



REPORT

Ensham Life of Mine Extension Project

APPENDIX E1: Surface Water Quality Assessment

Prepared for: Ensham Resources Pty Limited

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EXECUTIVE SUMMARY

Hydro Engineering & Consulting Pty Ltd (HEC) was commissioned by AECOM Australia Pty Ltd (AECOM), on behalf of Ensham Resources Pty Ltd (Ensham), to assess the potential impacts of the proposed Ensham Life of Mine Extension Project (the Project) on surface water values, in support of the Environmental Impact Statement (EIS) for the Project.

The Project proposes to increase the life of the existing underground operations by up to nine years to approximately 2037. The extension of the underground operation using existing infrastructure means that no surface construction or surface disturbance will be required to facilitate the Project.

This report:

- documents the baseline water quality data for surface water resources within and downstream of the Project Area
- determines applicable environmental values (EVs) and water quality objectives (WQOs) for comparison to baseline water quality data
- assesses the potential impacts to water quality and hence EVs as a result of the Project.

The most stringent WQOs for all physico-chemical constituents have been identified and used for comparative benchmarking of baseline data. Relevant EVs associated with the most stringent WQOs are aquatic ecosystems and recreation. Surface water quality monitoring at and in the vicinity of the Ensham Mine has been categorised into upstream sites, downstream sites and mine area sites.

At the four upstream sites, median values exceed WQOs at all sites for suspended solids, at two sites for nutrients, at two sites for EC (electrical conductivity – a measure of salinity) and at one site for turbidity. Continuously recorded (gauging station) EC values are low at high flows but cover a wide range at low to moderate flows. EC data at low to moderate flows is likely affected by regulated releases from Fairbairn Dam. Recorded values of iron, total manganese, aluminium, total chromium, copper and zinc were elevated compared with the WQOs at most sites.

At the five downstream sites, median values exceed WQOs at all sites for which data were available for suspended solids, at two sites for EC, at one site for turbidity, one site for total nitrogen and two sites for sulphate. Recorded values of iron, manganese, aluminium, total chromium, copper and zinc were elevated compared with the WQOs at most sites.

Limited data were available for the two mine area undisturbed sites. For those sites with sufficient data, EC, suspended solids, total iron, total manganese and total aluminium were elevated compared with the WQOs.

Data for RP1 (Environmental Authority [EA] release point) indicates elevated median EC, TDS, suspended solids, sulphate and hardness compared with the WQOs. However, 80th percentile EC, turbidity and sulphate values are less than EA limits for controlled release. It is noteworthy that median values for recorded trace metals concentrations at RP1 do not exceed the respective WQOs.

Ensham manage releases in accordance with EA EPML00732813 (dated 19 March 2020) and this has ensured that Ensham has complied with the defined EA water quality triggers and limits. A recent aquatic ecology study (Hydrobiology, 2019a) has concluded that continued release in accordance with EA limits should have insignificant to minor impacts to aquatic ecosystem values.

Given that no surface construction or surface disturbance will be required to facilitate the Project, the only potential change to release quantity and quality could result from changes to underground mine groundwater inflow. Groundwater inflow to future mining areas is predicted to have the same quality as previous groundwater inflows (SLR, 2020). Groundwater modelling has predicted that groundwater inflows should increase in the near-term (within the term of the existing operations)

before trending downwards with time, while fluctuating over a similar range as inflows predicted for the near-term. The higher rates of groundwater inflow will continue to be managed within the existing Ensham mine water management system, including the controlled release system, and be subject to the provisions of EA EPML00732813 (dated 19 March 2020), which ensure protection of environmental values through management of release volumes and monitoring of water quality. It is therefore concluded that no environmentally significant impacts to surface water quality should occur as a result of the Project.

In order to ensure no significant impacts to surface water quality, continued water quality monitoring in accordance with EA EPML00732813 is proposed.

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ABBREVIATIONS

AEP	Annual Exceedance Probability
CHP	Coal Handling Plant
DEHP	Department of Environment and Heritage Protection
EA	Environmental Authority
EIS	Environmental Impact Statement
EP Act	<i>Environmental Protection Act 1994 (Qld)</i>
EP Regulation	<i>Environmental Protection Regulation 2019</i>
EP Water and Wetland Biodiversity	<i>Environmental Protection (Water and Wetland Biodiversity) Policy 2019</i>
ERA	Environmentally Relevant Activity
ERJV	Ensham Resources Joint Venture
EV	Environmental Value
km	kilometre
LOD	limit of detection
µg	microgram
µS	microsiemen
m	metre
mg	milligram
mm	millimetre
MDL	Mineral Development Lease
MIA	Mine Infrastructure Area
ML (prefix)	Mining Lease
ML (suffix)	megalitre
ML/d	megalitres per day
Mtpa	million tonnes per annum
ROM	run-of-mine
RP	Release Point
WQO	Water Quality Objective

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1.0 INTRODUCTION

Hydro Engineering & Consulting Pty Ltd (HEC) was commissioned by AECOM Australia Pty Ltd (AECOM), on behalf of Ensham Resources Pty Ltd (Ensham), to assess the potential impacts of the proposed Ensham Life of Mine Extension Project (the Project) on surface water values, in support of the Environmental Impact Statement (EIS) for the Project.

1.1 PROJECT CONTEXT

Ensham Mine is an existing open-cut and underground bord and pillar coal mine located approximately 35 kilometres (km) east of Emerald in Queensland. The Project proposes to increase the life of the existing underground operations by extending the underground bord and pillar mine into an area identified as the Project Area (zones 1, 2, and 3) commencing from within Mining Lease (ML) 7459, ML 70326, ML 70365, and ML 70366 to an area west of ML 70365 within part of Mineral Development Licence (MDL 217) (Figure 1). The Project will produce up to approximately 4.5 million tonnes per annum and would extend the Ensham Life of Mine (LOM) by up to nine years to approximately 2037. The extension of the underground operation using existing infrastructure means that no surface construction or surface disturbance will be required to facilitate the Project.

1.2 PURPOSE OF REPORT

The objectives of this report are to:

- document the baseline water quality data for surface water resources within and downstream of the Project Area
- determine applicable environmental values (EVs) and water quality objectives (WQOs) for comparison to baseline water quality data
- assess the potential impacts to water quality and hence EVs as a result of the Project.

1.3 PROJECT DESCRIPTION

The Project proposes to extend the existing Ensham Mine underground operations into a portion of MDL 217 and existing ML areas. The activities associated with the Project that are covered by the existing approved operation are:

- further infill drilling activities (post ML approval)
- transfer of coal from the Project Area via the existing underground portal in C pit to the existing run-of-mine (ROM) stockpile using existing overland conveyors and haul roads
- reclaiming ROM coal by loaders and transporting by road trains, as per the current arrangements, to the existing crushing plant
- wastewater and sewage treatment using existing infrastructure
- ventilation supplied to the underground workings via the existing ventilation fans and associated infrastructure
- use of the existing rail loop and spur to transport product coal via the Blackwater rail corridor to the Port of Gladstone for export.

The Project will share facilities and infrastructure with the existing operations. It will further allow the Project the operational flexibility to use:

- an integrated water management system for the existing mine and the Project
- the existing portals for mine access which will limit the environmental impacts, costs, time and risks involved with construction of new portals

- the existing Mine Infrastructure Area (MIA) including the Coal Handling Plant (CHP) and other associated infrastructure that is located within the existing MLs.

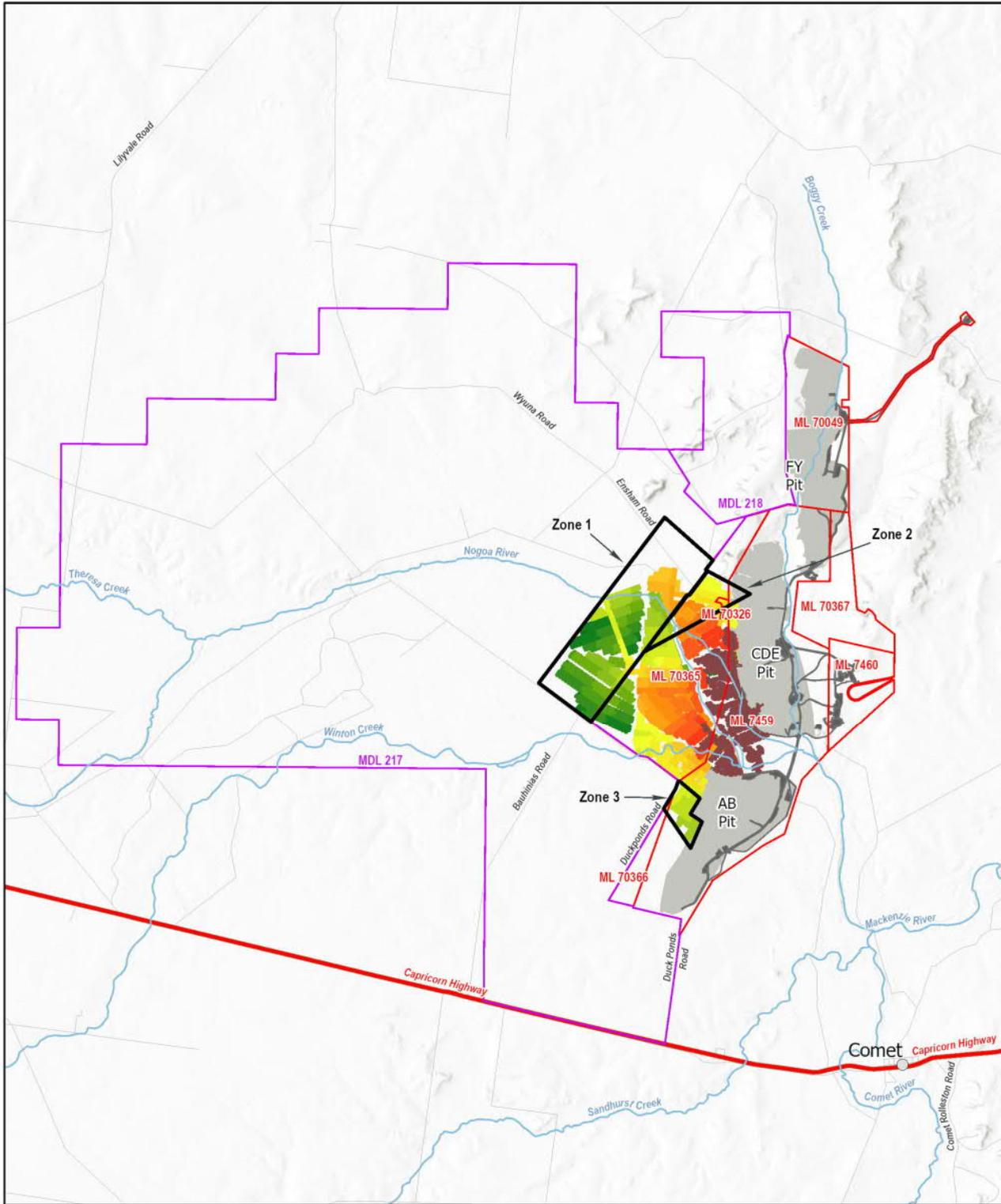


Figure 5



Legend

- Project Area
- Mining leases
- Mineral development licence
- Pit
- Mine Infrastructure footprint
- Existing mined areas

MINE PLAN - JAN 2020		Year
	2019	
	2020	
	2021	
	2022	
	2023	
	2024	
	2025	
	2026	
	2027	
	2028	
	2029	
	2030	
	2031	
	2032	
	2033	
	2034	
	2035	
	2036	
	2037	

Ensham Life of Mine Extension Project

Projection: GDA 1994 MGA Zone 55 Scale: 1:215,000
 Source: State of Queensland, 2019. ESRI Online data, 2020.
 Indemitsu RFI, 2020

Figure 1 Existing Operations and Extension Project Layout

The proposed mining sequence is based on the extension of the existing operation workings in both a northern and western direction. The conceptual mine sequence will commence in approximately 2021 to access the northern part of the proposed Project Area, targeting the thicker seam (AC) initially. The area south of the Nogoia River would be accessed in approximately 2024 with mining continuing in a western direction. In 2026, the south western part of the Project Area will be accessed to mine the AC and C seams.

Underground mining for the Project will occur at a depth of approximately 120 metres (m) to 210 m below the surface; however mining under the Nogoia River would occur at a range of 120 m to 190 m below the surface. As stated in the Project Subsidence Assessment (Gordon Geotechniques, 2020) subsidence is predicted to be typically less than 40 millimetres (mm) in the Project Area.

2.0 ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES

2.1 RELEVANT LEGISLATION

2.1.1 *Environmental Protection Act 1994*

The *Environmental Protection Act 1994* (Qld) (EP Act) lists obligations and duties to prevent environmental harm, nuisances and contamination. Section 9 of the EP Act defines environmental value as:

- a) *a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or*
- b) *another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.*

2.1.2 *Environmental Protection Regulation 2019*

The Environmental Protection Regulation 2019 (EP Regulation) prescribes the detail for processes contained in the EP Act. The EP Regulation provides detail on the EIS process, Environmentally Relevant Activities (ERAs) and regulatory requirements as well as information on management and offences.

2.1.3 *Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EP Water and Wetland Biodiversity)*

The purpose of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EP Water and Wetland Biodiversity) is to achieve the object of the EP Act in relation to waters and wetlands by:

- identifying environmental values for waters and wetlands
- identifying management goals for waters
- stating water quality guidelines and water quality objectives to enhance or protect the environmental values
- providing a framework for making consistent, equitable and informed decisions about waters
- monitoring and reporting on the condition of waters.

Section 8 of the EP Water and Wetland Biodiversity Policy states:

For particular water, the indicators and water quality guidelines for an environmental value are—

(a) decided using the following documents —

(i) site-specific documents for the water;

(ii) the document called ‘Queensland water quality guidelines 2009’, published on the department’s website;

(iii) the document called ‘Australian and New Zealand guidelines for fresh and marine water quality’, published in October 2018;

(iv) the document called ‘Australian drinking water guidelines, paper 6, national water quality management strategy’, dated 2011 and published on the National Health and Medical Research Council’s website;

(v) the document called ‘Guidelines for managing risks in recreational waters’, dated 2008 and published on the National Health and Medical Research Council’s website;

(vi) other relevant documents published by a recognised entity; or

(b) for water mentioned in schedule 1, column 1—the indicators stated in the document opposite the water in schedule 1, column 2.

Schedule 1 of the EP Water and Wetland Biodiversity Policy provides reference to the Nogoia River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011a) and the Mackenzie River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011b) both of which are deemed relevant to the Project.

2.2 PUBLISHED ENVIRONMENTAL VALUES

Table 1 of the Nogoia River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011a) provides environmental values for waters within the basin. The existing mine is located in both the Lower Nogoia main channel waters and the Lower Nogoia and Theresa Creek tributaries waters. The Project zones (Figure 1) are located wholly within the Lower Nogoia main channel waters.

Table 1 of the Mackenzie River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011b) provides environmental values for waters within the basin. The receiving environment for both the existing mine and the Project is within the Mackenzie main channel waters.

The Lower Nogoia main channel waters and the Mackenzie main channel waters are identified as having all the environmental values listed below while the Lower Nogoia and Theresa Creek tributaries waters are identified as having all except aquaculture:

- aquatic ecosystems
- irrigation
- farm supply/use
- stock water
- aquaculture
- human consumer
- primary recreation
- secondary recreation
- visual recreation
- drinking water
- industrial use
- cultural and spiritual values.

2.3 WATER QUALITY OBJECTIVES AND DEFAULT GUIDELINE VALUES

WQOs are defined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (www.waterquality.gov.au/anz-guidelines), herein referred to as the Guidelines, as the:

“...guideline value or narrative statement for each selected indicator that should ensure the protection of all identified community values. Where there are multiple environmental (community) values it is recommended that the most stringent guideline value be chosen to ensure that all community values are protected”

The Guidelines recommend that site specific trigger values (SSTVs) be adopted in preference to the default guideline values where warranted. The Guidelines recommend that SSTVs should be based on at least two years of monthly monitoring data from an appropriate site; for example, upstream of impacted areas, or from appropriate local reference systems that are representative of unimpacted water bodies. Derivation of SSTVs was not possible for any of the surface water quality monitoring sites in this analysis due to the lack of an appropriate reference site or sites.

WQOs of relevance to the Project are summarised in Table 1:

Table 1 Adopted water quality objectives

Constituent	Environmental Value	WQO
Electrical conductivity (EC)	Aquatic ecosystems	Lower Nogoia: <340 $\mu\text{S}^*/\text{cm}^{**}$ (baseflow) [∞] Theresa Creek: <720 $\mu\text{S}/\text{cm}$ (baseflow) [∞] Mackenzie River: <310 $\mu\text{S}/\text{cm}$ (baseflow) [∞]
Total dissolved solids (TDS)	Recreation	<1,000 $\text{mg}^\dagger/\text{L}^\ddagger$
pH	Aquatic ecosystems (tropical aquaculture)	6.8-8.5
Suspended solids	Aquatic ecosystems	<10 mg/L
Turbidity	Aquatic ecosystems	<50 NTU
Total nitrogen	Aquatic ecosystems	Lower Nogoia and Theresa Creek: <500 $\mu\text{g}^\wedge/\text{L}$ Mackenzie River: <775 $\mu\text{g}/\text{L}$
Total phosphorus	Aquatic ecosystems	Lower Nogoia and Theresa Creek: <50 $\mu\text{g}/\text{L}$ Mackenzie River: <160 $\mu\text{g}/\text{L}$
Sulphate as SO_4	Aquatic ecosystems	Lower Nogoia and Theresa Creek: <25 mg/L Mackenzie River: <10 mg/L
Hardness	Aquatic ecosystems (tropical aquaculture)	20-450 mg/L
Alkalinity	Aquatic ecosystems (tropical aquaculture)	20-400 mg/L
Iron	Aquatic ecosystems (tropical aquaculture)	<0.01 mg/L
Manganese	Aquatic ecosystems (tropical aquaculture)	<0.01 mg/L
Aluminium	Aquatic ecosystems	<0.03 mg/L
Chromium	Aquatic ecosystems	<0.001 mg/L
Copper	Aquatic ecosystems	<0.0014 mg/L
Nickel	Aquatic ecosystems	<0.01 mg/L
Zinc	Aquatic ecosystems	<0.008 mg/L

[∞] Comparison has been made against the baseflow EC (higher number – refer Table 1) because the flow regime at the time of sampling was unknown and the definition of high flow is unknown.

* microsiemens

** centimetre

† milligrams

‡ litre

^ micrograms

WQOs have been sourced for the Lower Nogoia, Theresa Creek and Mackenzie River catchments for each of the relevant water quality monitoring sites as summarised in Table 2.

Table 2 Water quality monitoring sites and source of water quality objective

Catchment	Source of water quality objectives	Relevant water quality monitoring sites
Lower Nogoia main channel Lower Nogoia and Theresa Creek tributaries	Nogoia River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011a)	ENMP01, ENMP02, ENMP03, ENMP04, ENMP04R09, ENMP05, WQ 130219A, Corkscrew Creek Access, Corkscrew Creek Duckpond, RP1, RP2, Boggy Ck X1, Boggy Ck X2, Boggy Ck X3, Boggy Ck X4, Boggy Ck X5, Boggy Ck X6, Boggy Ck Yongala Access Rd, Boggy Ck Diversion S, Boggy Ck Upstream, ENBCR81
Theresa Creek main channel	Nogoia River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011a)	WQ 130206A
Mackenzie main channel	Mackenzie River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011b)	ENMP06, WQ 130113A, ENBW

The most stringent WQOs for all physico-chemical constituents have been identified and used for comparative benchmarking of baseline data. As noted in the Nogoia River Sub-basin Environmental Values and Water Quality Objectives document (DEHP, 2011a), the median water quality value of a number of independent samples (preferably five or more) at a particular monitoring site should be compared to the WQO. For toxicant test data (i.e. aluminium, arsenic, boron, cadmium, chromium, cobalt, copper, manganese, mercury, molybdenum, nickel, selenium, silver, uranium, vanadium and zinc) Australian and New Zealand Governments (ANZG, 2018) guidelines recommend that action is triggered if the 95th percentile exceeds the WQO. ANZG (2018) guidelines also suggest a minimum of 40 samples are required to calculate the 95th percentile from a data set hence this statistic is only calculated where sufficient samples are available. Relevant statistics for all baseline data and associated WQOs are given in Appendix A, while a summary of key constituents is provided in Section 3.

The WQOs do not distinguish between “total” and “dissolved” samples both of which are common methods to express the results of analysis of metal constituents. From an aquatic ecology perspective, the total result can be considered an upper limit on the concentration of metals which can be compared with benchmark values while the dissolved result can be considered as being more representative of the bio-available fraction in the water. For this reason, both the total and dissolved samples have been included in this analysis.

3.0 SUMMARY OF BASELINE SURFACE WATER QUALITY

Surface water quality data comprises results of chemical and physical analysis of water samples collected at defined surface water quality monitoring sites. For the purposes of this assessment, baseline water quality is the quality characteristics of surface water within the Project Area and nearby areas upstream and downstream.

Surface water quality monitoring sites have been categorised according to their purpose and location as follows:

1. Upstream sites: located upstream of the Project Area (i.e. where surface water quality is not impacted by the Project)
2. Downstream sites: located downstream of the Project Area and activity where water may have been affected by site activities and disturbances
3. Mine area sites: located within the existing Mining Leases or Project Area. These sites have been further categorized according to purpose as follows:
 - Catchment runoff from areas undisturbed by mining or mining-related activity
 - Release water
 - Catchment runoff from areas disturbed by mining or mining-related activity.

The locations of surface water quality monitoring sites, divided into the categories above, are shown on Figure 2 and summarised in Table 3. The sites with a “WQ” prefix are Department of Natural Resources, Mines and Energy (DNRME) gauging stations and data has been taken from the DNRME water monitoring information portal (Qld Government, 2020). Note that for the three stream gauging stations in this analysis, both grab sample water quality data and continuously recorded electrical conductivity (EC) data has been analysed. The remaining sites are monitored by Ensham.

3.1 APPROACH TO BASELINE SURFACE WATER QUALITY ANALYSIS

The surface water quality baseline data set has been analysed by calculation of the following results and statistics: median, minimum, maximum, 20th percentile, 80th percentile, 95th percentile and number of samples. Some monitoring sites have a small number of samples available for analysis. For sites where there were less than five samples available, only the minimum and maximum statistics have been presented. For sites where there were between five and 10 samples available, the median, minimum and maximum statistics have been presented. For sites where there were more than 10 results available, the median, 20th percentile and 80th percentile have been presented. In addition, for sites with more than 40 results available, the 95th percentile (for toxicants only) has also been presented.

In many instances results of analyses are reported as below a laboratory limit of detection (LOD). In these instances, the sample has been assumed to be numerically equal to the LOD for the purpose of calculating statistics. This is considered to be a conservative assumption for baseline water quality analyses. At monitoring sites where a large proportion of (or all) results are below the LOD, the subsequent statistics can be misleading and comment has been provided for sites where this is applicable.

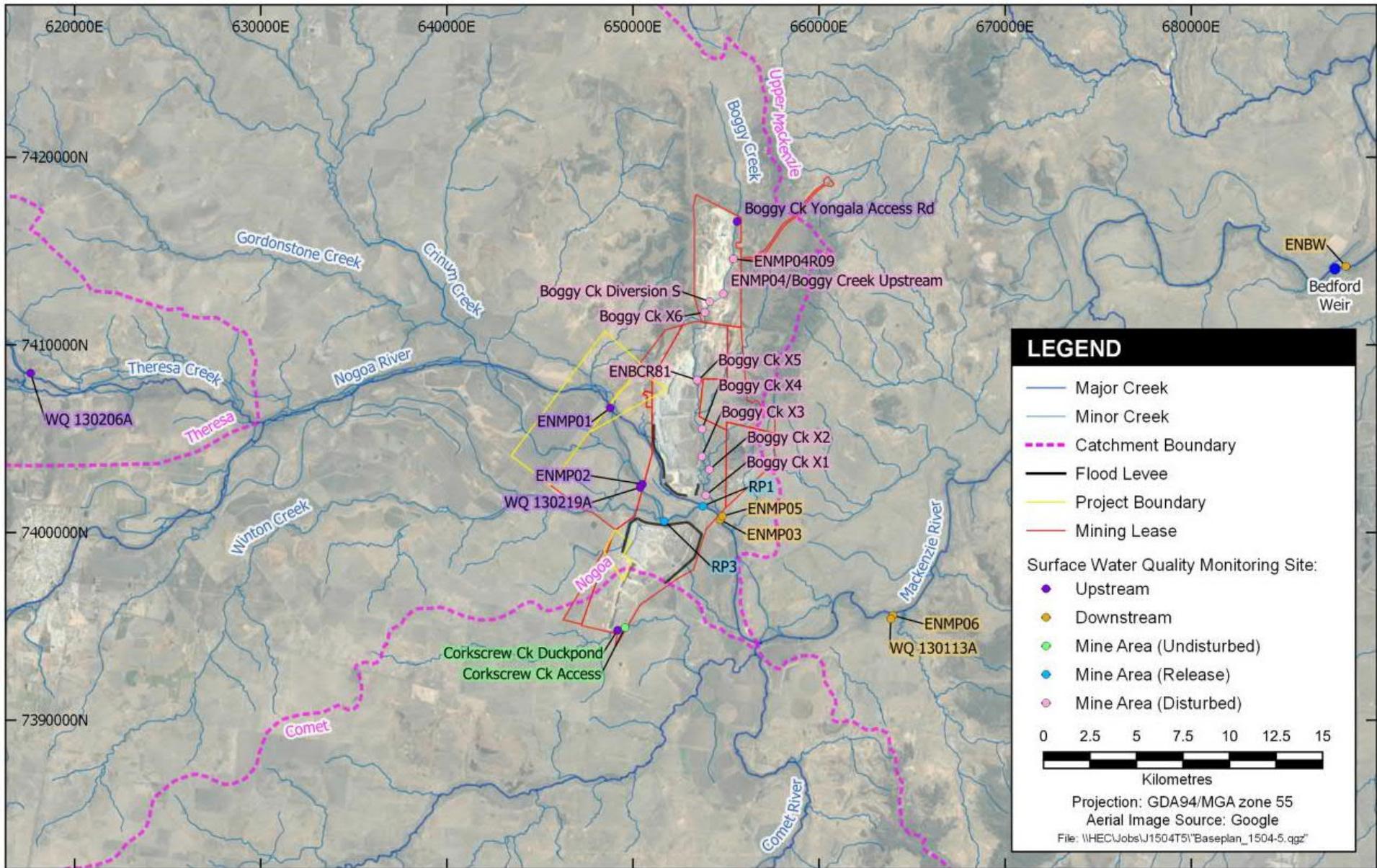


Figure 2 Location of surface water quality monitoring sites

Table 3 Summary of surface water quality monitoring sites

Category	Site	Location Description	Baseline Data Period
Upstream	Boggy Ck Yongala Access Rd	Boggy Creek crossing at Yongala Access Road	December 1991 to November 2018
	ENMP01	Nogoa River upstream of mine at western boundary of ML 70365	May 2011 to December 2012
	ENMP02	Nogoa River upstream of mine at eastern boundary of ML 70365 or western boundary of ML 7459 (EA site MP02)	February 2008 to April 2020
	WQ 130206A	Theresa Creek at Gregory Highway gauging station	December 1964 to August 2019*
	WQ 130219A	Nogoa River at Duckponds gauging station (same location as EA site MP02)	February 1993 to December 2019**
Downstream	ENMP03	Nogoa River downstream of mine at eastern boundary of ML 7459	January 2012 to December 2012
	ENMP05	Nogoa River downstream of mine at eastern boundary of ML 7459	February 2001 to April 2020
	ENMP06	Mackenzie River at Mike McArthur Bridge	January 2008 to April 2020
	WQ 130113A	Mackenzie River at Rileys Crossing gauging station	July 2008 to December 2019†
	ENBW	Bedford Weir	February 2012 to 30 March 2012
Mine area: Undisturbed	Corkscrew Creek Access	Corkscrew Creek at access road crossing	June 2008 to January 2009
	Corkscrew Creek Duckpond	Corkscrew Creek upstream of mine site	May 2008 to August 2009
Mine area: Release	RP1	Release Point 1 on the Nogoa River	December 2014 to January 2020
	RP2	Release Point 2 on Boggy Creek located at Ramp 8 Yongala Pit	No releases
	RP3	Release Point 3 on the Nogoa River	No releases to date
Mine area: Disturbed	ENMP04	Boggy Creek at Ramp 8 crossing	July 2012
	ENMP04R09	Boggy Creek at Ramp 9 crossing	February 2018
	Boggy Ck X1	Boggy Creek at Crossing 1	October 2005 to February 2018
	Boggy Ck X2	Boggy Creek at Crossing 2	June 2007 to February 2018
	Boggy Ck X3	Boggy Creek at Crossing 3	February 2018
	Boggy Ck X4	Boggy Creek at Crossing 4	February 2018
	Boggy Ck X5	Boggy Creek at Crossing 5 (same location as ENBCR81)	December 2006 to February 2018
	Boggy Ck X6	Boggy Creek at Crossing 6	February 2018
	Boggy Ck Diversion S	Southern end of the Boggy Creek diversion	December 2006 to January 2010
	Boggy Creek Upstream	Continuous data (10 minute interval for EC, turbidity and pH)	December 2014 to March 2019
	ENBCR81	Boggy Creek at Ramp 81 (same location as Boggy Ck X5)	July 2006 to January 2013

* Reliable continuous EC data available from March 2008 to January 2014.

** Reliable continuous EC data available from June 2006 to July 2019.

† Reliable continuous EC data available from November 2009 to January 2015.

Results have also been grouped into the following five water quality categories:

- General and physical indicators: Field EC, TDS, field pH, suspended solids and field turbidity
- Major nutrients: nitrogen and phosphorous species
- Sulphate, hardness and alkalinity
- Common metals: iron, manganese and aluminium (i.e. normally prevalent in natural surface waters)
- Trace metals: chromium, copper, nickel, zinc (i.e. normally found in low concentrations in natural surface waters).

Tabulated summaries of the baseline water quality data are given in Appendix A and an assessment of baseline water quality for each category is provided in Sections 3.2 to 3.6.

For the continuously recorded EC data, the data was filtered to analyse only data with a 'fair' quality code¹ or better and average daily data analysed (data is available at intervals of 1 hour). The continuous data was analysed separately to the grab sample data because the latter data points are usually well spaced in time and therefore represent data from independent 'events' whereas the continuous recorded EC on a given day will on most days be related to the EC on the day before.

3.2 UPSTREAM SITES

3.2.1 General and physical indicators

A summary of the general and physical indicators for upstream sites is presented in Table 4, while data for EC is summarised in Table 5, with continuous records for the gauging stations considered separately from grab sample data.

The median field and laboratory EC values at ENMP01 (619 and 476 $\mu\text{S}/\text{cm}$) exceed the WQO (340 $\mu\text{S}/\text{cm}$), however the median values for the other two Nogoia River upstream sites are below the relevant WQO. The EC WQO is higher for the Theresa Creek site (720 $\mu\text{S}/\text{cm}$) and the median field EC statistics fall below this. The median continuously recorded EC data for the two gauging stations is more than 40% higher than the grab sample data. This likely reflects the greater prevalence of baseflow/low flow data in the continuous data set and the likely effect of regulated releases from Fairbairn Dam. The relationship between continuous recorded EC and flow rate at WQ 130219A (Nogoia River) is plotted in Figure 3. This indicates low EC values at high flows (due to dilution effects), however there is a wide range of EC values at low to moderate flows.

Recorded TDS values were available at three of the five upstream sites and all three calculated median statistics are below the TDS WQO of 1,000 mg/L.

The pH results at upstream sites indicate waters are typically slightly alkaline with median pH (for the sites with adequate data to calculate a median) of between 7.7 and 8.1 which is within the WQO range (6.8 – 8.5).

Sufficient recorded suspended solids concentrations were available at all five upstream sites in order to calculate a median value and all five median values are above the suspended solids WQO of 10 mg/L.

Sufficient data were available at three of the five upstream sites to calculate the median field measured turbidity values, while there were sufficient laboratory turbidity data at four sites to

¹ Numerical quality codes are assigned to each recorded data point in the record, with higher values corresponding to poorer quality. A 'fair' quality code corresponds to a value of 20, so only data with a quality code of 20 or less was analysed.

calculate the median. For both, only the median at ENMP02 is above the WQO (50 NTU). At Boggy Ck Yongala Access Rd all four laboratory turbidity results were above the WQO.

Table 4 General and physical water quality indicators – upstream sites

Constituent	WQO	Statistic	ENMP01	ENMP02	WQ 130206A	WQ 130219A	Boggy Ck Yongala Access Rd
TDS (mg/L)	<1,000	Median	-	338	227	172	-
		Minimum	-	-	-	-	-
		Maximum	-	-	-	-	-
		20 th percentile	-	120	148	138	-
		80 th percentile	-	656	386	405	-
		No. samples	-	57	112	79	-
Field pH	6.8 - 8.5	Median	-	7.8	8.0	8.0	-
		Minimum	-	-	-	-	7.2
		Maximum	-	-	-	-	7.2
		20 th percentile	-	7.5	7.5	7.7	-
		80 th percentile	-	8.0	8.4	8.2	-
		No. samples	-	626	43	70	1
Lab pH	6.8 - 8.5	Median	7.9	7.8	7.9	8.1	-
		Minimum	-	-	-	-	6.3
		Maximum	-	-	-	-	7.2
		20 th percentile	7.8	7.6	7.5	7.9	-
		80 th percentile	8.1	8.1	8.3	8.3	-
		No. samples	11	439	113	79	4
Suspended solids (mg/L)	<10	Median	33	74	37	25	5,855
		Minimum	-	-	-	-	138
		Maximum	-	-	-	-	8,090
		20 th percentile	18	28	16	10	-
		80 th percentile	58	208	131	103	-
		No. samples	12	452	104	78	8
Field turbidity (NTU)	<50	Median	-	274	41	33	-
		Minimum	-	-	-	-	-
		Maximum	-	-	-	-	-
		20 th percentile	-	202	16	15	-
		80 th percentile	-	369	309	139	-
		No. samples	-	189	36	65	-
Lab turbidity (NTU)	<50	Median	33	146	37	23	-
		Minimum	-	-	-	-	319
		Maximum	-	-	-	-	2,250
		20 th percentile	11	17	10	10	-
		80 th percentile	72	1,186	100	126	-
		No. samples	11	135	90	79	4

Key:

	Less than 5 samples
	At least 5 samples, less than 10 samples
	Median exceeds WQO

Table 5 Electrical conductivity – upstream sites

Constituent	WQO	Statistic	ENMP01	ENMP02	WQ 130206A (grab samples)	WQ 130219A (grab samples)	WQ 130206A (daily data)	WQ 130219A (daily data)	Boggy Ck Yongala Access Rd
Field EC ($\mu\text{S}/\text{cm}$)	<340 WQ 130206A	Median	619	205	462	334	668	472	-
		Minimum	351	-	-	-	-	-	324
		Maximum	855	-	-	-	-	-	324
		20 th percentile	-	178	207	232	436	284	-
		80 th percentile	-	298	712	772	973	898	-
		No. samples	6	685	60	72	1423	2787	1
Lab EC ($\mu\text{S}/\text{cm}$)	<340 WQ 130206A	Median	476	205	407	328	-	-	-
		Minimum	-	-	-	-	-	-	43
		Maximum	-	-	-	-	-	-	160
		20 th percentile	368	155	245	245	-	-	-
		80 th percentile	779	332	664	756	-	-	-
		No. samples	11	439	113	79	-	-	4

Key:

	Less than 5 samples
	At least 5 samples, less than 10 samples
	Median exceeds WQO

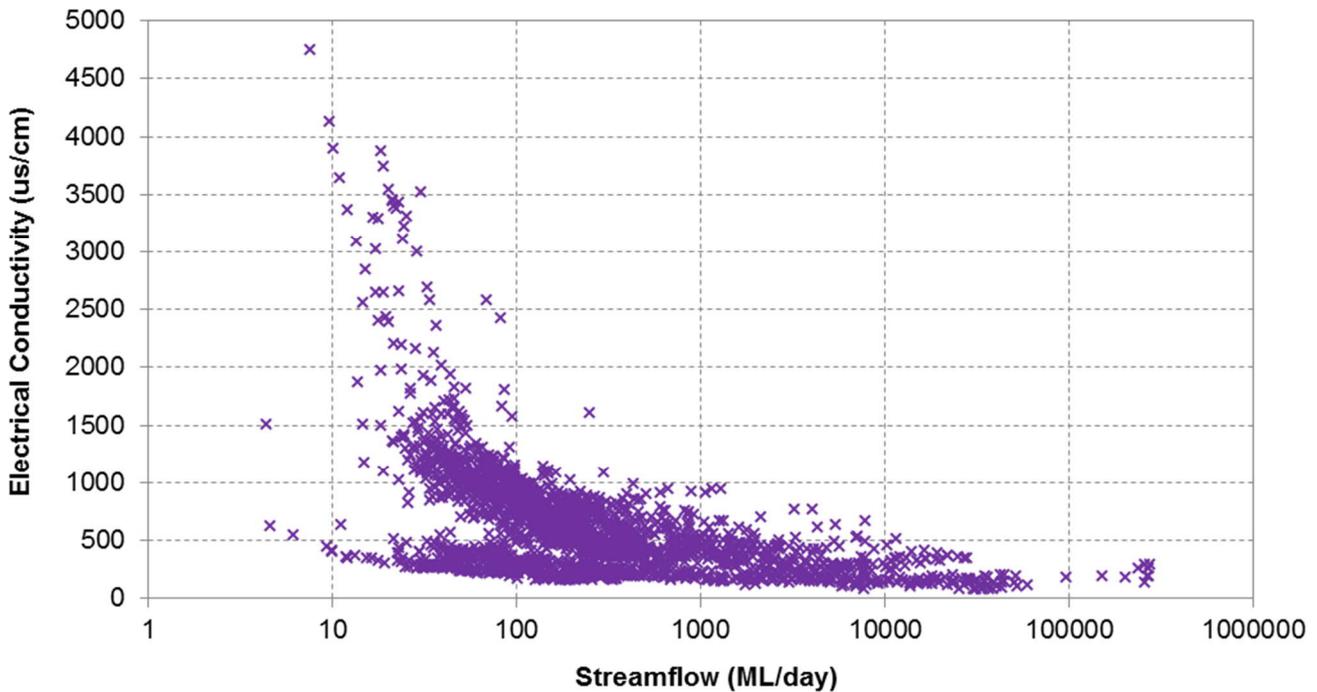


Figure 3 Recorded electrical conductivity and flow rate – Nogoia River at GS130219A

3.2.2 Major nutrients

A summary of the major nutrient data for upstream sites is presented in Table 6. No data were available for ENMP01 or Boggy Ck X1 sites.

Data in Table 6 show that major nutrient concentrations recorded at upstream sites are elevated relative to the WQOs. Sufficient total nitrogen data were available at two of the four upstream sites to calculate median total nitrogen statistics of 800 µg/L and 550 µg/L (for ENMP02 and WQ 130219A respectively) both of which are above the WQO (500 µg/L). Sufficient total phosphorus data were available at two of the four upstream sites to calculate median total phosphorus statistics of 120 µg/L and 140 µg/L (for WQO 130206A and WQ 130219A respectively) both of which are above the WQO (50 µg/L).

Table 6 Major nutrients – upstream sites

Constituent	WQO	Statistic	ENMP02	WQ 130206A	WQ 130219A	Boggy Ck Yongala Access Rd
Total nitrogen (µg/L)	<500	Median	800	-	550	-
		Minimum	-	-	-	4,300
		Maximum	-	-	-	4,300
		20 th percentile	600	-	418	-
		80 th percentile	1,260	-	692	-
		No. samples	33	-	63	1
Total phosphorus (µg/L)	<50	Median	-	120	140	-
		Minimum	580	-	-	-
		Maximum	580	-	-	-
		20 th percentile	-	50	54	-
		80 th percentile	-	315	204	-
		No. samples	1	51	74	-

Key:

Less than 5 samples

Median exceeds WQO

3.2.3 Sulphate, hardness and alkalinity

A summary of sulphate, hardness and alkalinity data for upstream sites is presented in Table 7.

Table 7 Sulphate, hardness and alkalinity – upstream sites

Constituent	WQO	Statistic	ENMP01	ENMP02	WQ 130206A	WQ 130219A	Boggy Ck Yongala Access Rd
Sulphate as SO ₄ (mg/L)	<25	Median	11	11	-	5.4	-
		Minimum	-	-	-	-	1.0
		Maximum	-	-	-	-	4.0
		20 th percentile	4.6	5.0	-	3.0	-
		80 th percentile	18	29	-	21	-
		No. samples	12	146	-	79	2
Hardness (mg/L)	20 - 450	Median	-	149	120	100	-
		20 th percentile	-	84	77	78	-
		80 th percentile	-	227	190	181	-
		No. samples	-	43	113	79	-
Alkalinity (mg/L)	20 - 400	Median	-	99	142	120	-
		20 th percentile	-	79	90	100	-
		80 th percentile	-	175	208	164	-
		No. samples	-	70	113	79	-

Sufficient recorded sulphate values were available at three of the five upstream sites to calculate a median and the value is below the WQO (25 mg/L) at all three sites. Recorded hardness values were also available at three of the five upstream sites where the median statistic is within the WQO range (20-450 mg/L) at all three. Sufficient alkalinity data were available at three of the five upstream sites to calculate median alkalinity statistics of 99 mg/L, 142 mg/L and 120 mg/L (for ENMP02, WQO 130206A and WQ 130219A respectively), with all three within the WQO range (20-400 mg/L).

3.2.4 Common metals

A summary of the data for common metals from upstream sites is presented in Table 8. No data were available for Boggy Ck X1.

Iron concentrations (both total and dissolved) are elevated relative the WQO (0.01 mg/L), however for ENMP01 and ENMP02, it is important to note that the minimum reported values are at LOD (0.025 mg/L) which exceeds the WQO. Recorded total iron concentrations were available at all four upstream sites and all four calculated median statistics are above the iron WQO of 0.01 mg/L. Recorded dissolved iron concentrations are available at all four upstream sites and three of the four calculated median statistics are above the iron WQO of 0.01 mg/L.

The median statistic calculated for total manganese exceeds the WQO (0.01 mg/L) at all four upstream sites. Sufficient samples to calculate the 95th percentile statistic (i.e. >40) were only available at ENMP02 and this exceeds the WQO. For dissolved manganese, sufficient data were available at three of the upstream sites to calculate the 95th percentile, each of which exceeds the WQO. However, for dissolved manganese values at WQ 130206A and WQ 130219A it is important to note that there are multiple LODs, some of which exceed the WQO. At ENMP01, where only 12 samples were available, the median statistic exceeds the WQO.

Table 8 Common metals – upstream sites

Constituent	WQO	Statistic	ENMP01	ENMP02	WQ 130206A	WQ 130219A
Iron total (mg/L)	<0.01	Median	1.2	3.5	0.70	0.50
		Minimum	-	-	-	0.27
		Maximum	-	-	-	0.90
		20 th percentile	0.88	0.84	0.30	-
		80 th percentile	3.4	6.9	1.3	-
		No. samples	11*	209*	10	5
Iron dissolved (mg/L)	<0.01	Median	0.025	0.025	0.020	0.010
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.025	0.025	0.010	0.010
		80 th percentile	0.025	0.10	0.11	0.020
		No. samples	12*	168*	77	66
Manganese total (mg/L)	<0.01	Median	0.10	0.070	0.045	0.020
		Minimum	-	-	-	0.020
		Maximum	-	-	-	0.030
		20 th percentile	0.031	0.0005	0.030	-
		80 th percentile	0.15	0.12	0.11	-
		95 th percentile	-	0.56	-	-
No. samples	12	197	10	5		
Manganese dissolved (mg/L)	<0.01	Median	0.017	0.0050	0.010	0.010
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.0030	0.0050	0.010	0.010
		80 th percentile	0.076	0.021	0.020	0.030
		95 th percentile	-	0.059	0.042	0.030
No. samples	12	169	49**	63***		

* Minimum value is at LOD which is above the WQO

** There are multiple LODs for this data and one of them is above the WQO

*** There are multiple LODs for this data (0.01, 0.02 and 0.03 mg/L), some of which are above the WQO

Key:

	At least 5 samples, less than 10 samples
	Median exceeds WQO
	95 th percentile exceeds WQO

Table 8 Common metals – upstream sites (continued)

Constituent	WQO	Statistic	ENMP01	ENMP02	WQ 130206A	WQ 130219A
Aluminium total (mg/L)	<0.03	Median	1.4	3.7	-	-
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.75	0.78	-	-
		80 th percentile	3.0	6.5	-	-
		95 th percentile	-	21	-	-
		No. samples	12	118	-	-
Aluminium dissolved (mg/L)	<0.03	Median	0.0075	0.050	0.050	0.050
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.0050	0.010	0.050	0.050
		80 th percentile	0.020	0.22	0.084	0.050
		95 th percentile	-	0.34	0.29	0.12
		No. samples	12	173	54	69

Key:

	At least 5 samples, less than 10 samples
	Median exceeds WQO
	95 th percentile exceeds WQO

Aluminium concentrations (both total and dissolved) were elevated relative to the WQO (0.03 mg/L). For ENMP01 and ENMP02, where total aluminium samples are available, the calculated median statistic exceeded the WQO. For dissolved aluminium, sufficient data were available at three of the upstream sites to calculate the 95th percentile, each of which exceeds the WQO. The median statistic also exceeded the WQO at WQ 130206A and WQ 130219A. At ENMP01, where only 12 samples were available, the median statistic did not exceed the WQO.

3.2.5 Trace metals

A summary of the data for trace metals from upstream sites is presented in Table 9. No data were available for Boggy Ck X1.

The median statistic calculated for total chromium exceeds the WQO (0.001 mg/L) at three of the five upstream sites. Sufficient samples to calculate the 95th percentile statistic (i.e. >40) were only available at ENMP02 and this exceeded the WQO. For dissolved chromium, sufficient data were available at one of the upstream sites (ENMP02) to calculate the 95th percentile and this exceeds the WQO.

The median statistic calculated for total copper exceeds the WQO (0.0014 mg/L) at the four upstream sites for which data were available. Sufficient samples to calculate the 95th percentile statistic (i.e. >40) were available at ENMP02 and this exceeded the WQO. For dissolved copper, sufficient data were available at three of the upstream sites (ENMP02, WQ 130206A and WQ 130219A) to calculate the 95th percentile and all three sites exceed the WQO. The median at three of the upstream sites (ENMP01, WQ 130206A and WQ 130219A) exceeded the WQO. However, it is important to note that the minimum reported values for dissolved copper at WQ 130206A and WQ 130219A were at LOD (0.01 mg/L) which exceeds the WQO.

Table 9 Trace metals – upstream sites

Constituent	WQO	Statistic	ENMP01	ENMP02	WQ 130206A	WQ 130219A
Chromium total (mg/L)	<0.001	Median	0.0020	0.0023	0.0015	0.0010
		Minimum	-	-	-	0.0010
		Maximum	-	-	-	0.0020
		20 th percentile	0.0005	0.0010	0.0010	-
		80 th percentile	0.0038	0.014	0.0020	-
		95 th percentile	-	0.062	-	-
		No. samples	12	136	10	5
Chromium dissolved (mg/L)	<0.001	Median	0.0005	0.0005	-	-
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.0005	0.0005	-	-
		80 th percentile	0.0005	0.0005	-	-
		95 th percentile	-	0.011	-	-
		No. samples	12	168	-	-
Copper total (mg/L)	<0.0014	Median	0.0025	0.017	0.0030	0.0020
		Minimum	-	-	-	0.0010
		Maximum	-	-	-	0.0050
		20 th percentile	0.0008	0.0030	0.0020	-
		80 th percentile	0.0040	0.030	0.0042	-
		95 th percentile	-	0.060	-	-
		No. samples	12	217	10	5
Copper dissolved (mg/L)	<0.0014	Median	0.0020	0.0020	0.030	0.030
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.0010	0.0010	0.030	0.030
		80 th percentile	0.0020	0.0050	0.050	0.030
		95 th percentile	-	0.0050	0.063	0.050
		No. samples	12	174	56*	73*

Table 9 Trace metals – upstream sites (continued)

Constituent	WQO	Statistic	ENMP01	ENMP02	WQ 130206A	WQ 130219A
Nickel total (mg/L)	<0.01	Median	0.0040	0.0050	0.0050	0.0050
		Minimum	-	-	-	0.0050
		Maximum	-	-	-	0.0050
		20 th percentile	0.0020	0.0032	0.0050	-
		80 th percentile	0.0058	0.0060	0.0080	-
		95 th percentile	-	0.032	-	-
		No. samples	12	217	10	5
Nickel dissolved (mg/L)	<0.01	Median	0.0015	0.0030	-	-
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.0006	0.0020	-	-
		80 th percentile	0.0020	0.0050	-	-
		95 th percentile	-	0.0050	-	-
		No. samples	12	174	-	-
Zinc total (mg/L)	<0.008	Median	0.0080	0.030	0.010	0.010
		Minimum	-	-	-	0.010
		Maximum	-	-	-	0.010
		20 th percentile	0.0025	0.0025	0.010	-
		80 th percentile	0.014	0.050	0.010	-
		95 th percentile	-	0.11	-	-
		No. samples	12	216	10*	5*
Zinc dissolved (mg/L)	<0.008	Median	0.012	0.0050	0.010	0.010
		Minimum	-	-	-	-
		Maximum	-	-	-	-
		20 th percentile	0.0064	0.0025	0.010	0.010
		80 th percentile	0.017	0.0050	0.020	0.010
		95 th percentile	-	0.018	0.050	0.048
		No. samples	12	173	47*	66*

* Minimum value is at LOD which is above the WQO

Key:

	At least 5 samples, less than 10 samples
	Median exceeds WQO
	95th percentile exceeds WQO

Recorded nickel values (total and dissolved) were available at the four upstream sites for which data is available, where the median statistic is below the WQO (0.01 mg/L) at all four sites. Sufficient total nickel samples to calculate the 95th percentile statistic (i.e. >40) were available at ENMP02 and this exceeds the WQO. Sufficient dissolved nickel samples to calculate the 95th percentile statistic were available at ENMP02 and this did not exceed the WQO. Sufficient dissolved nickel samples to calculate the median were available at ENMP01 and this does not exceed the WQO.

Recorded total zinc values were available at the four upstream sites for which data is available, where the median statistic was below the WQO (0.008 mg/L) at two of the four sites. The median statistic for dissolved zinc exceeds the WQO at three of the four sites. Sufficient total zinc samples to

calculate the 95th percentile statistic (i.e. >40) were available at ENMP02 and this exceeds the WQO. Sufficient dissolved zinc samples to calculate the 95th percentile statistic were available at three of the four sites for which data is available (ENMP02, WQ 130206A and WQ 130219A) and exceeds the WQO at all three sites. However it is important to note that the minimum reported values for both total and dissolved zinc at WQ 130206A and WQ 130219A are at LOD (0.01 mg/L) which exceeds the WQO.

3.3 DOWNSTREAM SITES

3.3.1 *General and physical indicators*

A summary of the general and physical indicators for downstream sites is presented in Table 10 while data for EC is summarised in Table 5, with continuous records for the gauging station considered separately from grab sample data.

Recorded TDS values were available at three of the five downstream sites and all three calculated median statistics were below the TDS WQO of 1,000 mg/L.

The pH data at downstream sites indicate waters are typically slightly alkaline with median pH between 7.9 and 8.4 which is within the WQO range (6.8 – 8.5).

Recorded suspended solids concentrations were available at all of the five downstream sites and all sites' calculated median statistics were above the suspended solids WQO of 10 mg/L.

Sufficient data were available at two of the five downstream sites to calculate the median field measured turbidity and three of the five downstream sites to calculate the median laboratory turbidity. The median of both laboratory and field turbidity at ENMP05 exceeds the WQO (50 NTU).

The median EC values at ENMP03 and ENMP05 are below the WQO for the Nogoia River (340 µS/cm). The EC WQO is lower for the Mackenzie River sites (310 µS/cm) and the median EC values at ENMP06 and WQ 130113A exceed the WQO.

Table 10 General and physical water quality indicators – downstream sites

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
TDS (mg/L)	<1,000	Median	-	455	474	385	-
		Minimum	-	-	-	-	-
		Maximum	-	-	-	-	-
		20 th percentile	-	187	150	236	-
		80 th percentile	-	756	696	611	-
		No. samples	-	58	38	22	-
Field pH	6.8 - 8.5	Median	-	7.9	7.9	8.4	-
		Minimum	-	-	-	-	-
		Maximum	-	-	-	-	-
		20 th percentile	-	7.6	7.4	8.2	-
		80 th percentile	-	8.1	8.2	8.6	-
		No. samples	-	676	197	24	-
Lab pH	6.8 - 8.5	Median	8.0	7.9	8.0	8.3	7.9
		Minimum	-	-	-	-	7.6
		Maximum	-	-	-	-	8.1
		20 th percentile	7.7	7.6	7.7	8.1	-
		80 th percentile	8.1	8.1	8.3	8.5	-
		No. samples	10	602	132	22	5
Suspended Solids (mg/L)	<10	Median	95	64	56	17	159
		Minimum	-	-	-	-	97
		Maximum	-	-	-	-	624
		20 th percentile	52	24	10	7.0	-
		80 th percentile	178	260	448	26	-
		No. samples	10	707	126	22	5
Field turbidity (NTU)	<50	Median	-	207	-	18	-
		Minimum	-	-	7.2	-	-
		Maximum	-	-	38	-	-
		20 th percentile	-	148	-	11	-
		80 th percentile	-	282	-	27	-
		No. samples	-	139	2	22	-
Lab turbidity (NTU)	<50	Median	-	122	44	13	-
		Minimum	5.8	-	-	-	-
		Maximum	85	-	-	-	-
		20 th percentile	-	24	8	8	-
		80 th percentile	-	926	1,374	23	-
		No. samples	3	177	94	22	-

Key:

	Less than 5 samples
	At least 5 samples, less than 10 samples
	Median exceeds WQO

Table 11 Electrical conductivity – downstream sites

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	WQ 130113A (daily data)	ENBW
Field EC (µS/cm)	<340 ENMP03 ENMP05	Median	319	314	373	724	506	-
		Minimum	190	-	-	-	-	256
		Maximum	351	-	-	-	-	309
	<310 ENMP06 WQ 130113A ENBW	20 th percentile	-	196	237	419	283	-
		80 th percentile	-	855	914	1,204	877	-
		No. samples	8	850	198	24	1185	4
Lab EC (µS/cm)	<340 ENMP03 ENMP05	Median	308	280	351	725		274
		Minimum	-	-	-	-		185
		Maximum	-	-	-	-		317
	<310 ENMP06 WQ 130113A ENBW	20 th percentile	270	173	235	441		
		80 th percentile	381	686	822	1,142		
		No. samples	10	710	132	22		5

Key:

	Less than 5 samples
	At least 5 samples, less than 10 samples
	Median exceeds WQO

3.3.2 Major nutrients

A summary of the major nutrient data for downstream sites is presented in Table 12.

Table 12 Major nutrients – downstream sites

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
Total nitrogen (µg/L)	<500 ENMP03 ENMP05	Median	-	800	600	530	-
		Minimum	1,600	-	-	-	-
		Maximum	1,600	-	-	-	-
	<775 ENMP06 WQ 130113A ENBW	20 th percentile	-	500	400	380	-
		80 th percentile	-	1,440	1,520	640	-
		No. samples	1	30	28	21	-
Total phosphorus (µg/L)	<50 ENMP03 ENMP05	Median	-	-	-	107	-
		Minimum	700	-	-	-	-
		Maximum	700	-	-	-	-
	<160 ENMP06 WQ 130113A ENBW	20 th percentile	-	-	-	95	-
		80 th percentile	-	-	-	140	-
		No. samples	1	-	-	21	-

Key:

	Less than 5 samples
	Median exceeds WQO

Sufficient total nitrogen data was available at three of the five downstream sites to calculate median total nitrogen concentrations of 800 µg/L, 600 µg/L and 530 µg/L (for ENMP05, ENMP06 and WQ 130113A respectively) of which only ENMP05 exceeds the Nogoia River WQO (500 µg/L). Sufficient total phosphorus data was available at one of the five downstream sites to calculate a median total phosphorus concentration of 107 µg/L (for WQO 130113A) which is below the Mackenzie River WQO (160 µg/L).

3.3.3 Sulphate, hardness and alkalinity

A summary of sulphate, hardness and alkalinity data for downstream sites is presented in Table 13.

Recorded sulphate values were available at all five downstream sites where the median value is below the Nogoia River WQO (25 mg/L) at both ENMP03 and ENMP05 but above the Mackenzie River WQO (10 mg/L) at ENMP06 and WQ 130113A. Recorded hardness values were available at three of the five downstream sites where the median value is within the WQO range (20-450 mg/L) at all three sites. Sufficient alkalinity data were available at three of the five downstream sites (ENMP05, ENMP06 and WQ 130113A) to calculate median alkalinity statistics all three of which are within the WQO range (20-400 mg/L).

Table 13 Sulphate, hardness and alkalinity – downstream sites

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
Sulphate as SO ₄ (mg/L)	<25 ENMP03 ENMP05	Median	3.3	16	11	21	0.50
		Minimum	-	-	-	-	0.50
		Maximum	-	-	-	-	7.0
	<10 ENMP06 WQ 130113A ENBW	20 th percentile	0.50	5.0	4.0	11	-
		80 th percentile	9.0	114	25	36	-
		No. samples	10	253	124	22	5
Hardness (mg/L)	20 - 450	Median	-	153	163	172	-
		Minimum	-	-	-	-	-
		Maximum	-	-	-	-	-
		20 th percentile	-	96	76	113	-
		80 th percentile	-	223	229	249	-
		No. samples	-	40	38	22	-
Alkalinity (mg/L)	20 - 400	Median	-	314	373	160	-
		Minimum	72	-	-	-	-
		Maximum	72	-	-	-	-
		20 th percentile	-	196	237	125	-
		80 th percentile	-	855	914	196	-
		No. samples	1	850	198	22	-

Key:

	Less than 5 samples
	At least 5 samples, less than 10 samples
	Median exceeds WQO

3.3.4 Common metals

A summary of the data for common metals from downstream sites is presented in Table 14.

Table 14 Common metals – downstream sites

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
Iron total (mg/L)	<0.01	Median	3.8	3.3	2.5	-	5.6
		Minimum	-	-	-	-	0.12
		Maximum	-	-	-	-	16
		20 th percentile	2.7	0.79	0.41	-	-
		80 th percentile	9.4	6.3	7.1	-	-
		No. samples	10	210	145	-	5
Iron dissolved (mg/L)	<0.01	Median	0.060	0.025	0.025	0.010	0.11
		Minimum	-	-	-	-	0.025
		Maximum	-	-	-	-	0.26
		20 th percentile	0.025	0.025	0.025	0.010	-
		80 th percentile	0.14	0.10	0.13	0.010	-
		No. samples	10*	158	115*	22	5

* Minimum value is at LOD which is above the WQO

Table 14 Common metals – downstream sites (continued)

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
Manganese total (mg/L)	<0.01	Median	0.17	0.053	0.040	-	0.16
		Minimum	-	-	-	-	0.0020
		Maximum	-	-	-	-	0.37
		20 th percentile	0.091	0.0005	0.0005	-	-
		80 th percentile	0.20	0.10	0.11	-	-
		95 th percentile	-	0.55	0.82	-	-
		No. samples	10	199	145	-	5
Manganese dissolved (mg/L)	<0.01	Median	0.0040	0.0050	0.0050	0.010	0.0020
		Minimum	-	-	-	-	0.00050
		Maximum	-	-	-	-	0.039
		20 th percentile	0.0017	0.0050	0.0020	0.010	-
		80 th percentile	0.021	0.011	0.010	0.010	-
		95 th percentile	-	0.031	0.040	-	-
		No. samples	10	158	115	22	5
Aluminium total (mg/L)	<0.03	Median	-	3.5	2.8	-	4.9
		Minimum	-	-	-	-	0.090
		Maximum	-	-	-	-	18
		20 th percentile	-	1.4	0.60	-	-
		80 th percentile	-	5.7	5.9	-	-
		95 th percentile	-	16	23	-	-
		No. samples	-	130	98	-	5
Aluminium dissolved (mg/L)	<0.03	Median	0.035	0.080	0.030	0.050	0.060
		Minimum	-	-	-	-	0.010
		Maximum	-	-	-	-	0.29
		20 th percentile	0.020	0.0070	0.0050	0.050	-
		80 th percentile	0.11	0.20	0.22	0.050	-
		95 th percentile	-	0.35	0.47	-	-
		No. samples	10	158	115	22*	5

* Minimum value is at LOD which is above the WQO

Key:

	At least 5 samples, less than 10 samples
	Median exceeds WQO
	95th percentile exceeds WQO

Total and dissolved iron concentrations are elevated relative to the WQO (0.01 mg/L), however for dissolved iron at ENMP03, ENMP05 and ENMP06, it is important to note that the minimum reported values are at LOD (0.025 mg/L) which exceeds the WQO. Recorded total iron concentrations were available at four of the five downstream sites and all four median values are above the iron WQO of 0.01 mg/L. Recorded dissolved iron concentrations were available at all five downstream sites and four of the five calculated median values are above the iron WQO of 0.01 mg/L.

The median value for total manganese exceeds the WQO (0.01 mg/L) at all four downstream sites where data were available. Sufficient samples to calculate the 95th percentile (i.e. >40) were only available at ENMP05 and ENMP06 and both values exceed the WQO. Dissolved manganese values

were available at all five downstream sites where the median values were below the WQO (0.01 mg/L) at all five sites. For dissolved manganese, sufficient data were available at two of the downstream sites (ENMP05 and ENMP06) to calculate the 95th percentile, with both exceeding the WQO.

Aluminium concentrations (both total and dissolved) were elevated relative to the WQO (0.03 mg/L). For ENMP05, ENMP06 and ENBW, where total aluminium results are available, the median values exceed the WQO. Dissolved aluminium values were available at all five downstream sites where the median value exceeds the WQO (0.01 mg/L) at three of the five sites. Sufficient data were available at two of the downstream sites to calculate the 95th percentile, both of which exceed the WQO.

3.3.5 Trace metals

A summary of the data for trace metals from downstream sites is presented in Table 15.

Table 15 Trace metals – downstream sites

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
Chromium total (mg/L)	<0.001	Median	0.0040	0.0020	0.0010	-	0.0070
		Minimum	-	-	-	-	0.0005
		Maximum	-	-	-	-	0.029
		20 th percentile	0.0028	0.0005	0.0005	-	-
		80 th percentile	0.010	0.014	0.021	-	-
		95 th percentile	-	0.047	0.083	-	-
		No. samples	10	117	85	-	5
Chromium dissolved (mg/L)	<0.001	Median	0.0005	0.0005	0.0005	-	0.0005
		Minimum	-	-	-	-	0.0005
		Maximum	-	-	-	-	0.0005
		20 th percentile	0.00050	0.0005	0.0005	-	-
		80 th percentile	0.00050	0.0005	0.0005	-	-
		95 th percentile	-	0.0052	0.0036	-	-
		No. samples	10	158	115	-	5
Copper total (mg/L)	<0.0014	Median	0.0045	0.020	0.0070	-	0.0060
		Minimum	-	-	-	-	0.0020
		Maximum	-	-	-	-	0.016
		20 th percentile	0.0040	0.0030	0.0020	-	-
		80 th percentile	0.0076	0.030	0.030	-	-
		95 th percentile	-	0.050	0.050	-	-
		No. samples	10*	212	145	-	5*
Copper dissolved (mg/L)	<0.0014	Median	0.0020	0.0025	0.0020	0.030	0.0020
		Minimum	-	-	-	-	0.0010
		Maximum	-	-	-	-	0.0020
		20 th percentile	0.0018	0.0010	0.0010	0.030	-
		80 th percentile	0.0020	0.0050	0.0050	0.030	-
		95 th percentile	-	0.0050	0.0050	-	-
		No. samples	10	158	115	22*	5

* Minimum value is at LOD which is above the WQO

Key:

At least 5 samples, less than 10 samples

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
		Median exceeds WQO					
		95th percentile exceeds WQO					

Table 15 Trace metals – downstream sites (continued)

Constituent	WQO	Statistic	ENMP03	ENMP05	ENMP06	WQ 130113A	ENBW
Nickel total (mg/L)	<0.01	Median	0.0060	0.0050	0.0050	-	0.0090
		Minimum	-	-	-	-	0.0020
		Maximum	-	-	-	-	0.030
		20 th percentile	0.0048	0.0040	0.0030	-	-
		80 th percentile	0.012	0.0060	0.0080	-	-
		95 th percentile	-	0.032	0.068	-	-
		No. samples	10	212	144	-	5
Nickel dissolved (mg/L)	<0.01	Median	0.0020	0.0040	0.0020	-	0.0020
		Minimum	-	-	-	-	0.0020
		Maximum	-	-	-	-	0.0020
		20 th percentile	0.0018	0.0020	0.0020	-	-
		80 th percentile	0.0020	0.0050	0.0050	-	-
		95 th percentile	-	0.0050	0.0050	-	-
		No. samples	10	158	115	-	5
Zinc total (mg/L)	<0.008	Median	0.011	0.030	0.020	-	0.014
		Minimum	-	-	-	-	0.014
		Maximum	-	-	-	-	0.033
		20 th percentile	0.0074	0.0050	0.0025	-	-
		80 th percentile	0.023	0.058	0.048	-	-
		95 th percentile	-	0.092	0.090	-	-
		No. samples	10	212	145	-	5
Zinc dissolved (mg/L)	<0.008	Median	0.014	0.0050	0.0025	0.010	0.017
		Minimum	-	-	-	-	0.0025
		Maximum	-	-	-	-	0.022
		20 th percentile	0.0025	0.0025	0.0025	0.010	-
		80 th percentile	0.017	0.0050	0.0050	0.010	-
		95 th percentile	-	0.016	0.017	-	-
		No. samples	10	158	115	22*	5

* Minimum value is at LOD which is above the WQO

Key:

	At least 5 samples, less than 10 samples
	Median exceeds WQO
	95th percentile exceeds WQO

The median statistic calculated for total chromium exceeds the WQO (0.001 mg/L) at all four downstream sites for which data were available. Sufficient samples to calculate the 95th percentile statistic (i.e. >40) were available at ENMP05 and ENMP06 with both exceeding the WQO. For dissolved chromium, the median values at all four downstream sites for which data were available

are below the WQO. Sufficient data were available at two of the downstream sites (ENMP05 and ENMP06) to calculate the 95th percentile and both are below the WQO.

The median statistic calculated for total copper exceeded the WQO (0.001 mg/L) at all four downstream sites for which data were available. It is important to note that the minimum reported values for ENMP03 and ENBW are at LOD (0.002 mg/L) which exceeds the WQO. Sufficient samples to calculate the 95th percentile statistic (i.e. >40) were available at ENMP05 and ENMP06 with both exceeding the WQO. For dissolved copper, sufficient data were available to calculate the median statistic at all five downstream sites with all exceeding the WQO, however it is important to note that the minimum reported values for WQ 130113A are at LOD (0.030 mg/L) which exceeds the WQO. Sufficient data were available at two of the five downstream sites to calculate the 95th percentile and both exceed the WQO.

Recorded nickel values (total and dissolved) were available at four of the five downstream sites where the median values are below the WQO (0.01 mg/L) at all four sites. Sufficient total nickel samples to calculate the 95th percentile statistic (i.e. >40) were available at ENMP05 and ENMP06 both of which exceed the WQO. Sufficient dissolved nickel samples to calculate the 95th percentile statistic were available at ENMP05 and ENMP06 both of which do not exceed the WQO.

Recorded total zinc values were available at all four of the five downstream sites where the median values are below the WQO (0.008 mg/L) at two of the four sites. The median value for dissolved zinc was calculated at all five downstream sites and exceeds the WQO at three of the five sites. However, it is important to note that the minimum reported values for WQ 130113A are at the LOD (0.01 mg/L) which exceeds the WQO. Sufficient total and dissolved zinc samples to calculate the 95th percentile statistic (i.e. >40) were available at ENMP05 and ENMP06 both of which exceed the WQO (total and dissolved).

3.4 MINE AREA: UNDISTURBED SITES

3.4.1 General and physical indicators

A summary of the general and physical indicators for mine area undisturbed sites is presented in Table 16.

Table 16 General and physical water quality indicators – mine area undisturbed sites

Constituent	WQO	Statistic	Corkscrew Ck Access	Corkscrew Ck Duckpond
Field EC (µS/cm)	<340	Median	1,200	1,204
		Minimum	-	-
		Maximum	-	-
		20 th percentile	1,130	1,092
		80 th percentile	1,780	1,770
		No. samples	28	34
Lab EC (µS/cm)	<340	Median	1,160	-
		Minimum	-	-
		Maximum	-	-
		20 th percentile	1036	-
		80 th percentile	1912	-
		No. samples	49	-
TDS (mg/L)	<1,000	Median	-	-
		Minimum	1,200	-
		Maximum	1,200	-

Constituent	WQO	Statistic	Corkscrew Ck Access	Corkscrew Ck Duckpond
		20 th percentile	-	-
		80 th percentile	-	-
		No. samples	1	-

Table 16 General and physical water quality indicators – mine area undisturbed sites (continued)

Constituent	WQO	Statistic	Corkscrew Ck Access	Corkscrew Ck Duckpond
Field pH	6.8 - 8.5	Median	8.5	8.4
		Minimum	-	-
		Maximum	-	-
		20 th percentile	8.2	8.2
		80 th percentile	8.7	8.7
		No. samples	28	34
Lab pH	6.8 - 8.5	Median	8.4	-
		Minimum	-	-
		Maximum	-	-
		20 th percentile	8.2	-
		80 th percentile	8.7	-
		No. samples	49	-
Suspended solids (mg/L)	<10	Median	54	-
		Minimum	-	-
		Maximum	-	-
		20 th percentile	32	-
		80 th percentile	84	-
		No. samples	49	-
Field turbidity (NTU)	<50	Median	-	83
		Minimum	11	-
		Maximum	11	-
		20 th percentile	-	29
		80 th percentile	-	225
		No. samples	1	58
Lab turbidity (NTU)	<50	Median	-	-
		Minimum	5	-
		Maximum	5	-
		20 th percentile	-	-
		80 th percentile	-	-
		No. samples	1	-

Key:

	Less than 5 samples
	Median exceeds WQO

The median EC values at both mine area undisturbed sites exceed the WQO (340 µS/cm). A single recorded TDS value was available at the Corkscrew Creek Access site which exceeds the TDS WQO of 1,000 mg/L. Field pH results at mine area undisturbed sites indicate waters are typically slightly alkaline (median of 8.4 and 8.5) which is within the WQO range (6.8 – 8.5). Recorded suspended solids concentrations are available at the Corkscrew Creek Access site and the median value (54 mg/L) exceeds the suspended solids WQO of 10 mg/L. Sufficient data were available at the Corkscrew Creek Duckpond site to calculate the median field measured turbidity of 83 NTU which exceeds the WQO (50 NTU).

3.4.2 Major nutrients

A summary of the major nutrient data for mine area undisturbed sites is presented in Table 17.

Table 17 Major nutrients – mine area undisturbed sites

Constituent	WQO	Statistic	Corkscrew Ck Access
Total nitrogen (µg/L)	<500	Minimum	1,300
		Maximum	1,300
		No. samples	1
Total phosphorus (µg/L)	<50	Minimum	430
		Maximum	430
		No. samples	1

Key:

	Less than 5 samples
	Median exceeds WQO

Results from the single sample from the Corkscrew Creek Access site are elevated in both total nitrogen (1,300 µg/L) and total phosphorous (430 µg/L) compared to the WQOs of 500 µg/L and 50 µg/L respectively.

3.4.3 Sulphate, hardness and alkalinity

A summary of sulphate, hardness and alkalinity data for mine area undisturbed sites is presented in Table 18.

Results from a single sample from the Corkscrew Creek Access site are elevated in sulphate (318 mg/L) compared to the WQO (25 mg/L). The single sample for alkalinity (220 mg/L) is within the WQO limits (20-400 mg/L).

Table 18 Sulphate, hardness and alkalinity – mine area undisturbed sites

Constituent	WQO	Statistic	Corkscrew Ck Access
Sulphate as SO ₄ (mg/L)	<25	Minimum	318
		Maximum	318
		No. samples	1
Alkalinity (mg/L)	20 - 400	Minimum	220
		Maximum	220
		No. samples	1

Key:

	Less than 5 samples
	Median exceeds WQO

3.4.4 Common metals

A summary of the data for common metals from mine area undisturbed sites is presented in Table 19.

Table 19 Common metals – mine area undisturbed sites

Constituent	WQO	Statistic	Corkscrew Ck Access	Corkscrew Ck Duckpond
Iron total (mg/L)	<0.01	Median	0.76	1.2
		Minimum	-	-
		Maximum	-	-
		20 th percentile	0.26	0.54
		80 th percentile	2.9	3.4
		No. samples	13	10
Iron dissolved (mg/L)	<0.01	Median	-	-
		Minimum	0.080	0.080
		Maximum	0.090	0.080
		20 th percentile	-	-
		80 th percentile	-	-
		No. samples	2	1
Manganese total (mg/L)	<0.01	Median	0.060	0.0010
		Minimum	-	-
		Maximum	-	-
		20 th percentile	0.024	0.0010
		80 th percentile	0.11	0.0010
		95 th percentile	-	-
		No. samples	13	10
Manganese dissolved (mg/L)	<0.01	Median	-	-
		Minimum	0.010	0.010
		Maximum	0.18	0.010
		20 th percentile	-	-
		80 th percentile	-	-
		95 th percentile	-	-
		No. samples	2	1

Table 19 Common metals – mine area undisturbed sites (continued)

Constituent	WQO	Statistic	Corkscrew Ck Access	Corkscrew Ck Duckpond
Aluminium total (mg/L)	<0.03	Median	1.1	2.1
		Minimum	-	-
		Maximum	-	-
		20 th percentile	0.82	0.94
		80 th percentile	2.8	3.4
		95 th percentile	-	-
		No. samples	13*	10*
Aluminium dissolved (mg/L)	<0.03	Median	-	-
		Minimum	0.010	0.25
		Maximum	0.25	0.25
		20 th percentile	-	-
		80 th percentile	-	-
		95 th percentile	-	-
		No. samples	2	1

* Minimum value is at LOD which is above the WQO

Key:

	Less than 5 samples
	Median exceeds WQO

Sufficient recorded total iron concentrations were available at both sites on Corkscrew Creek to calculate the median values, both of which are above the iron WQO of 0.01 mg/L. Insufficient data were available to calculate a median dissolved iron concentration on Corkscrew Creek.

The median value calculated for total manganese exceeds the WQO (0.01 mg/L) at one of the Corkscrew Creek sites. Insufficient data were available to calculate a median dissolved manganese concentration on Corkscrew Creek.

Aluminium concentrations (both total and dissolved) are elevated relative to the WQO (0.03 mg/L). Sufficient recorded total aluminium concentrations were available at both sites on Corkscrew Creek to calculate the median values, both of which are above the aluminium WQO of 0.03 mg/L. However, it is important to note that the minimum reported values are at LOD (0.1 mg/L) which exceeds the WQO. Insufficient data were available to calculate a median dissolved aluminium concentration on Corkscrew Creek.

3.4.5 Trace metals

A summary of the data for trace metals from mine area undisturbed sites is presented in Table 20.

No samples for total chromium were available on Corkscrew Creek and only three samples were available for dissolved chromium which is insufficient to calculate the median.

The median value calculated for total copper exceeds the WQO (0.001 mg/L) at both sites on Corkscrew Creek, however it is important to note that there are a number of reported values (that are not the minimum reported value) that are at LOD (0.010 mg/L) which exceeds the WQO. Insufficient samples were available to calculate the 95th percentile statistic for total copper. Only three samples were available for dissolved copper which is insufficient to calculate the median statistic.

Recorded total nickel values were available at both sites on mine area undisturbed sites on Corkscrew Creek where the median value is at the WQO (0.01 mg/L) at both sites. Sufficient total nickel samples to calculate the 95th percentile statistic (i.e. >40) were not available. Only three

samples were available for dissolved nickel which is insufficient to calculate the median statistic, however all three results are at or below the WQO.

Recorded total zinc values were available at both sites on Corkscrew Creek and the median value exceeds the WQO at both sites. However, it is important to note that the minimum reported values for Corkscrew Creek Duckpond are at LOD (0.010 mg/L) which exceeds the WQO. Dissolved zinc is also at LOD for the single reading at Corkscrew Creek Duckpond which exceeds the WQO and at LOD for both readings for Corkscrew Creek Access, one of which exceeds the WQO.

Table 20 Trace metals – mine area undisturbed sites

Constituent	WQO	Statistic	Corkscrew Ck Access	Corkscrew Ck Duckpond
Chromium dissolved (mg/L)	<0.001	Median	-	-
		Minimum	0.0020	0.014
		Maximum	0.014	0.014
		20 th percentile	-	-
		80 th percentile	-	-
		95 th percentile	-	-
		No. samples	2	1
Copper total (mg/L)	<0.0014	Median	0.020	0.025
		Minimum	-	-
		Maximum	-	-
		20 th percentile	0.010	0.010
		80 th percentile	0.030	0.030
		95 th percentile	-	-
		No. samples	13*	10*
Copper dissolved (mg/L)	<0.0014	Median	-	-
		Minimum	0.0020	0.010
		Maximum	0.010	0.010
		20 th percentile	-	-
		80 th percentile	-	-
		95 th percentile	-	-
		No. samples	2**	1**

Table 20 Trace metals – mine area undisturbed sites (continued)

Constituent	WQO	Statistic	Corkscrew Ck Access	Corkscrew Ck Duckpond
Nickel total (mg/L)	<0.01	Median	0.010	0.010
		Minimum	-	-
		Maximum	-	-
		20 th percentile	0.010	0.010
		80 th percentile	0.010	0.010
		95 th percentile	-	-
		No. samples	13	10
Nickel dissolved (mg/L)	<0.01	Median	-	-
		Minimum	0.0040	0.010
		Maximum	0.010	0.010
		20 th percentile	-	-
		80 th percentile	-	-
		95 th percentile	-	-
		No. samples	2	1
Zinc total (mg/L)	<0.008	Median	0.020	0.025
		Minimum	-	-
		Maximum	-	-
		20 th percentile	0.010	0.018
		80 th percentile	0.040	0.040
		95 th percentile	-	-
		No. samples	13	10*
Zinc dissolved (mg/L)	<0.008	Median	-	-
		Minimum	0.0050	0.010
		Maximum	0.010	0.010
		20 th percentile	-	-
		80 th percentile	-	-
		95 th percentile	-	-
		No. samples	2**	1*

* Minimum value is at LOD which is above the WQO

** There are multiple LODs for this data and one of them is above the WQO. Limited sample numbers and should not be compared against WQO with less than 5 samples as recommended by the guideline.

Key:

	Less than 5 samples
	Median exceeds WQO

3.5 MINE AREA: RELEASE WATER

3.5.1 General and physical indicators

A summary of the general and physical indicators for mine area release sites is presented in Table 21. Note that no data were available for RP2 or RP3, hence data are only shown for RP1.

Table 21 General and physical indicators – mine area release sites

Constituent	WQO	Statistic	RP1
Field EC (µS/cm)	<340	Median	8,320
		Minimum	-
		Maximum	-
		20 th percentile	6,420
		80 th percentile	8,600
		No. samples	61
Lab EC (µS/cm)	<340	Median	8,420
		Minimum	-
		Maximum	-
		20 th percentile	7,490
		80 th percentile	9,060
		No. samples	61
TDS (mg/L)	<1000	Median	4,810
		Minimum	3,420
		Maximum	6,200
		20 th percentile	-
		80 th percentile	-
		No. samples	5
Field pH	6.8 - 8.5	Median	8.2
		Minimum	-
		Maximum	-
		20 th percentile	7.9
		80 th percentile	8.5
		No. samples	62
Lab pH	6.8 - 8.5	Median	8.4
		Minimum	-
		Maximum	-
		20 th percentile	8.3
		80 th percentile	8.5
		No. samples	62
Suspended solids (mg/L)	<10	Median	18
		Minimum	-
		Maximum	-
		20 th percentile	9.0
		80 th percentile	46
		No. samples	62

Table 21 General and physical indicators – mine area release sites (continued)

Constituent	WQO	Statistic	RP1
Lab turbidity (NTU)	<50	Median	10
		Minimum	
		Maximum	
		20 th percentile	4
		80 th percentile	31
		No. samples	62

Key:

	At least 5 samples, less than 10 samples
	Median exceeds WQO

Water released from site at RP1 has elevated salinity (EC and TDS) values which exceed the WQO. Field pH results at RP1 indicate waters are typically slightly alkaline which is within the WQO range (6.8 – 8.5). The median suspended solids concentration (18 mg/L) is above the WQO of 10 mg/L, however median turbidity is below the WQO of 50 NTU. It should be noted that release from RP1 is governed by the requirements of Environmental Authority (EA) EPML00732813 (dated 19 March 2020), which includes release limits on EC, pH and turbidity and specifies a minimum flow rate at GS130219A.

3.5.2 Major nutrients

A summary of the major nutrients for mine area release sites is presented in Table 22. Note that no data were available for RP2, hence data are only shown for RP1.

Water quality samples at RP1 indicate that total nitrogen is variable (ranging from 300 to 2,100 µg/L). Median total nitrogen is equal to the WQO (500 µg/L). There were no samples available for total phosphorous.

Table 22 Major nutrients – mine area release sites

Constituent	WQO	Statistic	RP1
Total nitrogen (µg/L)	<500	Median	400
		Minimum	300
		Maximum	2,100
		20 th percentile	-
		80 th percentile	-
		No. samples	7

Key:

	At least 5 samples, less than 10 samples
--	--

3.5.3 Sulphate, hardness and alkalinity

A summary of sulphate, hardness and alkalinity data for mine area release sites is presented in Table 23. Note that no data were available for RP2, hence data is only shown for RP1.

Table 23 Sulphate, hardness and alkalinity – mine area release sites

Constituent	WQO	Statistic	RP1
Sulphate as SO ₄ (mg/L)	<25	Median	555
		Minimum	-
		Maximum	-
		20 th percentile	396
		80 th percentile	594
		No. samples	52
Hardness (mg/L)	20 - 450	Median	1,060
		Minimum	675
		Maximum	1,120
		20 th percentile	-
		80 th percentile	-
		No. samples	5
Alkalinity (mg/L)	20 - 400	Median	264
		Minimum	254
		Maximum	290
		20 th percentile	-
		80 th percentile	-
		No. samples	5

Key:

	At least 5 samples, less than 10 samples
	Median exceeds WQO

Results of water quality testing at RP1 indicate significantly elevated sulphate concentrations compared to the WQO of 25 mg/L with a median of 555 mg/L. All five samples available for hardness indicate elevated values compared to the WQO (between 20 and 450 mg/L). Alkalinity of the five samples is within the WQO (between 20 and 400 mg/L). It should be noted that release from RP1 is governed by the requirements of EA EPML00732813 (dated 19 March 2020), which includes release limits on sulphate and specifies a minimum flow rate at GS130219A.

3.5.4 Common metals

A summary of the data for common metals from mine area release sites is presented in Table 24. Note that no data were available for RP2, hence data are only shown for RP1.

The calculated median values for common metals at RP1 exceed the respective WQOs with the exception of dissolved manganese and dissolved aluminium. It should be noted that release from RP1 is governed by the requirements of EA EPML00732813 (dated 19 March 2020), which includes a minimum flow rate at GS130219A

Table 24 Common metals – mine area release sites

Constituent	WQO	Statistic	RP1
Iron total (mg/L)	<0.01	Median	0.29
		Minimum	-
		Maximum	-
		20 th percentile	0.16
		80 th percentile	0.68
		No. samples	18
Iron dissolved (mg/L)	<0.01	Median	0.025
		Minimum	-
		Maximum	-
		20 th percentile	0.025
		80 th percentile	0.025
		No. samples	18
Manganese total (mg/L)	<0.01	Median	0.038
		Minimum	-
		Maximum	-
		20 th percentile	0.020
		80 th percentile	0.082
		No. samples	18
Manganese dissolved (mg/L)	<0.01	Median	0.0040
		Minimum	-
		Maximum	-
		20 th percentile	0.0005
		80 th percentile	0.028
		No. samples	18
Aluminium total (mg/L)	<0.03	Median	0.20
		Minimum	0.070
		Maximum	1.1
		20 th percentile	-
		80 th percentile	-
		No. samples	5
Aluminium dissolved (mg/L)	<0.03	Median	0.0050
		Minimum	-
		Maximum	-
		20 th percentile	0.0050
		80 th percentile	0.0050
		No. samples	17

Key:

 At least 5 samples, less than 10 samples

Constituent	WQO	Statistic	RP1

Median exceeds WQO

3.5.5 Trace metals

A summary of the data for trace metals from mine area release sites is presented in Table 25.

Table 25 Trace metals – mine area release sites

Constituent	WQO	Statistic	RP1
Chromium total (mg/L)	<0.001	Median	0.0005
		Minimum	-
		Maximum	-
		20 th percentile	0.0005
		80 th percentile	0.0005
		95 th percentile	-
		No. samples	18
Chromium dissolved (mg/L)	<0.001	Median	0.0005
		Minimum	-
		Maximum	-
		20 th percentile	0.0005
		80 th percentile	0.0005
		95 th percentile	-
		No. samples	18
Copper total (mg/L)	<0.0014	Median	0.0010
		Minimum	-
		Maximum	-
		20 th percentile	0.0005
		80 th percentile	0.0030
		95 th percentile	-
		No. samples	18
Copper dissolved (mg/L)	<0.0014	Median	0.0005
		Minimum	-
		Maximum	-
		20 th percentile	0.0005
		80 th percentile	0.0010
		95 th percentile	-
		No. samples	18
Nickel total (mg/L)	<0.01	Median	0.002
		Minimum	-
		Maximum	-
		20 th percentile	0.001
		80 th percentile	0.0036
		95 th percentile	-
		No. samples	18
Nickel dissolved (mg/L)	<0.01	Median	0.001
		Minimum	-
		Maximum	-
		20 th percentile	0.0005

Constituent	WQO	Statistic	RP1
		80 th percentile	0.002
		95 th percentile	-
		No. samples	18

Table 25 Trace metals – mine area release sites (continued)

Constituent	WQO	Statistic	RP1
Zinc total (mg/L)	<0.008	Median	0.0055
		Minimum	-
		Maximum	-
		20 th percentile	0.0025
		80 th percentile	0.019
		95 th percentile	-
		No. samples	18
Zinc dissolved (mg/L)	<0.008	Median	0.0025
		Minimum	-
		Maximum	-
		20 th percentile	0.0025
		80 th percentile	0.0046
		95 th percentile	-
		No. samples	18

Note that no data were available for RP2, hence data are only shown for RP1.

The calculated median values for trace metals at RP1 do not exceed the respective WQOs.

3.6 MINE AREA: DISTURBED SITES

Whilst there are 11 mine area disturbed sites there are relatively few sample results available with a single sample result from four of the sites. Therefore, the assessment of baseline water quality at these sites should be regarded as being preliminary.

3.6.1 General and physical indicators

A summary of the general and physical indicators for mine area disturbed sites is presented in Table 26 and Table 27.

Sufficient field EC data were available at four of the ten mine area disturbed sites to calculate median field EC values and only Boggy Ck X1 exceeds the Nogoia River WQO (340 μ S/cm).

Recorded TDS values were not available at any of the mine area disturbed sites.

Sufficient field pH data were available at four of the 11 mine area disturbed sites to calculate median field pH values all of which are within the WQO range (6.8 – 8.5).

The limited turbidity data also indicates high values as might be expected of a disturbed site.

Table 26 General and physical indicators – mine area disturbed sites 1 of 2

Constituent	WQO	Statistic	Boggy Ck X1	Boggy Ck X2	Boggy Ck X3	Boggy Ck X4	Boggy Ck X5	Boggy Ck X6
Field EC (µS/cm)	<340	Median	464	236	-	-	121	-
		Minimum	-	132	119	99	62	-
		Maximum	-	3,180	119	99	541	-
		20 th percentile	256	-	-	-	-	-
		80 th percentile	1,646	-	-	-	-	-
		No. samples	12	7	1	1	5	-
Lab EC (µS/cm)	<340	Minimum	273	236	116	105	81	57
		Maximum	787	236	116	105	81	57
		No. samples	4	1	1	1	1	1
Field pH	6.8 - 8.5	Median	7.7	7.7	-	-	7.7	-
		Minimum	-	7.1	7.4	7.6	7.2	-
		Maximum	-	8.2	7.4	7.6	8.1	-
		20 th percentile	7.4	-	-	-	-	-
		80 th percentile	7.9	-	-	-	-	-
		No. samples	12	7	1	1	5	-
Lab pH	6.8 - 8.5	Minimum	6.8	6.5	7.8	7.5	6.8	6.8
		Maximum	7.5	6.5	7.8	7.5	6.8	6.8
		No. samples	4	1	1	1	1	1
Suspended solids (mg/L)	<10	Minimum	663	432	447	412	334	143
		Maximum	4,560	432	447	412	334	143
		No. samples	4	1	1	1	1	1
Field turbidity (NTU)	<50	Minimum	142	-	-	-	-	-
		Maximum	242	-	-	-	-	-
		No. samples	3	-	-	-	-	-
Lab turbidity (NTU)	<50	Minimum	180	838	830	754	659	401
		Maximum	6,620	838	830	754	659	401
		No. samples	4	1	1	1	1	1

Key:

	Less than 5 samples
	At least 5 samples, less than 10 samples
	Median exceeds WQO

Table 27 General and physical indicators – mine area disturbed sites 2 of 2

Constituent	WQO	Statistic	ENMP04	ENMP04R09	Boggy Ck Diversion Sth	ENBCR81
Field EC (µS/cm)	<340	Median	-	-	250	-
		Minimum	122	487	69	354
		Maximum	122	507	785	354
		No. samples	1	2	6	1
Lab EC (µS/cm)	<340	Median	-	-	-	-
		Minimum	122	47	-	328
		Maximum	122	341	-	837
		No. samples	1	3	-	3
Field pH	6.8 - 8.5	Median	-	-	7.0	-
		Minimum	-	6.7	4.7	8.0
		Maximum	-	6.8	7.4	8.0
		No. samples	-	2	6	1
Lab pH	6.8 - 8.5	Minimum	7.2	6.9	-	7.7
		Maximum	7.2	7.3	-	8.1
		No. samples	1	3	-	3
Suspended solids (mg/L)	<10	Median	-	-	-	-
		Minimum	-	-	-	11
		Maximum	-	-	-	275
		No. samples	-	-	-	3
Lab turbidity (NTU)	<50	Median	-	-	-	-
		Minimum	421	332	-	5.8
		Maximum	421	660	-	376
		No. samples	1	3	-	3

Key:

	Less than 5 samples
	At least 5 samples, less than 10 samples
	Median exceeds WQO

3.6.2 Major nutrients

A summary of the major nutrients for mine area disturbed sites is presented in Table 28.

There were two sample results available for total nitrogen at mine area disturbed sites; one at ENMP04R09 and one at Boggy Creek Yongala Access Road. Both exceed the WQO (500 µg/L). There were no total phosphorous results available.

Table 28 Major nutrients – mine area disturbed sites

Constituent	WQO	Statistic	ENMP04	ENMP04R09	Boggy Ck Diversion Sth	ENBCR81
Total nitrogen (µg/L)	<500	Median	-	-	-	-
		Minimum	-	1,000	-	-
		Maximum	-	1,000	-	-
		20 th percentile	-	-	-	-
		80 th percentile	-	-	-	-
		No. samples	-	1	-	-

Key:

	Less than 5 samples
	Median exceeds WQO

3.6.3 Sulphate, hardness and alkalinity

A summary of sulphate data for mine area disturbed sites is presented in Table 29 and Table 30.

There were 14 test results available for sulphate from the ten sampling sites in this group. Of these results only one exceeded the WQO (25 mg/L). There were no results available for hardness or alkalinity.

Table 29 Sulphate – mine area disturbed sites 1 of 2

Constituent	WQO	Statistic	Boggy Ck X1	Boggy Ck X2	Boggy Ck X3	Boggy Ck X4	Boggy Ck X5	Boggy Ck X6
Sulphate as SO ₄ (mg/L)	<25	Median	-	-	-	-	-	-
		Minimum	16	15	5.0	5.0	6.0	2.0
		Maximum	54	15	5.0	5.0	6.0	2.0
		20 th percentile	-	-	-	-	-	-
		80 th percentile	-	-	-	-	-	-
		No. samples	2	1	1	1	1	1

Key:

	Less than 5 samples
	Median exceeds WQO

Table 30 Sulphate – mine area disturbed sites 2 of 2

Constituent	WQO	Statistic	ENMP04	ENMP04R09	Boggy Ck Diversion Sth	ENBCR81
Sulphate as SO ₄ (mg/L)	<25	Median	-	-	-	-
		Minimum	0.50	0.50	-	8.0
		Maximum	0.50	13	-	22
		20 th percentile	-	-	-	-
		80 th percentile	-	-	-	-
		No. samples	1	3	-	3

Key:

	Less than 5 samples
	Median exceeds WQO

3.6.4 Common metals

A limited number of samples were available for three of the ten mine area disturbed sites (Boggy Creek X2, ENMP04 and ENBCR81) hence only data from these three sites are shown in Table 31.

There were five sample results available for total iron and dissolved iron at mine area disturbed sites and all exceed the WQO (0.01 mg/L).

There were five sample results available for total manganese at mine area disturbed sites and four of these samples exceed the WQO (0.01 mg/L). There were also five sample results available for dissolved manganese at the three mine area disturbed sites and two of these samples exceed the WQO.

There were four sample results available for total aluminium at mine area disturbed sites and all exceed the WQO (0.03 mg/L). There were five sample results available for dissolved aluminium at the three mine area disturbed sites and three of these samples exceed the WQO.

Table 31 Common metals – mine area disturbed sites

Constituent	WQO	Statistic	Boggy Ck X2	ENMP04	ENBCR81
Iron total (mg/L)	<0.01	Median	-	-	-
		Minimum	59	11	0.59
		Maximum	59	11	0.76
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		No. samples	2	1	2
Iron dissolved (mg/L)	<0.01	Median	-	-	-
		Minimum	0.030	2.6	0.025
		Maximum	0.030	2.6	0.025
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		No. samples	2	1	2
Manganese total (mg/L)	<0.01	Median	-	-	-
		Minimum	0.0010	0.074	0.11
		Maximum	0.86	0.074	0.20
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2
Manganese dissolved (mg/L)	<0.01	Median	-	-	-
		Minimum	0.010	0.0060	0.0020
		Maximum	0.010	0.0060	0.15
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2

Table 31 Common metals – mine area disturbed sites (continued)

Constituent	WQO	Statistic	Boggy Ck X2	ENMP04	ENBCR81
Aluminium total (mg/L)	<0.03	Median	-	-	-
		Minimum	31	-	0.53
		Maximum	31	-	0.63
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	-	2
Aluminium dissolved (mg/L)	<0.03	Median	-	-	-
		Minimum	0.29	4.7	0.0050
		Maximum	0.29	4.7	0.0050
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2

Key:

Less than 5 samples

3.6.5 Trace metals

A limited number of samples were available for three of the ten mine area disturbed sites (Boggy Creek X2, ENMP04 and ENBCR81) hence only data from these three sites are shown in Table 32.

There were three sample results available for total chromium at mine area disturbed sites and one exceeds the WQO (0.001 mg/L). There were five sample results available for dissolved chromium at the three mine area disturbed sites and three of these samples exceed the WQO.

There were five sample results available for total copper at mine area disturbed sites and all exceed the WQO (0.0014 mg/L). There were also five sample results available for dissolved copper at the three mine area disturbed sites and four of these samples exceed the WQO.

There were five sample results available for total zinc at mine area disturbed sites and three of these samples exceed the WQO (0.008 mg/L). There were also five sample results available for dissolved zinc at the three mine area disturbed sites and four of these samples exceed the WQO.

Table 32 Trace metals – mine area disturbed sites

Constituent	WQO	Statistic	Boggy Ck X2	ENMP04	ENBCR81
Chromium total (mg/L)	<0.001	Median	-	-	-
		Minimum	-	0.021	0.0005
		Maximum	-	0.021	0.0005
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	-	1	2

Table 32 Trace metals – mine area disturbed sites (continued)

Constituent	WQO	Statistic	Boggy Ck X2	ENMP04	ENBCR81
Chromium dissolved (mg/L)	<0.001	Median	-	-	-
		Minimum	0.013	0.0070	0.0005
		Maximum	0.013	0.0070	0.0005
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2
Copper total (mg/L)	<0.0014	Median	-	-	-
		Minimum	0.090	0.0080	0.0020
		Maximum	0.090	0.0080	0.0020
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2
Copper dissolved (mg/L)	<0.0014	Median	-	-	-
		Minimum	0.010	0.0030	0.0010
		Maximum	0.010	0.0030	0.0020
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2
Zinc total (mg/L)	<0.008	Median	-	-	-
		Minimum	0.15	0.028	0.0025
		Maximum	0.15	0.028	0.0025
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2
Zinc dissolved (mg/L)	<0.008	Median	-	-	-
		Minimum	0.010	0.0070	0.015
		Maximum	0.010	0.0070	0.018
		20 th percentile	-	-	-
		80 th percentile	-	-	-
		95 th percentile	-	-	-
		No. samples	2	1	2

Key:

Less than 5 samples

4.0 ASSESSMENT OF POTENTIAL IMPACTS TO SURFACE WATER QUALITY

4.1 ENVIRONMENTAL AUTHORITY PROVISIONS

The Project will extend the life of the existing underground operations by up to nine years to approximately 2037. The extension of the current underground operation using existing infrastructure means that no additional surface construction or surface disturbance will be required to facilitate the Project. The Project will continue to use the existing water management system and mine affected water release system, with controlled release occurring from Pits A, B, C, D, E, F and Y along with Ramp 24 Fill Point Dam and Ramp 3/4 Drain via two release points (RP1 and RP3), subject to the requirements of EA EPML00732813 (dated 19 March 2020). The key features of the EA which govern release include:

- mine affected water release quality limits (RP1 and RP3) of 12,500 $\mu\text{S}/\text{cm}$ EC, pH 6.5-9.0, sulphate 1,000 mg/L and turbidity 360 NTU
- release permitted from RP1 only when Nogoa River flow exceeds 30 m^3/s
- monitoring of water quality at downstream monitoring points ENMP05 and ENMP06 (refer Figure 2) during release events, with:
 - a 'cease release' EC trigger at ENMP05 of 850 $\mu\text{S}/\text{cm}$
 - an 'approval' trigger of 650 $\mu\text{S}/\text{cm}$ at ENMP06 (approval required to continue release if EC rises above this level)
 - 'investigation' triggers for pH (6.5 - 9.0), suspended solids (1,000 mg/L) and sulphate (250 mg/L), which, if exceeded, requires a comparison to upstream values which in turn, if exceeded, requires an investigation into the potential for environmental harm
 - 'investigation' triggers for a range of 23 water quality parameters, including trace metals (to be monitored at the release points and ENMP05 only), which, if exceeded at the release point, requires a comparison to ENMP05, which, if exceeded, requires an investigation into the potential for environmental harm.

Ensham manage releases using an EC calculator which models expected EC at ENMP05 and ENMP06 during releases using upstream monitored EC and flow rate and release water EC and release rate. This is used to manage release rates to ensure EA limits are not exceeded and, together with the conduct of monitoring as required by the EA during release, has ensured that Ensham has complied with the defined EA triggers and limits. It is noteworthy that median statistics for recorded trace metals concentrations at RP1 do not exceed the respective WQOs.

A recent study by Hydrobiology (2019a) concluded that "...the release of mine affected waters with an EC of 12,500 $\mu\text{S}/\text{cm}$ is expected to have insignificant to minor impacts to the aquatic ecosystem values from the proposed release point to MP5 and even less so to MP6". In addition, Receiving Environment Monitoring Program (REMP) monitoring results (e.g. Hydrobiology, 2019b) have shown that the EA release limits suitably protect defined environmental values including aquatic ecosystems.

4.2 PROJECT CHANGES AND POTENTIAL WATER QUALITY IMPACTS

Given that no surface construction and no additional surface disturbance will be required to facilitate the Project, potential changes to release quantity and quality could only occur as a result of changes to groundwater inflow (with groundwater contributing to the mine affected water system). Groundwater salinity, although variable, is moderately saline with groundwater samples from the coal measures displaying EC values ranging (80th/20th percentile) from approximately 4,000 to

11,000 $\mu\text{S}/\text{cm}$ (SLR, 2020). Groundwater inflow to future mining areas is predicted to have the same quality as previous groundwater inflows (SLR, 2020). Data from monitoring bores indicates the most prevalent environmentally significant metal species is iron, however it is noted that median recorded iron values at upstream sample sites (refer Section 3.2.4) exceed those at RP1 (refer Section 3.5.4) indicating significant background concentrations of iron.

Groundwater modelling for the Project has been undertaken by SLR (2020). Recorded groundwater inflow rates to the existing underground operations have ranged from 0.2 to 3.9 ML/d over the period between December 2016 and September 2018, with a model simulated value of 3.3 ML/d. Predictive groundwater modelling showed that the Project will result in additional groundwater inflow compared to the existing operations due to the proposed extension to the life of mine. The following specific observations are made regarding the inflow predictions:

- there is a gradual increase in predicted inflows from 2020 until approximately 2024 of up to some 2.5 ML/d
- this increase remains approximately constant until near the end of existing operations, modelled in 2030
- thereafter groundwater inflows varying between approximately 2.5 ML/d to 12.5 ML/d are predicted, which are of a similar or slightly less magnitude range to those predicted for the existing operations
- inherent model assumptions mean that these inflow predictions are likely an overestimation.

On the basis of these predictions, it is considered likely that groundwater inflows should increase in the near-term (within the term of the existing operations) before trending downwards with time, while fluctuating over a similar range as the near-term.

The higher rates of groundwater inflow will continue to be managed within the existing Ensham Mine water management system, including the controlled release system, and be subject to the provisions of EA EPML00732813 (dated 19 March 2020), which ensure protection of EVs through management of release volumes and monitoring of water quality. It is therefore concluded that no environmentally significant impacts to surface water quality should occur as a result of the Project activities.

5.0 CONCLUSIONS

Surface water quality monitoring at and in the vicinity of the Ensham Mine has been categorised into upstream sites, downstream sites and mine area sites. Comparisons have been made to WQOs for the Lower Nogoa, Theresa Creek and Mackenzie River catchments.

At the four upstream sites, median values exceed WQOs at all sites for suspended solids, at two sites for nutrients, at two sites for EC (salinity) and at one site for turbidity. Continuously recorded (gauging station) EC values are low at high flows but cover a wide range at low to moderate flows. EC data at low to moderate flows is likely affected by regulated releases from Fairbairn Dam. Recorded values of iron, total manganese, aluminium, total chromium, copper and zinc were elevated compared with the WQOs at most sites.

At the five downstream sites, median values exceed WQOs at all sites for which data were available for suspended solids, at two sites for EC, at one site for turbidity, one site for total nitrogen and two sites for sulphate. Recorded values of iron, manganese, aluminium, total chromium, copper and zinc were elevated compared with the WQOs at most sites.

Limited data were available for the two mine area undisturbed sites. For those sites with sufficient data, EC, suspended solids, total iron, total manganese and total aluminium were elevated compared with the WQOs.

Data for RP1 (EA release point) indicates elevated median EC, TDS, suspended solids, sulphate and hardness compared with the WQOs. However, 80th percentile EC, turbidity and sulphate values are less than EA limits for controlled release. It is noteworthy that median values for recorded trace metals concentrations at RP1 do not exceed the respective WQOs.

Ensham manage releases in accordance with EA EPML00732813 (dated 19 March 2020) and this has ensured that Ensham has complied with the defined EA water quality triggers and limits. A recent aquatic ecology study (Hydrobiology, 2019a) has concluded that continued release in accordance with EA limits should have insignificant to minor impacts to aquatic ecosystem values.

Given that no surface construction and no additional surface disturbance will be required to facilitate the Project, the only potential change to release quantity and quality could result from changes to underground mine groundwater inflow. Groundwater inflow to future mining areas is predicted to have the same quality as previous groundwater inflows (SLR, 2020). Groundwater modelling has predicted that groundwater inflows should increase in the near-term (within the term of the existing operations) before trending downwards with time, while fluctuating over a similar range as inflows predicted for the near-term. The higher rates of groundwater inflow will continue to be managed within the existing Ensham mine water management system, including the controlled release system, and be subject to the provisions of EA EPML00732813 (dated 19 March 2020), which ensure protection of environmental values through management of release volumes and monitoring of water quality. It is therefore concluded that no environmentally significant impacts to surface water quality should occur as a result of the Project.

In order to ensure no significant impacts to surface water quality, continued water quality monitoring in accordance with EA EPML00732813 is proposed.

6.0 REFERENCES

- Department of Environment and Heritage Protection (DEHP) 2011a, *Nogoa River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Nogoa River Sub-basin*, prepared by Environmental Policy and Planning, September.
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