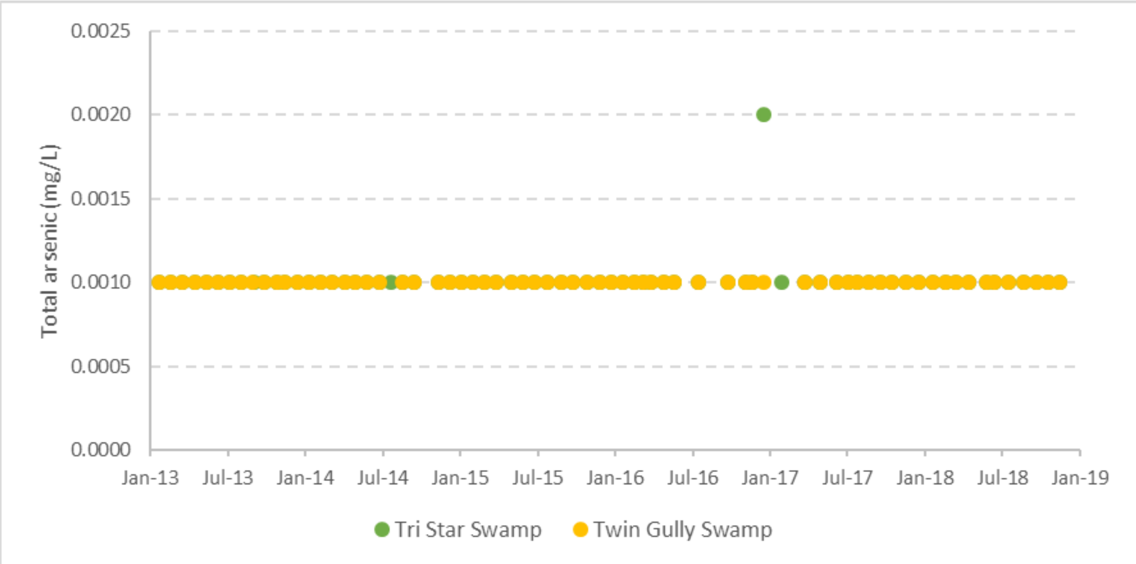

Dissolved uranium (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

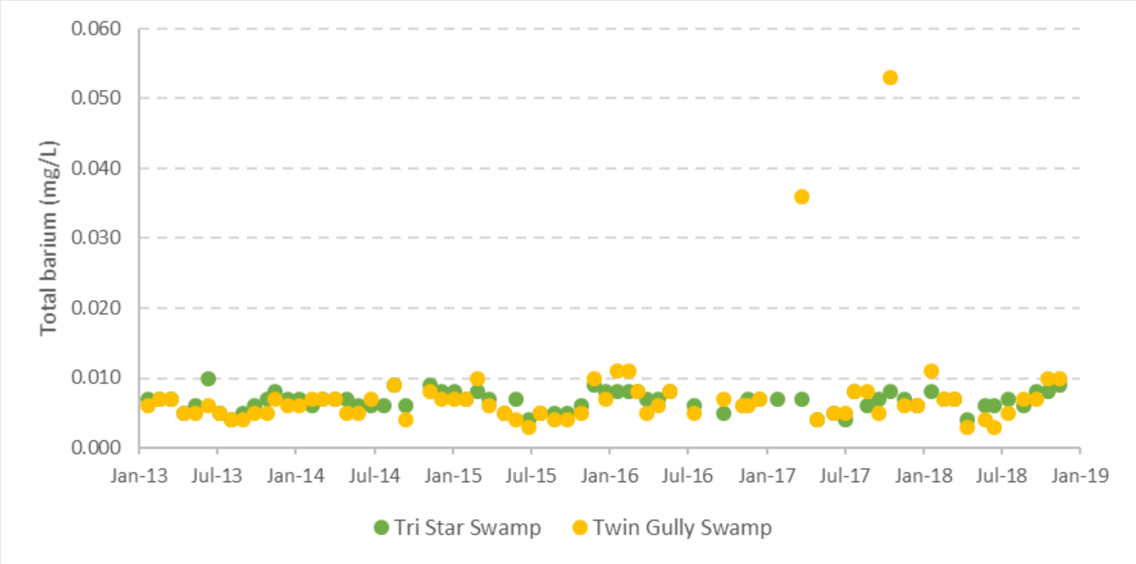

Dissolved zinc (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

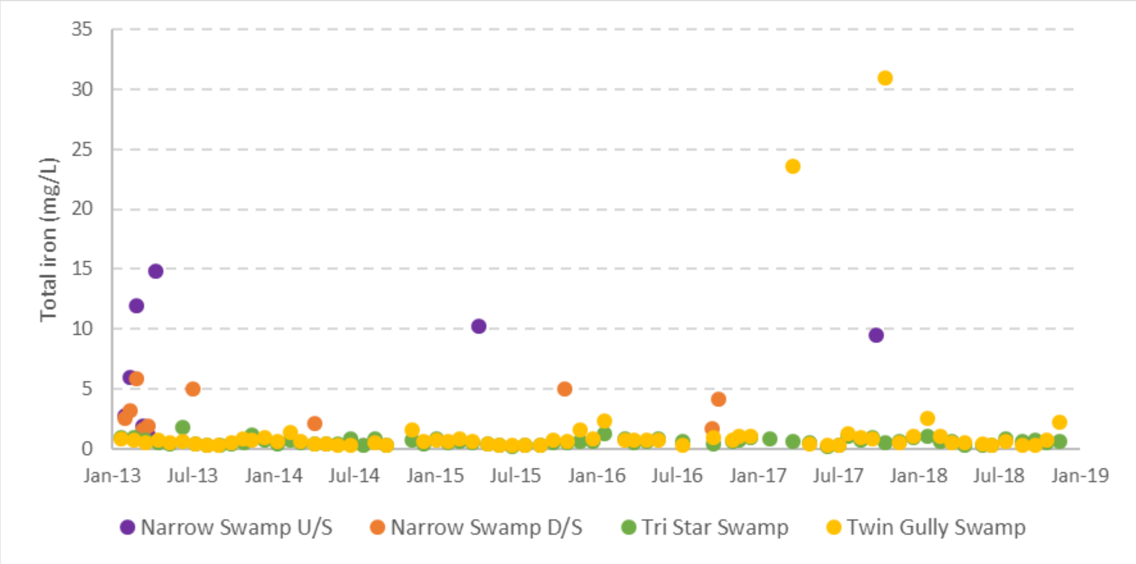
Total metals

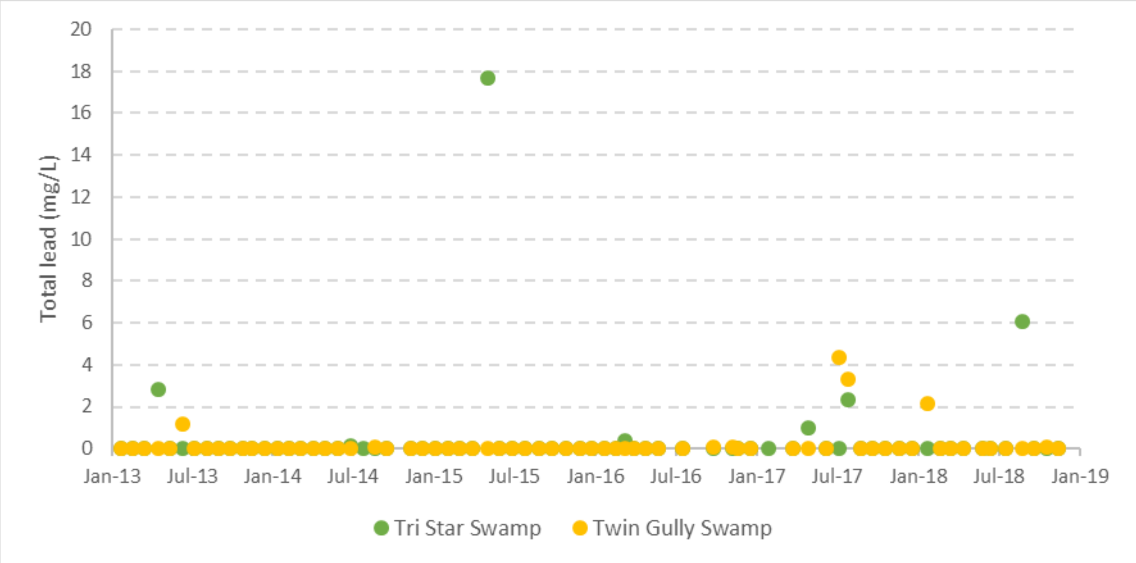


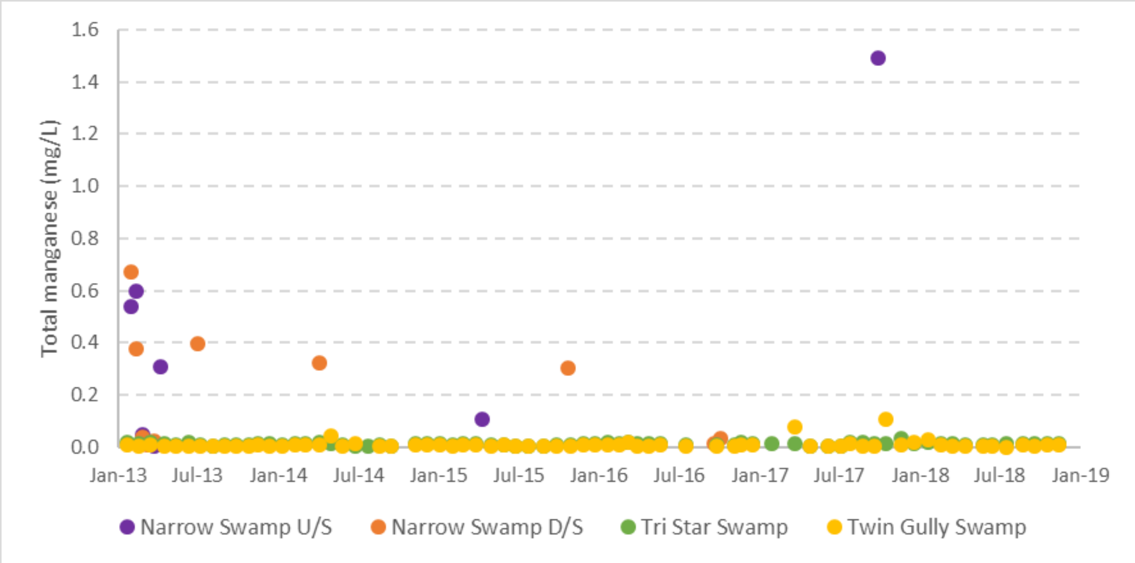




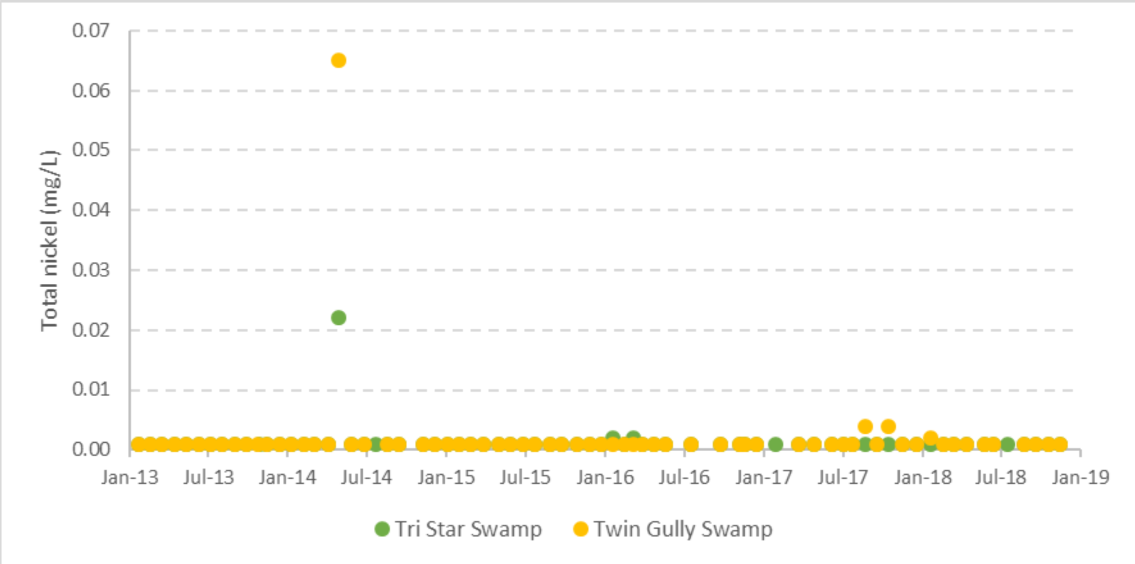

0.060
0.050
0.040
0.030
0.020
0.010
0.000
Total barium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp


35
30
25
20
15
10
5
0
Total iron (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Narrow Swamp U/S
Narrow Swamp D/S
Tri Star Swamp
Twin Gully Swamp

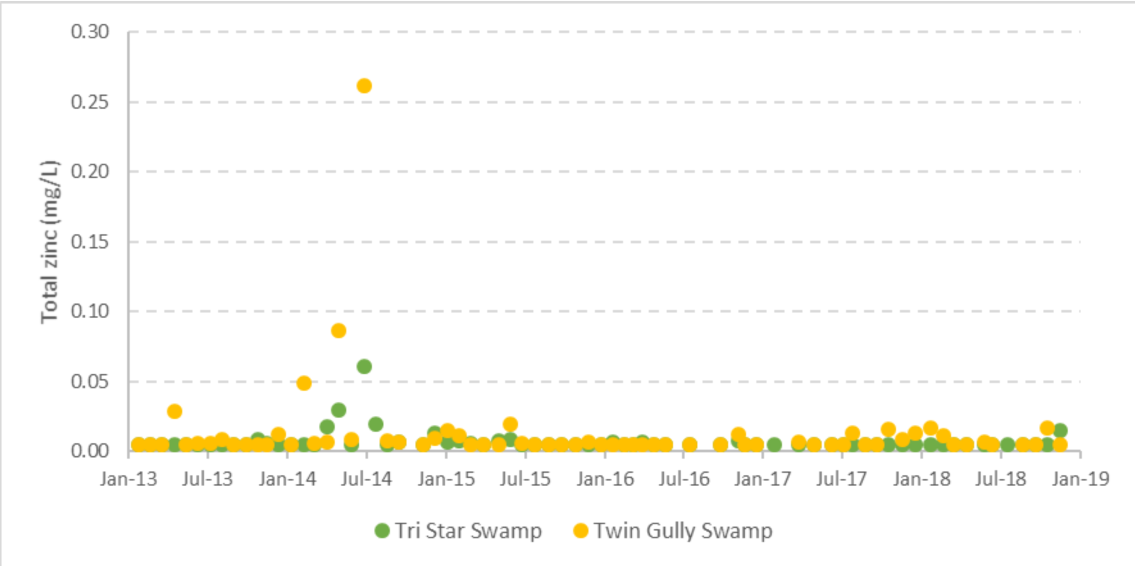

20
18
16
14
12
10
8
6
4
2
0
Total lead (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp



Total manganese (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Narrow Swamp U/S
Narrow Swamp D/S
Tri Star Swamp
Twin Gully Swamp

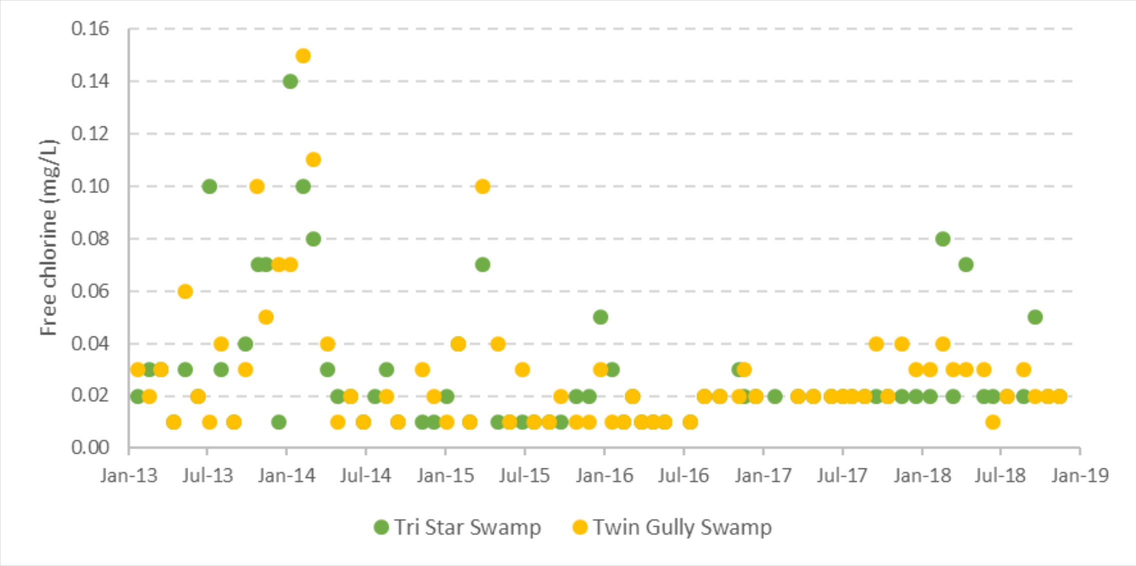


Total nickel (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

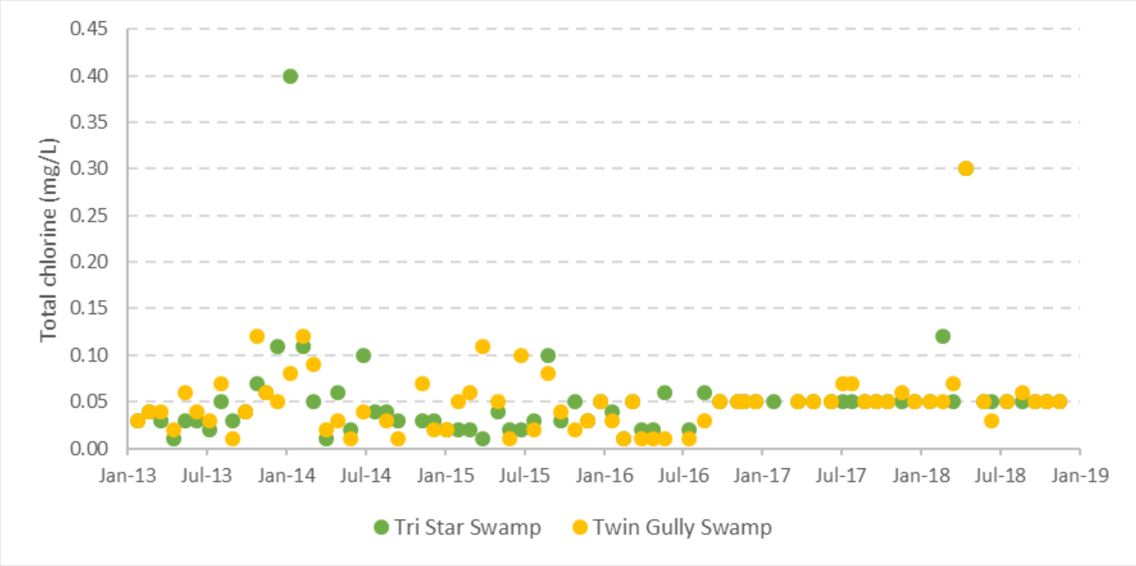


Total zinc (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

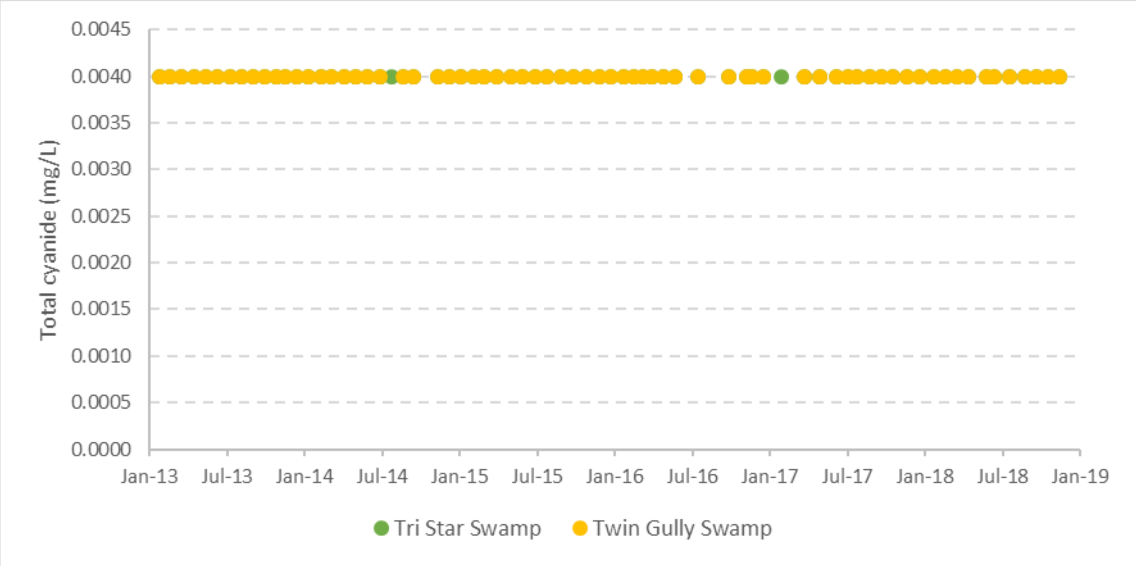
Other



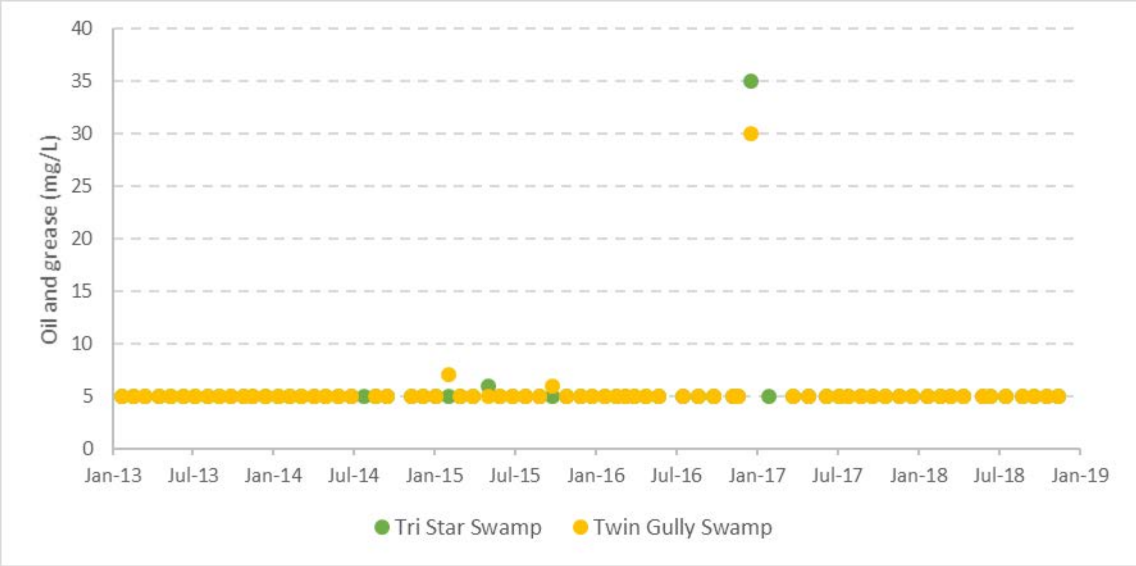
Free chlorine (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

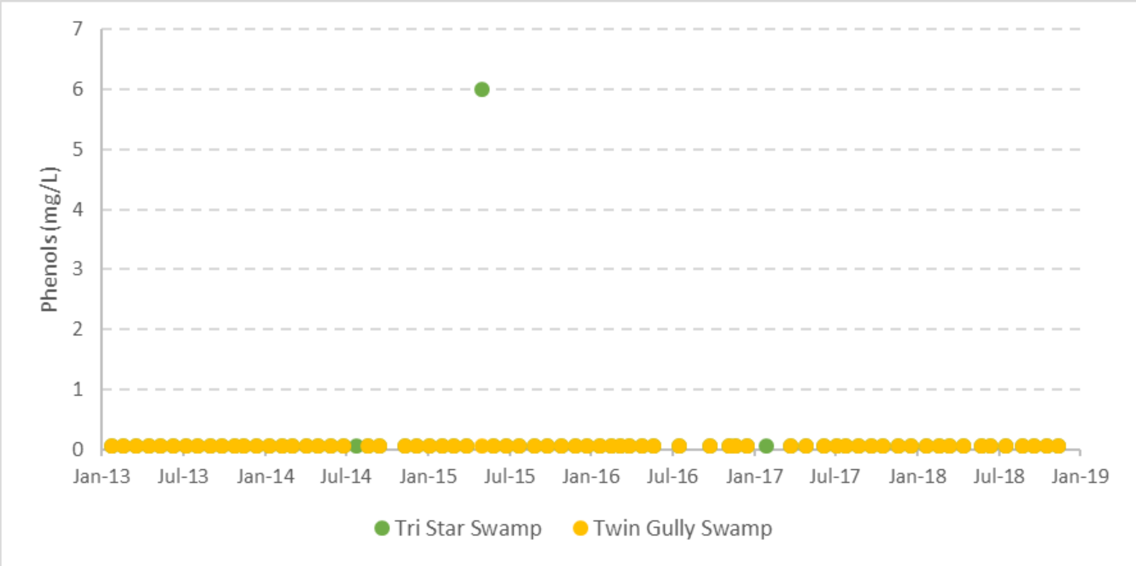


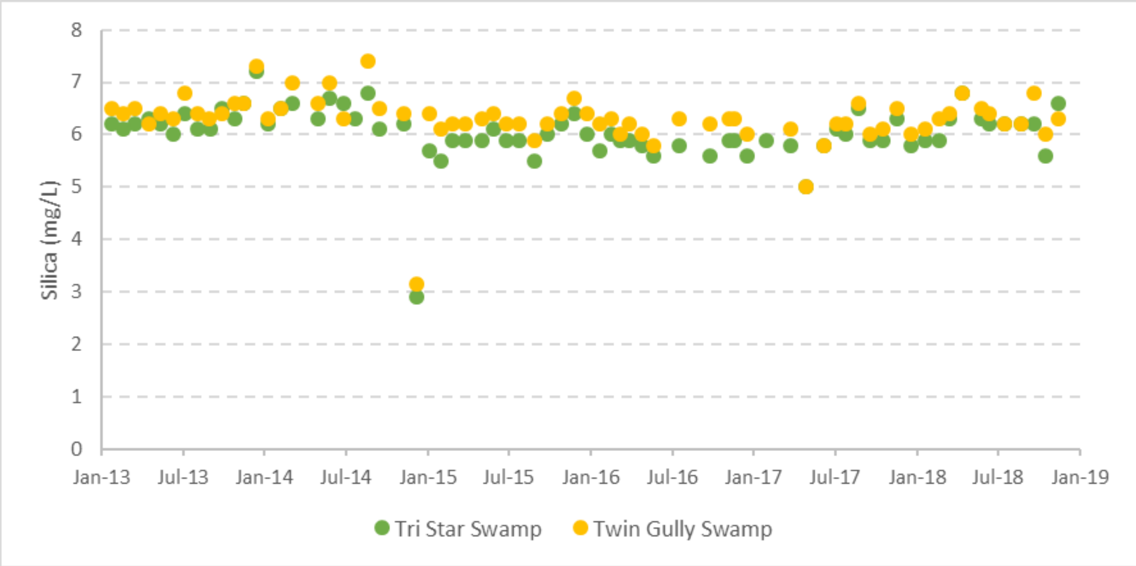
Total chlorine (mg/L)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

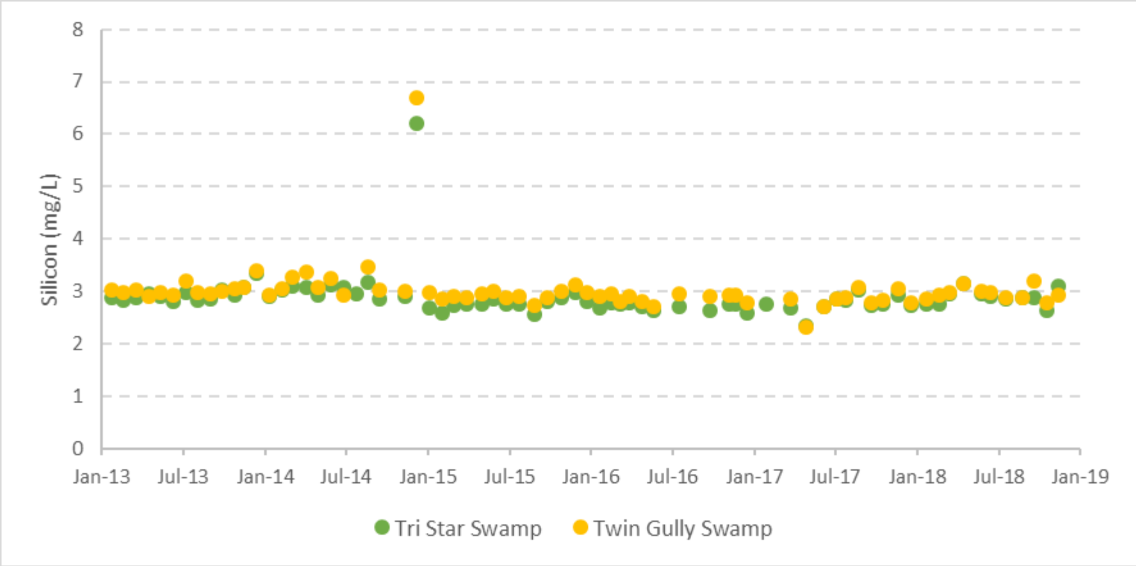


Total cyanide (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp

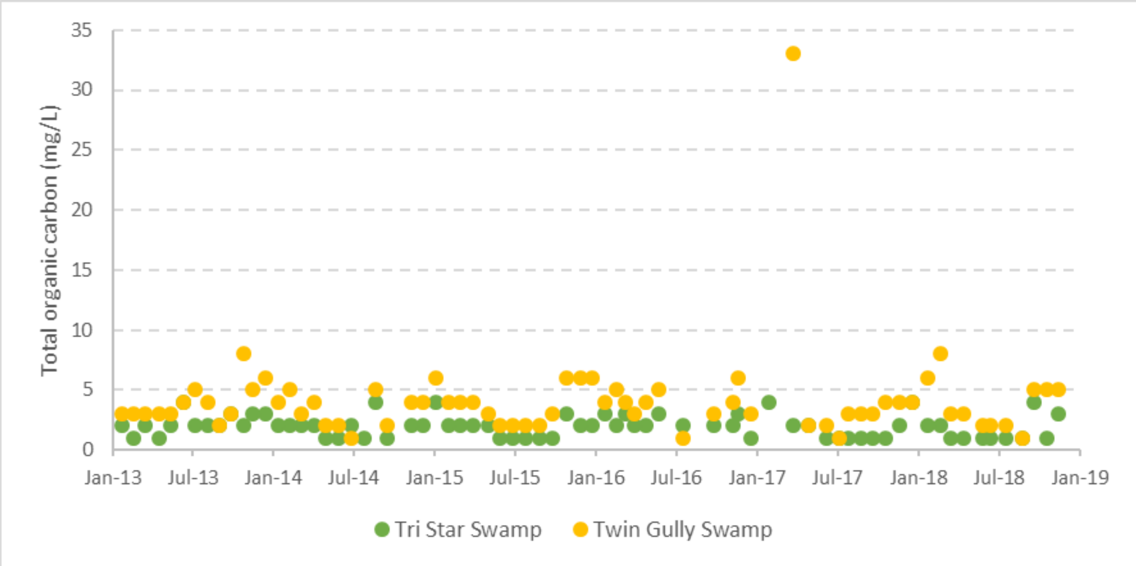

Oil and grease (mg/L)
40
35
30
25
20
15
10
5
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp


Phenols (mg/L)
7
6
5
4
3
2
1
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp


Silica (mg/L)
8
7
6
5
4
3
2
1
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Tri Star Swamp
Twin Gully Swamp



Silicon (mg/L)
0
1
2
3
4
5
6
7
8
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

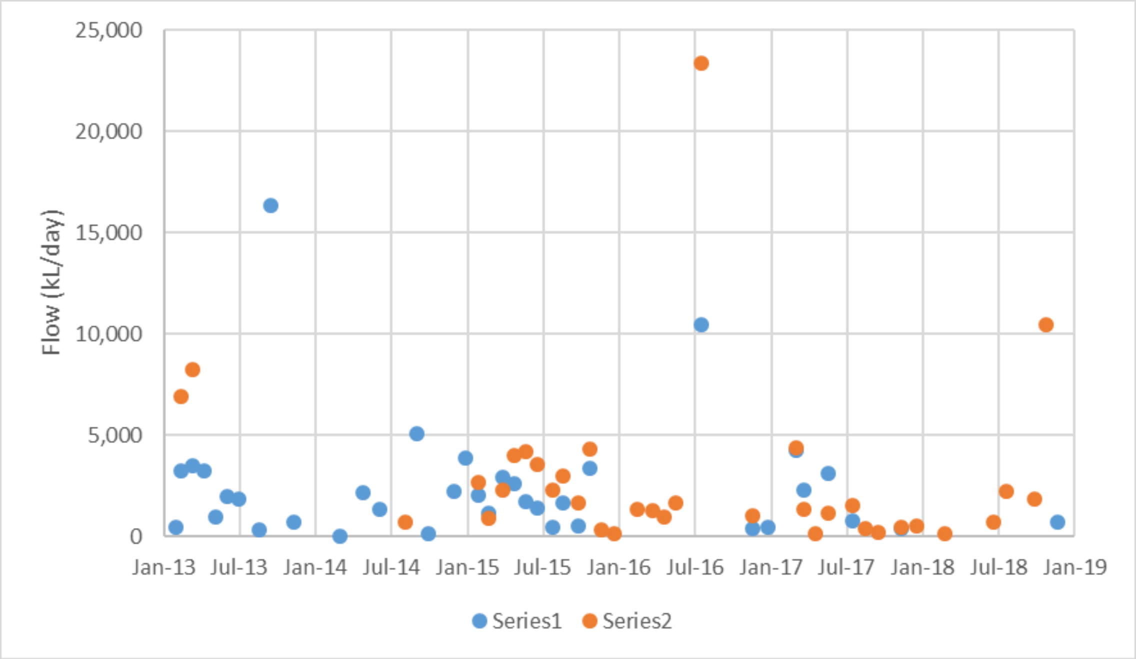


Total organic carbon (mg/L)
0
5
10
15
20
25
30
35
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Tri Star Swamp
Twin Gully Swamp

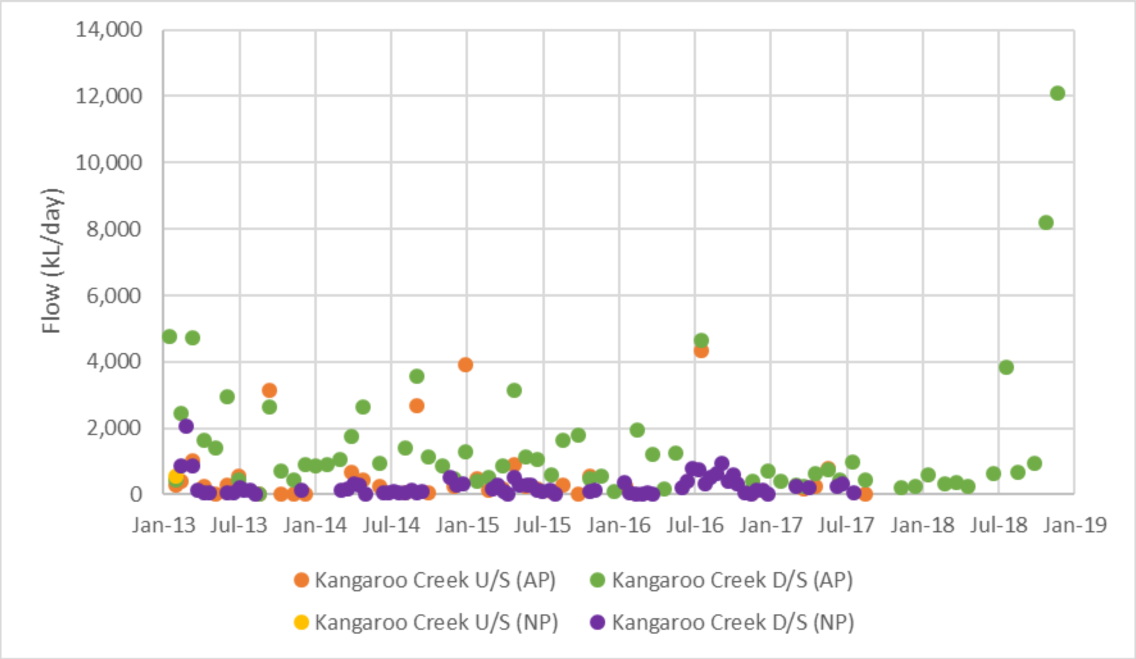
E.2 Surface water flow and depth monitoring

E.2.1 Watercourses

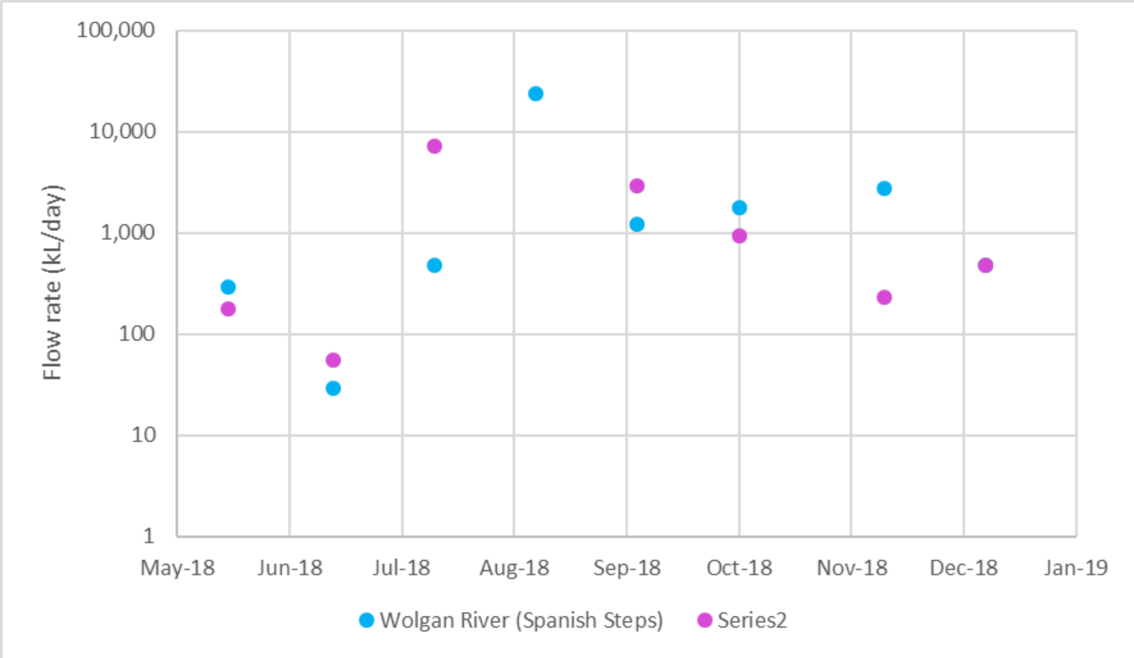
Coxs River



Kangaroo Creek

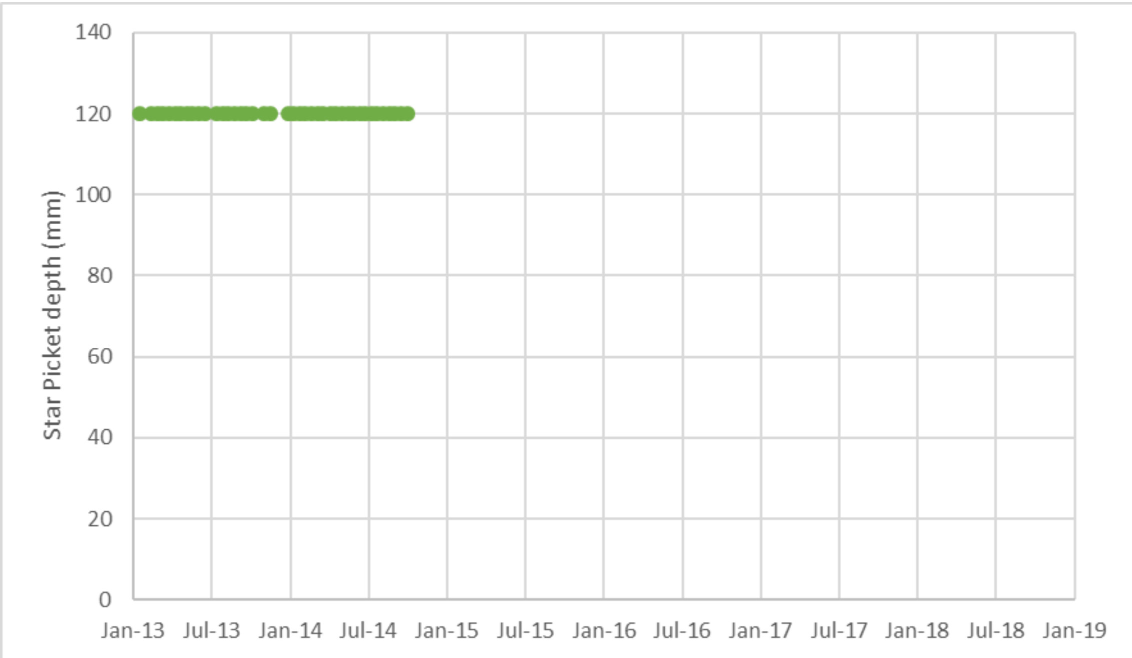


Wolgan River

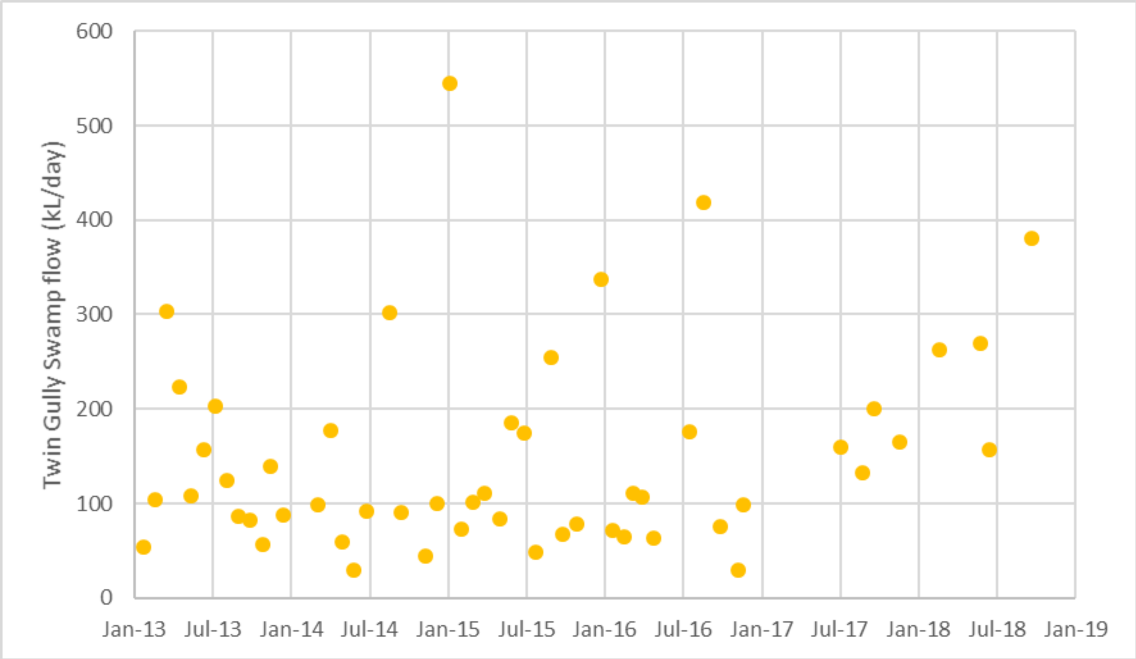


E.2.2 Swamps

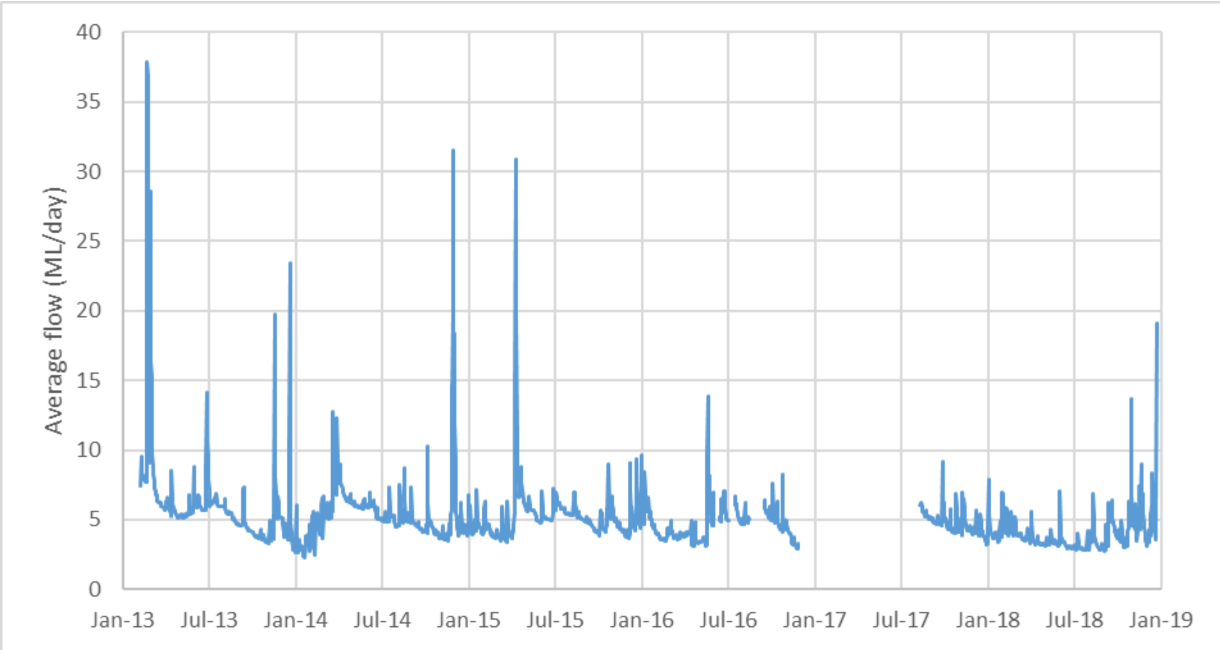
Star Picket



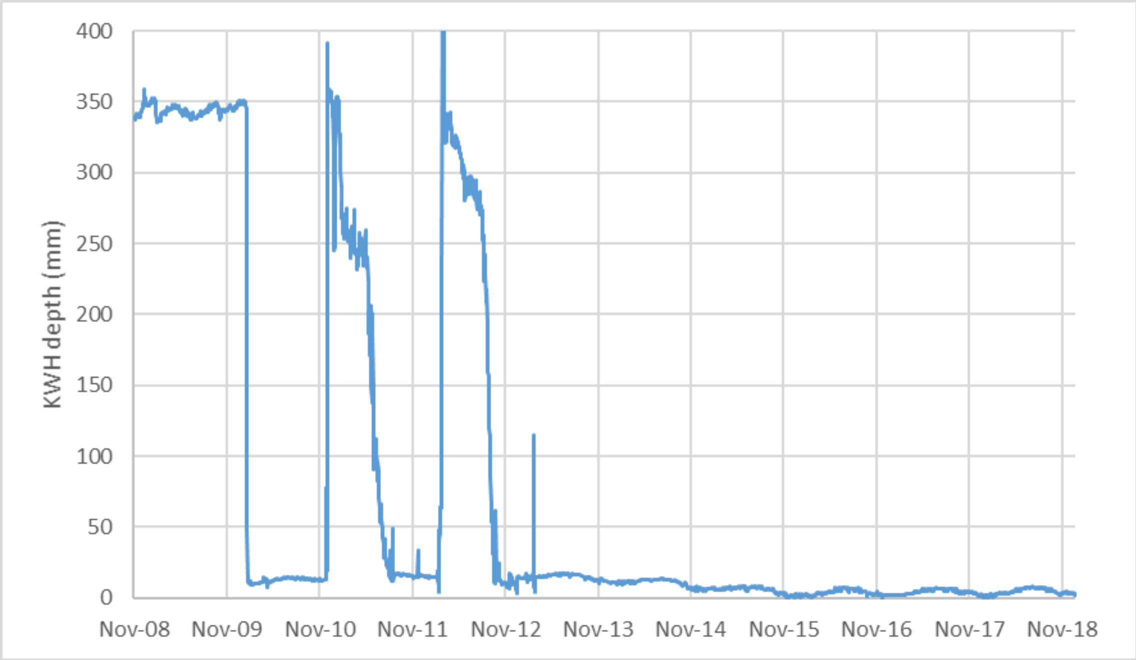
Twin Gully Swamp



Tri Star Swamp

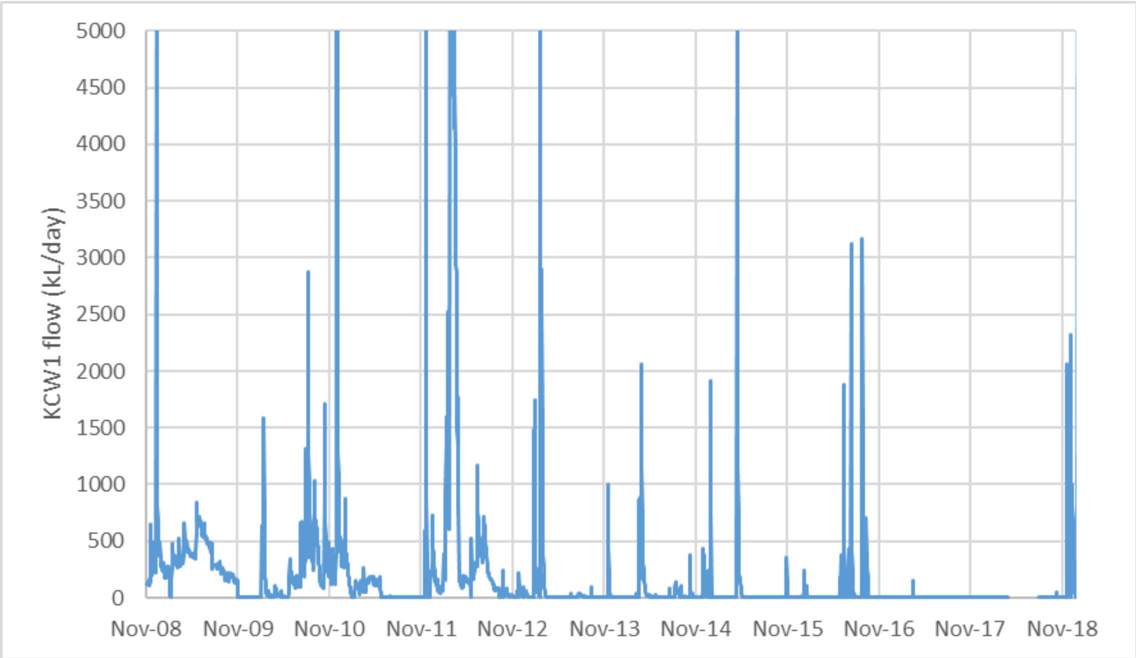


KWH



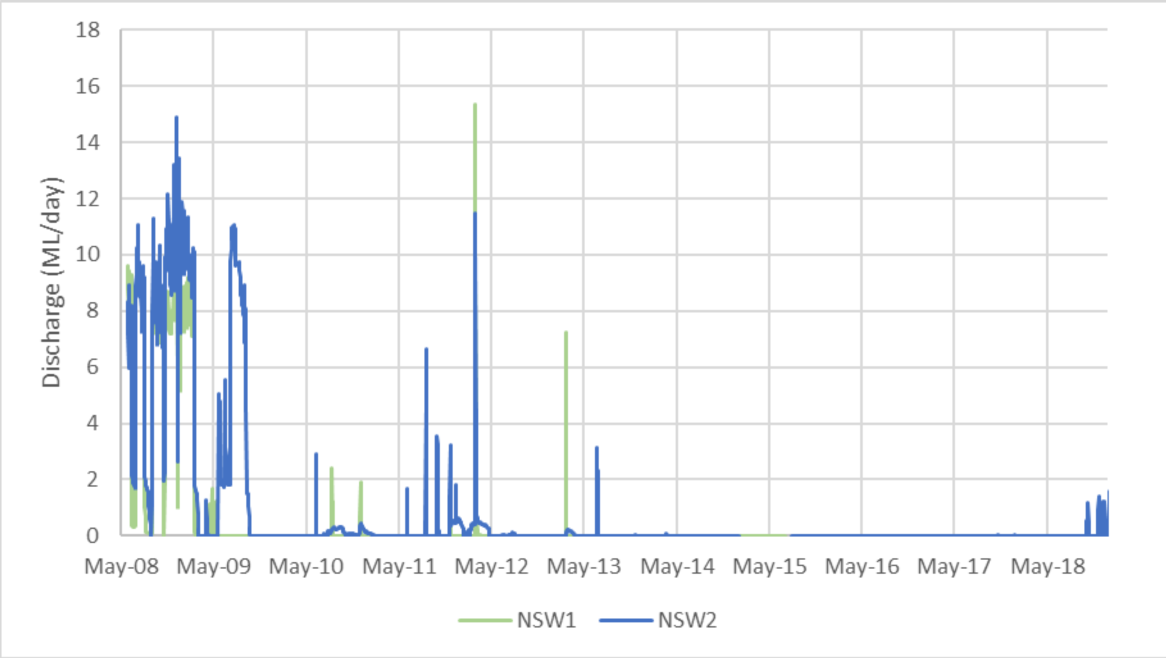
400
350
300
250
200
150
100
50
0
KWH depth (mm)
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
Nov-14
Nov-15
Nov-16
Nov-17
Nov-18

KCW1



5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
KCW1 flow (kL/day)
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
Nov-14
Nov-15
Nov-16
Nov-17
Nov-18

Narrow Swamp



E.3 Derivation of surface water quality triggers

E.3.1 Data requirements

ANZECC (2000) recommend that, for the purpose of deriving ambient concentrations and SSGVs, a sufficient amount of data needs to be collected and that it should characterise seasonal variations:

"A minimum of two years of continuous monthly data at the reference site is required before a valid trigger value can be established."

E.3.2 Guideline values

Threshold guideline values may be derived from:

- ANZECC (2000) default values (consistent with water quality objectives).
- Limits specified in relevant EPLs and development consents.
- SSGVs derived or recommended using site-specific water quality monitoring data.
- Local ecotoxicity testing.

ANZECC (2000) define guideline values as:

"…the concentrations (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem specific investigations or implementation of management/remedial actions."

E.3.3 Water quality objectives

Environmental values associated with the waterways and water sources within the area surrounding Angus Place Colliery include primary industry, aquatic ecosystems, recreational users, irrigation and stock watering. In this assessment, the guideline values from the ANZECC (2000) guidelines for the protection of 95% of aquatic species have been used, as they are considered to be the most sensitive and, regardless of the current water quality present within the receiving environment, foster an improved water quality standard in the future.

E.3.4 Ecosystem condition

The ANZECC (2000; Section 3.1.3.1) guidelines recognise the following three categories of ecosystem condition, with a level of protection assigned to each:

- High conservation/ecological value systems.
- Slightly to moderately disturbed systems.
- Highly disturbed systems.

Coxs River is considered to be a 'slightly to moderately disturbed' system, as the waterway has been adversely affected by human activities by a small to measurable degree. This is predominately due to the extensive current and historical disturbance in the catchment due to coal mining, power generation and agriculture.

E.3.5 Reference site

Monitoring site Coxs River Far U/S, located on Coxs River upstream of Angus Place Colliery, has been selected as the most appropriate reference site to provide background data to derive SSGVs. This site is located within the Coxs River catchment and is not measurably impacted by mining or power generation activities.

E.3.6 Default guideline values

Guideline values for many parameters are recommended by ANZECC (2000), which are usually derived from background assessments (physicochemical parameters and nutrients) and ecotoxicity studies (toxicants) and are not specific to the site studied. These guideline values should be considered as DGVs and their suitability should be verified by establishing local background conditions. DGVs were selected from the ANZECC (2000) guidelines, with state derived guideline values preferred to regionally derived guideline values.

Within the ANZECC (2000) guidelines, Coxs River falls into two different categories of ecosystem protection depending on the parameter reviewed, as identified in Table E-1.

Table E-1 ANZECC (2000) protection categories

Parameter	Category
Physicochemical parameters and nutrients (total nitrogen and phosphorus)	NSW upland river (ANZECC 2000; Table 3.3.2, 3.3.3 and 8.2.12).
Metals and nutrients (ammonia)	Freshwater category (ANZECC 2000; Table 3.4.1), with 95% species protection for slightly-moderately disturbed ecosystems.

A list of the DGVs recommended by ANZECC (2000) to assess water quality in the absence of adequate reference site monitoring data is presented in Table E-2. Note that the DGV for dissolved mercury is for a 99% species protection level as recommended by ANZECC (2000) due to potential bioaccumulation and secondary poisoning effects.

Table E-2 ANZECC (2000) default guideline values

Parameter	Units	DGV	Comments
Physicochemical			
EC	µS/cm	350	NSW upland river (Table 3.3.3).
pH	pH units	6.5–8.0	NSW upland river (Table 3.3.2).
TSS	mg/L	25	NSW upland river (Table 8.2.12).
Turbidity	NTU	25	NSW upland river (Table 3.3.3).
Nutrients			
Ammonia	mg/L	0.013	NSW upland river (Table 3.3.2).
Total nitrogen	mg/L	0.25	NSW upland river (Table 3.3.2).
Total phosphorus	mg/L	0.02	NSW upland river (Table 3.3.2).
Dissolved metals			
Aluminium	mg/L	0.055	Freshwater guideline for 95% species protection (Table 3.4.1). Applies for pH>6.5.
Arsenic	mg/L	0.024	Freshwater guideline for 95% species protection (Table 3.4.1). Applies to As (III).
Boron	mg/L	0.37	Freshwater guideline for 95% species protection (Table 3.4.1).

Parameter	Units	DGV	Comments
Cadmium	mg/L	0.0002	Freshwater guideline for 95% species protection (Table 3.4.1).
Copper	mg/L	0.0014	Freshwater guideline for 95% species protection (Table 3.4.1).
Iron	mg/L	0.3	Canadian guideline as recommended by ANZECC (2000; Section 8.3.7.1).
Lead	mg/L	0.0034	Freshwater guideline for 95% species protection (Table 3.4.1).
Manganese	mg/L	1.9	Freshwater guideline for 95% species protection (Table 3.4.1).
Mercury	mg/L	0.00006	Freshwater guideline for 99% species protection (Table 3.4.1)
Nickel	mg/L	0.011	Freshwater guideline for 95% species protection (Table 3.4.1).
Zinc	mg/L	0.008	Freshwater guideline for 95% species protection (Table 3.4.1).

E.3.7 Data below the limit of reporting

When the analytical result was below the LOR for a particular parameter, then the detection limit was included in the calculation. This is one of the approaches recommended by ANZECC (2000; Section 6.2.1). Table E-3 identifies the LOR for each water quality parameter monitored at Coxs River Far U/S used to derive SSGVs.

It is understood that this approach has limitations, in particular when over 25% of data is below the detection limit. Where greater than 25% of values for a parameter in the reference site dataset were below the LOR, the lowest detection limit reported for that dataset has been used in establishing the guideline values.

Table E-3 Limit of reporting for water quality parameters

Parameter	Units	Limit of reporting
Physicochemical		
EC	µS/cm	1
pH	pH units	0.01
TSS	mg/L	5
Turbidity	NTU	0.1
Nutrients		
Ammonia	mg/L	0.01
Total nitrogen	mg/L	0.1
Total phosphorus	mg/L	0.01

Parameter	Units	Limit of reporting
Dissolved metals		
Aluminium	mg/L	0.01
Antimony	mg/L	0.001
Arsenic	mg/L	0.001
Barium	mg/L	0.001
Boron	mg/L	0.05
Cadmium	mg/L	0.0001
Copper	mg/L	0.001
Iron	mg/L	0.05
Lead	mg/L	0.001
Lithium	mg/L	0.001
Manganese	mg/L	0.001
Mercury	mg/L	0.0001
Molybdenum	mg/L	0.001
Nickel	mg/L	0.001
Rubidium	mg/L	0.001
Strontium	mg/L	0.001
Uranium	mg/L	0.001
Zinc	mg/L	0.005

E.3.8 Derivation of site-specific guideline values

SSGVs were derived on the basis of the methodology outlined by ANZECC (2000) by calculating the 80th percentile of data collected at the reference site (and 20th percentile for pH, which is reported as a range). Table E-4 presents the surface water quality data for Coxs River Far U/S. The 80th percentile values for water quality data at Coxs River Far U/S have been calculated from the most recent 24 points of monthly monitoring data. Where the analytical result was below the LOR for a particular parameter, then the detection limit was used in the calculation.

Table E-4 Statistical analysis of Coxs River Far U/S water quality results

Parameter	Units	80th percentile value
Physicochemical		
EC	µS/cm	187
pH	pH units	6.3[a]–7.3
TSS	mg/L	5[b]
Turbidity	NTU	72

Nutrients		
Ammonia	mg/L	0.08
Total nitrogen	mg/L	2.44
Total phosphorus	mg/L	0.01[b]
Dissolved metals		
Aluminium	mg/L	0.06
Antimony	mg/L	0.001[b]
Arsenic	mg/L	0.001[b]
Barium	mg/L	0.074
Boron	mg/L	0.05[b]
Cadmium	mg/L	0.0001[b]
Copper	mg/L	0.001[b]
Iron	mg/L	11.5
Lead	mg/L	0.001[b]
Lithium	mg/L	0.001[b]
Manganese	mg/L	1.99
Molybdenum	mg/L	0.001[b]
Nickel	mg/L	0.001[b]
Rubidium	mg/L	0.009
Strontium	mg/L	0.049
Uranium	mg/L	0.001[b]
Zinc	mg/L	0.005[b]

[a] 20th percentile value.
[b] Limit of reporting.

The 80th percentile values for water quality data collected at the reference site Coxs River Far U/S were then compared with the DGVs recommended by ANZECC (2000), presented in Table E-2.

Table E-5 presents the DGVs recommended by ANZECC (2000), 80th percentile values for Coxs River Far U/S and the recommended SSGV.

Table E-5 Recommended guideline values

Parameter	Units	DGV (ANZECC 2000)	Coxs River Far U/S 80th percentile	Recommended SSGV
Physicochemical				
EC	µS/cm	350	187	350
pH	pH units	6.5–8.0	6.3[a]–7.3	6.3–8.0
TSS	mg/L	25	5[b]	25
Turbidity	NTU	25	72	72
Nutrients				
Ammonia	mg/L	0.013	0.08	0.08
Total nitrogen	mg/L	0.25	2.44	2.44
Total phosphorus	mg/L	0.02	0.01[b]	0.02
Dissolved metals				
Aluminium	mg/L	0.055	0.06	0.06
Antimony	mg/L	–	0.001[b]	0.001
Arsenic	mg/L	0.024	0.001[b]	0.024
Barium	mg/L	–	0.074	0.074
Boron	mg/L	0.37	0.05[b]	0.37
Cadmium	mg/L	0.0002	0.0001[b]	0.0002
Copper	mg/L	0.0014	0.001[b]	0.0014
Iron	mg/L	0.3	11.5	11.5
Lead	mg/L	0.0034	0.001[b]	0.0034
Lithium	mg/L	–	0.001[b]	0.001
Manganese	mg/L	1.9	1.99	1.99
Mercury	mg/L	0.00006	–	0.00006
Molybdenum	mg/L	–	0.001[b]	0.001
Nickel	mg/L	0.011	0.001[b]	0.011
Rubidium	mg/L	–	0.009	0.009
Strontium	mg/L	–	0.049	0.049
Uranium	mg/L	–	0.001[b]	0.001
Zinc	mg/L	0.008	0.005[b]	0.008

[a] 20th percentile value.
[b] Limit of reporting.

Appendix F – Baseline discharge water data

F.1 Statistical summary of water quality results

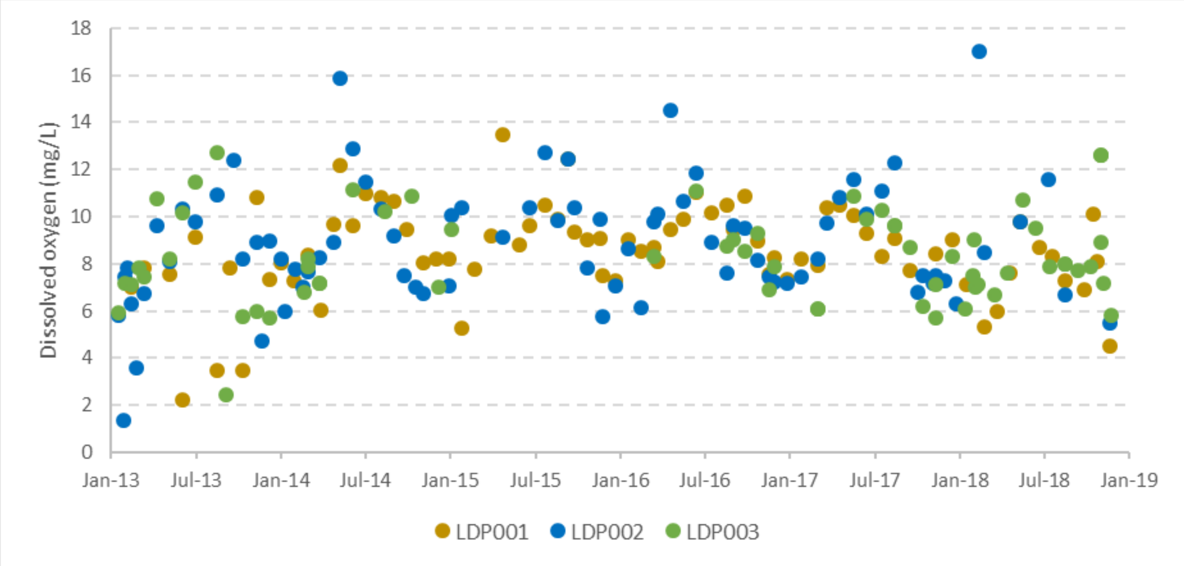
Parameters	Units	LDP002		LDP003	
		Count	Median	Count	Median
Physicochemical					
DO	mg/L	81	8.5	63	7.9
EC	µS/cm	98	301	81	120
pH	pH units	99	8.0	83	7.5
TDS	mg/L	80	203	56	105
TSS	mg/L	99	7	84	18
Turbidity	NTU	96	15	81	41
Major ions					
Bicarbonate alkalinity	mg/L	81	104	55	20
Carbonate alkalinity	mg/L	81	1	55	1
Hydroxide alkalinity	mg/L	81	1	55	1
Total alkalinity	mg/L	81	104	55	20
Calcium	mg/L	81	23	55	7
Chloride	mg/L	81	12	55	3
Magnesium	mg/L	81	5	55	2
Potassium	mg/L	81	7	55	3
Sodium	mg/L	81	26	55	8
Sulfate	mg/L	81	27	55	27
Total hardness	mg/L	81	79	55	28
Nutrients					
Ammonia	mg/L	81	0.02	54	0.03
Nitrate	mg/L	81	0.03	54	0.21
Nitrite	mg/L	81	0.01	54	0.01
Nitrate + nitrite	mg/L	81	0.03	54	0.21
Total fluoride	mg/L	70	0.3	45	0.1
TKN	mg/L	81	0.5	54	0.4
Total nitrogen	mg/L	81	0.6	54	0.6
Total phosphorus	mg/L	81	0.02	54	0.02
Dissolved metals					

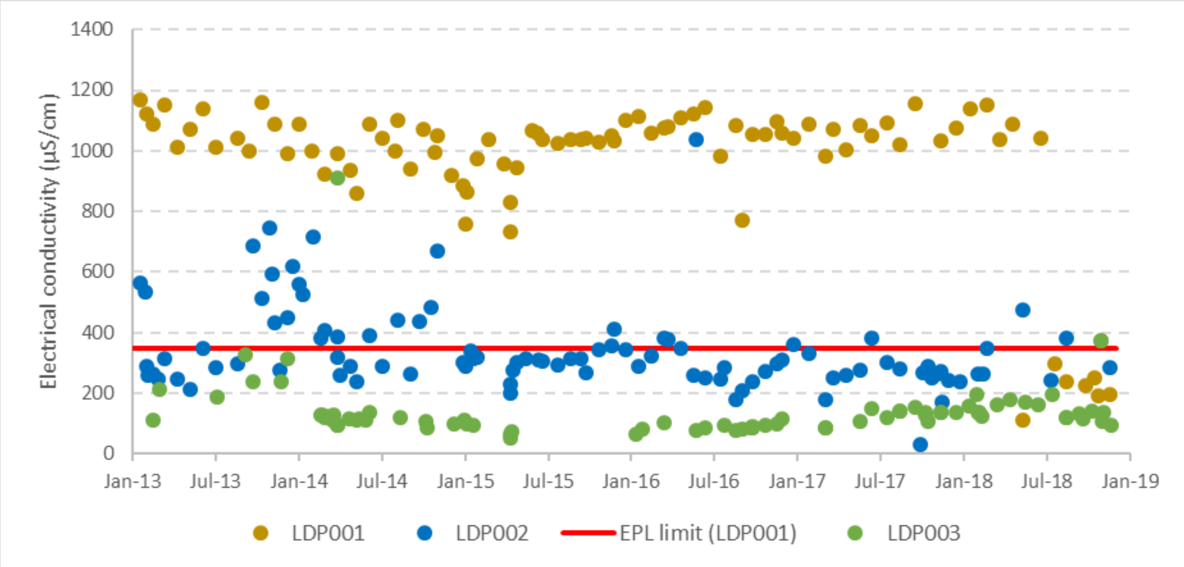
Parameters	Units	LDP002		LDP003	
		Count	Median	Count	Median
Aluminium	mg/L	80	0.03	54	0.05
Antimony	mg/L	81	0.001	54	0.001
Arsenic	mg/L	81	0.001	55	0.001
Barium	mg/L	81	0.058	53	0.017
Boron	mg/L	81	0.05	54	0.05
Cadmium	mg/L	81	0.0001	55	0.0001
Chromium (III)	mg/L	20	0.01	18	0.01
Chromium (VI)	mg/L	21	0.01	19	0.01
Copper	mg/L	81	0.001	55	0.001
Iron	mg/L	81	0.05	55	0.05
Lead	mg/L	81	0.001	55	0.001
Lithium	mg/L	81	0.012	55	0.005
Manganese	mg/L	81	0.029	54	0.005
Mercury	mg/L	14	0.0001	13	0.0001
Molybdenum	mg/L	81	0.002	55	0.001
Nickel	mg/L	81	0.003	54	0.003
Rubidium	mg/L	81	0.008	54	0.002
Strontium	mg/L	81	0.062	54	0.019
Uranium	mg/L	81	0.001	54	0.001
Zinc	mg/L	81	0.009	54	0.01
Total metals					
Aluminium	mg/L	80	0.20	54	0.73
Antimony	mg/L	69	0.001	35	0.001
Arsenic	mg/L	81	0.001	54	0.001
Barium	mg/L	81	0.065	54	0.027
Boron	mg/L	21	0.05	19	0.05
Cadmium	mg/L	21	0.0001	19	0.0001
Cobalt	mg/L	18	0.001	16	0.001
Copper	mg/L	22	0.001	18	0.001
Iron	mg/L	79	0.18	54	0.57

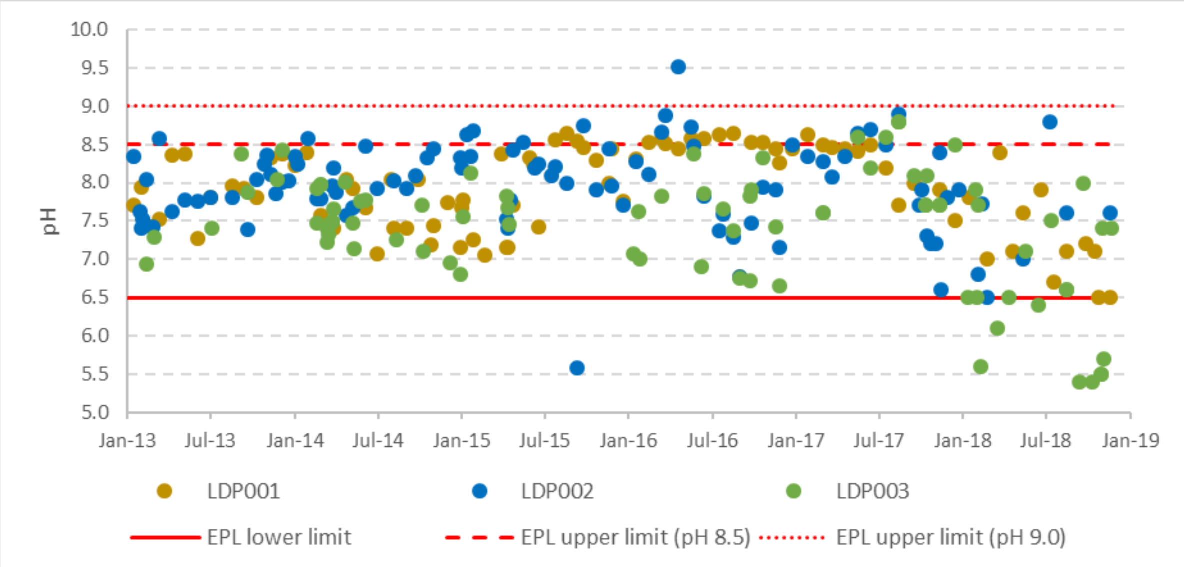
Parameters	Units	LDP002		LDP003	
		Count	Median	Count	Median
Lead	mg/L	81	0.001	52	0.001
Manganese	mg/L	81	0.062	52	0.011
Mercury	mg/L	21	0.0001	20	0.0001
Nickel	mg/L	81	0.003	52	0.005
Selenium	mg/L	22	0.01	18	0.01
Silver	mg/L	21	0.001	20	0.001
Uranium	mg/L	21	0.001	20	0.001
Zinc	mg/L	80	0.010	54	0.010
Other					
Anionic surfactants	mg/L	21	0.1	19	0.1
Free chlorine	mg/L	81	0.03	56	0.02
Total chlorine	mg/L	81	0.05	56	0.02
Total cyanide	mg/L	80	0.004	54	0.004
Oil and grease	mg/L	98	5	75	5
Phenols	mg/L	81	0.05	53	0.05
Silica	mg/L	78	5.6	52	2.4
Silicon	mg/L	81	2.63	55	1.12
Total organic carbon	mg/L	80	8	54	4

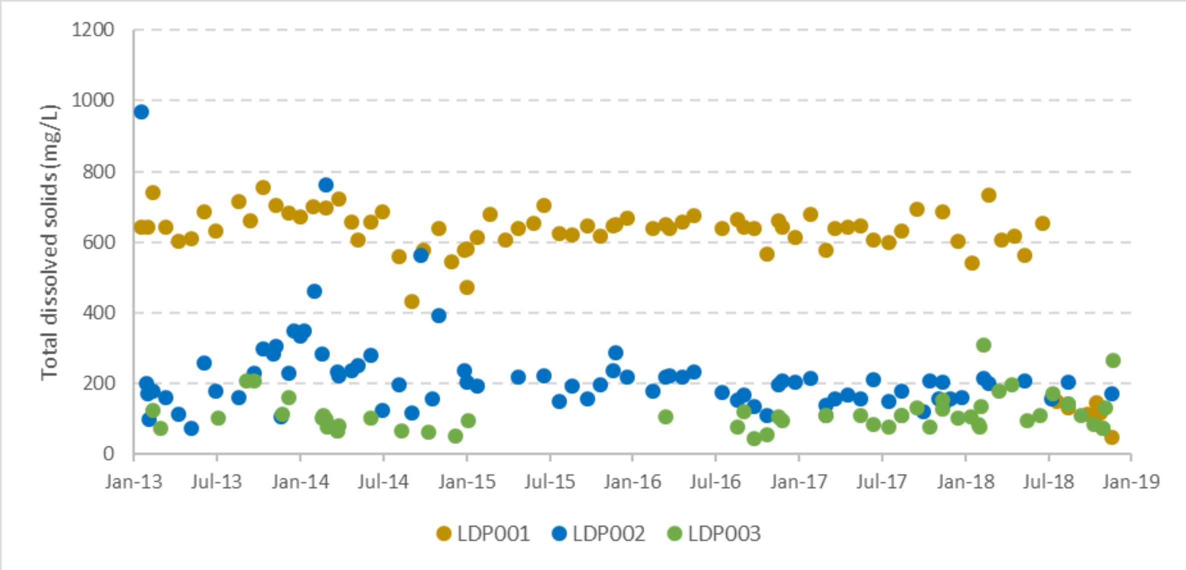
F.2 Time series graphs of water quality results

F.2.1 Physicochemical

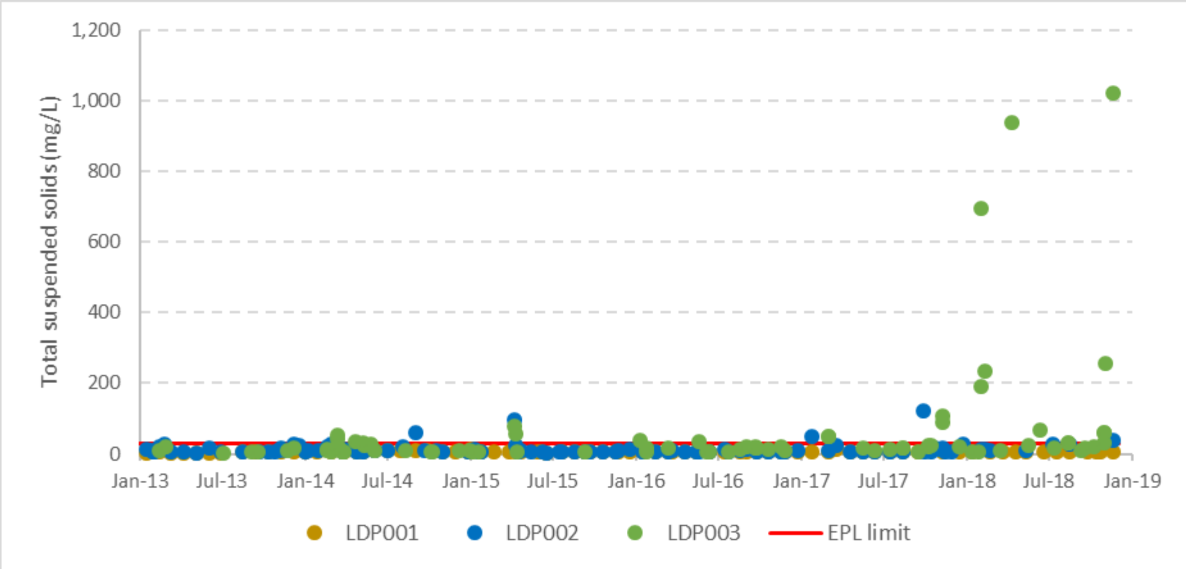




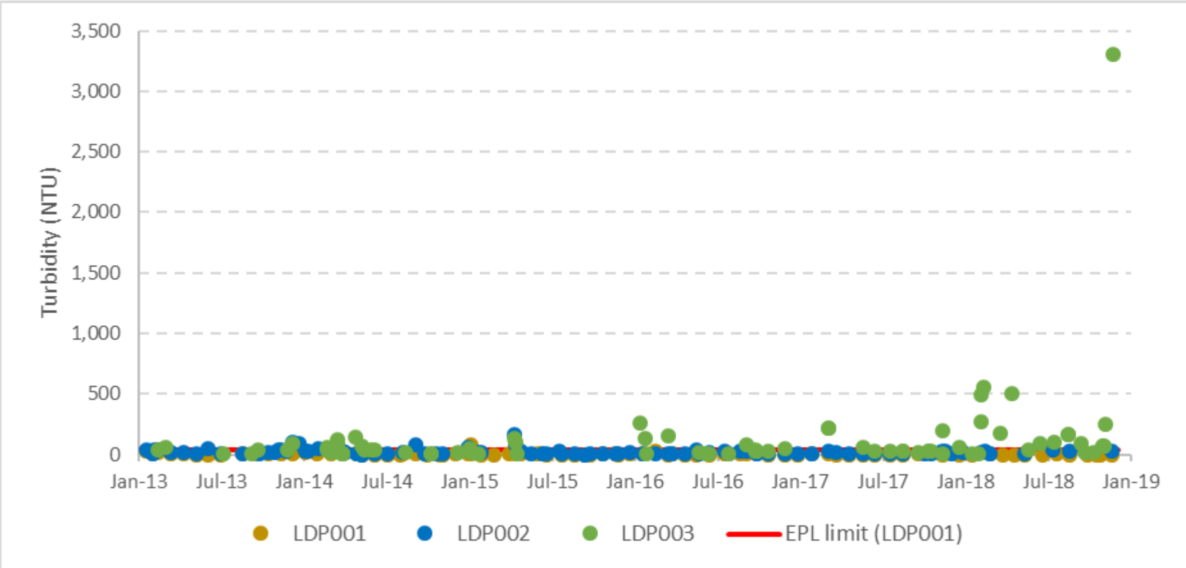




Total dissolved solids (mg/L)
1200
1000
800
600
400
200
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

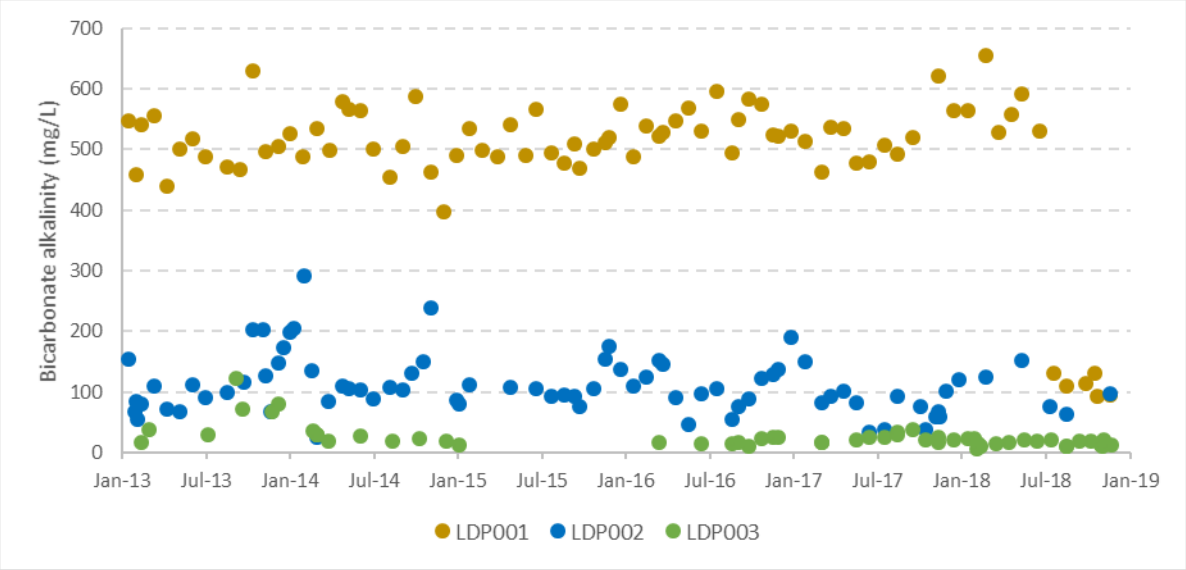


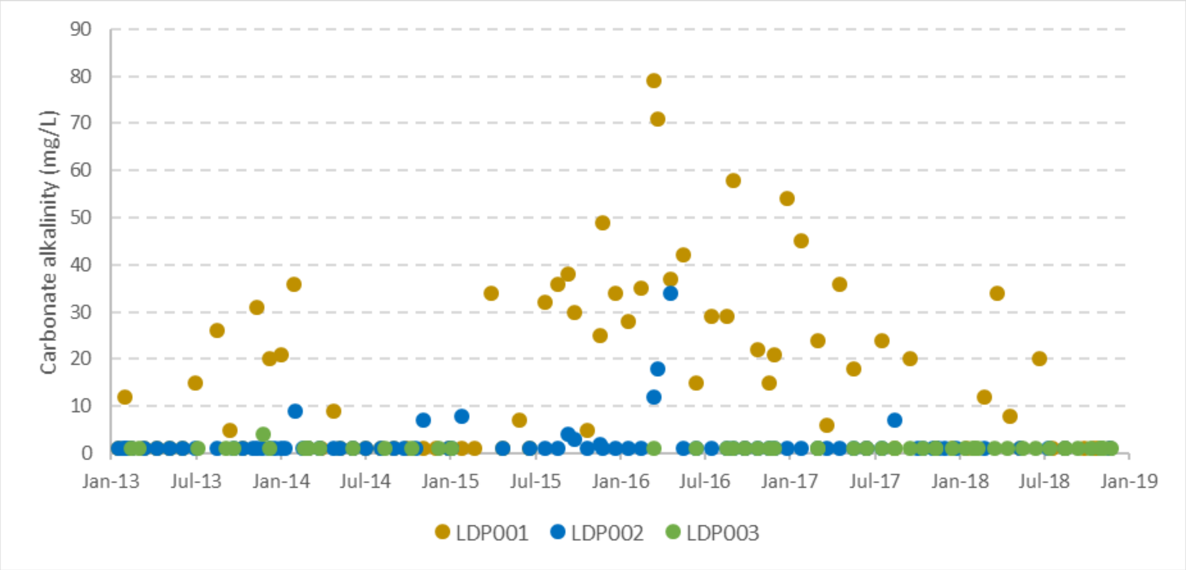
Total suspended solids (mg/L)
1,200
1,000
800
600
400
200
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003
EPL limit

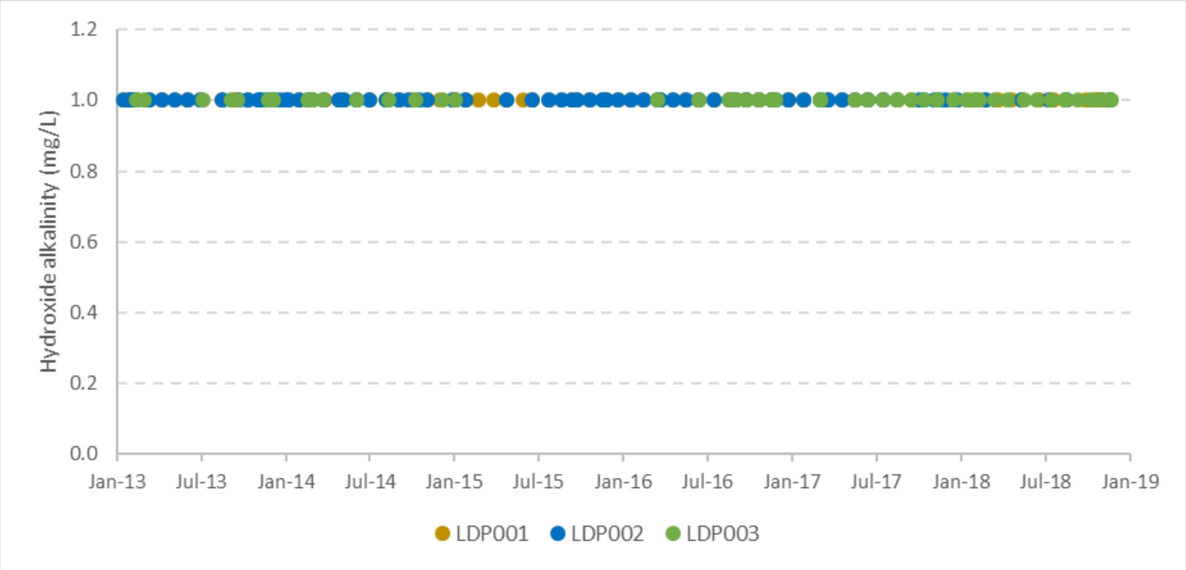


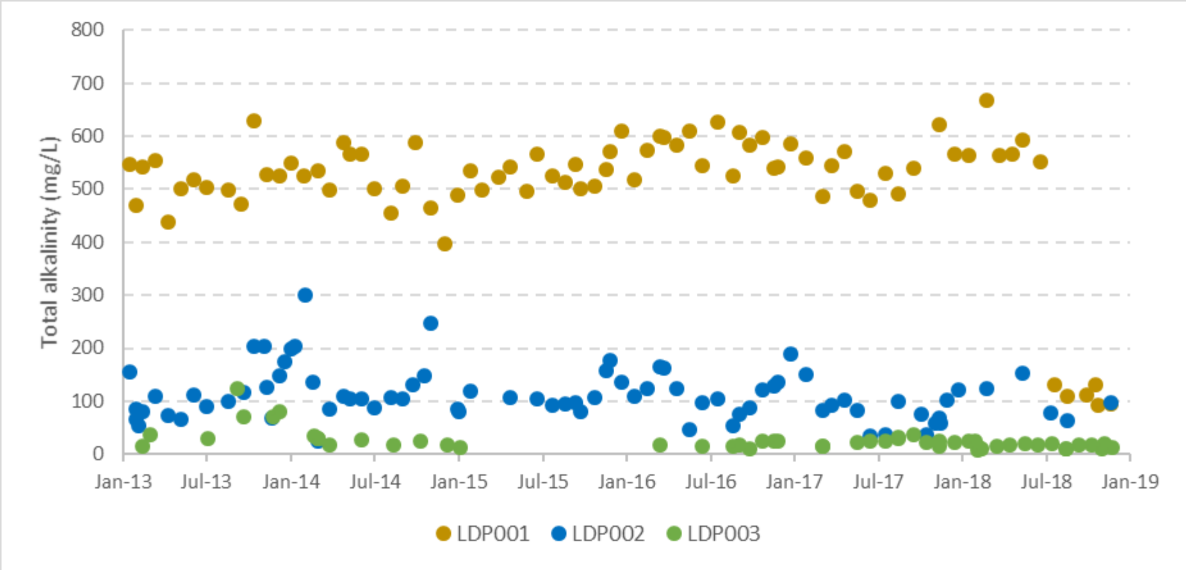
Turbidity (NTU)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003
EPL limit (LDP001)

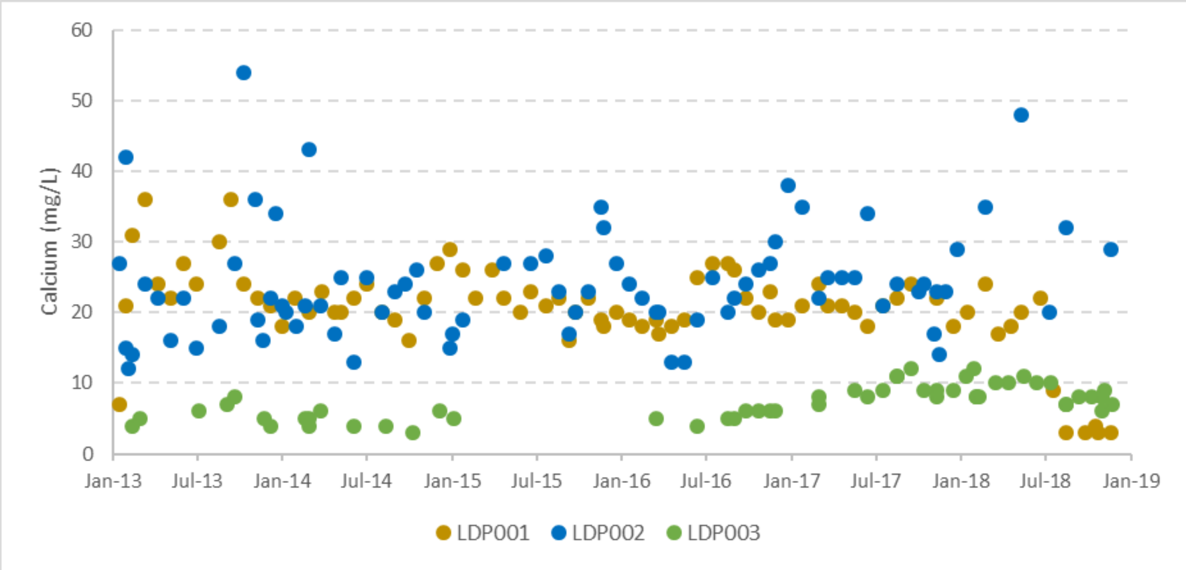
F.2.2 Major ions

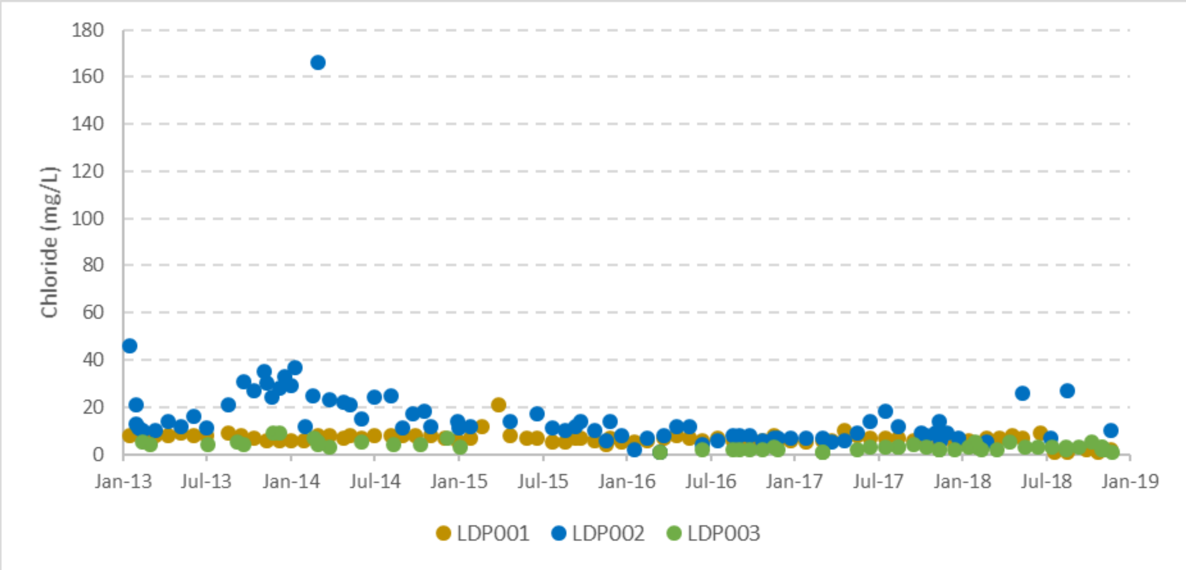


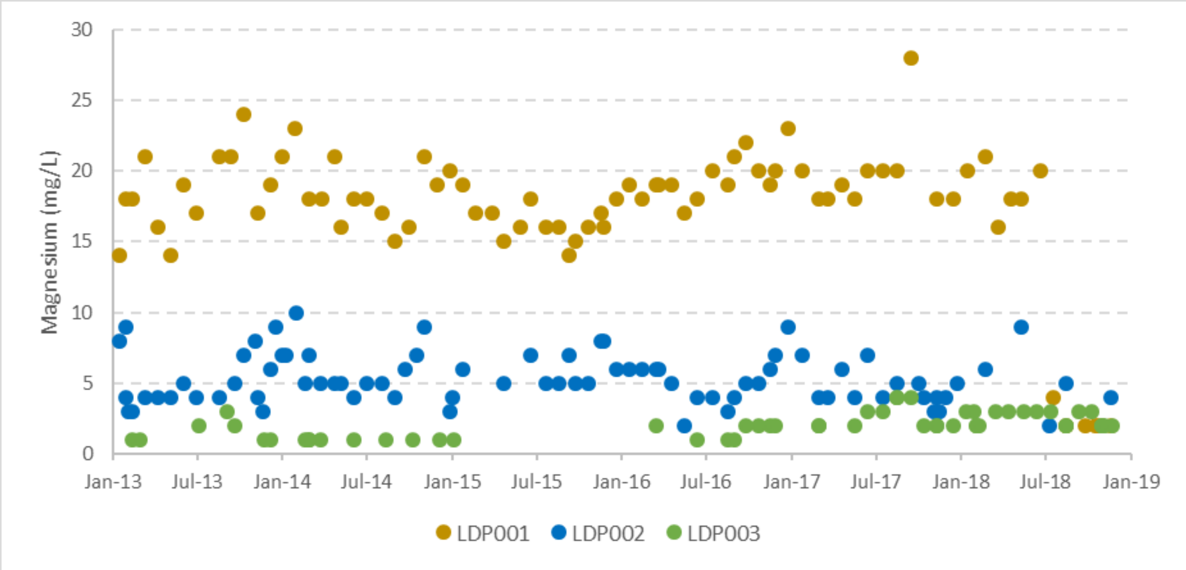




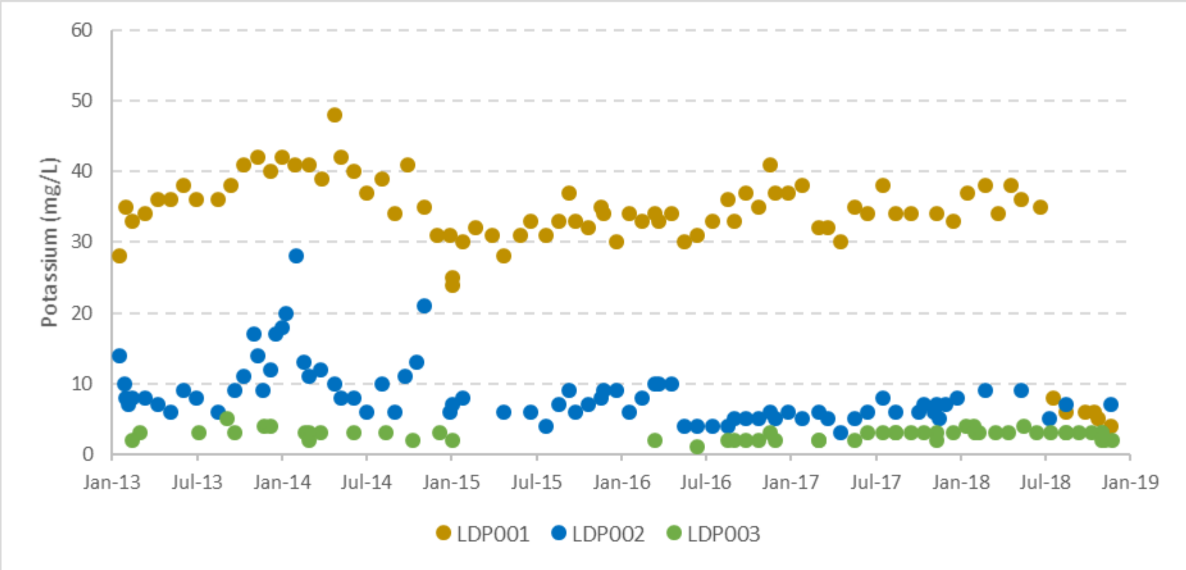

Total alkalinity (mg/L)
800
700
600
500
400
300
200
100
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003


Calcium (mg/L)
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

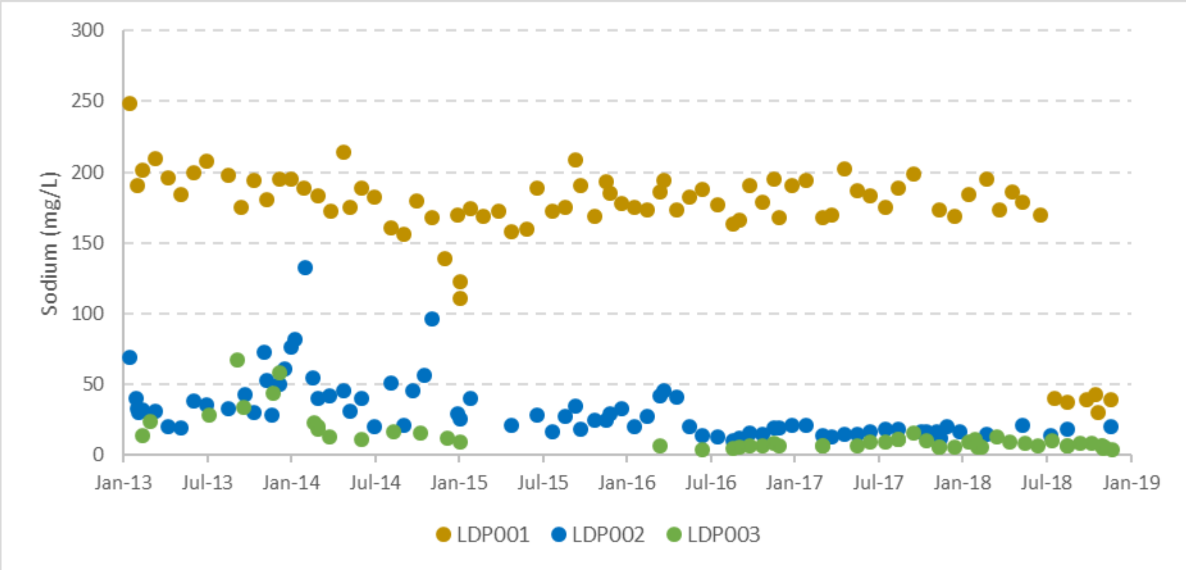

Chloride (mg/L)
180
160
140
120
100
80
60
40
20
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



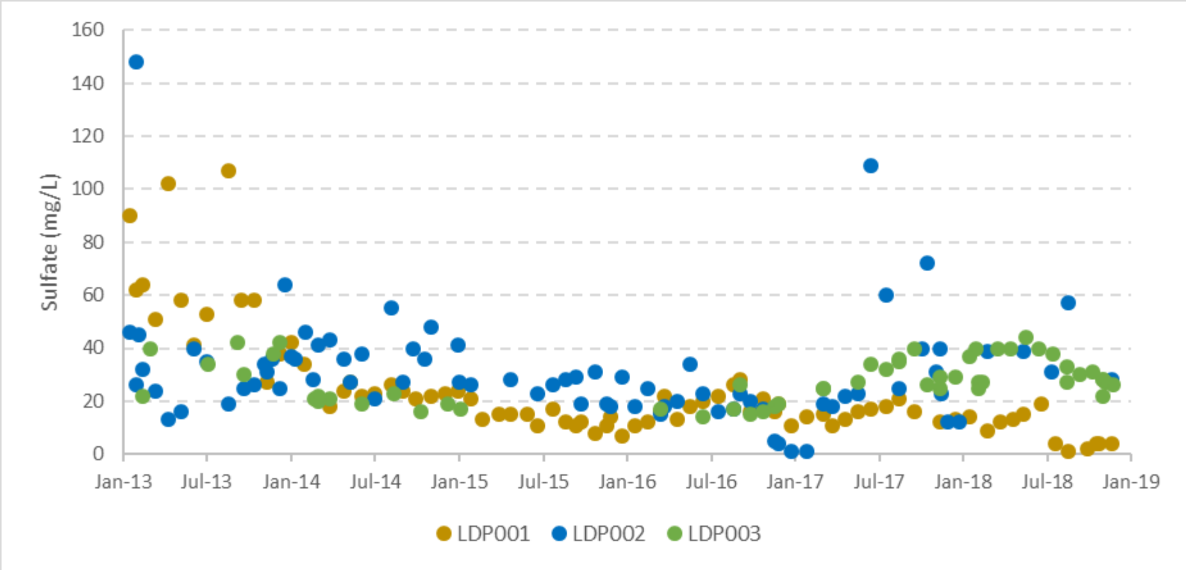
30
25
20
15
10
5
0
Magnesium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

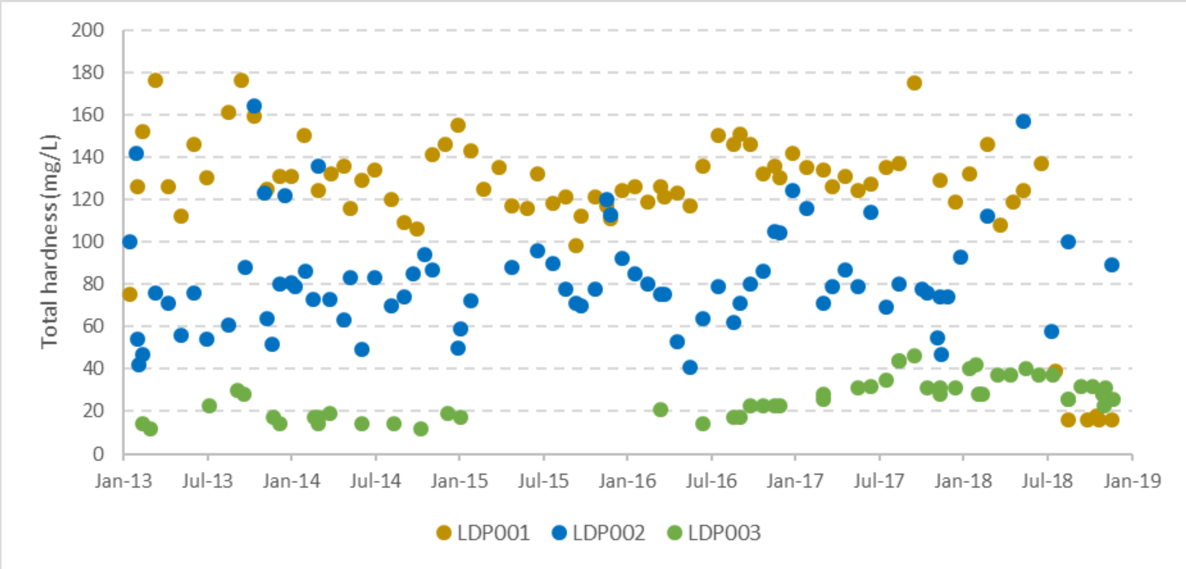


60
50
40
30
20
10
0
Potassium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

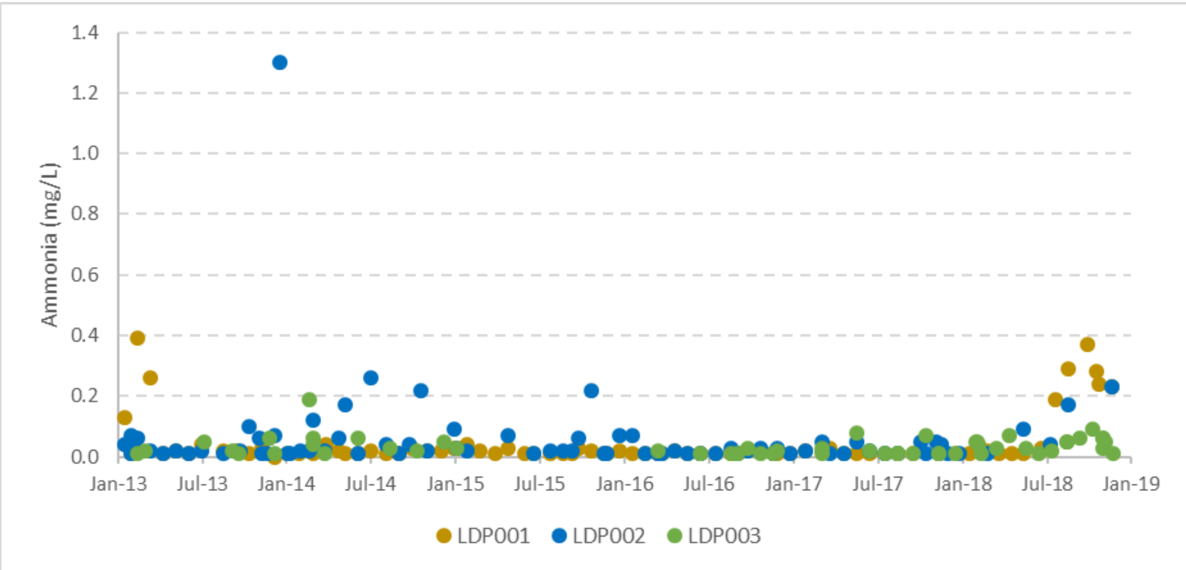


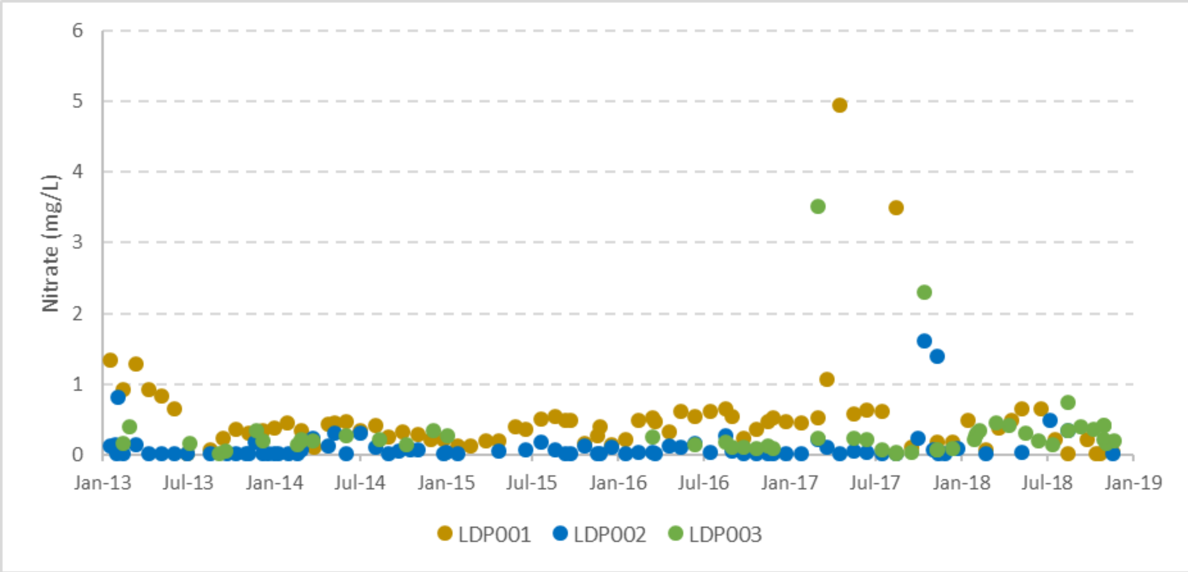
300
250
200
150
100
50
0
Sodium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



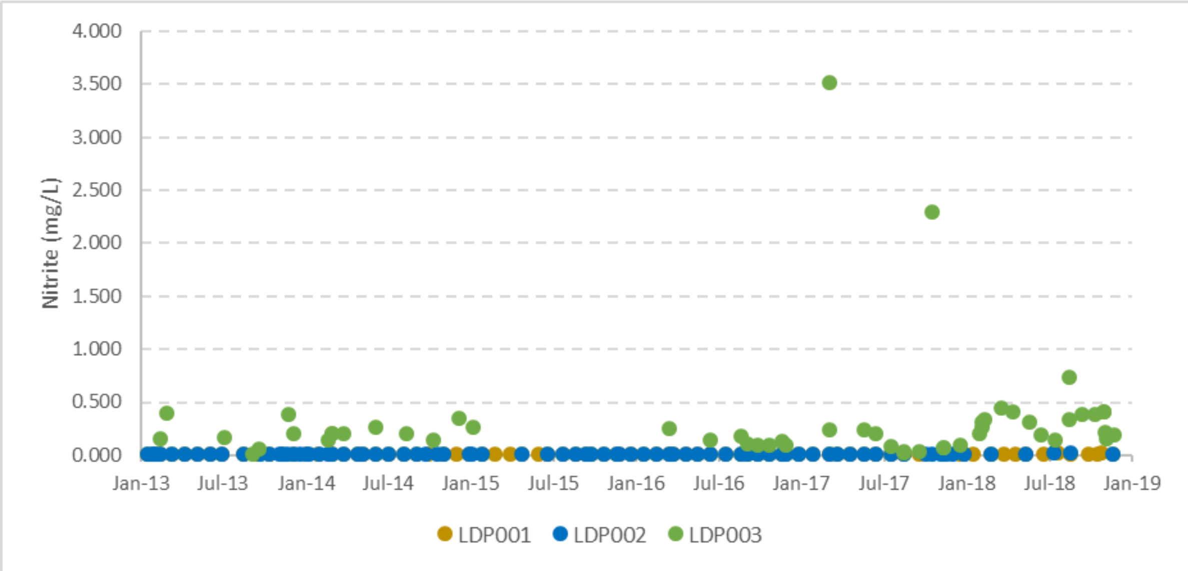


F.2.3 Nutrients

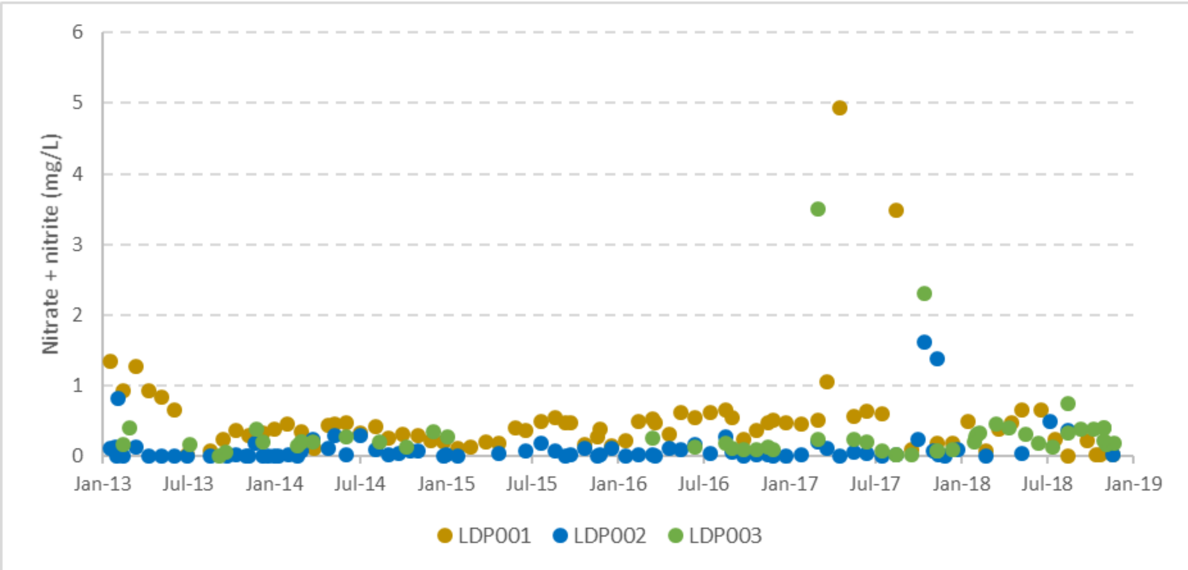




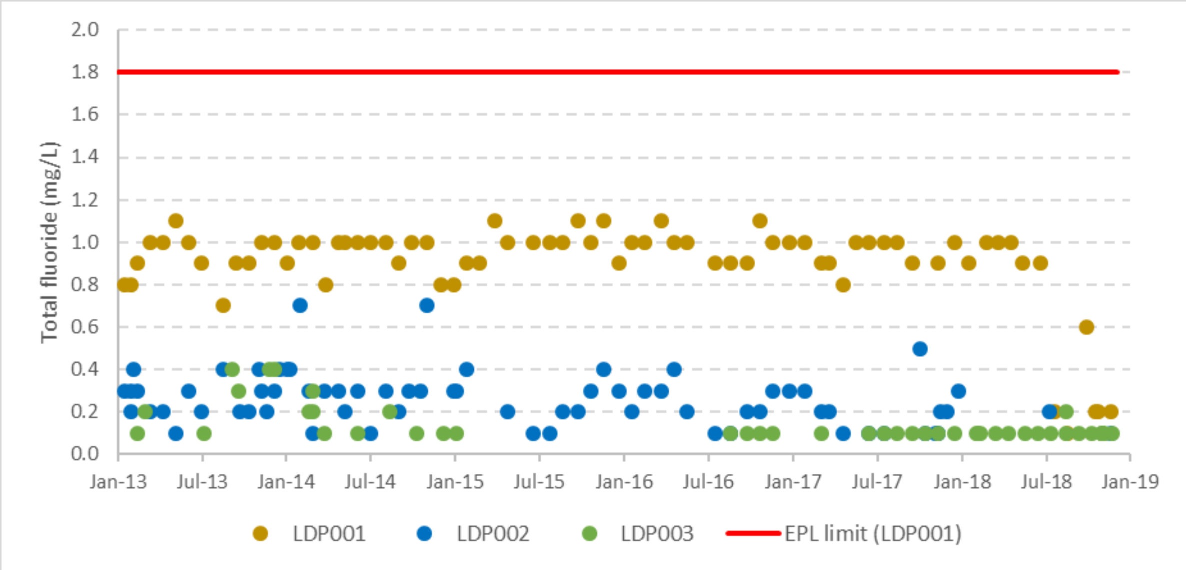
Nitrate (mg/L)
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



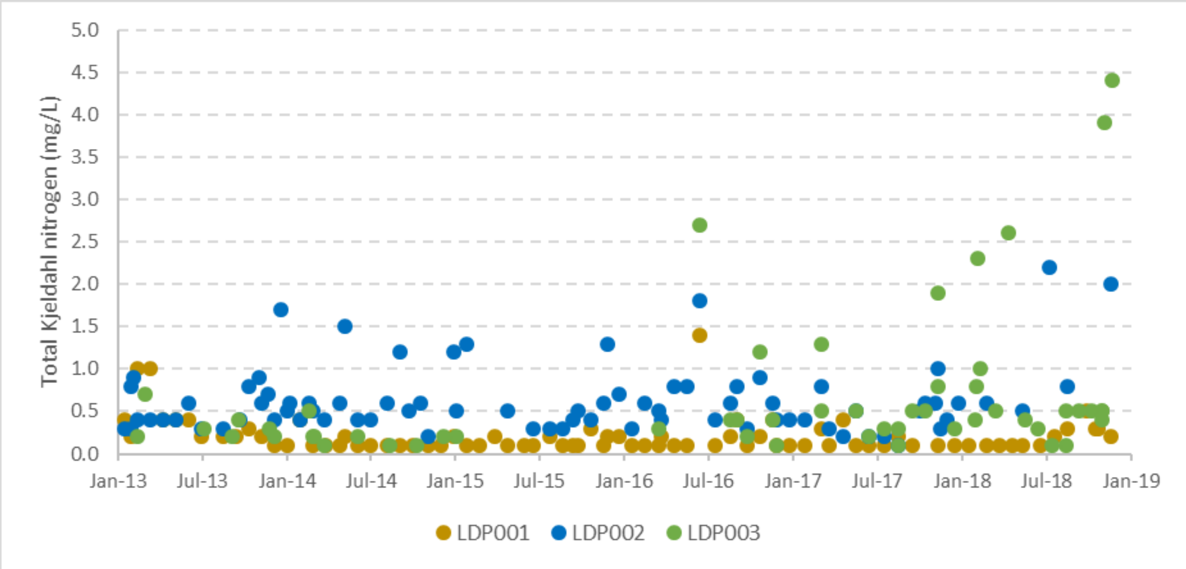
Nitrite (mg/L)
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



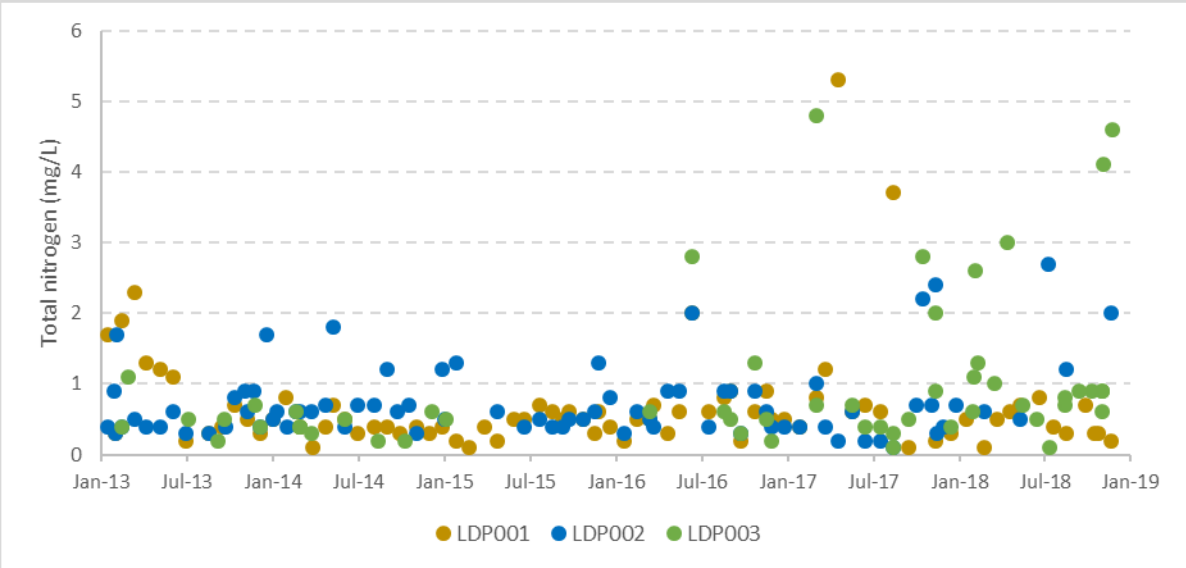
Nitrate + nitrite (mg/L)
6
5
4
3
2
1
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



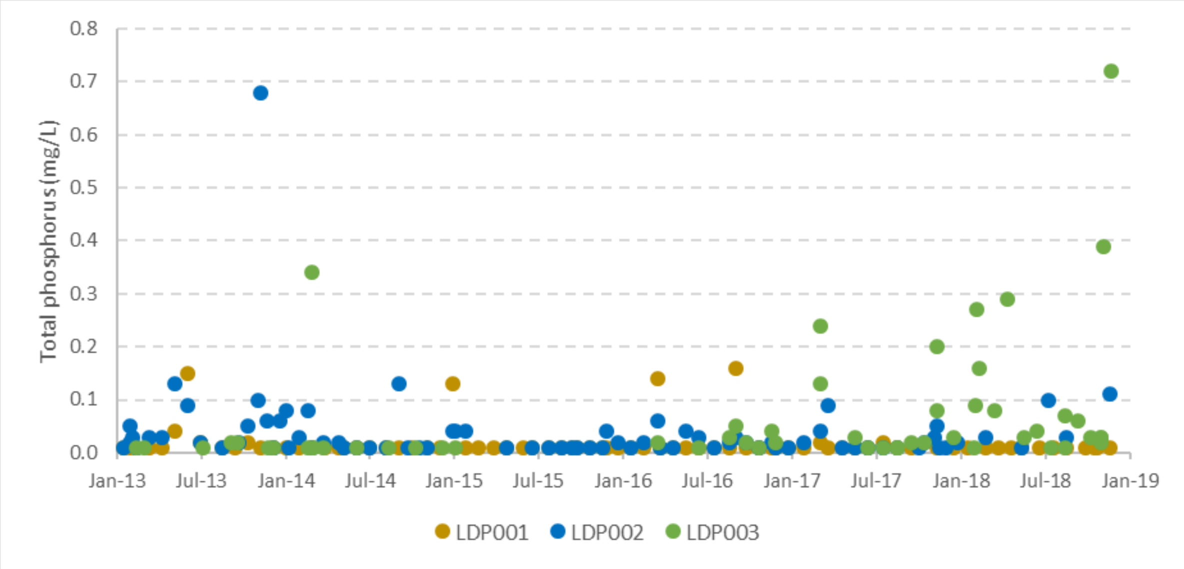
Total fluoride (mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003 EPL limit (LDP001)



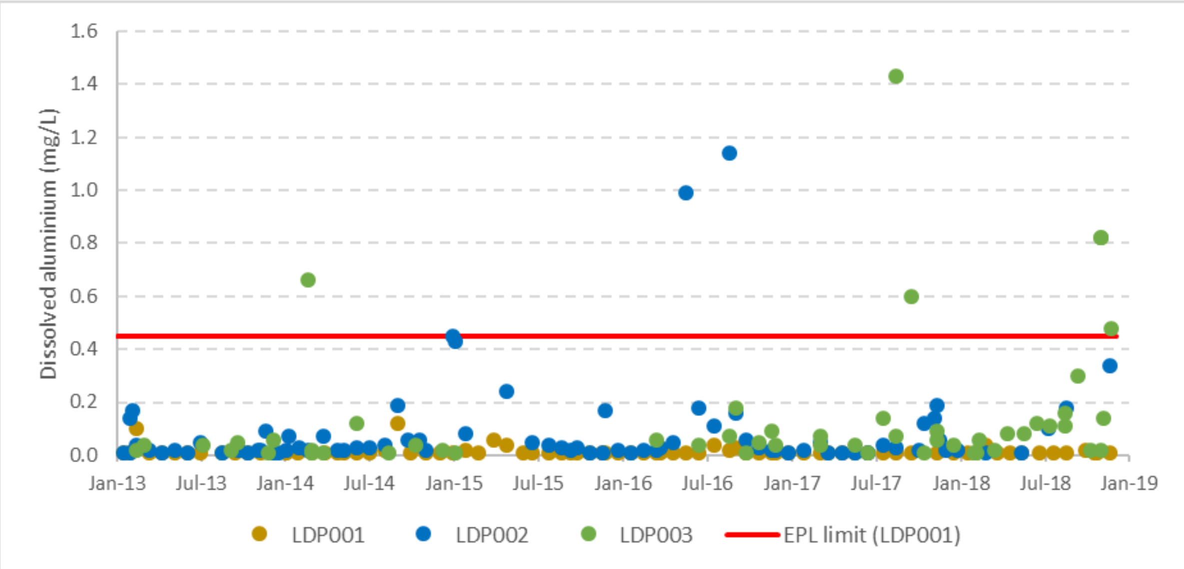
Total Kjeldahl nitrogen (mg/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003

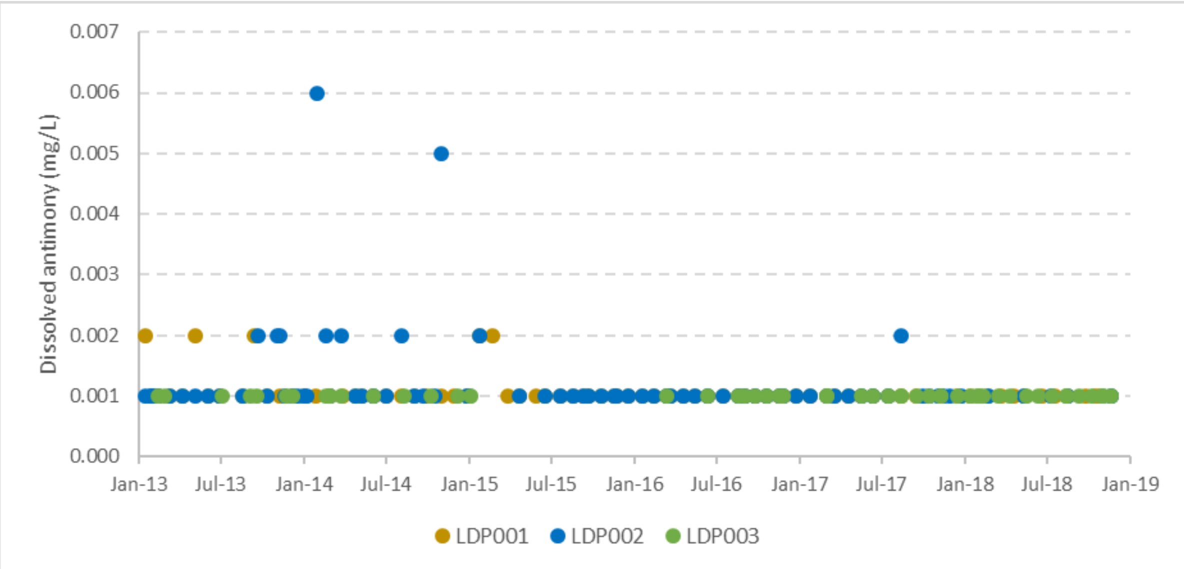


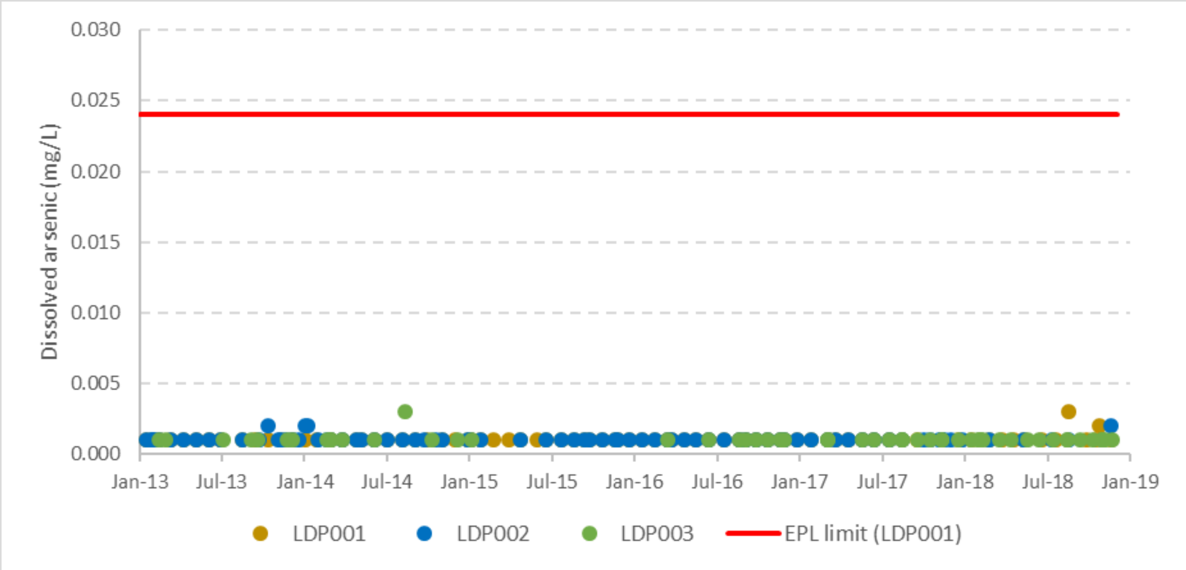
Total nitrogen (mg/L)
6
5
4
3
2
1
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003

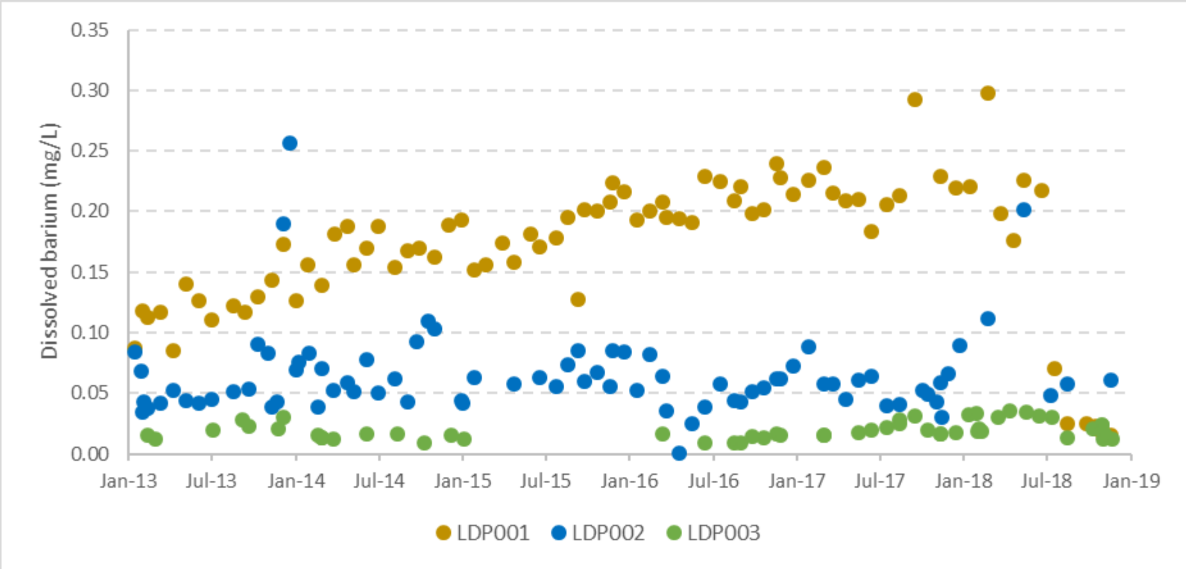


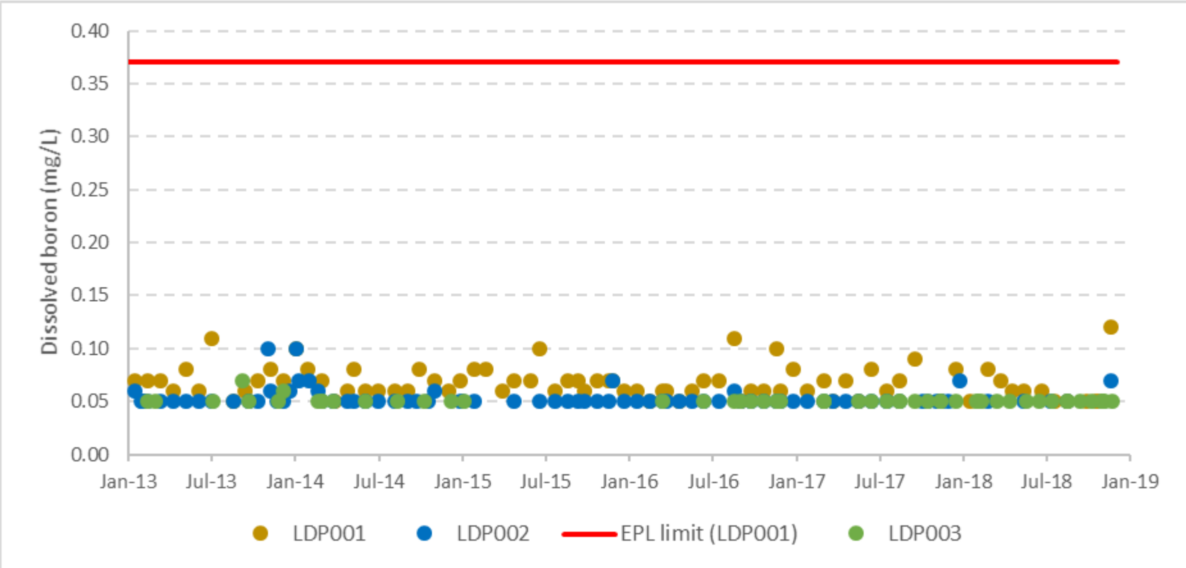
F.2.4 Dissolved metals

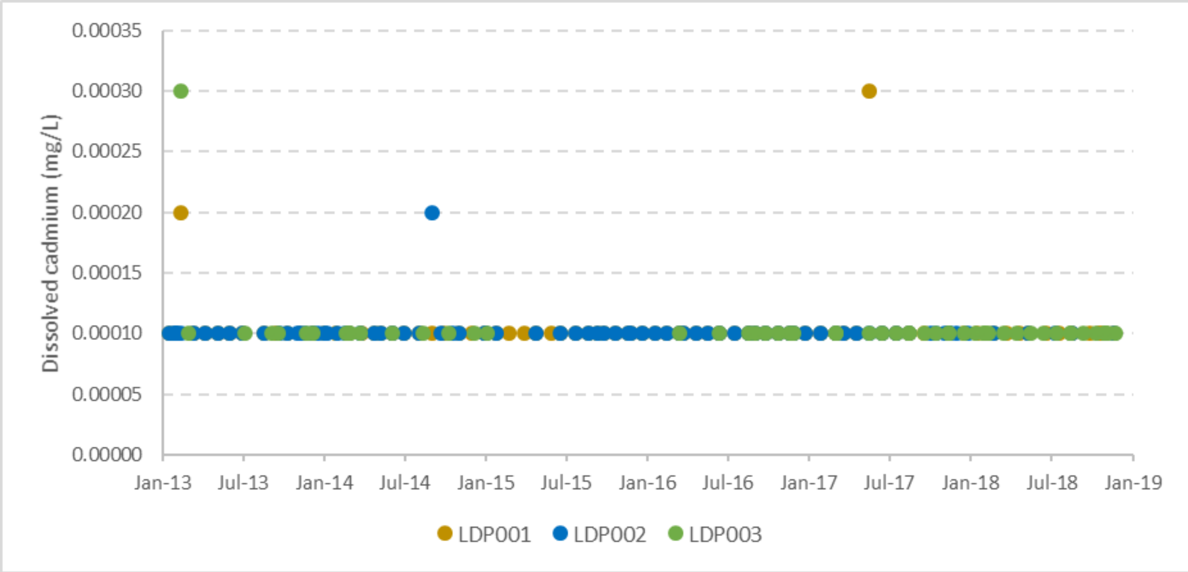




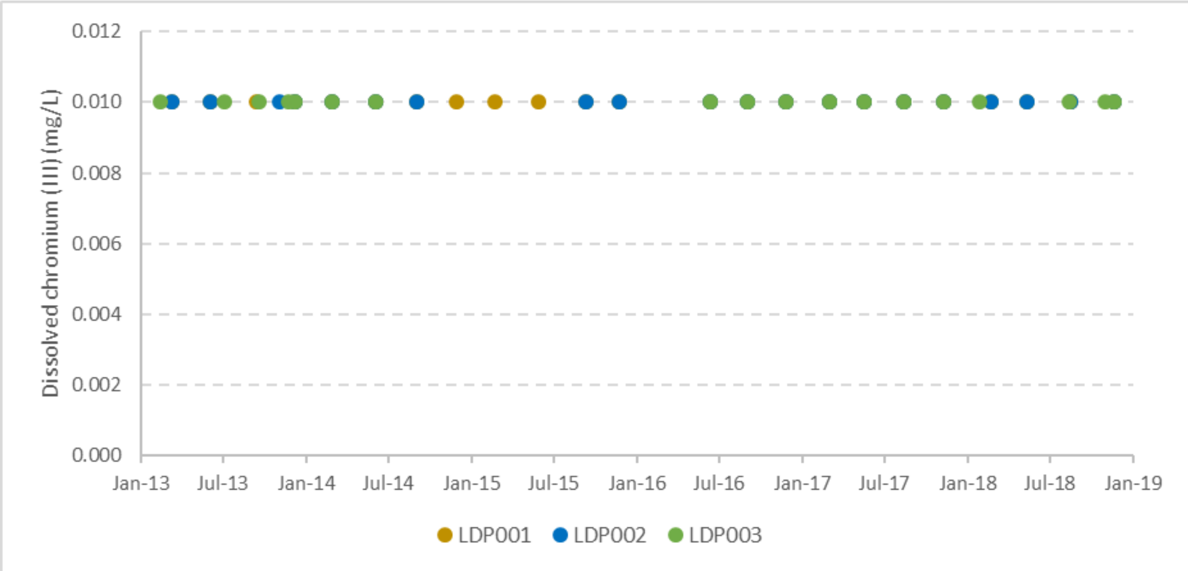

Dissolved arsenic (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003
EPL limit (LDP001)


Dissolved barium (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

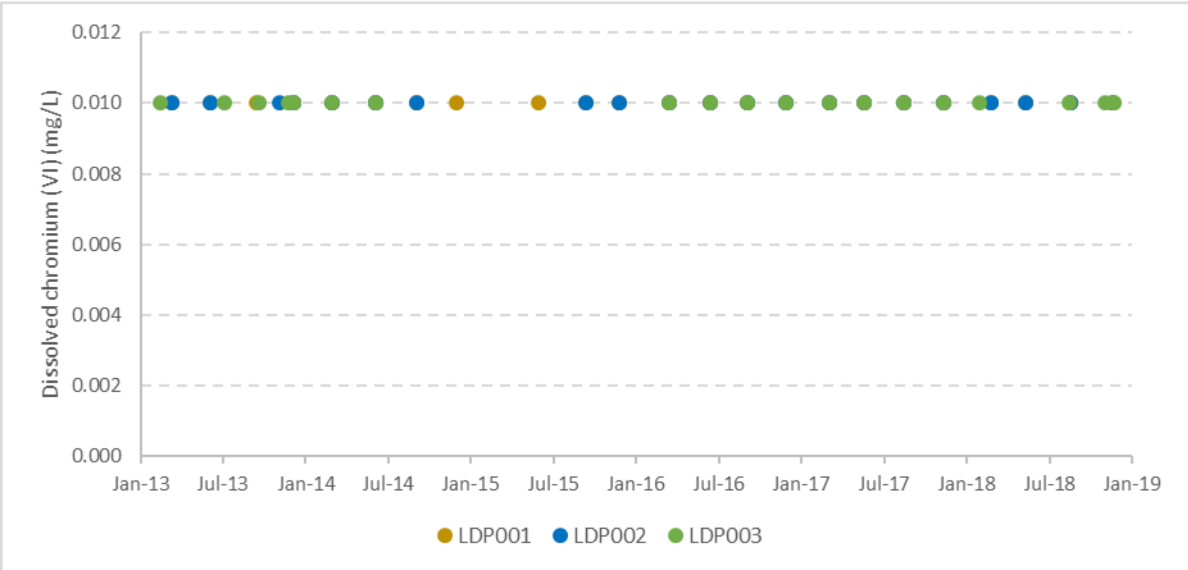

Dissolved boron (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
EPL limit (LDP001)
LDP003



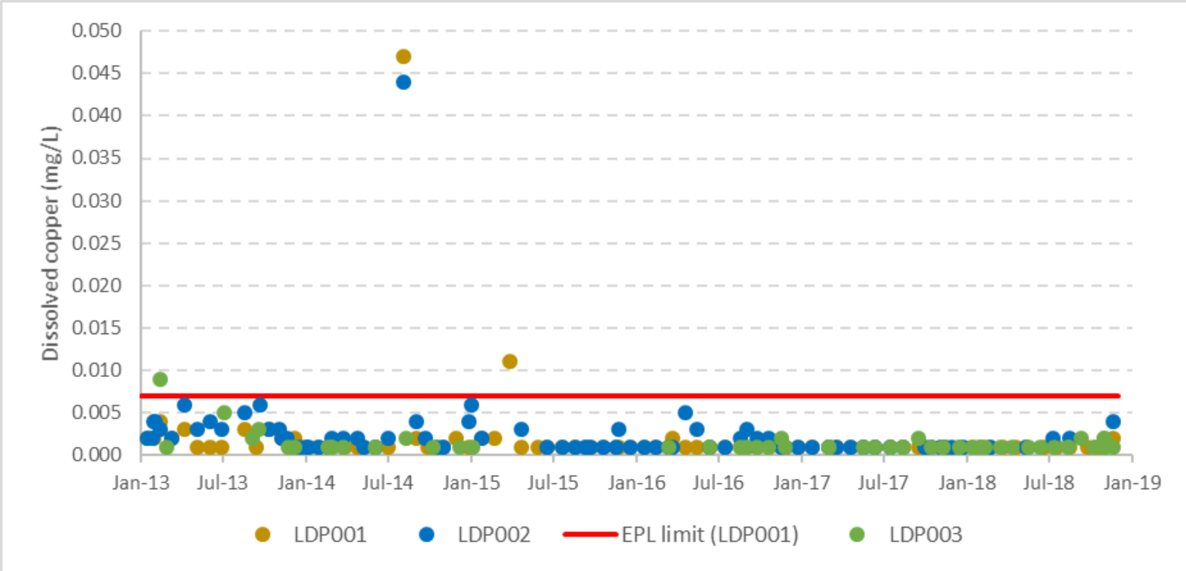
Dissolved cadmium (mg/L)
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



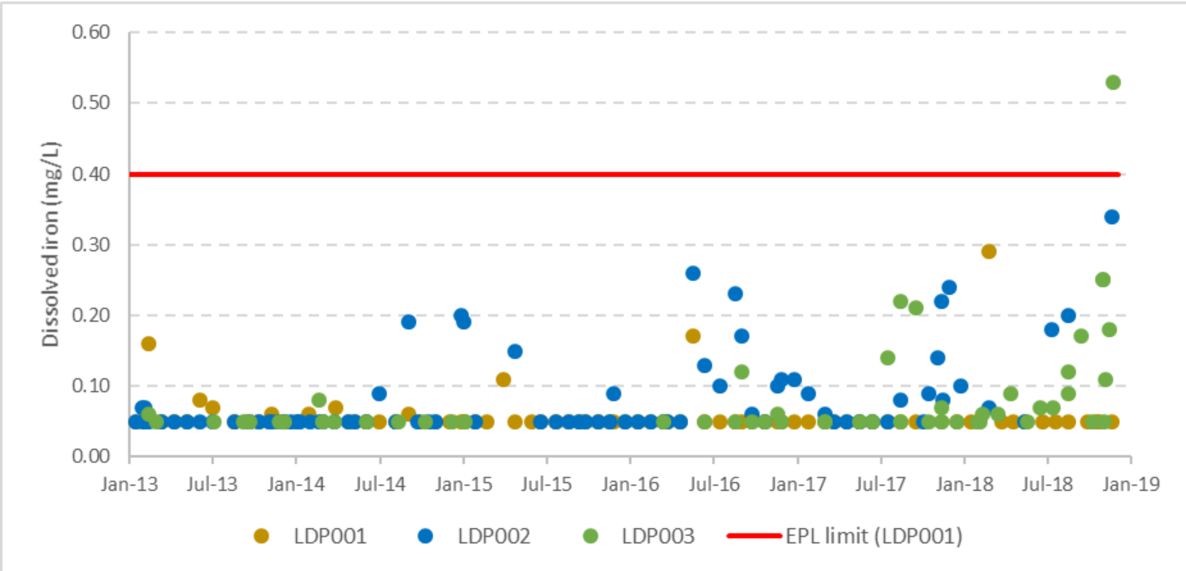
Dissolved chromium (III) (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



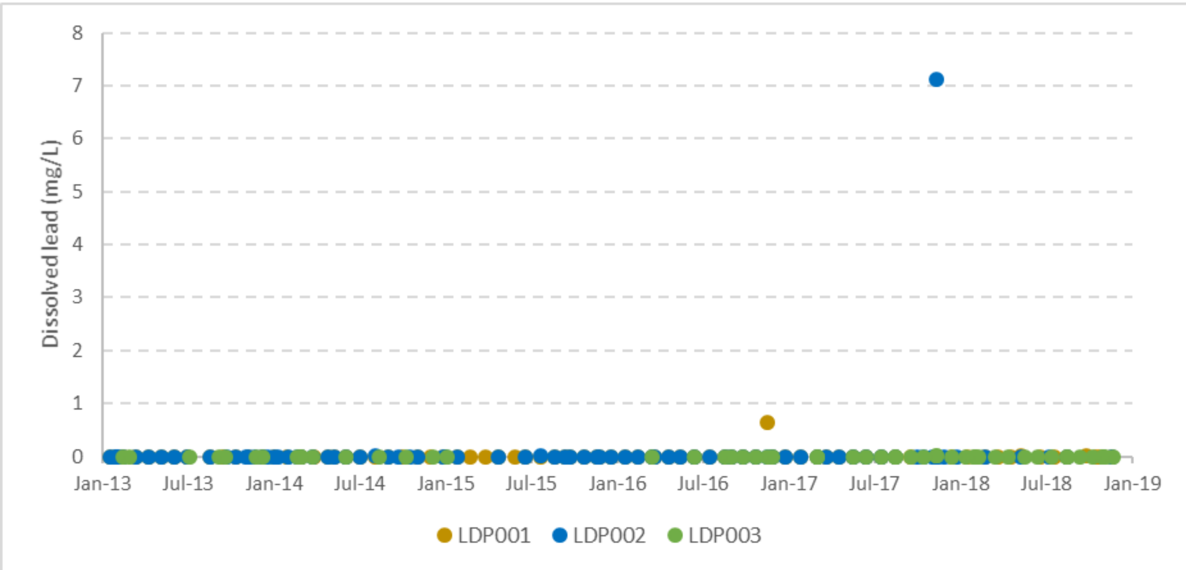
Dissolved chromium (VI) (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



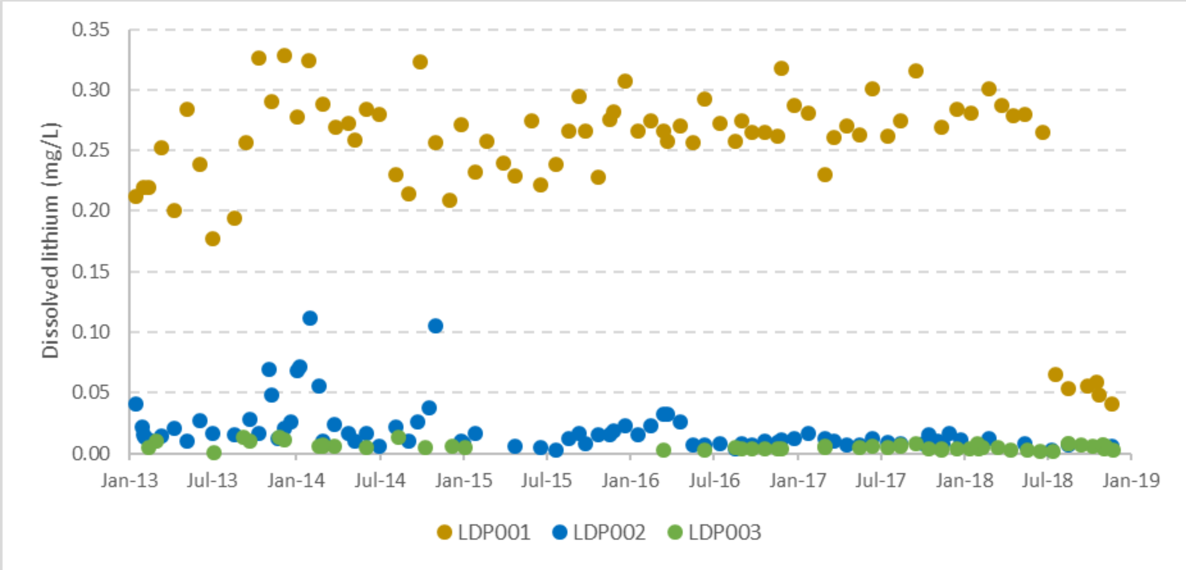
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved copper (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001
LDP002
EPL limit (LDP001)
LDP003

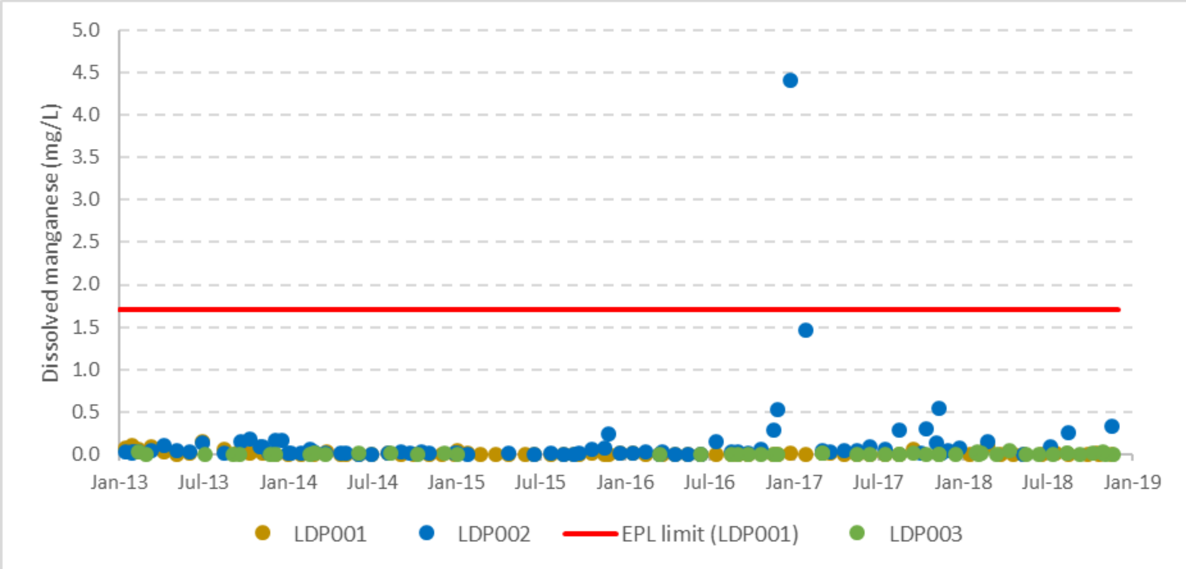


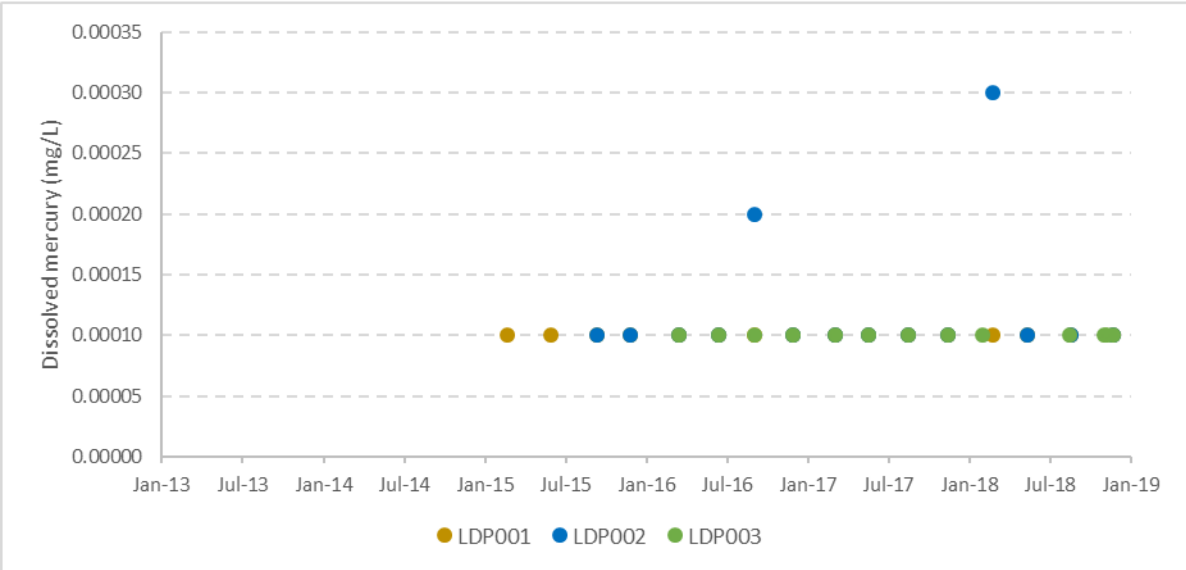
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Dissolved iron (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001
LDP002
LDP003
EPL limit (LDP001)

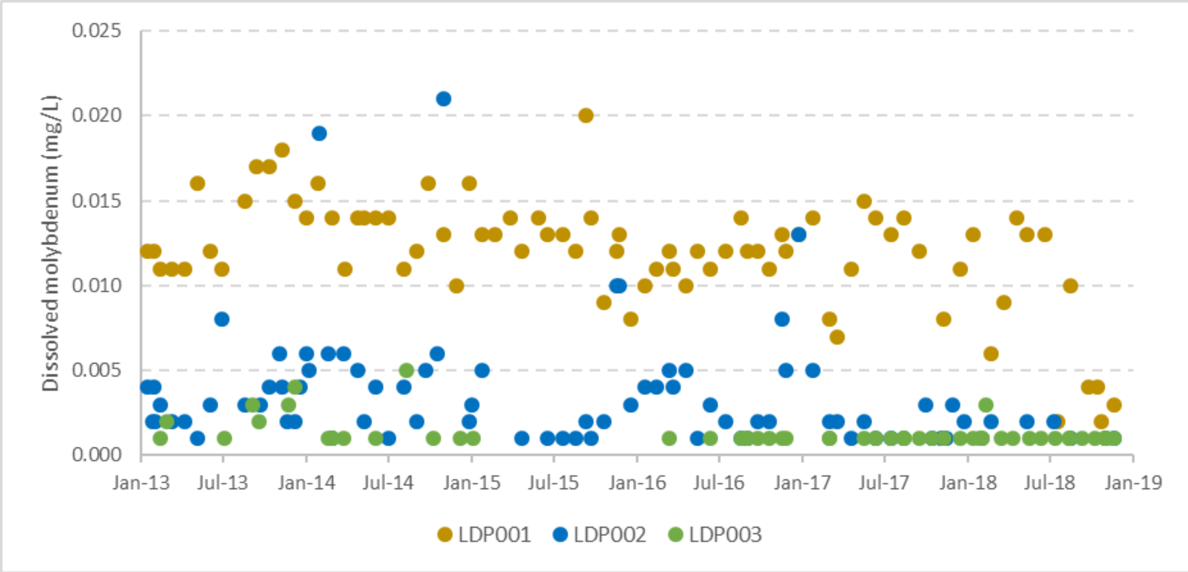


8
7
6
5
4
3
2
1
0
Dissolved lead (mg/L)
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001
LDP002
LDP003

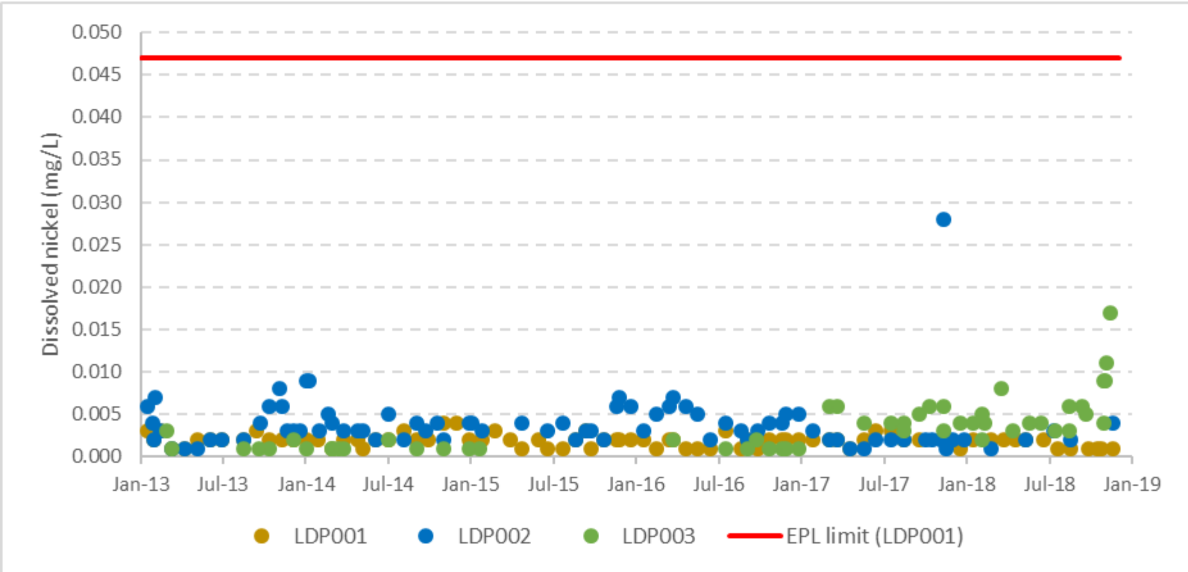

Dissolved lithium (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003


Dissolved manganese (mg/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 EPL limit (LDP001) LDP003

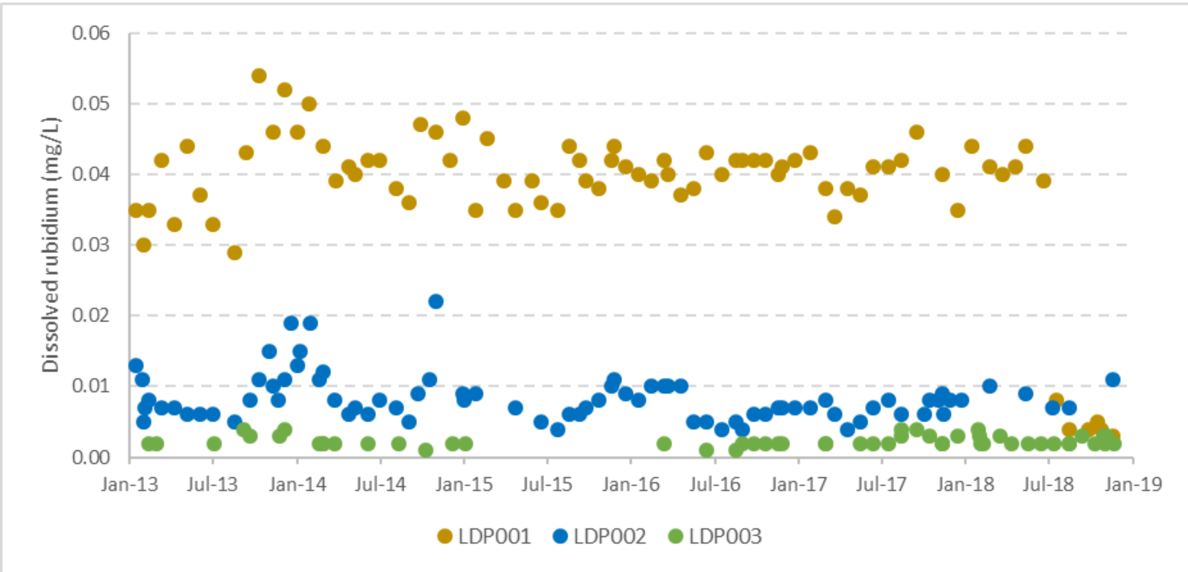

Dissolved mercury (mg/L)
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003



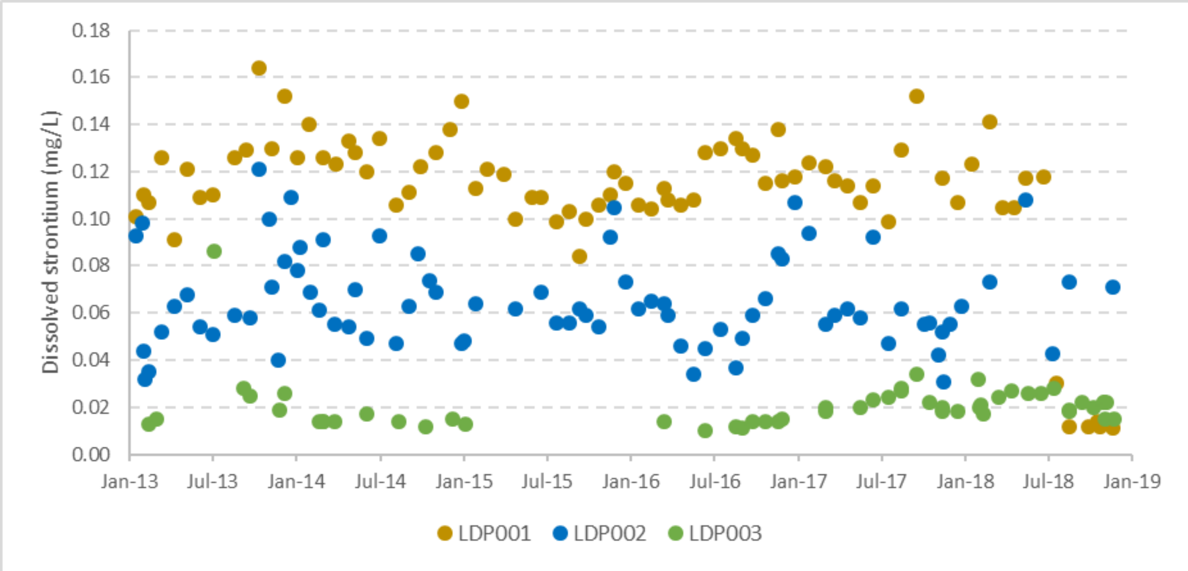
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved molybdenum (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



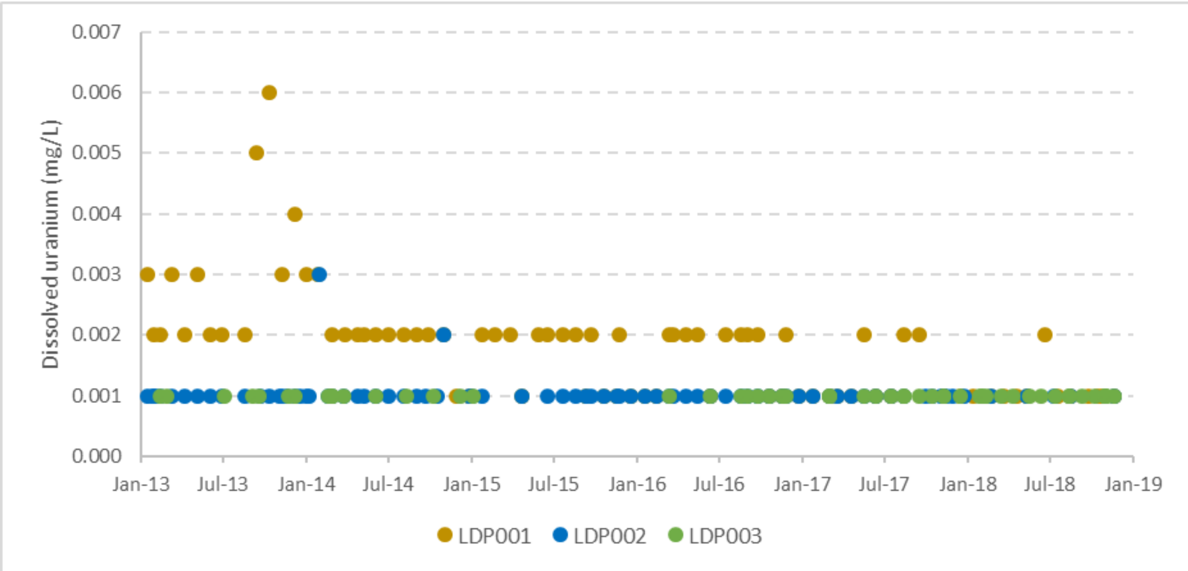
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Dissolved nickel (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003
EPL limit (LDP001)



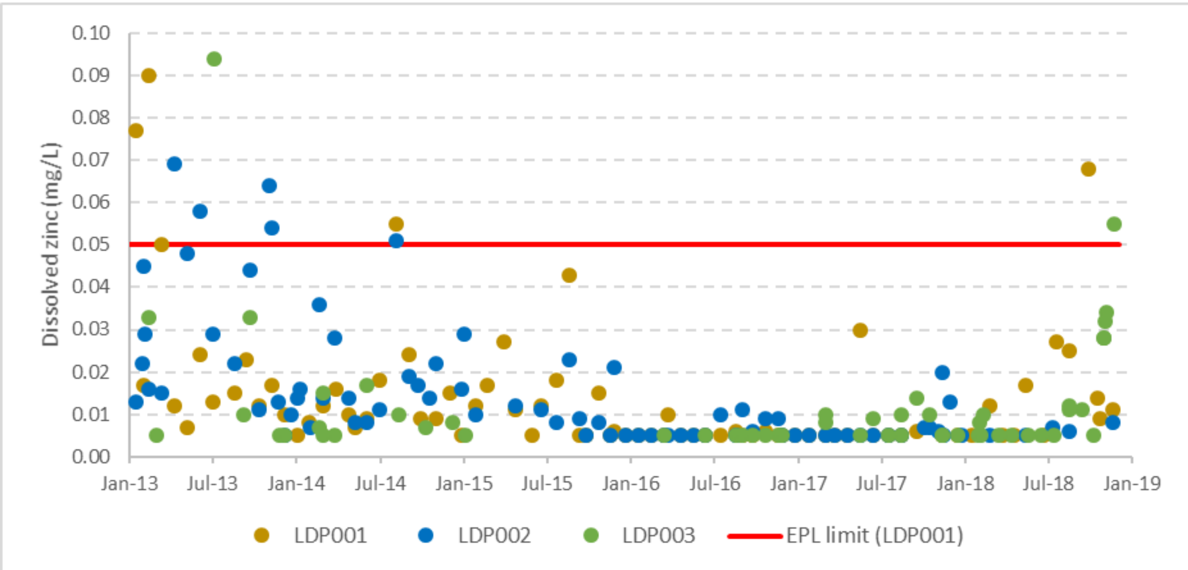
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Dissolved rubidium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



Dissolved strontium (mg/L)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

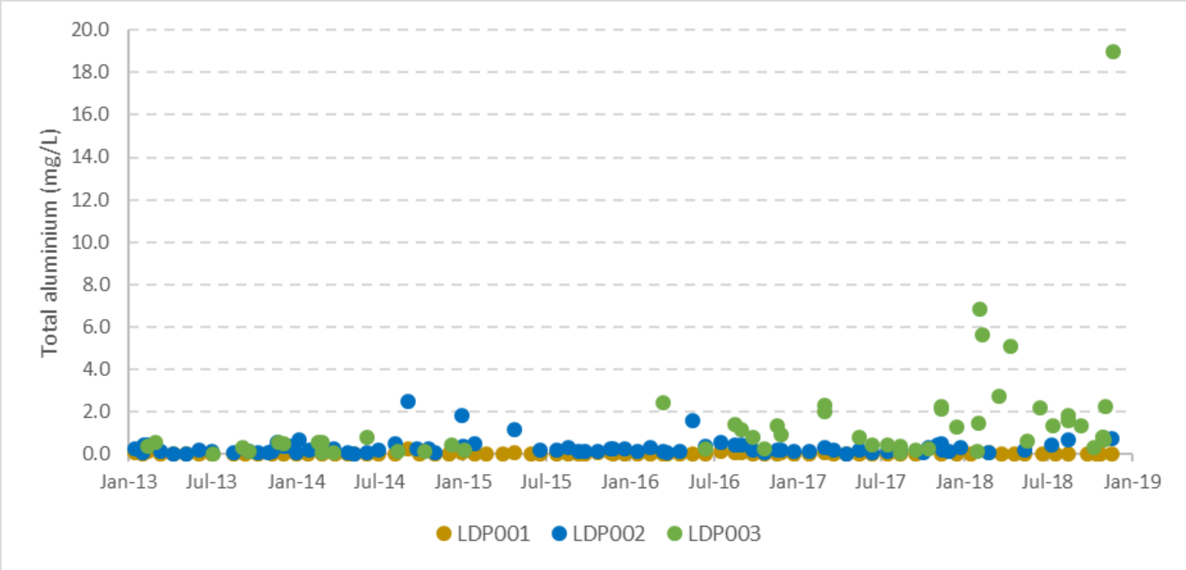


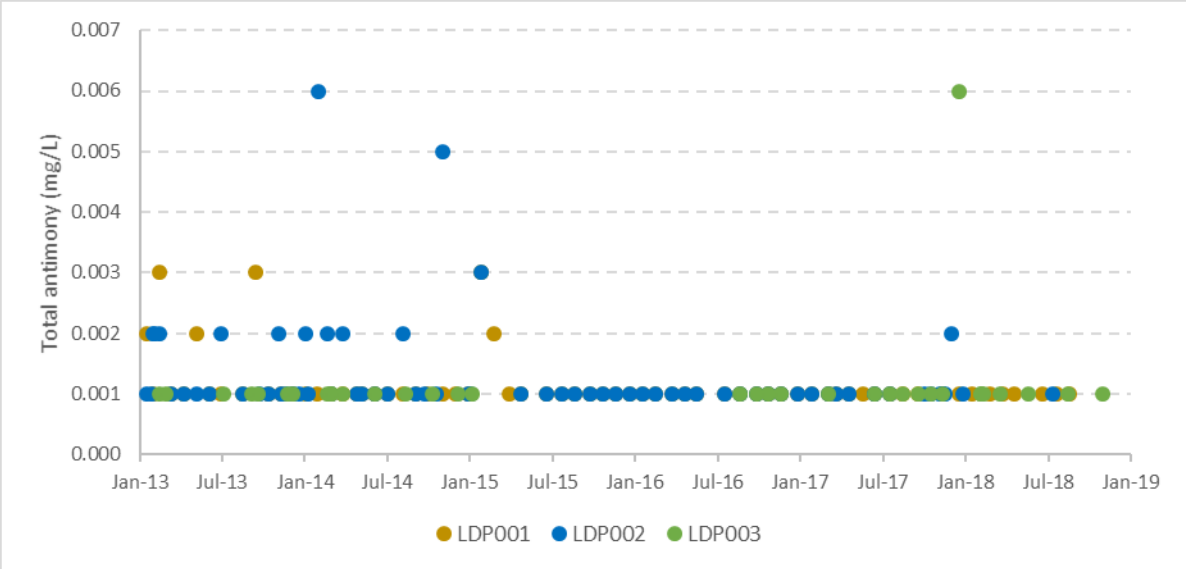
Dissolved uranium (mg/L)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

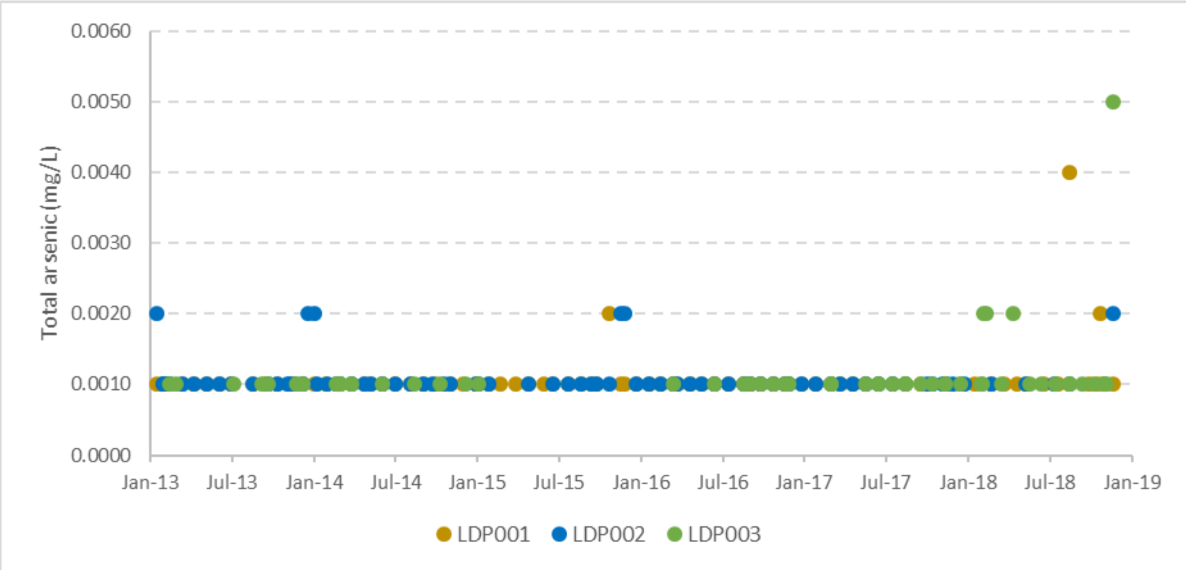


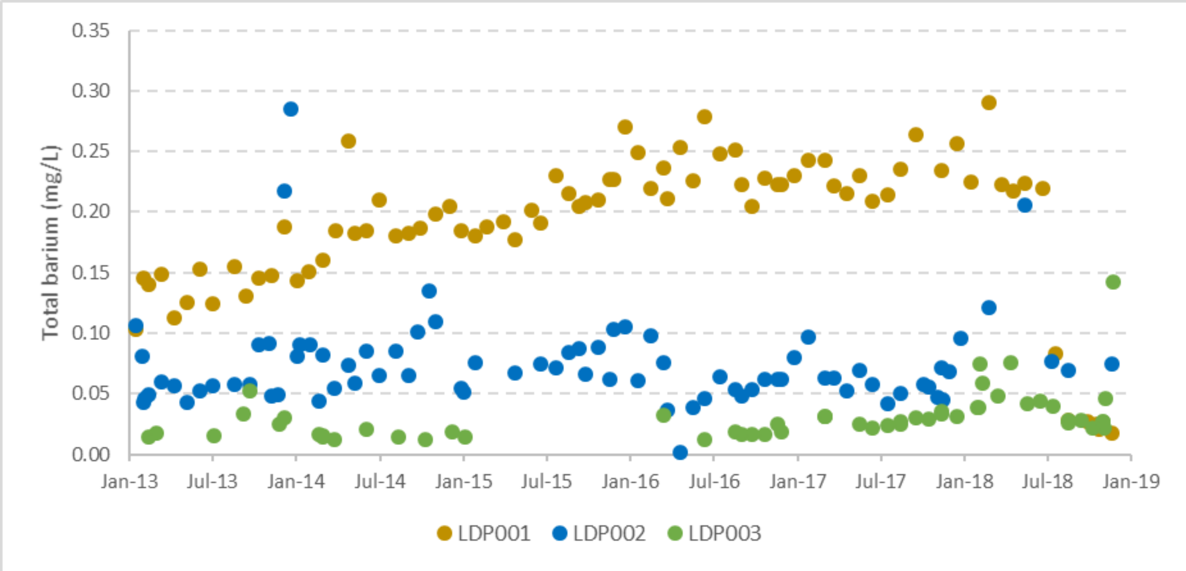
Dissolved zinc (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003
EPL limit (LDP001)

F.2.5 Total metals

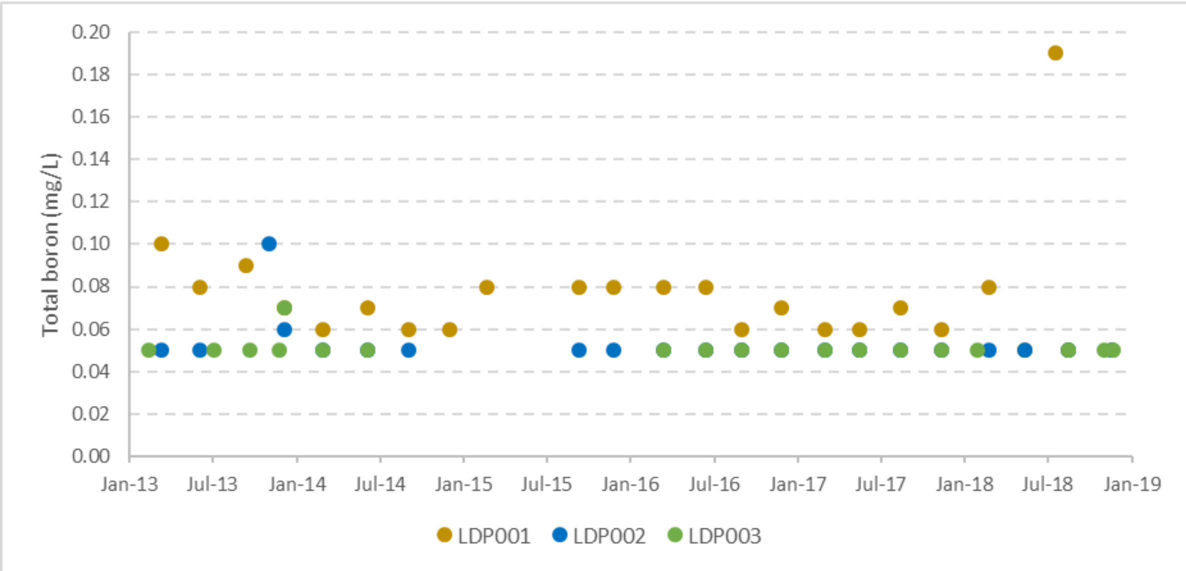




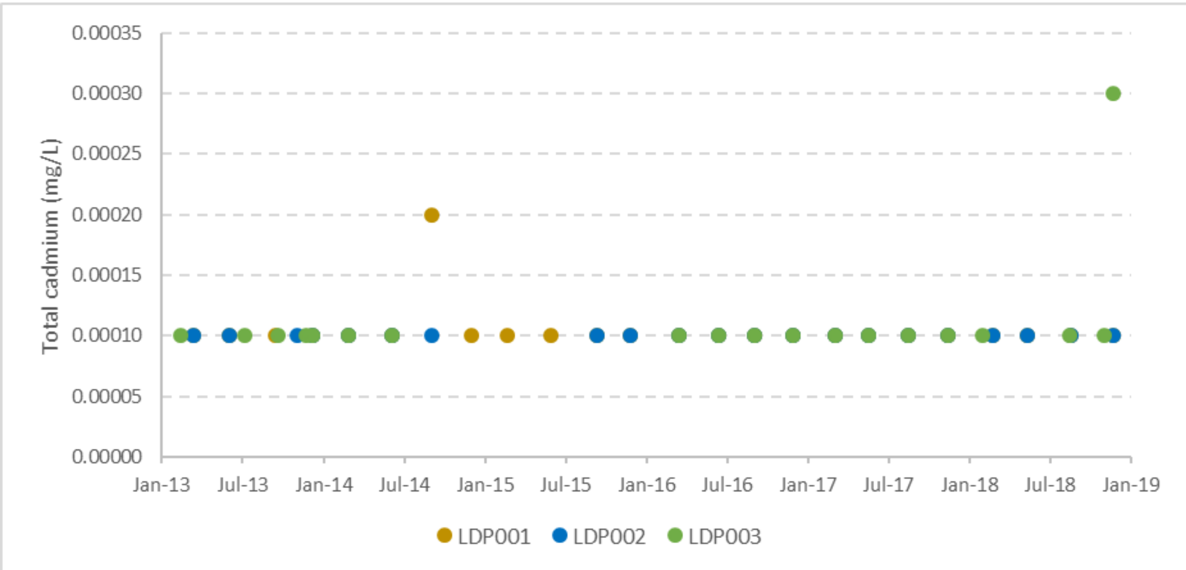




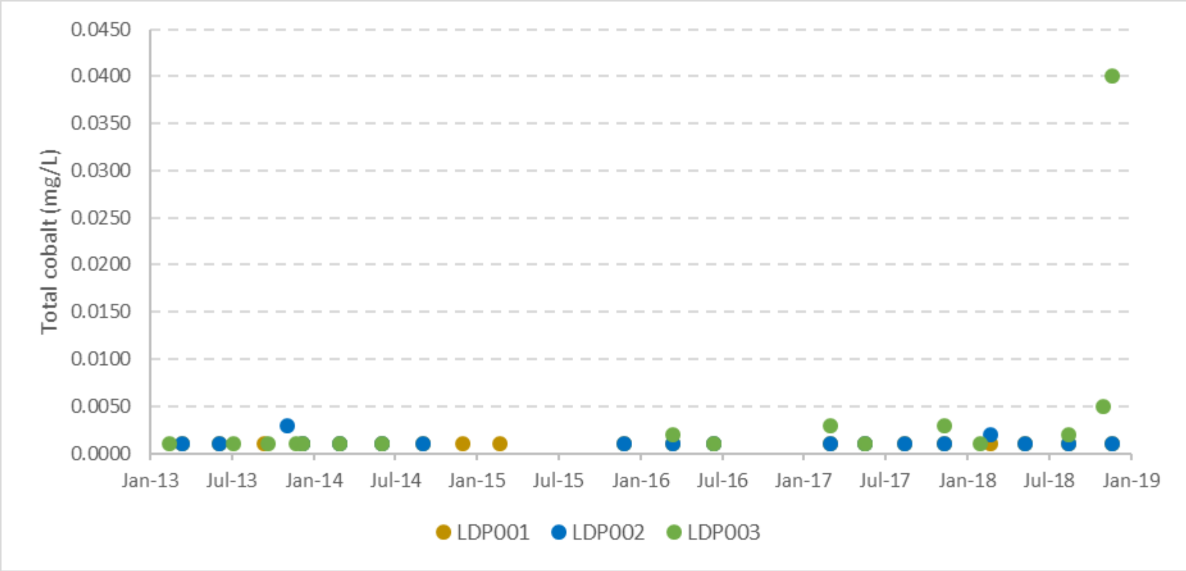
Total barium (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



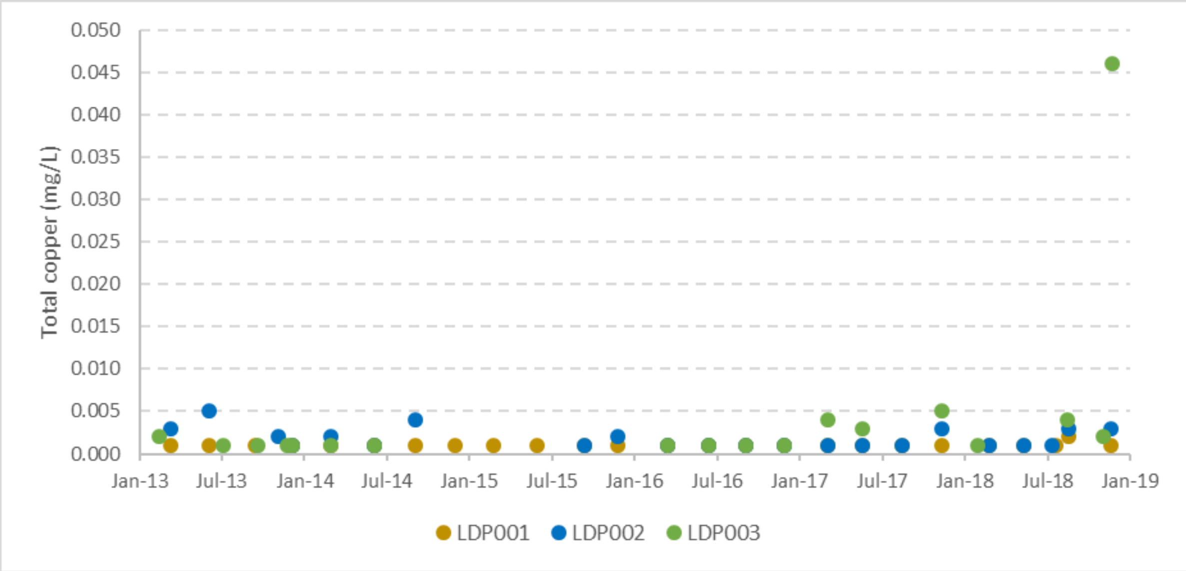
Total boron (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



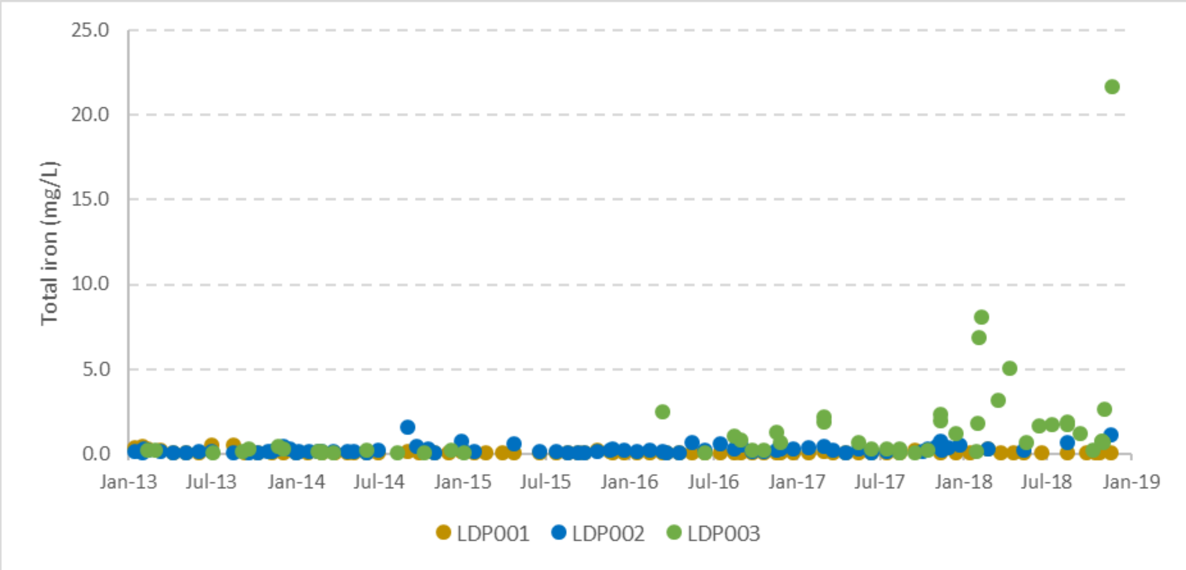
Total cadmium (mg/L)
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



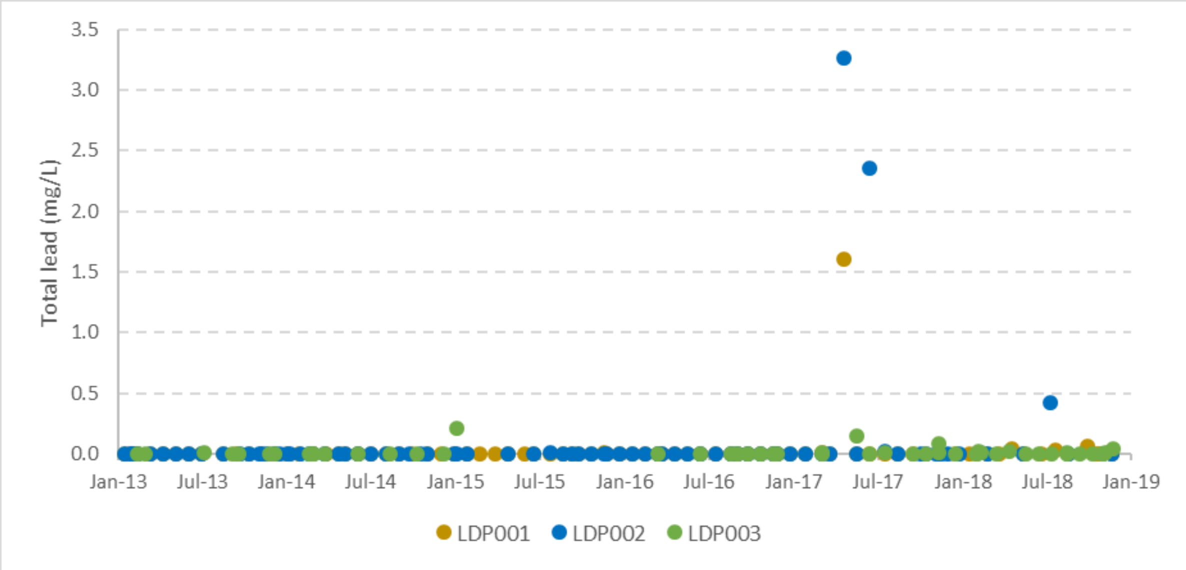
Total cobalt (mg/L)
0.0450
0.0400
0.0350
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

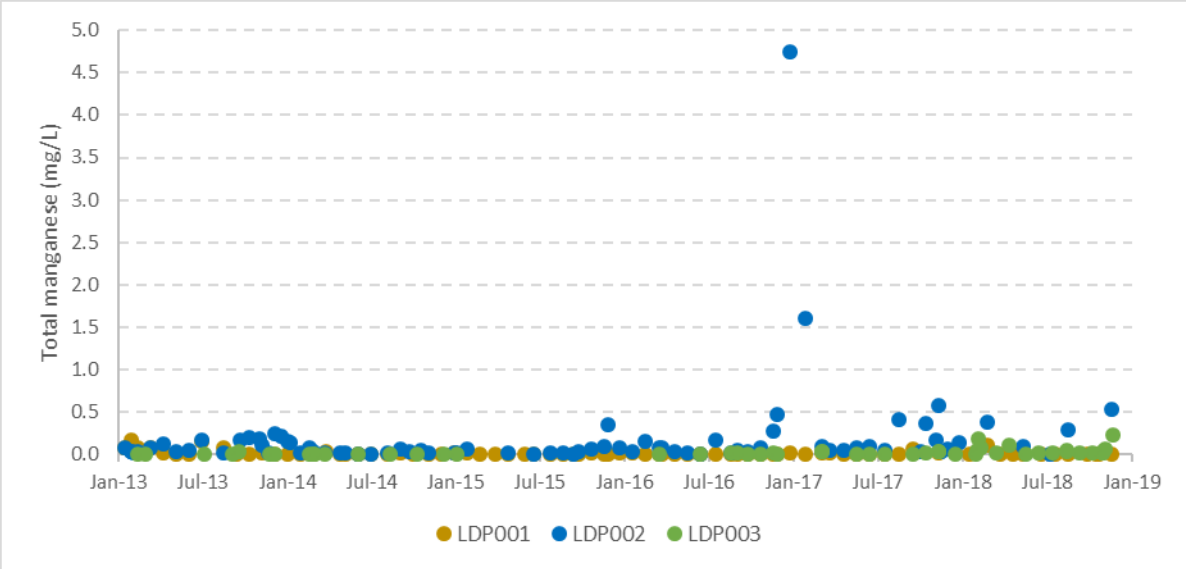


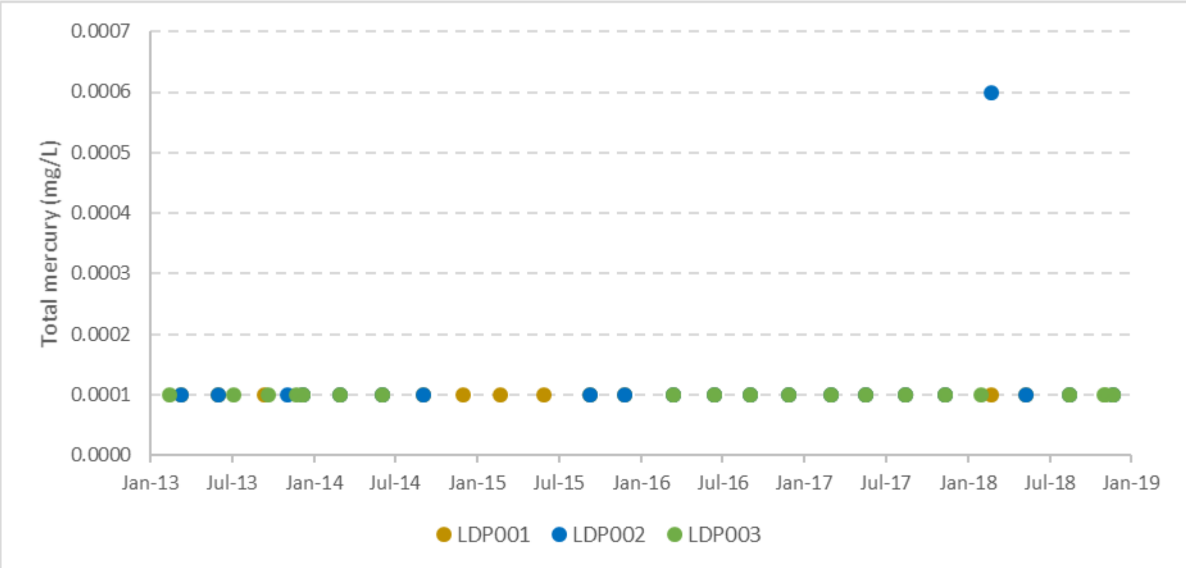
Total copper (mg/L)
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

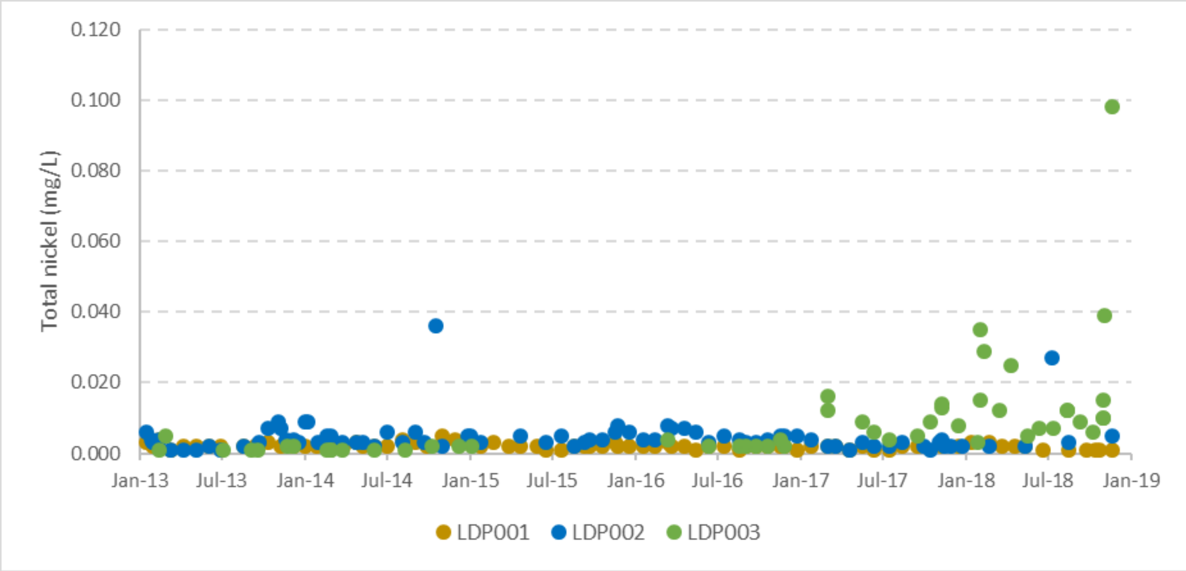


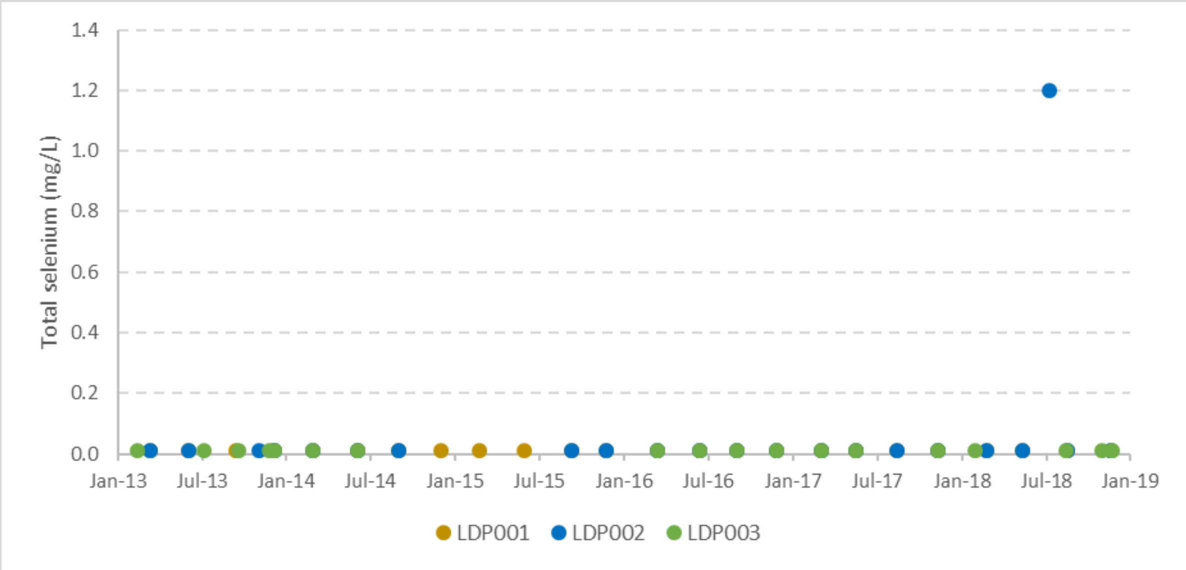
Total iron (mg/L)
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

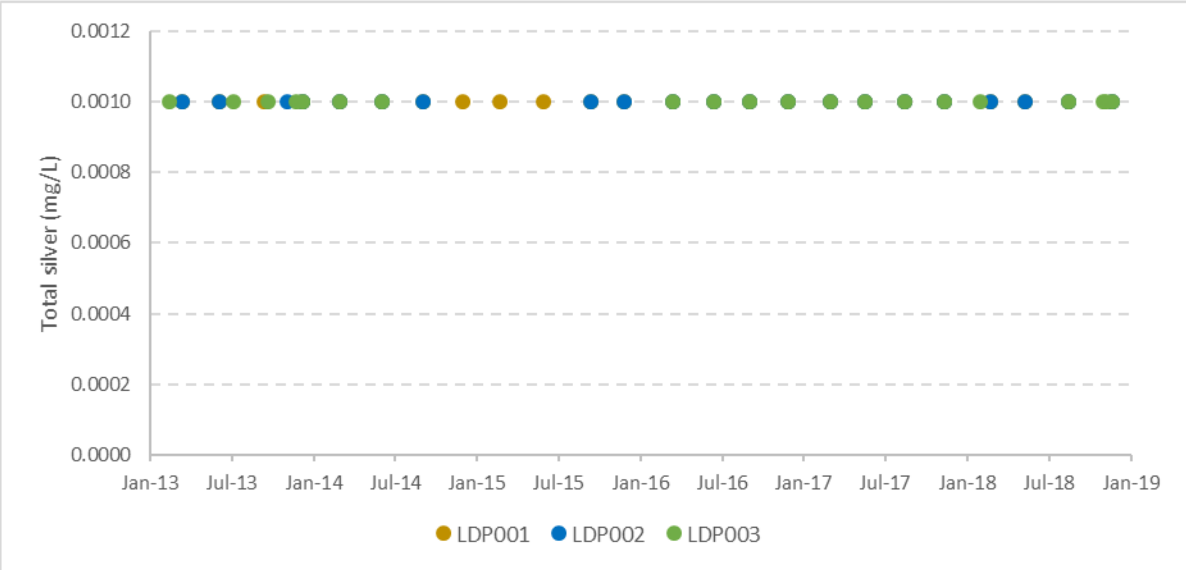

Total lead (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

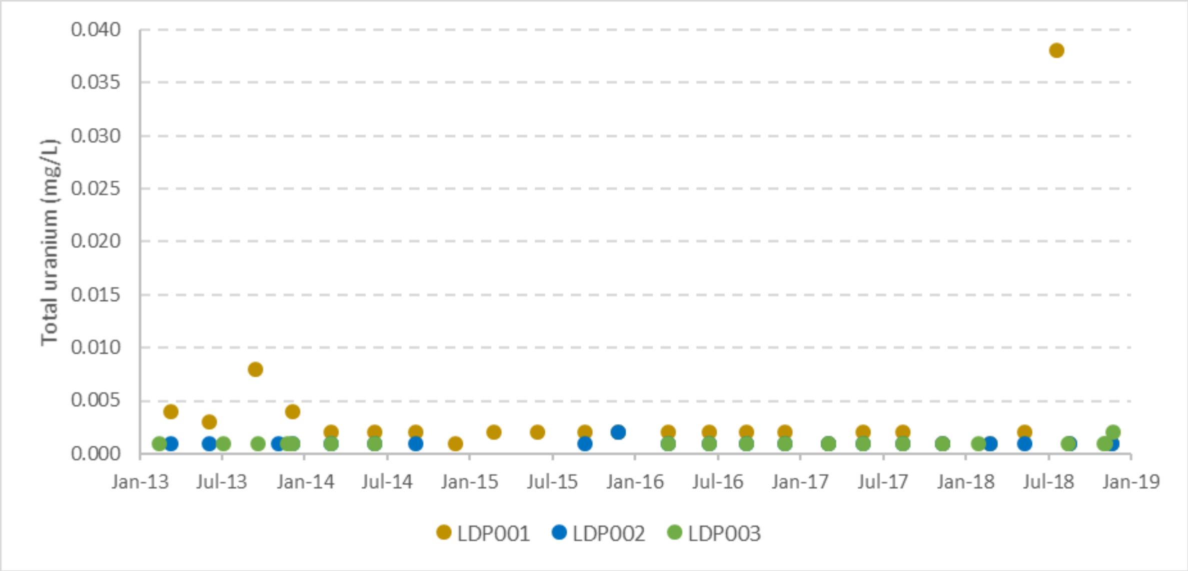

Total manganese (mg/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

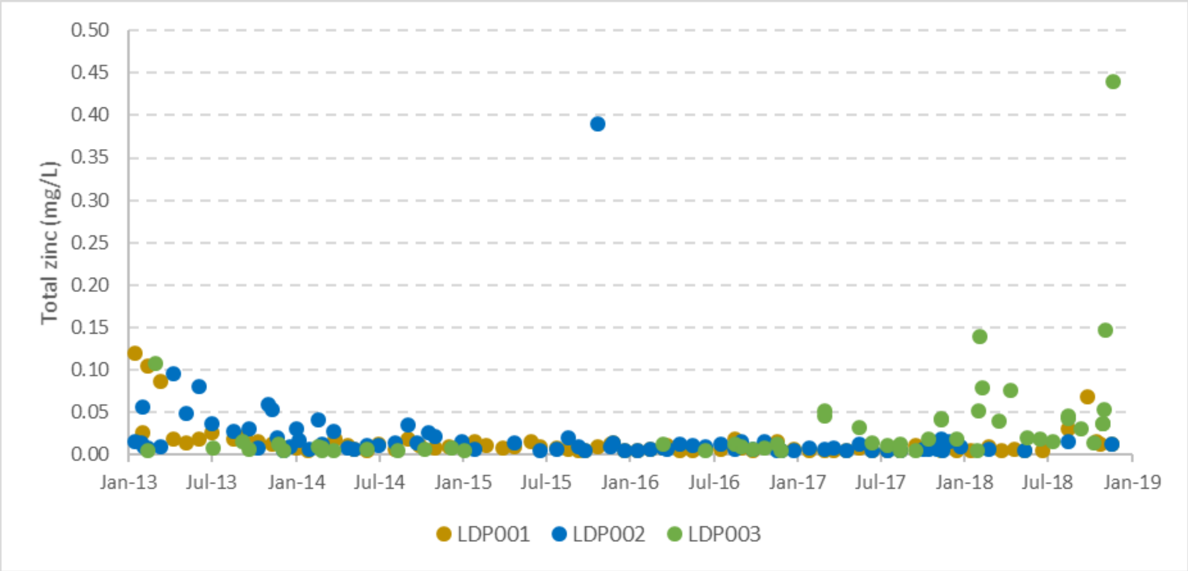

Total mercury (mg/L)
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003


0.120
0.100
0.080
0.060
0.040
0.020
0.000
Total nickel (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

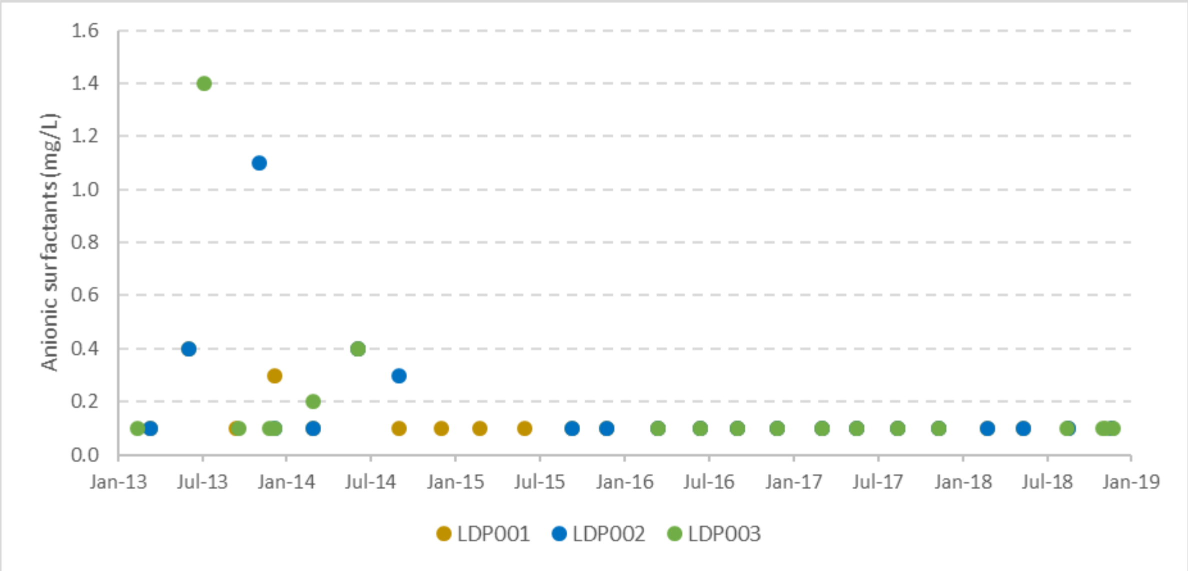

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Total selenium (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

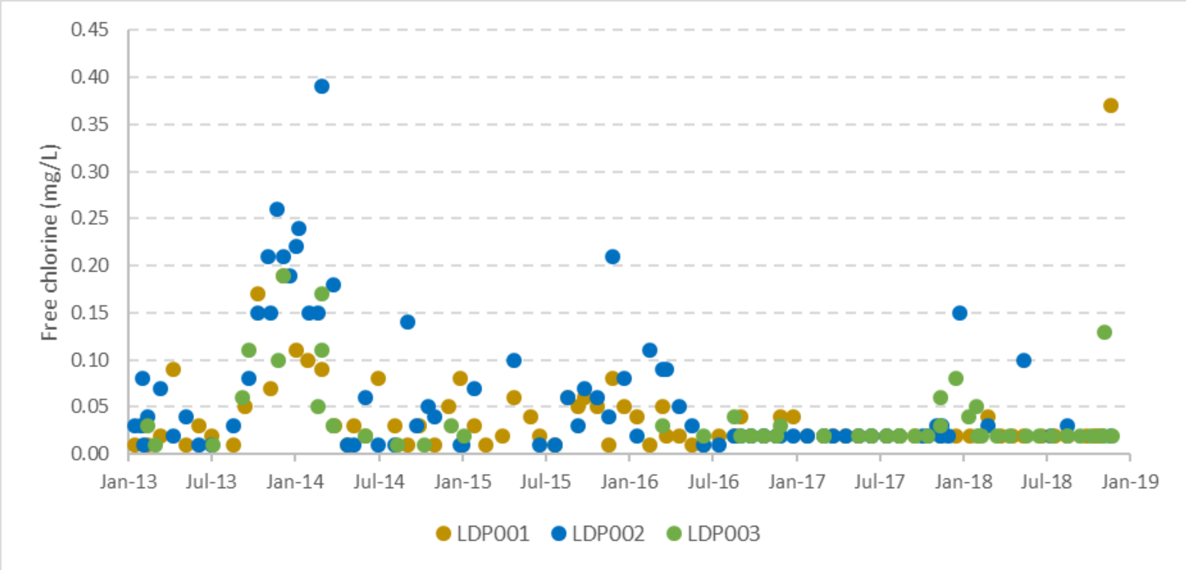

0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Total silver (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

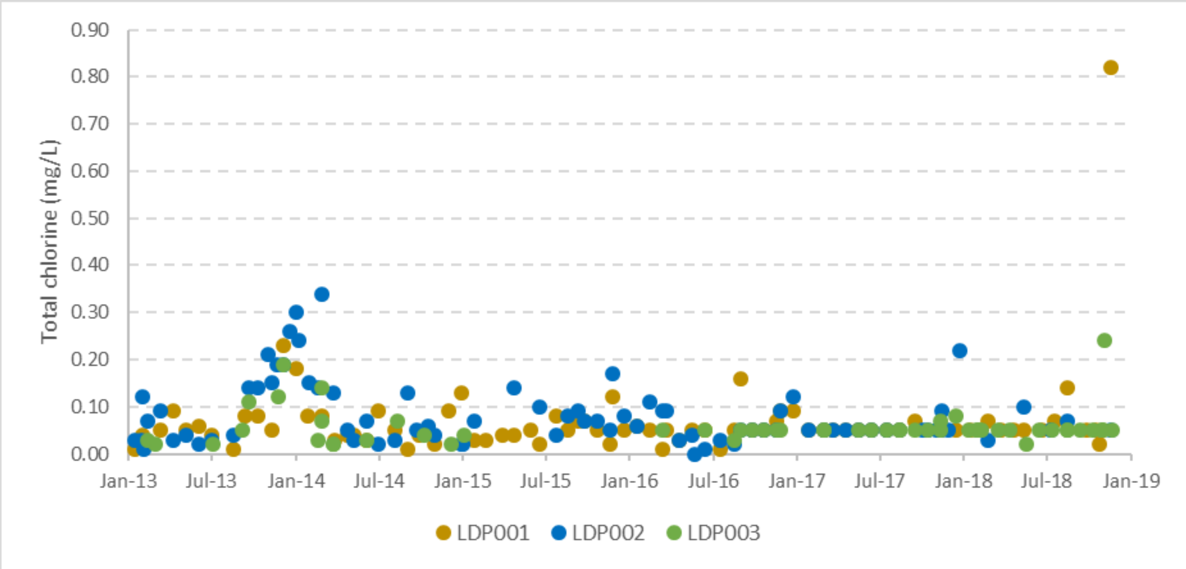

Total uranium (mg/L)
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003

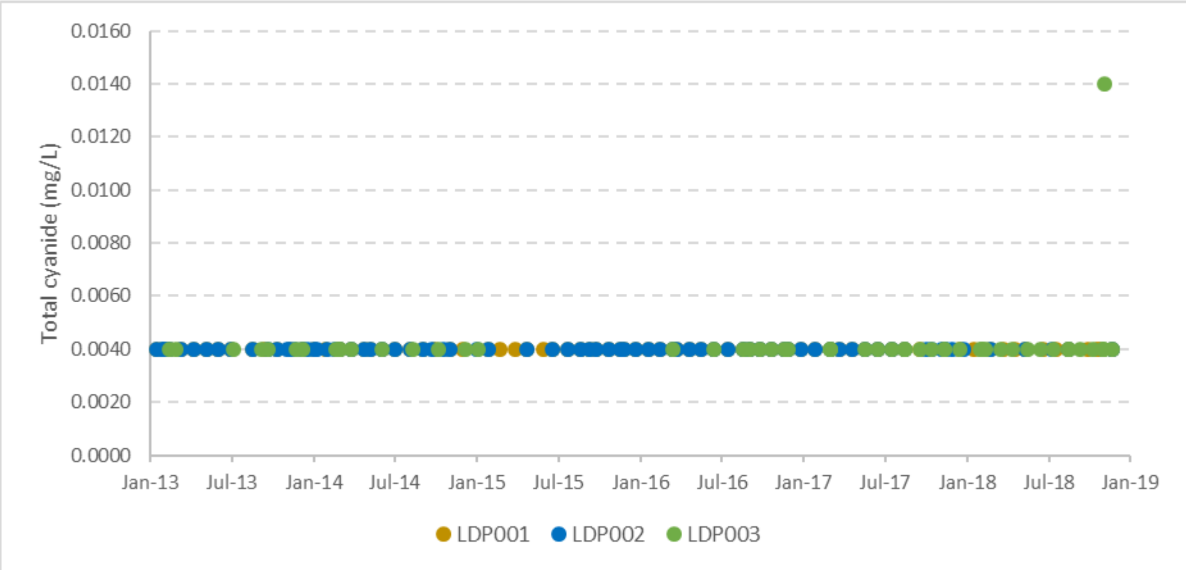

Total zinc (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003

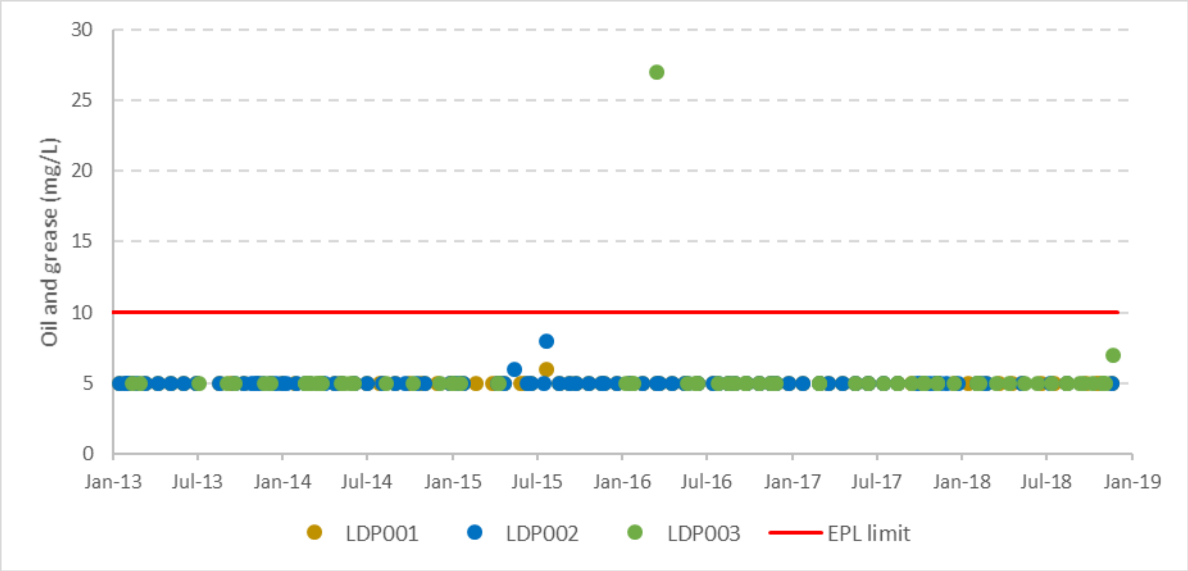
F.2.6 Other

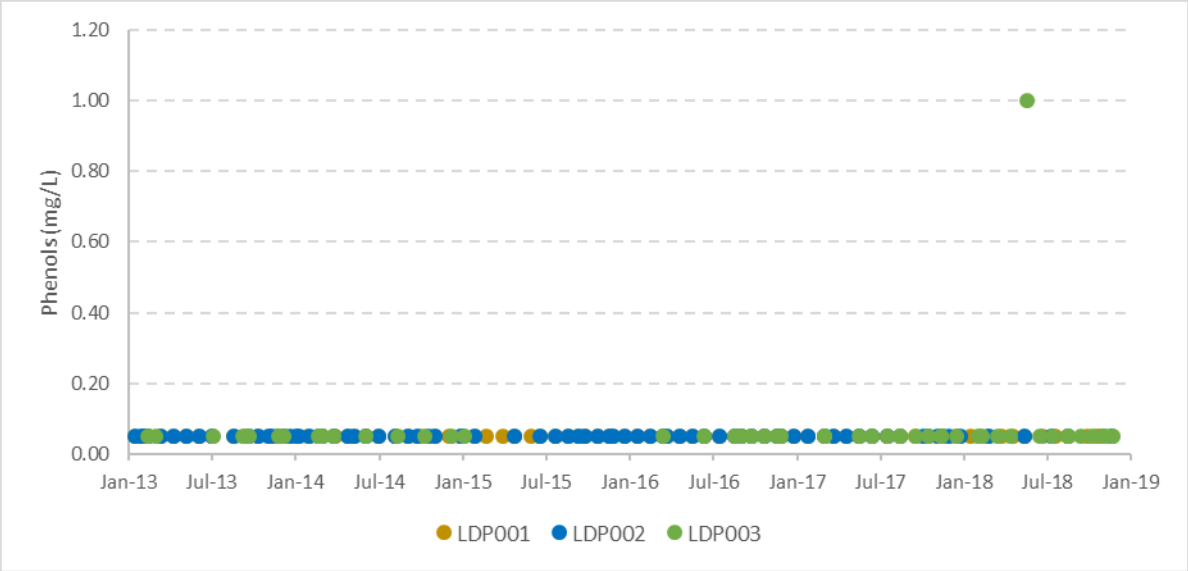

Anionic surfactants (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
LDP001 LDP002 LDP003

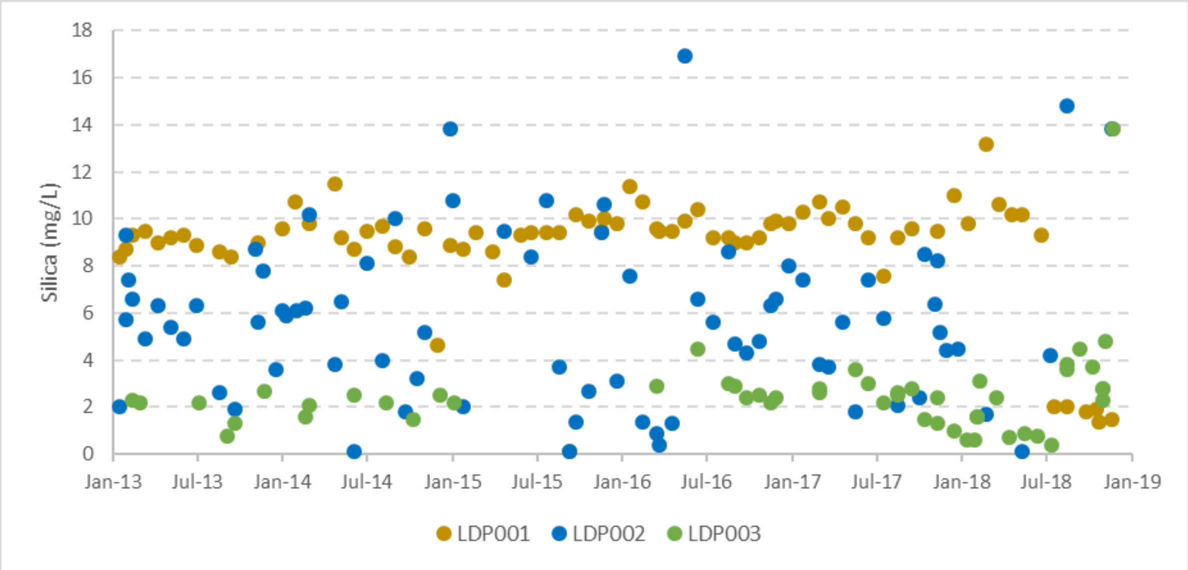

Free chlorine (mg/L)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

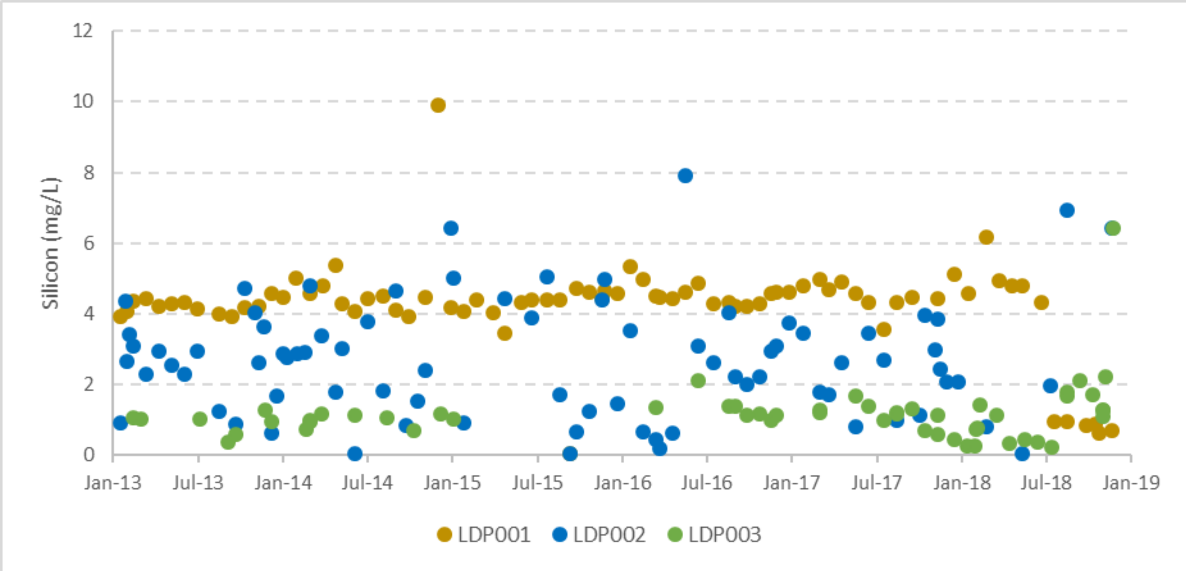

Total chlorine (mg/L)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003


Total cyanide (mg/L)
0.0160
0.0140
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

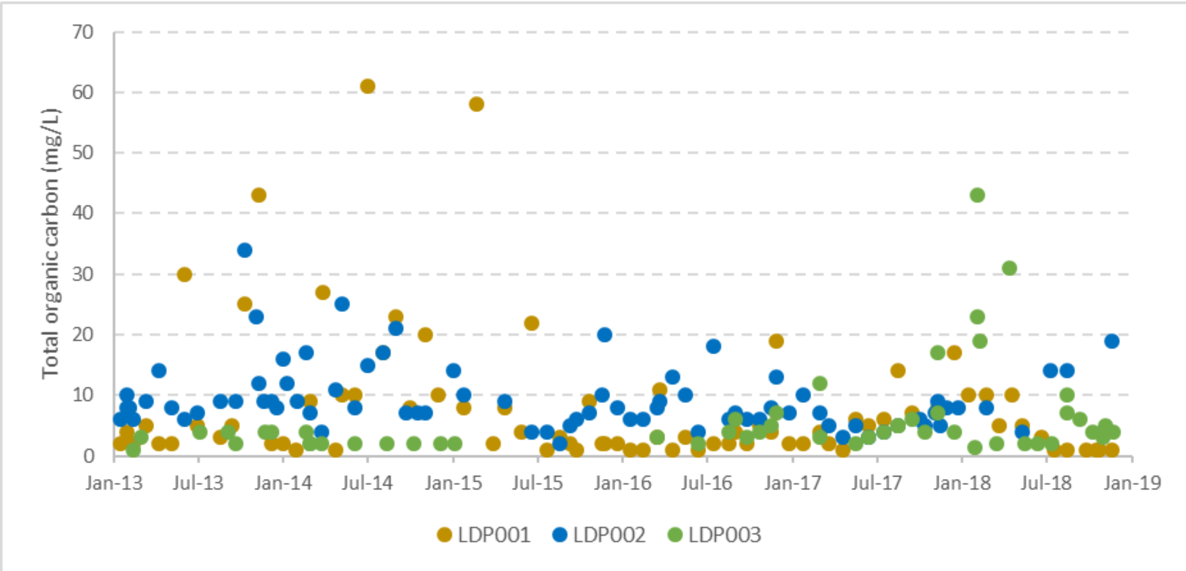

30
25
20
15
10
5
0
Oil and grease (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003
EPL limit


1.20
1.00
0.80
0.60
0.40
0.20
0.00
Phenols (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003


18
16
14
12
10
8
6
4
2
0
Silica (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



Silicon (mg/L)
12
10
8
6
4
2
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003



Total organic carbon (mg/L)
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
LDP001
LDP002
LDP003

Appendix G – Baseline potable and wastewater monitoring

G.1 Statistical summary of water quality results

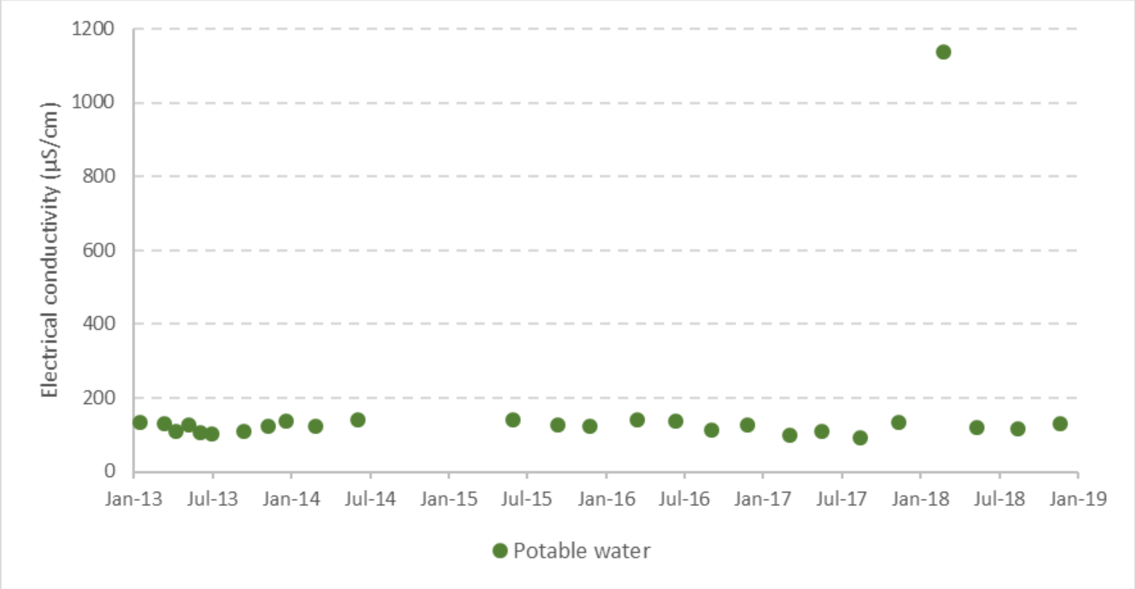
Parameters	Units	Potable water		Sewage treatment system	
		Count	Median	Count	Median
Physicochemical					
EC	µS/cm	26	126	–	–
pH	pH units	26	7.8	–	–
TSS	mg/L	22	5	61	26
Microbiological					
E. coli	CFU/100 mL	84	1	–	–
Faecal coliforms	CFU/100 mL	84	1	–	–
HPC at 22 °C	CFU/mL	84	300	–	–
HPC at 36 °C	CFU/mL	84	755	–	–
Total coliforms	CFU/100 mL	83	1	–	–
Nutrients					
Ammonia	mg/L	–	–	62	0.06
Nitrate + nitrite	mg/L	–	–	62	0.03
Total fluoride	mg/L	–	–	61	0.3
TKN	mg/L	–	–	62	3.8
Total nitrogen	mg/L	–	–	62	4.0
Total phosphorus	mg/L	–	–	62	0.67
Total metals					
Arsenic	mg/L	–	–	62	0.001
Boron	mg/L	–	–	56	0.05
Cadmium	mg/L	–	–	62	0.0001
Chromium	mg/L	–	–	35	0.001
Cobalt	mg/L	–	–	57	0.001
Copper	mg/L	–	–	62	0.001
Iron	mg/L	19	0.80	–	–
Lead	mg/L	–	–	62	0.001
Manganese	mg/L	20	0.010	62	0.232
Mercury	mg/L	–	–	61	0.0001
Nickel	mg/L	–	–	62	0.003

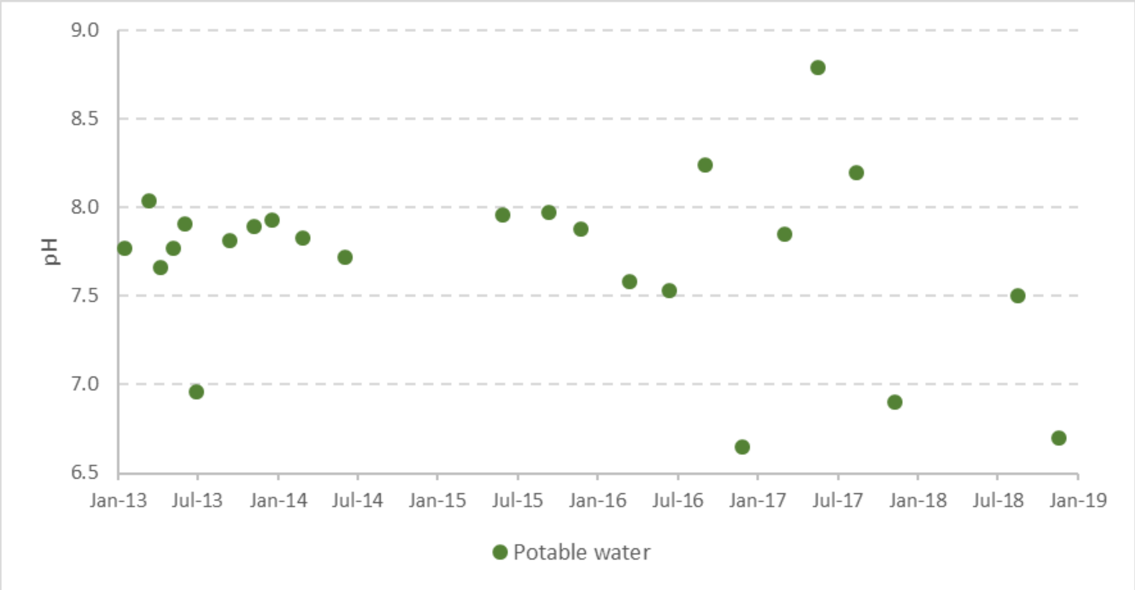
Parameters	Units	Potable water		Sewage treatment system	
		Count	Median	Count	Median
Selenium	mg/L	–	–	61	0.01
Zinc	mg/L	19	0.448	62	0.006
Other					
BOD	mg/L	–	–	59	7
Oil and grease	mg/L	21	5	–	–
Phenols	mg/L	–	–	61	0.05

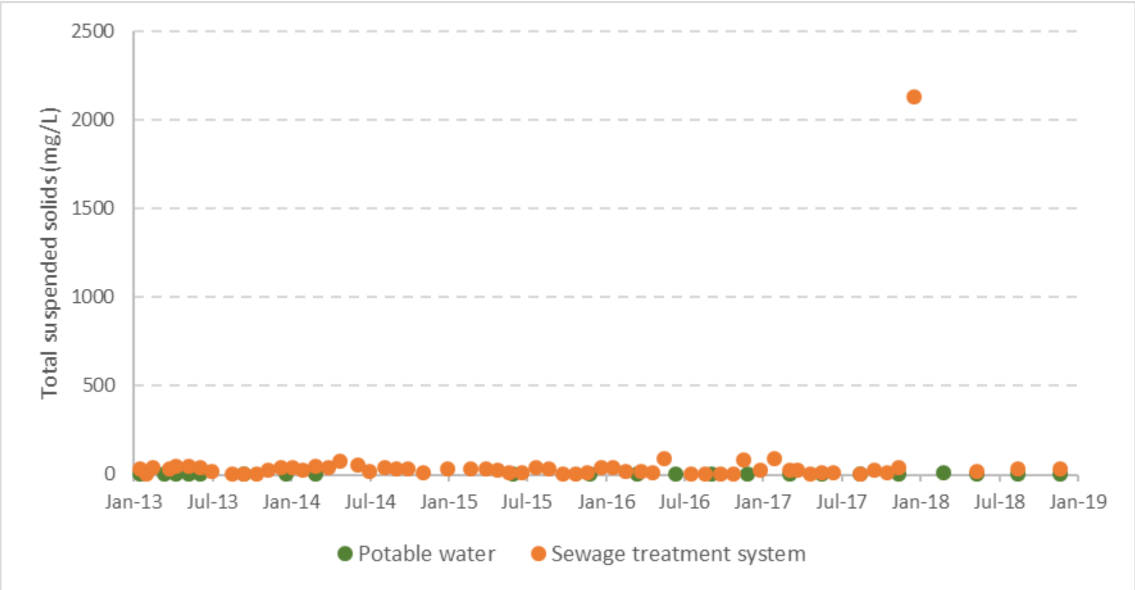
CFU – colony forming units.

G.2 Time series graphs of water quality results

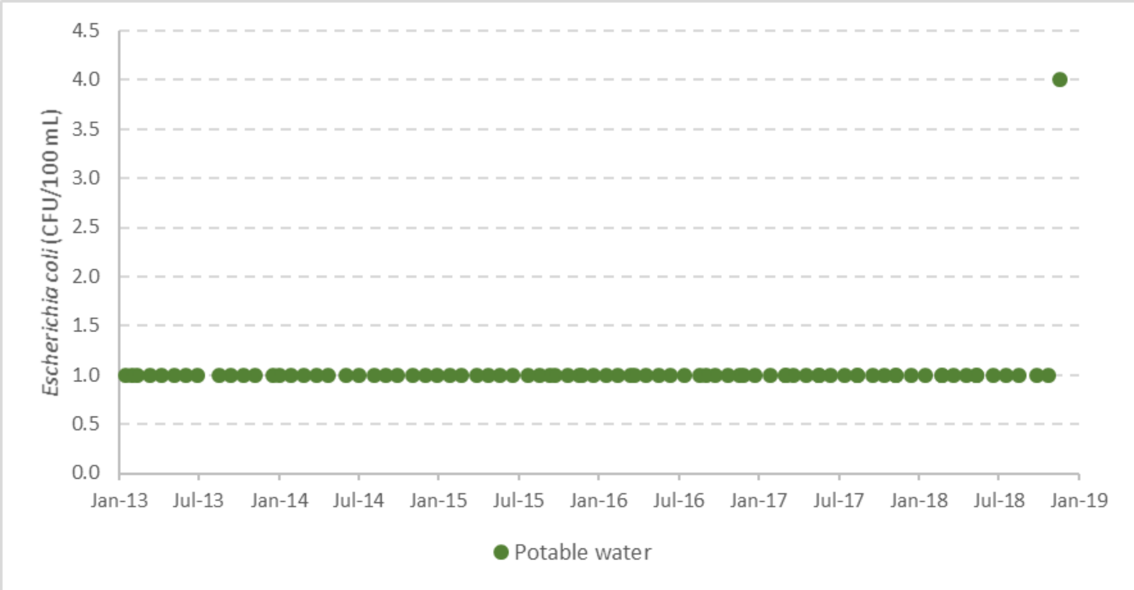
G.2.1 Physicochemical

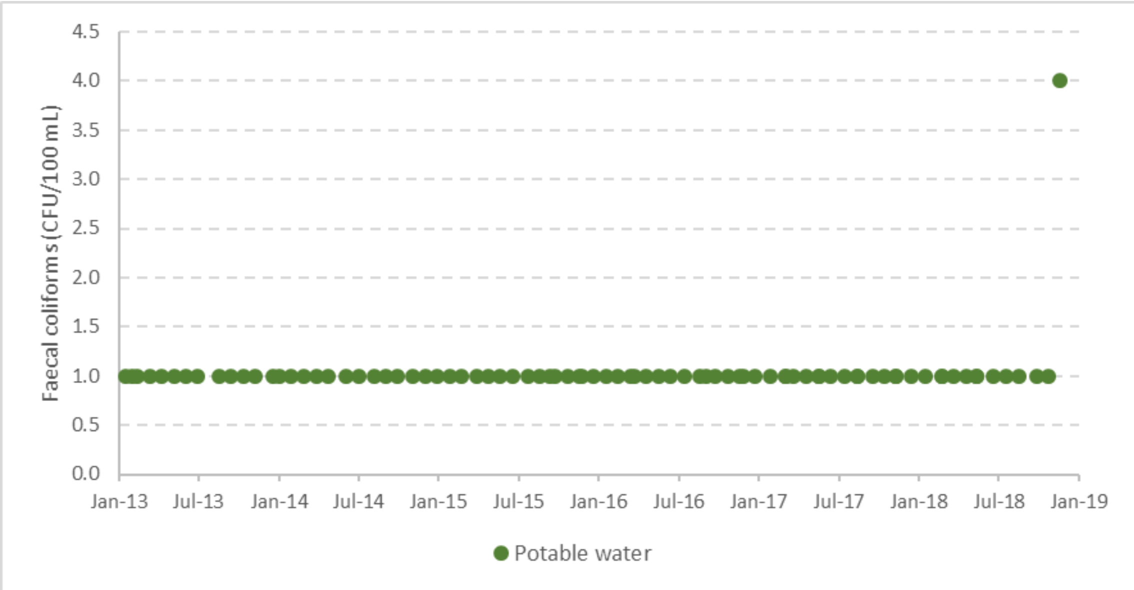


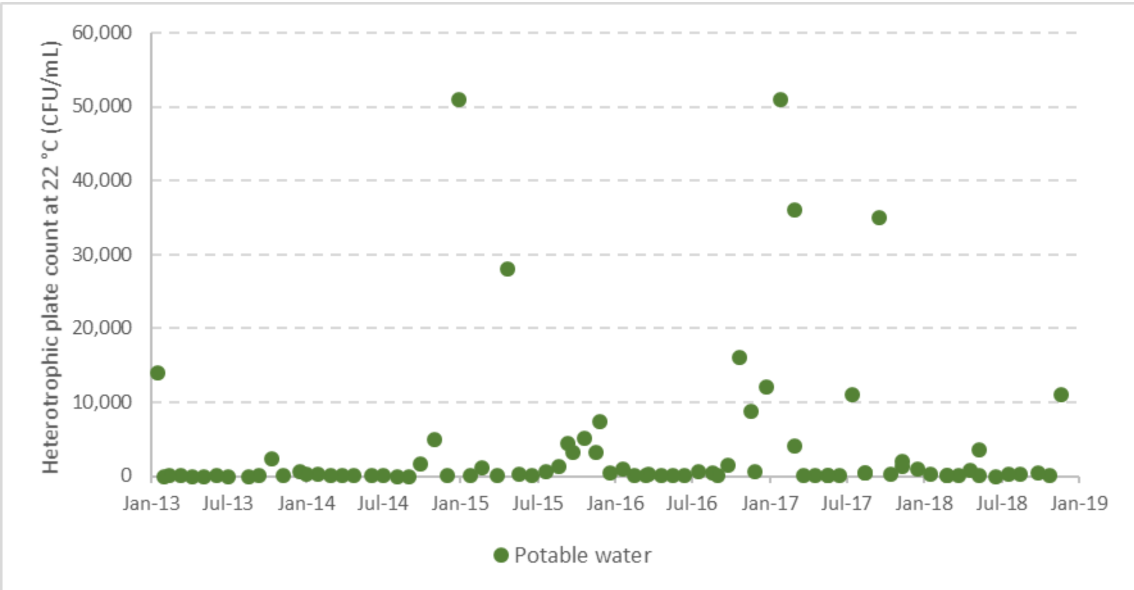


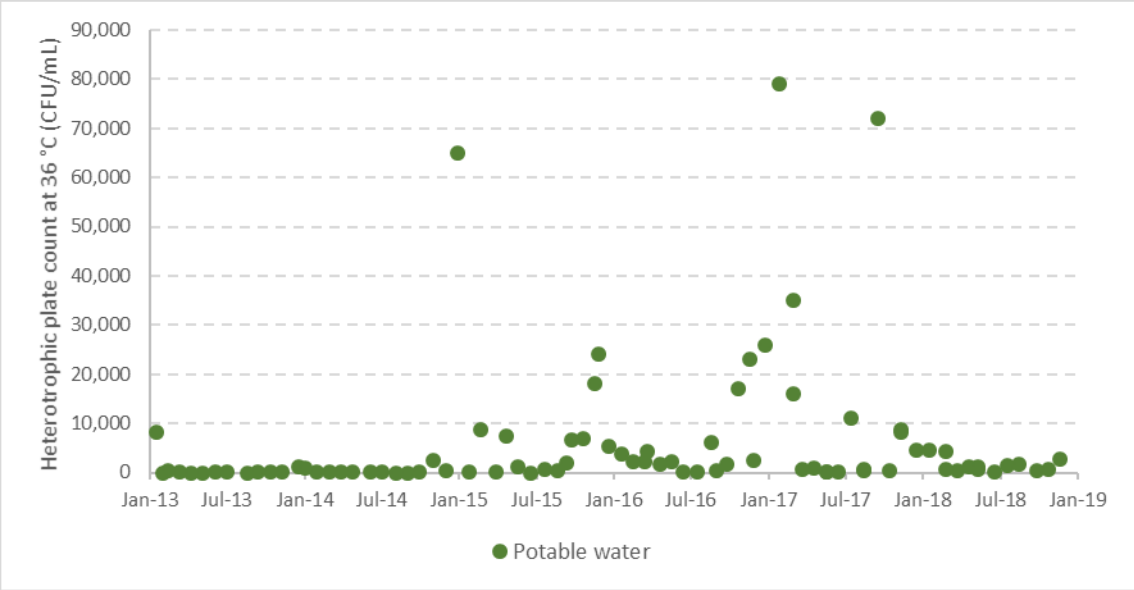


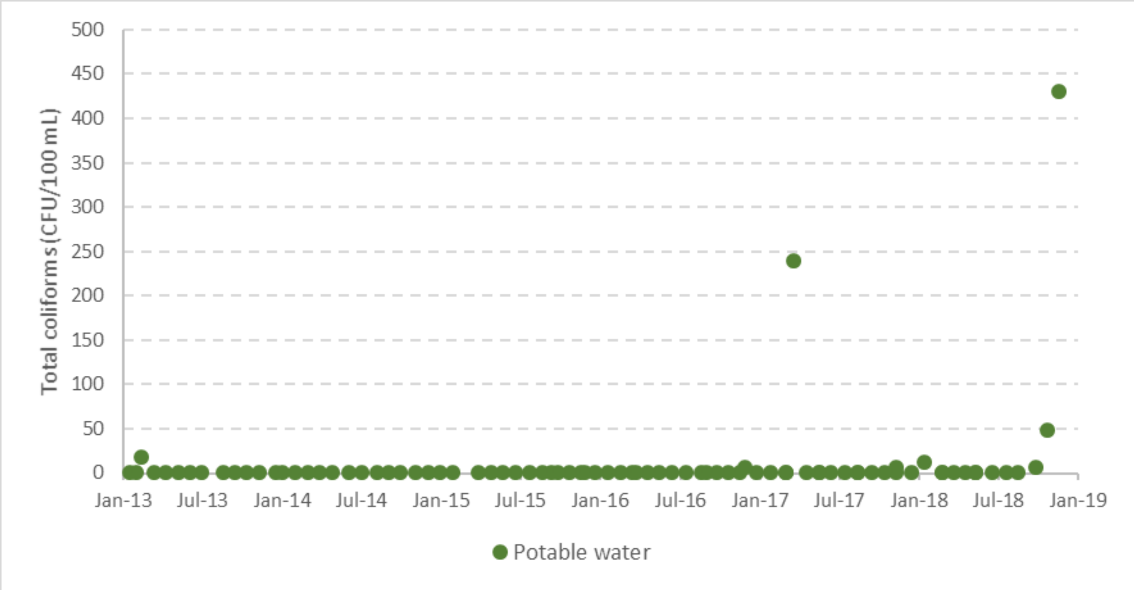
G.2.2 Microbiological



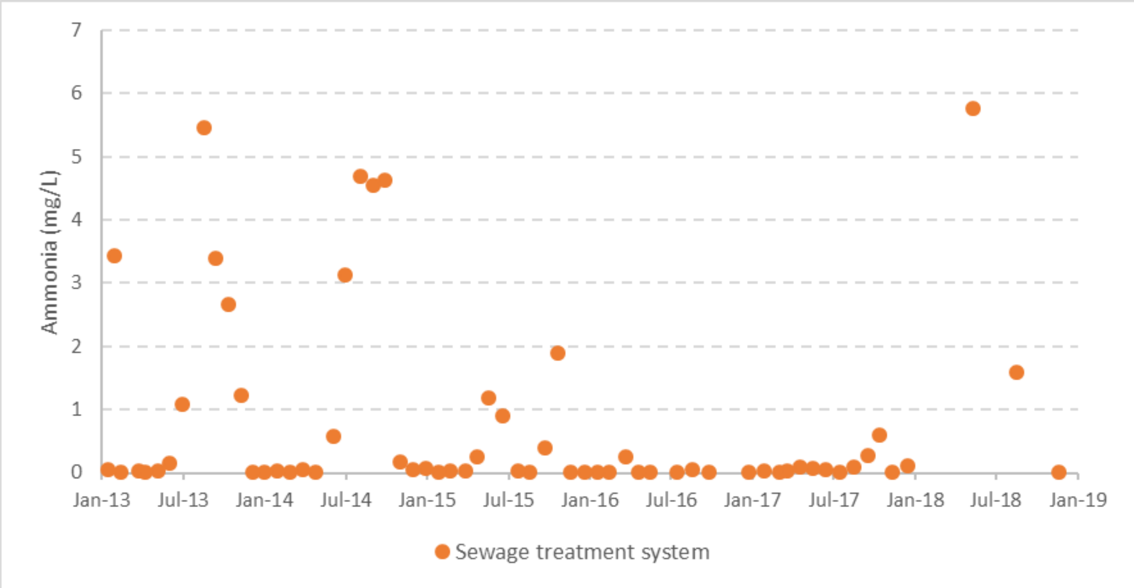


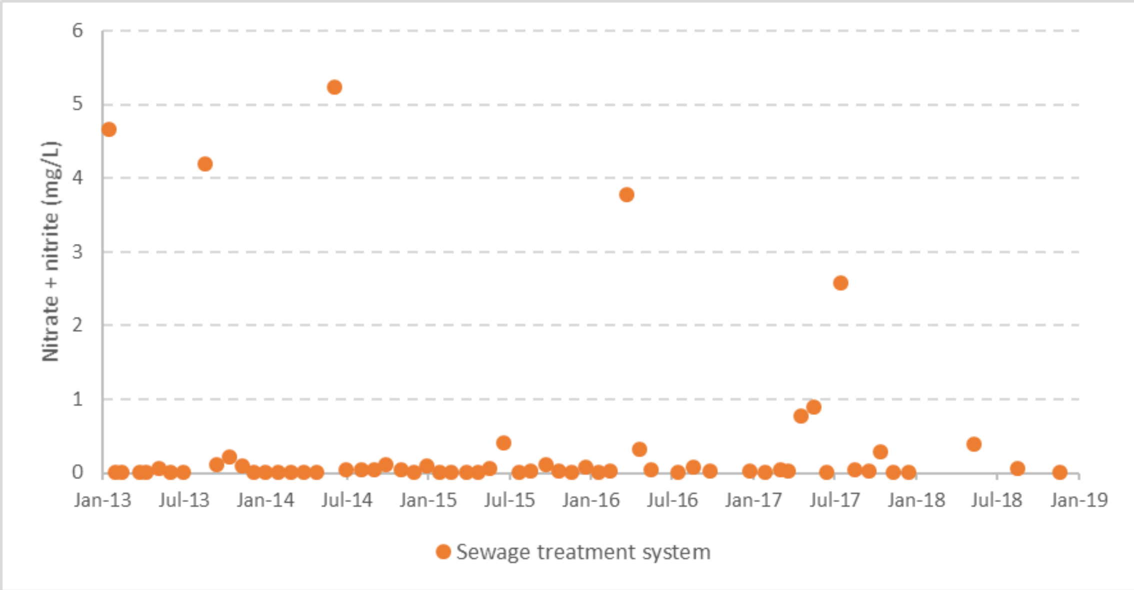


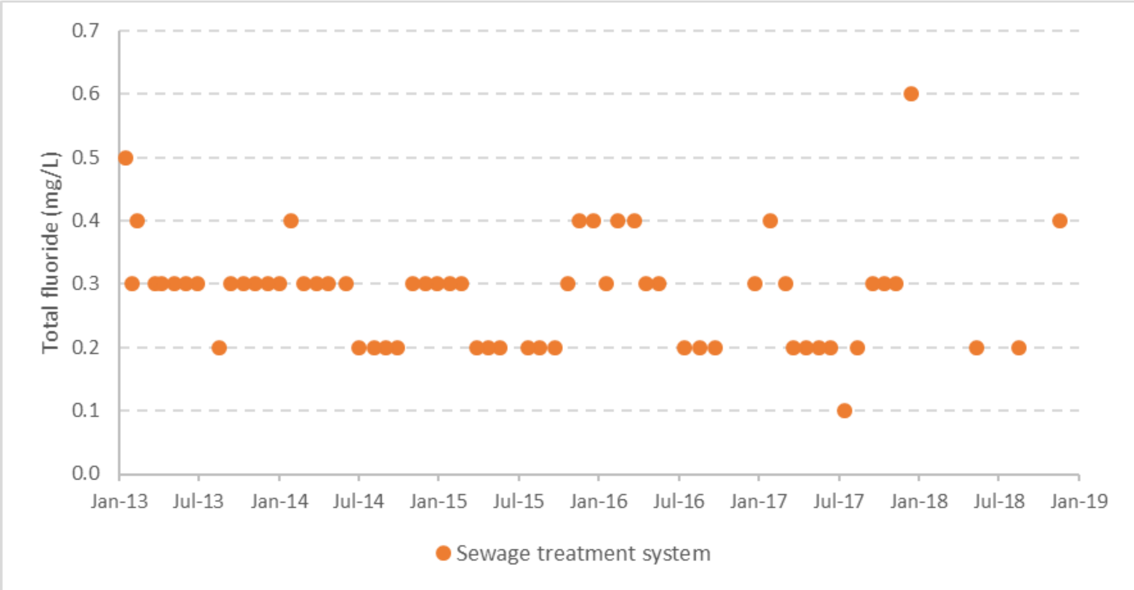


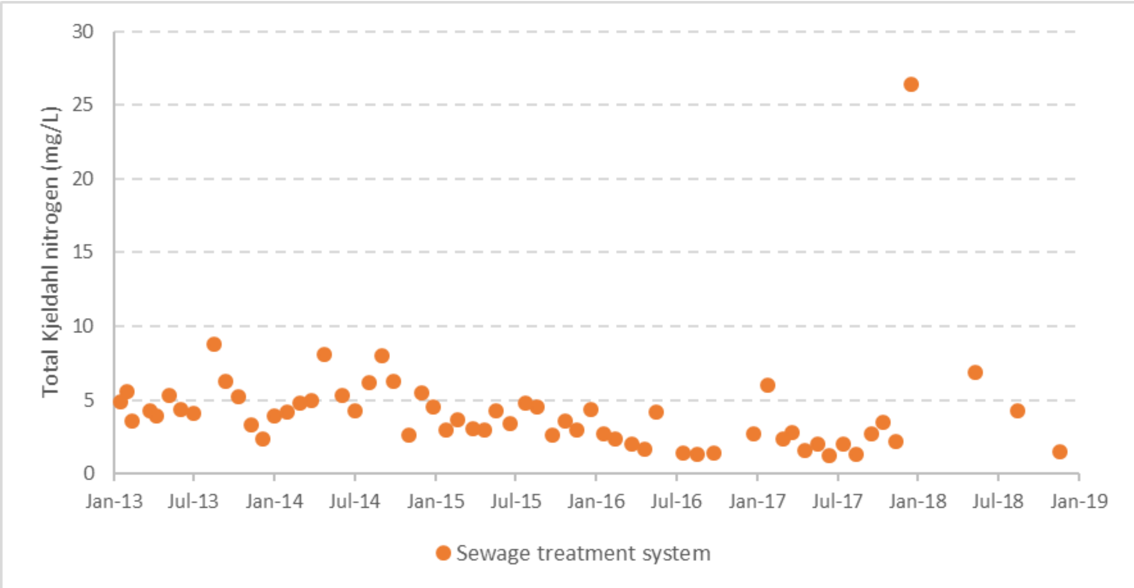


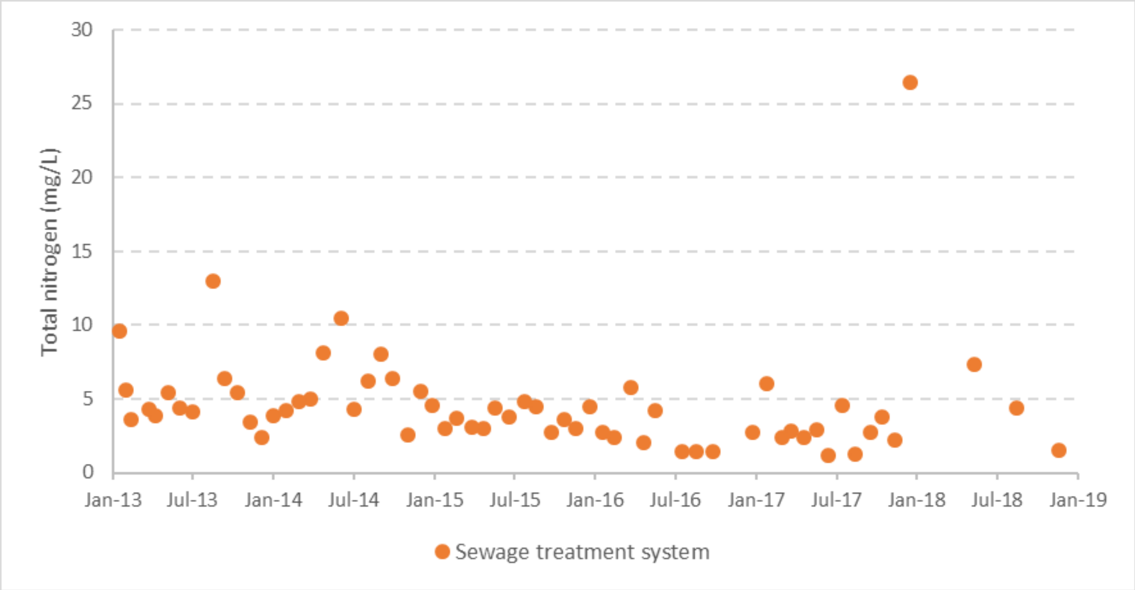
G.2.3 Nutrients

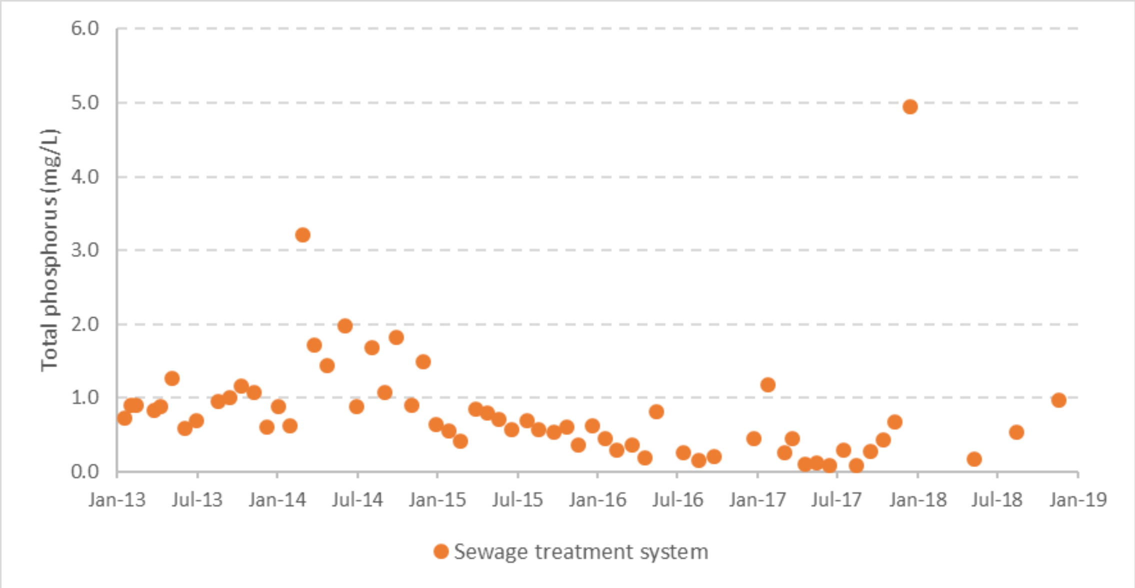



Nitrate + nitrite (mg/L)
0
1
2
3
4
5
6
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system

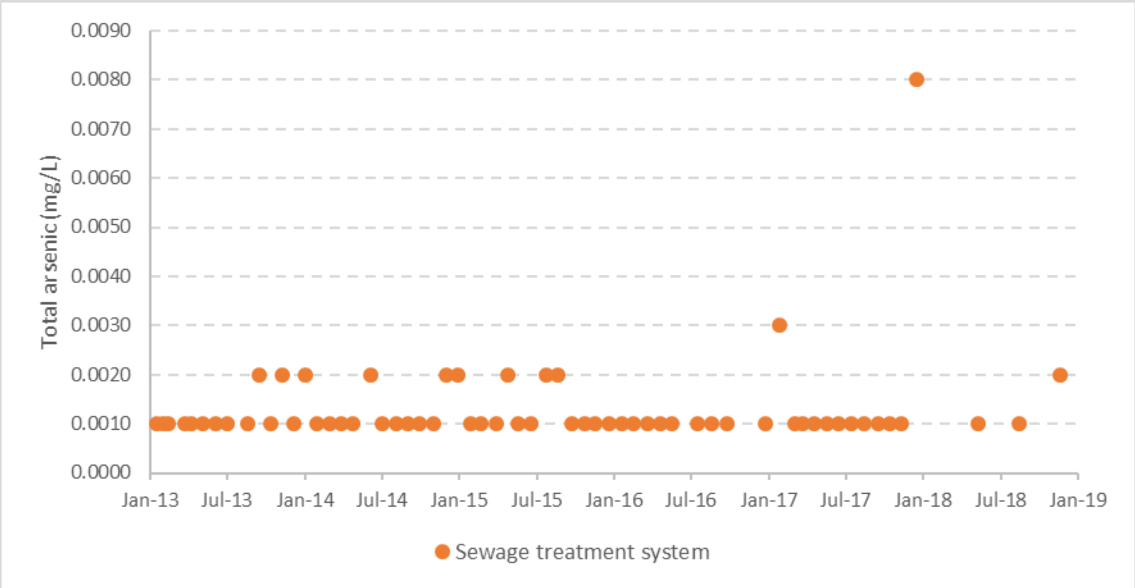

Total fluoride (mg/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system

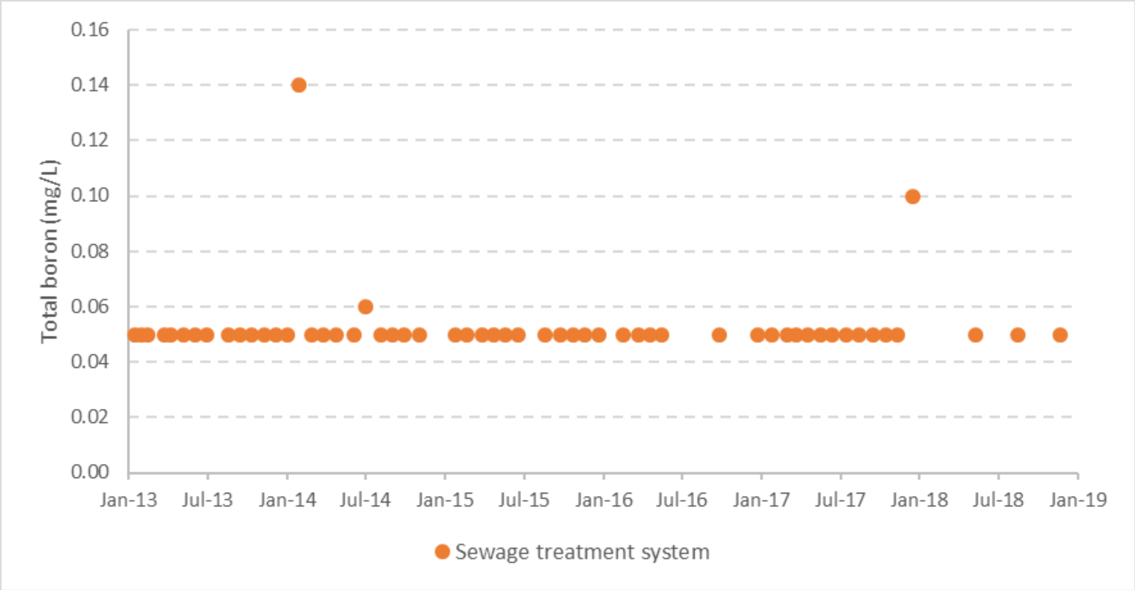

Total Kjeldahl nitrogen (mg/L)
0
5
10
15
20
25
30
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system

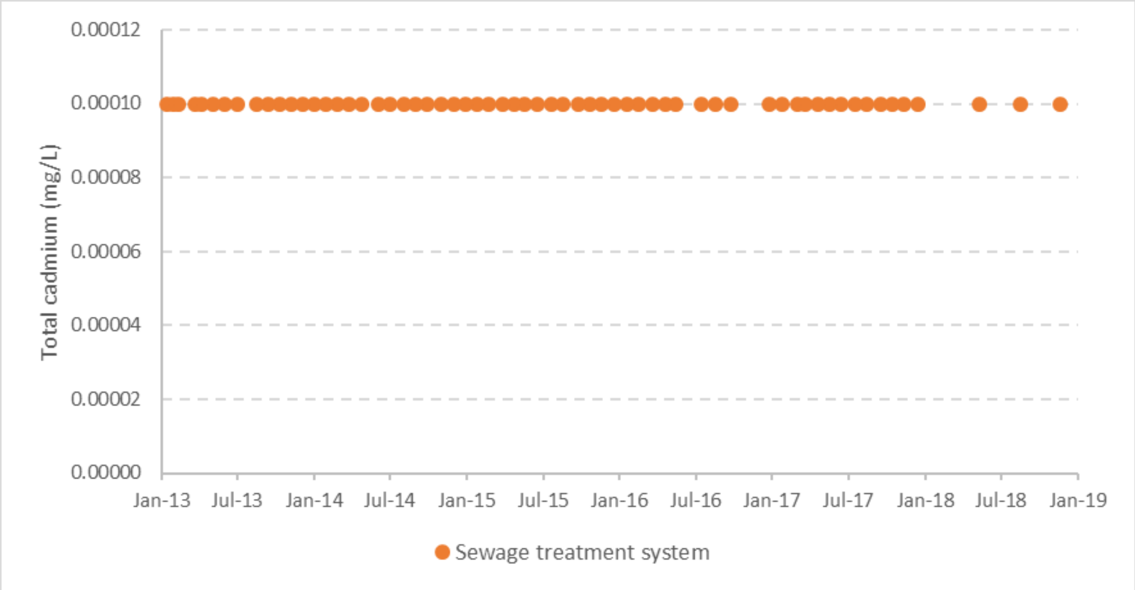


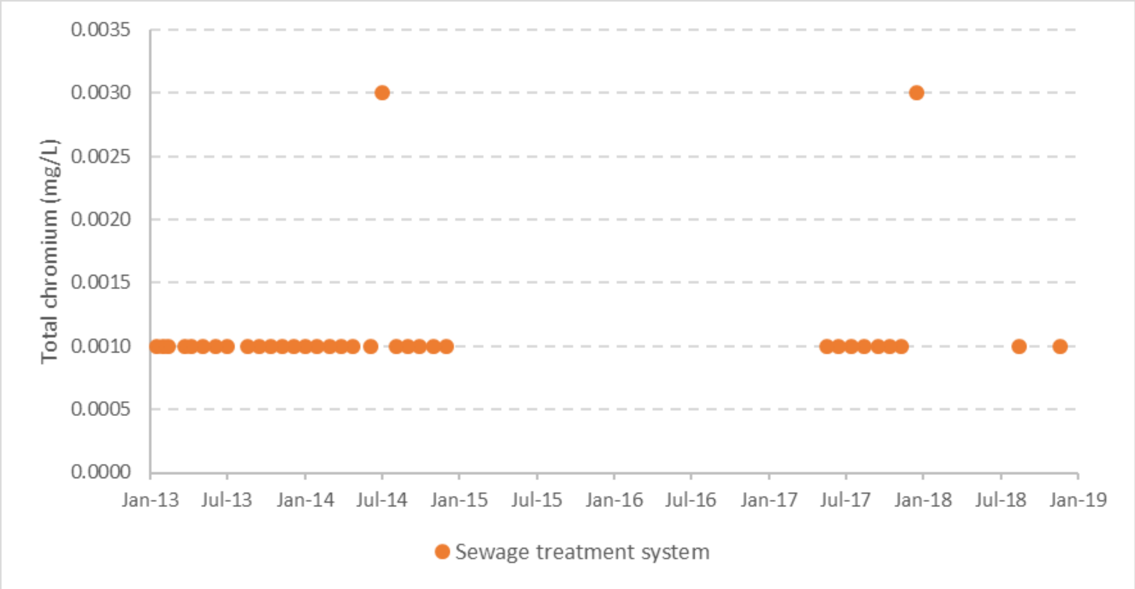


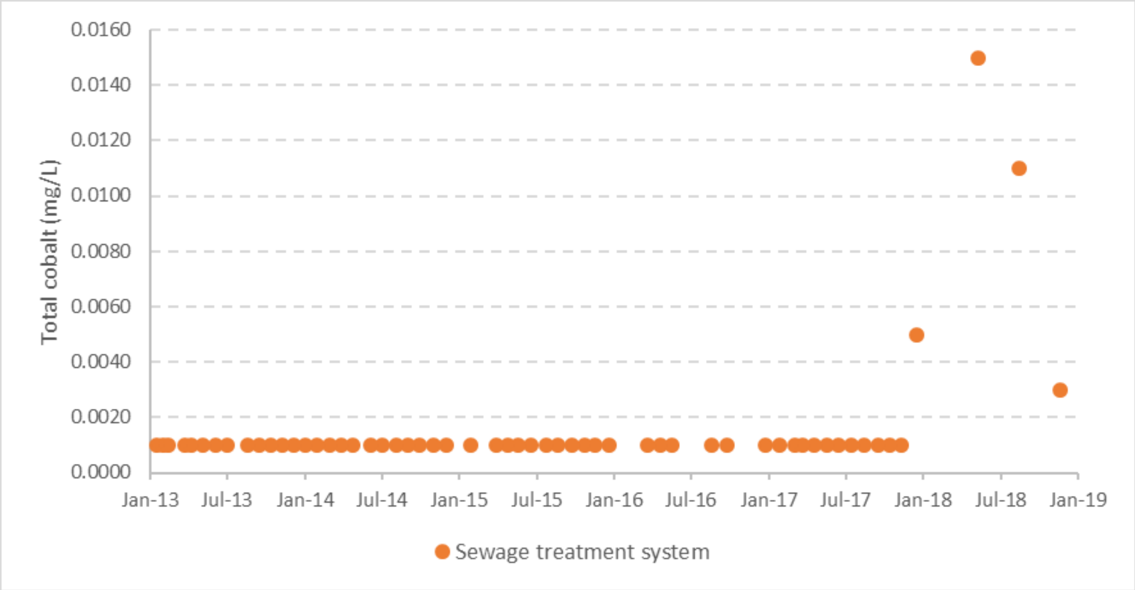
G.2.4 Total metals

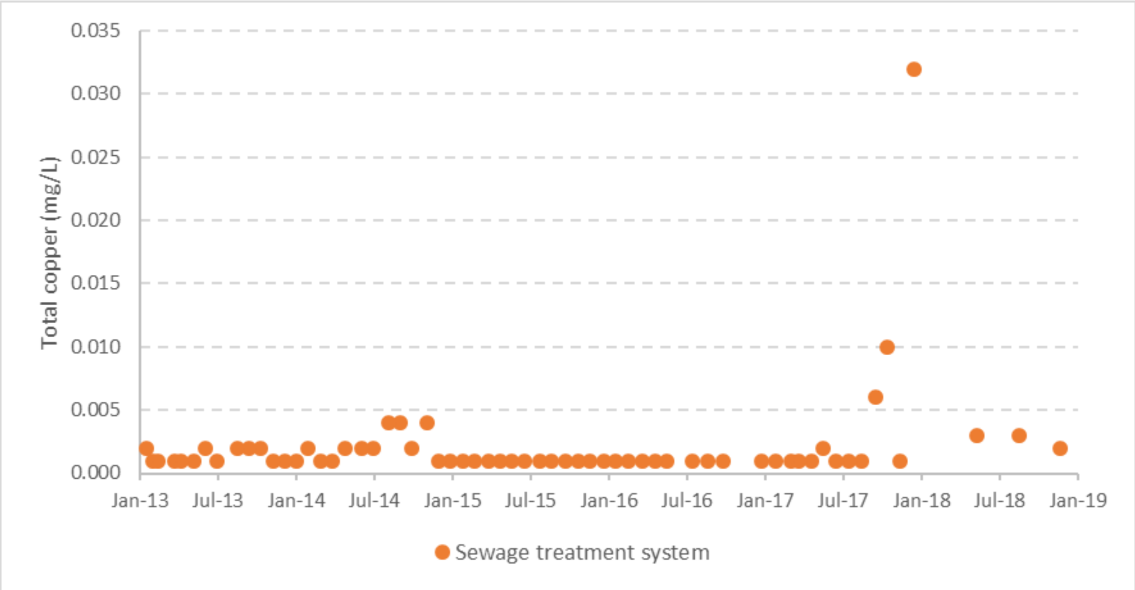


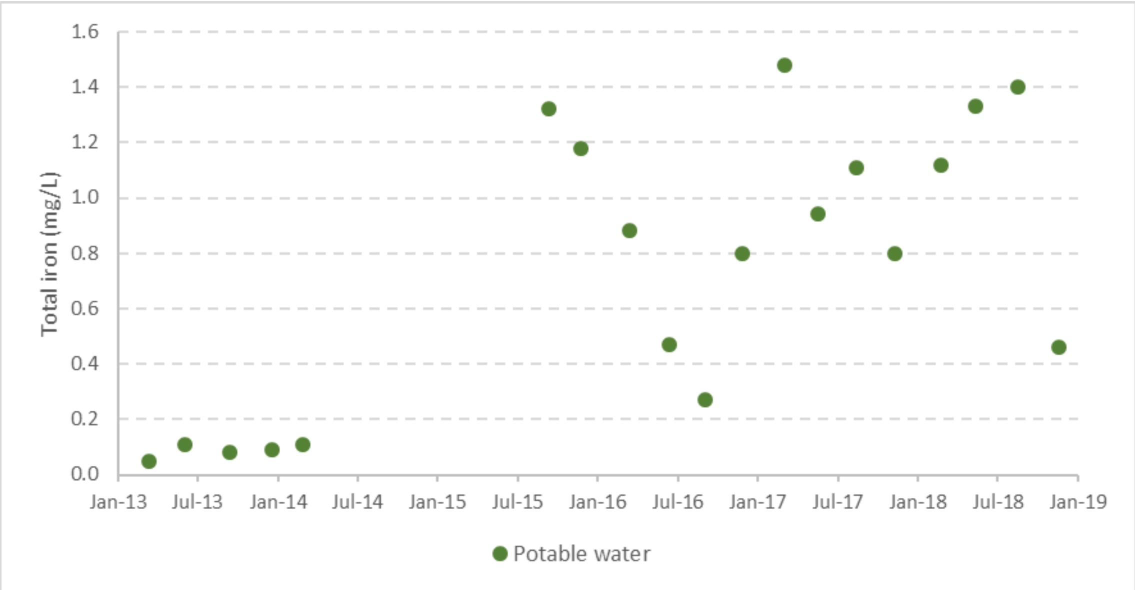

Total boron (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Sewage treatment system

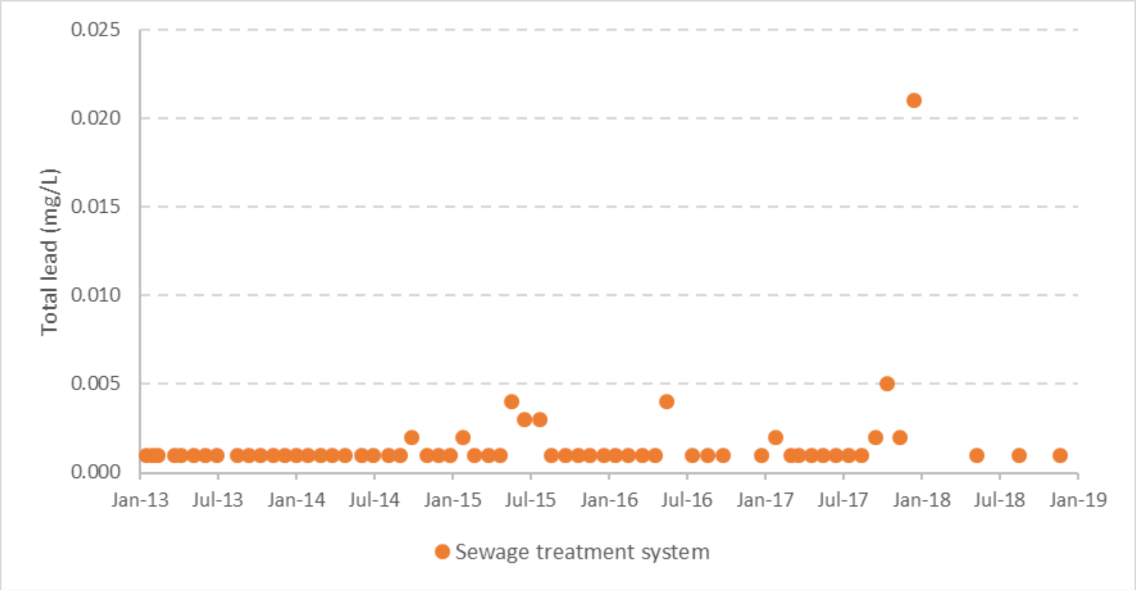

Total cadmium (mg/L)
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Sewage treatment system


Total chromium (mg/L)
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Sewage treatment system

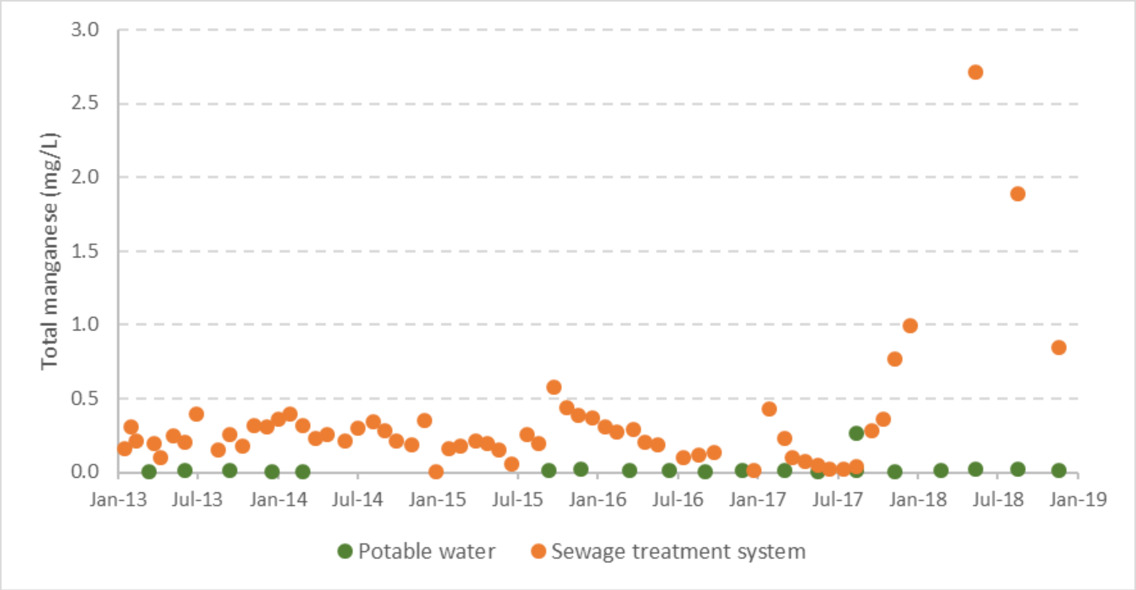

0.0160
0.0140
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
Total cobalt (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Sewage treatment system


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Total copper (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Sewage treatment system

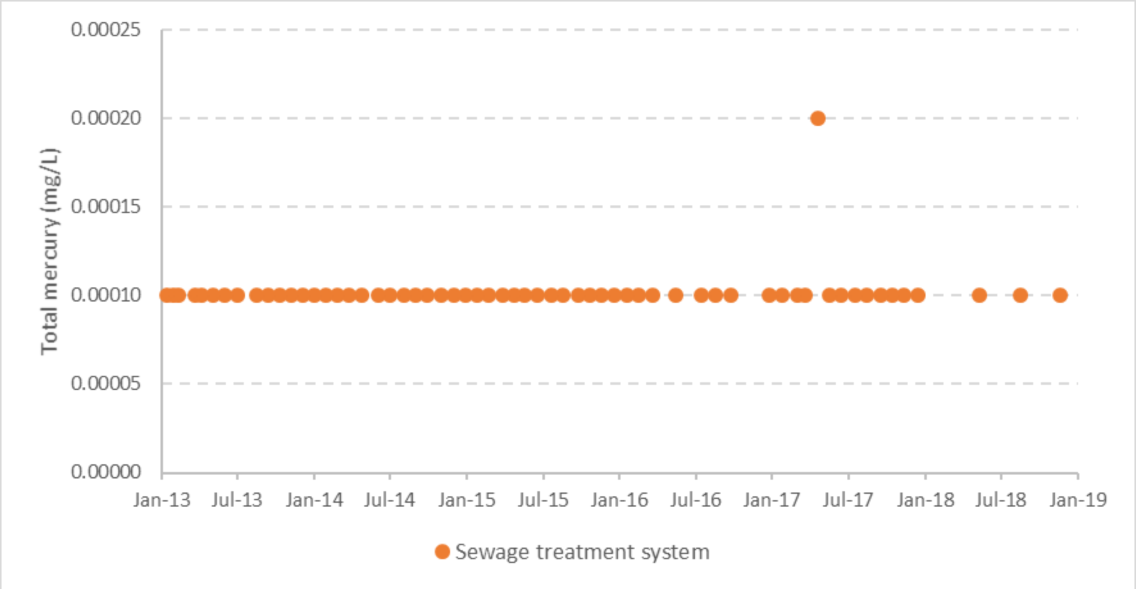

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Total iron (mg/L)
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Potable water



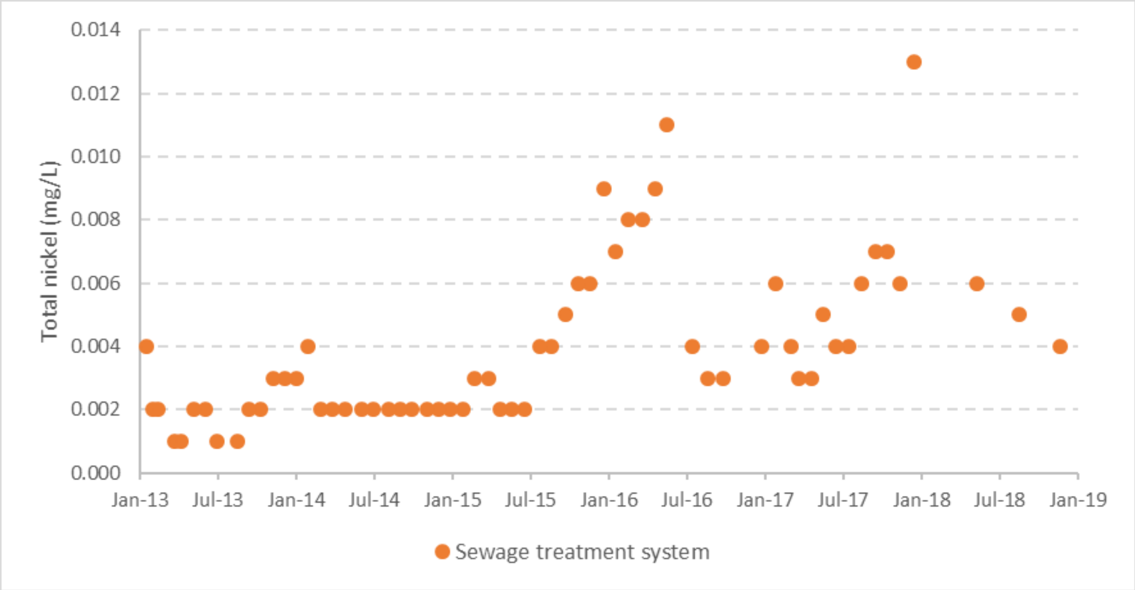
Total lead (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system



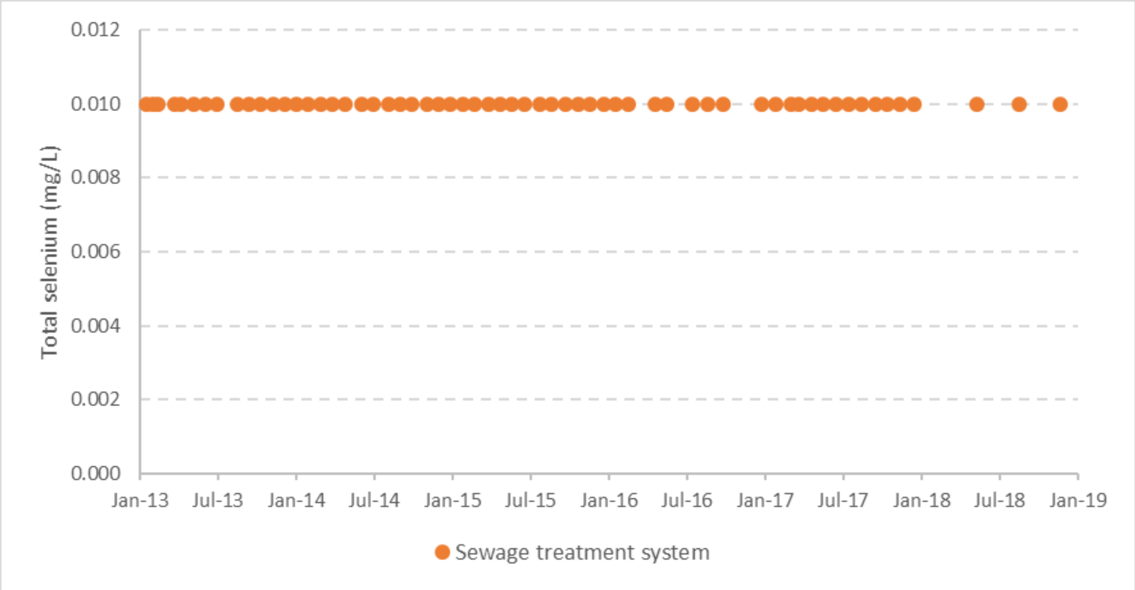
Total manganese (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Potable water
Sewage treatment system



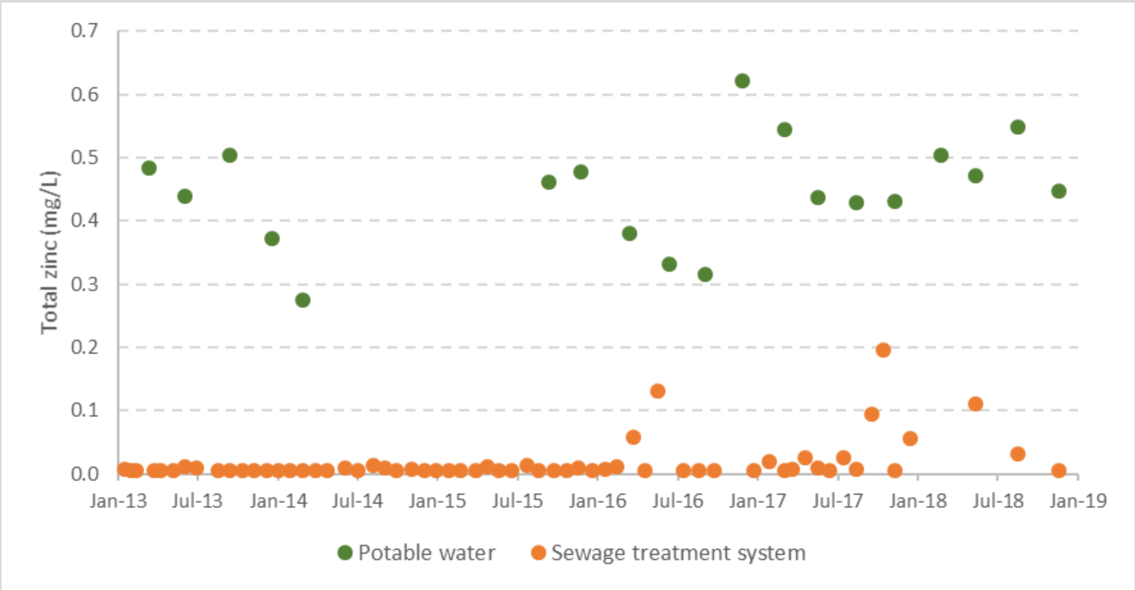
Total mercury (mg/L)
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system



Total nickel (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system

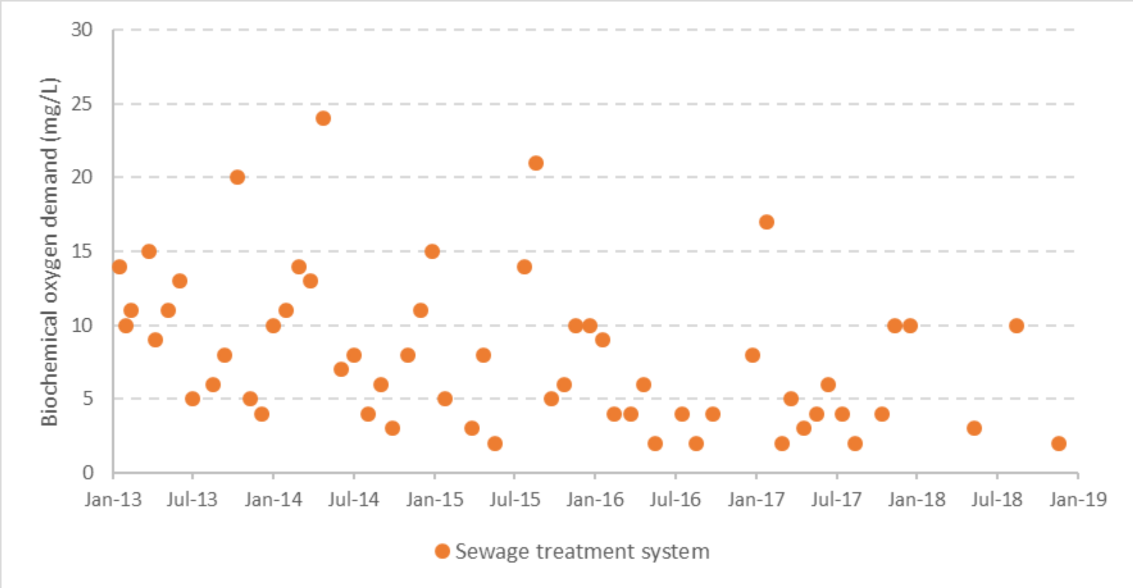


Total selenium (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system

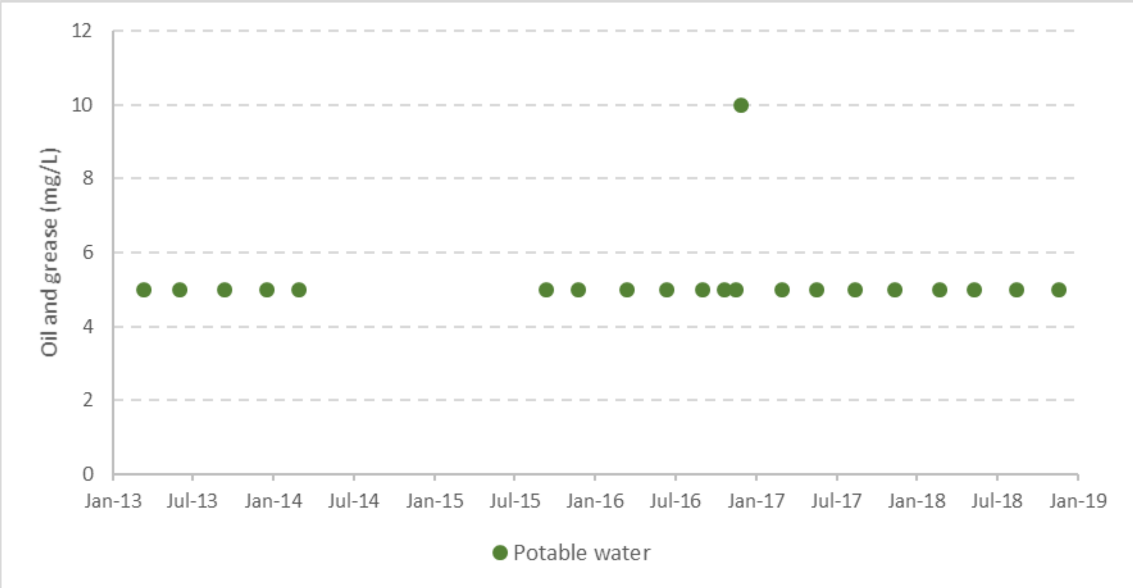


Total zinc (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Potable water
Sewage treatment system

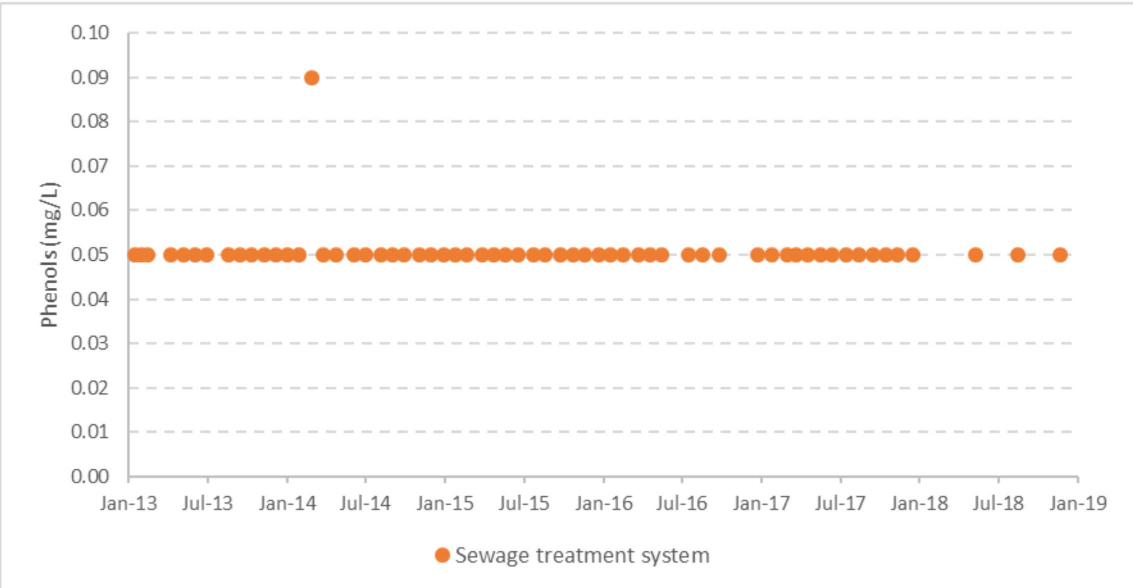
G.2.5 Other



Biochemical oxygen demand (mg/L)
30
25
20
15
10
5
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system

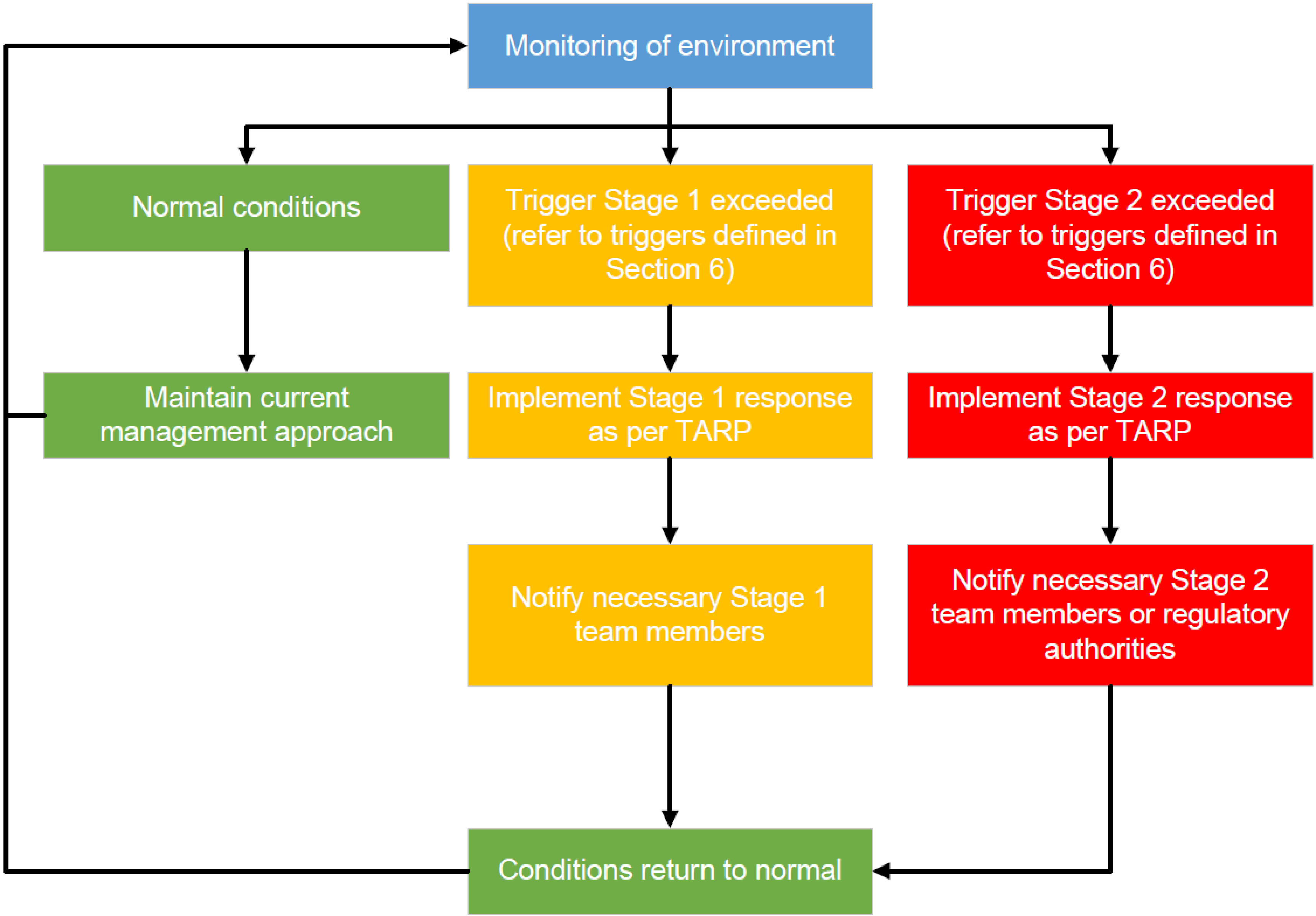


Oil and grease (mg/L)
12
10
8
6
4
2
0
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Potable water



Phenols (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-13 Jul-13 Jan-14 Jul-14 Jan-15 Jul-15 Jan-16 Jul-16 Jan-17 Jul-17 Jan-18 Jul-18 Jan-19
Sewage treatment system

Appendix H – Trigger action response plans



Monitoring of environment
Normal conditions
Trigger Stage 1 exceeded (refer to triggers defined in Section 6)
Trigger Stage 2 exceeded (refer to triggers defined in Section 6)
Maintain current management approach
Implement Stage 1 response as per TARP
Implement Stage 2 response as per TARP
Notify necessary Stage 1 team members
Notify necessary Stage 2 team members or regulatory authorities
Conditions return to normal

Site surface operations

Aspect	Normal	Stage 1	Stage 2	Notifications
Surface water storage volume	Storage captures events up to and including the design criteria.	**Trigger:** Storage is not dewatered appropriately following storm event in accordance with design criteria. **Action:** Investigate storage operation and dewatering options. Increase inspection frequency as required. Education of staff.	**Trigger:** Storage is discharging as a result of a storm event less than the design criteria. **Action:** Increase inspection frequency as required. Undertake water quality sampling of discharge and add flocculant as necessary. Undertake water quality sampling of downstream locations.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with Pollution Incident Response Management Plan (PIRMP) requirements or if material harm has occurred.
Clean water diversions	Clean water diverted around dirty water areas.	**Trigger:** Clean water bypass through dirty water areas. **Action:** Review catchment plan. Review design capacity of clean water system. Appropriately treat and manage dirty water.	**Trigger:** Clean water creates flooding problems through site. **Action:** Evacuate site if danger exists. Establish temporary bunding around clean water source. Utilise earthworks machinery to cut appropriate channel to manage clean water. Protect equipment and infrastructure. Utilise portable pumps to dewater flooded areas into storages.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

Aspect	Normal	Stage 1	Stage 2	Notifications
Erosion and sediment control	All controls are appropriately in place and well maintained. No disturbance areas or migration of sediment away from designated development areas.	**Trigger:** One or more areas of surface erosion in the form of rilling, bank erosion or other movement of sediment from an area of disturbance. Controls are not maintained or are inappropriately installed. **Action:** Seek to stabilise the area to stop the erosion process. This can include the use of groundcover or other temporary measures. Investigate works undertaken prior to the disturbance activities.	**Trigger:** Controls are not in place. Rainfall event has led to sediment migrating off site. **Action:** Isolate the area through diverting contributing surface flows to another appropriate control structure.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.
Hydrocarbon management	All hydrocarbon materials are stored appropriately.	**Trigger:** Minor spill occurs on site with limited risk of offsite migration. **Action:** Implement procedures in the PIRMP. Utilise spill kit.	**Trigger:** Major spill occurs on site with risk of offsite migration. **Action:** Isolate area and divert contributing surface flows. Engage waste contractor to clean spill. Investigate potential for contamination of waterways.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE if exceedance of limit occurs.

Aspect	Normal	Stage 1	Stage 2	Notifications
Water Transfer volume	Water transfer volume is within predictions of the site water balance and limits defined by MP06_0021.	**Trigger:** Forecasted transfer volume requirements exceeds predictions/limits. **Action:** Undertake investigation.	**Trigger:** Transfer volumes exceeds predictions/limits. **Action:** Undertake review of water management on site. Review on site transfers and predictions of hydrogeological model/site water balance model. Update models as required.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE and WaterNSW if exceedance of limit occurs as soon as practicable.

Watercourses

Aspect	Normal	Stage 1	Stage 2	Notifications
Water quality	Water quality at downstream monitoring locations within or below the SSGVs specified in (for Coxs River) or consistent with upstream monitoring location (for Wolgan River).	**Trigger:** Water quality is outside or above the values specified in Table 6-1 (for Coxs River) or statistically significantly different to upstream monitoring location (for Wolgan River) for at least one parameter for two consecutive sampling events. **Action:** Review recent monitoring results for adjacent sites and any relevant operational data (e.g. mining activities, clearing activities, meteorological data). Investigate the source of the exceedance and develop corrective/preventative actions based on outcomes (refer Appendix I).	**Trigger:** Investigation into Stage 1 trigger identifies that trigger exceedance is due to an operational activity. Community complaint to Centennial regarding surface water quality. **Action:** Determine if an incident has potentially occurred and investigate the source of the exceedance. Increase monitoring frequency and undertake additional monitoring (e.g. water quality, aquatic ecology) where relevant. Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation and/or additional monitoring (refer Appendix I). Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence. Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIEW as soon as practicable.

Aspect	Normal	Stage 1	Stage 2	Notifications
Water flow	Creek flow rates and relationships with rainfall are consistent with historical baseline results.	**Trigger:** Reduction in flow compared to historical baseline results. **Action:** Review recent monitoring results for adjacent sites and any relevant operational data (e.g. mining activities, clearing activities, meteorological data). Investigation the source of the reduction in flow and develop corrective/preventative actions based on outcomes (refer Appendix I).	**Trigger:** Loss of flow compared to historical baseline results is attributable to site operations. Community complaint to Centennial regarding surface water flow. **Action:** Review recent monitoring results for adjacent sites and any relevant operational data (e.g. mining activities, clearing activities, meteorological data). Determine if an incident has potentially occurred and investigate the source of the loss of flow. Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation (refer Appendix I). Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence. Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify DPIEW and WaterNSW (if within Coxs River catchment) as soon as practicable.

Discharge management

Aspect	Normal	Stage 1	Stage 2	Notifications
LDP discharge quality	Discharge quality is within limits defined by EPL.	**Trigger:** Water quality parameters exceed discharge limits for one parameter for one discharge event. **Action:** Undertake investigation. Repeat sampling. Consider a reduction in pumping from underground storage if appropriate.	**Trigger:** Water quality parameters exceed discharge limits for more than one parameter. **Action:** Undertake review of water management on site. Undertake incident investigation including ecotoxicology and aquatic ecology monitoring if appropriate.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE and WaterNSW if exceedance of limit occurs as soon as practicable.
LDP discharge volume	Discharge volume is within predictions of the site water balance and limits defined by EPL.	**Trigger:** Discharge volume exceeds predictions/limit for no more than one day. **Action:** Undertake investigation. Review monitoring equipment.	**Trigger:** Discharge volume exceeds predictions for more than one day. **Action:** Undertake review of water management on site. Review on site transfers and predictions of hydrogeological model/site water balance model. Update models as required.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE and WaterNSW if exceedance of limit occurs as soon as practicable.

Aspect	Normal	Stage 1	Stage 2	Notifications
Unlicensed emergency discharges	No discharges from emergency locations.	**Trigger:** Discharge from a non-EPL defined emergency discharge location. **Action:** Undertake investigation. Increase monitoring frequency downstream and undertake additional monitoring where relevant.	**Trigger:** Continued discharge from a non-EPL defined, emergency discharge location. **Action:** Undertake review of water management on site. Undertake incident investigation, including ecotoxicology and aquatic ecology monitoring if appropriate.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred. Notify DPIE and WaterNSW (if within Coxs River catchment) as soon as practicable.

Groundwater monitoring

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater level	Depth to groundwater is less than the depths outlined in Table 6-2 under the conditions outlined.	**Trigger:** Depth to groundwater is greater than the depths outlined in Table 6-2 under the short-term and long-term conditions outlined. **Action:** Undertake investigation including review of adjacent sites and any relevant operational data (e.g. mining activities, meteorological data) to determine if the change is due to mining related activities.	**Trigger:** Investigation into Stage 1 trigger identifies that trigger exceedance is due to an operational activity and is outside predictions from the hydrogeological model and impact assessment predictions. Community complaint to Centennial regarding loss of groundwater at landholder bore. **Action:** Verify whether monitoring results are consistent with hydrogeological model predictions and consider recalibration. Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation (refer Appendix I). Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence. Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.

Aspect	Normal	Stage 1	Stage 2	Notifications
Piezometric level	Piezometric pressure is above levels provided in Table 6-3 under the conditions outlined.	**Trigger:** Piezometric level is below the levels in Table 6-3 under the conditions outlined. **Action:** Undertake investigation including review of adjacent sites and any relevant operational data (e.g. mining activities, meteorological data) to determine if the change is due to mining related activities.	**Trigger:** Investigation into Stage 1 trigger identifies that trigger exceedance is due to an operational activity. Community complaint to Centennial regarding loss of groundwater at landholder bore. **Action:** Implement corrective/preventative actions, in consultation with relevant agencies, based on the outcomes of the investigation (refer Appendix I). Prioritise actions based on the risk to the environment and likelihood of further impact. Review the WMP and related procedures to prevent reoccurrence. Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater quality	Groundwater quality monitoring results are consistent with historical results.	**Trigger:** Review of groundwater quality monitoring data identifies a statistically significant change compared to historical results. **Action:** Undertake investigation including review of adjacent sites and any relevant operational data (e.g. mining activities, meteorological data) to determine if the change is due to mining related activities.	**Trigger:** Investigation into Stage 1 trigger identifies that trigger exceedance is due to mining-related activity. Community complaint to Centennial regarding groundwater quality at landholder bore. **Action:** If environmental impacts are unacceptable and/or if the beneficial use of the groundwater changes, remediation options will be considered. Loss of water supply to any adjacent landholder due to mining-related activities will need to be replaced by Centennial.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.

Stream health

Aspect	Normal	Stage 1	Stage 2	Notifications
Watercourse instabilities (Kangaroo Creek and Long Swamp)	Watercourse monitoring indicates no areas of new instabilities compared to historical monitoring (2017 baseline conditions).	**Trigger:** Visual inspection indicates one or more areas of minor instability. **Action:** Review historical monitoring records. Investigate the factors contributing to the instability, which may include advice from technical specialists. Implement corrective actions as required as soon practicable to stabilise the surface and/or watercourses based on the outcomes of the investigation. Increase monitoring frequency and undertake additional monitoring where relevant.	**Trigger:** Visual inspection indicates one or more areas of major instability. **Action:** Immediately isolate areas of instability and implement remediation measures to stabilise surface and/or watercourse. Investigate the factors contributing to the instability, which may include advice from technical specialists. Implement corrective actions as required as soon as practicable to stabilise the surface and/or watercourses based on the outcomes of the investigation (refer Appendix I). Prioritise actions based on the risk to the environment and likelihood of further impact. Increase monitoring frequency and undertake additional monitoring (e.g. watercourse stability, water quality, aquatic ecology) where relevant. Review WMP and related procedures to prevent reoccurrence.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.

Aspect	Normal	Stage 1	Stage 2	Notifications
Watercourse instabilities (all other watercourses)	Subsidence levels are within predictions.	**Trigger:** Subsidence levels 1.5 times greater than predicted values. **Action:** Undertake visual monitoring of watercourses to identify any instabilities that may have formed.	**Trigger:** Investigation into Stage 1 trigger indicates watercourse instabilities. **Action:** Investigate the factors contributing to the instability, which may include advice from technical specialists. Undertake additional monitoring (e.g. watercourse stability, water quality, aquatic ecology) where relevant. Implement corrective actions as required as soon as practicable to stabilise the surface and/or watercourses based on the outcomes of the investigation (refer Appendix I). Prioritise actions based on the risk to the environment and likelihood of further impact. Review WMP and related procedures to prevent reoccurrence.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.

Aspect	Normal	Stage 1	Stage 2	Notifications
Instream vegetation	No significant change in vegetation extent or quality compared with previous monitoring results.	**Trigger:** Visual inspections show change in extent and density of instream vegetation not specific to season. Introduction or increase in number of exotic species. **Action:** Review activities likely to influence instream vegetation. Review flow monitoring and rainfall data. Consider using RCE measure to quantify change from historical results.	**Trigger:** Visual inspections show significant change in extent and density of instream vegetation because of clearing or impact. **Action:** Increase monitoring frequency and undertake additional monitoring (e.g. watercourse stability, water quality, aquatic ecology) where relevant. Undertake water quality monitoring to determine potential impact on in situ conditions. Stabilise watercourse banks as necessary.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify DPIEW as soon as practicable.
In situ water quality	No significant change in water quality compared with previous monitoring results.	**Trigger:** Poor water quality observed compared with previous monitoring results. **Action:** Investigate sources of water quality degradation. Repeat sampling within one week.	**Trigger:** Continued poor water quality observed compared with previous monitoring results and attributable to site operations. **Action:** Review catchment inputs. Inspect waterway upstream of monitoring locations. Undertake analysis of full suite of parameters.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager immediately. **Stage 2:** Notify DPIEW as soon as practicable.

Appendix I – Surface and groundwater remediation measures

Surface water and groundwater remediation strategies can take one of two forms:

- Soft engineering solutions, which comprise of elements such as coir logs, jute matting, geotextile, rock armouring, timber log dissipaters and a range of other options that are generally designed to repair cracks and erosion and prevent recurrence by regulating the flow of surface and subsurface water. These solutions are generally biodegradable and therefore integrate into swamp/riparian systems.
- Hard engineering solutions comprise the use of concrete and various grouting techniques as well as earthworks. These solutions are used where either subsidence is persistent and results in water losses from waterways and swamps or areas of remnant ponding impact on waterway hydraulics.

A hierarchy of control will be used when implementing remediation works. Soft engineering solutions will be used initially to remediate any impacts that may occur. These soft engineering works will be monitored and maintained to ensure design performance. Hard engineering solutions will be used if monitoring demonstrates that the soft engineering solutions require additional works.

Potential engineering solutions may include but are not limited to those outlined below. These engineering solutions are not provided with significant detail as they only provide an indication of possible solutions as a last measure. As technology and research improves, alternative and better engineering solutions may be developed. This is why a detailed assessment and investigation needs to be instigated prior to the implementation of any engineering solutions. This should be followed by a detailed review by relevant government departments and specialist consultants.

The measures outlined below would need careful consideration and investigation by appropriate experts before they are adopted, to prevent any unintended adverse effects.

I.1 Surface water drainage to mitigate ponding

Where subsidence has resulted in a significant increase in remnant ponding, surface or subsurface water drains can be constructed to improve water carriage. These drains need to be designed to have sufficient capacity to drain areas affected by ponding. These drains are typically of a shallow design depending on existing surface gradients and direct surface water to establish drainage lines.

I.2 Infilling of surface cracks to prevent surface water loss

In the unlikely event that subsidence causes significant surface cracks, these may be infilled to prevent the loss of surface water. Surface cracks are typically remediated by backfilling these with surrounding surface material and then regrading to create a level surface. Disturbed areas are then rehabilitated by planting native endemic species to prevent soil erosion.

I.3 Creek realignment measures to improve flows

If sections of creek bed become hydrologically isolated or have significant areas of additional pooling caused by changes in bed gradients, then these bed sections may need to be realigned to improve flows. Realignments need to be designed based on surveyed long sections to best suit existing creek grades. This remediation measure typically involves excavating to regrade a creek bed section or removing elevated sections causing a constriction to flow. Upstream water would need to be contained to allow excavation and following realignment similar soil material would be reinstalled to stabilise the creek bed. Permits to work within a waterway would need to be obtained from relevant government authorities prior to commencing works.

I.4 Creek bed stabilisation measures to reduce erosion

Where creek gradient changes result in a significant increase in erosion, it may be necessary to reduce flow velocities in the creek to prevent further scouring and the resultant erosion. This can be achieved by a number of methods ranging from constructing bends in the creek line to establishing weir pools. These methods would require specific design to quantify the amount of flow reduction to stabilise the creek. It may also be necessary to stabilise banks by regrading bank areas to reduce incised sections and stabilising the soil by revegetating banks.

I.5 Measure to control out-of-channel erosion

Contour bunds can be used to redirect surface flows from areas at risk of increased erosion, particularly where exposed soils are subject to out-of-channel flows. These contour bunds act to reduce the flow path and redirect water away from areas of erosion. The contour bunds are typically constructed on a low gradient following an existing contour level redirecting surface water into existing drainage channels or water structures. Areas at rick of erosion can then be rehabilitated by establishing vegetation cover using native endemic species.

I.6 Diversion of water into creek or swamp

When considering this action, it is important to take secondary impacts into account. These may include erosion, water quality and impacts on the vegetation and fauna.

Water can be diverted into creeks and swamps from new or existing pipelines. Depending on where the water is required, energy dissipaters can be constructed to reduce the erosivity of the water. This can be implemented by constructing stepped ponding or broad/level stilling ponds. Detailed survey will be required to design these facilities to ensure they feed water to the relevant areas. Inspections of the subject area will be carried out to monitor further erosion. It may be necessary to vary the rate at which water is released or install natural snags to dissipate energy further or further stabilise banks.

I.7 Bentonite cut-off trenches to control groundwater flow

If near-surface cracking results in drainage of groundwater from a swamp, this may be prevented by constructing subsurface, bentonite-filled cut-off trenches to prevent lateral drainage groundwater and redirect it into the swamp. Depending on the location of the cracking, this may result in the loss of groundwater to a small portion of the swamp, in order to save the remainder. Detailed evaluation would be required to ensure that the cut-off trenches were appropriately located.

I.8 Subsurface drains

If different parts of one swamp become hydrogeologically isolated due to excessive ground movements, one method of restoring the pre-mining groundwater table would be to install subsurface drains to equalise the groundwater in each area. Care would be required in locating the drains to ensure that the desired results are achieved. This would also necessitate detailed survey and subsurface investigation.

I.9 Grouting of rock bars

Cracking of rock bars may lead to drainage of groundwater and surface water. Where possible, grouting of these rock bars may be effective in reducing water loss. Based on the outcomes of the ongoing monitoring program and any remedial measures undertaken, an assessment should be made of the potential for similar anomalous conditions to arise in subsequent areas are to be undermined. Recommendations should be made for control measures that may mitigate any such impact.

I.10 Grouting of aquifer cracks

Where cracks are identified in the near-surface aquifers that are causing loss of piezometric head, grouting may be used to fill the crack followed by re-injection of suitable water as required.