

Appendix S - Aquatic Ecology Survey Reports

Appendix S-1 - Aquatic Ecology Survey 2020

Toms Gully Aquatic Ecology Baseline Studies

Final Report



This report has been prepared for Hanking as a technical document to continue baseline data collection and assist with future impact assessment.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. As a result, not all relevant site features and conditions may have been identified in this report.

Rainfall data were obtained from external sources. Aquatic Ecology Services has made the assumption that all data has been validated and is correct.

Version	Prepared by	Reviewed by	Review Date
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1. Introduction

1.1 Background

Toms Gully Mine, located near Marrakai in the Northern Territory, has been in operation intermittently since 1988. The project area has operated under the ownership of several different operators, most recently Crocodile Gold until 2013; then after a period of Care and Maintenance, it was divested to Primary Gold. Primary Gold was acquired by Hanking and gained environmental approvals for an underground mining operation at the site.

Aquatic ecology monitoring has been undertaken at Toms Gully Mine in 2015, and 2017-2019. The surveys to date have gathered data on fish and macroinvertebrate communities as well as habitat information and water quality for Mount Bunday and Coulter Creeks. This resulted in a body of data that was used for the assessment of the impact of a proposed treated mine water release regime. Aquatic ecology monitoring has continued at the site to provide a continuous and robust data set. Data gathered during the baseline monitoring phase will assist in understanding aquatic ecosystem health changes that may occur as a result of operations at the Toms Gully Mine Site.

1.2 Catchment

The Toms Gully Mine is located adjacent to Mount Bunday Creek, which flows into Hardies Creek, a tributary of the Mary River Floodplain. The Mary River Coastal Floodplain is unusual in Northern Australia as it is lacking a single major river channel through the floodplain to the ocean. As a result, the floodplain is poorly drained and the inflow channel diffuses into vast seasonal swamps before reaching the sea through a number of tidal channels. The Mary River crossing at the Arnhem Highway is a convenient delineation between the upper (southern) catchment and the floodplains of the lower (northern) catchment. The crossing marks the approximate change in patterns of wet season river flow from channel to sheet flow (Schultz *et al.* 2002).

Coulter Creek is a low order stream, and a tributary of Mount Bunday Creek. The confluence of the two creeks is located approximately 4km downstream of the Arnhem Highway. The Creek originates upstream on the Old Mount Bunday Station, and previous studies have observed impacts at sites on Coulter Creek as a result of cattle access. The riparian zone along Coulter Creek is not continuous, and the greater catchment area has also been cleared for grazing. Mount Bunday Creek is a higher order stream, draining north to Hardies Creek and on to the Mary River. The Riparian zone of Mount Bunday Creek is more intact than Coulter Creek, and clearing of land beyond the riparian zone is more intensive surrounding Toms Gully Mine and downstream than in the upstream area that has been monitored. Although during sampling events there were observable breaks in surface water, where dry sand was present in the creek bed, surface water flow was recorded at most sites. Alluvial groundwater and surface water interact along Mount Bunday Creek, and there is likely an extended period of sub-surface flow in the dry season through the sandy substrates.

1.3 Scope

Aquatic Ecology Services was engaged by Hanking to undertake baseline surveys at the Toms Gully Mine to characterise the existing aquatic health and condition of the receiving environment. The survey included:

- A study design that incorporates locations upstream, within and downstream of the Toms Gully Mine Lease (ML), and as a minimum, assessment of Primary sites SWTG1A (control site) and SWTG2 (potential impact site downstream of Toms Gully Mine).
- Macroinvertebrate sampling and aquatic habitat assessment carried out in accordance with the NT AUSRIVAS Darwin-Daly Region Manual (Lamche 2007)
- Fish community sampling
- Water and sediment quality sampling
- Monitoring for the presence of the Mertens' Water Monitor (*Varanus mertensi*) and Mitchell's Water Monitor (*Varanus mitchelli*) surrounding the Toms Gully Mine site.

This report presents the results of the above monitoring conducted in May 2020.



2. Study design

2.1 Sampling Sites

Aquatic ecology sampling was undertaken at 14 sites in May 2020 (Table 1, Figure 1). Ten sites were sampled on Mount Bunday Creek, consisting of two sites upstream of the mine, five sites adjacent to the mine, and three sites downstream of the mine. Four sites were sampled on the reference system Coulter Creek. Remote cameras were deployed at six sites along Mount Bunday Creek (Figure 1).

2.2 Survey timing

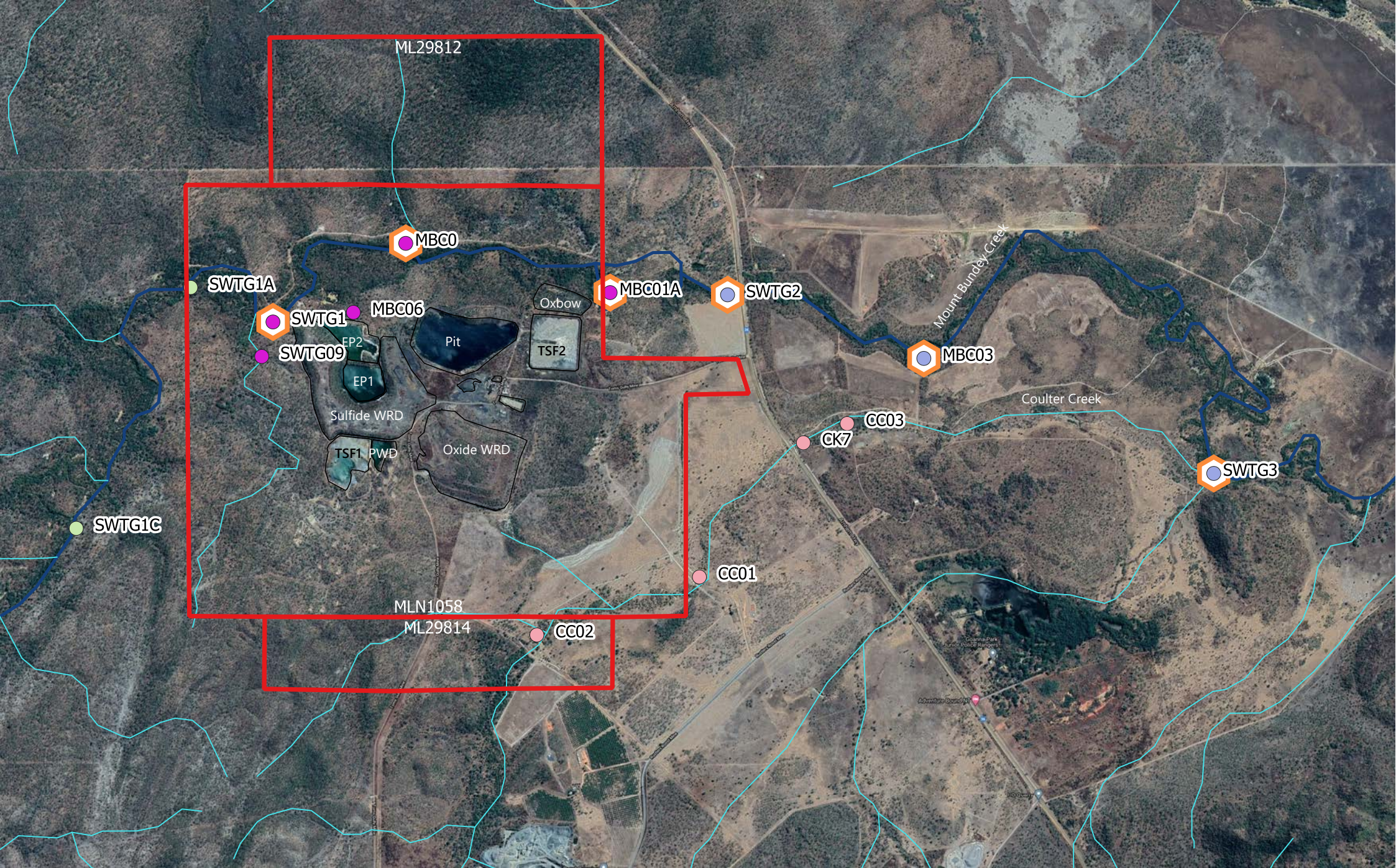
Sampling has routinely been conducted in the post-wet season during the recessional flow period, to capture data representative of the time of year when compliance monitoring would be undertaken. Sampling has generally been undertaken in late April to mid-May. In 2020, sampling was undertaken in early May to target adequate water availability at all sites.

Table 1 – Sample site locations visited in May 2020

Site	Site Type	Location	Easting	Northing
SWTG1C	Upstream	Mount Bunday Creek approximately 2.5 km upstream of SWTG1A.	775674	8579115
SWTG1A	Upstream	Mount Bunday Creek upstream of mine at lease boundary.	776351	8580503
SWTG09	Adjacent to Mine	Tributary adjacent to EP1 and EP2, approximately 200 m upstream of the confluence with Mount Bunday Creek.	776766	8580098
SWTG1	Adjacent to Mine	Mount Bunday Creek at confluence of tributary adjacent to EP1 and EP2	776825	8580290
MBC0	Adjacent to Mine	Mount Bunday Creek upstream of tributary draining EP1 and EP2	777606	8580736
MBC06	Adjacent to Mine	Mount Bunday Creek downstream on tributary draining EP1 and EP2	777293	8580350
MBC01A	Adjacent to Mine	Mount Bunday Creek downstream of wetland oxbow and Toms Gully Mine Tailings Dam 2 (TSF2). Located 700 m downstream of previously monitored site MBC01.	778787	8580437
SWTG2	Downstream	Compliance monitoring point at Arnhem Highway Crossing	779453	8580428
MBC03	Downstream	Mount Bunday Creek approximately 1.8 km downstream of SWTG2	780604	8580044

Site	Site Type	Location	Easting	Northing
SWTG3	Downstream	300 m upstream of confluence between Mount Bunday Creek and Coulter Creek	782278	8579366
CC02	Reference	Coulter Creek. Approx. 2 km upstream from CK7	778299	8578355
CC01	Reference	Coulter Creek approximately 1 km upstream from CK7	779293	8578801
CK7	Reference	Coulter Creek. Existing monitoring site located at highway crossing	779807	8579538
CC03	Reference	Coulter Creek approximately 750 m downstream of CK7	780166	8579675



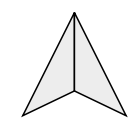
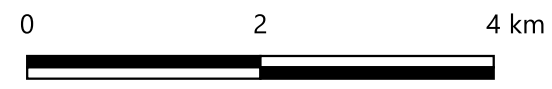


Toms Gully Aquatic Ecology Baseline Studies

Figure 1 - Study sites sampled, May 2020

Data source: ESRI Imagery 2020

-  Adjacent
-  Downstream
-  Upstream
-  Camera



3. Methods

3.1 Habitat assessment

At each site, descriptions of habitat characteristics were recorded following the criteria listed in the Northern Territory AUSRIVAS "Darwin-Daly Region Model" field sheets (Lamche, 2007). Habitat assessments were undertaken in consideration of the whole reach sampled, including:

- Site description
- Water quality
- Instream physical characteristics (flow velocity and depth, instream habitat characteristics, bank height, riparian zone width)
- Riparian vegetation characteristics (types, %cover, exotic species, erosion, land use)
- Water quality observations (clarity, odour, oils, foam/scum, plumes etc.)
- Sketches of the site, including a cross - section of the reach

The information recorded was used to assist interpretation of biological data and to provide input data for the Northern Territory AUSRIVAS model. Data recorded is also used in conjunction with the biological community information as the basis of the overall health assessment.

Photos were taken of upstream and downstream portions of the reach sampled, as well as bank habitat and other key habitat features. This further characterises the habitat conditions at each site, serving as a pictorial record of site conditions that can be tracked over time using photos taken from the same photo points.

3.2 Water and sediment quality sampling

3.2.1 *In situ water quality*

The physico-chemical parameters of the water at each site was measured using a calibrated multi-parameter water quality meter. The following parameters were recorded:

- Water temperature (°C)
- Dissolved oxygen (DO) concentrations (mg/L and % saturation)
- pH
- Electrical conductivity (EC) (µS/cm)
- Turbidity



3.2.2 Water and sediment grab sampling

Water and sediment sampling methods utilised at each site were in accordance with those outlined in ANZECC (2000) and Simpson and Batley (2016) and involved:

- Collection of water samples from below the water surface in the centre of the creek where possible
- The collection of multiple sub-samples of sediment using a spade of inert material and sieving of samples to collect the $\leq 2\text{mm}$ fraction.
- Compositing the sediment sub-samples into a receptacle (also composed of inert material) and mixing the contents.
- The collection of one QA/QC duplicate sample per project area to validate results.
- Collecting a sediment sub-sample from the mixture and placing it into a laboratory-supplied container, labelled with site and sample details.
- Keeping samples in chilled eskies for onward delivery to a NATA accredited laboratory for testing.

Analyses performed on surface waters are detailed in Table 2. Bioavailable metals data (from 1M HCl dilute acid digestion analysis) were analysed for the parameters shown in Table 3.

Table 2 - Testing parameters for water collected at Toms Gully

Suite	Analytes
Physico-chemical	Total dissolved solids (TDS), total suspended solids (TSS), turbidity
Major anions	Alkalinity, chloride, sulfate
Major cations	Calcium, magnesium, sodium, potassium
Metals (dissolved and total)	Aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide

Table 3 – Testing parameters for sediments collected at Toms Gully

Lab Analyses	Analytes
1M HCl extractable metals	Aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc.
Total recoverable metals	Mercury
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide
Other parameters	Particle size distribution (PSD), total organic carbon (TOC), moisture content.

Updated guideline values are not yet available for the Timor Sea Drainage Division (ANZG 2018). Therefore, *in situ* results were compared against ANZECC (2000) Tropical Australia guideline values for slightly-

moderately disturbed ecosystems (95% species protection). This aligns with the recommendations made by the NT EPA in the Assessment Report (NT EPA 2020).

3.3 Macroinvertebrates

3.3.1 Field sampling

Macroinvertebrate sampling and processing followed procedures outlined in the Northern Territory AUSRIVAS Manual for the Darwin-Daly Region (Lamche, 2007). Sampling involved one field team member scraping submerged root matter associated with the lower bank to agitate and remove macroinvertebrates into the water column, while the other field team member swept a dip net through the water column downstream of the edge habitat, to collect the dislodged animals. Areas of riffle or fast flowing habitat, Pandanus roots and severe bank undercuts were avoided when collecting edge habitat samples.

Once collected, the samples were washed through 10 mm and 250 µm mesh sieves. The coarse mesh sieve was examined for large, conspicuous taxa, and these were placed in the labelled sample container. The sample collected in the fine mesh sieve was also placed in the labelled sample container and filled with 70% ethanol. All samples were sent to the macroinvertebrate laboratory for further processing and identification.

3.3.2 Laboratory processing

Samples were washed through a series of sieves (10 mm, 500 µm and 250 µm mesh sizes). Any large, conspicuous taxa identified in the 10 mm mesh sieve were added to the contents of the large mesh fraction retained in the field. The contents of the 500 µm mesh sieve were retained for macroinvertebrate identification and enumeration, while the 250 µm fraction was retained as sample residue for quality assurance purposes. The contents of the 500 µm mesh fraction was poured into a Marchant sub-sampler (Marchant, 1989) and extractions made randomly from cells (aliquots) in this apparatus. These extractions were placed under a microscope and the taxa identified and counted. This process continued until either all aliquots were examined, or a total of 200 individuals had been counted and identified. The number of aliquots required to be processed to obtain a minimum 200 individual sub-sample was recorded in order to be able to calculate abundance. A Leica stereo-dissection microscope was used to examine specimens.

Taxa were identified to family level where possible, with the exception of key taxa identified in Lamche (2007), requiring identification to order level (e.g. Conchostraca). Quality assurance processes were followed as per Lamche (2007). Five percent of samples were sent to an external laboratory and checked for correct identification by an AUSRIVAS accredited Senior Taxonomist.

3.3.3 Data presentation

For this study, macroinvertebrate data was assessed using the NT AUSRIVAS Darwin-Daly Early (dry season) Family level Edge habitat model. Using site-specific information, the AUSRIVAS software makes predictions on the taxa which are likely to be present in the absence of environmental stress. The metric is calculated using a number between 0 and 1.2 which accounts for the number of taxa observed at a site that have a

>50% of being present based on site-specific data collected during sampling. These scores align with bandings that describe the level of impairment at a site relating to environmental stress (Table 4).

Table 4 – AUSRIVAS Darwin-Daly Model Bands

Band	O/E50 upper limit	Band Name	Band Description
X	>1.17	More biologically diverse than reference sites	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
A	1.17	Reference Condition	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
B	0.82	Significantly impaired	Fewer families than expected. Potential impact either on water quality or habitat quality or both resulting in loss of taxa.
C	0.48	Severely impaired	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
D	0.14	Extremely impaired	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

Macroinvertebrate community indices were calculated for each sample at each site. A summary of the univariate macroinvertebrate indices assessed as part of this study are provided below:

- Taxa richness – Total number of taxa present at the site used as a measure of diversity.
- PET richness – total number of families from orders Plecoptera, Ephemeroptera and Trichoptera. PET taxa are generally more sensitive to disturbance.
- SIGNAL-2 – a biotic index that allocates a value to each macroinvertebrate family based on their sensitivity to pollution. The metric is calculated by averaging the index of all families collected. Lamche (2007) cautions against the use of the SIGNAL-2 index for assessing the status of Northern Territory macroinvertebrate communities. This measure is however, considered appropriate for this study as the number of pollution-sensitive versus pollution-tolerant families does provide some insight to the level of stress that the macroinvertebrate community is experiencing.

In addition to univariate analysis of metrics, an assessment of differences in the macroinvertebrate community composition will be undertaken. NMDS Ordination provides a representation of the relative similarity of entities (i.e. samples) based on their attributes (i.e. macroinvertebrate community composition)

within a reduced dimensional space. This process was completed for samples collected in 2020, and a historical comparison of all samples collected between 2015 and 2020 was also undertaken.

3.4 Fish Community

Fish sampling was carried out primarily using backpack electrofishing. Electrofishing is a proven technique capable of capturing the majority of taxa present, as it is not size or species specific (as compared to gill nets for instance). Further, it is a nonlethal means of sampling when applied properly and can be used in a way that can provide quantitative data where required. However, at some sites electrofishing was not possible due to safety concerns regarding steep banks, deep pool habitat and the potential presence of estuarine crocodiles. Wherever instances such as these occurred, the field team recorded visual observations (to the best of their ability) regarding fish species present.

Where electrofishing was completed, a single pass from downstream to upstream was completed. All caught fish were identified in the field using appropriate keys (Allen et al. 2003) and counts for each species captured were recorded. The total number of fish captured at each site was derived from that information. All macrocrustaceans (Palaemonidae and Atyidae) caught at a site were also counted. Notes were also taken of any evidence of external lesions, parasites or deformities among the fish specimens collected at each of the study sites.

3.5 Water Monitors

Remote camera trapping was undertaken at six locations on Mount Bunday Creek. Sites were co-located with aquatic ecology monitoring locations where appropriate habitat for water monitors was found. Five cameras were located downstream of Toms Gully Mine, and one was located upstream. The camera upstream was set up to check for the presence of water monitors outside of the influence of the mine. All remote cameras were set up with guidance from Gillespie *et al.* (2005). Cameras were attached to trees approximately 0.5 m from the ground. Cameras were positioned where possible to include areas likely to be used for basking by water monitors, such as banks close to the water and logs. Cameras remained operational between 4 May and 20 August 2020.



4. Results and Discussion

All sites were accessible in May 2020, and conditions were appropriate for sampling at all but one site, MBC06. There was insufficient water for biological sampling at the site, yet water and sediment could be collected. A number of sites presented a safety risk to samplers due to the presence of crocodiles (both saltwater and freshwater), or changes to instream habitat were such that water was not at a depth wadable by staff with a backpack electrofisher. In these cases, fish sampling was not done. Table 5 details sampling carried out at each site.

Table 5 – Sampling completed at each site in May 2020

Site	Macroinvertebrate sampling	Fish sampling	Habitat assessment	Water quality	Remote camera
SWTG1A	✓	✓	✓	✓	
SWTG1C	✓	✓	✓	✓	
SWTG1	✓	✓	✓	✓	✓
SWTG2	✓	✓	✓	✓	✓
SWTG3	✓		✓	✓	✓
SWTG09	✓	✓	✓	✓	
MBC01A	✓		✓	✓	✓
MBC03	✓	✓	✓	✓	✓
MBC06			✓	✓	
MBC0	✓	✓	✓	✓	✓
CC01	✓	✓	✓	✓	
CC02	✓	✓	✓	✓	
CC03	✓	✓	✓	✓	
CK7	✓	✓	✓	✓	

4.1 Site Conditions

4.1.1 Climate

Rainfall data was sourced from the Bureau of Meteorology Point Stuart Wilderness Lodge station (station number 14263) (BOM 2020), the nearest active rainfall station to Toms Gully Mine. Rainfall data for the period July 2019 to June 2020 is presented in Figure 2. A comparison to long-term average rainfall is also displayed in Figure 2, and shows above average rainfall in January. This is indicative of recent years conditions, where rainfall has been more concentrated in a single or two months, and below average for the remainder of wet season months. Rainfall was well below average in the 2019 months of the wet season. Rainfall records show low rainfall in April, which would have resulted in falling and then stable creek conditions leading up to sampling.

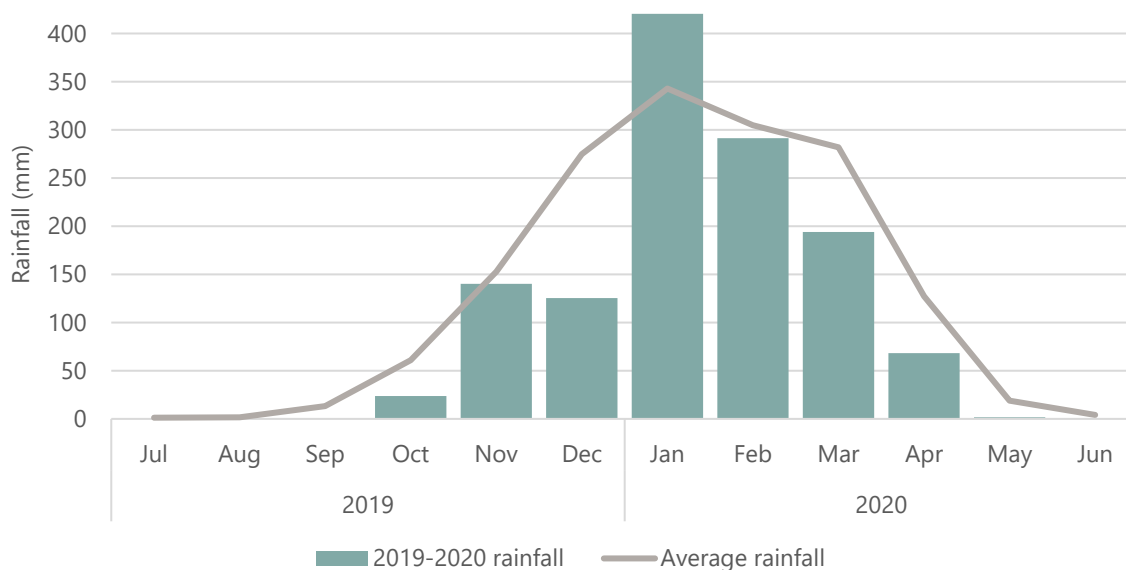


Figure 2 -Rainfall recorded at Point Stuart Wilderness Lodge 2019-2020 compared with long-term average rainfall

4.1.2 Site descriptions

A description of habitat characteristics associated with monitoring sites sampled in May 2020 are presented in Table 6 and Table 7, along with site photographs taken at the time of sampling.

Table 6 – Aquatic ecology sampling site descriptions on Mount Bunday Creek, May 2020

Site description	Site photo
SWTG1C - Upstream The site was made up of a number of isolated pools bound by bedrock. Water was clear. Bed material was a mixture of bedrock, cobbles and sand. The riparian zone was continuous, and overhanging vegetation trailed in water. Exposed roots and undercut banks were common, along with leaf packs and sticks. A large pool was located upstream, which showed evidence of crocodiles inhabiting the area.	
SWTG1A – Upstream The site was made up of a series of large pools. There was no visible flow at the time of sampling, but subsurface connection is assumed. The creek was lined by a closed canopy of riparian vegetation and so shading was high. The left bank was steep, and a mixture of consolidated clay and gravel with	

Site description	Site photo
sections of bedrock, while the right bank was a gentle slope and consisted of cobbles and pebbles.	
SWTG09 – Adjacent The site was a series of isolated pools separated by bedrock located on a tributary of Mount Bundey Creek. The pools had vertical banks that were undercut along almost the entire area of all pools. Each end of the pools was lined with bedrock and cobbles. The site had been intersected by a new fence line. Sampling was moved upstream to avoid habitat impacted by the fence line.	
SWTG1 – Adjacent The site is made up of two large, deep pools, connected by a shallow run. The substrate of both pools is made up of sand and gravel, and the connecting run has substrate made up of pebbles, cobbles and sand. Both banks of the pool are lined by continuous riparian vegetation providing shade and exposed roots. Undercut banks were prevalent, along with leaf packs and small log jams.	
MBC0 – Adjacent The site is located approximately 100 m upstream of the confluence between a small, unnamed tributary containing site MBC06 and Mount Bundey Creek. The site was well shaded due to a continuous riparian zone, and presence of trees along banks allowed for exposed roots, large woody debris and leaf packs to be common through the site. The majority of substrate at the site was made up of sand and pebbles. Long gliding pools were connected by shallow runs.	

Site description	Site photo
MBC06 – Adjacent The site is located on a small tributary of Mount Bunday Creek down gradient of EP2. The tributary was almost completely dry, with a number of small, shallow pools remaining. Water and sediment sampling were undertaken, but no biological monitoring was possible. Groundwater flowing from groundwater bores up-gradient of the creek was observed, and iron producing bacteria was seen on the substrate in pools.	
MBC01A – Adjacent The site is made up of two pools intersected by a cattle crossing. The upstream pool is deep, and has very steep clay banks. The downstream pool is shallow, with undercut banks. Both banks in the downstream pool are steep, and the riparian zone along the entire site is dense and continuous, except for the path leading to the cattle crossing on both sides. The substrate of the downstream pool is mostly sand, with some bedrock.	
SWTG2 - Downstream The site is made up of a series of pools connected by runs upstream of a stock crossing. The stock crossing has undergone significant upgrades, which have resulted in erosion and a change in flow through the site from previous years. Downstream of the crossing, the site was a wide, shallow pool. Substrate along the entire reach was a mixture of cobbles, pebbles and sand, with clay banks.	

Site description	Site photo
MBC03 - Downstream The site was characterised by a long shallow run connecting deep pools at either end of the reach. The majority of the run was 0.2 m deep and 3 m wide with some deeper sections adjacent to banks. The substrate was made up mainly of sand and gravel with some accumulation of silt in deeper areas. The creek was highly shaded and undercut banks and exposed fine roots were common on both sides of the creek.	
SWG3 - Downstream The site is the furthest downstream on Mount Bunday Creek, upstream of its confluence with Coulter Creek. The site was characterised by a long pool and run with large woody debris and undercut banks. Substrate was mostly sand, and the substrate was covered for most of the reach by detritus. Bait traps were deployed into a deep pool upstream that was considered unsafe to enter to electrofish.	

Table 7 - Aquatic ecology sampling site descriptions on Coulter Creek, May 2020

Site description	Site photo
CC02 - Reference The site is intersected by a ford made of, cobbles and clay. Upstream of the ford was a large, deep pool. The pool was considered unsafe to enter. Downstream of the ford was a series of pools connected by shallow runs that was 2 m wide for the majority of the reach. The creek was shaded by a dense, 5 m wide, native riparian strip on both banks. Beyond the riparian zone was cleared and the land used for grazing.	

Site description	Site photo
CC01 - Reference The site is located close to Mount Bunday Creek Station cattle yards, with a ford intersecting the creek. The reach extended from the ford downstream. The site was characterised by a meandering run with some deeper pools. Shading was lower in the downstream parts of the creek, with large patches of filamentous algae observed. Banks were eroded close to areas where cattle had been accessing the creek	
CK7 - Reference The site is located downstream of the Arnhem Highway and is a routine water quality monitoring location. The surrounding area is made up of cropping and grazing land. The riparian zone and creek itself were in relatively good condition, and included undercut banks, high shading and leaf litter. Water was slightly turbid and evidence of pigs feeding and wallowing in some pools was observed.	
CC03 - Reference The site is located approximately 1.7km downstream of the Arnhem Highway and is a pool 50 m in length, upstream and downstream of the pool was a shallow run. The pool has a moderate amount of shade, and its banks were heavily eroded with discontinuous riparian vegetation mixed with pasture grasses. The substrate was mostly bedrock, with some deposition of clay and silt in the downstream end of the pool.	

4.2 Water and sediment quality

4.2.1 In situ water quality

In situ water quality data is compiled and presented in Table 8, with comparisons made to ANZECC (2000) guideline values. The following observations about the results can be made:

- Temperatures ranged between 21.9 and 28.3°C, and temperatures were generally linked to the time of day that measurements were made
- All pH results were within the guideline value range, except for MBC01A. Most pH results were circumneutral.
- Dissolved oxygen was low at almost all sites. High shading within both creeks is likely the cause of lower dissolved oxygen than the guideline range. Two sites on Coulter creek recorded dissolved oxygen saturation within the guideline range
- Electrical conductivity was within the guideline value range for most sites. One site on Coulter Creek was above the upper value. The two sites on Mount Bunday Creek that recorded higher EC values were downstream of the tributary containing MBC06, which had a much higher EC recorded than any other. EC values were lower and within the guideline range further downstream.
- Turbidity was generally low across all sites, and exceeded the guideline at one location, which was noted to be heavily silted and contained a cattle crossing.

Table 8 – In situ water quality data collected at aquatic ecology sites in 2020. Guideline exceedances shaded grey

Site Code	Date	Time	Temp (°C)	pH	DO (%)	DO (mg/L)	EC (µS/cm)	Turbidity (NTU)
Guideline Value (ANZECC 2000)			-	6 - 8	85 - 110		20 – 250	50
SWTG1C	5/05/2020	11:10	24.8	6.94	80.1	6.61	66	2.6
SWTG1A	5/05/2020	8:20	23.2	6.46	29.7	2.52	75	21.7
SWTG1	4/05/2020	10:50	24.6	6.89	71.6	5.96	78	8.3
SWTG09	4/05/2020	8:40	21.9	6.92	24.3	2.1	144	34.1
MBC01A	3/05/2020	13:30	24.9	4.24	71	5.83	485	72.5
MBC0	4/05/2020	14:30	26.2	6.68	66.6	5.35	49	5.5
MBC06	3/05/2020	14:05	28.3	6.95	34.1	2.55	4741	6.3
SWTG2	3/05/2020	11:00	24.5	6.19	66	5.51	284	4.3
MBC03	6/05/2020	9:22	23.8	6.78	72.3	6.07	172	37.6
SWTG3	5/05/2020	15:05	24.2	6.68	30.4	2.54	120	26.4
CC02	2/05/2020	10:00	23.9	6.91	30.2	2.49	343	4.2
CC01	2/05/2020	14:00	25.3	7.24	91.3	7.47	191	36.8
CK07	3/05/2020	7:30	22.8	7.8	85.5	7.31	227	3.8
CC03	6/05/2020	12:00	26.3	6.94	52	4.16	213	24.5



4.2.2 Laboratory water quality

Results of laboratory analysis of water quality grab samples from Mount Bunday Creek are presented in Table 9. The following observations are made about the results:

- Elevated dissolved iron concentrations were a feature of surface water quality at a number of sites. The concentration of dissolved iron did not appear to have any clear pattern based on position of sites in the catchment. Local geology is likely to be iron-rich and is therefore dissolved in the waters of Mount Bunday Creek.
- Dissolved cobalt was also elevated upstream, adjacent to and downstream of Toms Gully Mine. Results for cobalt were inconsistent across the project area, and previous aquatic ecology monitoring results for cobalt have not returned concentrations above the guideline value (GHD 2018, GHD 2019). Therefore, these results may be an anomaly which should be viewed in the context of long-term results.
- The difference in alkalinity and ionic composition of surface water at MBC06 compared with other sites indicates the site is influenced by groundwater seepage. It is expected that during recessional flows, groundwater seepage makes up the majority of surface water at the site. Corresponding with the EC result at MBC06, TDS and sulfate results were highest at the site, compared with all sites on Mount Bunday Creek. Downstream at MBC01A, both analytes were lower, and ionic composition had changed.
- A number of dissolved metal concentrations exceeded the guideline values at MBC01A. Elevated dissolved metals at the site are likely to be linked to the location of the site in the catchment relative to TSF2. Several of the dissolved metals continued to exceed the guideline value downstream at SWTG2. All metals, besides zinc, had reduced below the guideline value further downstream at MBC03. Further downstream again, surface water at SWTG3 did not record any analyte with a concentration above the guideline values. The majority of dissolved metal concentrations had reduced to levels similar to sites upstream of the Toms Gully Mine.

Results of laboratory analysis of water quality grab samples from Coulter Creek are presented in Table 10. There was very little variation in results from all sites. A single exceedance of dissolved cobalt was recorded at CC01. Elevated cobalt has not previously been an issue within Coulter Creek (GHD 2018, GHD 2019) and so results should be viewed in the context of long-term results.

4.2.3 Sediment quality

Laboratory derived sediment quality results are presented in Table 11. The benthic layer at SWTG1C was made up predominantly of bedrock and so a sediment sample could not be obtained. Given the higher concentration of dissolved metals at sites downstream of TSF2, it was expected that some accumulation in sediments of those contaminants might be seen. It is possible that the low pH at MBC01A (also likely to be associated with the TSF) is allowing metals to remain in solution, rather than being bound to sediments. There does appear to be some precipitation of metals to sediments at downstream sites MBC03 and SWTG3, which coincide with lower dissolved metal concentrations in surface waters. These concentrations remain below the lower guideline values for sediment.

Table 9 – Laboratory derived water quality results from sites within Mount Bunday Creek

Analyte	Units	LOR	Control		Adjacent					Downstream			Default Guideline Value
			SWTG1C	SWTG1A	SWTG09	SWTG1	MBC0	MBC06	MBC01A	SWTG2	MBC03	SWTG3	
Physicochemical parameters													
TDS	mg/L	5	47	65	51	40	68	4470	70	66	984	66	NA
TSS	mg/L	5	10	32	26	13	22	12	155	10	50	18	NA
Major ions													
Bicarbonate alkalinity	mg/L	5	19	18	34	18	13	190	<5	6	9	16	NA
Carbonate alkalinity	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NA
Total alkalinity as CaCO ₃	mg/L	5	19	18	34	18	13	190	<5	6	9	16	NA
Sulfate as SO ₄	mg/L	1	<1	<1	<1	<1	2	3300	180	86	39	17	210
Chloride	mg/L	1	2	3	4	2	2	17	3	2	2	2	NA
Calcium	mg/L	0.5	2.7	1.9	7.1	2.2	2	330	31	16	7.6	5.3	NA
Magnesium	mg/L	0.5	1.9	1.7	2.6	1.6	1.2	660	19	10	5	3.4	NA
Potassium	mg/L	0.5	1.2	0.9	3.5	1	0.5	5	3.2	1.8	1.4	1.4	NA
Sodium	mg/L	0.5	4.8	4.5	2.4	3.8	2.5	54	6.8	5.1	4.3	3.8	NA



Analyte	Units	LOR	Control		Adjacent					Downstream			Default Guideline Value
			SWG1C	SWG1A	SWG09	SWG1	MBC0	MBC06	MBC01A	SWG2	MBC03	SWG3	
Dissolved metals													
Aluminium	mg/L	0.005	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2	0.03	<0.01	<0.01	pH <6.5: 0.08
													pH >6.5: 0.055
Arsenic	mg/L	0.001	<0.001	0.001	0.002	<0.001	<0.001	0.003	0.002	0.003	<0.001	<0.001	0.013
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.013	0.0043	0.0004	<0.0001	0.0002
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0031*
Cobalt	mg/L	0.001	<0.001	0.003	0.002	<0.001	<0.001	0.002	0.066	0.011	0.001	0.001	0.0014
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.12	0.008	0.001	0.001	0.0014
Iron	mg/L	0.002	0.12	1.4	1.1	0.17	0.07	0.15	1.3	0.02	0.05	0.05	0.7*
Manganese	mg/L	0.0005	0.12	0.67	0.53	0.16	0.057	2.9	3.1	1.1	0.16	0.29	1.9
Nickel	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.005	0.11	0.043	0.006	0.003	0.011
Uranium	mg/L	0.00005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0033	0.002	<0.0005	<0.0005	<0.0005	-
Zinc	mg/L	0.001	0.001	0.001	0.002	<0.001	<0.001	0.004	0.56	0.22	0.037	0.008	0.008

*Indicates draft guideline values (ANZG 2018)

Table 10 – Laboratory derived water quality results from sites within Coulter Creek

Analyte	Units	LOR	CC02	CC01	CK7	CC03	DGVs
Physicochemical parameters							
TDS	mg/L	10	43	64	52	51	NA
TSS	mg/L	5	9	33	21	10	NA



Analyte	Units	LOR	CC02	CC01	CK7	CC03	DGVs
Major ions							
Bicarbonate alkalinity	mg/L	5	61	34	35	27	NA
Carbonate alkalinity	mg/L	5	<5	<5	<5	<5	NA
Total alkalinity as CaCO ₃	mg/L	5	61	34	35	27	NA
Sulfate as SO ₄	mg/L	1	44	16	35	39	210
Chloride	mg/L	1	2	3	4	2	NA
Calcium	mg/L	0.5	13	6.2	8.8	8	NA
Magnesium	mg/L	0.5	12	5.8	8.5	8.1	NA
Potassium	mg/L	0.5	3.8	2.2	2.8	3	NA
Sodium	mg/L	0.5	3	5	3	3	NA
Dissolved metals							
Aluminium	mg/L	0.005	<0.01	<0.01	<0.01	<0.01	pH <6.5: 0.08
							pH >6.5: 0.055
Arsenic	mg/L	0.001	0.002	0.002	<0.001	<0.001	0.013
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.0031*
Cobalt	mg/L	0.001	0.001	0.002	<0.001	<0.001	0.0014
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.0014
Iron	mg/L	0.002	0.07	0.25	0.03	0.01	0.7*
Manganese	mg/L	0.0005	0.95	0.94	0.43	0.073	1.9
Nickel	mg/L	0.001	<0.001	0.001	0.005	0.003	0.011
Uranium	mg/L	0.00005	<0.0005	<0.0005	<0.0005	<0.0005	-
Zinc	mg/L	0.001	<0.001	0.002	0.002	0.005	0.008

*Indicates draft guideline values (ANZG 2018)



Table 11 – Sediment quality results from aquatic ecology monitoring sites, May 2020. All results presented in mg/kg

Sample	LOR	SWTG1A	SWTG09	SWTG1	MBC0	MBC06	MBC01A	SWTG2	MBC03	SWTG3	CC02	CC01	CK7	CC03	GV-low	GV-high
Total Organic Carbon (mg/kg)	100	12000	11000	2900	7100	18000	3900	4400	19000	15000	1100	6300	2700	4600		
Total Organic Carbon (%)	-	1.2	0.29	0.44	1.5	0.71	0.39	1.9	1.8	1.1	0.27	0.46	0.11	0.63		
Aluminium	2	270	320	140	270	800	330	330	1000	520	250	300	260	270		
Arsenic	4	<4	<4	<4	<4	6	<4	8	<4	<4	<4	<4	<4	<4	20	70
Cadmium	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	1.5	10
Cobalt	1	<1	1	<1	<1	1	1	2	2	6	6	2	5	4		
Chromium	1	<1	<1	<1	<1	1	<1	<1	1	<1	<1	1	<1	15	80	370
Copper	1	2	5	<1	2	37	3	5	18	11	1	2	2	3	65	270
Iron	2	1200	930	700	1100	1200	950	830	1200	1500	570	1800	930	1300		
Lead	2	5	9	3	5	7	7	9	7	9	19	8	12	9	50	220
Manganese	1	14	78	91	25	22	86	18	73	230	350	170	280	61		
Nickel	1	<1	1	<1	<1	4	<1	2	3	5	1	1	3	15	21	52
Zinc	1	<1	5	<1	1	20	3	13	13	30	<1	7	11	18	200	410



4.3 Macroinvertebrates

4.3.1 Taxa richness

Taxa richness results for all sites sampled in May 2020 are presented below in Figure 3. The following observations can be made:

- Taxa richness was generally lower at upstream sites on Mount Bundey Creek compared with other site types. This is most likely to be due to a lack of flow at either site, and therefore a lower diversity of microhabitats at both sites.
- The greatest variability in results were observed at sites adjacent to Toms Gully mine. The highest taxa richness was recorded at MBC0. Downstream of the site, taxa richness decreased. Given the poor water quality at MBC01A, this is not unexpected.
- Taxa richness remained low at downstream sites, but appeared to recover at the furthest downstream site, SWTG3. This change matches with recovery in water quality with increasing distance downstream of the mine lease boundary.
- Control sites showed very little variation in taxa richness, although the site furthest downstream did return the lowest taxa richness of any site. At the time of sampling, the site contained less favourable habitat than sites upstream and was not flowing. It is therefore not as likely to contain favourable microhabitats for macroinvertebrates.

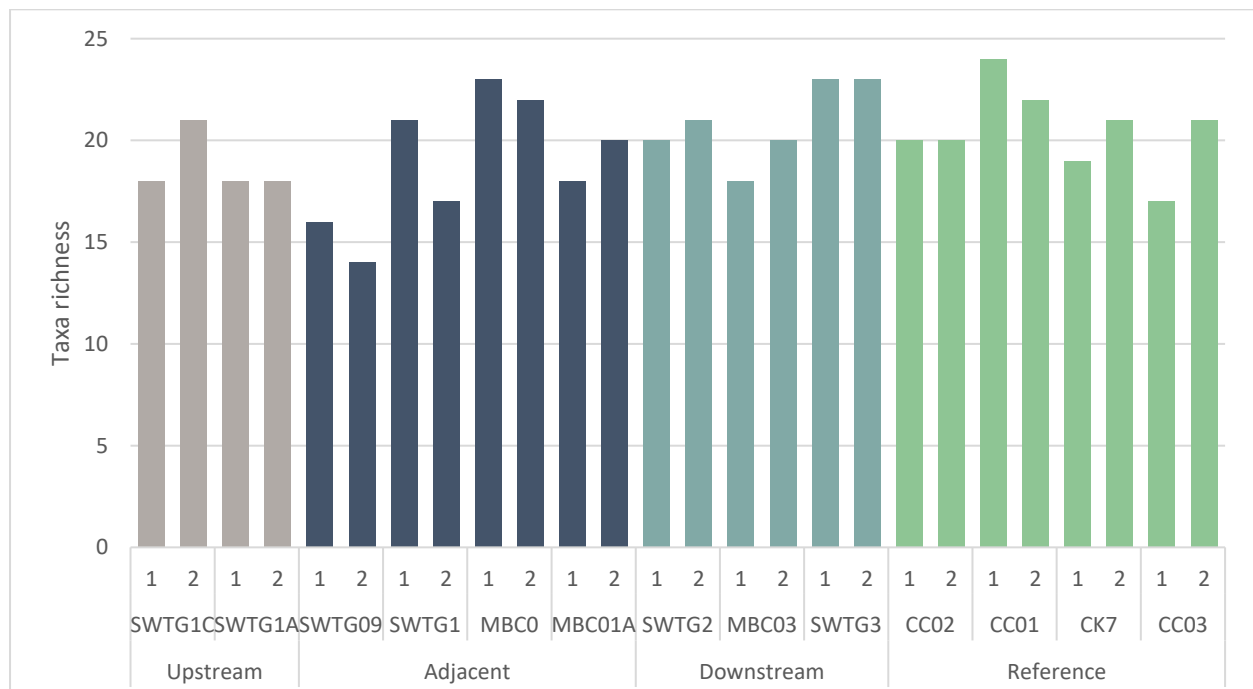


Figure 3 – Taxa richness at sites sampled in May 2020

4.3.2 PET Richness

The taxa richness results for all sites sampled in May 2020 are presented below in Figure 4. The following observations can be made:

- Sites located upstream and adjacent to Toms Gully Mine on Mount Bunday Creek returned similar PET richness results. The exception was SWTG09, which is a smaller tributary and is therefore not likely to contain as many sensitive taxa.
- PET richness was more variable downstream, and increased at the furthest downstream site, SWTG3. Variability at MBC01A and sites downstream are likely caused by differences in habitat availability, but are also likely to be linked to poor water quality at these sites.
- There was a separation in PET richness between sites upstream and downstream of the Arnhem Highway. More PET taxa were found at sites downstream. This indicates some differences in community composition, seeing as taxa richness at Coulter Creek sites were similar.

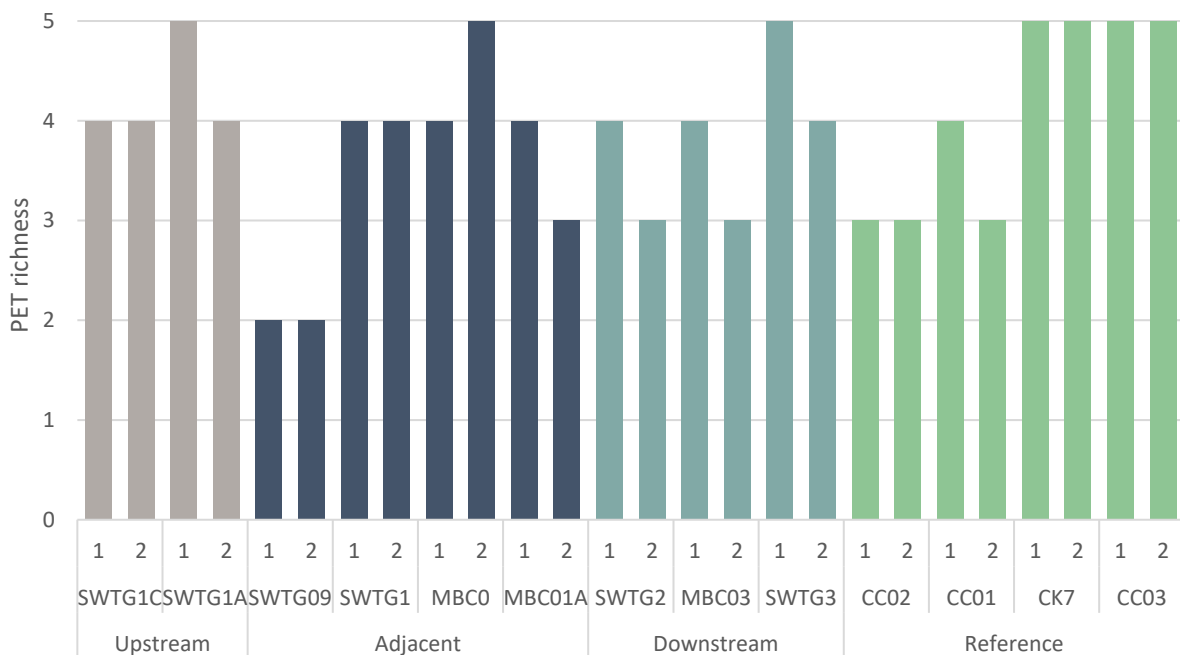


Figure 4 – PET richness at sites sampled in May 2020

4.3.3 SIGNAL-2

SIGNAL-2 scores for all samples collected in May 2020 are presented in Figure 5. Observations regarding the scores are as follows:

- There was very little variation in SIGNAL-2 scores between site types on Mount Bunday Creek (3.29-4.41).
- Sensitivity of taxa to pollution was highest at SWTG2 (but still considered low in terms of sensitivity). This is likely to be an inflated result, based on low taxa richness which has increased the average score.

- Coulter Creek also showed very little variability in SIGNAL-2 scores, with the furthest downstream site achieving the highest score.
- It should be noted that the SIGNAL score range at the sites are well within the pollution tolerant end of the scale (Marshall *et al.* 2001). The macroinvertebrate community surrounding Toms Gully Mine is made up of a community tolerant of intermittent flows and poorer water quality, which is in line with previous findings (GHD (2019)).

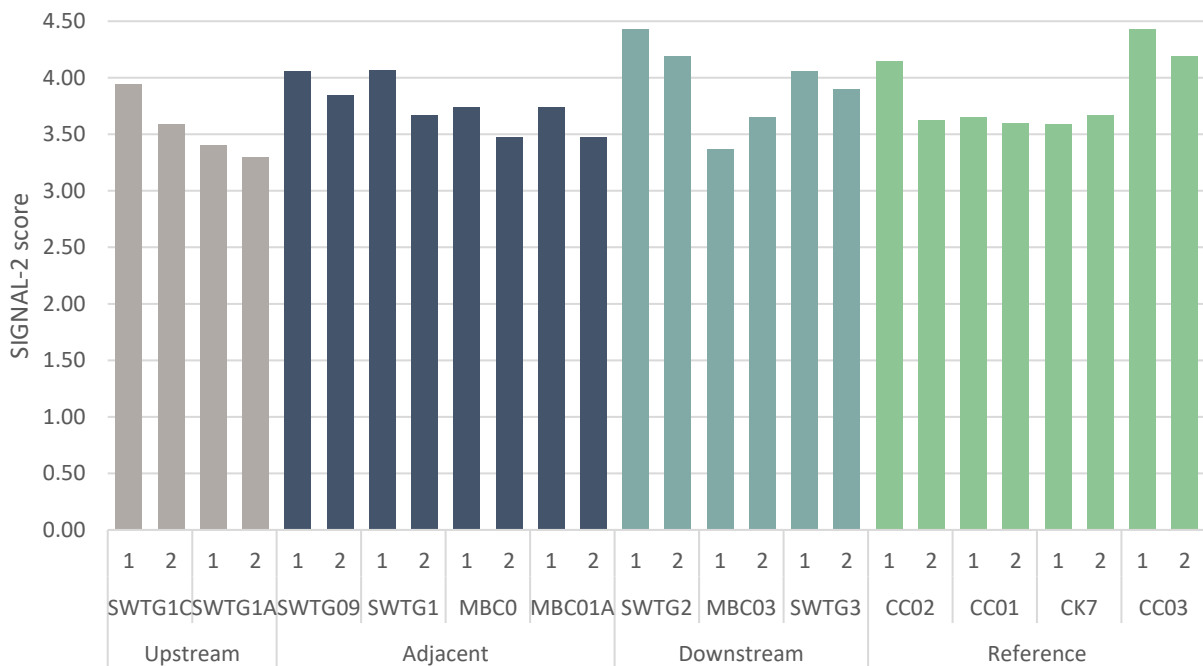


Figure 5 – SIGNAL-2 scores at all aquatic ecology sites visited in May 2020

4.3.4 AUSRIVAS

The outcome of the Darwin-Daly AUSRIVAS modelling for all sites sampled in May 2020 is presented below in Figure 6, and the following observations can be made:

- Where a site achieved both a Band A and a Band B result, the more conservative approach of Band B is assigned (Lamche 2007). Therefore, only sites MBC0 and SWTG3 are considered to be in reference condition. This fits well with water quality results and some other metrics, which suggest impairment downstream of MBC0, with recovery in both water quality and the macroinvertebrate community downstream at SWTG3.
- Although results varied to some degree, there was at least one sample in each site type that returned a Band A result, indicating reference condition.
- Sites upstream of the mine contained fewer families than expected by the model, and this indicates (as other metrics have also indicated) that habitat availability is likely to be driving the scores at the sites.
- On Mount Bunday Creek, the highest OE50 scores were returned at sites upstream of MBC01A, and samples on the tributary of Mount Bunday Creek (SWTG09) recorded the lowest OE50 scores.

- Coulter Creek site CK7 was considered to be in reference condition, whilst other sites were severely impaired. Several families were missing from all samples at all sites on Coulter Creek. This is likely an indication of its size and stream order in the catchment relative to Mount Bunday Creek.

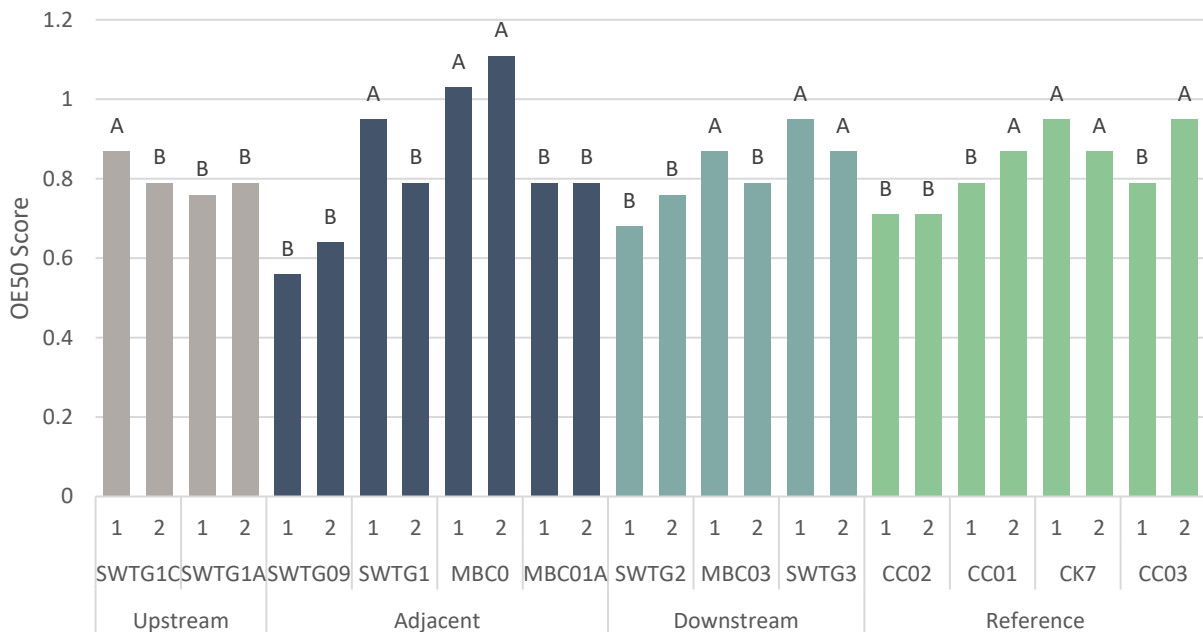


Figure 6 – AUSRIVAS modelling results from samples collected in May 2020

4.3.5 Community composition

The non-metric MDS plot displayed in Figure 7 provides an indication of the relative similarity in the macroinvertebrate community composition between samples collected on Mount Bunday Creek in May 2020. Site SWTG09, located on a much smaller tributary shows a clear separation from sites on Mount Bunday Creek proper. There was at least 50% similarity between all sites on Mount Bunday Creek in 2020, and at least 70% similarity between the majority of sites adjacent to and downstream of Toms Gully Mine.

The results of ANOSIM pairwise tests (Table 12) resulted in a significant difference ($p < 5\%$) between the macroinvertebrate community of upstream and downstream sites. This is not unexpected given habitat availability already noted, along with visible differences in macroinvertebrate community metrics. In the context of historical results, these differences will be an important feature of baseline data when mine water discharges commence.

The macroinvertebrate community of samples collected on Coulter Creek were found to be at least 60% similar to each other (Figure 8), and showed separation between samples collected upstream or downstream of the Arnhem highway. This aligns with some macroinvertebrate metrics calculated for the sites. The similarity between sites gives an indication that this data will be useful in assessing historical changes should operations at Toms Gully Mine begin.

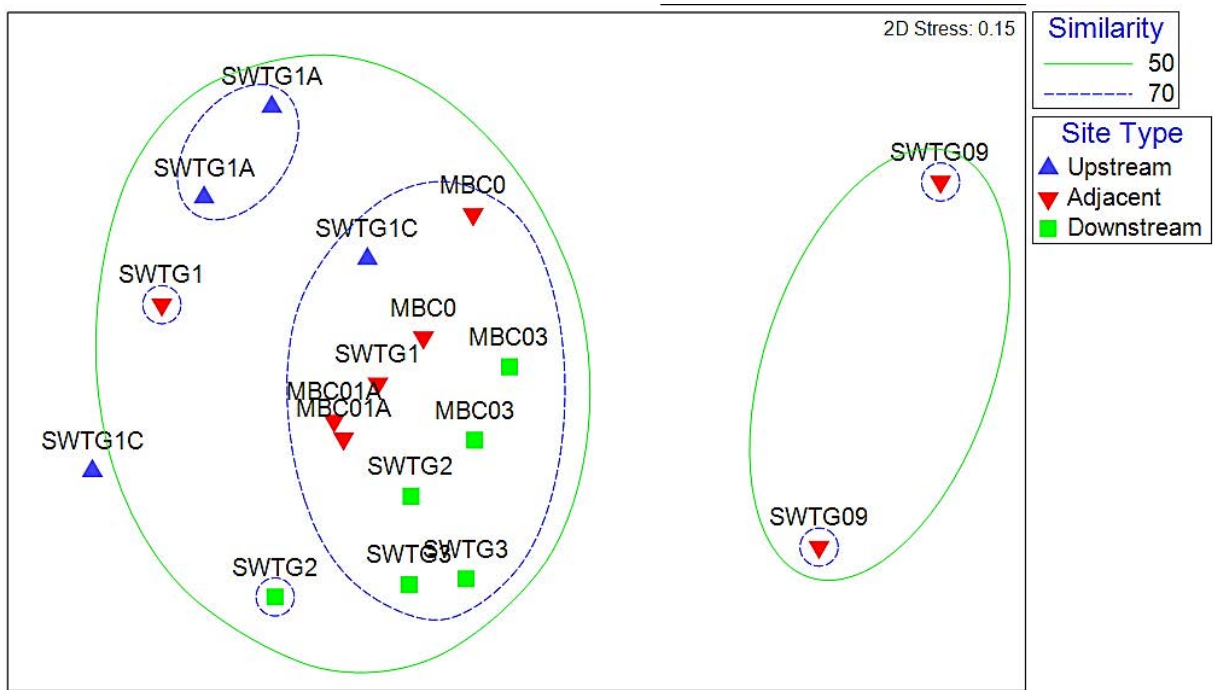


Figure 7 - NMDS demonstrating relative similarity of macroinvertebrate communities in samples collected on Mount Bunday Creek in May 2020

Table 12 – ANOSIM pairwise test results for site types on Mount Bunday Creek

Groups	R Statistic	Significance Level (%)	Possible permutations
Upstream, Adjacent	0.151	13.9	495
Upstream, Downstream	0.813	0.5	210
Adjacent, Downstream	0.148	7.7	999

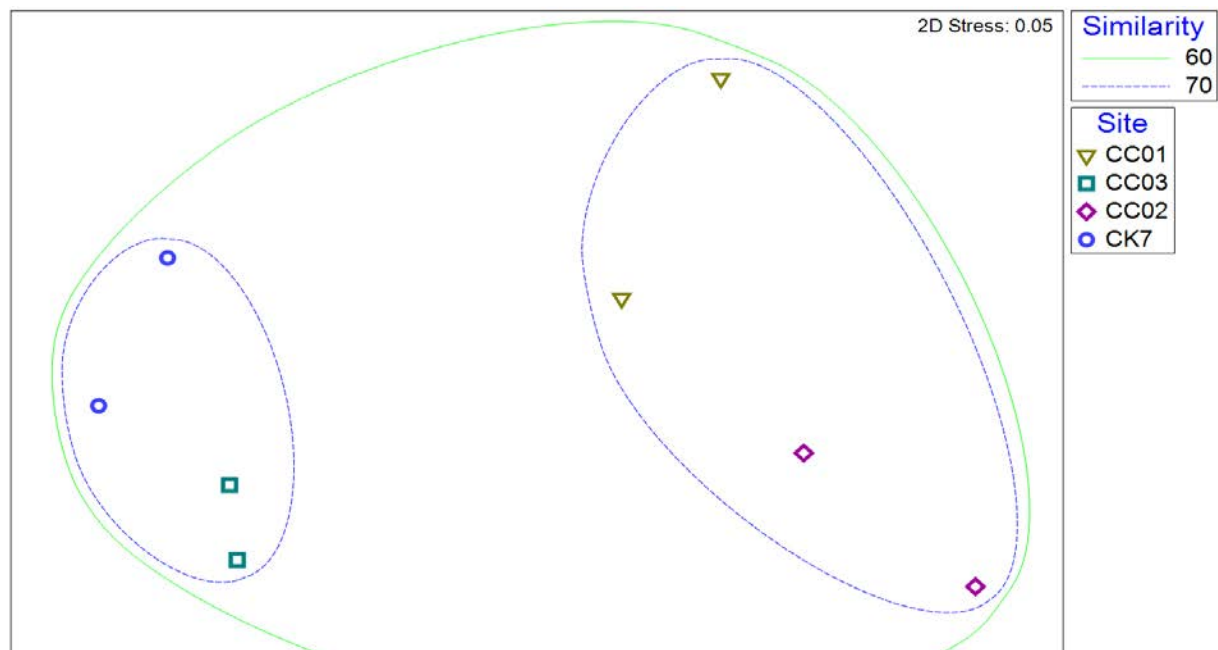


Figure 8 - NMDS showing similarity of macroinvertebrate community in samples on Coulter Creek in May 2020

4.4 Fish community

Fish sampling was possible at a number of sites on Mount Bunday and Coulter Creeks in 2020. Saltwater and freshwater crocodiles were present at several sites. When this occurred, sampling did not take place. Despite this, a number of key sites could be sampled, and the results of electrofishing at each site is presented below in Table 13.

A total of 889 fish were captured across six sites on Mount Bunday Creek and three sites on Coulter Creek. A single new species was captured in 2020 in Coulter Creek (*Porochilus obbes*). A more diverse fish community was found on Coulter Creek, but this is likely to be due to fish being stuck on the downstream side of cattle crossings and the highway crossing. The highest and same diversity of fish were captured at MBC0 and SWTG2, although a higher abundance of fish was captured at SWTG2. At most sites, fish were in good condition, although a number of species were found to have fin damage, missing tails (Plate 1) and ulcers at SWTG2. No fish downstream at MBC03 and SWTG3 were found to contain legions, fin erosion or tail damage.

Table 13 – Fish sampling results for all sites on Coulter and Mount Bunday Creek, May 2020

Species Name	Common name	SWTG1A	SWTG09	SWTG1	MBC0	SWTG2	MBC03	CC02	CC01	CK7
<i>Ambassis agrammus</i>	Sailfin Glassfish	2	0	0	0	2	13	123	64	10
<i>Ambassis interrupta</i>	Longfin Glassfish	1	0	4	28	15*	10	0	0	0
<i>Ambassis sp.</i>	North-west Glassfish	0	0	0	0	1	0	1	0	0
<i>Amniataba percoides</i>	Banded Grunter	0	0	0	0	0	0	68	0	0
<i>Craterocephalus stermerscarum</i>	Fly-specked Hardyhead	0	0	0	0	1	0	0	0	0
<i>Glossamia aprion</i>	Mouth Almighty	0	0	0	1	0	0	1	0	1
<i>Hepaphagus fuluginensis</i>	Sooty Grunter	0	0	0	2	1	0	0	0	0
<i>Leiopatheron unicolor</i>	Spangled Perch	2	6	2	5	0	5	1	7	1
<i>Melanotaenia splendida</i>	Eastern Rainbowfish	16	9	12	16	16*	176	24	39	15
<i>Mogurnda</i>	Northern Purple-spotted Gudgeon	17	27	13	53	12*	11	7	2	4
<i>Neosilurus hyrtlii</i>	Hyrtls Tandan	0	0	0	0	0	0	5	1	0
<i>Neosilurus ater</i>	Black Catfish	0	0	0	0	0	0	2	1	0
<i>Oxyleotris lineolata</i>	Sleepy Cod	0	0	0	1	0	0	0	0	0
<i>Oxyleotris selheimi</i>	Giant Gudgeon	0	0	0	1	1	0	19	9	1
<i>Porochilus obbesi</i>	Obbes Catfish	0	0	0	0	0	0	1	0	0
Diversity		5	3	4	8	8	5	11	7	6
Abundance		215	38	42	31	107	49	215	123	32

*indicates fish with fin damage/ulcers





Plate 1 -Missing tail of Eastern Rainbowfish at SWTG2



Plate 2 – Fin erosion and lesion on Purple-spotted Gudgeon

Fin damage in freshwater fish can be a naturally occurring phenomena that is related to fish competition and predation practices. It can also be linked to stress associated with poor water quality (Denton and Burdon-Jones 1989). Although it cannot be determined from this study if these impacts are directly associated with water quality at SWTG2, the site did record dissolved metal concentrations in surface water which could be potentially ecotoxic. Sites upstream without dissolved metals exceedances, and the site sampled downstream where only a single metal exceeded the guidelines did not contain any fish that appeared to be in poor health. Previous studies at Toms Gully Mine have identified ulcers and legions on fish close to TSF2 (GHD 2017). In 2017, fish at SWTG2 were not found to have these issues, and dissolved metals were also recorded at levels above guideline values at that time.

Rehabilitation of tailings storages is planned as part of the development of the Toms Gully Underground Project, which should assist with water quality issues close to the TSF. Ongoing monitoring should be conducted to assess impacts of dissolved metal concentrations and/or health recovery of fish downstream of Toms Gully Mine.

4.5 Water monitors

Camera units were deployed at six sites across the study areas and were active for between 128 and 133 days, depending on deployment date. This resulted in a total of 781 days of survey effort. All cameras were functional for the entirety of the deployment.

A total of 28 animals were identified on cameras between May and September 2020 (Table 14), including 16 species of birds, 8 mammals, 2 frogs and 2 reptiles. The target species, Mertens Water Monitor (*V. mertens*) was captured at the furthest upstream camera site (SWG1) and furthest downstream camera site (SWG3, Plate 3). There were no sightings of *V. mitchelli* on any of the remote camera units in 2020, as has been the case in previous monitoring events. A large number of non-target species were recorded on cameras during deployment, which is an indirect benefit of the monitoring that continues to add to the fauna register at the site.

Several introduced species, such as cane toads, wild pigs, wild dogs and cattle were common at the majority of sites, with cattle being the most photographed animal at any site.



Plate 3 – Mertens Water Monitor (*Varanus mertens*) captured at SWTG3.

Table 14 – Fauna captured on remote cameras May – September 2020

Group	Scientific Name	Common Name	Adjacent			Downstream		
			SWTG1	MBC01	MBC0	SWTG2	MBC03	SWTG03
Birds	<i>Accipiter fasciatus</i>	Brown Goshawk	✓			✓		
	<i>Anas superciliosa</i>	Pacific Black Duck		✓	✓			✓
	<i>Ardea ibis</i>	Cattle Egret					✓	
	<i>Ardea modesta (alba)</i>	Great Egret		✓		✓	✓	✓
	<i>Aquila audax</i>	Wedge Tailed Eagle				✓		
	<i>Burhinus grallarius</i>	Bush-Stone Curlew	✓					
	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	✓		✓			
	<i>Corvus orru</i>	Torresian Crow	✓			✓	✓	✓
	<i>Falco cenchroides</i>	Nankeen Kestrel						
	<i>Haliastur sphenurus</i>	Whistling kite		✓		✓		✓
	<i>Milvus migrans</i>	Black Kite				✓		
	<i>Myiagra inquieta</i>	Restless flycatcher		✓		✓		✓
	<i>Nycticorax caledonicus</i>	Nankeen Night Heron				✓		✓
	<i>Podargus strigoides</i>	Tawny Frogmouth					✓	
	<i>Radjah radjah</i>	Radjah Shelduck	✓			✓		
	<i>Threskiornis molucca</i>	Australian white ibis				✓		
Reptiles	<i>Scincidae</i>	Skink					✓	
	<i>Varanus mertensi</i>	Mertens' Water Monitor	✓					✓
Mammals	<i>Bos taurus</i>	Cattle		✓		✓	✓	✓



Group	Scientific Name	Common Name	Adjacent			Downstream		
			SWG1	MBC01	MBC0	SWG2	MBC03	SWG03
	<i>Canis lupus dingo</i>	Dingo	✓	✓	✓	✓	✓	✓
	<i>Canis lupus familiaris</i>	Wild Dog				✓		✓
	<i>Felis catus</i>	Cat				✓		
	<i>Hydromys chrysogaster</i>	Water Rat	✓		✓			
	<i>Macropus agilis</i>	Agile wallaby	✓	✓	✓	✓	✓	✓
	<i>Sus scrofa</i>	Feral pig	✓	✓	✓	✓	✓	✓
	<i>Tachyglossus aculeatus</i>	Echidna	✓					
Frogs/Toads	<i>Litoria caerulea</i>	Green Tree Frog					✓	
	<i>Rhinella marina</i>	Cane Toad	✓	✓		✓		✓
Total			12	9	6	17	10	13



5. Conclusions

5.1 Overview

Aquatic ecology surveys were successfully completed at Toms Gully Mine in 2020. All components were completed at sites where access, sufficient water and safety allowed. The following conclusions are made in regards to 2020 monitoring:

- Surface water quality sampling identified potential point source pollution related to an existing tailings storage facility (TSF2), which extended downstream for around 1km to compliance monitoring point SWTG2. Exceedances of the dissolved metal guideline values have been recorded during previously close TSF2. These results present a single sample in time, and should be viewed in the context of historical water quality monitoring. There were no exceedances of water quality guidelines in Coulter Creek.
- Salinity, hardness and ionic composition of surface water at MBC06 indicates it is influenced by groundwater seepage. For several years groundwater seepage from wells up-gradient of the small tributary of Mount Bunday Creek has been observed. Should Toms Gully Mine begin operations, it is expected that dewatering practices will alleviate seepage at this location.
- There was some accumulation of metals in sediments, but no exceedances of guideline values for any parameter. Metals in sediments are therefore not considered to have the potential to be released in concentrations which could be ecotoxic. The exceedance of surface water guideline values, but not sediment guideline values is possibly due to low pH allowing metals to remain dissolved in surface waters close to the TSF (at MBC01A). Downstream of TSF2 where pH was circumneutral, sediments were accumulating some metals, but remained below guideline values.
- Macroinvertebrate community health metrics showed some impairment within Mount Bunday Creek where poor water quality was recorded. Recovery of the macroinvertebrate community coincided with improvements in water quality at the furthest downstream site (SWTG3). The macroinvertebrate community on Coulter Creek was disturbed by ongoing cattle grazing, this did not appear to cause any major variability in the macroinvertebrate community across all sites.
- All macroinvertebrate community data should be viewed in the context of historical data when operations begin at Toms Gully Mine in order to allow for environmental influences (such as wet season rainfall variability) in understanding impacts associated with mining operations.
- Some species of the fish community directly downstream of Toms Gully Mine were found to be in poor condition in 2020. Fin erosion, tail damage and lesions were observed. This may be related to stress associated with poor water quality. Fish further downstream did not exhibit the same symptoms. Fish sampling was not possible due to crocodile safety concerns at MBC01A, the site of previous captures of fish with similar health issues.

- Mertens Water Monitors were observed upstream and downstream of Toms Gully Mine on remote camera traps in 2020. This demonstrates the reptile's continued use of the area, albeit in low numbers. Water monitors are likely to be existing in low numbers due to the presence of cane toads and feral pigs at the site, all of which have impacts on their life history. No Mitchells Water Monitors were captured, which is consistent with previous monitoring at the site.

5.2 Recommendations

It is recommended that the number of sites sampled surrounding Toms Gully Mine can be reduced, and some sampling components concentrated on sites where ongoing monitoring of impacts is necessary. This approach would also take into account safety concerns regarding increased sightings and inhabitation evidence of saltwater crocodiles within Mount Bunday Creek over the past two years. Suggested changes to sampling sites and components are detailed in Table 15. The recommended changes will result in seven sites being sampled on Mount Bunday Creek and three sampling sites on Coulter Creek. Data from all archived sites can be utilised in future monitoring as baseline data.

5.2.1 Site selection

The following considerations have been made in relation to site selection:

- Site SWTG09 is located on a small tributary of Mount Bunday Creek, which was originally included in the sampling design to capture any influence of the sulphide waste rock dump, and because the site was a historical surface water monitoring point. The site has been altered significantly by recent fencing works, are likely to show disturbance at the site not related to the mine. Any influence associated with flow from this site can be captured at SWTG1, which is located downstream
- Site MBC06 has remained highly influenced by groundwater for a number of years. This site should be removed as it is not representative of sites on Mount Bunday Creek, and rarely holds sufficient water for biological sampling.
- Sites on Coulter Creek can be reduced to a site upstream of the Arnhem Highway, and one downstream of the highway. an additional site on Coulter Creek should be established further downstream. The site should be located upstream of the Confluence with Mount Bunday Creek to allow for capture of downstream data associated with possible discharges to Lake Bazzamundi, which Aquatic Ecology Services understands will enter Coulter Creek downstream of the Arnhem Highway.
- It has been increasingly common to see crocodiles at Site MBC01A and its predecessor, MBC01. Wading in waters in this section of Mount Bunday Creek should therefore be avoided.

5.2.2 Sampling components

The following recommendations are made regarding sampling components:

- Impacts of poor water quality on fish have been observed at sites downstream of TSF2 on several occasions. It is expected that poor water quality associated with surface/groundwater connection



between tailings storages and Mount Bundey Creek may continue to impact on fish in the catchment. For this reason, fish sampling should concentrate on sites upstream and downstream of the TSF. It is considered that sufficient data has been collected for the Coulter Creek catchment in relation to the fish community.

- During aquatic ecology surveys, surface water and sediment sampling should continue at MBC01A to monitor influence of TSF2 over time, with SWTG2 providing a sufficient location for downstream biological monitoring.
- Sediment sampling should continue at all sites to monitor any potential accumulation of metals in sediments over time. 2020 was the first instance in which samples were sieved to only sample the fine sediment fractions. This process allows for the most conservative test of fine sediments most likely to bind metals. Sieving of samples should continue in the future to allow for historical comparison.
- Macroinvertebrates remain the most reliable indicator of aquatic ecosystem health and should be continued at all sites retained for the sampling program. Maintaining an unbroken record of biological monitoring at the site will allow for changes in ecosystem health to be recognised. Additionally, a data set which spans many years of variable climatic conditions allows for environmental factors to be considered when interpreting results during mining operations.
- Remote camera monitoring has been successful in capturing one of two target species, and is increasing Hanking's data set in relation to fauna present at the site. It is suggested that this monitoring continue to assist with detecting any changes in species accessing waterways and to gather information on animals potentially causing impacts to the watercourse that are unrelated to mining operations.



Table 15 – suggested changes to sampling plan at Toms Gully Mine for future baseline monitoring.

Site	Macroinvertebrates	Fish	Habitat assessment	Water quality	Remote cameras	Comments
SWTG1C	✓	✓	✓	✓		Retain as an upstream reference site, fishing not required
SWTG1A	✓		✓	✓		Retain as an upstream reference site
SWTG1	✓	✓	✓	✓	✓	Retain as an adjacent site, fishing not required
MBC0	✓		✓	✓	✓	Retain as an adjacent site
MBC01A				✓	✓	Retain site for water and sediment quality sampling only
SWTG2	✓	✓	✓	✓	✓	Retain as a downstream impact site
MBC03			✓	✓		Retain as downstream recovery site
SWTG3	✓		✓	✓	✓	Retain as downstream recovery site, fish sampling unsafe.
CC02	✓		✓	✓		Retain as reference site, fishing no longer required
CK7	✓		✓	✓		Retain as reference site, fishing no longer required
CC03						Remove site and establish new site closer to confluence of Mount Bunday Creek and Coulter Creek.
SWTG09						Remove
MBC06						Remove
CC01						Remove

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Appendix A. Certificates of Analysis



CERTIFICATE OF ANALYSIS 244117**Client Details**

Client	Primary Gold Ltd
Attention	Charles Hastie
Address	PO Box 1311, SUBIACO PO, WA, 6904

Sample Details

Your Reference	<u>Water Analysis</u>
Number of Samples	14 Waters
Date samples received	08/05/2020
Date completed instructions received	08/05/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	14/05/2020
Date of Issue	14/05/2020

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By

Heram Halim, Operations Manager

Authorised By

Michael Kubiak, Laboratory Manager

Client Reference: Water Analysis

Miscellaneous Inorganics

Our Reference			244117-1	244117-2	244117-3	244117-4	244117-5
Your Reference	UNITS	PQL	SWG1C	SWG1A	SWG01	SWG2	SWG3
Date Sampled			05/05/2020	05/05/2020	04/05/2020	03/05/2020	05/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Date analysed	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Dissolved Organic Carbon	mg/L	1	3	<1	2	1	3
pH	pH Units		6.7	6.2	6.6	5.9	6.4
Electrical Conductivity (EC)	µS/cm	1	51	46	45	230	90
Total Suspended Solids	mg/L	5	5	15	<5	6	<5
Total Dissolved Solids (grav)	mg/L	5	31	28	27	170	54
Turbidity	NTU	0.1	3.4	3.2	4.8	2.2	4.8

Miscellaneous Inorganics

Our Reference			244117-6	244117-7	244117-8	244117-9	244117-10
Your Reference	UNITS	PQL	MBC0	MBC1A	MBC3	MBC06	SWG09
Date Sampled			04/05/2020	03/05/2020	06/05/2020	03/05/2020	04/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Date analysed	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Dissolved Organic Carbon	mg/L	1	2	3	1	28	9
pH	pH Units		6.4	4.2	6.2	7.3	6.7
Electrical Conductivity (EC)	µS/cm	1	35	450	130	4,500	79
Total Suspended Solids	mg/L	5	5	15	<5	18	15
Total Dissolved Solids (grav)	mg/L	5	21	350	90	5,400	48
Turbidity	NTU	0.1	3.5	2.5	3.4	2.1	20

Miscellaneous Inorganics

Our Reference			244117-11	244117-12	244117-13	244117-14
Your Reference	UNITS	PQL	CK7	CC03	CC02	CC01
Date Sampled			02/05/2020	06/05/2020	02/05/2020	02/05/2020
Type of sample			Water	Water	Water	Water
Date prepared	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020
Date analysed	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020
Dissolved Organic Carbon	mg/L	1	4	4	7	2
pH	pH Units		7.0	6.9	6.9	6.9
Electrical Conductivity (EC)	µS/cm	1	160	160	220	130
Total Suspended Solids	mg/L	5	9	<5	14	<5
Total Dissolved Solids (grav)	mg/L	5	110	130	160	94
Turbidity	NTU	0.1	3.8	6.7	2.1	8.4

Client Reference: Water Analysis

Ionic Balance							
Our Reference			244117-1	244117-2	244117-3	244117-4	244117-5
Your Reference	UNITS	PQL	SWG1C	SWG1A	SWG01	SWG2	SWG3
Date Sampled			05/05/2020	05/05/2020	04/05/2020	03/05/2020	05/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Date analysed	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Calcium - Dissolved	mg/L	0.5	2.7	1.9	2.2	16	5.3
Potassium - Dissolved	mg/L	0.5	1.2	0.9	1	1.8	1.4
Magnesium - Dissolved	mg/L	0.5	1.9	1.7	1.6	10	3.4
Sodium - Dissolved	mg/L	0.5	4.8	4.5	3.8	5.1	3.8
Bicarbonate HCO ₃ ⁻ as CaCO ₃	mg/L	5	19	18	18	6	16
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	5	19	18	18	6	16
Chloride	mg/L	1	2	3	2	2	2
Sulphate	mg/L	1	<1	<1	<1	86	17
Ionic Balance	%		7.9	1.7	0.58	-2.4	-0.54
Hardness as CaCO ₃	mg/L	3	15	12	12	80	27

Ionic Balance							
Our Reference			244117-6	244117-7	244117-8	244117-9	244117-10
Your Reference	UNITS	PQL	MBC0	MBC1A	MBC3	MBC06	SWG09
Date Sampled			04/05/2020	03/05/2020	06/05/2020	03/05/2020	04/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Date analysed	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020	08/05/2020
Calcium - Dissolved	mg/L	0.5	2.0	31	7.6	330	7.1
Potassium - Dissolved	mg/L	0.5	0.5	3.2	1.4	5.0	3.5
Magnesium - Dissolved	mg/L	0.5	1.2	19	5.0	660	2.6
Sodium - Dissolved	mg/L	0.5	2.5	6.8	4.3	54	2.4
Bicarbonate HCO ₃ ⁻ as CaCO ₃	mg/L	5	13	<5	9	190	34
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	5	13	<5	9	190	34
Chloride	mg/L	1	2	3	2	17	4
Sulphate	mg/L	1	2	180	39	3,300	<1
Ionic Balance	%		-5.4	-5.5	-2.4	0.18	-2.4
Hardness as CaCO ₃	mg/L	3	9.9	150	40	3,500	28

Client Reference: Water Analysis

Ionic Balance						
Our Reference			244117-11	244117-12	244117-13	244117-14
Your Reference	UNITS	PQL	CK7	CC03	CC02	CC01
Date Sampled			02/05/2020	06/05/2020	02/05/2020	02/05/2020
Type of sample			Water	Water	Water	Water
Date prepared	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020
Date analysed	-		08/05/2020	08/05/2020	08/05/2020	08/05/2020
Calcium - Dissolved	mg/L	0.5	8.8	8.0	13	6.2
Potassium - Dissolved	mg/L	0.5	2.8	3.0	3.8	2.2
Magnesium - Dissolved	mg/L	0.5	8.5	8.1	12	5.8
Sodium - Dissolved	mg/L	0.5	6.0	5.9	7.0	4.6
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	35	27	61	34
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	5	35	27	61	34
Chloride	mg/L	1	3	3	3	5
Sulphate	mg/L	1	35	39	44	16
Ionic Balance	%		-1.7	-1.3	-4.6	-5.6
Hardness as CaCO ₃	mg/L	3	57	53	81	39

Client Reference: Water Analysis

Cyanides in Water							
Our Reference	UNITS	PQL	244117-1	244117-2	244117-3	244117-4	244117-5
Your Reference			SWG1C	SWG1A	SWG01	SWG2	SWG3
Date Sampled			05/05/2020	05/05/2020	04/05/2020	03/05/2020	05/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Date analysed	-		11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Free Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Cyanides in Water							
Our Reference	UNITS	PQL	244117-6	244117-7	244117-8	244117-9	244117-10
Your Reference			MBC0	MBC1A	MBC3	MBC06	SWG09
Date Sampled			04/05/2020	03/05/2020	06/05/2020	03/05/2020	04/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Date analysed	-		11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Free Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Cyanides in Water						
Our Reference	UNITS	PQL	244117-11	244117-12	244117-13	244117-14
Your Reference			CK7	CC03	CC02	CC01
Date Sampled			02/05/2020	06/05/2020	02/05/2020	02/05/2020
Type of sample			Water	Water	Water	Water
Date prepared	-		11/05/2020	11/05/2020	11/05/2020	11/05/2020
Date analysed	-		11/05/2020	11/05/2020	11/05/2020	11/05/2020
Free Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004

Client Reference: Water Analysis

Dissolved Metals in Water							
Our Reference			244117-1	244117-2	244117-3	244117-4	244117-5
Your Reference	UNITS	PQL	SWG1C	SWG1A	SWG01	SWG2	SWG3
Date Sampled			05/05/2020	05/05/2020	04/05/2020	03/05/2020	05/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Date analysed	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Aluminium-Dissolved	mg/L	0.01	0.01	<0.01	<0.01	0.03	<0.01
Arsenic-Dissolved	mg/L	0.001	<0.001	0.001	<0.001	0.003	<0.001
Cadmium-Dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.0043	<0.0001
Cobalt-Dissolved	mg/L	0.001	<0.001	0.003	<0.001	0.011	0.001
Chromium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	0.008	0.001
Iron-Dissolved	mg/L	0.01	0.12	1.4	0.17	0.02	0.05
Lead-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese-Dissolved	mg/L	0.005	0.12	0.67	0.16	1.1	0.29
Nickel-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	0.043	0.003
Uranium-Dissolved	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc-Dissolved	mg/L	0.001	0.001	0.001	<0.001	0.22	0.008

Dissolved Metals in Water							
Our Reference			244117-6	244117-7	244117-8	244117-9	244117-10
Your Reference	UNITS	PQL	MBC0	MBC1A	MBC3	MBC06	SWG09
Date Sampled			04/05/2020	03/05/2020	06/05/2020	03/05/2020	04/05/2020
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Date analysed	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Aluminium-Dissolved	mg/L	0.01	<0.01	2.0	<0.01	<0.01	<0.01
Arsenic-Dissolved	mg/L	0.001	<0.001	0.002	<0.001	0.003	0.002
Cadmium-Dissolved	mg/L	0.0001	<0.0001	0.013	0.0004	<0.0001	<0.0001
Cobalt-Dissolved	mg/L	0.001	<0.001	0.066	0.001	0.002	0.002
Chromium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper-Dissolved	mg/L	0.001	<0.001	0.12	0.001	<0.001	<0.001
Iron-Dissolved	mg/L	0.01	0.07	1.3	0.05	0.15	1.1
Lead-Dissolved	mg/L	0.001	<0.001	0.003	<0.001	<0.001	<0.001
Manganese-Dissolved	mg/L	0.005	0.057	3.1	0.16	2.9	0.53
Nickel-Dissolved	mg/L	0.001	<0.001	0.11	0.006	0.005	0.001
Uranium-Dissolved	mg/L	0.0005	<0.0005	0.0020	<0.0005	0.0033	<0.0005
Zinc-Dissolved	mg/L	0.001	<0.001	0.56	0.037	0.004	0.002

Client Reference: Water Analysis

Dissolved Metals in Water						
Our Reference			244117-11	244117-12	244117-13	244117-14
Your Reference	UNITS	PQL	CK7	CC03	CC02	CC01
Date Sampled			02/05/2020	06/05/2020	02/05/2020	02/05/2020
Type of sample			Water	Water	Water	Water
Date prepared	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020
Date analysed	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020
Aluminium-Dissolved	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Arsenic-Dissolved	mg/L	0.001	<0.001	<0.001	0.002	0.002
Cadmium-Dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt-Dissolved	mg/L	0.001	<0.001	<0.001	0.001	0.002
Chromium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Copper-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Iron-Dissolved	mg/L	0.01	0.03	0.01	0.07	0.25
Lead-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Manganese-Dissolved	mg/L	0.005	0.43	0.073	0.95	0.94
Nickel-Dissolved	mg/L	0.001	0.005	0.003	<0.001	0.001
Uranium-Dissolved	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc-Dissolved	mg/L	0.001	0.002	0.005	<0.001	0.002

Client Reference: Water Analysis

Total Metals in water							
Our Reference			244117-1	244117-2	244117-3	244117-4	244117-5
Your Reference	UNITS	PQL	SWG1C	SWG1A	SWG01	SWG2	SWG3
Date Sampled			05/05/2020	05/05/2020	04/05/2020	03/05/2020	05/05/2020
Type of sample			Water	Water	Water	Water	Water
Date digested	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Date analysed	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Aluminium-Total	mg/L	0.01	0.07	0.04	0.06	0.06	0.05
Arsenic-Total	mg/L	0.001	0.001	0.001	0.001	0.002	0.001
Cadmium-Total	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.0043	0.0001
Cobalt-Total	mg/L	0.001	<0.001	0.004	<0.001	0.012	0.001
Chromium-Total	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper-Total	mg/L	0.001	0.001	<0.001	<0.001	0.012	0.002
Iron-Total	mg/L	0.01	0.61	2.4	0.99	0.35	1.5
Lead-Total	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese-Total	mg/L	0.005	0.17	0.68	0.15	1.1	0.31
Nickel-Total	mg/L	0.001	<0.001	0.001	<0.001	0.047	0.003
Uranium-Total	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc-Total	mg/L	0.001	0.005	0.002	<0.001	0.23	0.01

Total Metals in water							
Our Reference			244117-6	244117-7	244117-8	244117-9	244117-10
Your Reference	UNITS	PQL	MBC0	MBC1A	MBC3	MBC06	SWG09
Date Sampled			04/05/2020	03/05/2020	06/05/2020	03/05/2020	04/05/2020
Type of sample			Water	Water	Water	Water	Water
Date digested	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Date analysed	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020	13/05/2020
Aluminium-Total	mg/L	0.01	0.02	2.0	0.05	0.02	0.06
Arsenic-Total	mg/L	0.001	0.001	0.002	0.001	0.004	0.004
Cadmium-Total	mg/L	0.0001	<0.0001	0.012	0.0005	<0.0001	<0.0001
Cobalt-Total	mg/L	0.001	<0.001	0.062	0.002	0.002	0.003
Chromium-Total	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper-Total	mg/L	0.001	<0.001	0.13	0.002	<0.001	<0.001
Iron-Total	mg/L	0.01	0.86	2.5	0.75	1.4	7.6
Lead-Total	mg/L	0.001	<0.001	0.004	<0.001	<0.001	0.002
Manganese-Total	mg/L	0.005	0.069	3.2	0.20	3.0	0.59
Nickel-Total	mg/L	0.001	<0.001	0.11	0.009	0.006	0.002
Uranium-Total	mg/L	0.0005	<0.0005	0.0026	<0.0005	0.0034	<0.0005
Zinc-Total	mg/L	0.001	<0.001	0.54	0.044	0.004	0.002

Client Reference: Water Analysis

Total Metals in water						
Our Reference			244117-11	244117-12	244117-13	244117-14
Your Reference	UNITS	PQL	CK7	CC03	CC02	CC01
Date Sampled			02/05/2020	06/05/2020	02/05/2020	02/05/2020
Type of sample			Water	Water	Water	Water
Date digested	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020
Date analysed	-		13/05/2020	13/05/2020	13/05/2020	13/05/2020
Aluminium-Total	mg/L	0.01	0.16	0.18	0.04	0.08
Arsenic-Total	mg/L	0.001	0.001	<0.001	0.002	0.004
Cadmium-Total	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt-Total	mg/L	0.001	0.001	<0.001	0.001	0.002
Chromium-Total	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Copper-Total	mg/L	0.001	<0.001	0.001	<0.001	<0.001
Iron-Total	mg/L	0.01	0.68	0.47	2.4	1.7
Lead-Total	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Manganese-Total	mg/L	0.005	0.49	0.083	0.98	0.93
Nickel-Total	mg/L	0.001	0.006	0.003	<0.001	0.001
Uranium-Total	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc-Total	mg/L	0.001	0.005	0.007	0.001	0.003

Client Reference: Water Analysis

Method ID	Methodology Summary
INORG-001	pH - Measured using pH meter and electrode base on APHA latest edition, Method 4500-H+. Please note that the results for water analyses may be indicative only, as analysis can be completed outside of the APHA recommended holding times. Soils are reported from a 1:5 water extract unless otherwise specified.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C based on APHA latest edition Method 2510. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition, Method 2320-B. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
INORG-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180±10°C
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The solids are dried at 104±5°C
INORG-022	Turbidity - measured nephelometrically using a turbidimeter, in accordance with APHA latest edition, 2130 B.
INORG-040	Ion Balance Calculation: Cations in water by ICP-OES; Anions in water by IC; Alkalinity in water by Titration using APHA methods.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110-B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
INORG-110	Total Nitrogen by high temperature catalytic combustion with chemiluminescence detection. Dissolved/Total Carbon and Dissolved/Total Organic and Inorganic Carbon by high temperature catalytic combustion with NDIR
METALS-008	Hardness calculated from Calcium and Magnesium as per APHA latest edition 2340B.
METALS-020	Determination of various metals by ICP-AES.
METALS-022	Determination of various metals by ICP-MS.

Client Reference: Water Analysis

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	244117-2
Date prepared	-			08/05/2020	1	08/05/2020	08/05/2020		08/05/2020	08/05/2020
Date analysed	-			08/05/2020	1	08/05/2020	08/05/2020		08/05/2020	08/05/2020
Dissolved Organic Carbon	mg/L	1	INORG-110	<1	1	3	3	0	102	97
pH	pH Units		INORG-001	[NT]	1	6.7	6.7	0	101	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	<1	1	51	46	10	100	[NT]
Total Suspended Solids	mg/L	5	INORG-019	<5	1	5	6	18	100	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	<5	1	31	28	10	101	[NT]
Turbidity	NTU	0.1	INORG-022	<0.1	1	3.4	[NT]		103	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	9	08/05/2020	08/05/2020		[NT]	[NT]
Date analysed	-			[NT]	9	08/05/2020	08/05/2020		[NT]	[NT]
Dissolved Organic Carbon	mg/L	1	INORG-110	[NT]	9	28	[NT]		[NT]	[NT]
pH	pH Units		INORG-001	[NT]	9	7.3	[NT]		[NT]	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	[NT]	9	4500	[NT]		[NT]	[NT]
Total Suspended Solids	mg/L	5	INORG-019	[NT]	9	18	[NT]		[NT]	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	[NT]	9	5400	[NT]		[NT]	[NT]
Turbidity	NTU	0.1	INORG-022	[NT]	9	2.1	2.1	0	[NT]	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	08/05/2020	08/05/2020		[NT]	[NT]
Date analysed	-			[NT]	11	08/05/2020	08/05/2020		[NT]	[NT]
Dissolved Organic Carbon	mg/L	1	INORG-110	[NT]	11	4	4	0	[NT]	[NT]
pH	pH Units		INORG-001	[NT]	11	7.0	7.0	0	[NT]	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	[NT]	11	160	160	0	[NT]	[NT]
Total Suspended Solids	mg/L	5	INORG-019	[NT]	11	9	[NT]		[NT]	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	[NT]	11	110	[NT]		[NT]	[NT]
Turbidity	NTU	0.1	INORG-022	[NT]	11	3.8	[NT]		[NT]	[NT]

Client Reference: Water Analysis

QUALITY CONTROL: Ionic Balance						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	244117-2
Date prepared	-			08/05/2020	1	08/05/2020	08/05/2020		08/05/2020	08/05/2020
Date analysed	-			08/05/2020	1	08/05/2020	08/05/2020		08/05/2020	08/05/2020
Calcium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	2.7	[NT]		94	[NT]
Potassium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	1.2	[NT]		94	[NT]
Magnesium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	1.9	[NT]		94	[NT]
Sodium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	4.8	[NT]		94	[NT]
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	INORG-006	<5	1	19	20	5	100	[NT]
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	INORG-006	<5	1	<5	<5	0	100	[NT]
Total Alkalinity as CaCO ₃	mg/L	5	INORG-006	<5	1	19	20	5	100	[NT]
Chloride	mg/L	1	INORG-081	<1	1	2	2	0	98	96
Sulphate	mg/L	1	INORG-081	<1	1	<1	<1	0	99	91
Hardness as CaCO ₃	mg/L	3	METALS-008	<3	1	15	[NT]		[NT]	[NT]

QUALITY CONTROL: Ionic Balance						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	08/05/2020	08/05/2020		[NT]	[NT]
Date analysed	-			[NT]	11	08/05/2020	08/05/2020		[NT]	[NT]
Calcium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	8.8	9.2	4	[NT]	[NT]
Potassium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	2.8	2.8	0	[NT]	[NT]
Magnesium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	8.5	8.9	5	[NT]	[NT]
Sodium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	6.0	6.2	3	[NT]	[NT]
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	INORG-006	[NT]	11	35	36	3	[NT]	[NT]
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	INORG-006	[NT]	11	<5	<5	0	[NT]	[NT]
Total Alkalinity as CaCO ₃	mg/L	5	INORG-006	[NT]	11	35	36	3	[NT]	[NT]
Chloride	mg/L	1	INORG-081	[NT]	11	3	[NT]		[NT]	[NT]
Sulphate	mg/L	1	INORG-081	[NT]	11	35	[NT]		[NT]	[NT]
Hardness as CaCO ₃	mg/L	3	METALS-008	[NT]	11	57	60	5	[NT]	[NT]

Client Reference: Water Analysis

QUALITY CONTROL: Cyanides in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	244117-2
Date prepared	-			11/05/2020	1	11/05/2020	11/05/2020		11/05/2020	11/05/2020
Date analysed	-			11/05/2020	1	11/05/2020	11/05/2020		11/05/2020	11/05/2020
Free Cyanide	mg/L	0.004	INORG-014	<0.004	1	<0.004	<0.004	0	97	106
WAD Cyanide	mg/L	0.004	INORG-014	<0.004	1	<0.004	<0.004	0	105	105
Total Cyanide	mg/L	0.004	INORG-014	<0.004	1	<0.004	<0.004	0	103	103

QUALITY CONTROL: Cyanides in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	11/05/2020	11/05/2020		[NT]	[NT]
Date analysed	-			[NT]	11	11/05/2020	11/05/2020		[NT]	[NT]
Free Cyanide	mg/L	0.004	INORG-014	[NT]	11	<0.004	<0.004	0	[NT]	[NT]
WAD Cyanide	mg/L	0.004	INORG-014	[NT]	11	<0.004	<0.004	0	[NT]	[NT]
Total Cyanide	mg/L	0.004	INORG-014	[NT]	11	<0.004	<0.004	0	[NT]	[NT]

Client Reference: Water Analysis

QUALITY CONTROL: Dissolved Metals in Water					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	244117-2
Date prepared	-			13/05/2020	1	13/05/2020	13/05/2020		13/05/2020	13/05/2020
Date analysed	-			13/05/2020	1	13/05/2020	13/05/2020		13/05/2020	13/05/2020
Aluminium-Dissolved	mg/L	0.01	METALS-022	<0.01	1	0.01	0.01	0	97	95
Arsenic-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	96	100
Cadmium-Dissolved	mg/L	0.0001	METALS-022	<0.0001	1	<0.0001	<0.0001	0	96	103
Cobalt-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	91	93
Chromium-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	93	95
Copper-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	92	96
Iron-Dissolved	mg/L	0.01	METALS-022	<0.01	1	0.12	0.12	0	101	#
Lead-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	94	98
Manganese-Dissolved	mg/L	0.005	METALS-022	<0.005	1	0.12	0.12	0	94	82
Nickel-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	92	94
Uranium-Dissolved	mg/L	0.0005	METALS-022	<0.0005	1	<0.0005	<0.0005	0	92	88
Zinc-Dissolved	mg/L	0.001	METALS-022	<0.001	1	0.001	0.001	0	93	101

QUALITY CONTROL: Dissolved Metals in Water					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	13/05/2020	13/05/2020		[NT]	[NT]
Date analysed	-			[NT]	11	13/05/2020	13/05/2020		[NT]	[NT]
Aluminium-Dissolved	mg/L	0.01	METALS-022	[NT]	11	<0.01	<0.01	0	[NT]	[NT]
Arsenic-Dissolved	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Cadmium-Dissolved	mg/L	0.0001	METALS-022	[NT]	11	<0.0001	<0.0001	0	[NT]	[NT]
Cobalt-Dissolved	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Chromium-Dissolved	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Copper-Dissolved	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Iron-Dissolved	mg/L	0.01	METALS-022	[NT]	11	0.03	0.03	0	[NT]	[NT]
Lead-Dissolved	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Manganese-Dissolved	mg/L	0.005	METALS-022	[NT]	11	0.43	0.43	0	[NT]	[NT]
Nickel-Dissolved	mg/L	0.001	METALS-022	[NT]	11	0.005	0.005	0	[NT]	[NT]
Uranium-Dissolved	mg/L	0.0005	METALS-022	[NT]	11	<0.0005	<0.0005	0	[NT]	[NT]
Zinc-Dissolved	mg/L	0.001	METALS-022	[NT]	11	0.002	0.002	0	[NT]	[NT]

Client Reference: Water Analysis

QUALITY CONTROL: Total Metals in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	244117-2
Date digested	-			13/05/2020	1	13/05/2020	13/05/2020		13/05/2020	13/05/2020
Date analysed	-			13/05/2020	1	13/05/2020	13/05/2020		13/05/2020	13/05/2020
Aluminium-Total	mg/L	0.01	METALS-022	<0.01	1	0.07	0.08	13	103	101
Arsenic-Total	mg/L	0.001	METALS-022	<0.001	1	0.001	0.001	0	100	100
Cadmium-Total	mg/L	0.0001	METALS-022	<0.0001	1	<0.0001	<0.0001	0	97	99
Cobalt-Total	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	96	98
Chromium-Total	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	99	100
Copper-Total	mg/L	0.001	METALS-022	<0.001	1	0.001	0.001	0	100	101
Iron-Total	mg/L	0.01	METALS-022	<0.01	1	0.61	0.67	9	112	#
Lead-Total	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	99	98
Manganese-Total	mg/L	0.005	METALS-022	<0.005	1	0.17	0.17	0	98	#
Nickel-Total	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	97	99
Uranium-Total	mg/L	0.0005	METALS-022	<0.0005	1	<0.0005	<0.0005	0	99	100
Zinc-Total	mg/L	0.001	METALS-022	<0.001	1	0.005	0.005	0	99	99

QUALITY CONTROL: Total Metals in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date digested	-			[NT]	11	13/05/2020	13/05/2020		[NT]	[NT]
Date analysed	-			[NT]	11	13/05/2020	13/05/2020		[NT]	[NT]
Aluminium-Total	mg/L	0.01	METALS-022	[NT]	11	0.16	0.17	6	[NT]	[NT]
Arsenic-Total	mg/L	0.001	METALS-022	[NT]	11	0.001	0.001	0	[NT]	[NT]
Cadmium-Total	mg/L	0.0001	METALS-022	[NT]	11	<0.0001	<0.0001	0	[NT]	[NT]
Cobalt-Total	mg/L	0.001	METALS-022	[NT]	11	0.001	0.001	0	[NT]	[NT]
Chromium-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Copper-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	0.001	0	[NT]	[NT]
Iron-Total	mg/L	0.01	METALS-022	[NT]	11	0.68	0.71	4	[NT]	[NT]
Lead-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Manganese-Total	mg/L	0.005	METALS-022	[NT]	11	0.49	0.52	6	[NT]	[NT]
Nickel-Total	mg/L	0.001	METALS-022	[NT]	11	0.006	0.006	0	[NT]	[NT]
Uranium-Total	mg/L	0.0005	METALS-022	[NT]	11	<0.0005	<0.0005	0	[NT]	[NT]
Zinc-Total	mg/L	0.001	METALS-022	[NT]	11	0.005	0.005	0	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
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Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.
Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.	
The recommended maximums for analytes in urine are taken from "2018 TLVs and BEIs", as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.	
Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2	

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

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Measurement Uncertainty estimates are available for most tests upon request.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Percent recovery not available due to the analyte signal being much greater than the spike amount. An acceptable recovery was achieved for the LCS.

CERTIFICATE OF ANALYSIS 244118**Client Details**

Client	Primary Gold Ltd
Attention	Charles Hastie
Address	PO Box 1311, SUBIACO PO, WA, 6904

Sample Details

Your Reference	<u>Toms Gully - Primary Gold</u>
Number of Samples	13 Sediment
Date samples received	08/05/2020
Date completed instructions received	08/05/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	15/05/2020
Date of Issue	15/05/2020
NATA Accreditation Number 2901. This document shall not be reproduced except in full.	
Accredited for compliance with ISO/IEC 17025 - Testing. Tests not covered by NATA are denoted with *	

Results Approved By

Heram Halim, Operations Manager

Authorised By

Michael Kubiak, Laboratory Manager

Client Reference: Toms Gully - Primary Gold

Cyanides in Soil						
Our Reference	UNITS	244118-1	244118-2	244118-3	244118-4	244118-5
Your Reference		SWTG1A	SWTG01	SWTG2	SWTG3	MBC0
Date Sampled		05/05/2020	04/05/2020	03/05/2020	05/05/2020	04/05/2020
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date prepared	-	11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Date analysed	-	11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Free Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
WAD Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Total Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5

Cyanides in Soil						
Our Reference	UNITS	244118-6	244118-7	244118-8	244118-9	244118-10
Your Reference		MBC01A	MBC03	MBC06	SWTG09	CK7
Date Sampled		03/05/2020	06/05/2020	03/05/2020	04/05/2020	02/05/2020
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date prepared	-	11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Date analysed	-	11/05/2020	11/05/2020	11/05/2020	11/05/2020	11/05/2020
Free Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
WAD Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Total Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5

Cyanides in Soil				
Our Reference	UNITS	244118-11	244118-12	244118-13
Your Reference		CC03	CC02	CC01
Date Sampled		06/05/2020	02/05/2020	02/05/2020
Type of sample		Sediment	Sediment	Sediment
Date prepared	-	11/05/2020	11/05/2020	11/05/2020
Date analysed	-	11/05/2020	11/05/2020	11/05/2020
Free Cyanide	mg/kg	<0.5	<0.5	<0.5
WAD Cyanide	mg/kg	<0.5	<0.5	<0.5
Total Cyanide	mg/kg	<0.5	<0.5	<0.5

Client Reference: Toms Gully - Primary Gold

Miscellaneous Inorg - soil

Our Reference		244118-1	244118-2	244118-3	244118-4	244118-5
Your Reference	UNITS	SWTG1A	SWTG01	SWTG2	SWTG3	MBC0
Date Sampled		05/05/2020	04/05/2020	03/05/2020	05/05/2020	04/05/2020
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date prepared	-	12/05/2020	12/05/2020	12/05/2020	12/05/2020	12/05/2020
Date analysed	-	12/05/2020	12/05/2020	12/05/2020	12/05/2020	12/05/2020
Total Organic Carbon by Combustion	mg/kg	12,000	2,900	4,400	15,000	7,100

Miscellaneous Inorg - soil

Our Reference		244118-6	244118-7	244118-8	244118-9	244118-10
Your Reference	UNITS	MBC01A	MBC03	MBC06	SWTG09	CK7
Date Sampled		03/05/2020	06/05/2020	03/05/2020	04/05/2020	02/05/2020
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date prepared	-	12/05/2020	12/05/2020	12/05/2020	12/05/2020	12/05/2020
Date analysed	-	12/05/2020	12/05/2020	12/05/2020	12/05/2020	12/05/2020
Total Organic Carbon by Combustion	mg/kg	3,900	19,000	18,000	11,000	2,700

Miscellaneous Inorg - soil

Our Reference		244118-11	244118-12	244118-13
Your Reference	UNITS	CC03	CC02	CC01
Date Sampled		06/05/2020	02/05/2020	02/05/2020
Type of sample		Sediment	Sediment	Sediment
Date prepared	-	12/05/2020	12/05/2020	12/05/2020
Date analysed	-	12/05/2020	12/05/2020	12/05/2020
Total Organic Carbon by Combustion	mg/kg	4,600	1,100	6,300

Client Reference: Toms Gully - Primary Gold

Metals 1M HCl extractable						
Our Reference	UNITS	244118-1	244118-2	244118-3	244118-4	244118-5
Your Reference		SWTG1A	SWTG01	SWTG2	SWTG3	MBC0
Date Sampled		05/05/2020	04/05/2020	03/05/2020	05/05/2020	04/05/2020
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Aluminium	mg/kg	270	140	330	520	270
Arsenic	mg/kg	<4	<4	8	<4	<4
Cadmium	mg/kg	<0.5	<0.5	<0.5	0.7	<0.5
Cobalt	mg/kg	<1	<1	2	6	<1
Chromium	mg/kg	<1	<1	<1	<1	<1
Copper	mg/kg	2	<1	5	11	2
Iron	mg/kg	1,200	700	830	1,500	1,100
Lead	mg/kg	5	3	9	9	5
Manganese	mg/kg	14	91	18	230	25
Nickel	mg/kg	<1	<1	2	5	<1
Zinc	mg/kg	<1	<1	13	30	1

Metals 1M HCl extractable						
Our Reference	UNITS	244118-6	244118-7	244118-8	244118-9	244118-10
Your Reference		MBC01A	MBC03	MBC06	SWTG09	CK7
Date Sampled		03/05/2020	06/05/2020	03/05/2020	04/05/2020	02/05/2020
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Aluminium	mg/kg	330	1,000	800	320	260
Arsenic	mg/kg	<4	<4	6	<4	<4
Cadmium	mg/kg	<0.5	<0.5	0.5	<0.5	<0.5
Cobalt	mg/kg	1	2	1	1	5
Chromium	mg/kg	<1	1	1	<1	<1
Copper	mg/kg	3	18	37	5	2
Iron	mg/kg	950	1,200	1,200	930	930
Lead	mg/kg	7	7	7	9	12
Manganese	mg/kg	86	73	22	78	280
Nickel	mg/kg	<1	3	4	1	3
Zinc	mg/kg	3	13	20	5	11

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Metals 1M HCl extractable				
Our Reference		244118-11	244118-12	244118-13
Your Reference	UNITS	CC03	CC02	CC01
Date Sampled		06/05/2020	02/05/2020	02/05/2020
Type of sample		Sediment	Sediment	Sediment
Aluminium	mg/kg	270	250	300
Arsenic	mg/kg	<4	<4	<4
Cadmium	mg/kg	<0.5	<0.5	<0.5
Cobalt	mg/kg	4	6	2
Chromium	mg/kg	16	<1	1
Copper	mg/kg	3	1	2
Iron	mg/kg	1,300	570	1,800
Lead	mg/kg	9	19	8
Manganese	mg/kg	63	350	170
Nickel	mg/kg	16	1	1
Zinc	mg/kg	18	<1	7

Client Reference: Toms Gully - Primary Gold

Method ID	Methodology Summary
Ext-054	Analysed by Envirolab Services Sydney, accreditation number 2901
INORG-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids are extracted in a caustic media prior to analysis.

Client Reference: Toms Gully - Primary Gold

QUALITY CONTROL: Cyanides in Soil					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	244118-2
Date prepared	-			11/05/2020	1	11/05/2020	11/05/2020		11/05/2020	11/05/2020
Date analysed	-			11/05/2020	1	11/05/2020	11/05/2020		11/05/2020	11/05/2020
WAD Cyanide	mg/kg	0.5	INORG-014	<0.5	1	<0.5	<0.5	0	106	97
Total Cyanide	mg/kg	0.5	INORG-014	<0.5	1	<0.5	<0.5	0	99	97

QUALITY CONTROL: Cyanides in Soil					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	11/05/2020	11/05/2020		[NT]	[NT]
Date analysed	-			[NT]	11	11/05/2020	11/05/2020		[NT]	[NT]
WAD Cyanide	mg/kg	0.5	INORG-014	[NT]	11	<0.5	<0.5	0	[NT]	[NT]
Total Cyanide	mg/kg	0.5	INORG-014	[NT]	11	<0.5	<0.5	0	[NT]	[NT]

Client Reference: Toms Gully - Primary Gold

QUALITY CONTROL: Miscellaneous Inorg - soil					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			12/05/2020	1	12/05/2020	12/05/2020		12/05/2020	[NT]
Date analysed	-			12/05/2020	1	12/05/2020	12/05/2020		12/05/2020	[NT]
Total Organic Carbon by Combustion	mg/kg	100	Ext-054	<100	1	12000	14000	15	108	[NT]

QUALITY CONTROL: Miscellaneous Inorg - soil					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	12/05/2020	12/05/2020		[NT]	[NT]
Date analysed	-			[NT]	11	12/05/2020	12/05/2020		[NT]	[NT]
Total Organic Carbon by Combustion	mg/kg	100	Ext-054	[NT]	11	4600	4600	0	[NT]	[NT]

Client Reference: Toms Gully - Primary Gold

QUALITY CONTROL: Metals 1M HCl extractable					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	244118-2
Aluminium	mg/kg	2	Ext-054	<2	1	270	260	4	96	99
Arsenic	mg/kg	4	Ext-054	<4	1	<4	<4	0	104	92
Cadmium	mg/kg	0.5	Ext-054	<0.5	1	<0.5	<0.5	0	100	104
Cobalt	mg/kg	1	Ext-054	<1	1	<1	<1	0	97	103
Chromium	mg/kg	1	Ext-054	<1	1	<1	<1	0	96	103
Copper	mg/kg	1	Ext-054	<1	1	2	2	0	97	103
Iron	mg/kg	2	Ext-054	<2	1	1200	1100	9	98	#
Lead	mg/kg	2	Ext-054	<2	1	5	5	0	99	104
Manganese	mg/kg	1	Ext-054	<1	1	14	18	25	98	87
Nickel	mg/kg	1	Ext-054	<1	1	<1	<1	0	100	106
Zinc	mg/kg	1	Ext-054	<1	1	<1	<1	0	99	104

QUALITY CONTROL: Metals 1M HCl extractable					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Aluminium	mg/kg	2	Ext-054	[NT]	11	270	270	0	[NT]	[NT]
Arsenic	mg/kg	4	Ext-054	[NT]	11	<4	<4	0	[NT]	[NT]
Cadmium	mg/kg	0.5	Ext-054	[NT]	11	<0.5	<0.5	0	[NT]	[NT]
Cobalt	mg/kg	1	Ext-054	[NT]	11	4	4	0	[NT]	[NT]
Chromium	mg/kg	1	Ext-054	[NT]	11	16	15	6	[NT]	[NT]
Copper	mg/kg	1	Ext-054	[NT]	11	3	3	0	[NT]	[NT]
Iron	mg/kg	2	Ext-054	[NT]	11	1300	1300	0	[NT]	[NT]
Lead	mg/kg	2	Ext-054	[NT]	11	9	9	0	[NT]	[NT]
Manganese	mg/kg	1	Ext-054	[NT]	11	63	61	3	[NT]	[NT]
Nickel	mg/kg	1	Ext-054	[NT]	11	16	15	6	[NT]	[NT]
Zinc	mg/kg	1	Ext-054	[NT]	11	18	18	0	[NT]	[NT]

Result Definitions

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NA	Test not required
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Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2	

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Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

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Measurement Uncertainty estimates are available for most tests upon request.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

TOC and 1M HCl extractable metals analysis conducted by Envirolab Services. Report 242591.

1M HCl extractable (Bioavailable) metals - The sample is extracted with 1M HCl for one hour at room temperature. The extract is analysed by ICP-OES for all metals except Mercury which is tested by CV-AAS.

Percent recovery is not possible to report due to the high concentration of the elements in the sample. However an acceptable recovery was obtained for the LCS.

Appendix B. Raw Macroinvertebrate Data

Order	Family/Sub-family	SWTG1C	SWTG1C	SWTG1A	SWTG1A	SWTG1	SWTG1	SWTG09	SWTG09	MBC01A	MBC01A	MBC0	MBC0	SWTG2	SWTG2	MBC03	MBC03	SWTG3	SWTG3
Replicate		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Acarina	Acarina	63	200	50	100	10	0	17	14	33	38	18	30	33	35	11	45	28	45
Bivalvia	Hyriidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	18
Bivalvia	Sphaeriidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	13	50	0	0	50	50	13	20	117	100	9	20	0	29	0	9	33	82
Coleoptera	Elmidae	25	0	40	80	0	20	0	0	0	0	9	10	0	0	0	0	0	0
Coleoptera	Gyrinidae	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Hydraenidae	0	0	0	0	10	0	0	0	0	0	18	10	0	0	0	0	0	0
Coleoptera	Hydrochidae	38	25	50	80	0	0	6	10	0	0	36	50	50	12	11	9	0	0
Coleoptera	Hydrophilidae	0	0	20	20	10	20	0	0	50	25	27	50	50	18	22	0	0	9
Coleoptera	Scirtidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Conchostraca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decapoda	Atyidae	13	100	0	0	10	30	15	46	33	25	45	60	33	12	6	9	6	18
Decapoda	Palaemonidae	0	50	0	0	20	10	2	58	0	0	27	20	0	0	17	18	6	9
Diptera	Ceratopogonidae	38	50	20	40	170	70	0	10	33	38	82	100	217	59	61	173	267	745
Diptera	Chaoboridae	0	0	0	0	0	0	98	124	0	0	0	0	0	0	0	0	0	0
Diptera	Chironominae	388	325	630	1200	240	160	160	88	683	613	427	510	733	341	244	382	333	564
Diptera	Culicidae	0	125	10	20	20	20	4	0	17	13	0	0	83	12	0	9	6	0
Diptera	Empididae	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Orthocladinae	0	0	0	0	10	0	0	0	33	13	36	40	0	18	17	36	6	18
Diptera	Tabanidae	0	0	0	0	0	0	0	0	0	0	0	0	33	12	0	0	33	73
Diptera	Tanyderidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	9
Diptera	Tanypodinae	463	1175	650	1000	560	830	58	64	350	275	536	550	1517	518	417	736	183	309
Diptera	Tipulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0



Order	Family/Sub-family	SWG1C	SWG1C	SWG1A	SWG1A	SWG1	SWG1	SWG09	SWG09	MBC01A	MBC01A	MBC0	MBC0	SWG2	SWG2	MBC03	MBC03	SWG3	SWG3
Ephemeroptera	Baetidae	225	250	140	400	240	270	40	12	217	125	27	80	83	71	44	109	22	55
Ephemeroptera	Caenidae	1000	2900	360	900	1010	1090	0	20	1133	738	527	600	50	47	106	155	167	245
Ephemeroptera	Leptophlebiidae	38	200	10	0	30	0	0	0	17	0	27	20	0	0	22	0	0	0
Gastropoda	Planorbidae	125	525	10	40	10	0	4	0	33	38	0	0	67	24	6	9	6	9
Gastropoda	Bithyniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Planorbidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Hemiptera	Corixidae	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Gerridae	25	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Hemiptera	Hydrometridae	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Mesoveliidae	0	0	10	40	0	0	0	10	0	0	9	10	0	0	0	0	0	0
Hemiptera	Micronectidae	13	100	0	100	20	20	13	0	17	50	0	50	83	59	0	9	11	9
Hemiptera	Nepidae	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Hemiptera	Notonectidae	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Hemiptera	Pleidae	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Veliidae	0	50	0	40	0	0	2	0	17	25	0	20	0	12	17	9	11	27
Nematoda	Nematoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0	0	0	0	0	0	0	17	6	0	0	11	9
Odonata	Corduliidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Epiprocta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0
Odonata	Libellulidae	0	0	0	0	0	0	0	0	33	13	0	0	0	0	0	0	0	0
Oligochaeta	Oligochaeta	63	50	0	0	40	0	6	0	167	113	36	50	100	47	106	45	56	73
Trichoptera	Ecnomidae	0	0	0	0	0	0	0	0	0	0	0	10	17	0	0	0	6	9
Trichoptera	Hydroptilidae	0	25	10	20	0	10	0	0	0	0	0	0	0	0	0	0	6	0
Trichoptera	Leptoceridae	25	0	50	120	70	30	2	0	200	113	27	40	233	65	50	73	44	91
Turbellaria	Dugesidae	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbellaria	Temnocephalidae	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Order	Family/Sub-family	CC02	CC02	CC01	CC01	CK7	CK7	CC03	CC03
Replicate		1	2	1	2	1	2	1	2
Acarina	Acarina	22	0	38	13	50	40	25	11
Bivalvia	Hyriidae	0	0	13	13	17	20	0	0
Bivalvia	Sphaeriidae	22	11	0	0	0	0	0	0
Coleoptera	Dytiscidae	33	33	0	38	50	20	0	11
Coleoptera	Elmidae	0	11	0	25	17	20	13	11
Coleoptera	Hydraenidae	0	0	25	0	0	40	0	0
Coleoptera	Hydrophilidae	0	0	13	0	50	20	13	22
Coleoptera	Scirtidae	11	0	0	0	0	0	0	0
Crustacea	Conchostraca	11	0	13	0	0	0	0	0
Decapoda	Atyidae	0	11	13	0	0	0	0	0
Decapoda	Palaemonidae	44	0	25	13	33	0	0	0
Diptera	Ceratopogonidae	222	189	100	150	83	180	188	144
Diptera	Chironominae	544	311	575	1100	50	180	600	567
Diptera	Culicidae	0	11	0	13	17	100	38	22
Diptera	Muscidae	0	0	13	0	0	0	0	0
Diptera	Orthocladiinae	0	0	0	13	17	0	38	33
Diptera	Tanyderidae	0	0	0	0	0	0	13	22
Diptera	Tanypodinae	644	933	425	363	767	380	400	333
Ephemeroptera	Baetidae	111	56	75	150	217	420	113	133
Ephemeroptera	Caenidae	444	822	763	575	1750	2100	938	889
Ephemeroptera	Leptophlebiidae	0	0	0	0	17	20	13	22
Gastropoda	Planorbidae	89	100	188	75	150	220	88	56
Gastropoda	Bithyniidae	0	0	13	0	0	0	0	0
Gastropoda	Planorbidae	0	0	0	0	0	20	0	0
Hemiptera	Gerridae	11	11	0	0	0	0	0	0
Hemiptera	Mesoveliidae	0	0	0	0	0	20	0	0
Hemiptera	Micronectidae	167	78	63	75	0	20	0	0
Hemiptera	Notonectidae	0	11	13	13	17	0	0	0
Hemiptera	Veliidae	22	0	0	0	0	0	0	11
Nematoda	Nematoda	0	0	38	0	0	0	0	0
Odonata	Coenagrionidae	11	22	13	13	0	0	0	0
Odonata	Corduliidae	0	0	0	0	33	20	0	0
Odonata	Libellulidae	33	11	13	13	0	0	0	0
Oligochaeta	Oligochaeta	0	56	100	138	0	40	38	56
Trichoptera	Hydroptilidae	0	0	13	0	50	20	13	33
Trichoptera	Leptoceridae	22	22	25	88	150	240	63	67
Turbellaria	Temnocephalidae	25	0	0	0	0	0	0	0





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Appendix S-2 - Aquatic Ecology Survey 2019



Primary Gold Limited
Toms Gully EIS - Baseline Studies
Aquatic ecology report 2019

October 2019

Executive summary

In situ water quality results from the April 2019 aquatic ecology survey indicated that electrical conductivity (EC) was elevated above the site-specific trigger value (SSTV) at the majority of sites in the study area in 2019, though results were lower than those observed in 2018. The highest EC was observed at aquatic ecology monitoring site MBC06 with a value more than 100 times higher than the SSTV. As identified in 2018, it is likely that this elevated EC at MBC06, along with highly elevated concentrations of sulfate, calcium and magnesium, when compared with results from all other sites, are due to seepage from a nearby groundwater bore.

Water at MBC06 had the highest concentrations of dissolved arsenic, cobalt, manganese, nickel and uranium of all the sites assessed, with cobalt and nickel concentrations exceeding the SSTVs. This provides further evidence that this site is being influenced by groundwater seepage.

Concentrations of dissolved aluminium exceeded the SSTV at adjacent surface water monitoring sites SWTG09 and SWTG1 and downstream sites MBC01A, SWTG2 and SWTG3, with the highest concentration observed at MBC01A. Dissolved aluminium concentrations were below the SSTV at all control and reference sites, indicating possible contributions of aluminium to Mount Bunday Creek from overland flows from Toms Gully Mine. However, the potential impacts appear to be largely localised with furthest downstream sites MBC03 and SWTG3, containing comparatively reduced concentrations of metals apart from aluminium. As such, any impacts on aquatic ecosystems due to water quality are likely to be localised.

Sediment quality in the study area was generally good in 2019, with only cadmium at MBC06 found in concentrations above the default guideline value (DGV), indicating the potential for toxicity to aquatic biota at this location.

The macroinvertebrate community was in good condition at most sites in the study area based on the results of AUSRIVAS modelling and other macroinvertebrate metrics. The exception was MBC06 which exhibited poor macroinvertebrate community condition, likely due to the poor water and sediment quality observed.

*Three sightings of Mertens' Water Monitors (*Varanus mertensi*) were recorded in 2019 at two sites, including one site upstream of Toms Gully Mine, and one site far downstream. No monitors were observed at any site adjacent to the mine or immediately downstream.*

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.4 and the assumptions and qualifications contained throughout the report.

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Appendix B – Raw macroinvertebrate data

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Appendix D – Sediment quality QA

Appendix E – Macroinvertebrate identification QA

Appendix F – Remote camera species list

1. Introduction

1.1 Background

Toms Gully Mine, located near Marrakai in the Northern Territory, has been in operation intermittently since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery, the project area has operated under the ownership of several companies. Most recently, the site was operated by Crocodile Gold until 2010; then after a period of care and maintenance, it was divested to Primary Gold Limited (Primary).

Primary, the current lease owner, proposes to recommence underground mining and ore processing at the Toms Gully Mine.

An aquatic ecology monitoring program conducted in 2015, 2017 and 2018 gathered data on water quality, macroinvertebrate and fish communities, and habitat information for Mount Bunday and Coulter Creeks. This report builds upon the data that has already been collected during those sampling events.

1.2 Scope

The scope of work for this study included:

- An aquatic ecology survey carried out in April 2019 to characterise the existing aquatic health and condition of the receiving environment, including:
 - Macroinvertebrate sampling and aquatic habitat assessment carried out in accordance with the NT AUSRIVAS Darwin-Daly Region Manual (Lamche 2007), with the inclusion of replicate sampling
 - Fish sampling
 - Water and sediment quality sampling and analysis at each site where aquatic ecology monitoring takes place.
- A study design that incorporates locations upstream, within and downstream of the Toms Gully Mine Lease (ML), and as a minimum, assessment of Primary sites SWTG1A (control site) and SWTG2 (potential impact site downstream of Toms Gully Mine).
- Monitoring for the presence of the Mertens' Water Monitor (*Varanus mertensi*) and Mitchell's Water Monitor (*Varanus mitchelli*) downstream of the Toms Gully Mine site.

This report presents the results of the above monitoring conducted in April 2019, as well as an historical analysis of macroinvertebrate results from previous studies in 2015, 2017 and 2018.

1.3 Assumptions

Some data used as part of this report was gathered from external sources, and has not been verified by GHD. Climate data gathered from the Bureau of Meteorology was assumed to be validated and correct at the time it was accessed.

1.4 Limitations

This report has been prepared by GHD for Primary Gold Limited and may only be used and relied on by Primary Gold Limited for the purpose agreed between GHD and the Primary Gold Limited as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Primary Gold Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Primary Gold Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Study area

2.1 Climate

The area in which Toms Gully Mine is located has a tropical monsoonal climate with a pronounced wet season from October to April.

Rainfall data was sourced from the Bureau of Meteorology Point Stuart Wilderness Lodge station (station number 14263) (BOM 2018), the nearest active rainfall station to Toms Gully Mine. Rainfall data for May 2018 to April 2019 is displayed in Figure 2-1 and includes a comparison to long-term monthly median results from data recorded between 1957 and 2019. Rainfall exceeded the long-term median during three of the seven wet season months prior to April sampling.

Watercourses in the study area are ephemeral and cease to flow during the late dry season, but have regular flows during the wet season. Semi-permanent waterholes exist in the area. These are likely to be ecologically important and serve as a refuge for fish and aquatic reptiles during the dry season, as well as being water sources for terrestrial fauna.

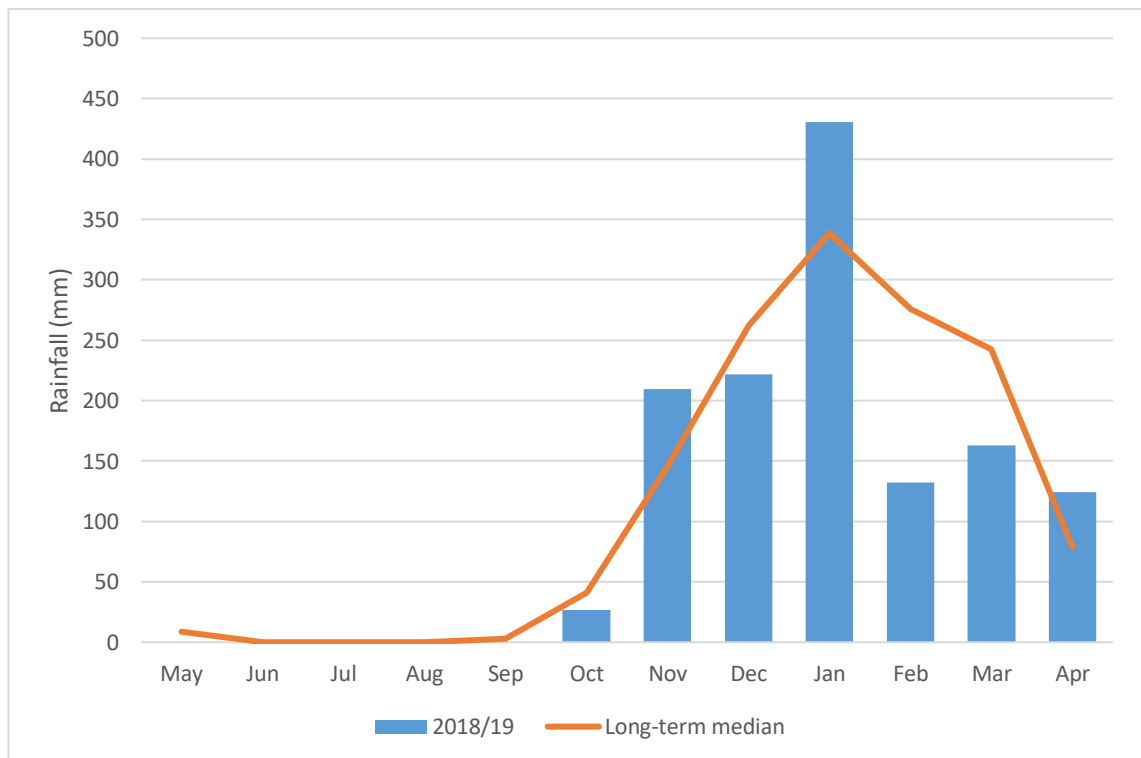


Figure 2-1 Monthly rainfall at Point Stuart Wilderness Lodge weather station (14263) 2018/19, with comparison to long-term median results

2.2 Waterways in the project area

The Toms Gully Mine site is located within the Mount Bunday Creek catchment, which comprises a series of small ridges and dissected hills that are drained by small, steep rivulets converging into Mount Bunday Creek. The majority of the catchment upstream of the project area consists of outcropping rock with thin soil cover and shallow alluvium drainage lines. The total catchment area upstream from the mine is approximately 117 km². Toms Gully mine site is situated at approximately 40 m AHD and, is therefore considered to be a lowland river for assessment against water quality guidelines. For the purpose of AUSRIVAS assessment, the site is located within the Darwin-Daly Catchment.

Mount Bunday Creek flows west to east along the northern section of the project area. The creek is approximately 30 km long with 13 km of the creek upstream of the mine site. It has several tributaries upstream of the project area. Downstream from the mine site it drains into Hardies Creek, and then the Mary River.

Coulter Creek is a tributary of Mount Bunday Creek and flows southwest to east (to the south of the project area). Coulter Creek flows into Mount Bunday Creek downstream of the project area, and compliance monitoring site SWTG2, and therefore, is not influenced by Toms Gully Mine.

3. Methodology

3.1 Survey timing

Sampling was undertaken between 15 and 20 April 2019. Rainfall during April was higher than median levels (Figure 2-1), resulting in higher water levels across all sites than during previous monitoring events.

A crocodile spotter was present for all field surveys to reduce the risk of crocodile attack.

3.2 Survey sites

3.2.1 Aquatic ecology survey

Aquatic ecology sampling was undertaken at 14 sites in April 2019 as outlined in Table 3-1 and Figure 3-1. On Mount Bunday Creek, 10 sites were sampled, consisting of two control sites upstream of the mine (including new site SWTG1C), five sites adjacent to the mine, and three sites downstream of the mine. Four sites were sampled on the reference system Coulter Creek. There is no direct discharge from the mine site into Coulter Creek.

Table 3-1 Aquatic ecology monitoring site details for sites visited in April 2019. Coordinates in zone 52L.

Site	Easting	Northing	Location	Site Type
Mount Bunday Creek Catchment				
SWTG1C	775674	8579115	Mount Bunday Creek approximately 2.5 km upstream of SWTG1A.	Control
SWTG1A	776351	8580503	Mount Bunday Creek upstream of mine at lease boundary.	Control
SWTG09	776766	8580098	Tributary adjacent to EP1 and EP2, approximately 200 m upstream of the confluence with Mount Bunday Creek.	Adjacent to Mine
SWTG1	776825	8580290	Mount Bunday Creek at confluence of tributary adjacent to EP1 and EP2	Adjacent to Mine
MBC0	777606	8580736	Mount Bunday Creek upstream of tributary draining EP1 and EP2	Adjacent to Mine
MBC06	777293	8580350	Mount Bunday Creek downstream on tributary draining EP1 and EP2	Adjacent to Mine
MBC01A	778787	8580437	Mount Bunday Creek downstream of wetland oxbow and Toms Gully Mine Tailings Dam 2 (TSF2). Located 700 m downstream of previously monitored site MBC01.	Adjacent to Mine
SWTG2	779453	8580428	Compliance monitoring point at Arnhem Highway Crossing	Downstream
MBC03	780604	8580044	Mount Bunday Creek approximately 1.8 km downstream of SWTG2.	Downstream
SWTG3	782278	8579366	300 m upstream of confluence between Mount Bunday Creek and Coulter Creek	Downstream
Coulter Creek Catchment (Reference sites)				
CC02	778299	8578355	Coulter Creek. Approx. 2 km upstream from CK7	Reference
CC01	779293	8578801	Coulter Creek approximately 1 km upstream from CK7	Reference

Site	Easting	Northing	Location	Site Type
CK7	779807	8579538	Coulter Creek. Existing monitoring site located at highway crossing	Reference
CC03	780166	8579675	Coulter Creek approximately 750 m downstream of CK7	Reference

3.2.2 Water monitor survey

Remote cameras were set up in six locations along Mount Bunday Creek (Table 3-2; Figure 3-2) in order to monitor the presence of Mitchell's and Mertens' Water Monitors. Where possible, cameras were set up in locations close to aquatic ecology sites where habitat was considered favourable for their presence. One camera was located upstream of Toms Gully Mine, and the remaining five were located downstream.

Table 3-2 Remote camera locations

Camera Code	Easting	Northing	Associated aquatic ecology site
M1	778691	8580427	MBC01
M3	776351	8580503	SWTG1A (control site)
M4	780126	8580212	Not applicable.
M5	779453	8580428	SWTG2
M7	778787	8580437	MBC01A
M8	782278	8579366	SWTG3

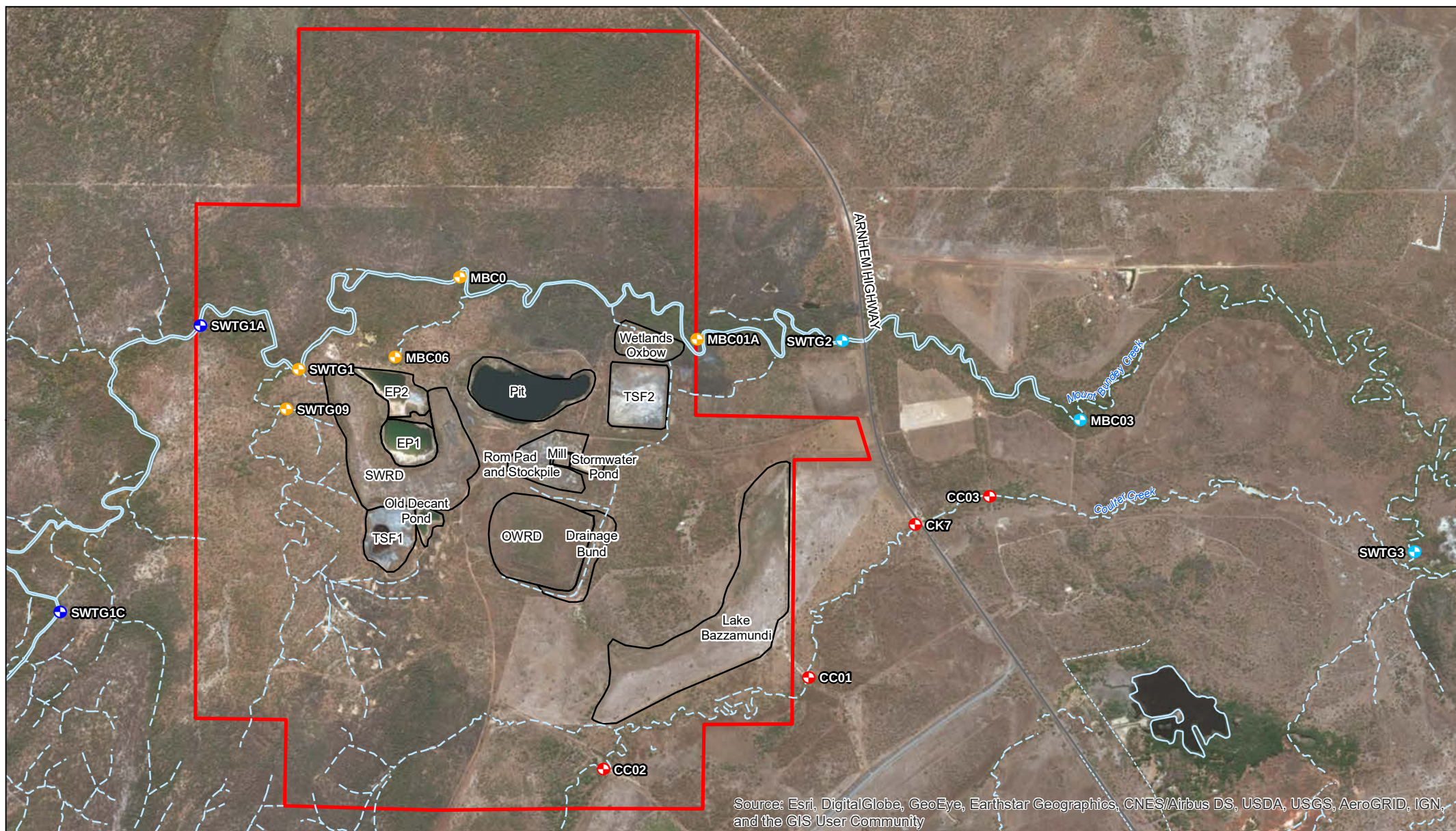
3.3 Habitat assessment

Information about site habitat conditions were recorded at each site following the criteria listed in the Northern Territory AUSRIVAS Darwin-Daly field sheets (Lamche 2007). Habitat assessment at each site included the whole reach (100 m section of the river), the habitats sampled, and the surrounding terrestrial environment. This included information on:

- Site description, including field estimates of stream width, bank height and riparian width
- Characteristics of macroinvertebrate habitat
- Riparian vegetation characteristics (types, % cover, exotic species, erosion, land use)
- Water and sediment quality observations (clarity, odour, oils, foam/scum, plume) and
- A sketch of each site.

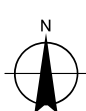
The information recorded was used to help interpret trends in the biological data and to provide input data for the Darwin-Daly AUSRIVAS model.

Photos were taken of upstream and downstream sections of the sampled stream reach, as well as bank habitat and other key habitat features to further characterise the habitat conditions at each site. These serve as a pictorial record of site conditions that can be tracked over time using photos taken from the same points.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Paper Size A4
0 125 250 500 750
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52



LEGEND

Aquatic ecology monitoring site

Adjacent to Mine

Control
Downstream

Reference



Site Boundary

Mine Site Layout

Water Body Perennial

Watercourse Intermittent

Drain

Roads



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Toms Gully Baseline Studies
Aquatic Ecology Report

Job Number 43-22623
Revision 0
Date 17 Oct 2019

Aquatic ecology monitoring
sites visited April 2019

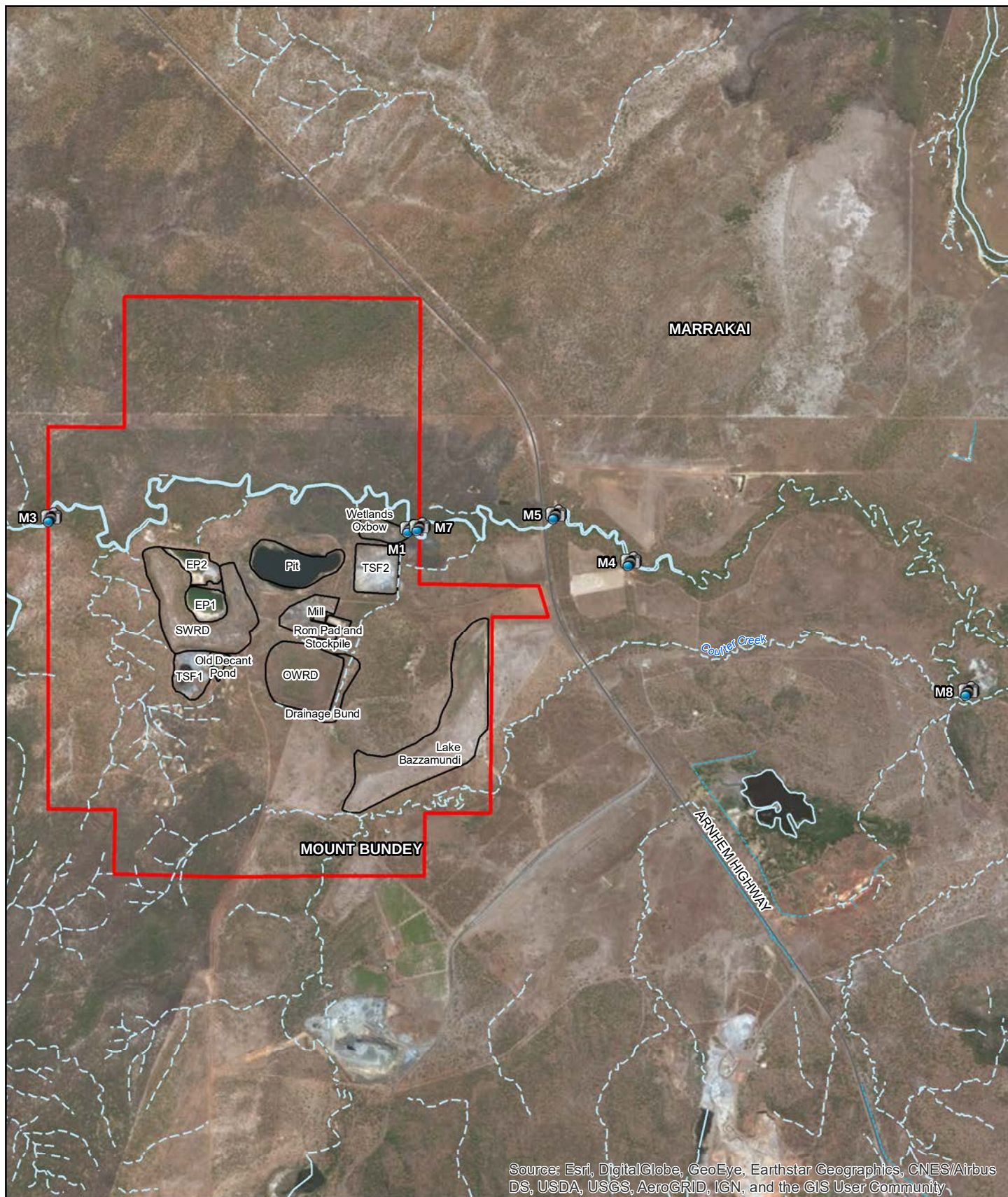
Figure 3-1

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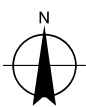
Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmorton, fmacKay, pkien



LEGEND

- Site Boundary
- Mine Site Layout
- Remote camera location
- Water Body Perennial
- Watercourse Intermittent
- Drain
- Roads

Paper Size A4
0 250 500 750 1,000 1,250
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52



PRIMARY
GOLD



Primary Gold Limited
Toms Gully Baseline Studies
Aquatic Ecology Report

Location of remote cameras
used in April 2019 survey

Job Number 43-22623
Revision 0
Date 17 Oct 2019

Figure 3-2

3.4 Water quality

3.4.1 *In situ* water quality

In situ physical and chemical parameters were measured at each site using an Aquaread multi-parameter water quality meter. The water quality meter was calibrated in accordance with the manufacturer's specifications, and used in accordance with operating protocols defined in the GHD Quality Systems manual.

The Aquaread Water Quality meter was used to measure pH, electrical conductivity (EC) ($\mu\text{S}/\text{cm}$), water temperature ($^{\circ}\text{C}$), dissolved oxygen (DO) concentrations (% saturation and mg/L) and turbidity (NTU).

3.4.2 Grab samples

One surface water grab sample was collected at each site prior to the collection of fish and macroinvertebrate samples. Water requiring analysis of dissolved metals was field filtered using a dedicated high volume $45\ \mu\text{m}$ filter prior to collection in the sample bottle. Water samples were analysed for the parameters in Table 3-3. Laboratory certificates of analysis are presented in Appendix A.

Table 3-3 Laboratory water quality analytical schedule

Suite	Analytes
Physico-chemical	Total dissolved solids (TDS), total suspended solids (TSS), turbidity
Major anions	Alkalinity, chloride, sulfate
Major cations	Calcium, magnesium, sodium, potassium
Metals (dissolved and total)	Aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide

3.4.3 Data analysis

Water quality results were compared against the Site Specific Trigger Values (SSTVs) derived for Toms Gully Mine by Stauber and Batley (2018).

3.5 Sediment quality

Sediment samples were collected in accordance with the sediment-water interface hand corer methods as outlined in the Sediment Quality Assessment (Simpson and Batley 2016) guide. Sediment samples were collected at each of the monitoring sites using a plastic trowel. A minimum of two samples were collected from each site and homogenised to produce one composite sediment sample.

The sediment samples were analysed for the parameters presented in Table 3-4 by a NATA accredited laboratory. The laboratory certificate of analysis is presented in Appendix A.

Table 3-4 Laboratory sediment quality analytical schedule

Lab Analyses	Analytes
1M HCl extractable metals	Aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc.
Total recoverable metals	Mercury
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide
Other parameters	Particle size distribution (PSD), total organic carbon (TOC), moisture content.

3.5.1 Data analysis

Sediment quality results from each survey site were compared to the revised toxicant default guideline values (DGVs) sediment quality guidelines for metals and metalloids, as outlined in ANZG (2018). The sediment DGVs represent the thresholds above which biological effects are possible. GV-high values are the thresholds above which there is a high probability of biological effects (ANZG 2018).

3.6 Macroinvertebrates

3.6.1 Sampling methods

Macroinvertebrate sampling and processing followed procedures outlined in the Northern Territory AUSRIVAS manual for the Darwin-Daly region (Lamche 2007). Sampling involved one field team member scraping submerged root matter associated with the lower bank to agitate and remove macroinvertebrates into the water column, while the other field team member swept a dip net through the water column downstream of the edge habitat, to collect the dislodged animals. Areas of riffle or fast flowing habitat, Pandanus roots and severe bank undercuts were avoided when collecting edge habitat samples.

Once collected, the samples were washed through 10 mm and 250 µm mesh sieves. The course mesh sieve was examined for large, conspicuous taxa, and these were placed in the labelled sample container. The sample collected in the fine mesh sieve was also placed in the labelled sample container and filled with 70% ethanol. All samples were processed and macroinvertebrates identified by Aquatic Ecology Services.

3.6.2 Laboratory processing

In addition to the field sieving outlined in 3.6.1, samples were washed through a series of sieves (10 mm, 500 µm and 250 µm mesh sizes) in the laboratory. Any large, conspicuous taxa identified in the 10 mm mesh sieve were added to the contents of the large mesh fraction retained in the field. The contents of the 500 µm mesh sieve were retained for macroinvertebrate identification and enumeration, while the 250 µm fraction was retained as sample residue for quality assurance purposes. The contents of the 500 µm mesh fraction was poured into a Marchant sub-sampler (Marchant, 1989) and extractions made randomly from cells (aliquots) in this apparatus. These extractions were placed under a microscope and the taxa identified and counted. This process continued until either all aliquots were examined, or a total of 200 individuals had been counted and identified. The number of aliquots required to be processed to obtain a minimum 200 individual sub-sample was recorded in order to be able to calculate abundance. Leica MZ9.5 stereo-dissection microscopes with planachromat objectives and a zoom capability between 6.3x and 60x were used to examine specimens.

Taxa were identified to family level where possible, with the exception of key taxa identified in Lamche (2007) as either requiring identification to sub-family level (e.g. Chironomidae) or only to order level (e.g. Acarina). All taxa have been identified using the keys specified in Hawking (2000). Following identification, taxa counts were recorded in Microsoft Excel and samples preserved. Raw macroinvertebrate data are presented in Appendix B.

3.6.3 Data analysis

A number of indices can be used to assess and/or quantify the influence of anthropogenic activities on macroinvertebrate communities. Responses to contaminants or changes in flow can result in anything from changes in abundance and diversity through to changes in community composition such as the loss or reduction of sensitive taxa. As such, a multiple lines of evidence approach has been adopted with regards to interpreting macroinvertebrate community data, with multiple indices calculated.

Univariate analyses

Table 3-5 provides a summary of the univariate macroinvertebrate indices assessed as part of this study and, where relevant, a description of how to interpret results relating to those indices. Lamche (2007) cautions against the use of the SIGNAL-2 index for assessing the status of Northern Territory macroinvertebrate communities. This measure is however, considered appropriate for this study as the number of pollution-sensitive versus pollution-tolerant families does provide some insight into the condition of the macroinvertebrate community.

Table 3-5 Macroinvertebrate indices used as part of this assessment

Macroinvertebrate Index	Description
Taxa richness	The total number of taxa present at each site is a direct measure of diversity. It assumes that a high number of taxa within a site indicate that the various water quality, habitat and food requirements of taxa have been met (though this could also occur through anthropogenic effects that increase food or habitat supply). A negative environmental impact would normally result in the loss of taxa and a decline in taxa richness at a site.
PET richness	PET Richness was calculated as the total number of families from three orders of macroinvertebrates; Ephemeroptera (mayflies); Plecoptera (stoneflies); and Trichoptera (caddisflies). These orders tend to include taxa that are sensitive to disturbance (though some have moderate tolerances to pollution). Therefore, higher numbers of PET taxa are generally taken to indicate a lower level of disturbance.
SIGNAL-2	SIGNAL-2 is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of 10 indicates high pollution sensitivity whilst a value of 1 indicates high pollution tolerance (Chessman 1995). SIGNAL-2 represents the average pollution sensitivity of taxa in a sample. Higher SIGNAL-2 scores generally indicate a higher proportion of pollution-sensitive taxa in a sample. However, high SIGNAL-2 scores can sometimes be observed when there is a small number of taxa collected (i.e. low taxa richness). For this reason, SIGNAL-2 must be assessed in combination with other macroinvertebrate indices.

Macroinvertebrate Index	Description
AUSRIVAS OE50 and bandings	Under the AUSRIVAS model, the expected (E) fauna from reference sites with similar sets of predictor variables (physical and chemical characteristics which cannot be influenced due to human activities e.g. altitude) are compared to the fauna observed (O) during monitoring and the ratio derived is then used to indicate the condition of the macroinvertebrate community. The critical metric in the AUSRIVAS model is the OE50, which is calculated from the O and E measures for macroinvertebrates with a predicted probability greater than 50% of occurring at the site based on habitat variables recorded. The OE50 ratio can range from 0, when none of the expected taxa are found at a site, to >1, when either all the expected taxa are found in a sample or when more families are found in a sample than predicted by the model. The scores derived from the model can be placed in bands delineated by the Monitoring River Health Initiative, which allows assessment of the level of environmental health at a site, as shown in Table 3-6.

Table 3-6 AUSRIVAS OE50 scores and bands for the Darwin-Daly Model.

Band Label	OE50 Upper Limit	Band Name	Band Description
Band X	>1.18	More biologically diverse than reference sites	More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
Band A	1.18	Reference condition	Expected number of families within the range found at 80% of the reference sites.
Band B	0.81	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of families.
Band C	0.44	Severely impaired	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
Band D	0.07	Extremely impaired	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

For this study, macroinvertebrate data was assessed using the NT AUSRIVAS Darwin-Daly Early (dry season) Family level Edge habitat model. The habitat variables required to run this model are latitude, longitude, RIP500 (amount of square kilometres of rainforest within a 500 m radius of a given site) and average stream width. RIP500 data has been estimated using vegetation classification GIS data obtained from DLRM.

Multivariate analysis

A non-metric Multi-Dimensional Scaling (NMDS) analysis was conducted to identify temporal and spatial trends in macroinvertebrate community composition. This multivariate analysis was performed in PRIMER 7 (Clarke and Gorley 2015) statistical analysis software.

Non-metric MDS or ordination provides a graphical representation of the relative similarity of entities (i.e. samples) based on their attributes (i.e. macroinvertebrate community composition) within a reduced dimensional space. The more similar samples are to each other, the closer they are located within the ordination space. The non-metric MDS ordination was performed on Bray-Curtis similarity coefficients which are suitable for biological data (Bray and Curtis 1957). The 2-dimensional ordination has been displayed as this is more easily interpreted than the 3-dimensional plot.

The stress level is a measure of the distortion produced by compressing multi-dimensional data into a reduced set of dimensions and would increase as the number of axes (i.e. dimensions) is reduced. If the stress is over 0.2, the MDS plot must be interpreted with caution.

An Analysis Of Similarities test (ANOSIM) was performed on the macroinvertebrate similarity matrix to test whether macroinvertebrate communities were statistically different between site types and between sampling events. This method permutes the observed data and tests the between group similarity observed under this “random” data set. These values are then compared to the observed similarity and the significance of the test based on whether higher or equal similarity was experienced under the permuted datasets. Interpretation of this technique is based on significance ($p < 5\%$) and strength of the relationship, denoted as R.

3.7 Fish surveys

Electrofishing was attempted at SWTG1, but the turbidity of the water made it difficult to see stunned fish. Electrofishing was not conducted at any other site in 2019 due to fast flowing streams, turbid water and high water levels. Bait trapping was employed at all aquatic ecology sites except SWTG3 and SWTG09. Bait trapping involved setting five rectangular box traps (2 mm mesh size) for approximately four hours at each site. Each trap was baited and deployed close to representative physical habitat structure (e.g. rocks, snags, roots, macrophytes, etc) to maximise the likelihood of catching fish and freshwater prawns.

3.8 Water monitors

All remote cameras were set up with guidance from Gillespie *et al.* (2015). Cameras were attached to trees approximately 0.5 m from the ground, with a bait placed in front of the camera. Cameras were positioned where possible to include areas likely to be used for basking by water monitors, such as banks close to the water and logs. The cameras remained operational between 10 May and 21 August 2018. The camera located upstream (Figure 3-2) of Toms Gully Mine was set up to check for the presence of water monitors outside of the influence of the mine.

3.9 Quality assurance

In accordance with GHD's Quality Assurance (QA) protocol, duplicate water and sediment samples were collected at the same time as the collection of the primary samples during April 2019. The collection of duplicate water and sediment samples allows for the assessment of the potential level of uncertainty associated with natural variability, sampling method, preservation, or laboratory analysis. The results of the duplicate samples are presented in Appendix C for water quality and Appendix D for sediment quality. There were some small differences in the results between the primary sample and the duplicate sample for both water and sediment. However, the variance was within the laboratories acceptable limits.

Two macroinvertebrate samples were reanalysed by a different GHD taxonomist to check the accuracy of identification, the results of which are presented in Appendix E. The percentage of families identified correctly was 100% for both QA samples.

3.10 Summary of sampling tasks

Due to water availability and site characteristics, not all sites were subject to the full spectrum of sampling as described in Sections 3.1 to 3.8. Table 3-7 summarises the sampling tasks carried out at each site.

Table 3-7 Summary of sampling carried out at each site in April 2019

Site	Macroinvertebrate sampling	Fish sampling	Habitat assessment	Water quality	Remote camera
SWTG1A	✓	✓	✓	✓	✓ (M3)
SWTG1C	✓	✓	✓	✓	
SWTG1	✓	✓	✓	✓	
SWTG2	✓	✓	✓	✓	✓ (M5)
SWTG3	✓		✓	✓	✓ (M8)
SWTG09	✓		✓	✓	
MBC01A	✓	✓	✓	✓	✓ (M7)
MBC03		✓	✓	✓	
MBC06	✓	✓	✓	✓	
MBC0	✓		✓	✓	
CC01	✓	✓	✓	✓	
CC02	✓	✓	✓	✓	
CC03	✓	✓	✓	✓	
CK7	✓	✓	✓	✓	
M1					✓
M4					✓

4. Results and discussion

4.1 Site conditions

A description of habitat characteristics associated with monitoring sites sampled in April 2019 are presented in Table 4-1, along with site photographs taken at the time of sampling. At the time of sampling, the water was flowing at the majority of sites and water levels were high compared to previous sampling events.

Left and right banks, as referenced in Table 4-1 is determined when facing downstream.

Table 4-1 Habitat descriptions for sites sampled in April 2019

Site/habitat description	
Control	
SWTG1C	
The site was made up of a series of pools connected by riffles. Flow was strong on the right bank, which was steep and made up of bedrock, exposed roots and clay. The right bank was gentle, and the substrate was cobbles and bedrock. The creek did not span the entire channel, and was confined to the right bank. Vegetation in the riparian zone was growing close to the bank and providing shade to the entire creek. The right side of the channel had trees growing in it, denoting that flow did not increase into this section of the channel often. The substrate was mostly cobbles, but some sand pockets were located on the left side of the creek, where flow was gentle.	
<u>Edge 1 sample:</u>	Left bank. Backwater with submerged woody habitat (SWH) and undercuts. Small pockets of sand and detritus.
<u>Edge 2 sample:</u>	Left bank. Cobbles and leaf packs in a backwater downstream. Exposed roots from Callistemons. Not much sand. Periphyton covering cobbles.
SWTG1A	
Sampling location was moved 100 m downstream due to depth and water clarity. The site was characterised by a wide, shallow pool with gentle flow. Downstream was a stock crossing and deeper pool. The upstream pool was lined by riparian vegetation which was overhanging, and shaded edges. The left bank was steep, and a mixture of consolidated clay and gravel with sections of bedrock, while the right bank was a gentle slope and consisted of cobbles and pebbles. Flow was observably faster along the left bank. Some SWH and undercut roots were present on the left bank, creating a backwater. The riparian zone was ~30 m wide on both sides, and the pool sampled was around 8 m wide and 30 cm deep.	
<u>Edge 1 sample:</u>	Sampled left bank around SWH and some of right bank in sunny areas.

Site/habitat description	
<u>Edge 2 sample:</u>	Sampled right bank in shallow areas, some trailing veg and leaf packs.
Adjacent	
SWTG09	
The site was a series of isolated pools separated by bedrock located on a tributary of Mount Bunday Creek. The pools had vertical banks that were undercut along almost the entire area of all pools. Each end of the pools were lined with bedrock and cobbles. Trees lined the site, but the riparian zone was discontinuous. Shade was high, as the creek was narrow (2 m wide) and the canopy was enclosed in some areas. SWH was present in some larger pools, and fine detritus was common. Cattle had been accessing the site, and areas beyond the riparian zone had been disturbed by pigs. Debris on banks indicated that high flow had occurred at some point prior to sampling.	
<u>Edge 1 sample:</u>	Overhanging trees, exposed roots and an undercut bank. Some cobbles and leaf packs sampled, lots of fine detritus.
<u>Edge 2 sample:</u>	Overhanging trees, exposed roots and an undercut bank. Some cobbles and leaf packs sampled, lots of fine detritus
SWTG1	
The site is made up of two large, deep pools, connected by a shallow run. The substrate of both pools is made up of sand and gravel, and the connecting run has substrate made up of pebbles, cobbles and sand. SWH was found through the extent of the reach and the right bank was undercut, exposing roots from riparian vegetation. Banks were approximately 3.5 m high and were very steep. Riparian vegetation was thick, extending at least 20 m from each bank. Riparian vegetation was overhanging and shaded most of the creek. Large trees lined the banks, with their roots exposed, creating good habitat for larger fish.	
<u>Edge 1 sample:</u>	Sand, gravel and clay. Exposed roots and SWH sampled
<u>Edge 2 sample:</u>	Undercut bank and roots sampled as well as a cobble lined backwater.
MBC0	
The site was almost completely inundated with water. Given the height of banks observed in previous years, water was estimated to be at least 3 m deep. No sampling was undertaken due to safety risks associated with depth, flow and potential presence of crocodiles.	

Site/habitat description

MBC06

The site is located on a small tributary of Mount Bunday Creek draining away from EP2. The site was made up of a single isolated pool winding along the creek for around 25 m, with an average width of 2 m. The substrate was a mixture of bedrock, cobbles, silt and clay, with small amounts of SWH and leaf packs. An oil slick was observed on the surface. When sampling macroinvertebrates, an anoxic odour was released from sediment. Towards EP2, water was observed seeping from the ground close to a groundwater bore, which was oxidising and iron floc was present. There was no surface water connection to the pool. The riparian zone was narrow, and did not persist for more than 5 m from the water.



Edge 1 sample:

Undercut banks and exposed roots. Lots of detritus and sticks.

Edge 2 sample:

Backwater with detritus, on right bank, lots of iron floc and silt. Small section of exposed roots.

MBC01A

MBC01 was relocated 700 m downstream based on a recommendation in 2018 report (GHD 2018a). The site is made up of two pools intersected by a cattle crossing. The upstream pool is deep, and has very steep clay banks. The downstream pool is shallow, with SWH and undercut banks. Both banks in the downstream pool are steep, and the riparian zone along the entire site is dense and continuous, except for the path leading to the cattle crossing on both sides. The substrate of the downstream pool is mostly sand, with some bedrock. Detritus was present in backwaters.



Edge 1 sample:

Backwater with SWH and leaf packs. Some exposed roots.

Edge 2 sample:

Along right bank, undercut with fine exposed roots, some algae and fine detritus.

Downstream

SWG2

The site is made up of a series of pools connected by runs upstream of a stock crossing. Downstream of the crossing, the site was a wide, shallow pool. Substrate along the entire reach was a mixture of cobbles, pebbles and sand, with clay banks. Continuous riparian vegetation was observed at the site, except through the causeway path, resulting in heavy deposition of detritus and SWH within the creek. Exposed roots were common in deeper pools. Trailing vegetation (parra grass and riparian overhang) was common along the length of the site.



Edge 1 sample:

Undercut bank and trailing vegetation from overhanging trees.

Backwater sections with some detritus. Lots of sand and pebbles.

Edge 2 sample:

Trailing vegetation and sandy gentle sloped edge.

Site/habitat description

MBC03

The site is located on a bend and was characterised by a long shallow run connecting deep pools at either end of the reach. The majority of the run was 0.2 m deep and 3 m wide with some deeper sections adjacent to banks. SWH and leaf packs were found through the reach. Substrate was made up mainly of sand and gravel with some silty deposits in deeper areas. The creek was highly shaded and the riparian zone extended for 20 m on the right bank and >30 m on the left bank. The right bank was very steep and 3.5 m high, whereas the left bank was a gentle slope reaching a similar height. Undercut banks and exposed fine roots were common on both sides of the creek.



Edge 1 sample: Undercut bank and exposed roots. Log jam with leaf packs.

Edge 2 sample: Undercut bank and sandy shallow backwater.

SWTG3

Remote camera set up and WQ sample taken, but no macros or fish. The site is located downstream of the Coulter Creek confluence, and is the furthest downstream site on Mount Bundey Creek. At the time of sampling, the water level at the site was well above the water mark. Water flow and turbidity were high, and it was deemed to be unsafe to undertake biological sampling. There did not appear to be any changes in the riparian zone from 2018.



Reference

CC02

This is the furthest upstream site on Coulter Creek, and is intersected by a ford made of boulders, cobbles and clay. Upstream of the ford was a large, deep pool containing SWH. The pool was considered unsafe to enter. Downstream of the ford was a series of pools connected by shallow runs that was 2 m wide for the majority of the reach. The creek was shaded by a dense, 5 m wide, native riparian strip on both banks. Beyond the riparian zone was cleared and the land used for grazing. An oil slick was observed directly downstream of the ford. Macroinvertebrate sampling was undertaken downstream of the ford.



Edge 1 sample: SWH, undercut banks and leaf packs. Some exposed roots. Sandy.

Edge 2 sample: Trailing veg, some bamboo. Stick and leaf jams. Sandy.

Site/habitat description

CC01

The site is normally a set of isolated pools, but was flowing during sampling. The site is located close to Mount Bunday Creek Station cattle yards, with a ford intersecting the creek. The reach extended from the ford downstream. The site was characterised by a meandering run with some deeper pools. Shading was lower in the downstream parts of the creek, with large patches of filamentous algae observed. Banks were eroded close to areas where cattle had been accessing the creek. A representative from Mount Bunday Creek Station advised that cattle were regularly herded through this section of the creek and over the ford. The upstream section of the reach was shaded and had a riparian strip around 5 m wide. Exposed roots and SWH were common.



Edge 1 sample:

Exposed fine roots and undercut banks. Some detritus.

Edge 2 sample:

Lots of filamentous algae and thick and deep detritus packs. Anoxic.

CK7

The site is an existing water quality monitoring point for Tom's Gully Mine, located on the downstream side of the crossing of Coulter Creek with the Arnhem Highway. The site was made up of a series of deep pools connected by shallow runs. Steep, eroded banks were covered by pasture grasses, and some sparse riparian trees. The substrate was mostly bedrock, with gravel, sand and clay present in areas of low flow. Evidence of cattle and pig access to the creek from both banks was observed. Some undercut banks and exposed roots and shade were present in the deeper pools. Archerfish observed in deep pools.



Edge 1 sample:

Backwater areas with trailing grass. Lots of bedrock substrate, but also leaf packs and sticks. Not much shade.

Edge 2 sample:

Leaf packs, exposed roots and gravel sampled in shallower pools. Shady.

CC03

Site in previous years of sampling has been a set of isolated pools, but was a connected flowing creek in 2019. The site is located approximately 1.7 km downstream of the Arnhem Highway and is a pool 50 m in length, upstream and downstream of the pool was a shallow run. The pool has a moderate amount of shade, and its banks were heavily eroded with discontinuous riparian vegetation mixed with pasture grasses. The substrate was mostly bedrock, with some deposition of clay and silt in the downstream end of the pool.



Edge 1 sample:

Backwater with SWH and leaf packs. Some exposed roots.

Edge 2 sample:

Along right bank, undercut with fine exposed roots, fine detritus.

4.2 Water quality

4.2.1 *In situ* water quality

Table 4-2 presents the *in situ* water quality results for April 2019.

pH values were within SSTV limits at all sites, but were very slightly acidic at downstream sites in Mount Bunday Creek, and most alkaline at adjacent site SWTG1.

EC was above the SSTV at all sites except control site SWTG1C. These results may indicate influences from the mine area via overland flows and/or seepages.

Water at MBC06 was very saline compared to all other sites, with EC more than 100 times the SSTV. Seepage from a nearby groundwater bore is thought to be causing higher EC at MBC06 which has only been evident at the site since 2018 (GHD 2017; GHD 2018a). Seepage from the ground close to a groundwater bore was observed during the 2019 field survey. EC at sites downstream of MBC06 was slightly higher than observed at sites upstream of MBC06 on Mount Bunday Creek, but decreased with distance downstream. EC results were slightly lower at all sites in 2019 compared with results from 2018 (GHD 2018a); likely due to dilution. DO concentrations were low (below the lower SSTV) at all sites except Coulter Creek sites CC02 and CK7. The lowest DO saturation was recorded at MBC06, and was slightly lower and adjacent and downstream sites than at control sites. DO results at all sites except MBC06 were higher in 2019 than 2018. This is likely to be due to the increased flow at all sites in 2019 compared to 2018.

Turbidity was below the SSTV at all sites and lower in Coulter Creek than in Mount Bunday Creek.

Table 4-2 *In situ* water quality results, April 2019

Site	Date	Time	Temp (°C)	pH	EC (µS/cm)	DO (% sat.)	DO (mg/L)	Turbidity (NTU)
SSTV	NA	NA	NA	5.8-8.0	41	85-120	NA	87
Control								
SWTG1C	15/4/19	8:37	27.8	7.1	39	80.1	6.79	21.1
SWTG1A	15/4/19	10:35	28.0	7.1	46	84.3	7.57	23.5
Adjacent								
SWTG09	16/4/19	14:40	28.2	7.0	47	60.6	5.87	19.4
SWTG1	17/4/19	7:40	27.0	7.6	71	78.3	7.51	19.1
MBC06	17/4/19	16:05	28.2	7.0	4286	51.3	2.56	57.1
MBC01A	16/4/19	14:05	28.9	7.1	105	74.2	7.17	59.1
Downstream								
SWTG2	17/4/19	15:20	28.8	6.7	83	79.5	7.25	17.3
MBC03	18/4/19	8:30	27.3	6.7	82	77.5	7.42	17.8
Reference								
CC02	19/4/19	8:39	27.6	7.1	152	89.2	7.21	10.4
CC01	18/4/19	13:55	28.6	7.3	134	78.1	7.97	12.9
CK7	19/4/19	7:30	27.0	7.1	130	88.9	7.58	5.1
CC03	18/4/19	10:45	27.8	7.2	128	82.3	8.05	10.8

Results in yellow are above the relevant SSTV

4.2.2 Laboratory analysis

Table 4-3 and Table 4-4 present the laboratory analytical results for surface water samples collected in April 2019 in Mount Bunday and Coulter Creek sites, respectively. Free cyanide, WAD cyanide and total cyanide were not detected in concentrations above the laboratory limit of reporting (LOR) at any site. Therefore, these data have not been included in Table 4-3 or Table 4-4. Laboratory certificates of analysis showing data for all measured parameters are provided in Appendix A.

The ionic composition of water varied between sites. Water at MBC06 contained high concentrations of bicarbonate alkalinity, sulfate, chloride, magnesium and potassium, relative to all other sites. The concentration of sulfate at MBC06 exceeded the SSTV and was over 50 times higher than sulfate concentrations recorded at any other site.

Water samples from MBC0 and MBC03 were dominated by carbonate alkalinity and sodium, with concentrations of these ions many multitudes higher than concentrations at all other sites. Water at all other sites, including all control and reference sites, was dilute, with comparatively low concentrations of all major ions.

Concentrations of dissolved aluminium exceeded the SSTV at adjacent sites SWTG09 and SWTG1 and downstream sites MBC01A, SWTG2 and SWTG3, with the highest concentration observed at MBC01A. Dissolved aluminium concentrations were below the SSTV at all control and reference sites, indicating possible contributions of aluminium to Mount Bunday Creek from overland flows from Toms Gully Mine.

Adjacent site MBC06 was the only site at which the concentration of dissolved aluminium was below the LOR. Water at this site, however, had the highest concentrations of dissolved arsenic, cobalt, manganese, nickel and uranium of all sites, with the cobalt and nickel concentrations exceeding the SSTVs. Concentrations of the above elements at MBC06 were observed to be many times higher than those at other sites in April 2019, indicating a localised impact at this site, potentially from groundwater seepage that is also suspected to be contributing to the very high EC observed at this site. Water at downstream site SWTG2 exceeded the SSTVs for dissolved copper and zinc, and was the only site at which dissolved cadmium was observed in concentrations above the LOR.

The elevated dissolved metal concentrations observed at MBC06 and SWTG2, as well as the elevated concentrations of dissolved aluminium, copper, nickel and zinc observed at some adjacent and downstream sites, compared with concentrations at control and reference sites, indicate a potential influence from runoff or overland flows from Toms Gully Mine areas during wet conditions. The impacts do not persist downstream from MBC06 and SWTG2, with furthest downstream sites MBC03 and SWTG3, containing comparatively reduced concentrations of metals apart from aluminium. As such, any impacts on aquatic ecosystems due to water quality are likely to be localised.

Table 4-3 Laboratory surface water quality results Mount Bunday Creek sites, April 2019

Analyte	Units	LOR	Control		Adjacent					Downstream			SSTV
			SWTG1C	SWTG1A	SWTG09	SWTG1	MBC0	MBC06	MBC01A	SWTG2	MBC03	SWTG3	
Physicochemical parameters													
TDS	mg/L	10	42	61	60	48	1120	4530	74	60	975	71	NA
TSS	mg/L	5	8	35	24	11	27	10	134	7	54	17	NA
Major ions													
Bicarbonate alkalinity	mg/L	1	12	10	15	10	6	179	11	10	87	27	NA
Carbonate alkalinity	mg/L	1	<1	<1	<1	<1	846	4	<1	<1	620	<1	NA
Hydroxide alkalinity	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA
Total alkalinity as CaCO3	mg/L	1	12	10	15	10	852	183	11	10	707	27	NA
Sulfate as SO4	mg/L	1	1	1	<1	1	1	3340	11	11	57	12	210
Chloride	mg/L	1	2	2	3	2	3	19	2	2	3	3	NA
Calcium	mg/L	0.5	1.1	0.9	1.5	1.1	1.2	216	2.8	2.7	2.4	4	NA
Magnesium	mg/L	0.5	1	1.1	1.2	1.1	<0.5	583	2	2	<0.5	2.5	NA
Potassium	mg/L	0.5	0.9	1	0.9	1.1	1.3	2.5	0.9	1	1.1	1.3	NA
Sodium	mg/L	0.5	3	3.1	4.4	3.1	430	52.9	3.2	3.1	348	3.6	NA
Dissolved metals													
Aluminium	mg/L	0.005	0.164	0.197	0.606	0.433	0.028	<0.005	0.773	0.386	0.042	0.470	0.295*
Arsenic	mg/L	0.0002	0.0007	0.0006	0.0005	0.0006	0.0010	0.0019	0.0006	0.0007	0.0010	0.0006	0.042
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00015	<0.00005	0.00033	<0.00005	<0.00005	0.0004
Chromium	mg/L	0.0002	0.0002	0.0002	0.0010	0.0003	<0.0002	<0.0002	0.0005	0.0003	<0.0002	0.0004	0.0060
Cobalt	mg/L	0.0001	0.0002	<0.0001	0.0002	0.0001	<0.0001	0.0027	0.0002	0.0006	<0.0001	0.0001	0.0014
Copper	mg/L	0.0005	<0.0005	<0.0005	0.0014	<0.0005	0.0006	0.0014	0.0018	0.0027	0.0009	0.0015	0.0018
Iron	mg/L	0.002	0.681	0.351	0.411	0.448	0.012	0.057	0.590	0.495	0.010	0.759	2.7
Manganese	mg/L	0.0005	0.0246	0.0010	0.0021	0.0009	<0.0005	0.8060	0.0019	0.0680	<0.0005	0.0016	2.5
Nickel	mg/L	0.0005	<0.0005	<0.0005	0.0007	<0.0005	<0.0005	0.0246	0.0018	0.0045	<0.0005	0.0015	0.0130
Uranium	mg/L	0.00005	0.00011	0.00006	0.00012	0.00007	0.00006	0.0227	0.0001	0.00012	0.00006	0.00008	NA
Zinc	mg/L	0.001	<0.001	<0.001	0.004	<0.001	0.002	0.014	0.007	0.015	<0.001	0.004	0.015

Analyte	Units	LOR	Control		Adjacent					Downstream			SSTV
			SWTG1C	SWTG1A	SWTG09	SWTG1	MBC0	MBC06	MBC01A	SWTG2	MBC03	SWTG3	
Total metals													
Aluminium	mg/L	0.005	0.842	0.679	0.604	0.621	0.536	0.039	0.695	0.543	0.037	0.526	NA
Arsenic	mg/L	0.0002	0.0010	0.0009	0.0006	0.0009	0.0010	0.0030	0.0010	0.0010	0.0008	0.0013	NA
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00025	0.00047	0.00035	<0.00005	0.00015	NA
Chromium	mg/L	0.0002	0.0008	0.0006	0.0012	0.0006	0.0006	0.0003	0.0006	0.0005	<0.0002	0.0007	NA
Cobalt	mg/L	0.0001	0.0003	0.0002	0.0005	0.0002	0.0002	0.002	0.0033	0.0007	<0.0001	0.0042	NA
Copper	mg/L	0.0005	0.0007	0.0007	0.0021	0.0008	0.0017	0.002	0.0047	0.0036	0.0009	0.0029	NA
Iron	mg/L	0.002	1.120	0.922	0.616	0.804	0.860	0.798	1.070	0.920	0.003	2.010	NA
Lead	mg/L	0.0001	0.0005	0.0005	0.0006	0.0004	0.0026	<0.0001	0.0007	0.0004	<0.0001	0.0005	NA
Manganese	mg/L	0.0005	0.0259	0.0114	0.0301	0.0040	0.0106	0.4680	0.1350	0.0630	<0.0005	0.1960	NA
Nickel	mg/L	0.0005	<0.0005	<0.0005	0.001	<0.0005	0.0008	0.0266	0.0061	0.0054	<0.0005	0.0041	NA
Uranium	mg/L	0.00005	0.00013	0.00011	0.00011	0.00009	0.00010	0.02270	0.00022	0.00016	0.00011	0.00016	NA
Zinc	mg/L	0.001	<0.001	<0.001	0.009	0.016	0.048	0.030	0.026	0.022	<0.001	0.018	NA

Results in yellow are above the relevant SSTV

* SSTV for aluminium applies for pH >6.5

Table 4-4 Laboratory water quality results Coulter Creek sites, April 2019

Analyte	Units	LOR	Reference				SSTV
			CC02	CC01	CK7	CC03	
Physicochemical parameters							
TDS	mg/L	10	87	93	79	86	NA
TSS	mg/L	5	8	35	<5	5	NA
Major ions							
Bicarbonate alkalinity	mg/L	1	12	12	12	12	NA
Carbonate alkalinity	mg/L	1	<1	<1	<1	<1	NA
Total alkalinity as CaCO3	mg/L	1	12	12	12	12	NA
Sulfate as SO4	mg/L	1	30	24	26	25	210
Chloride	mg/L	1	2	2	2	3	NA
Calcium	mg/L	0.5	5.1	4.6	4.6	4.4	NA
Magnesium	mg/L	0.5	5.2	4.4	4.6	4.5	NA
Sodium	mg/L	0.5	4.3	3.8	3.8	3.6	NA
Potassium	mg/L	0.5	2.2	1.8	2	1.8	NA
Dissolved metals							
Aluminium	mg/L	0.005	0.126	0.250	0.087	0.162	0.295*
Arsenic	mg/L	0.0002	0.0006	0.0006	0.0008	0.0008	0.042
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.0004
Chromium	mg/L	0.0002	0.0003	0.0003	0.0002	0.0002	0.006
Cobalt	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0014
Copper	mg/L	0.0005	<0.0005	<0.0005	0.0007	0.0009	0.0018
Iron	mg/L	0.002	0.559	0.604	0.553	0.544	2.7
Manganese	mg/L	0.0005	0.0022	0.0020	0.0028	0.0016	2.5
Nickel	mg/L	0.0005	<0.0005	<0.0005	0.0020	0.0019	0.013
Uranium	mg/L	0.00005	0.00008	0.00008	0.00010	0.00011	NA
Zinc	mg/L	0.001	0.003	<0.001	0.005	0.004	0.015
Total metals							
Aluminium	mg/L	0.005	0.209	0.212	0.289	0.191	NA
Arsenic	mg/L	0.0002	0.0008	0.0009	0.0009	0.0009	NA
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	NA
Chromium	mg/L	0.0002	0.0004	0.0005	0.0004	0.0003	NA
Cobalt	mg/L	0.0001	0.0003	0.0003	0.0008	0.0006	NA
Copper	mg/L	0.0005	0.0006	0.0008	0.0009	0.0008	NA
Iron	mg/L	0.002	0.921	0.911	0.882	0.694	NA
Lead	mg/L	0.0001	0.0005	0.0006	0.0005	0.0002	NA
Manganese	mg/L	0.0005	0.0956	0.0598	0.0512	0.0382	NA
Nickel	mg/L	0.0005	0.0008	0.0008	0.0026	0.0028	NA
Uranium	mg/L	0.00005	0.00012	0.00014	0.00015	0.00015	NA
Zinc	mg/L	0.001	0.005	0.004	0.012	0.005	NA

Results in yellow are above the relevant SSTV

* SSTV for aluminium applies for pH >6.5

4.3 Sediment quality

4.3.1 Particle size distribution

Particle size distribution results for sediment samples collected in April 2019 are displayed in Figure 4-1. Sediment collected from control sites SWTG1C and SWTG1A, and adjacent site SWTG1, contained the highest proportion of coarse particles, each comprised of over 50 percent gravel, and only 5-6 percent fine particles (clay or silt). Sediment samples collected from adjacent sites SWTG09 and MBC06, and reference sites CC01 and CC03, contained the highest proportion of fine particles, with samples from each site comprising over 50 percent clay or silt.

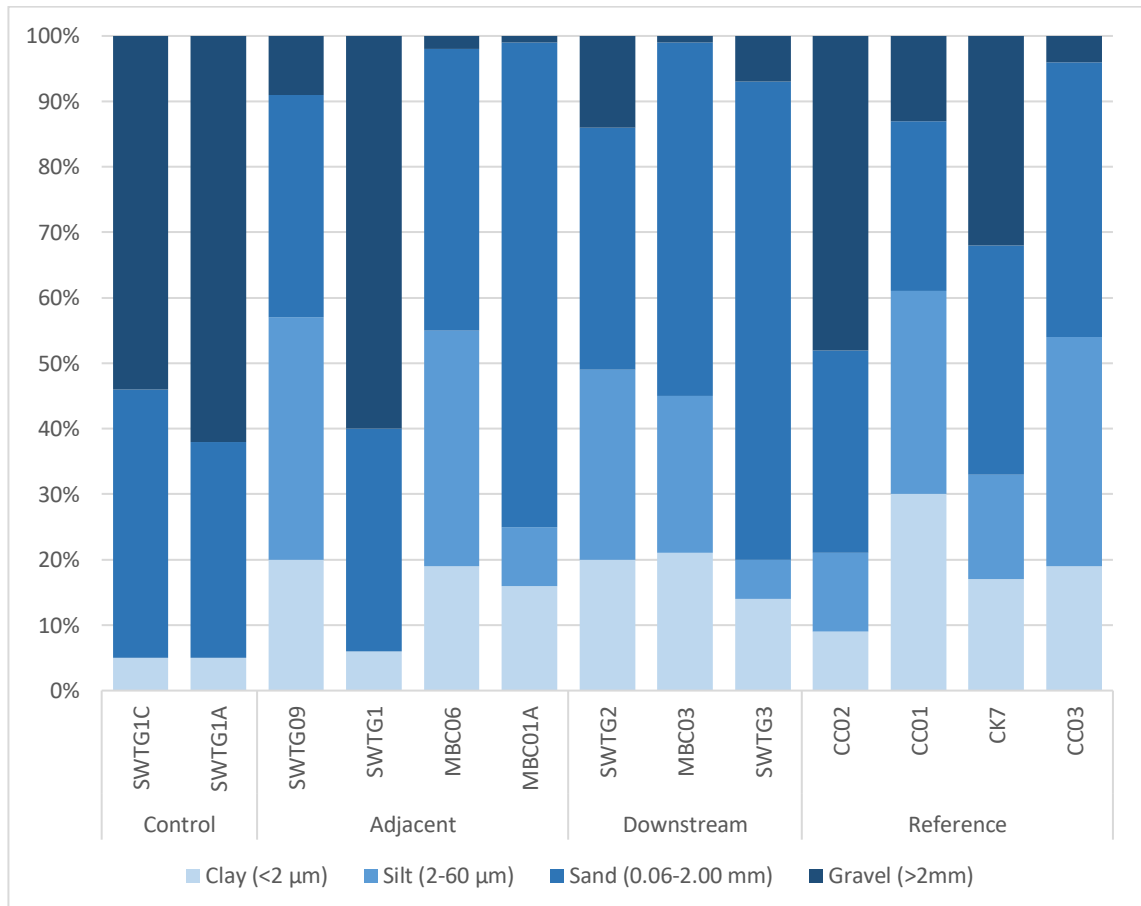


Figure 4-1 Particle size distribution in sediment samples collected April 2019

4.3.2 Laboratory analysis

Table 4-5 and Table 4-6 present the results of the laboratory analysis of sediment samples collected in April 2019 at Mount Bunday and Coulter Creek sites respectively. Parameters measured at concentrations below the LOR at all sites and have not been presented in Table 4-5 and Table 4-6. Laboratory certificates of analysis showing data for all measured parameters are provided in Appendix A.

Concentrations of all 1M HCl-extractable sediment metals were below the respective DGVs at all sites in 2019, except for cadmium at site MBC06 which is adjacent to the mine.

As with water at Mount Bunday Creek sites, the sediments at MBC06 and SWTG2 contained higher concentrations of metals than all other sites in the study area. Along with elevated cadmium, the sediment at MBC06 also contained the highest concentration of acid-extractable aluminium, arsenic, copper, iron, nickel, uranium and zinc of all sites in the study area. Sediment collected from downstream site SWTG2 contained the highest concentrations of chromium, cobalt, lead and manganese of all sites. Of these metals, there are only DGVs for chromium and lead and these DGVs were not exceeded at SWTG2.

MBC06 contained the highest concentration of total organic carbon of all sites in the study area, followed by SWTG2, as well as both sites containing a relatively high proportion of fine sediment particles (clay and silt) compared to other sites (Figure 4-1). These factors are likely to have contributed to the higher concentrations of metals identified in the sediments at these sites, as metals are known to bind preferentially to organic carbon and fine sediment particles (Simpson and Batley 2016).

Despite elevated metal concentrations in the water at some sites adjacent to and downstream of Toms Gully Mine, concentrations of most metals in sediments were low across the project area. It is recommended that sediment monitoring be continued in future monitoring events to determine whether any accumulation of sediment metals is occurring in Mount Bunday Creek under lower flow conditions.

Table 4-5 Laboratory sediment quality results Mount Bunday Creek sites, April 2019

Analyte	Units	LOR	Control		Adjacent				Downstream			DGV	GV-high
			SWG1C	SWG1A	SWG09	SWG1	MBC06	MBC01A	SWG2	MBC03	SWG3		
1M HCl-extractable metals													
Aluminium	mg/kg	50	120	100	710	130	1540	420	1080	500	790	NA	NA
Arsenic	mg/kg	1	<1.0	<1.0	<1.0	<1.0	4.3	<1.0	1.4	<1.0	<1.0	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	0.2	<0.1	1.6	<0.1	0.6	0.2	0.3	1.5	10
Chromium	mg/kg	1	<1.0	<1.0	1.5	<1.0	1.6	<1.0	2.8	<1.0	<1.0	80	370
Cobalt	mg/kg	0.5	1	1	2.3	0.8	4.3	1.7	8.3	<0.5	4.9	NA	NA
Copper	mg/kg	1	<1.0	<1.0	8.4	<1.0	31.4	3.2	14.2	10.1	7.3	65	270
Iron	mg/kg	50	940	630	2240	920	6680	660	6120	660	2640	NA	NA
Lead	mg/kg	1	3.8	3.7	13.3	3.5	9.5	4.9	13.6	5.2	6.6	50	220
Manganese	mg/kg	10	85	113	72	71	82	69	400	14	109	NA	NA
Nickel	mg/kg	1	<1.0	<1.0	2.3	<1.0	11.4	<1.0	4.8	1.1	4.0	21	52
Uranium	mg/kg	1	<1.0	<1.0	1.1	<1.0	3.6	<1.0	1.2	<1.0	<1.0	NA	NA
Zinc	mg/kg	1	1.4	1.4	7.3	1.6	60.8	4.7	31.6	6.2	26.8	200	410
Total recoverable metals													
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	1
Cyanide													
Free cyanide	mg/kg	1	<1	<1	1	<1	<1	<1	<1	<1	<1	NA	NA
WAD cyanide	mg/kg	1	<1	<1	1	<1	<1	<1	<1	<1	<1	NA	NA
Total cyanide	mg/kg	1	<1	<1	2	<1	3	<1	2	<1	1	NA	NA
Other parameters													
TOC	%	0.02	0.35	0.08	1.19	0.11	5.04	0.16	3.42	0.67	0.99	NA	NA
Moisture content	%	0.1	22.3	18.8	40.2	17.8	47.6	22.2	38.6	26.2	28.8	NA	NA

Results in yellow are above the relevant DGV

Results in gold are above the GV-high

Table 4-6 Laboratory sediment quality results Coulter Creek sites, April 2019

Analyte	Units	LOR	Reference				DGV	GV-high
			CC02	CC01	CK7	CC03		
1M HCl-extractable metals								
Aluminium	mg/kg	50	260	410	380	320	NA	NA
Arsenic	mg/kg	1	<1.0	<1.0	<1.0	<1.0	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	0.2	0.2	1.5	10
Chromium	mg/kg	1	<1.0	<1.0	<1.0	<1.0	80	370
Cobalt	mg/kg	0.5	2.2	1.8	10.3	7.3	NA	NA
Copper	mg/kg	1	1.2	3	3.7	4.5	65	270
Iron	mg/kg	50	930	1300	2090	2260	NA	NA
Lead	mg/kg	1	18.4	14.5	22.7	14.1	50	220
Manganese	mg/kg	10	137	114	410	221	NA	NA
Nickel	mg/kg	1	<1.0	<1.0	6.2	3.3	21	52
Uranium	mg/kg	1	3.5	1.3	1.2	1.2	NA	NA
Zinc	mg/kg	1	1.7	1.2	38.6	17.6	200	410
Total recoverable metals								
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	0.15	1
Cyanide								
Free cyanide	mg/kg	1	<1	<1	<1	<1	NA	NA
WAD cyanide	mg/kg	1	<1	<1	<1	<1	NA	NA
Total cyanide	mg/kg	1	<1	<1	<1	<1	NA	NA
Other parameters								
TOC	%	0.02	0.08	0.27	0.67	0.4	NA	NA
Moisture content	%	0.1	18.6	24.4	26.2	25.7	NA	NA

Results in yellow are above the relevant DGV

Results in gold are above the GV-high

4.4 Macroinvertebrate community

4.4.1 Univariate indices

Taxa richness results for samples collected in April 2019 are presented in Figure 4-2. Taxa richness was lowest at adjacent site MBC06, where a maximum of 15 taxa were collected from the two replicate samples. All other samples collected from potentially impacted sites adjacent to and downstream of Toms Gully Mine contained between 22 and 28 taxa. Taxa richness was also low at the furthest upstream site on Mount Bunday Creek, control site SWTG1C, and the furthest downstream site on Coulter Creek, reference site CC03.

Taxa richness was highest at Coulter Creek reference site CC01, and decreased in a downstream direction from this point. At control sites, taxa richness was much higher at SWTG1A than at SWTG1C, with 25 taxa collected in both replicates at SWTG1A, compared with 18 taxa in both replicates at SWTG1C.

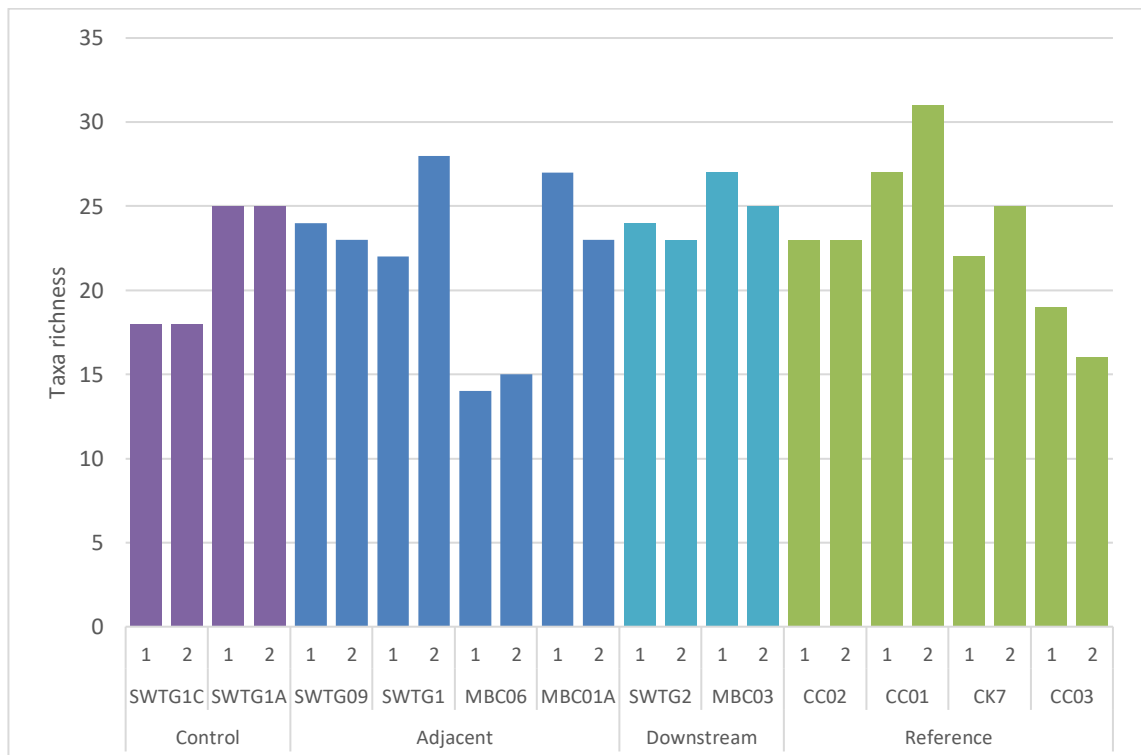


Figure 4-2 Taxa richness of samples collected April 2019

PET richness results for samples collected in April 2019 are presented in Figure 4-3. PET richness ranged between 2 and 6 across all samples collected. PET richness was highest at adjacent sites SWTG1 and MBC01A, reference site CC01, and in one replicate sample from downstream site MBC03. As with taxa richness, PET richness was lowest at MBC06 adjacent to Toms Gully Mine. MBC03 displayed the greatest variability between samples, with a 3 and 6 taxa collected in replicate one and two, respectively, while PET richness in replicate samples at all other sites differed by no more than one PET taxon.

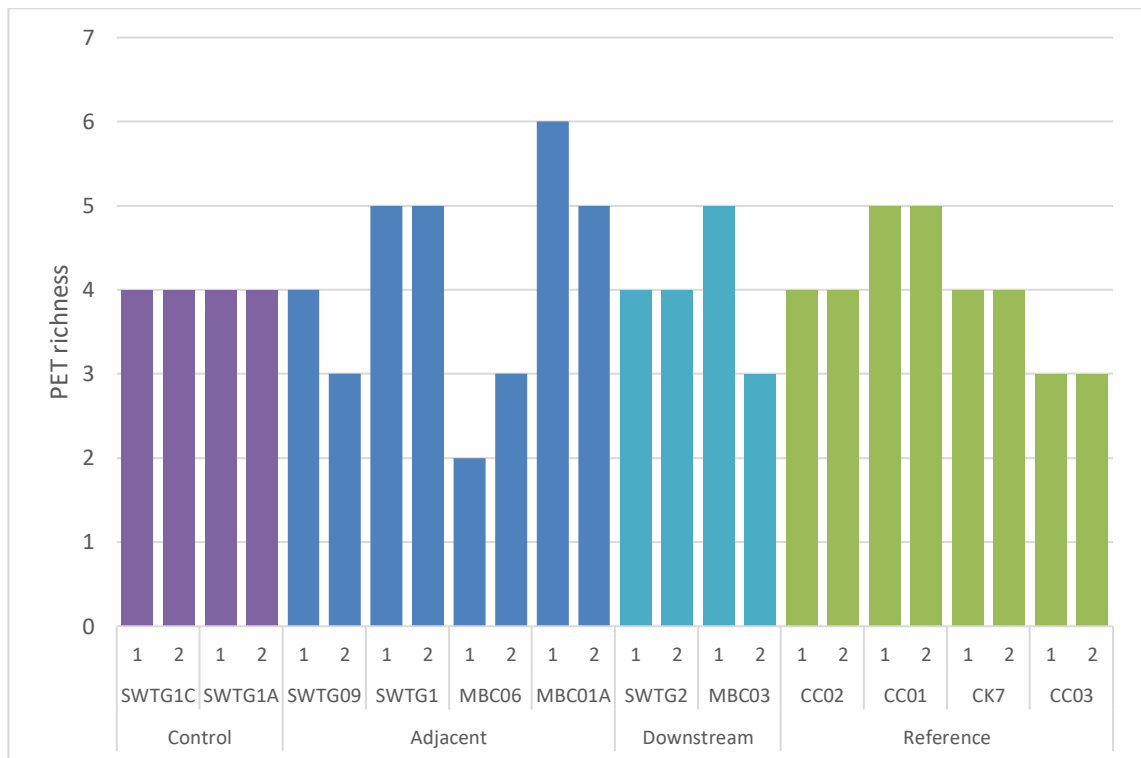


Figure 4-3 PET richness of samples collected April 2019

SIGNAL-2 results for samples collected in April 2019 are presented in Figure 4-4. The highest SIGNAL-2 score was observed in one replicate sample from downstream site MBC03, though this site demonstrated considerable variability in SIGNAL-2 scores between samples. SIGNAL-2 scores were also high at both control sites, adjacent sites SWTG1 and MBC01A, and reference site CC02. SIGNAL-2 scores were lowest at adjacent sites SWTG09 and MBC06.

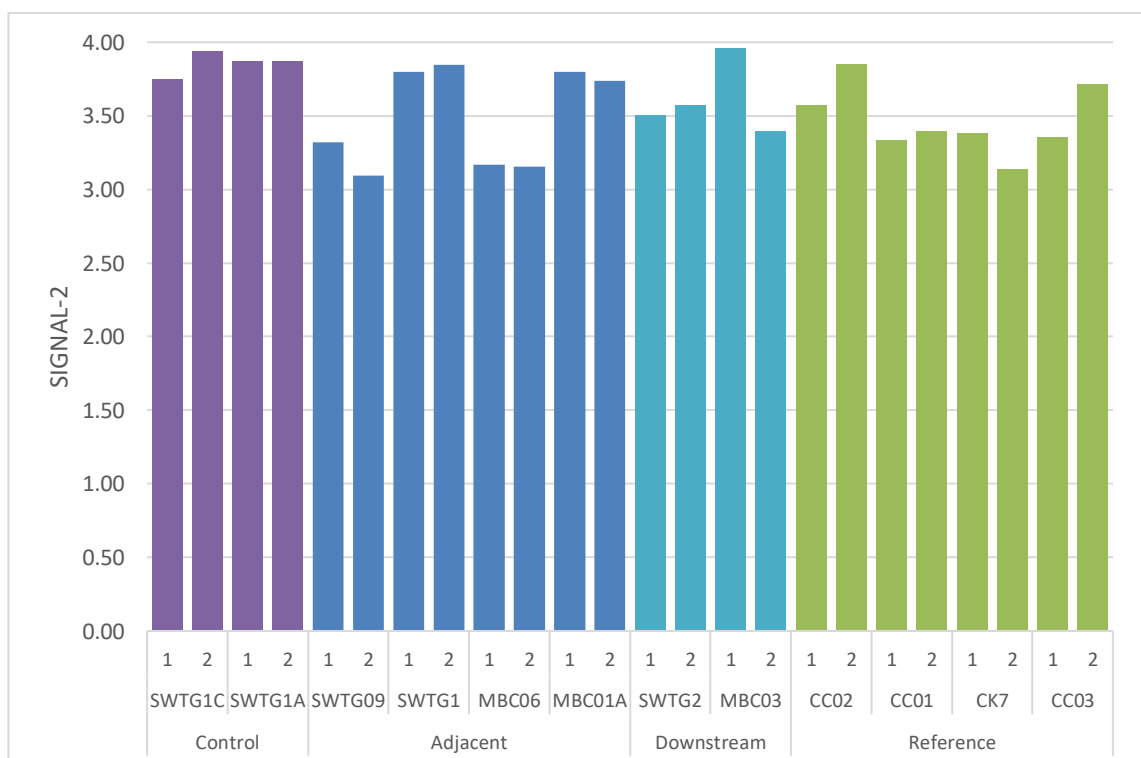


Figure 4-4 SIGNAL-2 results of samples collected April 2019

A total of 49 macroinvertebrate families were collected during the April 2019 sampling event. The distribution of those taxa across 14 orders is displayed in Figure 4-5, based on the relative abundance of each macroinvertebrate order collected in a sample.

The macroinvertebrate community composition of samples is fairly similar across all sites, with the majority of samples comprising primarily of Diptera, Ephemeroptera and Hemiptera. The community composition at MBC06 was the most distinct, with both replicate samples containing a larger proportion (more than three-quarters) of Diptera than all other sites. No Gastropoda were collected in either MBC06 sample, a group which were collected in every sample. SWTG1 was the only site at which Diptera were not the most abundant macroinvertebrate order, with Ephemeroptera instead making up the majority the samples at this site.

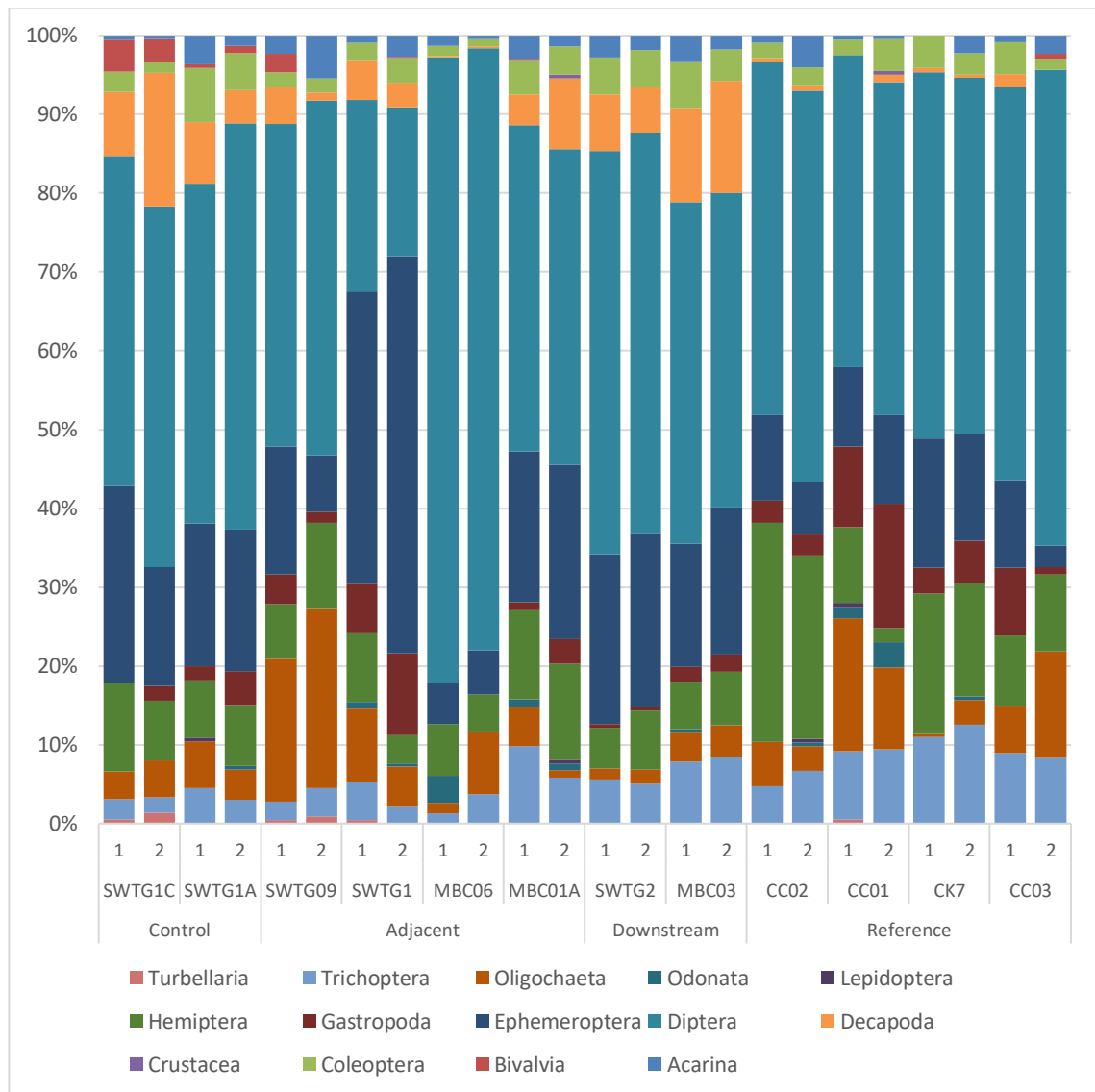


Figure 4-5 Macroinvertebrate community composition based on relative abundance of macroinvertebrate orders, April 2019

The results of the Darwin-Daly AUSRIVAS model are presented in Figure 4-6. The protocol for interpretation of AUSRIVAS model outputs stipulates that where two samples from the same site are found to be in different bandwidths, the lower bandwidth be assigned for the site. This resulted in sites SWTG1C, CC01, CK7 and CC03 being placed in Band B, despite having one replicate sample which scored in Band A. Band B indicates that these sites are significantly impaired with some taxa that were expected to be collected, not observed at these sites in 2019.

Sites SWTG1A, SWTG1, MBC01A, SWTG2 and MBC03, were placed in Band A, indicating that these sites are similar to reference condition, with most of the expected taxa collected in both replicate samples.

OE50 scores were lowest in both replicate samples from MBC06, with replicate 1 containing fewer than 50 percent of the taxa that were expected to be found by the model.

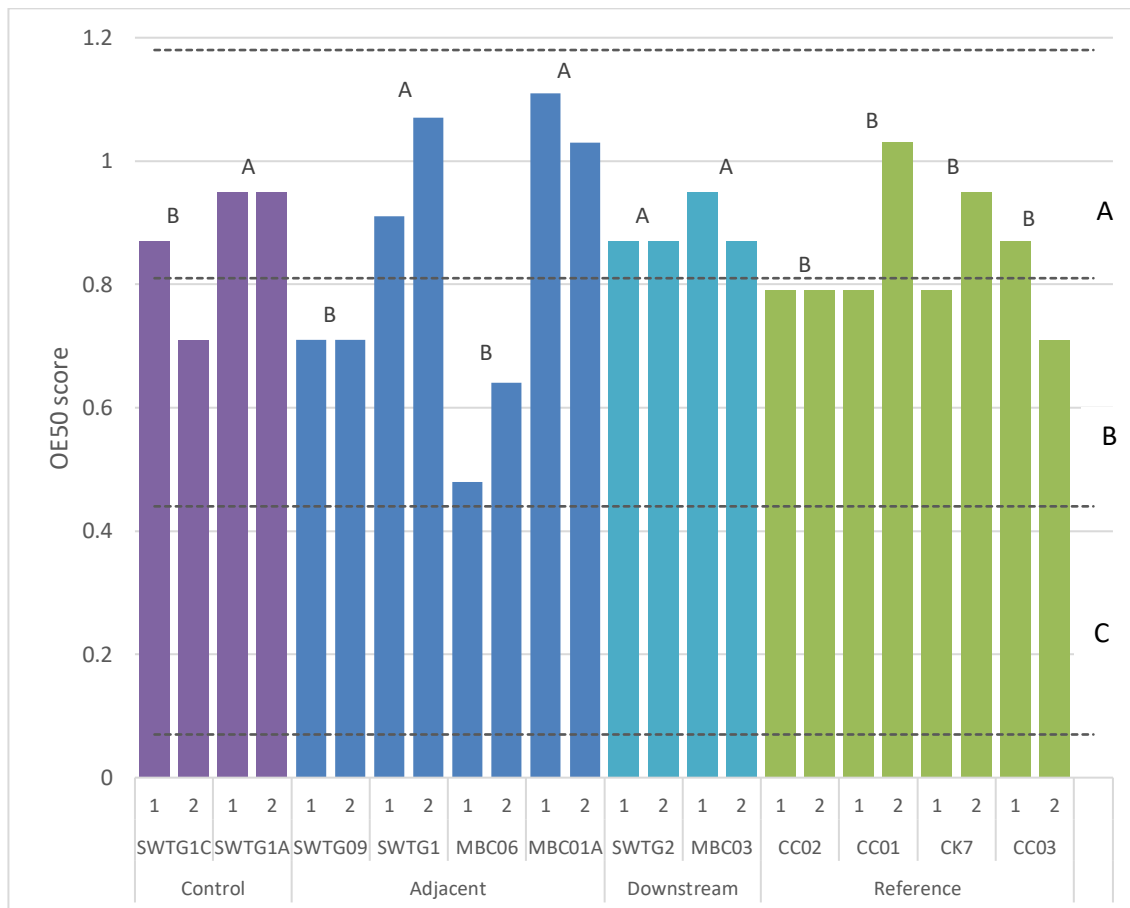


Figure 4-6 AUSRIVAS OE50 results and bandings for sites sampled in 2019

Macroinvertebrate samples collected from MBC06 in 2019 contained the lowest taxa richness, PET richness, SIGNAL-2 score and AUSRIVAS OE50 score of all sites indicating that the macroinvertebrate community at this site was in the poorest condition. Given that the macroinvertebrate habitat at MBC06 was similar to that observed at other sites, it is likely that the very high EC and elevated metal concentrations in water and sediment samples at this site have impaired the macroinvertebrate community. In addition to this, the different ionic composition of water at this site compared to others may have influenced the macroinvertebrate community, causing taxa that were expected to be found at the site to be absent from samples.

These impacts were not observed downstream from this point, with all other sites adjacent to and downstream of Toms Gully Mine displaying improved macroinvertebrate health in comparison to results observed at MBC06. The elevated concentrations of dissolved copper and zinc observed in water samples from SWTG2 do not appear to have had an impact on the macroinvertebrate health at this site, with a relatively high PET richness and SIGNAL-2 observed compared to other sites in the study area, and an AUSRIVAS OE50 Band A ranking, indicating the macroinvertebrate community at the site is similar to that expected in a site of reference condition.

The macroinvertebrate community at MBC01A, the site immediately downstream of TSF2, contained the highest PET richness and OE50 scores of all sites, as well as high SIGNAL-2 scores relative to scores at all other sites in the study area. This indicates that any runoff from TSF2 is unlikely to be impacting the macroinvertebrate communities in Mount Bunday Creek, as well as demonstrating that the impacts observed at MBC06, the site immediately upstream from MBC01A, are localised and do not persist downstream from this point.

There was some evidence of impairment of the macroinvertebrate community at SWTG09, with reduced AUSRIVAS OE50, PET richness and SIGNAL-2 observed compared to other sites. The water and sediment quality results do not provide an explanation for the observed impairment. Although the aluminium concentration exceeded the SSTV in the water sample collected at this site in April 2019, it was no higher than some other sites at which the macroinvertebrate condition was improved. The habitat was relatively consistent with other sites, although, evidence of cattle and pig disturbance was observed as was debris indicating flooding prior to sampling.

4.4.2 Multivariate analysis

The non-metric MDS plot displayed in Figure 4-7 provides an indication of the relative similarity in the macroinvertebrate community composition between samples collected in 2019.

Samples collected from downstream sites were all clustered closely together, demonstrating minimum of 80 percent similarity in the macroinvertebrate community composition of these samples. Similarly, samples collected from control sites also demonstrated at least 80 percent similarity to each other, while also showing similarity to select adjacent site samples. Samples collected from reference sites were separated from other site types, and were mostly similar to each other, with the exception of replicate 2 from CC03, which demonstrated a unique community composition.

Samples collected from adjacent site MBC06 were 80 percent similar to each other, but were separated from all other samples collected in 2019, reflecting the difference in macroinvertebrate community composition at this site caused by the poor water and sediment quality observed.

ANOSIM identified that there was a significant ($p < 5\%$) difference in community composition between site types (Table 4-7). The pairwise tests identified the macroinvertebrate community composition of samples collected at reference sites was significantly different ($p < 5\%$) to samples collected from all other site types. As reference sites are on Coulter Creek, while all other site types are on Mount Bunday Creek, it is likely that natural geological differences account for these change in community composition. The community composition at control sites was also determined to be significantly different ($p < 5\%$) to that at downstream sites in 2019. This result is also likely to be due to environmental differences in the upstream and downstream reaches of Mount Bunday Creek.

Table 4-7 ANOSIM pairwise test results for 2019 samples by site type

Groups	R statistic	Significance level %	Possible permutations
Control, Adjacent	0.034	29.5	495
Control, Downstream	0.708	2.9	35
Control, Reference	0.684	0.2	495
Adjacent, Downstream	-0.013	44.8	495
Adjacent, Reference	0.226	1.5	6435
Downstream, Reference	0.381	2.0	495

Non-metric MDS

Transform: Presence/absence
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.19

Similarity
— 60
- - - 80

Site Type
▲ Control
▼ Adjacent
■ Downstream
◆ Reference

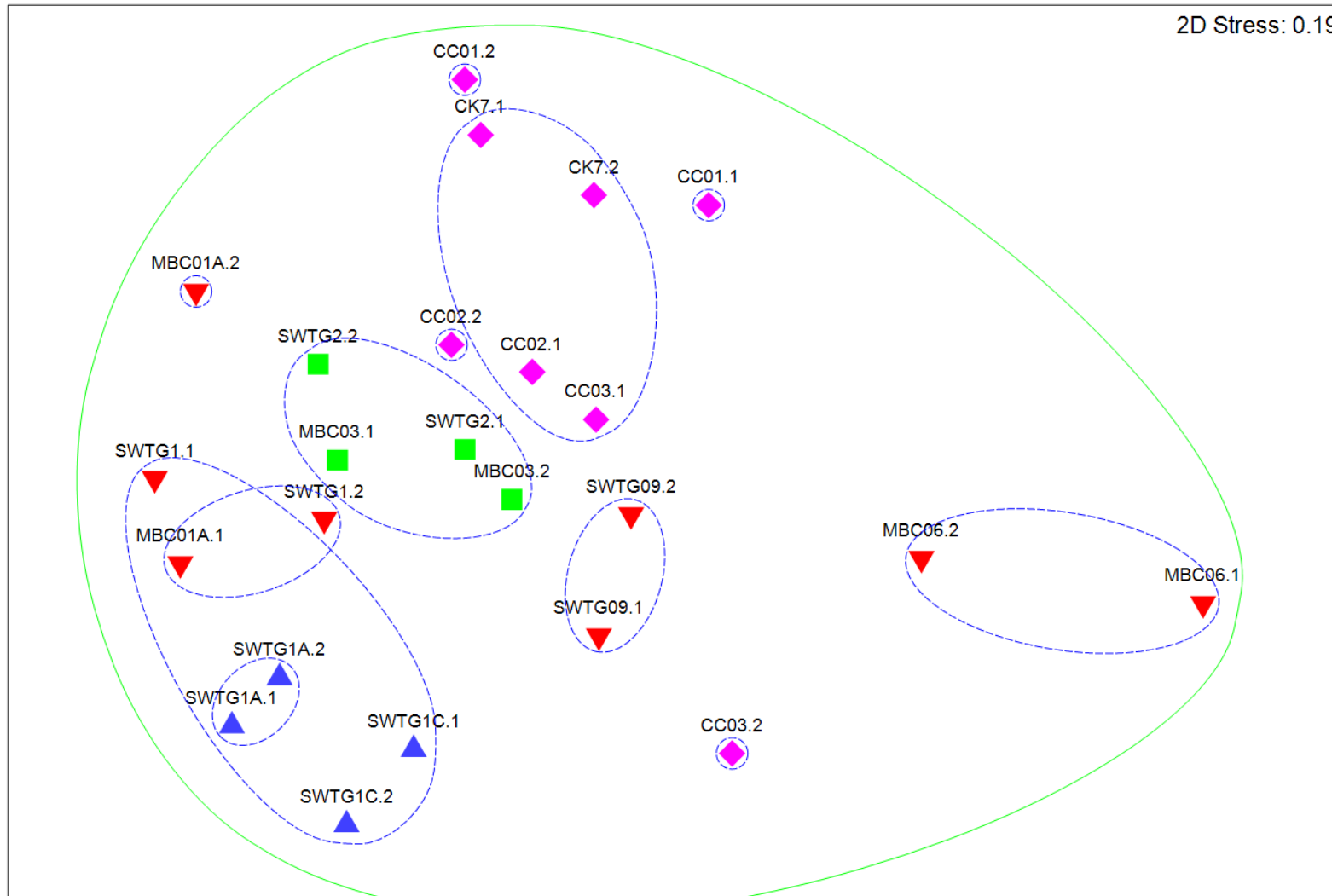


Figure 4-7 NMDS demonstrating relative similarity of macroinvertebrate communities in samples collected in 2019

The non-metric MDS plot displayed in Table 4-8 provides an indication of the relative similarity in the macroinvertebrate community composition between samples collected during different sampling events. Due to the high number of samples displayed, the stress of the plot is >0.20, and as such, the results should be interpreted with caution.

Replicate samples collected from each site in 2017, 2018 and 2019 were pooled to allow for the presentation of a single point for each site and sampling event and to minimise the stress in the plot. Only one macroinvertebrate sample was collected at each site in 2015 which may explain the differences observed in community composition during this sampling event and the greater variability between samples collected in this year.

Points are roughly clustered into years demonstrating similarity in community composition between different sites during the same sampling event. This indicates that the macroinvertebrate community composition varies more temporally than spatially within the study area. All samples collected in 2017 are clustered closely together with a minimum of 70 percent similarity between sites. Similarly, the majority of sites sampled in 2018 and 2019 are clustered together with a similarity of 70 percent or greater.

Samples collected from MBC06 in 2018 and 2019 are grouped together, but are separated from the large grouping of samples from other sites from these sampling events. This similarity in community composition is likely due to the unique composition of the water at this site which has been evident since the 2018 sampling event (GHD 2017; GHD 2018a).

ANOSIM identified that there were significant differences ($p < 5\%$) in community composition between sampling events. Pairwise testing indicated a significant difference ($p < 5\%$) in the macroinvertebrate community composition between each year of sampling, indicating that the macroinvertebrate community composition has been distinct during each sampling event (Table 4-8).

These results demonstrate the importance of accounting for temporal variability when assessing macroinvertebrate condition in the study area. Macroinvertebrate communities are sensitive to environmental changes, such as different flow conditions and water availability that can differ between sampling events.

Table 4-8 ANOSIM pairwise test results for samples by sampling event

Groups	R statistic	Significance level %	Possible permutations
2015, 2017	0.608	0.01	2496144
2015, 2018	0.496	0.01	2496144
2015, 2019	0.487	0.01	1352078
2017, 2018	0.426	0.01	5200300
2017, 2019	0.754	0.01	5200300
2018, 2019	0.136	0.70	5200300

Non-metric MDS

Transform: Presence/absence
Transform: Presence/absence
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.22

Similarity

- 40
- - - 60
- . - 70

Year

- ▲ 2015
- ▼ 2017
- 2018
- ◆ 2019

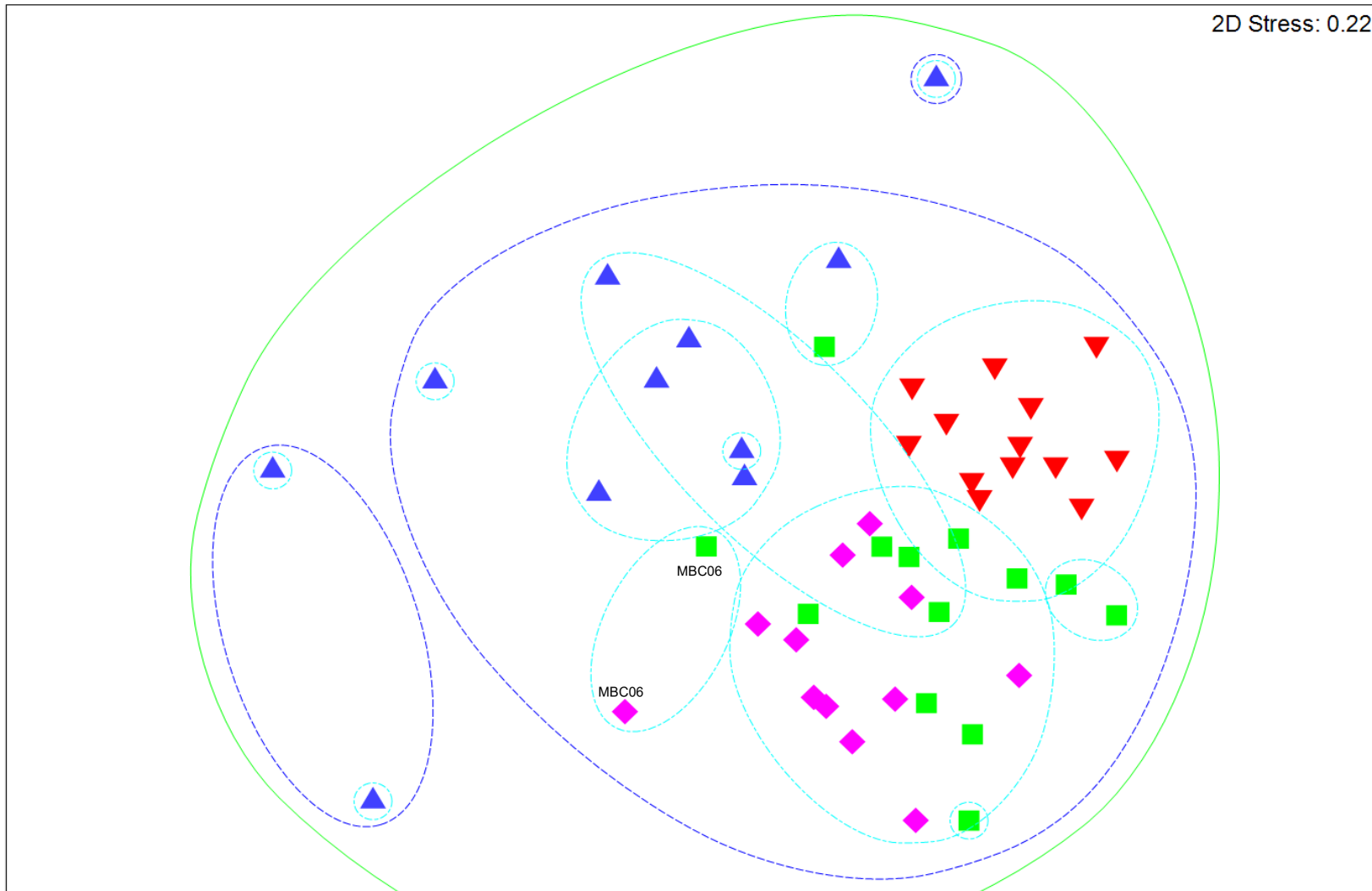


Figure 4-8 NMDS demonstrating relative similarity of macroinvertebrate communities in samples by sampling event

4.5 Fish community

Electrofishing was attempted at SWTG1, but the turbidity of the water made it difficult to see stunned fish. Electrofishing was not attempted at any other site due to deep, turbid, or fast flowing water. Bait traps were deployed at sites listed in Table 3-7.

One Mouth Almighty (*Glossamia aprion*) was caught in a bait trap deployed at SWTG1. Archer fish (*Toxotes sp.*) were observed in deep pools at CK7 but were not captured in bait traps.

No other fish species were observed at any site in 2019.

4.6 Water monitors

4.6.1 Sampling effort

Camera units were deployed at six sites across the study areas and were active for between 116 and 120 days, depending on deployment date (Table 4-9). Camera unit M1 was bumped by an animal and stopped taking photos on 31 May 2019, after 43 days of operation. Camera unit M5 malfunctioned soon after deployment and captured photos for 16 hours only. All other cameras were working effectively for the full length of deployment.

Table 4-9 Remote camera locations and deployment

Camera code	Camera in	Camera out	Days deployed	Comments
M1	18/04/2019	14/08/2019	118	Located at MBC01. Stopped taking photos on 31/5/19 (operational for 43 days).
M3	16/04/2019	14/08/2019	120	Located at SWTG1A.
M4	20/04/2019	14/08/2019	116	No associated aquatic ecology site.
M5	17/04/2019	14/08/2019	119	Located at SWTG2. Operational for 16 hours only.
M7	17/04/2019	14/08/2019	119	Located at MBC01A.
M8	19/04/2019	14/08/2019	117	Located at SWTG3.

4.6.2 Target species

One Mertens' Water Monitor (*Varanus mertensi*) was recorded by camera unit M3, upstream of the mine area on 16 June 2019 (Photo 4-1). Two *V. mertensi* were recorded by camera unit M8, at the site furthest downstream of the mine on Mount Bunday Creek, the first on 7 June 2019 (Photo 4-2) and the second on 11 July 2019 (Photo 4-3). This was the largest number of *V. mertensi* recorded in the study area during aquatic ecology monitoring between 2015 and 2019. No *V. mertensi* were observed at any site on Mount Bunday Creek adjacent to Toms Gully Mine or immediately downstream.

There were no sightings of *V. mitchelli* on any of the remote camera units in 2019, as have been the case in previous monitoring events. A large number of non-target species were recorded on cameras during deployment.



Photo 4-1 **Mertens' Water Monitor** (*Varanus mertensi*) photographed on camera unit M3 on 16/6/19



Photo 4-2 **Mertens' Water Monitor** (*Varanus mertensi*) photographed on camera unit M8 on 7/6/19



Photo 4-3 **Mertens' Water Monitor** (*Varanus mertensi*) photographed on camera unit M8 on 11/7/19

4.6.3 Non-target species

Remote cameras recorded 30 non-target species across the study area. No non-target species listed under the *Territory Parks and Wildlife Conservation Act* or the *Environmental Protection and Biodiversity Conservation Act* (1999) were observed at any site in 2019.

A number of introduced species were found on all camera units except M5, including cattle and pigs. Wild dogs were common in 2019, as was the case in 2018, being recorded on all cameras except M1 and M8. No cane toads were observed in 2019, contrary to 2018 monitoring which recorded cane toads at three sites.

The most common native species recorded was the Agile Wallaby (*Macropus agilis*). A wide variety of native bird species were also observed across the sites, with White Ibis (*Threskionis Molucca*) and Nankeen Night Heron (*Nycticorax caledonicus*) observed at all sites where cameras were operational for the full duration of the study.

Native rodent species were less common in 2019 than 2018, and the threatened species Pale Field Rat (*Rattus tunneyi*) and Black-footed Tree Rat (*Mesembriomys gouldii*) that were observed in 2018 were not recorded at any site in 2019. These species, however, were both observed at M5 in 2018, and may not have been observed in 2019 due to the malfunction of the camera unit at this site.

A full list of species that could be positively identified can be found in Appendix F.

5. Conclusions and recommendations

5.1 Conclusions

The key results of 2019 aquatic ecology monitoring are:

- *In situ* water quality results indicated EC was elevated above the SSTV at the majority of sites in the study area in 2019, though results were lower than those observed in 2018.
- Similarly, dissolved oxygen concentrations were below the SSTV at most sites in 2019, though results at all sites except MBC06 were higher in 2019 than 2018, likely due to higher flow in 2019.
- The elevated EC that was first observed at MBC06 in 2018 persisted in 2019. As identified in 2018, it is likely that this elevated EC, along with highly elevated concentrations of sulfate, calcium and magnesium, when compared with results from all other sites, are present at MBC06 due to seepage from groundwater. EC and concentrations of all major ions were lower at MBC06 in 2019 than 2018, likely due to the slightly higher water level causing a dilution to groundwater seepage present at the site.
- Concentrations of dissolved aluminium were elevated above the SSTV at a number of sites adjacent to and downstream of Toms Gully Mine. At MBC06 dissolved cobalt and nickel exceeded the SSTVs, while at SWTG2, dissolved copper and zinc exceeded the SSTVs. Concentrations of all dissolved metals were below the SSTVs at all control and reference sites, suggesting that runoff from Toms Gully Mine may be contributing metals to Mount Bunday Creek during wet conditions.
- Sediment quality in the study area was generally good in 2019, with only cadmium at MBC06 found in concentrations above the DGV, indicating the potential for toxicity to aquatic biota.
- The macroinvertebrate community at MBC06 was in the poorest condition of all sites, with the lowest taxa richness, PET richness, SIGNAL-2 scores and OE50 scores of all sites. These impacts are likely due to the poor quality water and sediment quality observed at this site due to seepage from contaminated groundwater.
- The macroinvertebrate community at MBC01A contained the highest PET richness and OE50 scores of all sites, as well as high SIGNAL-2 scores relative to scores at all other sites in the study area. This site is immediately downstream of both TSF2 and MBC06, indicating that the impacts observed at MBC06 do not persist downstream and potential runoff from TSF2 has not impacted the health of the macroinvertebrate community at this site during this sampling event.
- Historical analysis of macroinvertebrate communities has indicated that there has been significant temporal variability in the study area, likely due to the differing wet season conditions.
- Due to unsuitable conditions, electrofishing was not conducted in 2019. This led to only a single fish being recorded in the study area during this monitoring event, a significant decline from previous monitoring events.
- Three sightings of Mertens' Water Monitors (*Varanus mertensi*) were recorded in 2019 at two sites, including one site upstream of Toms Gully Mine, and one site far downstream. No monitors were observed at any site adjacent to the mine or immediately downstream.

- Fewer non-target threatened species were observed in 2019 than 2018, though this may have been influenced by the malfunction of camera unit M5, where threatened species Pale Field Rat (*Rattus tunneyi*) and Black-footed Tree Rat (*Mesembriomys gouldii*) were observed in 2018.

5.2 Recommendations

The following recommendations are made for future monitoring:

- Site SWTG1A was moved 100 m downstream for sampling in 2019 due to water depth and clarity, and associated safety issues. It is recommended that this new location be retained for ongoing monitoring due to easier site access and improved safety.
- MBC01 was relocated 700 m downstream and sampled as MBC01A in 2019 as recommended in the 2018 report (GHD 2018a) due to disturbance of original site by a cattle crossing. MBC01A also contains a cattle crossing, but was much less degraded, with much less erosion, and was considered safer to sample. It is recommended that MBC01A be retained in future monitoring programs. There should be ongoing assessment of cattle disturbance during future monitoring events and if further degradation occurs an alternative site may need to be sought.
- It was recommended in the 2018 report (GHD 2018a) that site CC02 be moved due to major modifications to the creek channel by a cattle crossing. On return to the site in 2019, the area downstream of the cattle crossing had settled, and silt accumulated the previous year had been washed away. The macroinvertebrate habitats at the site looked to not be impacted so the original site was retained. It is recommended that this site be retained in the monitoring program although relocation should be considered if future degradation occurs due to cattle access.
- Sediment quality was monitored in Mt Bunday and Coulter Creeks during the annual aquatic ecology survey for the first time in 2019; noting that it has previously been assessed around the Toms Gully site by GHD (2018b). This monitoring has determined that despite elevated metal concentrations in the water at some sites adjacent to and downstream of Toms Gully Mine, there was little accumulation of these metals in sediments. It is recommended that sediment monitoring be continued in future monitoring events to determine whether any accumulation of sediment metals is occurring in Mount Bunday Creek under lower flow conditions and to provide a baseline for potential future mining. Sediment monitoring should also be repeated in Coulter Creek to provide a gauge of natural environmental variability.
- It is recommended that future monitoring be carefully timed, taking into consideration the volume and timing of rainfall during the wet season, so that receding water levels at the back of the seasonal hydrograph and water clarity are suitable for electrofishing, whilst also ensuring that safety during sampling is maintained.

6. References

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Simpson, S L and Batley, G B (2016) *Sediment Quality Assessment, A Practical Guide*, second edition, CSIRO Publishing.

Stauber, JL and Batley GE (2018) *Review of site-specific trigger values for Toms Gully Mine, NT*. CSIRO Land and Water, Australia.

Appendices

Appendix A – Laboratory certificates of analysis

CERTIFICATE OF ANALYSIS

Work Order : **ES1912530**
Client : **GHD PTY LTD**
Contact : **MS NICOLE CONROY**
Address : **LEVEL 5 66 SMITH STREET**
DARWIN NT, AUSTRALIA 0800
Telephone : **----**
Project : **432262302**
Order number : **----**
C-O-C number : **----**
Sampler : **Cameron Crawford**
Site : **----**
Quote number : **EN/005/18**
No. of samples received : **29**
No. of samples analysed : **29**

Page : 1 of 14
Laboratory : Environmental Division Sydney
Contact : Andrew Epps
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone : +61 7 3552 8639
Date Samples Received : 24-Apr-2019 08:15
Date Analysis Commenced : 24-Apr-2019
Issue Date : 03-May-2019 17:08



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Dianne Blane	Laboratory Coordinator (2IC)	Newcastle - Inorganics, Mayfield West, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EG094: It has been confirmed by re-digestion and re-analysis that total Cobalt and Manganese concentrations are less than dissolved for sample ES1912530 - #009. For all other samples and analytes where AF is greater than total, the difference is within experimental variation of the methods.
- TDS by method EA-015 may bias high for various samples due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
Client sampling date / time					16-Apr-2019 00:00	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-016	ES1912530-017	ES1912530-018	ES1912530-019	ES1912530-020
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		22.3	18.8	17.8	38.6	28.8
EA150: Particle Sizing									
+75µm	----	1	%		95	95	94	48	78
+150µm	----	1	%		94	95	94	40	74
+300µm	----	1	%		94	94	91	29	65
+425µm	----	1	%		93	91	87	25	55
+600µm	----	1	%		90	88	82	22	42
+1180µm	----	1	%		72	75	69	18	17
+2.36mm	----	1	%		47	56	56	12	2
+4.75mm	----	1	%		32	40	41	7	<1
+9.5mm	----	1	%		17	22	11	<1	<1
+19.0mm	----	1	%		2	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		5	5	6	20	14
Silt (2-60 µm)	----	1	%		<1	<1	<1	29	6
Sand (0.06-2.00 mm)	----	1	%		41	33	34	37	73
Gravel (>2mm)	----	1	%		54	62	60	14	7
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.60	2.54	2.62	2.47	2.54
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Aluminium	7429-90-5	50	mg/kg		120	100	130	1080	790
Arsenic	7440-38-2	1.0	mg/kg		<1.0	<1.0	<1.0	1.4	<1.0
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	<0.1	0.6	0.3
Cobalt	7440-48-4	0.5	mg/kg		1.0	1.0	0.8	8.3	4.9
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	<1.0	2.8	<1.0
Copper	7440-50-8	1.0	mg/kg		<1.0	<1.0	<1.0	14.2	7.3
Iron	7439-89-6	50	mg/kg		940	630	920	6120	2640
Lead	7439-92-1	1.0	mg/kg		3.8	3.7	3.5	13.6	6.6
Manganese	7439-96-5	10	mg/kg		85	113	71	400	109
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	<1.0	4.8	4.0
Zinc	7440-66-6	1.0	mg/kg		1.4	1.4	1.6	31.6	26.8



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
Client sampling date / time					16-Apr-2019 00:00	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-016	ES1912530-017	ES1912530-018	ES1912530-019	ES1912530-020
				Result	Result	Result	Result	Result	Result
EG020-SDH: 1M HCl Extractable metals by ICPMS									
Uranium	7440-61-1	1.0	mg/kg		<1.0	<1.0	<1.0	1.2	<1.0
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	1	mg/kg		<1	<1	<1	<1	<1
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	1	mg/kg		<1	<1	<1	2	1
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	1	mg/kg		<1	<1	<1	<1	<1
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.35	0.08	0.11	3.42	0.99



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				MBC02A Received as MBC01A	MBC03	MBC06	SWTG09	CK7
Client sampling date / time				17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	24-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1912530-022	ES1912530-023	ES1912530-024	ES1912530-025	ES1912530-026
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	22.2	26.2	47.6	40.2	26.2
EA150: Particle Sizing								
+75µm	----	1	%	73	52	35	33	65
+150µm	----	1	%	64	37	18	18	55
+300µm	----	1	%	46	14	11	12	45
+425µm	----	1	%	39	7	10	11	42
+600µm	----	1	%	28	4	8	11	40
+1180µm	----	1	%	3	2	4	10	37
+2.36mm	----	1	%	<1	<1	1	8	30
+4.75mm	----	1	%	<1	<1	<1	8	17
+9.5mm	----	1	%	<1	<1	<1	7	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	16	21	19	20	17
Silt (2-60 µm)	----	1	%	9	24	36	37	16
Sand (0.06-2.00 mm)	----	1	%	74	54	43	34	35
Gravel (>2mm)	----	1	%	1	1	2	9	32
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.57	2.45	2.45	2.48	2.59
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	420	500	1540	710	380
Arsenic	7440-38-2	1.0	mg/kg	<1.0	<1.0	4.3	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.2	1.6	0.2	0.2
Cobalt	7440-48-4	0.5	mg/kg	1.7	<0.5	4.3	2.3	10.3
Chromium	7440-47-3	1.0	mg/kg	<1.0	<1.0	1.6	1.5	<1.0
Copper	7440-50-8	1.0	mg/kg	3.2	10.1	31.4	8.4	3.7
Iron	7439-89-6	50	mg/kg	660	660	6680	2240	2090
Lead	7439-92-1	1.0	mg/kg	4.9	5.2	9.5	13.3	22.7
Manganese	7439-96-5	10	mg/kg	69	14	82	72	410
Nickel	7440-02-0	1.0	mg/kg	<1.0	1.1	11.4	2.3	6.2
Zinc	7440-66-6	1.0	mg/kg	4.7	6.2	60.8	7.3	38.6



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				MBC02A Received as MBC01A	MBC03	MBC06	SWTG09	CK7
Client sampling date / time				17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	24-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1912530-022	ES1912530-023	ES1912530-024	ES1912530-025	ES1912530-026
				Result	Result	Result	Result	Result
EG020-SDH: 1M HCl Extractable metals by ICPMS								
Uranium	7440-61-1	1.0	mg/kg	<1.0	<1.0	3.6	1.1	1.2
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK025SF: Free CN by Segmented Flow Analyser								
Free Cyanide	----	1	mg/kg	<1	<1	<1	1	<1
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	1	mg/kg	<1	<1	3	2	<1
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser								
Weak Acid Dissociable Cyanide	----	1	mg/kg	<1	<1	<1	1	<1
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.16	0.67	5.04	1.19	0.67



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	CC03	CC02	CC01	CK-DUP	----
Client sampling date / time					24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	----
Compound	CAS Number	LOR	Unit		ES1912530-027	ES1912530-028	ES1912530-029	ES1912530-030	-----
					Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		25.7	18.6	24.4	34.7	----
EA150: Particle Sizing									
+75µm	----	1	%		42	76	31	70	----
+150µm	----	1	%		18	71	23	57	----
+300µm	----	1	%		7	68	18	42	----
+425µm	----	1	%		6	67	16	37	----
+600µm	----	1	%		5	66	15	34	----
+1180µm	----	1	%		4	61	14	29	----
+2.36mm	----	1	%		3	42	13	23	----
+4.75mm	----	1	%		2	12	10	19	----
+9.5mm	----	1	%		<1	<1	5	15	----
+19.0mm	----	1	%		<1	<1	<1	<1	----
+37.5mm	----	1	%		<1	<1	<1	<1	----
+75.0mm	----	1	%		<1	<1	<1	<1	----
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		19	9	30	13	----
Silt (2-60 µm)	----	1	%		35	12	31	13	----
Sand (0.06-2.00 mm)	----	1	%		42	31	26	49	----
Gravel (>2mm)	----	1	%		4	48	13	25	----
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	----
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.56	2.60	2.57	2.55	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Aluminium	7429-90-5	50	mg/kg		320	260	410	880	----
Arsenic	7440-38-2	1.0	mg/kg		<1.0	<1.0	<1.0	1.1	----
Cadmium	7440-43-9	0.1	mg/kg		0.2	<0.1	<0.1	0.3	----
Cobalt	7440-48-4	0.5	mg/kg		7.3	2.2	1.8	12.0	----
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	<1.0	2.1	----
Copper	7440-50-8	1.0	mg/kg		4.5	1.2	3.0	5.2	----
Iron	7439-89-6	50	mg/kg		2260	930	1300	3120	----
Lead	7439-92-1	1.0	mg/kg		14.1	18.4	14.5	20.5	----
Manganese	7439-96-5	10	mg/kg		221	137	114	406	----
Nickel	7440-02-0	1.0	mg/kg		3.3	<1.0	<1.0	8.2	----
Zinc	7440-66-6	1.0	mg/kg		17.6	1.7	1.2	48.5	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	CC03	CC02	CC01	CK-DUP	----
Client sampling date / time					24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	----
Compound	CAS Number	LOR	Unit		ES1912530-027	ES1912530-028	ES1912530-029	ES1912530-030	-----
					Result	Result	Result	Result	----
EG020-SDH: 1M HCl Extractable metals by ICPMS									
Uranium	7440-61-1	1.0	mg/kg		1.2	3.5	1.3	1.6	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	1	mg/kg		<1	<1	<1	<1	----
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	1	mg/kg		<1	<1	<1	<1	----
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	1	mg/kg		<1	<1	<1	<1	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.40	0.08	0.27	0.67	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
Client sampling date / time					[16-Apr-2019]	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-001	ES1912530-002	ES1912530-003	ES1912530-004	ES1912530-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.60	7.22	7.19	7.13	7.53
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		29	28	29	45	73
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		42	61	48	60	71
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		8	35	11	7	17
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L		12	10	10	10	27
Total Alkalinity as CaCO ₃	----	1	mg/L		12	10	10	10	27
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA									
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L		1	1	1	11	12
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		2	2	2	2	3
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	0.5	mg/L		1.1	0.9	1.1	2.7	4.0
Magnesium	7439-95-4	0.5	mg/L		1.0	1.1	1.1	2.0	2.5
Sodium	7440-23-5	0.5	mg/L		3.0	3.1	3.1	3.1	3.6
Potassium	7440-09-7	0.5	mg/L		0.9	1.0	1.1	1.0	1.3
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		164	197	433	386	470
Arsenic	7440-38-2	0.2	µg/L		0.7	0.6	0.6	0.7	0.6
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	0.33	<0.05
Chromium	7440-47-3	0.2	µg/L		0.2	0.2	0.3	0.3	0.4
Cobalt	7440-48-4	0.1	µg/L		0.2	<0.1	0.1	0.6	0.1
Copper	7440-50-8	0.5	µg/L		<0.5	<0.5	<0.5	2.7	1.5
Iron	7439-89-6	2	µg/L		681	351	448	495	759



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
Client sampling date / time				[16-Apr-2019]	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1912530-001	ES1912530-002	ES1912530-003	ES1912530-004	ES1912530-005
				Result	Result	Result	Result	Result
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued								
Lead	7439-92-1	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.5	µg/L	24.6	1.0	0.9	68.0	1.6
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	4.5	1.5
Uranium	7440-61-1	0.05	µg/L	0.11	0.06	0.07	0.12	0.08
Zinc	7440-66-6	1	µg/L	<1	<1	<1	15	4
EG094T: Total metals in Fresh water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	842	679	621	543	526
Arsenic	7440-38-2	0.2	µg/L	1.0	0.9	0.9	1.0	1.3
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	<0.05	0.35	0.15
Chromium	7440-47-3	0.2	µg/L	0.8	0.6	0.6	0.5	0.7
Cobalt	7440-48-4	0.1	µg/L	0.3	0.2	0.2	0.7	4.2
Copper	7440-50-8	0.5	µg/L	0.7	0.7	0.8	3.6	2.9
Iron	7439-89-6	2	µg/L	1120	922	804	920	2010
Lead	7439-92-1	0.1	µg/L	0.5	0.5	0.4	0.4	0.5
Manganese	7439-96-5	0.5	µg/L	25.9	11.4	4.0	63.0	196
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	5.4	4.1
Uranium	7440-61-1	0.05	µg/L	0.13	0.11	0.09	0.16	0.16
Zinc	7440-66-6	1	µg/L	<1	<1	16	22	18
EK025SF: Free CN by Segmented Flow Analyser								
Free Cyanide	----	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser								
Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	0.32	0.28	0.28	0.48	0.87
Total Cations	----	0.01	meq/L	0.29	0.30	0.31	0.46	0.60
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	2	2	2	2	3



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MBC0	MBC01A	MBC03	MBC06	SWTG09
Client sampling date / time					17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-006	ES1912530-007	ES1912530-008	ES1912530-009	ES1912530-010
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		10.8	7.76	10.5	8.32	7.74
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		2040	46	1600	4400	34
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		1120	----	975	----	----
Total Dissolved Solids @180°C	----	10	mg/L		----	74	----	4530	60
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		27	134	54	10	24
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		846	<1	620	4	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		6	11	87	179	15
Total Alkalinity as CaCO3	----	1	mg/L		852	11	707	183	15
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		1	11	57	3340	<1
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		3	2	3	19	3
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	0.5	mg/L		1.2	2.8	2.4	216	1.5
Magnesium	7439-95-4	0.5	mg/L		<0.5	2.0	<0.5	583	1.2
Sodium	7440-23-5	0.5	mg/L		430	3.2	348	52.9	4.4
Potassium	7440-09-7	0.5	mg/L		1.3	0.9	1.1	2.5	0.9
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		28	773	42	<5	606
Arsenic	7440-38-2	0.2	µg/L		1.0	0.6	1.0	1.9	0.5
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	0.15	<0.05
Chromium	7440-47-3	0.2	µg/L		<0.2	0.5	<0.2	<0.2	1.0
Cobalt	7440-48-4	0.1	µg/L		<0.1	0.2	<0.1	2.7	0.2
Copper	7440-50-8	0.5	µg/L		0.6	1.8	0.9	1.4	1.4



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MBC0	MBC01A	MBC03	MBC06	SWTG09
Client sampling date / time					17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-006	ES1912530-007	ES1912530-008	ES1912530-009	ES1912530-010
					Result	Result	Result	Result	Result
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued									
Iron	7439-89-6	2	µg/L		12	590	10	57	411
Lead	7439-92-1	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.5	µg/L		<0.5	1.9	<0.5	806	2.1
Nickel	7440-02-0	0.5	µg/L		<0.5	1.8	<0.5	24.6	0.7
Uranium	7440-61-1	0.05	µg/L		0.06	0.10	0.06	22.7	0.12
Zinc	7440-66-6	1	µg/L		2	7	<1	14	4
EG094T: Total metals in Fresh water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		536	695	37	39	604
Arsenic	7440-38-2	0.2	µg/L		1.0	1.0	0.8	3.0	0.6
Cadmium	7440-43-9	0.05	µg/L		<0.05	0.47	<0.05	0.25	<0.05
Chromium	7440-47-3	0.2	µg/L		0.6	0.6	<0.2	0.3	1.2
Cobalt	7440-48-4	0.1	µg/L		0.2	3.3	<0.1	2.0	0.5
Copper	7440-50-8	0.5	µg/L		1.7	4.7	0.9	2.0	2.1
Iron	7439-89-6	2	µg/L		860	1070	3	798	616
Lead	7439-92-1	0.1	µg/L		2.6	0.7	<0.1	<0.1	0.6
Manganese	7439-96-5	0.5	µg/L		10.6	135	<0.5	468	30.1
Nickel	7440-02-0	0.5	µg/L		0.8	6.1	<0.5	26.6	1.0
Uranium	7440-61-1	0.05	µg/L		0.10	0.22	0.11	22.7	0.11
Zinc	7440-66-6	1	µg/L		48	26	<1	30	9
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		17.1	0.50	15.4	73.7	0.38
Total Cations	----	0.01	meq/L		18.8	0.47	15.3	61.1	0.39
Ionic Balance	----	0.01	%		4.64	----	0.37	9.35	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		3	3	2	10	3



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	CK7	CC03	CC02	CC01	CK-DUP
Client sampling date / time					19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-011	ES1912530-012	ES1912530-013	ES1912530-014	ES1912530-015
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.30	7.28	7.30	7.23	7.23
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		73	72	82	71	72
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		79	86	87	93	82
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	5	8	35	6
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		12	12	12	12	11
Total Alkalinity as CaCO3	----	1	mg/L		12	12	12	12	11
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		26	25	30	24	25
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		2	3	2	2	3
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	0.5	mg/L		4.6	4.4	5.1	4.6	4.8
Magnesium	7439-95-4	0.5	mg/L		4.6	4.5	5.2	4.4	4.7
Sodium	7440-23-5	0.5	mg/L		3.8	3.6	4.3	3.8	7.0
Potassium	7440-09-7	0.5	mg/L		2.0	1.8	2.2	1.8	2.2
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		87	162	126	250	125
Arsenic	7440-38-2	0.2	µg/L		0.8	0.8	0.6	0.6	0.8
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L		0.2	0.2	0.3	0.3	0.4
Cobalt	7440-48-4	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	0.1
Copper	7440-50-8	0.5	µg/L		0.7	0.9	<0.5	<0.5	1.4
Iron	7439-89-6	2	µg/L		553	544	559	604	588



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				CK7	CC03	CC02	CC01	CK-DUP
Client sampling date / time				19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1912530-011	ES1912530-012	ES1912530-013	ES1912530-014	ES1912530-015
				Result	Result	Result	Result	Result
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued								
Lead	7439-92-1	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.5	µg/L	2.8	1.6	2.2	2.0	4.7
Nickel	7440-02-0	0.5	µg/L	2.0	1.9	<0.5	<0.5	2.2
Uranium	7440-61-1	0.05	µg/L	0.10	0.11	0.08	0.08	0.12
Zinc	7440-66-6	1	µg/L	5	4	3	<1	7
EG094T: Total metals in Fresh water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	289	191	209	212	283
Arsenic	7440-38-2	0.2	µg/L	0.9	0.9	0.8	0.9	1.0
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L	0.4	0.3	0.4	0.5	0.4
Cobalt	7440-48-4	0.1	µg/L	0.8	0.6	0.3	0.3	0.8
Copper	7440-50-8	0.5	µg/L	0.9	0.8	0.6	0.8	0.8
Iron	7439-89-6	2	µg/L	882	694	921	911	868
Lead	7439-92-1	0.1	µg/L	0.5	0.2	0.5	0.6	0.6
Manganese	7439-96-5	0.5	µg/L	51.2	38.2	95.6	59.8	48.2
Nickel	7440-02-0	0.5	µg/L	2.6	2.8	0.8	0.8	2.6
Uranium	7440-61-1	0.05	µg/L	0.15	0.15	0.12	0.14	0.16
Zinc	7440-66-6	1	µg/L	12	5	5	4	8
EK025SF: Free CN by Segmented Flow Analyser								
Free Cyanide	----	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser								
Weak Acid Dissociable Cyanide	----	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	0.84	0.84	0.92	0.80	0.82
Total Cations	----	0.01	meq/L	0.82	0.79	0.92	0.80	0.99
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	3	3	3	3	4

Appendix B – Raw macroinvertebrate data

Mount Bunday Creek sites

Order	Family/Sub-family	SWG1C_1	SWG1C_2	SWG1A_1	SWG1A_2	SWG09_1	SWG09_2	SWG1_1	SWG1_2	MBC06_1	MBC06_2	MBC01A_1	MBC01A_2	SWG2_1	SWG2_2	MBC03_1	MBC03_2
<i>Acarina</i>	<i>Acarina</i>	1	1	67	15	50	92	10	22	13	3	27	17	75	15	37	27
<i>Bivalvia</i>	<i>Corbiculidae</i>	8	5	8	10	50											
<i>Bivalvia</i>	<i>Hyriidae</i>		1	1	1				1			1					
<i>Coleoptera</i>	<i>Dytiscidae</i>	1		42	20		8		7	13	5	18	17	63	22	16	27
<i>Coleoptera</i>	<i>Elmidae</i>							10	4							5	
<i>Coleoptera</i>	<i>Gyrinidae</i>			33	20			5	7			5				11	7
<i>Coleoptera</i>	<i>Hydraenidae</i>			25	10				4			5	17				
<i>Coleoptera</i>	<i>Hydrochidae</i>			25	5	10	15					5		13	4	11	7
<i>Coleoptera</i>	<i>Hydrophilidae</i>	4	3			30	8	10	4			9	11	50	11	26	20
<i>Crustacea</i>	<i>Conchostraca sp.</i>												6				
<i>Decapoda</i>	<i>Atyidae</i>	10	22	33	10	100	15	45	15			27	89	188	44	126	180
<i>Decapoda</i>	<i>Palaemonidae</i>	5	12	106	38			12	8			7	22	3	1	8	28
<i>Decapoda</i>	<i>Parathelphusidae</i>	1	2	4	1	1	2	1	3	2	1	2		1	2	2	5
<i>Diptera</i>	<i>Ceratopogonidae</i>	8	11	100	15	20	46	40	26		5	14	6	50	11	37	93
<i>Diptera</i>	<i>Chironominae</i>	34	45	317	275	440	377	135	70	396	176	200	317	775	233	205	247
<i>Diptera</i>	<i>Culicidae</i>					10	46	10	4	26	11	5		50		21	13
<i>Diptera</i>	<i>Orthocladiinae</i>	2		17	5	10	8	30	33			41	72	75	56	26	60
<i>Diptera</i>	<i>Tabanidae</i>			8								9					
<i>Diptera</i>	<i>Tanypodinae</i>	38	41	350	300	400	285	60	15	378	237	114	100	400	107	189	187
<i>Diptera</i>	<i>Tipulidae</i>				5				7					13	4	16	
<i>Ephemeroptera</i>	<i>Baetidae</i>	22	19	100	20	160	92	110	104	52	26	100	67	175	37	79	167
<i>Ephemeroptera</i>	<i>Caenidae</i>	17	9	183	155	170	31	300	300		5	55	200	388	133	84	113
<i>Ephemeroptera</i>	<i>Leptophlebiidae</i>	10	4	50	35	20		10	11			23	6	13	7	16	
<i>Gastropoda</i>	<i>Ancylidae</i> (<i>Planorbidae</i>)		4	33	50	80	23	70	85			9	33			5	33

Order	Family/Sub-family	SWG1C_1	SWG1C_2	SWG1A_1	SWG1A_2	SWG09_1	SWG09_2	SWG1_1	SWG1_2	MBC06_1	MBC06_2	MBC01A_1	MBC01A_2	SWG2_1	SWG2_2	MBC03_1	MBC03_2
<i>Gastropoda</i>	<i>Planorbidae</i>												6	13	4	16	
<i>Hemiptera</i>	<i>Belostomatidae</i>					10											
<i>Hemiptera</i>	<i>Gelastocoridae</i>											5					1
<i>Hemiptera</i>	<i>Gerridae</i>			17	10	10	8		4	1	3			13		11	13
<i>Hemiptera</i>	<i>Mesoveliidae</i>				5	10	15		4		3			38	7		7
<i>Hemiptera</i>	<i>Micronectidae</i>	22	16	108	75	70	138	100	19	39	16	100	150	50	22	58	60
<i>Hemiptera</i>	<i>Nepidae</i>						1								1	1	1
<i>Hemiptera</i>	<i>Notonectidae</i>					20	8			26	5						
<i>Hemiptera</i>	<i>Pleidae</i>					30	15							25	22		13
<i>Hemiptera</i>	<i>Veliidae</i>			8					4					13	7		7
<i>Lepidoptera</i>	<i>Crambidae</i>			8									6				
<i>Odonata</i>	<i>Coenagrionidae</i>				5			10									
<i>Odonata</i>	<i>Isostictidae</i>									9							
<i>Odonata</i>	<i>Libellulidae</i>								4	26		9	6			5	
<i>Odonata</i>	<i>Zygoptera</i>												6				
<i>Oligochaeta</i>	<i>Oligochaeta</i>	7	10	108	45	390	385	105	41	13	45	45	11	38	15	42	60
<i>Trichoptera</i>	<i>Calamoceratidae</i>															5	
<i>Trichoptera</i>	<i>Ecnomidae</i>											5					
<i>Trichoptera</i>	<i>Hydroptilidae</i>							10	4			5	6				
<i>Trichoptera</i>	<i>Leptoceridae</i>	5	4	83	35	50	62	45	15	13	21	82	67	150	41	84	127
<i>Turbellaria</i>	<i>Dugesidae</i>	1	3			10	15	5									

Coulter Creek sites

Order	Family/Sub-family	CC02_1	CC02_2	CC01_1	CC01_2	CK7_1	CK7_2	CC03_1	CC03_2
<i>Acarina</i>	<i>Acarina</i>	20	47	8	11		45	5	14
<i>Bivalvia</i>	<i>Corbiculidae</i>								3
<i>Bivalvia</i>	<i>Hyriidae</i>								1
<i>Coleoptera</i>	<i>Dytiscidae</i>	20	5	9	44	31	18	1	9
<i>Coleoptera</i>	<i>Hydraenidae</i>				11		9	5	
<i>Coleoptera</i>	<i>Hydrochidae</i>				11				
<i>Coleoptera</i>	<i>Hydrophilidae</i>	10	5	23	11	31	27	17	
<i>Coleoptera</i>	<i>Scirtidae</i>	10	16		22	8			
<i>Crustacea</i>	<i>Conchostraca sp.</i>				11				
<i>Decapoda</i>	<i>Atyidae</i>		5						
<i>Decapoda</i>	<i>Palaemonidae</i>	10	2		22	8	9	7	
<i>Decapoda</i>	<i>Parathelphusidae</i>	3	1		1	1		2	
<i>Diptera</i>	<i>Ceratopogonidae</i>	10	26	38	22	54	55	17	11
<i>Diptera</i>	<i>Chironominae</i>	390	284	315	256	446	509	119	254
<i>Diptera</i>	<i>Culicidae</i>	20		15	78	54	45	12	3
<i>Diptera</i>	<i>Orthocladinae</i>	130	89	123	156	92	173	12	6
<i>Diptera</i>	<i>Tabanidae</i>				11				
<i>Diptera</i>	<i>Tanypodinae</i>	400	184	138	522	138	136	119	97
<i>Ephemeroptera</i>	<i>Baetidae</i>	120	42	85	156	146	82	48	3
<i>Ephemeroptera</i>	<i>Caenidae</i>	90	32	69	122	131	191	14	14
<i>Ephemeroptera</i>	<i>Leptophlebiidae</i>	20	5	8					
<i>Gastropoda</i>	<i>Ancylidae (Planorbidae)</i>	20	26	138	356	46	91	33	6
<i>Gastropoda</i>	<i>Planorbidae</i>	40		15	33	8	18	14	
<i>Gastropoda</i>	<i>Viviparidae</i>		5	9	2	1	1		
<i>Hemiptera</i>	<i>Belostomatidae</i>						1		
<i>Hemiptera</i>	<i>Gerridae</i>	10	32	8			27	5	3
<i>Hemiptera</i>	<i>Mesoveliidae</i>	20		8	11	8	18		
<i>Hemiptera</i>	<i>Micronectidae</i>	510	226	115	11	254	227	45	57
<i>Hemiptera</i>	<i>Nepidae</i>	1							
<i>Hemiptera</i>	<i>Notonectidae</i>			8	11				
<i>Hemiptera</i>	<i>Ochteridae</i>						9		
<i>Hemiptera</i>	<i>Pleidae</i>	50	16	15	11	31	9		
<i>Hemiptera</i>	<i>Veliidae</i>					8			
<i>Lepidoptera</i>	<i>Crambidae</i>		5	8					
<i>Odonata</i>	<i>Coenagrionidae</i>				22				
<i>Odonata</i>	<i>Isostictidae</i>				11				
<i>Odonata</i>	<i>Libellulidae</i>			8	34				
<i>Odonata</i>	<i>Lindeniidae</i>			8					
<i>Odonata</i>	<i>Zygoptera</i>		5	8	11		9		
<i>Oligochaeta</i>	<i>Oligochaeta</i>	120	37	269	256	8	64	33	83
<i>Trichoptera</i>	<i>Calamoceratidae</i>				11				
<i>Trichoptera</i>	<i>Ecnomidae</i>								
<i>Trichoptera</i>	<i>Hydroptilidae</i>			15	33	31	18		
<i>Trichoptera</i>	<i>Leptoceridae</i>	100	79	123	189	154	236	50	51
<i>Turbellaria</i>	<i>Dugesidae</i>			8					

Appendix C – Water quality QA

Analyte	Units	LOR	CK7	CK-DUP
Physicochemical parameters				
TDS	mg/L	10	79	82
TSS	mg/L	5	<5	6
Major ions				
Bicarbonate alkalinity as CaCO ₃	mg/L	1	12	11
Carbonate alkalinity as CaCO ₃	mg/L	1	<1	<1
Hydroxide alkalinity as CaCO ₃	mg/L	1	<1	<1
Total alkalinity as CaCO ₃	mg/L	1	12	11
Sulfate as SO ₄	mg/L	1	26	25
Chloride	mg/L	1	2	3
Calcium	mg/L	0.5	4.6	4.8
Magnesium	mg/L	0.5	4.6	4.7
Sodium	mg/L	0.5	3.8	7
Potassium	mg/L	0.5	2.0	2.2
Dissolved metals				
Aluminium	mg/L	0.005	0.087	0.125
Arsenic	mg/L	0.0002	0.0008	0.0008
Cadmium	mg/L	0.00005	<0.00005	<0.00005
Chromium	mg/L	0.0002	0.0002	0.0004
Cobalt	mg/L	0.0001	<0.0001	0.0001
Copper	mg/L	0.0005	0.0007	0.0014
Iron	mg/L	0.002	0.553	0.588
Lead	mg/L	0.0001	<0.0001	<0.0001
Manganese	mg/L	0.0005	0.0028	0.0047
Mercury	mg/L	0.0001	<0.0001	<0.0001
Nickel	mg/L	0.0005	0.002	0.0022
Uranium	mg/L	0.00005	0.0001	0.00012
Zinc	mg/L	0.001	0.005	0.007
Total metals				
Aluminium	mg/L	0.005	0.289	0.283
Arsenic	mg/L	0.0002	0.0009	0.001
Cadmium	mg/L	0.00005	<0.00005	<0.00005
Chromium	mg/L	0.0002	0.0004	0.0004
Cobalt	mg/L	0.0001	0.0008	0.0008
Copper	mg/L	0.0005	0.0009	0.0008
Iron	mg/L	0.002	0.882	0.868
Lead	mg/L	0.0001	0.0005	0.0006
Manganese	mg/L	0.0005	0.0512	0.0482
Mercury	mg/L	0.0001	<0.0001	<0.0001
Nickel	mg/L	0.0005	0.0026	0.0026
Uranium	mg/L	0.00005	0.00015	0.00016
Zinc	mg/L	0.001	0.012	0.008
Cyanide				
Free cyanide	mg/L	0.004	<0.004	<0.004
Weak acid dissociable cyanide	mg/L	0.004	<0.004	<0.004
Total cyanide	mg/L	0.004	<0.004	<0.004

Appendix D – Sediment quality QA

Analyte	Units	LOR	CK7	CK-DUP
			24/04/2019	24/04/2019
1M HCl-extractable metals				
Aluminium	mg/kg	50	380	880
Arsenic	mg/kg	1	<1.0	1.1
Cadmium	mg/kg	0.1	0.2	0.3
Cobalt	mg/kg	0.5	10.3	12
Chromium	mg/kg	1	<1.0	2.1
Copper	mg/kg	1	3.7	5.2
Iron	mg/kg	50	2090	3120
Lead	mg/kg	1	22.7	20.5
Manganese	mg/kg	10	410	406
Nickel	mg/kg	1	6.2	8.2
Uranium	mg/kg	1	1.2	1.6
Zinc	mg/kg	1	38.6	48.5
Total recoverable metals				
Mercury	mg/kg	0.1	<0.1	<0.1
Cyanide				
Free Cyanide	mg/kg	1	<1	<1
Weak Acid Dissociable Cyanide	mg/kg	1	<1	<1
Total Cyanide	mg/kg	1	<1	<1
Other parameters				
Total Organic Carbon	%	0.02	0.67	0.67
Moisture Content	%	0.1	26.2	34.7

Appendix E – Macroinvertebrate identification QA

Macroinvertebrate Identification Quality Assurance Certificate

Site Code: CC02
Identification Date: 13/6/2019
QA Date: 24/6/2019

Replicate: 2 of 2
Identifier: TS
Senior Taxonomist: S. Jones

Habitat: Edge
Identification Level: Family

Taxonomy	Original Count	QA Count	Comment
Acarina	9	8	Possible transfer issue
Dytiscidae	1	1	
Hydrophilidae	1	1	
Scirtidae	3	3	
Atyidae	1	1	
Ceratopogonidae	5	5	
Chironominae	54	52	Possible transfer issue
Orthocladinae	17	16	Possible transfer issue
Tanypodinae	35	35	
Baetidae	8	7	Possible transfer issue
Caenidae	6	6	
Leptophlebiidae	1	1	
Ancyliidae (Planorbidae)	5	5	
Viviparidae	1	1	
Gerridae	6	6	
Micronectidae	43	42	Possible transfer issue
Pleidae	3	3	
Crambidae	1	1	
Zygoptera	1	1	
Oligochaeta	7	6	Possible transfer issue
Leptoceridae	15	15	

Percentage Correct: 100%

QA Result: **Pass**

Tara Steele

Identifying Taxonomist

Susan Jones

Senior QA Taxonomist

Macroinvertebrate Identification Quality Assurance Certificate

Site Code: SWTG2
Identification Date: 18/6/2019
QA Date: 24/6/2019

Replicate: 2 of 2
Identifier: TS
Senior Taxonomist: S. Jones

Habitat: Edge
Identification Level: Family

Taxonomy	Original Count	QA Count	Comment
Acarina	4	4	
Dytiscidae	6	5	Possible transfer issue
Hydrochidae	1	1	
Hydrophilidae	3	3	
Atyidae	12	12	
Ceratopogonidae	3	3	
Chironominae	63	63	
Orthocladinae	15	15	
Tanypodinae	29	29	
Tipulidae	1	1	
Baetidae	10	10	
Caenidae	36	36	
Leptophlebiidae	2	1	
Planorbidae	1	1	
Mesoveliidae	2	2	
Micronectidae	6	6	
Pleidae	6	6	
Veliidae	2	2	
Oligochaeta	4	4	
Leptoceridae	11	11	

Percentage Correct: 100%

QA Result: **Pass**

Tara Steele

Identifying Taxonomist

Susan Jones

Senior QA Taxonomist

Appendix F – Remote camera species list

Group	Common Name	Scientific Name	Listing	Camera unit					
			NT	M1	M3	M4	M5	M7	M8
Bird	Australian White Ibis	<i>Threskionis molucca</i>			✓	✓		✓	✓
Bird	Pacific Black Duck	<i>Anas superciliosa</i>						✓	
Bird	Restless flycatcher	<i>Myiagra inquieta</i>							✓
Bird	Bar-shouldered Dove	<i>Geopelia humeralis</i>			✓	✓			✓
Bird	Black Kite	<i>Milvus migrans</i>						✓	
Bird	Blue-faced honeyeater	<i>Gracula cyanotis</i>					✓		
Bird	Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>			✓				✓
Bird	Blue-winged Kookaburra	<i>Dacelo leachii</i>			✓				✓
Bird	Goshawk / Sparrowhawk	<i>Accipiter spp.</i>			✓	✓			
Bird	Brown Goshawk	<i>Accipiter fasciatus</i>							✓
Bird	Bush-Stone Curlew	<i>Burhinus grallarius</i>							✓
Bird	Burdekin Duck	<i>Tadorna radjah</i>							✓
Bird	Great Egret	<i>Ardea modesta</i>		✓		✓		✓	✓
Bird	Intermediate Egret	<i>Ardea intermedia</i>				✓		✓	
Bird	Pied Cormorant	<i>Phalacrocorax varius</i>			✓	✓			
Bird	Nankeen Night Heron	<i>Nycticorax caledonicus</i>			✓	✓		✓	✓
Bird	Nankeen Kestrel	<i>Falco cenchroides</i>				✓	✓		
Bird	Straw-necked Ibis	<i>Threskionis spinicollis</i>			✓	✓			
Bird	Tawny Frogmouth	<i>Podargus strigoides</i>				✓			
Bird	Torresian Crow	<i>Corvus orru</i>						✓	
Bird	Whistling Kite	<i>Haliastur sphenurus</i>				✓			
Bird	White-faced Heron	<i>Egretta novaehollandiae</i>			✓	✓		✓	
Bird	Bush-Stone Curlew	<i>Burhinus grallarius</i>			✓				
Mammal	Agile Wallaby	<i>Macropus agilis</i>		✓	✓	✓		✓	✓
Mammal	Cattle	<i>Bos indicus/taurus</i>		✓	✓	✓		✓	
Mammal	Dingo	<i>Canis lupus dingo</i>			✓	✓	✓	✓	
Mammal	Pig	<i>Sus scrofa</i>				✓		✓	✓
Mammal	Water Rat	<i>Hydromys chrysogaster</i>				✓		✓	✓
Mammal	Northern Brown Bandicoot	<i>Isodon macrourus</i>			✓				
Mammal	Echidna	<i>Tachyglossus aculeatus</i>							✓
Reptile	Mertens' Water Monitor	<i>Varanus mertensi</i>	VU		✓				✓

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		Name	Signature	Name	Signature	Date
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Appendix S-3 - Aquatic Ecology Survey 2018



Primary Gold Limited
Toms Gully Baseline Studies
Aquatic Ecology Data Report

November 2018

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1. Introduction

1.1 Background

Toms Gully Mine, located near Marrakai in the Northern Territory, has been in operation intermittently since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery, the project area has operated under the ownership of several different operators, most recently Crocodile Gold until 2010; then after a period of Care and Maintenance, it was divested to Primary Gold.

Primary Gold Limited, the current lease owner, proposes to recommence underground mining and ore processing at the Toms Gully Mine, including:

- construction of a new process water dam;
- dewatering and refurbishment of the existing workings;
- upgrade of the new tailings storage facility; and
- refurbishment and upgrade of the processing circuit.

An aquatic ecology monitoring program conducted in 2015 and 2017 gathered data on fish, and macroinvertebrate communities as well as habitat information and water quality for Mount Bunday and Coulter Creeks.

1.2 Scope

The scope of works for this study includes:

- An aquatic ecology survey carried out in May 2018 - to characterise the existing aquatic health and condition of the receiving environment. The study includes:
 - Macroinvertebrate community sampling and aquatic habitat assessment - carried out in accordance with the NT AUSRIVAS Darwin-Daly Region Manual (with the inclusion of replicate sampling)
 - Fish community sampling
 - Water quality sampling and analysis (including *in situ* monitoring physico-chemical parameters) - undertaken at each site where aquatic ecology monitoring takes place.
- A study design that incorporates locations upstream, within and downstream of the Toms Gully ML, and as a minimum, would include Primary Gold sites SWTG1A (reference site) and SWTG2 (potential impact site).
- Monitoring for the presence of the Mertens Water Monitor (*Varanus mertensi*) and Mitchell's Water Monitor (*Varanus mitchelli*) downstream of the Toms Gully Mine site.

This data report presents the data collected during field surveys and remote camera monitoring undertaken in 2018.

1.3 Assumptions

Some data used as part of this report was gathered from external sources, and has not been verified by GHD. Climate data gathered from the Bureau of Meteorology was assumed to be validated and correct at the time it was accessed.

2. Study Area

2.1 Climate

The area in which Toms Gully Mine is located has a tropical monsoonal climate with a pronounced wet season from October to April.

Rainfall data was sourced from the Bureau of Meteorology Point Stuart Wilderness Lodge station (station number 14263) (BOM 2018), the nearest active rainfall station to Toms Gully Mine. Rainfall data for May 2017 to April 2018 is displayed in Figure 2-1 and includes a comparison to long-term monthly median results from data recorded between 1957 and 2018. Rainfall exceeded the long-term median during four of the seven wet season months prior to sampling, with rainfall during January 2018 recording the highest January rainfall total since monitoring began at this site in 1957.

Watercourses in the study area are ephemeral and cease to flow during the late dry season, but have regular flows during the wet season. Semi-permanent waterholes exist in the area. These are likely to be ecologically important and serve as a refuge for fish and aquatic reptiles during the dry season, as well as water sources for terrestrial fauna.

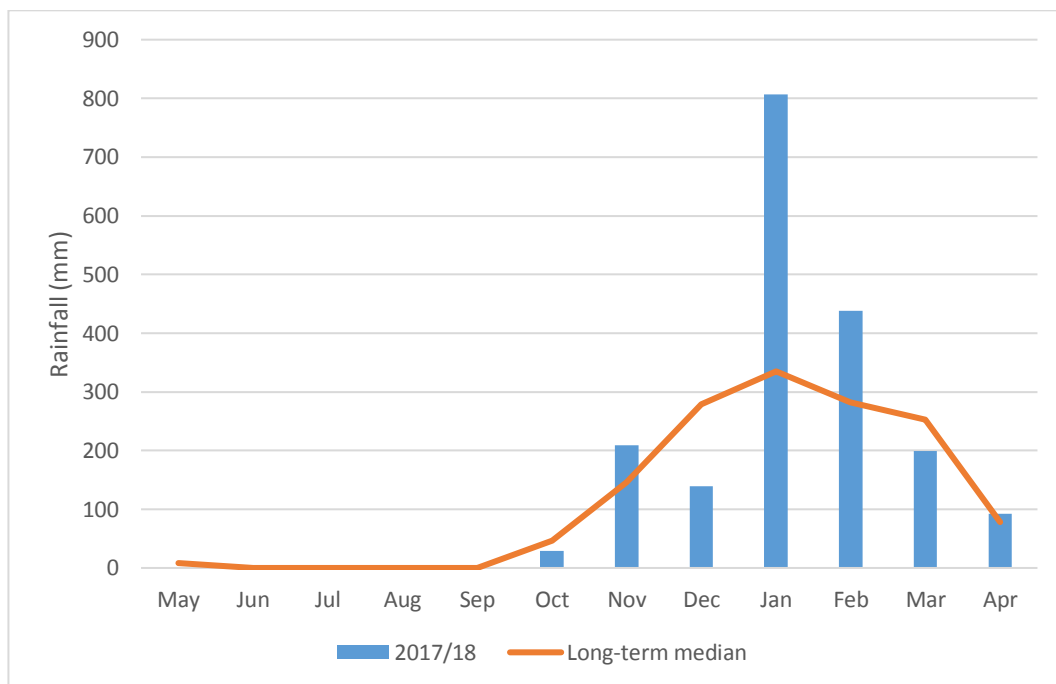


Figure 2-1 Monthly rainfall at Point Stuart Wilderness Lodge weather station (14263) 2017/18, with comparison to long-term median results

2.2 Survey timing

Sampling was undertaken between 7 and 15 May 2018. Work was scheduled to begin in April, but the timing and intensity of rainfall over the wet season meant that additional time was required to allow the watercourses to return to a steady state of flow. The additional time allowed water conditions at sampling sites to be shallow, and clear enough to enter safely, due to the likely presence of crocodiles. It is likely that during average wet seasons, sampling in May will be more appropriate, but sampling timing each year should be flexible based on the timing and intensity of previous wet season rainfall.

All surveys included the use of a crocodile spotter to reduce the risk of crocodile attack.

2.3 Survey sites and study design

2.3.1 Site description

The Toms Gully Mine site is within the Mount Bunday Creek catchment, which comprises a series of small ridges and dissected hills that are drained by small, steep rivulets, which converge into Mount Bunday Creek. The majority of the catchment upstream of the project area consists of outcropping rock with thin soil cover and shallow alluvium drainage lines. The total catchment area upstream from the mine is approximately 117 km². Toms Gully mine site is situated at approximately 40 m AHD and, in terms of assessment against water quality guidelines, is a lowland river ecosystem. For the purpose of AUSRIVAS assessment, the site is located within the Darwin-Daly Catchment.

Mount Bunday Creek flows west to east along the northern section of the project area. The creek is approximately 30 km long with 13 km of the creek upstream of the mine site. It has several tributaries upstream of the project area. Downstream from the mine site it drains into Hardies Creek, and then the Mary River.

Coulter Creek is a tributary of Mount Bunday Creek and flows southwest to east (to the south of the project area). Coulter Creek flows into Mount Bunday Creek downstream of the project area, and compliance monitoring site SWTG2.

2.3.2 Survey sites

Thirteen sites were accessed and sampled in May 2018, details of which are displayed in Table 2-1. On Mount Bunday Creek, 10 sites were sampled, which consisted of two control sites upstream of the mine, five sites adjacent to the mine, and three sites downstream of the mine. A new site, SWTG1C was sampled in 2018 as an additional control site upstream of the mine on Bunday Creek. Three sites on the reference system Coulter Creek were also sampled. There is no direct discharge from the mine site into Coulter Creek.

Remote cameras were set up in six locations along Mount Bunday Creek (Table 2-2) in order to monitor the presence of Mitchell's and Mertens Water Monitors. Where possible, cameras were set up in locations close to aquatic ecology sites where habitat was considered favourable for their presence. One camera was located upstream of the mine, and the remaining five were located downstream.

The locations of aquatic ecology monitoring sites and remote camera sites are presented in Figure 2-2 and Figure 2-3.

Table 2-1 Aquatic ecology monitoring site details for sites visited in May 2018. Coordinates in zone 52L.

Site	Easting	Northing	Location	Site Type
Mount Bunday Creek Catchment				
SWTG1C	775674	8579115	Mount Bunday Creek approximately 2.5 km upstream of SWTG1A.	Control
SWTG1A	776351	8580503	Mount Bunday Creek upstream of mine at lease boundary.	Control
SWTG1	776825	8580290	Mount Bunday Creek at confluence of tributary adjacent to EP1 and EP2	Adjacent to Mine
SWTG2	779453	8580428	Compliance monitoring point at Arnhem Highway Crossing	Downstream
SWTG3	782278	8579366	300 m upstream of confluence between Mount Bunday Creek and Coulter Creek	Downstream

Site	Easting	Northing	Location	Site Type
SWTG09	776766	8580098	Tributary adjacent to EP1 and EP2, approximately 200 m upstream of the confluence with Mount Bunday Creek.	Adjacent to Mine
MBC01	778724	8580370	Mount Bunday Creek at confluence of tributary draining New Tailings Dam area	Adjacent to Mine
MBC03	780604	8580044	Mount Bunday Creek approximately 1.8 km downstream of SWTG2.	Downstream
MBC06	777293	8580350	Mount Bunday Creek downstream on tributary draining EP1 and EP2	Adjacent to Mine
MBC0	777606	8580736	Mount Bunday Creek upstream of tributary draining EP1 and EP2	Adjacent to Mine
Coulter Creek Catchment				
CC01	779293	8578801	Coulter Creek approximately 1 km upstream from CK7	Reference
CC02	778299	8578355	Coulter Creek. Approx. 2 km upstream from CK7	Reference
CC03	780166	8579675	Coulter Creek approximately 750 m downstream of CK7	Reference
CK7	779807	8579538	Coulter Creek. Existing monitoring site located at highway crossing	Reference

Table 2-2 Remote camera locations

Camera Code	Easting	Northing	Comments
M1	778691	8580427	Located at site MBC01
M2	780604	8580044	Located at site MBC03
M3	776351	8580503	Located at site SWTG1A
M4	780126	8580212	
M5	779453	8580428	Located at site SWTG2
M6	779377	8580450	

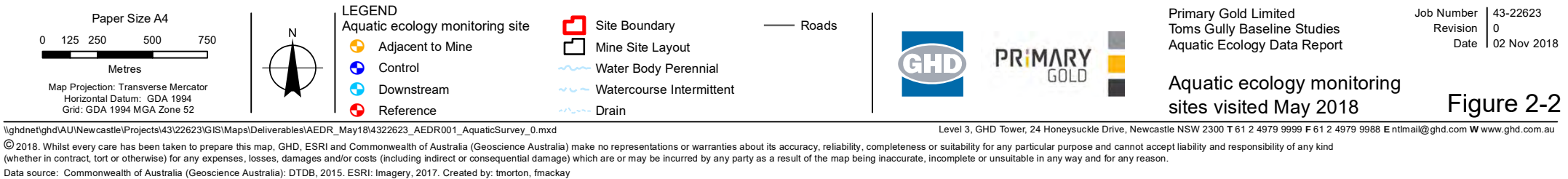
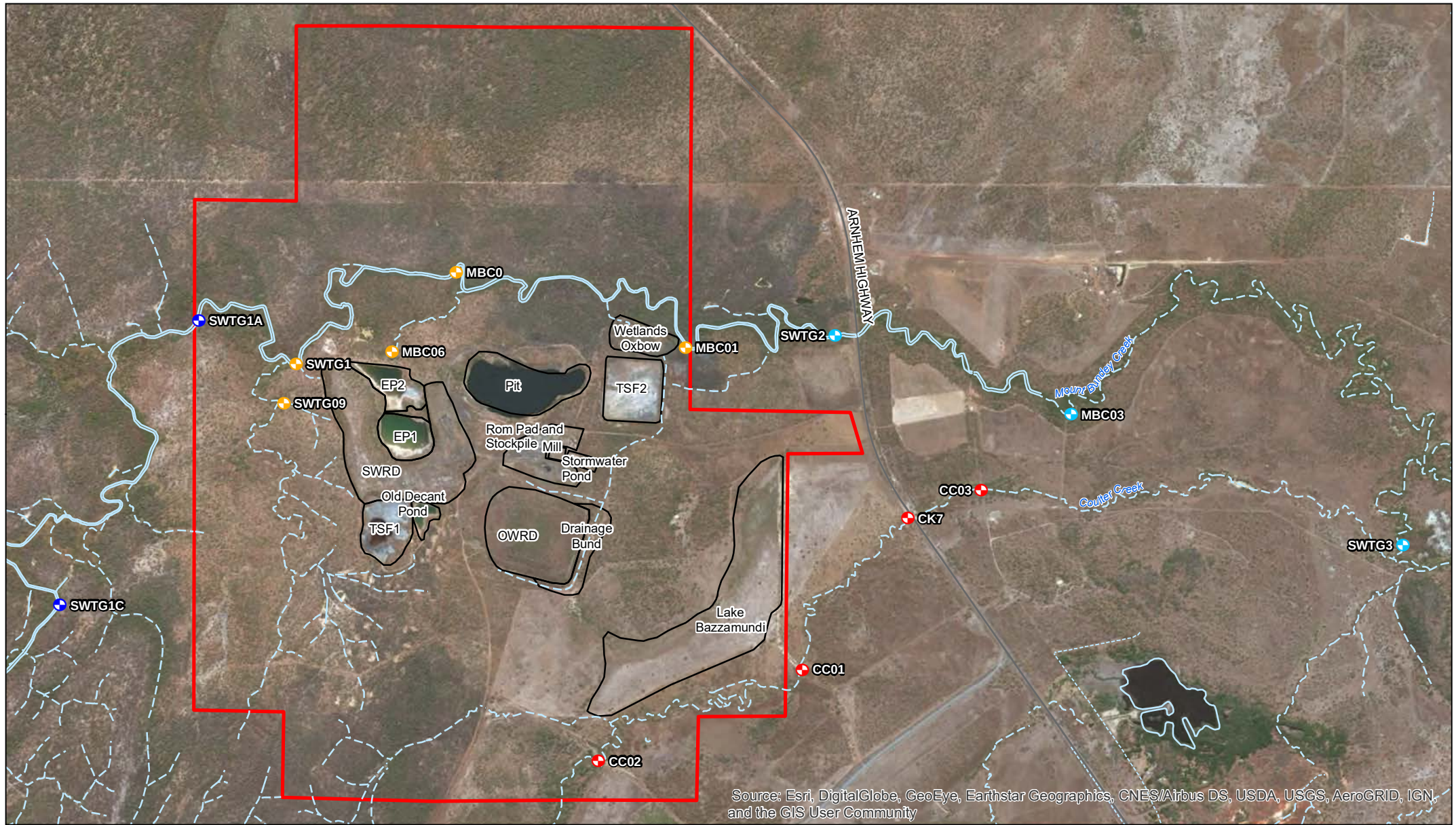
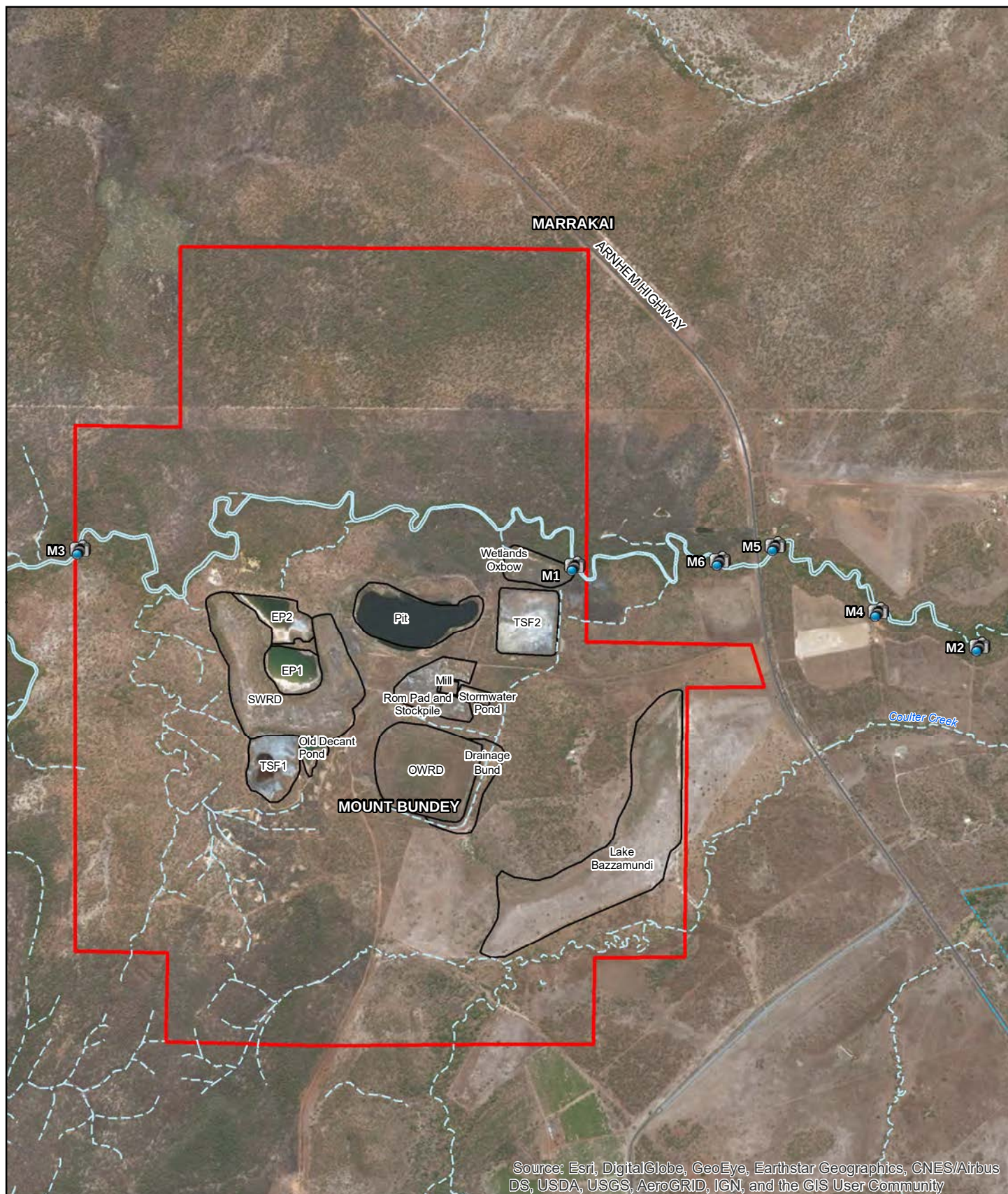


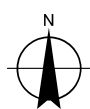
Figure 2-2



LEGEND

- Site Boundary
- Mine Site Layout
- Remote camera location
- Roads
- Water Body Perennial
- Watercourse Intermittent
- Drain

Paper Size A4
0 250 500 750
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52



Primary Gold Limited
Toms Gully Baseline Studies
Aquatic Ecology Data Report

Location of remote cameras
used in May 2018 survey

Job Number 43-22623
Revision 0
Date 02 Nov 2018

Figure 2-3

3. Methodology

3.1 Habitat assessment

Information about site habitat conditions were recorded at each site following the criteria listed in the Northern Territory AUSRIVAS Darwin-Daly field sheets (Lamche, 2007). Habitat assessment at each site included the whole reach (100 m section of the river), the habitats sampled, and the surrounding terrestrial environment. This included information on:

- Site description, including field estimates of stream width, bank height and riparian width
- Characteristics of macroinvertebrate habitat
- Riparian vegetation characteristics (types, %cover, exotic species, erosion, land use)
- Water and sediment quality observations (clarity, odour, oils, foam/scum, plume) and
- Sketch of the site.

The information recorded was used to help interpret trends in the biological data and to provide input data for the Northern Territory AUSRIVAS model.

Photos were taken of upstream and downstream portions of the stream reach sampled, as well as bank habitat and other key habitat features to further characterise the habitat conditions at each site. These serve as a pictorial record of site conditions that can be tracked over time using photos taken from the same points.

3.2 Water quality

3.2.1 *In situ* water quality

In-situ physical and chemical parameters were measured at each site using a YSI Pro DSS multi-parameter water quality meter. The water quality meter was calibrated in accordance with the manufacturer's specifications, and used in accordance with operating protocols defined in the GHD Quality Systems manual.

The YSI Water Quality meter was used to measure pH, electrical conductivity (EC) ($\mu\text{S}/\text{cm}$), water temperature ($^{\circ}\text{C}$), Dissolved Oxygen (DO) concentrations (% saturation and mg/L) and turbidity (NTU).

3.2.2 Laboratory analysis

One water grab sample was collected at each site prior to the collection of fish and macroinvertebrate samples. Water requiring analysis of dissolved metals was field filtered using a dedicated high volume 45 μm filter prior to collection in the sample bottle. Water samples were analysed for the parameters in Table 3-1. Laboratory certificates of analysis are presented in Appendix A.

Table 3-1 Analytes tested

Suite	Analytes
Physico-chemical	pH, EC, total dissolved solids (TDS), turbidity
Major anions	Alkalinity, chloride, sulfate
Major cations	Calcium, magnesium, sodium, potassium, hardness.
Metals (dissolved and total)	Aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc.
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide.

3.2.3 Data analysis

Water quality results were compared against the Site Specific Trigger Values (SSTVs) derived for Toms Gully Mine by GHD (2015).

3.3 Macroinvertebrates

3.3.1 Sampling methods

Macroinvertebrate sampling and processing followed procedures outlined in the Northern Territory AUSRIVAS Manual for the Darwin-Daly Region (Lamche, 2007). Sampling involved one field team member scraping submerged root matter associated with the lower bank to agitate and remove macroinvertebrates into the water column, while the other field team member swept a dip net through the water column downstream of the edge habitat, to collect the dislodged animals. Areas of riffle or fast flowing habitat, Pandanus roots and severe bank undercuts were avoided when collecting edge habitat samples.

Once collected, the samples were washed through 10 mm and 250 µm mesh sieves. The course mesh sieve was examined for large, conspicuous taxa, and these were placed in the labelled sample container. The sample collected in the fine mesh sieve was also placed in the labelled sample container and filled with 70% ethanol. All samples were sent to the GHD laboratory for further processing and macroinvertebrate identification.

3.3.2 Laboratory processing

Samples were washed through a series of sieves (10 mm, 500 µm and 250 µm mesh sizes). Any large, conspicuous taxa identified in the 10 mm mesh sieve were added to the contents of the large mesh fraction retained in the field. The contents of the 500 µm mesh sieve were retained for macroinvertebrate identification and enumeration, while the 250 µm fraction was retained as sample residue for quality assurance purposes. The contents of the 500 µm mesh fraction was poured into a Marchant sub-sampler (Marchant, 1989) and extractions made randomly from cells (aliquots) in this apparatus. These extractions were placed under a microscope and the taxa identified and counted. This process continued until either all aliquots were examined, or a total of 200 individuals had been counted and identified. The number of aliquots required to be processed to obtain a minimum 200 individual sub-sample was recorded in order to be able to calculate abundance. Leica MZ9.5 stereo-dissection microscopes with planachromat objectives and a zoom capability between 6.3x and 60x were used to examine specimens.

Taxa were identified to family level where possible, with the exception of key taxa identified in Lamche (2007) as either requiring identification to sub-family level (e.g. Chironomidae) or only to order level (e.g. Acarina). All taxa have been identified using the keys specified in Hawking (2000). Following identification, taxa counts were recorded in Microsoft Excel and samples preserved and archived by GHD. Raw macroinvertebrate data is presented in Appendix B.

3.3.3 Data analysis

A number of indices can be used to assess and/or quantify the influence of anthropogenic activities on macroinvertebrate communities. Responses to contaminants or changes in flow can result in anything from changes in abundance and diversity through to changes in community composition through the loss or reduction of sensitive taxa. As such, a multiple lines of evidence approach has been adopted with regards to interpreting macroinvertebrate community data.

Univariate analysis

Table 3-2 provides a summary of the univariate macroinvertebrate indices assessed as part of this study and, where relevant, a description of how to interpret results relating to those indices. Lamche (2007) cautions against the use of the SIGNAL-2 index for assessing the status of Northern Territory macroinvertebrate communities. This measure is however, considered appropriate for this study as the number of pollution-sensitive versus pollution-tolerant families does provide some insight to the level of stress that the macroinvertebrate community is experiencing.

Table 3-2 Macroinvertebrate Indices used as part of this assessment.

Macroinvertebrate Index	Description
Abundance	The total number of individual taxa observed at each site. Generally, increased abundance can be taken to mean better conditions and increased access to habitat and food resources. However, high abundances can also occur under degraded conditions where pollution-tolerant taxa proliferate. Hence, abundance is a measure that must be interpreted with caution and in combination with other metrics and community composition data. Abundance was calculated based on the multiplication of raw abundance data by the inverse of the proportion of sample processed.
Taxa Richness	The total number of taxa present at each site is a direct measure of diversity. It assumes that a high number of taxa within a site indicate that the various water quality, habitat and food requirements of taxa have been met (though this could also occur through anthropogenic effects that increase food or habitat supply). A negative environmental impact would normally result in the loss of taxa and a decline in taxa richness at a site.
PET Richness	PET Richness was calculated as the total number of families from three orders of macroinvertebrates; Ephemeroptera (mayflies); Plecoptera (stoneflies); and Trichoptera (caddisflies). These orders include taxa that are very sensitive to disturbance (though some have moderate tolerances to pollution). Therefore, higher numbers of PET taxa are generally taken to indicate a lower level of disturbance.
SIGNAL-2	SIGNAL-2 is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of 10 indicates high pollution sensitivity whilst a value of 1 indicates high pollution tolerance (Chessman 1995). SIGNAL-2 represents the average pollution sensitivity of taxa in a sample. Higher SIGNAL-2 scores generally indicate a higher proportion of pollution-sensitive taxa in a sample. However, high SIGNAL-2 scores can sometimes be observed when there is a small number of taxa collected (i.e. low taxa richness). For this reason, SIGNAL-2 must be assessed in combination with other macroinvertebrate metrics.
AUSRIVAS OE50 and Bandings	Under the AUSRIVAS model, the expected (E) fauna from reference sites with similar sets of predictor variables (physical and chemical characteristics which cannot be influenced due to human activities e.g. altitude) are compared to the fauna observed (O) during monitoring and the ratio derived is then used to indicate the condition of the macroinvertebrate community. The critical metric in the AUSRIVAS model is the OE50, which is calculated from the O and E measures for macroinvertebrates with a predicted probability greater than 50% of occurring at the site based on habitat variables recorded. The OE50 ratio can range from 0, when none of the expected taxa are found at a site, to >1, when either all the expected taxa are found in a sample or when more families are found in a sample than predicted by the model. The scores derived from the model can be placed in bands delineated by the Monitoring River Health Initiative, which allows assessment of the level of environmental health at a site, as shown in Table 3-3.

Table 3-3 AUSRIVAS OE50 scores and bands for the Darwin-Daly Model.

Band Label	OE50 Upper Limit	Band Name	Band Description
Band X	>1.18	More biologically diverse than reference sites	More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
Band A	1.18	Reference condition	Expected number of families within the range found at 80% of the reference sites.
Band B	0.81	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of families.
Band C	0.44	Severely impaired	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
Band D	0.07	Extremely impaired	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

For this study, macroinvertebrate data was assessed using the NT AUSRIVAS Darwin-Daly Early (dry season) Family level Edge habitat model. The habitat variables required to run this model are latitude, longitude, RIP500 (amount of square kilometres of rainforest within a 500 m radius of a given site) and average stream width. RIP500 data has been estimated using vegetation classification GIS data obtained from DLRM.

3.4 Fish surveys

Fish surveys in 2018 used a combination of backpack electrofishing, bait trapping and seine netting.

Electrofishing is a proven technique capable of capturing the majority of taxa present, as it is not size or species specific. Further, it is a non-lethal means of sampling when applied correctly and can be used in a way that can provide quantitative data where required. However, at some sites electrofishing was not possible due to high salinity, or safety concerns regarding steep banks, deep pool habitat and the potential presence of estuarine crocodiles. At some of these sites, bait trapping or seine netting was able to be carried out instead. This meant that larger fish species at those sites were unlikely to be caught. Where electrofishing was used, a single pass electrofishing approach of 1200 seconds on time was carried out. Sampling was carried out from downstream to upstream, where appropriate, and in such a way that fish were herded toward banks of shallow waters near sand bars using the electrical field so they can be easily captured.

Bait trapping involved setting five commercial rectangular bait traps (2 mm mesh size) for approximately two hours at each site. These traps are used to target smaller, cryptic species of fish and freshwater prawns. Each trap was baited and deployed close to representative physical habitat structure (e.g. rocks, snags, roots, macrophytes, etc) to maximise the likelihood of catching fish and freshwater prawns.

A seine net is generally operated by two people – one on each end of the net. Typically, one person remains stationary on the bank, while the other person walks the net out and back around, arcing towards the bank. At this time, the net is brought onto the bank, thereby enclosing captured fish and crustaceans in the cod-end of the net. Seine netting was used in shallow pools as an additional method to backpack electrofishing.

All caught fish were identified in the field using appropriate keys (e.g. Allen *et al.* 2003) and counts for each species captured were recorded. The total number of fish captured at each site was derived from that information. All macrocrustaceans (Palaemonidae and Atyidae) caught at a site were also counted. Notes were also taken of any evidence of external lesions, parasites or deformities among the fish specimens collected at each of the study sites.

3.5 Water monitors

Remote camera trapping was undertaken at six locations on Mount Bunday Creek in May 2018. Sites were co-located with aquatic ecology monitoring locations where appropriate habitat for water monitors was found. Five cameras were located downstream of Toms Gully Mine, and one was located upstream. The camera upstream was set up to check for the presence of water monitors outside of the influence of the mine. All remote cameras were set up with guidance from Gillespie *et al.* (2015). Cameras were attached to trees approximately 0.5 m from the ground, with a bait placed in front of the camera. Cameras were positioned where possible to include areas likely to be used for basking by water monitors, such as banks close to the water and logs. The Cameras remained operational between 10 May and 21 August 2018.

3.6 Summary of sampling tasks

Due to water availability and site characteristics, not all sites were subject to the full spectrum of sampling as described in Sections 3.1 to 3.5. Habitat assessment, macroinvertebrate sampling and water quality sampling was undertaken at all aquatic ecology monitoring sites. Table 3-4 summarises the sampling tasks carried out at each site.

Table 3-4 Summary of sampling carried out at each site in May 2018

Site	Macroinvertebrate sampling	Fish sampling	Habitat assessment	Water quality	Remote camera
SWTG1A	✓	✓	✓	✓	✓
SWTG1C	✓		✓	✓	
SWTG1	✓	✓	✓	✓	
SWTG2	✓	✓	✓	✓	✓
SWTG3	✓	✓	✓	✓	
SWTG09	✓		✓	✓	
MBC01	✓		✓	✓	
MBC03	✓	✓	✓	✓	✓
MBC06	✓		✓	✓	
MBC0	✓	✓	✓	✓	
CC01	✓	✓	✓	✓	
CC02	✓	✓	✓	✓	
CC03	✓	✓	✓	✓	
CK7	✓	✓	✓	✓	
M1					✓
M4					✓
M6					✓

4. Results

4.1 Site conditions

4.1.1 General Site Notes

A description of habitat characteristics associated with monitoring sites sampled in May 2018 is presented in Table 4-1. The majority of sites were not flowing at the time of sampling. Evidence that flows had recently ceased at most sites on Mount Bunday Creek was observed, with those furthest downstream still flowing while sampling took place.

Table 4-1 Habitat descriptions for sites sampled in May 2018

Site/habitat description	Site photo
Control sites	
SWG1C SWTG1C was a number of isolated pools bordered by rocks and boulders, with exposed bedrock forming a near vertical bank approximately 8 m high. Substrate consisted of sand and silt with a covering of leaf litter. Riparian vegetation included <i>Ficus</i> sp., <i>Melaleuca</i> sp. and other trees. Instream features included algae covered cobbles and boulders, and exposed roots from riparian vegetation. A large freshwater crocodile was observed at this site. Only a single pool was considered safe to enter and was sampled (pictured right)	
SWG1A SWTG1A consisted of two large pools connected by a small channel, with no flow at the time of sampling. The bottom of the pools was not visible, making it difficult to determine the composition of the substrate, as well as making the site a potential crocodile habitat. Both pools were lined by a thick strip of native vegetation and had steep banks approximately 4 m high. A large amount of woody debris was found at the site, and most of the banks contained exposed roots and undercut banks.	
Potentially impacted sites	
SWG09 SWTG09 was made up of two small, clear pools separated by a section of bedrock with no connecting flows. The site was characterised by angled and undercut banks, with exposed roots and snags lining much of the pools, as well as overhanging vegetation. The substrate was a mix of cobbles, pebbles and sand. The larger pool contained leaf packs, while the smaller pool contained algae. Riparian vegetation was a mix of trees, shrubs, grasses and bamboo.	

Site/habitat description	Site photo
SWTG1 SWTG1 was a long, shallow channel connecting two large, deep pools. The wetted width was approximately 2.5 m wide in the channel sections and 8 m wide in the pool sections. No flow was observed during sampling. Substrate comprised cobbles and pebbles embedded in gravel and sand. Large woody debris and leaf packs were found through the extent of the reach and banks were undercut, exposing roots from riparian vegetation. Banks were approximately 3.5 m high and were very steep. Riparian vegetation was thick, extending at least 20 m from each bank and shading most of the creek.	
MBC0 MBC0 consisted of a number of pools separated by a series of short runs. The reach was well shaded due to a continuous riparian zone comprising of Melaleucas and Eucalypts. The presence of trees along banks allowed for exposed roots, snags, large woody debris and leaf packs to be common through the site. The substrate was rocky and contained algal growth.	
MBC06 MBC06 consisted of a narrow, isolated pool. Water was clear but an oil slick was present in some areas. The substrate was a mixture of sand, silt and clay. Instream habitats included overhanging vegetation, woody debris, snags and leaf packs. Electrofishing could not be undertaken at this site due to high salinity. More water was observed at the site than on any previous occasion.	
MBC01 MBC01 had been highly modified in 2018. Details are below in Section 4.1.2. A large pool with an average width of 5 m was slightly turbid, and was located upstream of a narrow run, which entered another deep, wide pool. The depth and turbidity of the pools meant the bottom was not visible, making the site a potential crocodile habitat and inaccessible for electrofishing. The creek was heavily shaded, with the riparian vegetation made up of Pandanus, native bamboo and riparian trees. Undercut banks, exposed roots, snags and overhanging vegetation were present.	

Site/habitat description	Site photo
SWTG2 SWTG2 is intersected by a causeway, with upstream sections of the creek made up of a series of deep pools connected by runs. Downstream of the causeway, the site was a wide, shallow pool, with clear water. Substrate along the entire reach was a mixture of cobbles, pebbles and sand, and banks were made of clay. Riparian vegetation was dense and comprised of native trees and bamboo. Banks were undercut exposing roots, while overhanging vegetation, snags and leaf packs were common.	
MBC03 MBC03 was characterised by a long shallow run with a large pool at the upstream end. The creek was highly shaded in this area and the riparian zone extended for 20 m on the right bank and >30 m on the left bank. The right bank was very steep and 3.5 m high, whereas the left bank was a gentle slope reaching a similar height. The site contained floating leaf litter and detritus. Large woody debris was found through the reach as were leaf packs. Substrate was made up mainly of sand and gravel.	
SWTG3 SWTG3 was characterised by a long pool and run with large woody debris and undercut banks. Substrate was sand and silt, while banks were comprised of sand and clay. The substrate was heavily covered by detritus. The riparian zone contained bamboo and Melaleuca, though very little understory vegetation was present. The site contained undercut banks, exposed roots, snags and leaf packs.	
Reference sites	
CC01 CC01 is located close to cattle yards of Mount Bunday Creek Station, and contained a ford intersecting the creek. The reach extended from the ford downstream. The site was characterised by a series of isolated pools. Shading was lower in the downstream parts of the creek, while the upstream section of the reach was shaded and had a riparian strip around 5 m wide. Banks were undercut, with exposed roots, snags, large woody debris, overhanging vegetation and leaf packs providing aquatic habitats at the site.	

Site/habitat description	Site photo
CC02 The site was dry at the time of sampling, and therefore sampling could not be completed. The site had experienced significant change in geomorphology and structure since 2017. These changes are detailed in Section 4.1.2. The reach was characterised by a meandering channel through large stands of bamboo. There was a large cattle crossing through the upstream end of the reach, and substrate within the channel was made up of clay and sand. The reach was heavily shaded outside of the cattle crossing.	
CC03 CC03 is characterised by a large isolated pool approximately 50 m in length. Riparian vegetation was primarily bamboo which provided minimal shading. The substrate was mostly bedrock, with some deposition of sand and silt. The site contained floating leaf litter and detritus, and a sheen was visible on the surface of the water. Overhanging vegetation was present and banks were heavily eroded.	
CK7 CK7 is located on the downstream side of the crossing of Coulter Creek with the Arnhem Highway. It was characterised as a series of isolated pools of varying depth. Water was murky and the pool bottoms were not visible. The substrate was mostly sand and silt, with some exposed bedrock. Riparian vegetation was bamboo, trees and grasses. Floating leaves were present, along with undercut banks and overhanging vegetation.	

4.1.2 Channel modifications

In 2018, two sites were observed to have been modified significantly to allow for cattle crossings to occur. The first was located on Mount Bunday Creek at site MBC01. A large crossing had been pushed across the channel of Mount Bunday Creek after the wet season, which had then washed out (Figure 4-1). The area downstream of the site changed from a shallow pool to a deep one, with the upstream area collecting large trees creating a large pool (Figure 4-2). The pools were connected by a shallow run. Heavy erosion and vegetation removal was evident on the banks at the site.

The second modification was located on Coulter Creek. The furthest upstream site on the creek had undergone a large amount of modification to make cattle access down a mustering laneway simpler. The creek has been diverted and isolated a meander of the creek entirely. Coulter Creek runs straight for around 50 m through an area that has also had vegetation removed. These changes have resulted in erosion at the site as a result of channel straightening and cattle traffic across the creek.



Figure 4-1 Cattle crossing installed at MBC01.



Figure 4-2 MBC01 facing downstream in 2017 (left) and 2018 (right)



Figure 4-3 Facing upstream at CC02 in 2017 (left) and 2018 (right).

4.2 Water quality

4.2.1 *In situ* water quality

Table 4-2 presents the *in situ* water quality results for May 2018. Key results include:

- pH was within SSTV limits at all sites, with the exception of MBC01 and SWTG3, where pH was below the lower trigger value.
- EC was below the SSTV at all sites except MBC01 and MBC06. Water at MBC06 was very saline compared to all other sites, with EC of greater than 20 times the SSTV recorded
- DO was low, being recorded below the lower SSTV at all sites in May 2018
- Turbidity was below the SSTV at all sites.

Table 4-2 *In situ* water quality results, May 2018

Site	Time	Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO (%)	Turbidity (NTU)
SSTV	NA	NA	5.8-8.0	250	NA	85-120	60
SWTG1C	13:09	23.0	6.42	68	5.57		3.6
SWTG1A	16:00	26.6	5.94	47	5.25	59	6.3
SWTG09	13:10	24.6	6.73	102	3.15	35	11.4
SWTG1	10:40	25.4	6.54	58	6.82	82	5.1
MBC0	8:49	21.1	6.56	32	6.42	70	4.2
MBC06	9:00	22.6	6.97	5,087	5.50	54	5.8 [^]
MBC01	8:30	24.0	5.37	356	3.84	41	17 [^]
SWTG2	15:30	25.8	6.7	229	6.25	65	1.8 [^]
MBC03	9:00	24.2	6.01	170	5.06	55	4.0
SWTG3	8:00	23.0	5.71	126	3.95	43	18
CC01	11:00	24.0	6.55	173	6.72	78	24
CC03	12:00	25.8	6.39	154	2.31	38	22
CK7	7:30	22.7	7.99	186	6.84	76	22

Results in gold are above the relevant SSTV

[^] Results derived from laboratory analysis

4.2.2 Laboratory analysis

Table 4-3 presents the results of the laboratory analysis of water samples collected in May 2018. The following key results from laboratory analysis were observed:

- Concentrations of every major anion and cation were highest at MBC06, with most being observed in concentrations many times higher than those of all other sites.
- All sites on Mount Bunday Creek upstream of the tributary draining EP1 and EP2 are ionically dilute and exhibited balanced ionic chemistry. All other sites were dominated by sulfate anions, and calcium and magnesium cations.
- Most sites in the Mount Bunday Creek and Coulter Creek catchments had low alkalinities. The highest alkalinity in the Mount Bunday Creek catchment was observed at MBC06, while CC01 had the highest alkalinity in the Coulter Creek catchment
- Chloride concentrations were low at most sites, ranging between 3 and 6 mg/L at all sites except MBC06, where chloride was observed at 23 mg/L
- Sulfate was found in concentrations above the SSTV at MBC06 and MBC01, with concentrations at MBC06 observed at exceptionally high concentrations. Sulfate at all other sites was below the SSTV
- Concentrations of all major cations were highest at MBC06 and decreased in a downstream direction along Mount Bunday Creek
- The hardest water was observed at MBC06, where water was extremely hard. Water was softest at the control sites SWTG1C and SWTG1A, and the adjacent site MBC0.
- Concentrations of all dissolved metals were below the SSTVs at the control site SWTG1C
- Concentrations of dissolved chromium and lead were below the respective laboratory limits of reporting (LORs) at all sites
- Concentrations of dissolved arsenic and manganese were below the SSTV at all sites
- The concentration of dissolved aluminium at MBC01 exceeded the SSTV. At all other sites the dissolved aluminium concentration was below the SSTV
- Concentrations of dissolved cadmium were all below the laboratory LOR at all sites except MBC01 and SWTG2 where concentrations were found in excess of the SSTV.
- Concentrations of dissolved cobalt exceeded the SSTV at SWTG1, MBC06, MBC01, SWTG2, MBC03, SWTG3 and CC03. The highest dissolved cobalt concentration was recorded at MBC01.
- Concentrations of dissolved copper exceeded the SSTV at most sites, with the highest concentration observed at MBC01
- Dissolved iron concentrations exceeded the SSTV at most sites. The highest dissolved iron concentrations were observed at SWTG3 and MBC01.
- Concentrations of dissolved nickel were above the SSTV at MBC01 and SWTG2
- Dissolved uranium was below the LOR except for the concentrations observed at MBC06 and MBC01.
- Dissolved zinc concentrations at MBC01, SWTG2 and MBC03 exceeded the SSTV, with the highest concentrations observed at MBC01.
- Total cyanide was detected in samples collected from CC01 and CC03 at concentrations below the SSTV. There was no cyanide detected in any other sample, with all free cyanide, WAD cyanide and total cyanide results were below the respective LORs.

Table 4-3 Laboratory water quality results May 2018. All units are mg/L except where specified.

Analyte	LOR	Control		Adjacent					Downstream			Reference			SSTV
		SWG1C	SWG1A	SWG09	SWG1	MBC0	MBC06	MBC01	SWG2	MBC03	SWG3	CC01	CC03	CK7	
Physico-chemical parameters															
pH	0.1	7.0	6.0	7.0	6.5	6.4	7.5	3.9	5.9	6.2	6.6	7.1	6.8	7.0	5.8-8.0
EC (µS/cm)	1	68	35	100	48	31	5,800	490	230	160	120	180	150	180	250
TDS	5	41	21	62	29	19	6900	290	140	94	71	110	87	110	NA
Turbidity (NTU)	0.1	2.5	5	4.4	7.2	4.2	5.8	17	1.8	2.8	15	7.3	12	5.8	60
Major anions															
Bicarbonate as CaCO ₃	5	27	11	38	16	10	190	<5	5	7	22	57	34	28	NA
Carbonate as CaCO ₃	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NA
Hydroxide as CaCO ₃	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NA
Total Alkalinity	5	27	11	38	16	10	190	<5	5	7	22	57	34	28	NA
Chloride	1	3	3	6	3	2	23	3	2	3	3	6	5	4	NA
Sulfate	1	<1	<1	1	1	1	4,700	210	87	52	23	20	22	43	129
Major cations															
Calcium	0.5	4	1.3	8	2.4	1.4	490	36	16	10	7.5	11	7	8.7	NA
Magnesium	0.5	2.8	1.1	4	1.7	1	840	22	11	6.7	5.2	11	7.1	9.2	NA
Potassium	0.5	1.5	0.6	2.7	0.7	<0.5	8.6	3	1.7	1.6	1.8	2.8	3.7	3.2	NA
Sodium	0.5	4.5	3.1	3.9	3.7	2.3	74	7.3	5.4	4.8	4.6	6.2	6.5	8.2	NA
Hardness as CaCO ₃	3	21	8	36	13	8	4,700	180	83	53	40	70	47	60	NA
Dissolved metals															
Aluminium	0.01	0.07	0.03	0.1	0.05	0.06	<0.01	1.4	0.03	0.05	0.05	0.06	0.07	0.12	0.260
Arsenic	0.001	0.001	<0.001	<0.001	0.001	<0.001	0.003	0.002	<0.001	<0.001	0.002	0.001	0.002	<0.001	0.140
Cadmium	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.012	0.003	0.0006	0.0002	<0.0001	<0.0001	<0.0001	0.0008
Chromium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.040
Cobalt	0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.002	0.074	0.008	0.002	0.004	<0.001	0.005	<0.001	0.0014
Copper	0.001	<0.001	0.007	0.01	0.005	0.009	0.004	0.086	0.006	0.002	0.002	0.007	0.001	0.004	0.0025

Analyte	LOR	Control		Adjacent					Downstream			Reference			SSTV
		SWG1C	SWG1A	SWG09	SWG1	MBC0	MBC06	MBC01	SWG2	MBC03	SWG3	CC01	CC03	CK7	
Iron	0.01	0.29	0.51	0.74	1.1	0.29	0.41	2.3	0.05	1.1	2.8	0.37	1.4	0.08	0.300
Lead	0.001	<0.001	<0.001	0.001	<0.001	0.002	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0094
Manganese	0.005	0.11	0.093	0.038	0.5	0.023	1.6	3.5	0.93	0.26	1.1	1.2	0.88	0.059	3.600
Nickel	0.001	<0.001	0.002	0.003	0.002	0.002	0.008	0.12	0.039	0.009	0.007	0.002	0.01	0.004	0.017
Uranium	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.01	0.0008	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NA
Zinc	0.001	0.003	0.009	0.012	0.008	0.019	0.006	0.61	0.18	0.048	0.011	0.005	0.015	0.006	0.031
Total metals															
Aluminium	0.01	0.01	0.02	0.02	0.01	0.01	<0.01	1.4	0.04	<0.01	0.04	0.06	0.1	0.1	NA
Arsenic	0.001	0.001	<0.001	<0.001	0.001	<0.001	0.003	0.002	<0.001	<0.001	0.002	0.002	0.002	<0.001	NA
Cadmium	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.012	0.0029	0.0005	0.0001	<0.0001	<0.0001	<0.0001	NA
Chromium	0.001	<0.001	<0.001	<0.001	<0.001	0.009	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Cobalt	0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.003	0.074	0.008	0.001	0.004	0.001	0.008	0.001	NA
Copper	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.09	0.004	0.003	0.002	<0.001	0.002	0.002	NA
Iron	0.01	0.3	1.1	0.84	1.5	0.37	1.6	3.3	0.25	0.25	2.9	0.91	1.8	0.19	NA
Lead	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	NA
Manganese	0.005	0.13	0.11	0.051	0.51	0.029	1.7	3.6	0.92	0.23	1.1	1.3	1.6	0.081	NA
Nickel	0.001	0.001	<0.001	0.001	0.001	0.006	0.008	0.13	0.04	0.01	0.007	0.002	0.014	0.005	NA
Uranium	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.011	0.0021	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NA
Zinc	0.001	<0.001	0.002	0.001	0.002	0.001	0.003	0.61	0.18	0.049	0.01	0.004	0.018	0.009	NA
Cyanide															
Free Cyanide	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	NA
WAD Cyanide	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	NA
Total Cyanide	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.009	0.008	<0.004	0.018

4.3 Macroinvertebrate community

4.3.1 Relative abundance

The relative abundance of macroinvertebrate samples collected in May 2018 is presented in Figure 4-4. Relative abundance was highest at the Coulter Creek reference sites and at three sites adjacent to the mine site. Sites downstream of the mine on Mount Bunday Creek had the lowest relative abundance, as did sites SWTG09 and MBC01 adjacent to the mine. Several sites showed variability in abundance between replicate samples.

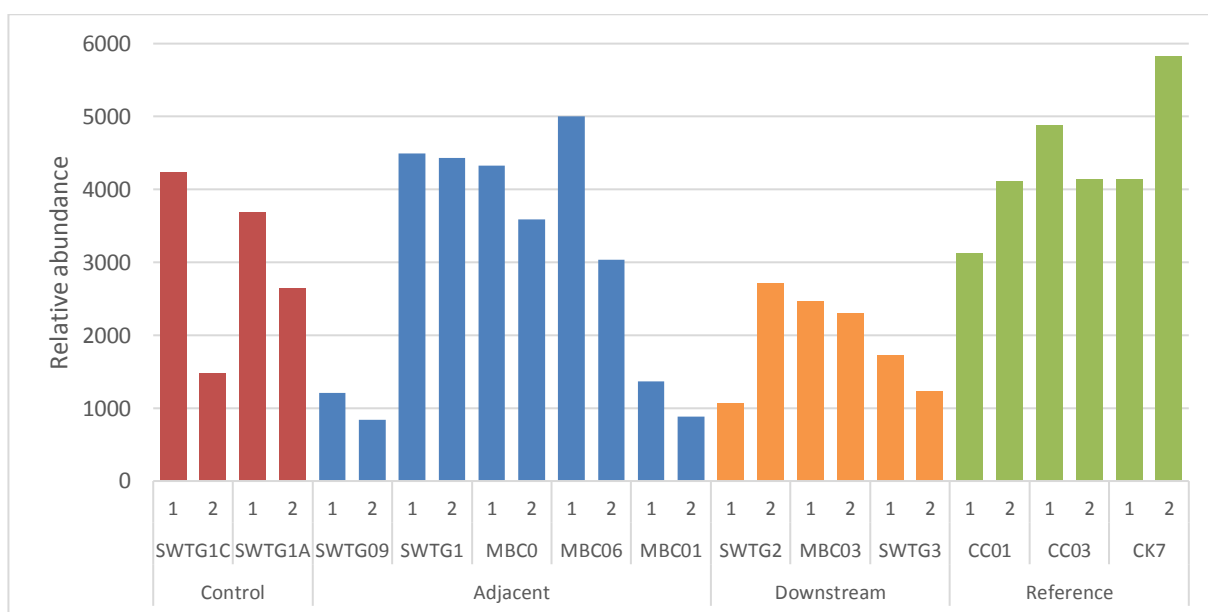


Figure 4-4 Relative abundance of samples collected in May 2018

4.3.2 Taxa richness

Taxa richness results for sites sampled in May 2018 are presented in Figure 4-5. SWTG2 and MBC03, downstream of the mine, contained the highest taxa richness, with downstream sites generally exhibiting a higher taxa richness than other site types. Taxa richness was generally lower in samples collected adjacent to the mine, with the lowest taxa richness recorded at MBC06.

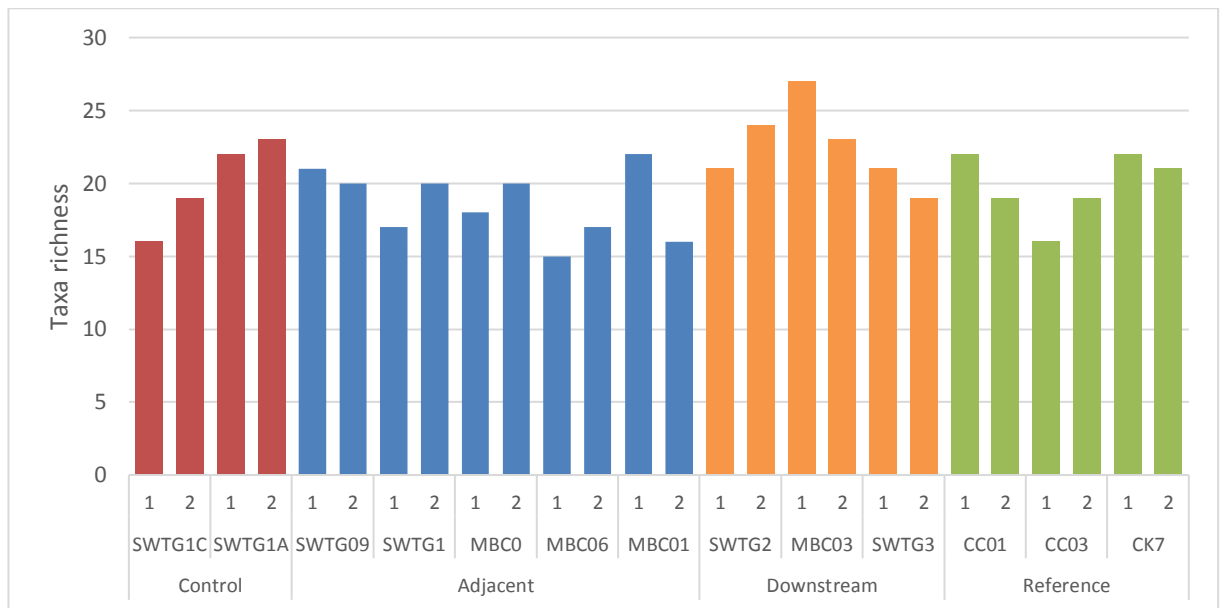


Figure 4-5 Taxa richness of samples collected in May 2018

4.3.3 PET richness

PET richness results for sites sampled in May 2018 are presented in Figure 4-6. PET richness ranged between two and five across all samples collected. PET richness was highest at the control sites, where both sites recorded four and five PET taxa collected, as did adjacent site SWTG1 and reference site CC01. The lowest PET richness results were recorded at three of the sites adjacent to the mine, which each recorded two PET taxa in one replicate. MBC06 had the lowest PET richness overall, with only three PET taxa found in total across the two replicate samples.

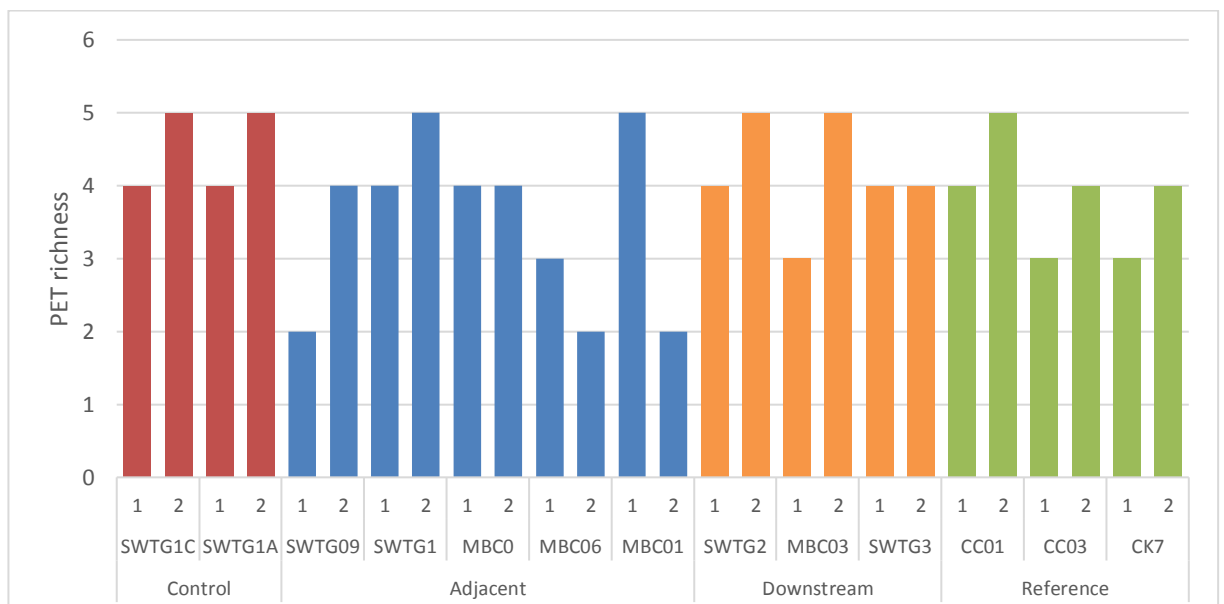


Figure 4-6 PET richness of samples collected in May 2018

4.3.4 SIGNAL-2

SIGNAL-2 results for sites sampled in May 2018 are presented in Figure 4-7. SIGNAL-2 scores were highest adjacent to the mine at MBC0 and SWTG1. Downstream Bunday Creek sites showed the most consistency in results, with little variability observed between sites or replicates. The lowest SIGNAL-2 results were observed at SWTG09 and MBC06.

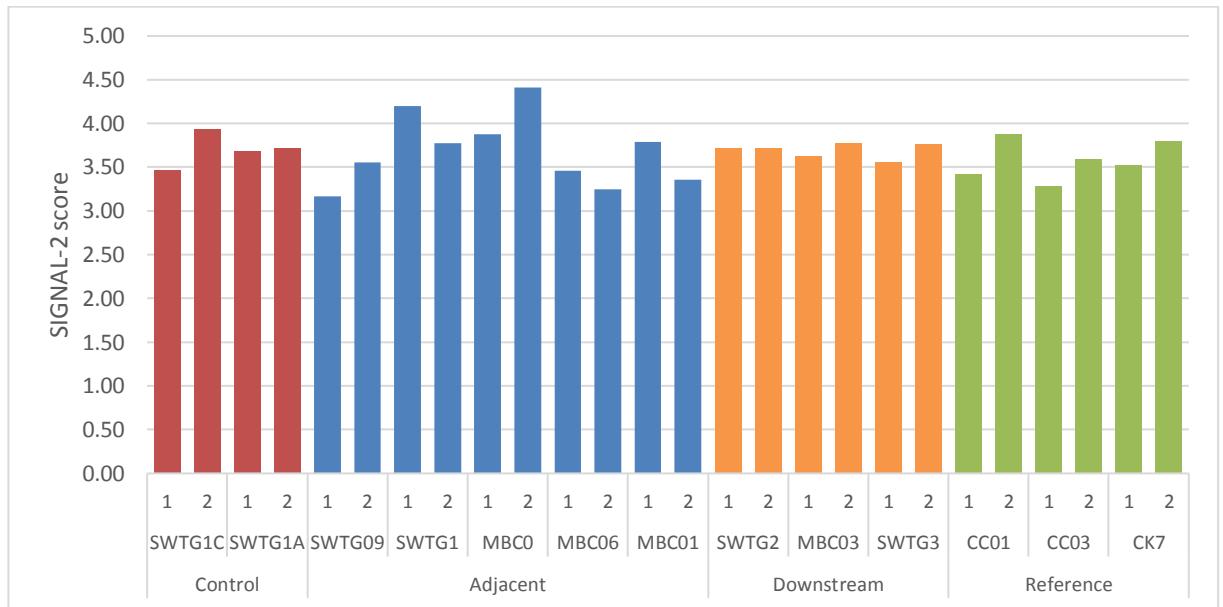


Figure 4-7 SIGNAL-2 results from sites sampled in May 2018

4.3.5 AUSRIVAS

The results of the Darwin-Daly AUSRIVAS model are presented in Figure 4-8. Downstream site MBC03 received the highest OE50 scores with a Band A result, indicating the model has determined the macroinvertebrate community to be in a reference condition. The lowest scores were observed at SWTG09 and MBC06 adjacent to the mine, with these sites receiving a Band B score, indicating that there is a significant impairment to the macroinvertebrate community.

One control site, two adjacent sites, two downstream sites and one reference site received a Band A score in both replicate samples in 2018, indicating no observable pattern between site type and OE50 score in 2018. The protocol for interpretation of AUSRIVAS model outputs stipulates that where two samples from the same site are found to be in different bandwidths, the lower bandwidth be assigned for that site. This resulted in SWTG1C and MBC01 receiving a Band B result in 2018.

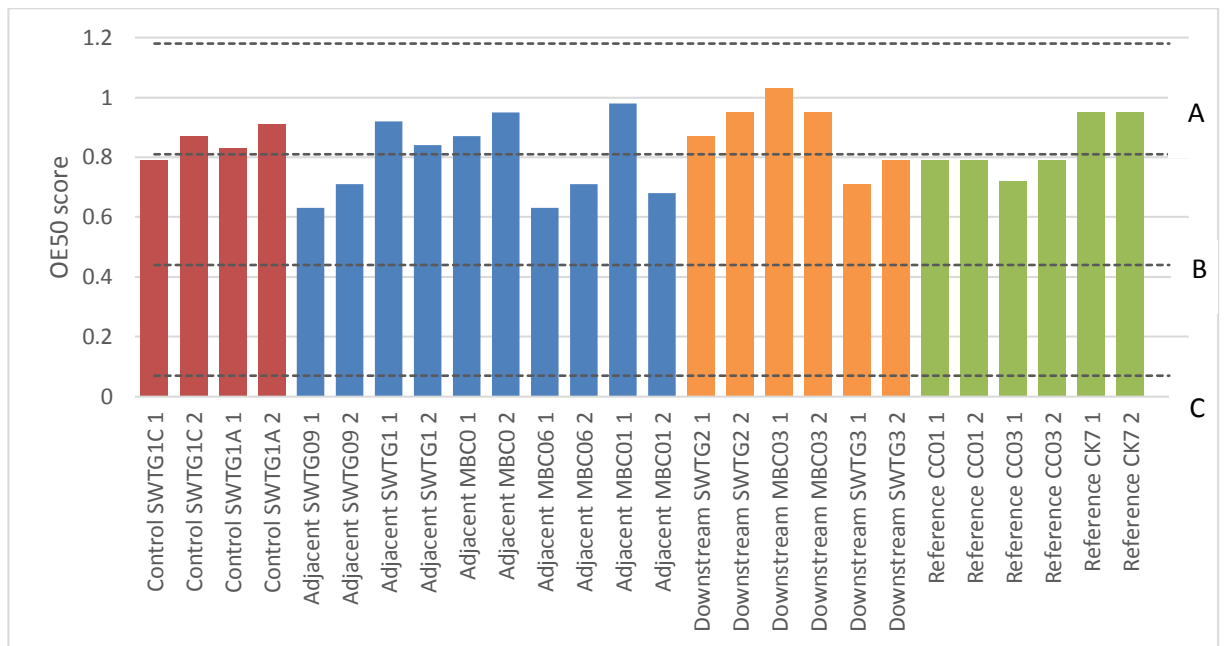


Figure 4-8 AUSRIVAS OE50 results and bandings for sites sampled in 2018

4.3.6 Community composition

A total of 59 families were collected during the 2018 sampling event. The distribution of those taxa across 17 orders is presented in Figure 4-9.

Taxa in both Mount Bunday Creek and Coulter Creek were dominated by Diptera (flies) and Coleoptera (beetles). Ephemeroptera (mayflies) and Hemiptera (true bugs) were also common across all sites. Hydrozoa were collected from all Coulter Creek sites but were not found in any Mount Bunday Creek sample.

A full list of taxa collected during May 2018 sampling can be found in Appendix B.

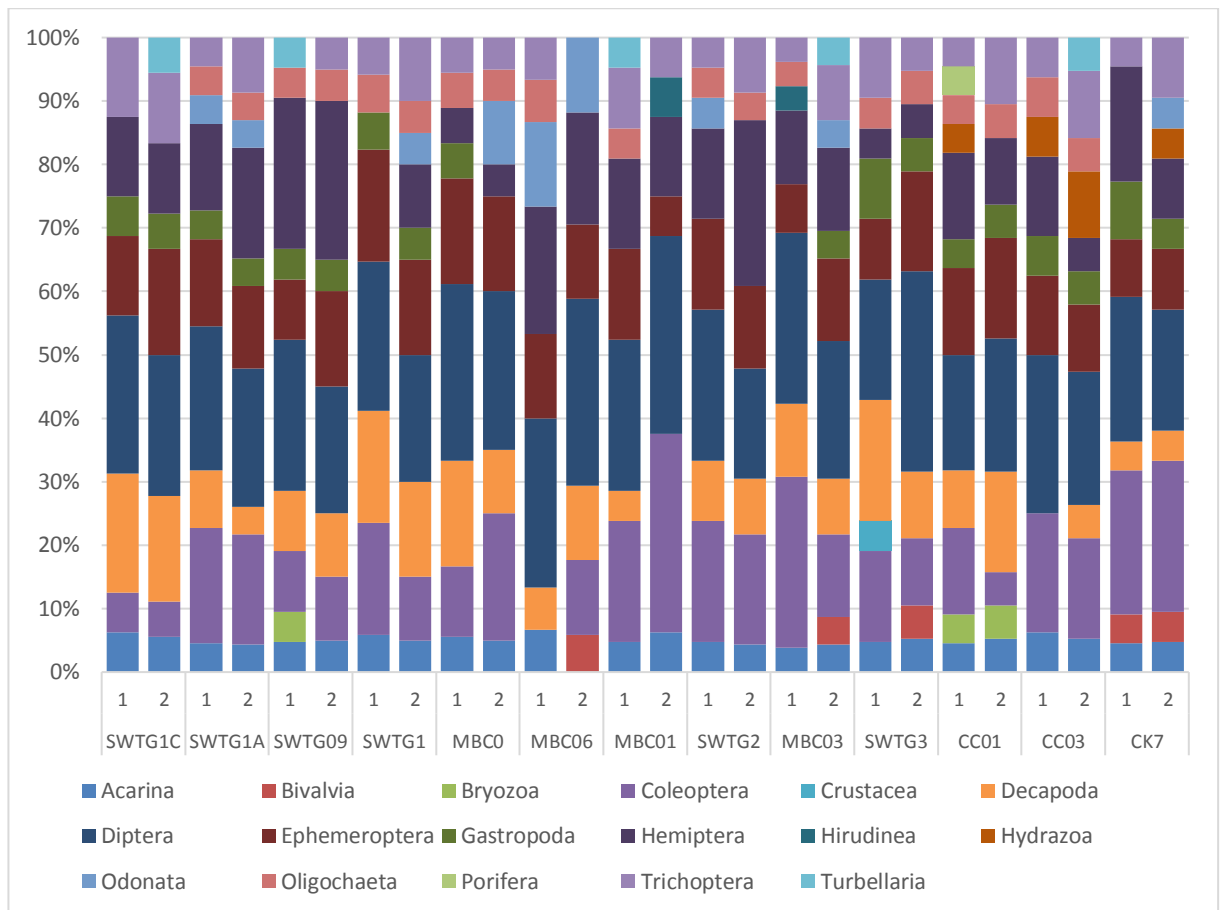


Figure 4-9 Community composition of macroinvertebrate orders for samples collected May 2018

4.4 Fish community

A total of 332 individuals belonging to 11 identifiable fish species were recorded during the May 2018 sampling event (Table 4-4). One unidentifiable fry was caught at CK7 which was not included in calculations of species diversity.

No sampling was undertaken at MBC01 and CC03, due to site suitability and safety concerns, and MBC06 due to high salinity.

Of the 11 identifiable species of fish recorded in May 2018, Rainbowfish made up the largest number of those collected during sampling, followed by Northern Trout Gudgeon. These species were also the most widely distributed across sites, with Northern Trout Gudgeon observed at all sites except SWTG09, and Rainbowfish observed at all sites except SWTG1A and SWTG3.

Control site SWTG1C recorded the highest total number of fish caught, followed by MBC0, with both sites dominated by a single species. Diversity of species at Mount Bunday Creek sites was lowest at the four most upstream sites, and was highest at sites downstream of the mine.

Diversity at sites in Coulter Creek had increased since sampling in 2017, with diversity at these sites similar to that of Mount Bunday Creek sites.

Table 4-4 Fish caught during May 2018 sampling event

Species	Common Name	Control		Adjacent			Downstream			Reference		TOTAL
		SWG1C	SWG1A	SWG09	SWG1	MBC0	SWG2	MBC03	SWG3	CC01	CK7	
<i>Ambassis agrammus</i>	Sailfin Glassfish	4		13			3	1	2			23
<i>Ambassis interrupta</i>	Longspine Glassfish						1			4		5
<i>Anodontoglanis dahli</i>	Toothless Catfish			1								1
<i>Glossamia aprion</i>	Mouth Almighty							1				1
<i>Hephaestus fuliginosus</i>	Sooty Grunter						2	3				5
<i>Leiopotherapon unicolor</i>	Spangled Perch					1	1			1	2	5
<i>Melanotaenia splendida</i>	Rainbowfish	91		25	18	4	22	14		6	1	181
<i>Mogurnda mogurnda</i>	Northern Trout Gudgeon	5	7		4	58	3	8	8	2	3	98
<i>Neosilurus ater</i>	Black Catfish				1	2		1	1			5
<i>Neosilurus hyrtl</i>	Hyrtl's Tandan								1	3		4
<i>Oxyeleotris lineolatus</i>	Sleepy Cod					1			1	1		3
Total Number Observed		100	7	39	23	66	32	28	13	17	6	332
Total Number of Species		3	1	3	3	5	6	6	5	6	3	11

4.5 Water monitors

4.5.1 Sampling effort

Camera units were deployed at six sites across the study areas and were active for between 100 and 104 days, depending on deployment date (Table 4-5). A fire occurred on the neighbouring property, and as a result, camera unit M2 was completely destroyed and no images were available. Camera units M4 and M5 were damaged by fire and ceased recording on 18 August. All other cameras were working effectively for the full length of deployment.

Table 4-5 Remote camera locations and deployment

Camera Code	Camera in	Camera out	Days deployed	Comments
M1	10/5/18	20/08/18	102	Located at MBC01
M2	10/5/18	20/08/18	102	Located at MBC03, destroyed in fire
M3	08/5/18	20/08/18	104	Located at SWTG1A
M4	10/5/18	20/08/18	100	Damaged by fire
M5	12/5/18	20/08/18	98	Damaged by fire
M6	09/5/18	20/08/18	103	Located at site SWTG2.

4.5.2 Target species

A single individual species of Mertens' Water Monitor (*Varanus mertensi*) was recorded within the study area on camera unit M6, located downstream of the mine on Mount Bunday Creek (Photo 4-1) There were no sightings of *V. mitchelli* on any of the remote camera units. A large number of non-target species were recorded on cameras during deployment.



Photo 4-1 Mertens Water Monitor (*Varanus mertensi*) photographed on camera unit M6, 13/5/18.

4.5.3 Non-target species

Remote cameras recorded 35 non-target species across the study area. A number of introduced species were found on all camera units, including cane toads on M1 and M5, feral cats on M3, M5 and M6, and cattle, horses and pigs. Wild dogs were a feature in 2018, being recorded on almost all cameras, and not recorded on a single camera in 2017. Feral pigs appeared to be less prevalent in 2018, which may be as a result of an increase in the presence of predators (dogs).

The most common native species recorded was the Agile Wallaby (*Macropus agilis*). A wide variety of native bird species were also observed across the sites.

Along with the Mertens' Water Monitor, two further listed, threatened species were sighted by the remote cameras:

- Pale Field Rat (*Rattus tunneyi*) on camera units M5 and M6 (Photo 4-2) is listed as Vulnerable under the *Territory Parks and Wildlife Conservation Act*,
- Black-footed Tree Rat (*Mesembriomys gouldii*) on camera unit M5 (Photo 4-3) is listed as Vulnerable under the *Territory Parks and Wildlife Conservation Act*, and is listed as Endangered under the *Environmental Protection and Biodiversity Conservation Act* (1999).

A full list of species that could be positively identified can be found in Appendix C.



Photo 4-2 Pale field rat (*Rattus tunneyi*)



Photo 4-3 Black-footed tree rat (*Mesembriomys gouldii*)

5. Conclusions and Recommendations

Aquatic ecology monitoring was completed successfully in May 2018, including the following observations:

- *In situ* water quality was generally observed within the SSTVs, with dissolved oxygen being outside the range for all sites. This is a common occurrence in the waterways associated with Toms Gully, and is likely a function of high shading and lack of flow at most sites. Dissolved oxygen levels are expected to fluctuate and so these one-off readings are not of concern.
- Water chemistry results indicated possible interaction between groundwater and surface water at MBC06, which also resulted in water possibly backing up in Mount Bunday Creek to MBC0 resulting in higher metal concentrations than previously recorded. Higher EC was also a feature at MBC0 and downstream of the confluence of Mount Bunday Creek and the unnamed creek on which MBC06 is located.
- Macroinvertebrate communities varied in univariate metrics to a greater extent at sites adjacent to and downstream of Toms Gully Mine. This may be as a result of higher EC associated with groundwater seepage upstream of MBC06, and some higher metal concentrations found at those sites compared with upstream and reference sites. MBC01 showed some signs of impairment associated with geomorphological changes at the site.
- Despite elevated concentrations of some metals and elevated EC adjacent to and downstream of Toms Gully Mine, there were no visible health issues observed for fish collected in 2018. Fish abundance was generally higher at all sites, with Coulter Creek being particularly high compared with previous years.
- Modifications to channel geomorphology in Coulter Creek and Mount Bunday Creek resulted in obvious changes to the sampling effort that could be applied. In particular, changes to Coulter Creek have resulted in high amounts of erosion.
- A single Merten's Water Monitor was observed downstream of Toms Gully Mine in 2018. This is contrary to results in 2017, which resulted in one individual being observed upstream. A lower number of pigs and cane toads observed in 2018 may have resulted in more favourable conditions for water monitors downstream. This monitoring has the added benefit of indirectly observing other vulnerable and threatened species, making it a valuable component of monitoring to date and into the future.

The following recommendations are made for future monitoring

- It is suggested that the monitoring sites on Mount Bunday Creek (MBC01) and Coulter Creek (CC02) be relocated upstream in an effort to avoid the impacts related to cattle movement and likely future earthworks at these sites.
- All other sites are recommended for ongoing monitoring as part of an annual sampling program, including fauna camera trapping.
- The monitoring program does not currently incorporate sediment monitoring. Should elevated concentrations of metals adjacent to and downstream of Toms Gully persist in 2019, it is suggested that sediment monitoring occur annually thereafter to characterise sediments as well as monitor any accumulation of metals in sediments.

6. References

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Appendices

Appendix A – Laboratory certificate of analysis

CERTIFICATE OF ANALYSIS 210878

Client Details

Client	GHD Services Pty Ltd - Darwin
Attention	Tara Steele
Address	Level 7, 24 Mitchell Street, DARWIN, NT, 0800

Sample Details

Your Reference	<u>GHD - Water Analysis</u>
Number of Samples	16 Water
Date samples received	17/05/2018
Date completed instructions received	21/05/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	25/05/2018
Date of Issue	25/05/2018
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Results Approved By

Joshua Lim, Operations Manager

Authorised By



Todd Lee, Laboratory Manager

Client Reference: GHD - Water Analysis

Miscellaneous Inorganics							
Our Reference			210878-1	210878-2	210878-3	210878-4	210878-5
Your Reference	UNITS	PQL	EP2	SWG3	CC01	CC03	CK7
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		21/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		21/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
pH	pH Units		3.2	6.6	7.1	6.8	7.0
Electrical Conductivity (EC)	µS/cm	1	5,600	120	180	150	180
Acidity as CaCO ₃	mg/L	5	2,800	8	6	6	<5
Total Dissolved Solids (grav)	mg/L	5	8,100	71	110	87	110
Turbidity	NTU	0.1	0.3	15	7.3	12	5.8

Miscellaneous Inorganics							
Our Reference			210878-6	210878-7	210878-8	210878-9	210878-10
Your Reference	UNITS	PQL	MBC01	MBC03	MBC06	SWG09	SWG1
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
pH	pH Units		3.9	6.2	7.5	7.0	6.5
Electrical Conductivity (EC)	µS/cm	1	490	160	5,800	100	48
Acidity as CaCO ₃	mg/L	5	31	5	16	<5	6
Total Dissolved Solids (grav)	mg/L	5	290	94	6,900	62	29
Turbidity	NTU	0.1	17	2.8	5.8	4.4	7.2

Miscellaneous Inorganics							
Our Reference			210878-11	210878-12	210878-13	210878-14	210878-15
Your Reference	UNITS	PQL	SWG1A	SWG2	MBC0	SWG1C	CK5
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
pH	pH Units		6.0	5.9	6.4	7.0	7.4
Electrical Conductivity (EC)	µS/cm	1	35	230	31	68	170
Acidity as CaCO ₃	mg/L	5	11	6	<5	<5	<5
Total Dissolved Solids (grav)	mg/L	5	21	140	19	41	100
Turbidity	NTU	0.1	5.0	1.8	4.2	2.5	12

Miscellaneous Inorganics			
Our Reference			210878-16
Your Reference	UNITS	PQL	MBCDUP
Type of sample			Water
Date prepared	-		22/05/2018
Date analysed	-		22/05/2018
pH	pH Units		6.2
Electrical Conductivity (EC)	µS/cm	1	160
Acidity as CaCO ₃	mg/L	5	<5
Total Dissolved Solids (grav)	mg/L	5	94
Turbidity	NTU	0.1	2.9

Client Reference: GHD - Water Analysis

Cyanides in Water							
Our Reference	UNITS	PQL	210878-1	210878-2	210878-3	210878-4	210878-5
Your Reference			EP2	SWG3	CC01	CC03	CK7
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		24/05/2018	24/05/2018	24/05/2018	24/05/2018	24/05/2018
Date analysed	-		24/05/2018	24/05/2018	24/05/2018	24/05/2018	24/05/2018
Free Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	0.004	<0.004	<0.004	0.009	0.008	<0.004

Cyanides in Water							
Our Reference	UNITS	PQL	210878-6	210878-7	210878-8	210878-9	210878-10
Your Reference			MBC01	MBC03	MBC06	SWG09	SWG1
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		24/05/2018	24/05/2018	24/05/2018	24/05/2018	24/05/2018
Date analysed	-		24/05/2018	24/05/2018	24/05/2018	24/05/2018	24/05/2018
Free Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Cyanides in Water							
Our Reference	UNITS	PQL	210878-11	210878-12	210878-13	210878-14	210878-15
Your Reference			SWG1A	SWG2	MBC0	SWG1C	CK5
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		24/05/2018	24/05/2018	24/05/2018	24/05/2018	24/05/2018
Date analysed	-		24/05/2018	24/05/2018	24/05/2018	24/05/2018	24/05/2018
Free Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Cyanides in Water			
Our Reference	UNITS	PQL	210878-16
Your Reference			MBCDUP
Type of sample			Water
Date prepared	-		24/05/2018
Date analysed	-		24/05/2018
Free Cyanide	mg/L	0.004	<0.004
WAD Cyanide	mg/L	0.004	<0.004
Total Cyanide	mg/L	0.004	<0.004

Client Reference: GHD - Water Analysis

Ionic Balance							
Our Reference			210878-1	210878-2	210878-3	210878-4	210878-5
Your Reference	UNITS	PQL	EP2	SWG3	CC01	CC03	CK7
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Calcium - Dissolved	mg/L	0.5	82	7.5	11	7.0	8.7
Potassium - Dissolved	mg/L	0.5	1.3	1.8	2.8	3.7	3.2
Magnesium - Dissolved	mg/L	0.5	630	5.2	11	7.1	9.2
Sodium - Dissolved	mg/L	0.5	3.9	4.6	6.2	6.5	8.2
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	<5	22	57	34	28
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	5	<5	22	57	34	28
Chloride	mg/L	1	7	3	6	5	4
Sulphate	mg/L	1	5,500	23	20	22	43
Ionic Balance	%		-35	2.5	1.5	1.7	1.6
Hardness as CaCO ₃	mg/L	3	2,800	40	70	47	60

Ionic Balance							
Our Reference			210878-6	210878-7	210878-8	210878-9	210878-10
Your Reference	UNITS	PQL	MBC01	MBC03	MBC06	SWG09	SWG1
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Calcium - Dissolved	mg/L	0.5	36	10	490	8.0	2.4
Potassium - Dissolved	mg/L	0.5	3.0	1.6	8.6	2.7	0.7
Magnesium - Dissolved	mg/L	0.5	22	6.7	840	4.0	1.7
Sodium - Dissolved	mg/L	0.5	7.3	4.8	74	3.9	3.7
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	<5	7	190	38	16
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	5	<5	7	190	38	16
Chloride	mg/L	1	3	3	23	6	3
Sulphate	mg/L	1	210	52	4,700	1	1
Ionic Balance	%		-5.1	0.089	-2.7	1.6	1.1
Hardness as CaCO ₃	mg/L	3	180	53	4,700	36	13

Client Reference: GHD - Water Analysis

Ionic Balance							
Our Reference			210878-11	210878-12	210878-13	210878-14	210878-15
Your Reference	UNITS	PQL	SWG1A	SWG2	MBC0	SWG1C	CK5
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Calcium - Dissolved	mg/L	0.5	1.3	16	1.4	4.0	8.6
Potassium - Dissolved	mg/L	0.5	0.6	1.7	<0.5	1.5	2.7
Magnesium - Dissolved	mg/L	0.5	1.1	11	1.0	2.8	10
Sodium - Dissolved	mg/L	0.5	3.1	5.4	2.3	4.5	6.6
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	11	5	10	27	34
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	5	11	5	10	27	34
Chloride	mg/L	1	3	2	2	3	3
Sulphate	mg/L	1	<1	87	1	<1	37
Ionic Balance	%		0.86	-0.81	-3.9	3.6	3.2
Hardness as CaCO ₃	mg/L	3	8	83	8	21	64

Ionic Balance			
Our Reference			210878-16
Your Reference	UNITS	PQL	MBCDUP
Type of sample			Water
Date prepared	-		22/05/2018
Date analysed	-		22/05/2018
Calcium - Dissolved	mg/L	0.5	9.8
Potassium - Dissolved	mg/L	0.5	1.5
Magnesium - Dissolved	mg/L	0.5	6.6
Sodium - Dissolved	mg/L	0.5	4.9
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	7
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	5	<5
Total Alkalinity as CaCO ₃	mg/L	5	7
Chloride	mg/L	1	3
Sulphate	mg/L	1	52
Ionic Balance	%		-0.22
Hardness as CaCO ₃	mg/L	3	52

Client Reference: GHD - Water Analysis

Dissolved Metals in Water							
Our Reference			210878-1	210878-2	210878-3	210878-4	210878-5
Your Reference	UNITS	PQL	EP2	SWG3	CC01	CC03	CK7
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Aluminium-Dissolved	mg/L	0.01	480	0.05	0.06	0.07	0.12
Arsenic-Dissolved	mg/L	0.001	0.019	0.002	0.001	0.002	<0.001
Cadmium-Dissolved	mg/L	0.0001	0.43	0.0002	<0.0001	<0.0001	<0.0001
Cobalt-Dissolved	mg/L	0.001	2.3	0.004	<0.001	0.005	<0.001
Chromium-Dissolved	mg/L	0.001	0.070	<0.001	<0.001	<0.001	<0.001
Copper-Dissolved	mg/L	0.001	7.9	0.002	0.007	0.001	0.004
Iron-Dissolved	mg/L	0.01	7.4	2.8	0.37	1.4	0.08
Lead-Dissolved	mg/L	0.001	0.006	<0.001	<0.001	<0.001	<0.001
Manganese-Dissolved	mg/L	0.005	25	1.1	1.2	0.88	0.059
Nickel-Dissolved	mg/L	0.001	12	0.007	0.002	0.010	0.004
Zinc-Dissolved	mg/L	0.001	24	0.011	0.005	0.015	0.006
Uranium-Dissolved	mg/L	0.0005	0.30	<0.0005	<0.0005	<0.0005	<0.0005

Dissolved Metals in Water							
Our Reference			210878-6	210878-7	210878-8	210878-9	210878-10
Your Reference	UNITS	PQL	MBC01	MBC03	MBC06	SWG09	SWG1
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Aluminium-Dissolved	mg/L	0.01	1.4	0.05	<0.01	0.10	0.05
Arsenic-Dissolved	mg/L	0.001	0.002	<0.001	0.003	<0.001	0.001
Cadmium-Dissolved	mg/L	0.0001	0.012	0.0006	<0.0001	<0.0001	<0.0001
Cobalt-Dissolved	mg/L	0.001	0.074	0.002	0.002	<0.001	0.002
Chromium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper-Dissolved	mg/L	0.001	0.086	0.002	0.004	0.010	0.005
Iron-Dissolved	mg/L	0.01	2.3	1.1	0.41	0.74	1.1
Lead-Dissolved	mg/L	0.001	0.002	<0.001	<0.001	0.001	<0.001
Manganese-Dissolved	mg/L	0.005	3.5	0.26	1.6	0.038	0.50
Nickel-Dissolved	mg/L	0.001	0.12	0.009	0.008	0.003	0.002
Zinc-Dissolved	mg/L	0.001	0.61	0.048	0.006	0.012	0.008
Uranium-Dissolved	mg/L	0.0005	0.0008	<0.0005	0.010	<0.0005	<0.0005

Client Reference: GHD - Water Analysis

Dissolved Metals in Water							
Our Reference			210878-11	210878-12	210878-13	210878-14	210878-15
Your Reference	UNITS	PQL	SWG1A	SWG2	MBC0	SWG1C	CK5
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Date analysed	-		22/05/2018	22/05/2018	22/05/2018	22/05/2018	22/05/2018
Aluminium-Dissolved	mg/L	0.01	0.03	0.03	0.06	0.07	0.11
Arsenic-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	0.001	<0.001
Cadmium-Dissolved	mg/L	0.0001	<0.0001	0.0030	<0.0001	<0.0001	<0.0001
Cobalt-Dissolved	mg/L	0.001	<0.001	0.008	<0.001	<0.001	<0.001
Chromium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper-Dissolved	mg/L	0.001	0.007	0.006	0.009	<0.001	0.011
Iron-Dissolved	mg/L	0.01	0.51	0.05	0.29	0.29	0.16
Lead-Dissolved	mg/L	0.001	<0.001	<0.001	0.002	<0.001	<0.001
Manganese-Dissolved	mg/L	0.005	0.093	0.93	0.023	0.11	0.019
Nickel-Dissolved	mg/L	0.001	0.002	0.039	0.002	<0.001	0.005
Zinc-Dissolved	mg/L	0.001	0.009	0.18	0.019	0.003	0.025
Uranium-Dissolved	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Dissolved Metals in Water			
Our Reference			210878-16
Your Reference	UNITS	PQL	MBCDUP
Type of sample			Water
Date prepared	-		22/05/2018
Date analysed	-		22/05/2018
Aluminium-Dissolved	mg/L	0.01	0.02
Arsenic-Dissolved	mg/L	0.001	<0.001
Cadmium-Dissolved	mg/L	0.0001	0.0005
Cobalt-Dissolved	mg/L	0.001	0.001
Chromium-Dissolved	mg/L	0.001	<0.001
Copper-Dissolved	mg/L	0.001	0.013
Iron-Dissolved	mg/L	0.01	0.26
Lead-Dissolved	mg/L	0.001	<0.001
Manganese-Dissolved	mg/L	0.005	0.22
Nickel-Dissolved	mg/L	0.001	0.01
Zinc-Dissolved	mg/L	0.001	0.060
Uranium-Dissolved	mg/L	0.0005	<0.0005

Client Reference: GHD - Water Analysis

Total Metals in water							
Our Reference			210878-1	210878-2	210878-3	210878-4	210878-5
Your Reference	UNITS	PQL	EP2	SWG3	CC01	CC03	CK7
Type of sample			Water	Water	Water	Water	Water
Date digested	-		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Date analysed	-		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Aluminium-Total	mg/L	0.01	490	0.04	0.06	0.10	0.1
Arsenic-Total	mg/L	0.001	0.019	0.002	0.002	0.002	<0.001
Cadmium-Total	mg/L	0.0001	0.44	0.0001	<0.0001	<0.0001	<0.0001
Cobalt-Total	mg/L	0.001	2.5	0.004	0.001	0.008	0.001
Chromium-Total	mg/L	0.001	0.073	<0.001	<0.001	<0.001	<0.001
Copper-Total	mg/L	0.001	7.9	0.002	<0.001	0.002	0.002
Iron-Total	mg/L	0.01	7.8	2.9	0.91	1.8	0.19
Lead-Total	mg/L	0.001	0.005	<0.001	<0.001	0.001	<0.001
Manganese-Total	mg/L	0.005	28	1.1	1.3	1.6	0.081
Nickel-Total	mg/L	0.001	13	0.007	0.002	0.014	0.005
Zinc-Total	mg/L	0.001	26	0.010	0.004	0.018	0.009
Uranium-Total	mg/L	0.0005	0.32	<0.0005	<0.0005	<0.0005	<0.0005

Total Metals in water							
Our Reference			210878-6	210878-7	210878-8	210878-9	210878-10
Your Reference	UNITS	PQL	MBC01	MBC03	MBC06	SWG09	SWG1
Type of sample			Water	Water	Water	Water	Water
Date digested	-		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Date analysed	-		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Aluminium-Total	mg/L	0.01	1.4	<0.01	<0.01	0.02	0.01
Arsenic-Total	mg/L	0.001	0.002	<0.001	0.003	<0.001	0.001
Cadmium-Total	mg/L	0.0001	0.012	0.0005	<0.0001	<0.0001	<0.0001
Cobalt-Total	mg/L	0.001	0.074	0.001	0.003	<0.001	0.002
Chromium-Total	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001
Copper-Total	mg/L	0.001	0.090	0.003	<0.001	<0.001	<0.001
Iron-Total	mg/L	0.01	3.3	0.25	1.6	0.84	1.5
Lead-Total	mg/L	0.001	0.002	<0.001	<0.001	<0.001	<0.001
Manganese-Total	mg/L	0.005	3.6	0.23	1.7	0.051	0.51
Nickel-Total	mg/L	0.001	0.13	0.01	0.008	0.001	0.001
Zinc-Total	mg/L	0.001	0.61	0.049	0.003	0.001	0.002
Uranium-Total	mg/L	0.0005	0.0021	<0.0005	0.011	<0.0005	<0.0005

Client Reference: GHD - Water Analysis

Total Metals in water							
Our Reference			210878-11	210878-12	210878-13	210878-14	210878-15
Your Reference	UNITS	PQL	SWG1A	SWG2	MBC0	SWG1C	CK5
Type of sample			Water	Water	Water	Water	Water
Date digested	-		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Date analysed	-		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Aluminium-Total	mg/L	0.01	0.02	0.04	0.01	0.01	0.27
Arsenic-Total	mg/L	0.001	<0.001	<0.001	<0.001	0.001	0.001
Cadmium-Total	mg/L	0.0001	<0.0001	0.0029	<0.0001	<0.0001	<0.0001
Cobalt-Total	mg/L	0.001	<0.001	0.008	<0.001	<0.001	0.001
Chromium-Total	mg/L	0.001	<0.001	<0.001	0.009	<0.001	0.002
Copper-Total	mg/L	0.001	<0.001	0.004	0.001	<0.001	0.002
Iron-Total	mg/L	0.01	1.1	0.25	0.37	0.30	0.62
Lead-Total	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001
Manganese-Total	mg/L	0.005	0.11	0.92	0.029	0.13	0.064
Nickel-Total	mg/L	0.001	<0.001	0.040	0.006	0.001	0.005
Zinc-Total	mg/L	0.001	0.002	0.18	0.001	<0.001	0.012
Uranium-Total	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Total Metals in water			
Our Reference			210878-16
Your Reference	UNITS	PQL	MBCDUP
Type of sample			Water
Date digested	-		23/05/2018
Date analysed	-		23/05/2018
Aluminium-Total	mg/L	0.01	0.03
Arsenic-Total	mg/L	0.001	<0.001
Cadmium-Total	mg/L	0.0001	0.0006
Cobalt-Total	mg/L	0.001	0.002
Chromium-Total	mg/L	0.001	<0.001
Copper-Total	mg/L	0.001	0.002
Iron-Total	mg/L	0.01	1.1
Lead-Total	mg/L	0.001	<0.001
Manganese-Total	mg/L	0.005	0.25
Nickel-Total	mg/L	0.001	0.01
Zinc-Total	mg/L	0.001	0.048
Uranium-Total	mg/L	0.0005	<0.0005

Client Reference: GHD - Water Analysis

Method ID	Methodology Summary
INORG-001	pH - Measured using pH meter and electrode base on APHA latest edition, Method 4500-H+. Please note that the results for water analyses may be indicative only, as analysis can be completed outside of the APHA recommended holding times. Soils are reported from a 1:5 water extract unless otherwise specified.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C based on APHA latest edition Method 2510. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-005	Acidity - determined by titration based on APHA latest edition, Method 2310 B. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition, Method 2320-B. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
INORG-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180±5°C
INORG-022	Turbidity - measured nephelometrically using a turbidimeter, in accordance with APHA latest edition, 2130 B.
INORG-040	Ion Balance Calculation: Cations in water by ICP-OES; Anions in water by IC; Alkalinity in water by Titration using APHA methods.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110-B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
METALS-008	Hardness calculated from Calcium and Magnesium as per APHA latest edition 2340B.
METALS-020	Metals in soil and water by ICP-OES.
METALS-022	Determination of various metals by ICP-MS.

Client Reference: GHD - Water Analysis

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			22/05/2018	1	21/05/2018	21/05/2018		22/05/2018	[NT]
Date analysed	-			22/05/2018	1	21/05/2018	21/05/2018		22/05/2018	[NT]
pH	pH Units		INORG-001	[NT]	1	3.2	3.2	0	100	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	<1	1	5600	5600	0	104	[NT]
Acidity as CaCO ₃	mg/L	5	INORG-005	<5	1	2800	2700	4	100	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	<5	1	8100	[NT]		103	[NT]
Turbidity	NTU	0.1	INORG-022	<0.1	1	0.3	[NT]		98	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	22/05/2018	22/05/2018		[NT]	[NT]
Date analysed	-			[NT]	11	22/05/2018	22/05/2018		[NT]	[NT]
pH	pH Units		INORG-001	[NT]	11	6.0	6.1	2	[NT]	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	[NT]	11	35	35	0	[NT]	[NT]
Acidity as CaCO ₃	mg/L	5	INORG-005	[NT]	11	11	10	10	[NT]	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	[NT]	11	21	21	0	[NT]	[NT]
Turbidity	NTU	0.1	INORG-022	[NT]	11	5.0	[NT]		[NT]	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	7	22/05/2018	[NT]		[NT]	[NT]
Date analysed	-			[NT]	7	22/05/2018	[NT]		[NT]	[NT]
pH	pH Units		INORG-001	[NT]	7	6.2	[NT]		[NT]	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	[NT]	7	160	[NT]		[NT]	[NT]
Acidity as CaCO ₃	mg/L	5	INORG-005	[NT]	7	5	[NT]		[NT]	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	[NT]	7	94	[NT]		[NT]	[NT]
Turbidity	NTU	0.1	INORG-022	[NT]	7	2.8	2.8	0	[NT]	[NT]

Client Reference: GHD - Water Analysis

QUALITY CONTROL: Cyanides in Water					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	210878-2
Date prepared	-			24/05/2018	1	24/05/2018	24/05/2018		24/05/2018	24/05/2018
Date analysed	-			24/05/2018	1	24/05/2018	24/05/2018		24/05/2018	24/05/2018
Free Cyanide	mg/L	0.004	INORG-014	<0.004	1	<0.004	<0.004	0	97	95
WAD Cyanide	mg/L	0.004	INORG-014	<0.004	1	<0.004	<0.004	0	94	97
Total Cyanide	mg/L	0.004	INORG-014	<0.004	1	<0.004	<0.004	0	100	79

QUALITY CONTROL: Cyanides in Water					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	24/05/2018	24/05/2018		[NT]	[NT]
Date analysed	-			[NT]	11	24/05/2018	24/05/2018		[NT]	[NT]
Free Cyanide	mg/L	0.004	INORG-014	[NT]	11	<0.004	<0.004	0	[NT]	[NT]
WAD Cyanide	mg/L	0.004	INORG-014	[NT]	11	<0.004	<0.004	0	[NT]	[NT]
Total Cyanide	mg/L	0.004	INORG-014	[NT]	11	<0.004	<0.004	0	[NT]	[NT]

Client Reference: GHD - Water Analysis

QUALITY CONTROL: Ionic Balance						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			22/05/2018	1	22/05/2018	22/05/2018		22/05/2018	[NT]
Date analysed	-			22/05/2018	1	22/05/2018	22/05/2018		22/05/2018	[NT]
Calcium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	82	[NT]		99	[NT]
Potassium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	1.3	[NT]		100	[NT]
Magnesium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	630	[NT]		100	[NT]
Sodium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	3.9	[NT]		100	[NT]
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	INORG-006	<5	1	<5	<5	0	96	[NT]
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	INORG-006	<5	1	<5	<5	0	96	[NT]
Total Alkalinity as CaCO ₃	mg/L	5	INORG-006	<5	1	<5	<5	0	96	[NT]
Chloride	mg/L	1	INORG-081	<1	1	7	7	0	100	[NT]
Sulphate	mg/L	1	INORG-081	<1	1	5500	5300	4	102	[NT]
Hardness as CaCO ₃	mg/L	3	METALS-008	<3	1	2800	[NT]		[NT]	[NT]

QUALITY CONTROL: Ionic Balance						Duplicate		Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	22/05/2018	22/05/2018		[NT]	[NT]
Date analysed	-			[NT]	11	22/05/2018	22/05/2018		[NT]	[NT]
Calcium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	1.3	[NT]		[NT]	[NT]
Potassium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	0.6	[NT]		[NT]	[NT]
Magnesium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	1.1	[NT]		[NT]	[NT]
Sodium - Dissolved	mg/L	0.5	METALS-020	[NT]	11	3.1	[NT]		[NT]	[NT]
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	INORG-006	[NT]	11	11	11	0	[NT]	[NT]
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	5	INORG-006	[NT]	11	<5	<5	0	[NT]	[NT]
Total Alkalinity as CaCO ₃	mg/L	5	INORG-006	[NT]	11	11	11	0	[NT]	[NT]
Chloride	mg/L	1	INORG-081	[NT]	11	3	3	0	[NT]	[NT]
Sulphate	mg/L	1	INORG-081	[NT]	11	<1	<1	0	[NT]	[NT]
Hardness as CaCO ₃	mg/L	3	METALS-008	[NT]	11	8	[NT]		[NT]	[NT]

Client Reference: GHD - Water Analysis

QUALITY CONTROL: Dissolved Metals in Water					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			22/05/2018	8	22/05/2018	22/05/2018		22/05/2018	[NT]
Date analysed	-			22/05/2018	8	22/05/2018	22/05/2018		22/05/2018	[NT]
Aluminium-Dissolved	mg/L	0.01	METALS-022	<0.01	8	<0.01	0.02	67	96	[NT]
Arsenic-Dissolved	mg/L	0.001	METALS-022	<0.001	8	0.003	0.002	40	98	[NT]
Cadmium-Dissolved	mg/L	0.0001	METALS-022	<0.0001	8	<0.0001	<0.0001	0	99	[NT]
Cobalt-Dissolved	mg/L	0.001	METALS-022	<0.001	8	0.002	0.002	0	104	[NT]
Chromium-Dissolved	mg/L	0.001	METALS-022	<0.001	8	<0.001	<0.001	0	95	[NT]
Copper-Dissolved	mg/L	0.001	METALS-022	<0.001	8	0.004	0.003	29	100	[NT]
Iron-Dissolved	mg/L	0.01	METALS-022	<0.01	8	0.41	0.40	2	101	[NT]
Lead-Dissolved	mg/L	0.001	METALS-022	<0.001	8	<0.001	<0.001	0	99	[NT]
Manganese-Dissolved	mg/L	0.005	METALS-022	<0.005	8	1.6	1.6	0	99	[NT]
Nickel-Dissolved	mg/L	0.001	METALS-022	<0.001	8	0.008	0.008	0	100	[NT]
Zinc-Dissolved	mg/L	0.001	METALS-022	<0.001	8	0.006	0.005	18	99	[NT]
Uranium-Dissolved	mg/L	0.0005	METALS-022	<0.0005	8	0.010	0.010	0	98	[NT]

Client Reference: GHD - Water Analysis

QUALITY CONTROL: Total Metals in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	210878-2
Date digested	-			23/05/2018	1	23/05/2018	23/05/2018		23/05/2018	23/05/2018
Date analysed	-			23/05/2018	1	23/05/2018	23/05/2018		23/05/2018	23/05/2018
Aluminium-Total	mg/L	0.01	METALS-022	<0.01	1	490	480	2	97	71
Arsenic-Total	mg/L	0.001	METALS-022	<0.001	1	0.019	0.019	0	102	102
Cadmium-Total	mg/L	0.0001	METALS-022	<0.0001	1	0.44	0.44	0	103	102
Cobalt-Total	mg/L	0.001	METALS-022	<0.001	1	2.5	2.5	0	[NT]	[NT]
Chromium-Total	mg/L	0.001	METALS-022	<0.001	1	0.073	0.073	0	100	97
Copper-Total	mg/L	0.001	METALS-022	<0.001	1	7.9	7.8	1	106	103
Iron-Total	mg/L	0.01	METALS-022	<0.01	1	7.8	7.6	3	111	[NT]
Lead-Total	mg/L	0.001	METALS-022	<0.001	1	0.005	0.005	0	104	102
Manganese-Total	mg/L	0.005	METALS-022	<0.005	1	28	27	4	102	[NT]
Nickel-Total	mg/L	0.001	METALS-022	<0.001	1	13	13	0	104	101
Zinc-Total	mg/L	0.001	METALS-022	<0.001	1	26	25	4	104	98
Uranium-Total	mg/L	0.0005	METALS-022	<0.0005	1	0.32	0.31	3	103	103

QUALITY CONTROL: Total Metals in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date digested	-			[NT]	11	23/05/2018	23/05/2018		[NT]	[NT]
Date analysed	-			[NT]	11	23/05/2018	23/05/2018		[NT]	[NT]
Aluminium-Total	mg/L	0.01	METALS-022	[NT]	11	0.02	0.01	67	[NT]	[NT]
Arsenic-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Cadmium-Total	mg/L	0.0001	METALS-022	[NT]	11	<0.0001	<0.0001	0	[NT]	[NT]
Cobalt-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Chromium-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Copper-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Iron-Total	mg/L	0.01	METALS-022	[NT]	11	1.1	1.0	10	[NT]	[NT]
Lead-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Manganese-Total	mg/L	0.005	METALS-022	[NT]	11	0.11	0.11	0	[NT]	[NT]
Nickel-Total	mg/L	0.001	METALS-022	[NT]	11	<0.001	<0.001	0	[NT]	[NT]
Zinc-Total	mg/L	0.001	METALS-022	[NT]	11	0.002	0.002	0	[NT]	[NT]
Uranium-Total	mg/L	0.0005	METALS-022	[NT]	11	<0.0005	<0.0005	0	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.
Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.	

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Appendix B – Raw macroinvertebrate data

Class/Order	Family/Sub-family	SWG1C	SWG1C	SWG1A	SWG1A	SWG09	SWG09	SWG1	SWG1
Replicate		1	2	1	2	1	2	1	2
Acarina	Acarina sp.	460	80	150	25	29	40	160	200
Bivalvia	Cyrenidae	0	0	0	0	0	0	0	0
Bivalvia	Hyriidae	0	0	0	0	0	0	0	0
Bryozoa		0	0	0	0	29	0	0	0
Coleoptera	Dytiscidae	40	0	183	101	0	0	0	40
Coleoptera	Elmidae	0	0	0	0	0	0	20	0
Coleoptera	Georissidae	0	0	0	0	0	0	0	0
Coleoptera	Gyrinidae	0	7	33	0	0	0	0	0
Coleoptera	Hydraenidae	0	0	83	13	12	8	20	0
Coleoptera	Hydrochidae	0	0	300	100	18	8	20	60
Coleoptera	Hydrophilidae	0	0	0	25	0	0	0	0
Coleoptera	Scirtidae	0	0	0	0	0	0	0	0
Crustacea	Ostracoda sp.	0	0	0	0	0	0	0	0
Decapoda	Atyidae	160	13	0	0	100	44	20	20
Decapoda	Caridea sp.	147	15	35	27	0	30	147	126
Decapoda	Decapoda sp.	0	0	0	0	12	0	0	0
Decapoda	Palaemonidae	6	29	1	13	0	0	22	1
Decapoda	Parastacidae	0	0	0	0	0	0	0	0
Decapoda	Parathelphusidae	2	1	1	0	6	4	3	2
Diptera	Ceratopogonidae	40	7	117	75	12	0	40	100
Diptera	Chaoboridae	0	0	0	0	6	0	0	0
Diptera	Chironomidae sp.	0	0	0	0	0	0	0	0
Diptera	Chironominae	520	120	817	1288	112	96	200	320
Diptera	Culicidae	20	27	233	38	18	24	20	80
Diptera	Orthoclaadiinae	0	0	0	25	0	4	0	0
Diptera	Psychodidae	0	0	0	0	0	0	0	0
Diptera	Tabanidae	0	0	0	0	0	0	0	0
Diptera	Tanypodinae	60	27	350	238	247	192	140	320
Diptera	Tipulidae	0	0	17	0	0	0	0	0
Ephemeroptera	Baetidae	360	100	217	63	94	8	520	220
Ephemeroptera	Caenidae	1540	660	700	263	100	12	2620	2520
Ephemeroptera	Leptophlebiidae	0	67	50	63	0	8	20	20
Gastropoda	Ancylidae	140	267	17	25	100	24	40	20
Gastropoda	Planorbidae	0	0	0	0	0	0	0	0
Gastropoda	Viviparidae	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	0	0	0	0	0	0	0	0
Hemiptera	Gerridae	0	0	0	0	6	8	0	0
Hemiptera	Hydrometridae	0	0	0	0	6	0	0	0
Hemiptera	Mesoveliidae	0	0	17	0	6	4	0	0
Hemiptera	Micronectidae	520	27	0	13	29	72	0	20
Hemiptera	Nepidae	0	0	0	1	0	0	0	0
Hemiptera	Notonectidae	0	0	17	13	6	16	0	0
Hemiptera	Pleidae	0	0	0	0	0	0	0	40

Class/Order	Family/Sub-family	SWG1C	SWG1C	SWG1A	SWG1A	SWG09	SWG09	SWG1	SWG1
Replicate		1	2	1	2	1	2	1	2
Hemiptera	Veliidae	20	7	17	13	0	16	0	0
Hirudinea	Erpobdellidae	0	0	0	0	0	0	0	0
Hirudinea	Glossiphoniidae	0	0	0	0	0	0	0	0
Hydrazoa	Clavidae	0	0	0	0	0	0	0	0
Hydrazoa	Hydridae	0	0	0	0	0	0	0	0
Odonata	Epiprocta sp.	0	7	0	0	0	0	0	0
Odonata	Libellulidae	0	0	0	13	0	0	0	0
Odonata	Macromiidae	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0	0	20
Odonata	Platycnemidae	0	0	0	0	0	0	0	0
Odonata	Zygoptera sp.	0	0	17	0	0	0	0	0
Oligochaeta	Oligochaeta sp.	0	0	117	38	259	208	40	60
Porifera	Spongillidae	0	0	0	0	0	0	0	0
Trichoptera	Calamoceratidae	0	0	0	13	0	0	0	20
Trichoptera	Ecnomidae	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	120	7	0	0	0	0	0	0
Trichoptera	Leptoceridae	80	7	200	163	0	16	440	220
Trichoptera	Trichoptera sp.	0	0	0	0	0	0	0	0
Turbellaria	Dugesidae	0	0	0	0	0	0	0	0
Turbellaria	Temnocephalidae	0	7	0	0	6	0	0	0

Class/Order	Family/Sub-family	MBC0	MBC0	MBC06	MBC06	MBC01	MBC01	SWG2	SWG2	MBC03	MBC03
Replicate		1	2	1	2	1	2	1	2	1	2
Acarina	Acarina sp.	60	14	25	0	6	39	65	80	240	89
Bivalvia	Cyrenidae	0	0	0	25	0	0	0	0	0	11
Bivalvia	Hyriidae	0	0	0	0	0	0	0	0	0	0
Bryozoa		0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	20	14	0	1	838	348	55	70	30	0
Coleoptera	Elmidae	0	14	0	0	6	0	0	0	10	0
Coleoptera	Georissidae	0	0	0	0	0	4	0	0	0	0
Coleoptera	Gyrinidae	0	29	0	0	0	0	10	10	52	11
Coleoptera	Hydraenidae	0	0	0	0	0	13	0	40	10	22
Coleoptera	Hydrochidae	0	29	0	25	69	9	25	110	30	0
Coleoptera	Hydrophilidae	20	0	0	0	25	26	10	0	1	22
Coleoptera	Scirtidae	0	0	0	0	0	0	0	0	10	0
Crustacea	Ostracoda sp.	0	0	0	0	0	0	0	0	0	0
Decapoda	Atyidae	0	0	25	2	0	0	0	0	28	11
Decapoda	Caridea sp.	42	31	0	0	0	0	6	22	0	61
Decapoda	Decapoda sp.	0	0	25	50	0	0	0	0	20	0
Decapoda	Palaemonidae	24	46	0	1	13	0	2	1	28	11
Decapoda	Parastacidae	1	0	0	0	0	0	0	0	0	0
Decapoda	Parathelphusidae	2	1	0	0	0	0	2	2	4	0
Diptera	Ceratopogonidae	360	86	325	200	138	217	105	140	70	78

Class/Order	Family/Sub-family	MBC0	MBC0	MBC06	MBC06	MBC01	MBC01	SWG2	SWG2	MBC03	MBC03
Replicate		1	2	1	2	1	2	1	2	1	2
Diptera	Chaoboridae	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae sp.	0	0	0	25	0	0	0	0	20	0
Diptera	Chironominae	1720	1100	3800	1926	56	109	315	870	783	533
Diptera	Culicidae	20	14	0	75	6	0	10	500	110	78
Diptera	Orthoclaadiinae	120	57	25	0	0	0	5	0	250	11
Diptera	Psychodidae	0	0	0	0	0	0	0	0	0	0
Diptera	Tabanidae	0	0	0	0	0	4	0	0	0	0
Diptera	Tanypodinae	520	714	325	250	50	26	130	220	331	500
Diptera	Tipulidae	0	0	0	0	13	4	0	0	20	0
Ephemeroptera	Baetidae	20	114	150	250	6	0	10	60	20	78
Ephemeroptera	Caenidae	1160	1129	25	25	25	22	185	300	132	444
Ephemeroptera	Leptophlebiidae	20	14	0	0	6	0	20	10	0	11
Gastropoda	Ancylidae	20	0	0	0	0	0	0	0	0	89
Gastropoda	Planorbidae	0	0	0	0	0	0	0	0	0	0
Gastropoda	Viviparidae	0	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	0	0	0	25	0	0	0	0	0	0
Hemiptera	Gerridae	60	71	0	1	25	17	10	10	21	56
Hemiptera	Hydrometridae	0	0	0	0	0	0	0	0	0	0
Hemiptera	Mesoveliidae	0	0	0	0	0	0	0	40	20	22
Hemiptera	Micronectidae	0	0	25	0	19	9	15	20	0	0
Hemiptera	Nepidae	0	0	0	0	0	0	0	1	0	0
Hemiptera	Notonectidae	0	0	25	25	6	0	0	0	0	11
Hemiptera	Pleidae	0	0	0	0	0	0	0	20	0	0
Hemiptera	Veliidae	0	0	25	0	0	0	5	10	40	0
Hirudinea	Erpobdellidae	0	0	0	0	0	0	0	0	10	0
Hirudinea	Glossiphoniidae	0	0	0	0	0	4	0	0	0	0
Hydrazoa	Clavidae	0	0	0	0	0	0	0	0	0	0
Hydrazoa	Hydridae	0	0	0	0	0	0	0	0	0	0
Odonata	Epiprocta sp.	0	0	0	75	6	0	0	10	10	11
Odonata	Libellulidae	0	0	25	25	0	0	0	0	0	11
Odonata	Macromiidae	0	1	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	25	0	0	0	0	0	0	0
Odonata	Platycnemidae	0	0	0	0	0	0	0	0	0	0
Odonata	Zygoptera sp.	0	14	0	25	0	0	5	0	0	0
Oligochaeta	Oligochaeta sp.	20	14	25	0	6	0	10	50	90	0
Porifera	Spongillidae	0	0	0	0	0	0	0	0	0	0
Trichoptera	Calamoceratidae	0	0	0	0	0	0	0	20	0	22
Trichoptera	Ecnomidae	0	0	0	0	6	0	0	0	0	0
Trichoptera	Hydroptilidae	0	0	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	120	86	50	0	25	30	60	100	72	67
Trichoptera	Trichoptera sp.	0	0	75	0	0	0	0	0	0	22
Turbellaria	Dugesiidae	0	0	0	0	13	0	0	0	0	11
Turbellaria	Temnocephalidae	0	0	0	0	0	0	0	0	0	0

Class/Order	Family/Sub-family	SWG3	SWG3	CC01	CC01	CC03	CC03	CK7	CK7
Replicate		1	2	1	2	1	2	1	2
Acarina	Acarina sp.	50	33	129	180	40	60	360	140
Bivalvia	Cyrenidae	0	0	0	0	0	0	0	0
Bivalvia	Hyriidae	0	6	0	0	0	0	3	24
Bryozoa		0	0	143	60	0	0	0	0
Coleoptera	Dytiscidae	200	44	0	20	80	20	20	80
Coleoptera	Elmidae	0	0	0	0	0	0	0	20
Coleoptera	Georissidae	0	0	0	0	0	0	0	0
Coleoptera	Gyrinidae	33	11	0	0	0	0	2	0
Coleoptera	Hydraenidae	0	0	57	0	40	80	40	80
Coleoptera	Hydrochidae	0	0	43	0	20	20	20	40
Coleoptera	Hydrophilidae	25	0	14	0	0	0	1	40
Coleoptera	Scirtidae	0	0	0	0	0	0	0	0
Crustacea	Ostracoda sp.	8	0	0	0	0	0	0	0
Decapoda	Atyidae	17	28	0	40	0	0	0	0
Decapoda	Caridea sp.	0	0	0	0	0	0	0	0
Decapoda	Decapoda sp.	42	6	14	40	0	0	0	0
Decapoda	Palaemonidae	18	6	30	2	0	1	1	2
Decapoda	Parastacidae	1	0	0	0	0	0	0	0
Decapoda	Parathelphusidae	2	0	2	1	0	0	0	0
Diptera	Ceratopogonidae	67	56	186	40	20	60	20	420
Diptera	Chaoboridae	0	0	0	0	0	0	0	0
Diptera	Chironomidae sp.	0	0	0	0	0	0	0	0
Diptera	Chironominae	158	272	857	980	2000	1880	520	1060
Diptera	Culicidae	8	6	114	180	20	100	120	80
Diptera	Orthocladiinae	0	17	0	0	0	0	40	0
Diptera	Psychodidae	0	6	0	0	0	0	0	0
Diptera	Tabanidae	0	0	0	0	0	0	0	0
Diptera	Tanypodinae	175	122	271	560	640	560	220	560
Diptera	Tipulidae	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae	25	11	186	60	320	40	280	420
Ephemeroptera	Caenidae	642	433	714	1700	1200	580	1920	2220
Ephemeroptera	Leptophlebiidae	0	11	14	20	0	0	0	0
Gastropoda	Ancylidae	8	0	0	0	60	40	240	420
Gastropoda	Planorbidae	42	33	0	0	0	0	0	0
Gastropoda	Viviparidae	0	0	7	6	0	0	4	0
Hemiptera	Corixidae	0	0	0	0	0	0	0	0
Hemiptera	Gerridae	0	0	0	20	0	0	20	0
Hemiptera	Hydrometridae	0	0	0	0	0	0	0	0
Hemiptera	Mesoveliidae	0	6	14	0	40	0	20	0
Hemiptera	Micronectidae	17	0	14	0	40	0	20	60
Hemiptera	Nepidae	0	0	0	1	0	0	0	0
Hemiptera	Notonectidae	0	0	29	0	0	0	0	0
Hemiptera	Pleidae	0	0	0	0	0	0	0	0
Hemiptera	Veliidae	0	0	0	0	0	40	60	40
Hirudinea	Erpobdellidae	0	0	0	0	0	0	0	0
Hirudinea	Glossiphoniidae	0	0	0	0	0	0	0	0

Class/Order	Family/Sub-family	SWG3	SWG3	CC01	CC01	CC03	CC03	CK7	CK7
Replicate		1	2	1	2	1	2	1	2
Hydrazoa	Clavidae	0	0	0	0	0	20	0	0
Hydrazoa	Hydridae	0	0	14	0	40	240	0	20
Odonata	Epiprocta sp.	0	0	0	0	0	0	0	0
Odonata	Libellulidae	0	0	0	0	0	0	0	0
Odonata	Macromiidae	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0	0	0
Odonata	Platycnemidae	0	0	0	0	0	0	0	20
Odonata	Zygoptera sp.	0	0	0	0	0	0	0	0
Oligochaeta	Oligochaeta sp.	75	94	114	100	120	300	0	0
Porifera	Spongillidae	0	0	14	0	0	0	0	0
Trichoptera	Calamoceratidae	42	0	0	0	0	20	0	20
Trichoptera	Ecnomidae	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	0	0	0	20	0	0	0	0
Trichoptera	Leptoceridae	75	33	143	80	200	60	200	60
Trichoptera	Trichoptera sp.	0	0	0	0	0	0	0	0
Turbellaria	Dugesidae	0	0	0	0	0	20	0	0
Turbellaria	Temnocephalidae	0	0	0	0	0	0	0	0

Appendix C – Remote cameras species list

Group	Common Name	Scientific Name	Listing		Camera unit				
			EPBC	NT	M1	M3	M4	M5	M6
Amphibian	Cane Toad	<i>Rhinella marina</i>			✓			✓	✓
Bird	Australian White Ibis	<i>Threskionis molucca</i>			✓	✓	✓	✓	✓
Bird	Bar-shouldered Dove	<i>Geopelia humeralis</i>			✓	✓	✓	✓	✓
Bird	Black Kite	<i>Milvus migrans</i>			✓		✓	✓	✓
Bird	Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>						✓	
Bird	Blue-winged Kookaburra	<i>Dacelo leachii</i>			✓		✓	✓	
Bird	Brown Goshawk	<i>Accipiter fasciatus</i>			✓	✓	✓		✓
Bird	Cattle Egret	<i>Ardea ibis</i>							✓
Bird	Great Egret	<i>Ardea modesta</i>							✓
Bird	Intermediate Egret	<i>Ardea intermedia</i>				✓		✓	
Bird	Little Pied Cormorant	<i>Microcarbo melanoleucos</i>				✓			
Bird	Nankeen Night Heron	<i>Nycticorax caledonicus</i>			✓	✓	✓	✓	✓
Bird	Rainbow Pitta	<i>Pitta iris</i>					✓		
Bird	Royal Spoonbill	<i>Platalea regia</i>						✓	
Bird	Straw-necked Ibis	<i>Threskionis spinicollis</i>			✓	✓	✓	✓	✓
Bird	Sulphur-crested Cockatoo	<i>Cacatua galerita</i>						✓	✓
Bird	Tawny Frogmouth	<i>Podargus strigoides</i>					✓	✓	
Bird	Torresian Crow	<i>Corvus orru</i>							✓
Bird	Whistling Kite	<i>Haliastur sphenurus</i>				✓	✓	✓	✓
Bird	White-faced Heron	<i>Egretta novaehollandiae</i>			✓	✓		✓	✓
Bird	White-necked Heron	<i>Ardea pacifica</i>				✓			✓
Bird	Willie Wagtail	<i>Rhipidura leucophrys</i>						✓	
Mammal	Agile Wallaby	<i>Macropus agilis</i>			✓	✓	✓	✓	✓
Mammal	Black-footed Tree Rat	<i>Mesembriomys gouldii</i>	EN	VU				✓	
Mammal	Brushtail Possum	<i>Trichosurus vulpecula arnhemensis</i>			✓	✓	✓	✓	✓
Mammal	Cat	<i>Felis catus</i>				✓		✓	✓
Mammal	Cattle	<i>Bos indicus/taurus</i>			✓			✓	✓
Mammal	Dingo	<i>Canis lupus dingo</i>			✓	✓	✓	✓	✓
Mammal	Horse	<i>Equus caballus</i>				✓	✓		
Mammal	Northern Brown Bandicoot	<i>Isodon macrourus</i>			✓	✓		✓	✓
Mammal	Pale Field Rat	<i>Rattus tunneyi</i>		VU				✓	✓
Mammal	Pig	<i>Sus scrofa</i>						✓	
Mammal	Rodent sp.						✓		
Mammal	Water Rat	<i>Hydromys chrysogaster</i>			✓	✓	✓	✓	✓

Group	Common Name	Scientific Name	Listing		Camera unit				
			EPBC	NT	M1	M3	M4	M5	M6
Reptile	Freshwater Crocodile	<i>Crocodylus johnsoni</i>							✓
Reptile	Mertens Water Monitor	<i>Varanus mertensi</i>		VU					✓

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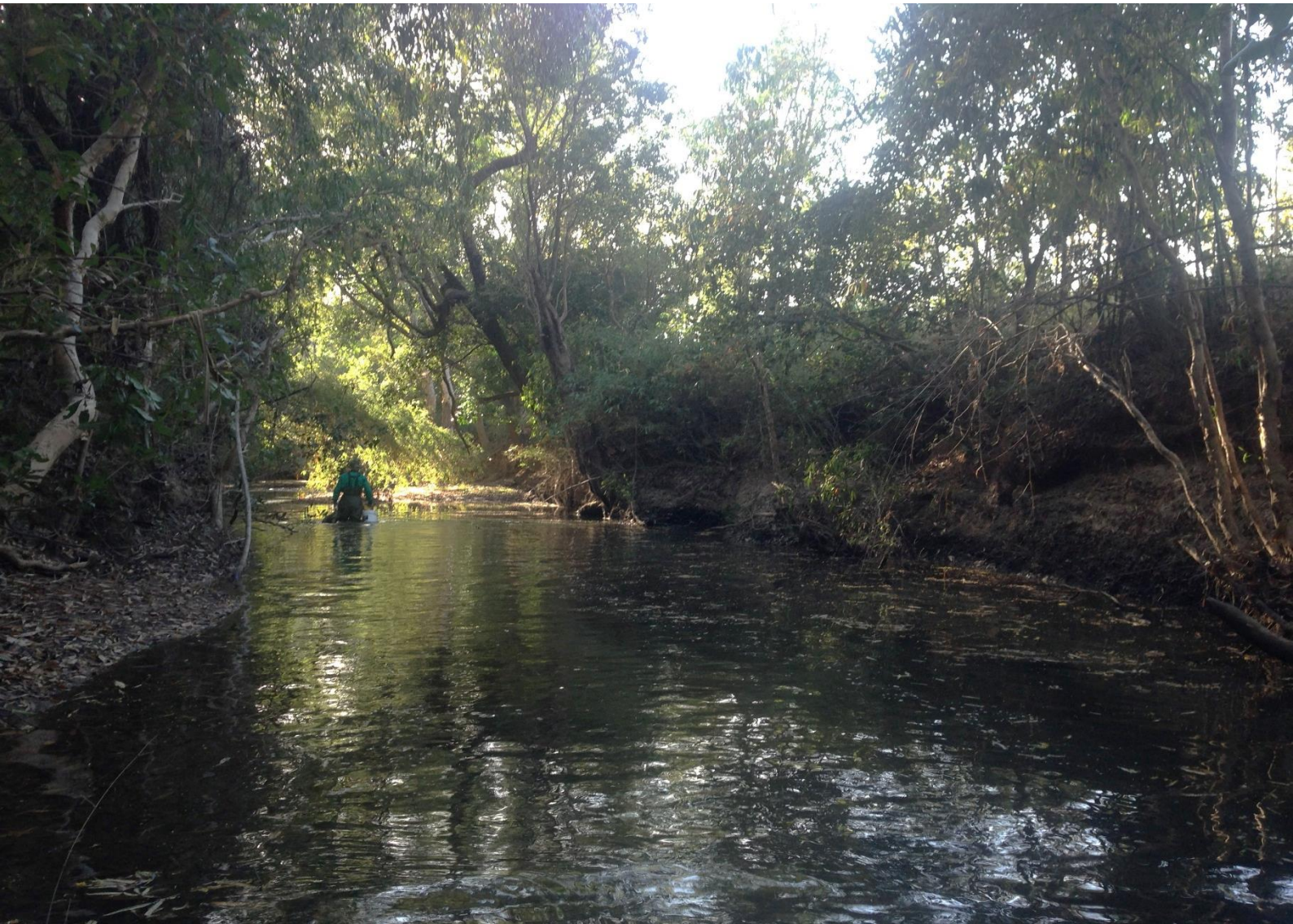
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Revision	Author	Reviewer		Approved for Issue		
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A	T. Steele	N.Conroy		J.Woodworth		31/10/2018

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Appendix S-4 - Aquatic Ecology Survey 2017



Primary Gold Limited
Toms Gully EIS - Baseline Studies
Aquatic Ecology Monitoring 2017

March 2018

Executive summary

Toms Gully Mine, located near Mount Bunday in the Northern Territory, has been in operation since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery the project area has been operating intermittently under the ownership of several different operators, most recently by Crocodile Gold until 2010, then after a period of Care and Maintenance, it was divested to Primary Gold Limited (Primary). Primary, the new lease owner, proposes to recommence underground mining and ore processing at the Toms Gully Mine. This will include:

- *Construction of a new process water dam;*
- *Dewatering and refurbishment of the existing workings;*
- *Upgrade of the new tailings storage facility; and*
- *Refurbishment and upgrade of the processing circuit.*

The NT EPA determined that the Project requires assessment under the Environmental Assessment Act at the level of an Environmental Impact Statement (EIS). A baseline aquatic ecology study was carried out in 2015, which coincided with an abnormally low rainfall wet season. In response to this, a second round of monitoring under higher rainfall conditions was requested by DME.

GHD, in discussions with Primary, DPIR and the EPA, developed a scope of works for this study. The overall goal of monitoring was to:

- *Build on the current data set to characterise the aquatic environments surrounding Toms Gully Mine.*
- *Collect water quality samples to be analysed in a laboratory, to aid in the interpretation of biological data.*
- *Monitor the presence or likely presence of Water Monitors (Varanus mertensi and Varanus mitchelli)*

Monitoring was to be carried out in such a way that locations upstream, within and downstream of the Toms Gully ML were sampled, but as a minimum, were to include Primary Gold sites SWTG1A (reference site) and SWTG2 (potential impact site).

Sampling was to cover macroinvertebrate community sampling, fish community sampling, water quality sample collection and aquatic habitat assessment. Macroinvertebrate community sampling and aquatic habitat assessment were to be done in accordance with the NT AUSRIVAS Darwin-Daly Region Model. Habitat assessment was to include in situ monitoring physico-chemical parameters at each site.

Sampling was undertaken between 19 and 26 May 2017. Work was scheduled to begin in April, but high rainfall over the wet season denoted that additional time was required to allow the watercourses to return to a steady state of flow. The additional time allowed water conditions at sampling sites to be shallow and clear enough to enter safely, due to the likely presence of saltwater crocodiles. The results of that survey are presented in this report. The key findings are as follows:

- *Some sites featured low pH and high conductivity compared with sites upstream of mining infrastructure, as well as elevated concentrations of dissolved metals. Even though low pH and elevated EC is a feature of the study area based on the findings of GHD (2015), some values were outside of the SSTVs. The location of those sites in relation to existing mine*

infrastructure suggests a possible impact of those on the water quality in receiving waters, though local factors cannot be ruled out.

- *An additional four species of fish were added to those collected in 2015, for 17 of the 37 known species of the area found in Mount Bunday Creek. Electrofishing was successfully undertaken at all sites in 2017, and additional methods that were undertaken resulted in a greater number of fish being collected, but did not result in additional species being caught.*
- *Some fish species collected at a single site adjacent to Toms Gully Mine were found to be in poor condition, swimming sluggishly or having legions. The cause of which is unknown, but could be related to localised poor water quality at that site. As there were no other fish found with behavioural or physical impairments downstream of this site, it is possible that the impact is localised or may be caused by another factor in the environment. Fish diversity was also found to be lower at sites downstream of and including the site, which corresponded with higher concentrations of some dissolved metals.*
- *A total of 55 macroinvertebrate taxa were recorded from the study area in May 2017 from 13 sites. Those fauna included all taxa sampled previously by Crocodile Gold in 2010 and 2012 and GHD in 2015 as well as some additional taxa. Accordingly, taxa richness was generally higher this year compared to previous years. Although taxa richness was higher, the macroinvertebrate community did not comprise a high number of pollution sensitive families, regardless of site type. This denotes that the community of the study area is made up of robust families that are less sensitive to changes in water quality and flow. Although there were some differences seen in the community close to tailings dam 2, habitat availability was found to be a greater driver of the macroinvertebrate community in the study area than water quality, and the poorer results were likely a consequence of differences in habitat at those sites.*
- *A single Mertens Water Monitor (*Varanus mertensi*) was recorded on a camera upstream of Toms Gully Mine. Habitat appropriate for both species of Water Monitors was identified adjacent to and downstream of the mine, yet no Water Monitors were seen on cameras. A large number of non-target species were captured including Cane Toads (*Rhinella marina*) and feral pigs (*Sus scrofa*), as well as a feral cat. These are likely having a detrimental impact on water monitor populations across the region.*

In terms of study limitations and recommendations for ongoing work:

- *To improve the ability to compare future water quality monitoring results to the Site Specific Trigger Values (SSTVs) presented in GHD (2015), it is recommended that laboratory methods be chosen so that their precision allows for the detection of metal concentrations at or below the relevant SSTVs.*
- *Future monitoring should continue to incorporate replicate sampling, but in order to improve statistical power, an additional site upstream of mining activities is recommended. Coulter Creek has provided a good baseline of reference data from a nearby watercourse, yet the continued use of this creek for comparison may be diminished by ongoing changes to land use associated with the operation of Old Mount Bunday Station. The establishment of additional control sites upstream of SWTG1A is therefore important to the assessment of impacts associated with Toms Gully Mine during its maintenance and operational phases.*
- *Poor fish condition, as well as low abundance and diversity appeared to be related to water quality parameters that are potentially ecotoxic; therefore, long-term water quality data should be investigated. Ongoing monitoring of fish communities is recommended, should results of the water quality investigation lead to the conclusion that mining infrastructure is the source of contaminants.*

- *If future studies include the monitoring of Mitchell's and Mertens Water Monitors the sampling effort should increase, including the use of multiple cameras at each site and cover a greater number of sites. Cameras should be deployed for a period of three months during the dry season to coincide with the breeding season of both species of monitors.*

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- Appendix B – Certificate of Analysis – water quality
- Appendix C – Raw Macroinvertebrate Data
- Appendix D – Remote Cameras Species List

1. Introduction

1.1 Background

Toms Gully Mine, located near Marrakai in the Northern Territory, has been in operation intermittently since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery, the project area has operated under the ownership of several different operators, most recently Crocodile Gold until 2010; then after a period of Care and Maintenance, it was divested to Primary Gold.

Operating conditions at Toms Gully Mine have been subject to regulatory obligations including waste discharge licences (WDLs). The most recent WDL 131-01 was valid between February 2013 and 31 August 2014.

Primary Gold Limited, the current lease owner, proposes to recommence underground mining and ore processing at the Toms Gully Mine, including:

- construction of a new process water dam;
- dewatering and refurbishment of the existing workings;
- upgrade of the new tailings storage facility; and
- refurbishment and upgrade of the processing circuit.

The NT EPA determined that the Project required assessment under the Environmental Assessment Act at the level of an Environmental Impact Statement (EIS).

In 2015, GHD undertook an assessment of existing information relating to the site, and an analysis of information gaps and key risk areas; with reference to the NT EPA Statement of Reasons for the decision, and the EIS Terms of Reference (TOR) (EPA 2014). The gap analysis identified the need for additional aquatic ecology surveys to be undertaken within and adjacent to the Toms Gully Mine Lease Area to collect baseline data to inform the EIS.

As well as this, GHD undertook a preliminary risk assessment for the proposed upgrades to Toms Gully Mine. Amongst the potential impacts identified, impacts on aquatic ecosystems included those that related to:

- Failure of existing / new infrastructure and Acid, Neutral and Saline Mine Drainage;
- Water management, particularly controlled and uncontrolled release off site during low flow in creek, uncontrolled release off site during extreme weather events, first flush of stored oxidation products in Waste Rock Dump and altered hydraulic connectivity to surrounding springs and creeks;
- Erosion and sedimentation; and

An aquatic ecology monitoring program was undertaken in 2015, in which fish, macroinvertebrate and habitat information was gathered for Mount Bunday and Coulter Creeks. The 2014/2015 wet season recorded below average rainfall for much of the NT. Therefore, at the request of the Department of Mines and Energy (DME) now known Department of Primary Industry and Resources, and in consultation with the NT EPA, a further round of monitoring was required to understand the surrounding aquatic environments under more typical climatic conditions. Rainfall received in the Mary River catchment in the 2016/2017 wet season was much higher than the previous years, and so monitoring at the site was deemed appropriate under those conditions.

1.1 Scope of works

The scope of works for this study includes:

- An additional baseline survey carried out in May 2017 - to characterise the existing aquatic health and condition of the receiving environment. The study includes:
 - Macroinvertebrate community sampling and aquatic habitat assessment - carried out in accordance with the NT AUSRIVAS Darwin-Daly Region Manual (with the inclusion of replicate sampling)
 - Fish community sampling
 - Water quality sampling and analysis (including *in situ* monitoring physico-chemical parameters) - undertaken at each site where aquatic ecology monitoring takes place.
- A study design that incorporates locations upstream, within and downstream of the Toms Gully ML, and as a minimum, would include Primary Gold sites SWTG1A (reference site) and SWTG2 (potential impact site).
- An assessment for the presence of the Mertens Water Monitor (*Varanus mertensi*) and Mitchell's Water Monitor (*Varanus mitchelli*) downstream of the Toms Gully Mine site.

1.2 Assumptions

Some data used as part of this report was gathered from external sources, and has not been verified by GHD. These data sources include:

- RIP500 data used to run AUSRIVAS modelling software has been estimated using vegetation classification GIS data obtained from the Northern Territory Department of Land Resource Management (DLRM).
- Climate data gathered from the Bureau of Meteorology was assumed to be validated and correct at the time it was accessed.

2. Study Area

2.1 Mine and Bioregion Location

The Toms Gully Mine site lies within the Pine Creek bioregion (Figure 2 1). The Pine Creek bioregion comprises foothill environments below and to the west of the western Arnhem Land sandstone massif. Its main defining feature is the highly mineraliferous Pine Creek Geosyncline, comprising Archaean granite and gneiss overlain by Palaeoprotozoic sediments.

Land types of the Pine Creek bioregion are mainly hilly to rugged ridges with undulating plains. Vegetation communities include eucalypt woodlands, patches of monsoon forests, Melaleuca woodlands, riparian vegetation and tussock grasslands. The major vegetation types are eucalypt tall open forests typically dominated by Darwin Woollybutt (*Eucalyptus miniata*) and Darwin Stringybark (*E. tetradonta*), and woodlands (dominated by a range of Eucalyptus species); with smaller areas of monsoon rainforest.

2.2 The Mary River Floodplain

The Toms Gully Mine is located adjacent to Mount Bunday Creek, which flows into Hardies Creek, a tributary of the Mary River Floodplain (Figure 2-1). The headwaters of the Mary River are located near Douglas Springs, approximately 60 km to the east of Pine Creek. The river flows generally north-west, until meeting the main tributary, the McKinlay River, 155 km downstream and just 2 km south of the Arnhem Highway crossing. The Mary River Catchment covers approximately 8000 km².

Geologically, the Mary River catchment is dominated by the mineral rich Pine Creek Geosyncline (Schultz *et al* 2002). More recent volcanic and intrusive events have formed the rugged granite hills of the southernmost part of the catchment. Erosion and weathering of the rugged plateau have produced the foothills of the mid-catchment.

The Mary River Coastal Floodplain is unusual in Northern Australia as it is lacking a single major river channel through the floodplain to the ocean. As a result, the floodplain is poorly drained and the inflow channel diffuses into vast seasonal swamps before reaching the sea through a number of tidal channels. Compared to other coastal floodplains in the Northern Territory, this feature results in greater areas of wetland habitats flooded over extended periods and an extremely complex and productive system (DNRETAS 2017).

The Mary River crossing at the Arnhem Highway is a convenient delineation between the upper (southern) catchment and the floodplains of the lower (northern) catchment. The crossing marks the approximate change in patterns of wet season river flow from channel to sheet flow (Schultz *et al* 2002). Floodplains associated with the middle and upper catchment, the Pleistocene floodplains, are not flooded for long periods during the wet season and contain sand and clay sediments. Further downstream, and north of the Mary River Crossing, the seasonally inundated flood basins (alluvial floodplains) have typically clay soils with some silts and sands, and broad, shallow flow during the wet season (Schultz *et al* 2002).

Scientists from the Northern Territory Department of Land Resource Management have identified areas of national or international significance for biodiversity conservation (site of conservation significance aka SOCS). One of these SOCS is the Mary River Coastal Floodplain. Most of the Mary River coastal floodplain SOCS lies within the Darwin Coastal bioregion, except in the upper reaches, where the floodplain intersects the Arnhem Highway and the Mt Bunday hills, at which point the site intersects the Pine Creek Bioregion (Figure 2 1).

The Mary River Coastal Floodplain SOCS extends from the junction of the Mary and McKinlay Rivers near the Arnhem Highway in the south, to Point Stuart in the east (including Swim Creek

Plain), and Lake Finniss and the Adelaide River floodplain in the west. The SOCS encompasses an area of 1674 km² and is predominantly a seasonally inundated freshwater floodplain. The site shares boundaries with the Adelaide River coastal floodplain to the west and the Alligator Rivers coastal floodplain to the east, and the floodplains of the Adelaide, Mary and Alligator Rivers form one very large interconnected wetland system each wet season (DNRETAS 2017).

The SOCS is also listed as a wetland of national significance in the Directory of Important Wetlands in Australia, (DIWA: NT026 Mary Floodplain system). The floodplain is the most significant and reliable breeding site for Magpie Goose in the Northern Territory, and numbers exceed 400,000 birds in some years. The floodplain environments also provide a major breeding area for many fish species, notably Barramundi (DNRETAS 2017).

2.3 Existing Land Use

The Mary River catchment is not considered to be under intensive use, but it does support a wide range of land and water uses including pastoralism (63%), conservation (31%) and defence training (6%). Other land uses include mining, tourism and recreation, wildlife harvesting, commercial fishing and horticulture (Schultz *et al.* 2002).

Pervasive land management issues that affect biodiversity values in the Mary River Catchment include feral animals, weeds and inappropriate fire regimes.

There is significant fire activity in the bioregion (particularly in the late dry season) due to large tracts of grazing land that have nil to low levels of pastoral development and consequently minimal firebreaks and control measures. Feral animals (pigs, cattle, horses and buffalo) and weeds (especially Mission grass and Gamba grass) are widespread.

2.4 Beneficial use objectives

The Water Act provides a framework for the declaration of beneficial use and objectives in the Northern Territory. Currently Mount Bunday Creek Beneficial Use Declaration (1997) states that: Stock water supply is the beneficial use extending from the Arnhem Highway Crossing approximately 3 km downstream (further downstream of SWTG2). The remainder of Mount Bunday Creek has aquatic ecosystem protection objectives defined by ANZECC (2000) as 80% species protection level for water quality assessment (GHD 2015) and for this report.

GHD has designated Toms Gully study area waterways as belonging to the highly disturbed system category, which is associated with an 80% species protection level rating in terms of water quality assessment (GHD 2015). It should be noted that:

- there are *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed fish species present in the broader Mary River catchment;
- physical aquatic habitat at the site was observed to be in relatively good condition;
- previous monitoring by Crocodile Gold has found that in many cases the macroinvertebrate community was relatively intact based on community composition; and
- the 80% species protection level offers a greater level of ecosystem protection than the stock watering trigger values (GHD 2015).

Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmorton

2.5 Regional Climate

The area in which Tom's Gully Mine is located has a tropical monsoonal climate with a pronounced wet season from October to April.

Rainfall data for the last 12 months was available from the Bureau of Meteorology (BOM 2017a) for the weather station located at Point Stuart Wilderness Lodge (station number 14263), the nearest active rainfall gauge station operated by BOM. Rainfall exceeded the long-term median in 7 of the 12 months prior to sampling in 2017 (Figure 2-2). This is consistent with conditions across northern Australia, in particular in the Northern Territory, which experienced higher than average rainfall for the wet season (BOM 2017b).

Watercourses in the study area are ephemeral and cease to flow during the late dry season, but have regular flows during the wet season, extending into the early dry season for the major watercourses. Some seasonal and semi-permanent waterholes exist in the area. These are likely to be ecologically important and serve as a refuge for fish and aquatic reptiles during the dry season.

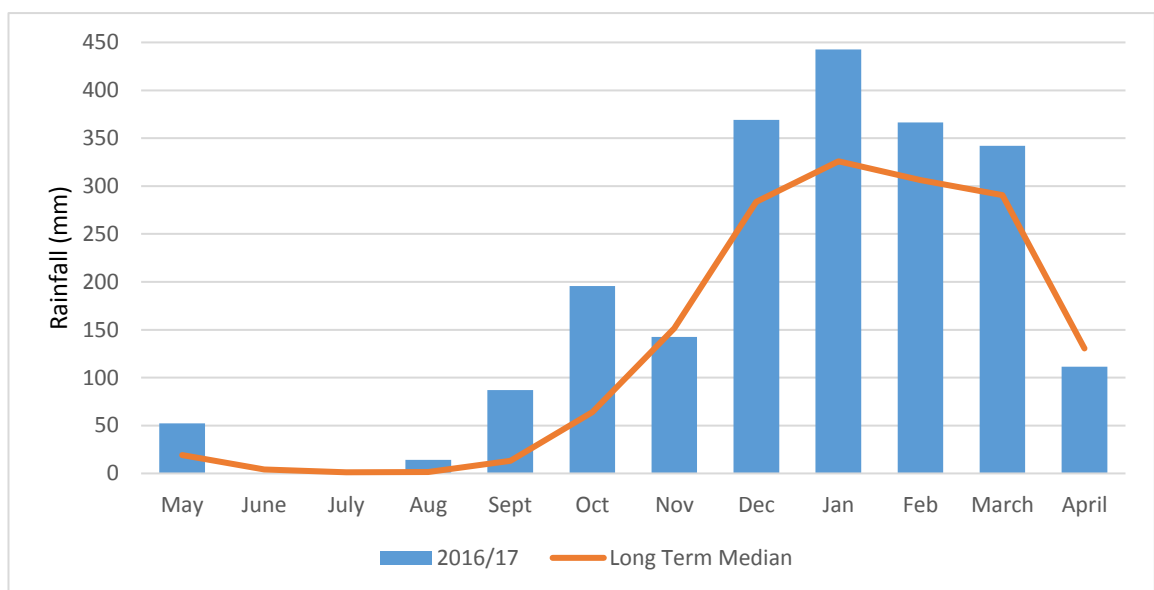


Figure 2-2 Monthly rainfall (mm) recorded at The Point Stuart Wilderness Lodge weather station over the 12 months compared to long term median monthly (BOM 2017a).

2.6 Survey Sites and Study Design

2.6.1 Site description

The Toms Gully Mine site is within the Mount Bunday Creek catchment, which comprises a series of small ridges and dissected hills that are drained by small, steep rivulets, which converge into Mount Bunday Creek. The majority of the catchment upstream of the project area consists of outcropping rock with thin soil cover and shallow alluvium drainage lines. The total catchment area upstream from the mine is approximately 117 km². Mount Bunday Creek flows west to east along the northern section of the project area.

Coulter Creek is a tributary of Mount Bunday Creek and flows southwest to east (to the south of the project area). Coulter Creek flows into Mount Bunday Creek downstream of the project area, and compliance monitoring site SWTG2.

Mount Bunday Creek is approximately 30 km long with 13 km of the creek upstream of the mine site. The creek has several tributaries upstream of the project area. Downstream from the mine site it drains into Hardies Creek, and then the Mary River.

Toms Gully mine site is situated at approximately 40 m AHD and, in terms of assessment against water quality guidelines, is a lowland river ecosystem. For the purpose of AUSRIVAS assessment, the site is located within the Darwin-Daly Catchment.

2.6.2 Survey Timing

Sampling was undertaken between 19 and 26 May 2017. Work was scheduled to begin in April, but the high rainfall over the wet season meant that additional time was required to allow the watercourses to return to a steady state of flow. The additional time allowed water conditions at sampling sites to be shallow and clear enough to enter safely, due to the likely presence of saltwater crocodiles.

All surveys included the use of a crocodile spotter to reduce the risk of crocodile attack.

2.6.3 Survey Sites

Thirteen sites were successfully accessed and sampled in May 2017 (Table 2-1). These covered sites on Mount Bunday and Coulter Creeks. Both are ephemeral streams, and had low flow and some isolated pools at the time of sampling. There is no direct discharge from the mine site into Coulter Creek.

Site samples followed the sampling design carried out in April 2015 (GHD 2015), with alterations to align with advice from DME. Site SWTG2 was sampled, as conditions allowed for safe access to the site in 2017, whereas site CC05 could not be reached due to wet conditions along the lower reaches of Coulter Creek. An additional site (MBC0) was sampled on Mount Bunday Creek to aid in the characterisation the watercourse upstream of the new tailings dam.

DME advised that Coulter Creek was not appropriate for sampling as a control system as a result of the 2015 sampling event. As conditions in 2015 were particularly dry, the sites were sampled again in 2017 to test if the system could be used as a control, as the prevailing conditions should have been optimal.

Remote cameras were set up in six locations along Mount Bunday Creek (Table 2-2) in order to monitor the presence of Mitchell's and Mertens water Monitors. Where possible, cameras were set up in locations close to aquatic ecology sites where habitat was considered favourable for their presence. One camera was located upstream of the mine, and the remaining five were located downstream.

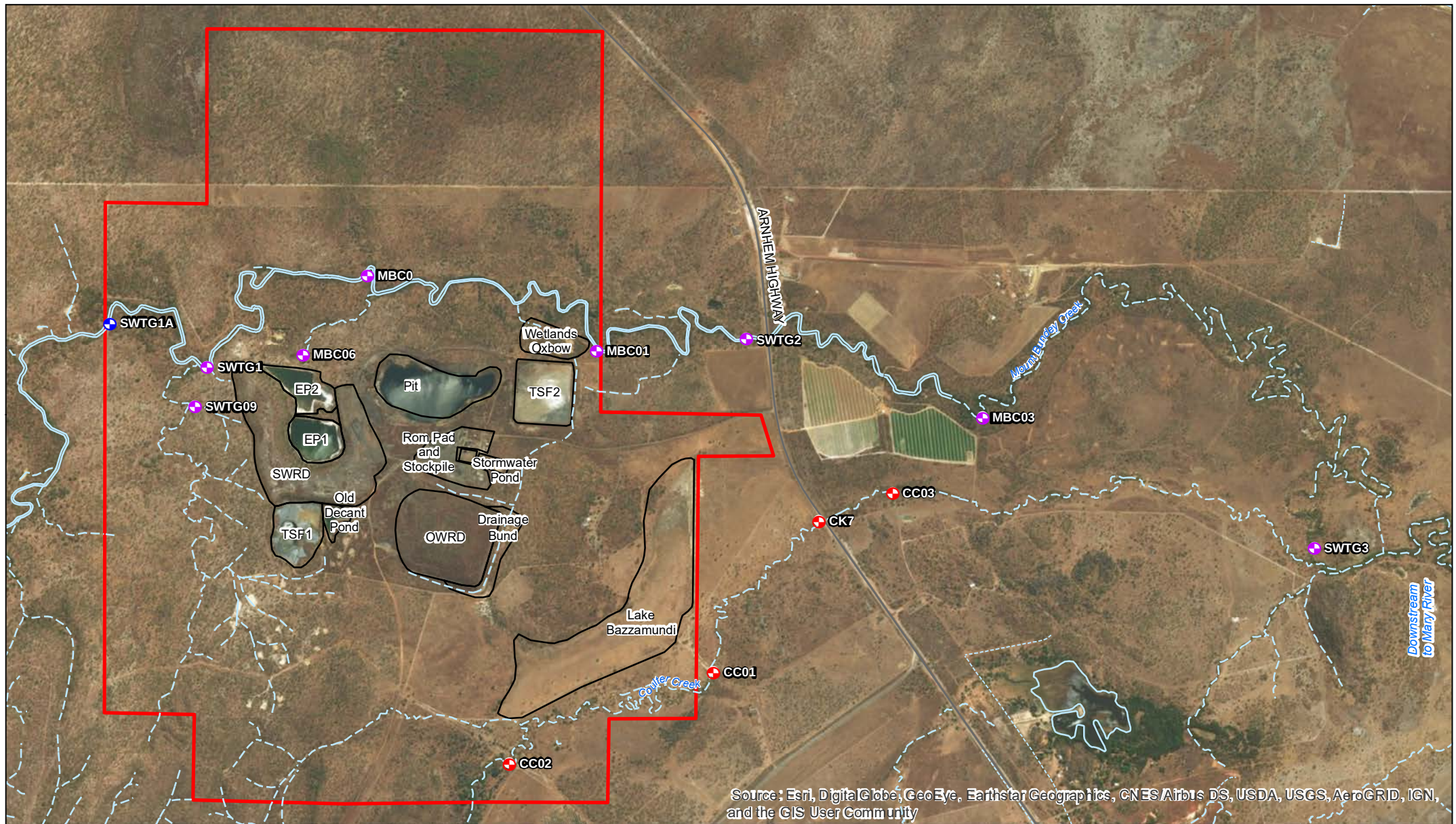
The location of aquatic ecology and remote camera sites are presented in Figure 2-3 and Figure 2-4.

Table 2-1 Aquatic Ecology site location details surveyed in 2017.
Coordinates in Zone 52L.

Site	Easting	Northing	Location	Site Type
Mount Bunday Creek Catchment				
SWTG1A	776351	8580503	Mount Bunday Creek upstream of mine at lease boundary.	Control
SWTG1	776825	8580290	Mount Bunday Creek at confluence of tributary draining EP1 and EP2	Adjacent to Mine
SWTG2	779453	8580428	Compliance monitoring point at Arnhem Highway Crossing	Downstream
SWTG3	782278	8579366	300 m upstream of confluence between Mount Bunday Creek and Coulter Creek	Downstream
SWTG09	776766	8580098	Tributary adjacent to EP1 and EP2	Adjacent to Mine
MBC01	778724	8580370	Mount Bunday Creek at confluence of tributary draining New Tailings Dam area	Adjacent to Mine
MBC03	780604	8580044	Mount Bunday Creek 500 m downstream of MBC02	Downstream
MBC06	777293	8580350	Mount Bunday Creek on downstream tributary draining EP1 and EP2	Adjacent to Mine
MBC0	777606	8580736	Mount Bunday Creek upstream of tributary draining EP1 and EP2	Adjacent to Mine
Coulter Creek Catchment				
CC01	779293	8578801	Coulter Creek. Approx. 1 km upstream from CK7	Reference
CC02	778299	8578355	Coulter Creek. Approx. 2 km upstream from CK7	Reference
CC03	780166	8579675	Coulter Creek. ~750 m downstream of CK7	Reference
CK7	779807	8579538	Coulter Creek. Existing monitoring site located at highway crossing	Reference

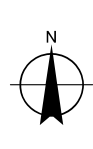
Table 2-2 Remote camera locations. Coordinates in Zone 52L.

Camera Code	Easting	Northing	Comments
M1	778691	8580427	
M2	780604	8580044	Located at site MBC03
M3	776351	8580503	Located at AE site SWTG1A
M4	780126	8580212	
M5	779453	8580428	Located upstream at site SWTG2
M6	779377	8580450	



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Paper Size A4
0 125 250 500 750
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52



LEGEND

- Site Boundary
- Mine Site Layout
- Roads
- Water Body Perennial
- Watercourse Intermittent
- Drain



PRIMARY
GOLD

Primary Gold Limited
Toms Gully EIS
Aquatic Ecology Monitoring 2017

Job Number | 43-22623
Revision | 0
Date | 22 Sep 2017

Aquatic ecology monitoring
sites visited May 2017

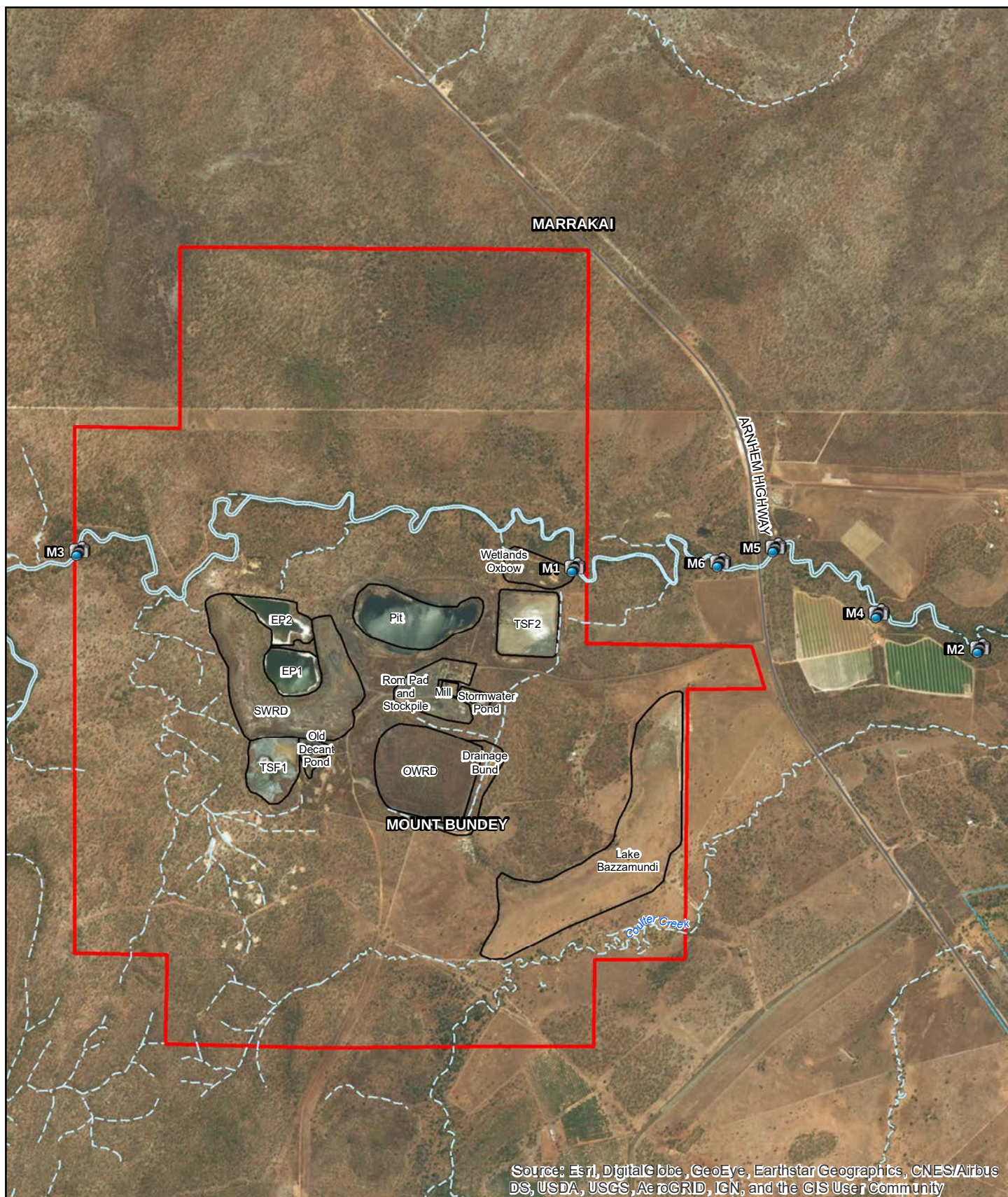
Figure 2-3

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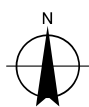
Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmtorn



LEGEND

- Site Boundary
- Mine Site Layout
- Remote camera location
- Water Body Perennial
- Watercourse Intermittent
- Drain
- Roads

Paper Size A4
0 250 500 750
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52



PRIMARY GOLD



Primary Gold Limited
Toms Gully EIS
Aquatic Ecology Monitoring 2017
Remote camera locations
May 2017

Job Number 43-22623
Revision 0
Date 22 Sep 2017

Figure 2-4

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Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmorton

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3. Methods

3.1 Habitat assessment

Information about site habitat conditions were recorded at each site following the criteria listed in the Northern Territory AUSRIVAS Darwin-Daly field sheets (Lamche, 2007). Habitat assessment at each site included the whole reach (100 m section of the river), the habitats sampled, and the surrounding terrestrial environment. This included information on:

- Site description
- Water Quality
- Characteristics of macroinvertebrate habitat
- Instream physical characteristics (flow velocity and depth, instream habitat characteristics, bank height, riparian width)
- Riparian vegetation characteristics (types, %cover, exotic species, erosion, land use),
- Water quality observations (clarity, odour, oils, foam/scum, plume, sediment oils, sediment odours) and
- Sketch of the site and cross section.

The information recorded was used to help interpret trends in the biological data and to provide input data for the Northern Territory AUSRIVAS model (e.g. mean stream width, mean flow). All stream width and flow data collected was based on field estimates.

Photos were taken of upstream and downstream portions of the stream reach sampled, as well as bank habitat and other key habitat features to further characterise the habitat conditions at each site. These serve as a pictorial record of site conditions that can be tracked over time using photos taken from the same photo points.

3.2 Water Quality

3.2.1 *In situ*

In-situ physical and chemical parameters were measured at each site using a YSI Pro DSS multi-parameter water quality meter. The water quality meter was calibrated in accordance with the manufacturer's specifications, and used in accordance with operating protocols defined in the GHD Quality Systems manual.

The YSI Water Quality meter was used to measure pH; electrical conductivity (EC) ($\mu\text{S}/\text{cm}$); water temperature ($^{\circ}\text{C}$) and Dissolved Oxygen (DO) concentrations (% saturation and mg/L) and turbidity (NTU).

3.2.2 Laboratory analysis

One water grab sample was collected at each site prior to the collection of fish and macroinvertebrate samples. Water requiring analysis of dissolved metals was field filtered using a dedicated high volume $45\ \mu\text{m}$ filter prior to collection in the sample bottle. Water samples were analysed for the parameters in Table 3-1.

Table 3-1 Analytes tested.

Suite	Analytes
Physico-chemical	pH, EC, total dissolved solids (TDS), turbidity
Major anions	Alkalinity, chloride, sulfate
Major cations	Calcium, magnesium, sodium, potassium, hardness.
Metals (dissolved and total)	Arsenic, aluminium, cadmium, cobalt, chromium, copper, iron, lead, manganese, nickel, uranium, zinc.
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide.

3.2.3 Data analysis

Water quality results were compared against the Site Specific Trigger Values (SSTVs) derived for Toms Gully Mine by GHD (2015).

3.3 Macroinvertebrates

3.3.1 Sampling Methods

Macroinvertebrate sampling and processing followed procedures outlined in the Northern Territory AUSRIVAS Manual for the Darwin-Daly Region (Lamche, 2007). Sampling involved one field team member scraping submerged root matter associated with the lower bank to agitate and remove macroinvertebrates into the water column, while the other field team member swept a dip net through the water column downstream of the edge habitat, to collect the dislodged animals. Areas of riffle or fast flowing habitat, Pandanus roots and severe bank undercuts were avoided when collecting edge habitat samples.

Once collected, the samples were washed through 10 mm and 250 µm mesh sieves. The course mesh sieve was examined for large, conspicuous taxa, and these were placed in the labelled sample container. The sample collected in the fine mesh sieve was also placed in the labelled sample container and filled with 70% ethanol. All samples were sent to the GHD laboratory in Brisbane for further processing and macroinvertebrate identification.

3.3.2 Laboratory Processing

Each sample collected was registered into GHD's sample registration system and allocated a unique identifying number.

Samples were washed through a series of sieves (10 mm, 500 µm and 250 µm mesh sizes). Any large, conspicuous taxa identified in the 10 mm mesh sieve were added to the contents of the large mesh fraction retained in the field. The contents of the 500 µm mesh sieve were retained for macroinvertebrate identification and enumeration, while the 250 µm fraction was retained as sample residue for quality assurance purposes. The contents of the 500 µm mesh fraction was poured into a Marchant sub-sampler (Marchant, 1989) and extractions made randomly from cells (aliquots) in this apparatus. These extractions were placed under a microscope and the taxa identified and counted. This process continued until either all aliquots were examined, or a total of 200 individuals had been counted and identified. The number of aliquots required to be processed to obtain a minimum 200 individual sub-sample was recorded in order to be

able to calculate abundance. Leica MZ9.5 stereo-dissection microscopes with planachromat objectives and a zoom capability between 6.3x and 60x were used to examine specimens.

Taxa were identified to family level where possible, with the exception of key taxa identified in Lamche (2007) as either requiring identification to sub-family level (e.g. Chironomidae) or only to order level (e.g. Acarina). All taxa have been identified using the keys specified in Hawking (2000). Following identification, taxa counts were recorded in MS Excel and samples preserved and archived by GHD. Raw macroinvertebrate data is presented in Appendix A.

3.3.3 Data Analysis

A number of indices can be used to assess and/or quantify the influence of anthropogenic activities on macroinvertebrate communities. Responses to contaminants or changes in flow can result in anything from changes in abundance and diversity through to changes in community composition through the loss or reduction of sensitive taxa. As such, a multiple lines of evidence approach has been adopted with regards to interpreting macroinvertebrate community data.

Univariate analysis

Table 3-2 provides a summary of the univariate macroinvertebrate indices assessed as part of this study and, where relevant, a description of how to interpret results relating to those indices. Lamche (2007) cautions against the use of the SIGNAL-2 index for assessing the status of Northern Territory macroinvertebrate communities. This measure is however, considered appropriate for this study as the number of pollution-sensitive versus pollution-tolerant families does provide some insight to the level of stress that the macroinvertebrate community is experiencing.

Table 3-2 Macroinvertebrate Indices used as part of this assessment.

Macroinvertebrate Index	Description
Abundance	The total number of individual taxa observed at each site. Generally, increased abundance can be taken to mean better conditions and increased access to habitat and food resources. However, high abundances can also occur under degraded conditions where pollution-tolerant taxa proliferate. Hence, abundance is a measure that must be interpreted with caution and in context with other metrics and community composition data. Abundance was calculated based on the multiplication of raw abundance data by the inverse of the proportion of sample processed.
Taxa Richness	The total number of taxa present at each site is a direct measure of diversity. It assumes that a high number of taxa within a site indicate that the various water quality, habitat and food requirements of taxa have been met (though this could also occur through anthropogenic effects that increase food or habitat supply). A negative environmental impact would normally result in the loss of taxa and a decline in Taxa Richness at a site.
PET Richness	PET Richness was calculated as the total number of families ¹ from three orders of macroinvertebrates; Ephemeroptera (mayflies); Plecoptera (stoneflies); and Trichoptera (caddisflies). PET taxa include taxa that are

¹ Some specimens (particularly juveniles) could only be identified to order level. Hence, PET richness here refers to both family and order level PET richness. This is consistent with previous sampling rounds

Macroinvertebrate Index	Description
	very sensitive to disturbance (though some have moderate tolerances to pollution). Higher numbers of PET taxa indicate are generally taken to indicate a lower level of disturbance.
SIGNAL-2	SIGNAL-2 is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of 10 indicates high sensitivity whilst a value of 1 indicates high pollution tolerance (Chessman, 1995). SIGNAL-2 represent the average pollution sensitivity SIGNAL-2 rating within a given sample, which in turn, represents the relative proportion of pollution-tolerant and pollution-sensitive taxa in a sample. Higher SIGNAL-2 scores indicate a higher proportion of pollution-sensitive taxa in a sample.
AUSRIVAS O/E50 and Bandings	The AUSRIVAS uses site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress. The expected (E) fauna from reference sites with similar sets of predictor variables (physical and chemical characteristics which cannot be influenced due to human activities, e.g. altitude) are compared to the observed (O) fauna that were actually collected at a given site and the ratio derived is then used to indicate the extent of any impact. Both O and E measures relate to macroinvertebrates that have a predicted probability greater than 50% of occurring at the site based on habitat variables recorded. Hence, the critical metric in the AUSRIVAS model is called O/E50. The O/E50 ratio can range from zero, when none of the expected taxa are found at a site, to >1, when either all the expected taxa are found in a sample or when more families are found in a sample than predicted by the model. The scores derived from the model can be placed in bands (Table 3-3) delineated by the Monitoring River Health Initiative, which allows assessment of the level of environmental health at a site.

Table 3-3 AUSRIVAS bands for the Darwin-Daly Model.

Band Label	Upper Limit	Band Name	Band Description
Band X	>1.18	More biologically diverse than reference sites	More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
Band A	1.18	Reference condition	Expected number of families within the range found at 80% of the reference sites.
Band B	0.81	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of families.
Band C	0.44	Severely impaired	Many fewer families than expected. Loss of families from substantial impairment of

			expected biota caused by water and/or habitat quality.
Band D	0.07	Extremely impaired	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

For this study, macroinvertebrate data was assessed using the NT AUSRIVAS Darwin-Daly Early (dry season) Family level Edge habitat model. The habitat variables required to run this model are latitude, longitude, RIP500 (amount of square kilometres of rainforest within a 500 m radius of a given site) and average stream width. RIP500 data has been estimated using vegetation classification GIS data obtained from DLRM.

Note also that, where possible, data from 2017 was compared against that collected in 2015 as well as historical Crocodile Gold macroinvertebrate monitoring data from 2010 and 2012.

Multivariate techniques

The below multivariate analyses were performed using PRIMER version 6.1.6. Prior to analysis, data were fourth-root transformed in order to reduce the biasing influence of rare as well as abundant taxa on results.

NMDS Ordination provides a representation of the relative similarity of entities (i.e. samples) based on their attributes (i.e. macroinvertebrate community composition) within a reduced dimensional space. The more similar sites are to each other, the closer they are located in the NMDS ordination space. In this study, NMDS plots were used to display the similarity between site types (Impacted and Control) and Years (sampling events). A similarity matrix for all pairs of samples based on the Bray-Curtis similarity coefficient was calculated. Stress, which is a measure of the distortion produced by compressing multi-dimensional data into a reduced set of dimensions, was used to gauge how reliable the patterns presented in two-dimensional NMDS plots are. Stress levels above 0.20 indicate a poor representation of inter-sample similarity and, as such, the NMDS results with stress values of this order require interpretation with caution (Clarke *et al* 2014).

3.4 Fish Survey

3.4.1 Sampling Methods

Previous sampling undertaken in 2015 used a combination of backpack electrofishing and bait trapping. It was identified during field surveys, that additional methods could aid in the collection of fish where other methods were found to be less successful. In 2017, seine netting and cast netting were added to the methods employed where site characteristics allowed.

Electrofishing is a proven technique capable of capturing the majority of taxa present, as it is not size or species specific (compared to gill nets for instance). Further, it is a non-lethal means of sampling when applied properly and can be used in a way that can provide quantitative data where required. However, at some sites electrofishing was not possible due to safety concerns regarding steep banks, deep pool habitat and the potential presence of saltwater crocodiles. At such sites, only bait trapping was carried out. This meant that larger fish species at those sites were unlikely to be caught. The field team noted that at some sites, bait trapping even, had limited effectiveness in catching smaller species. Wherever instances such as these occurred, the field team recorded visual observations (to the best of their ability) regarding fish species present. Where electrofishing was used, a single pass electrofishing approach of 1200 seconds on time was carried out. Sampling was carried out from downstream to upstream, where

appropriate, and in such a way that fish were herded toward banks of shallow waters near sand bars using the electrical field so they can be easily captured.

Bait trapping involved setting five commercial rectangular bait traps (2mm mesh size) for approximately two hours at each site. These traps are used to target smaller, cryptic species of fish and freshwater prawns. Each trap was baited with cat biscuits and deployed close to representative physical habitat structure (e.g. rocks, snags, roots, macrophytes, etc.) to maximise the likelihood of catching fish and freshwater prawns.

A seine net is generally operated by two people – one on each end of the net. Typically, one person remains stationary on the bank, while the other person ‘walks’ the net out and back around, arcing towards the bank. At this time, the net is brought onto the bank, thereby enclosing captured fish and crustaceans in the cod-end of the net. Seine netting was used in shallow pools as an additional method to backpack electrofishing.

A seven-foot soft nylon cast net was utilised, however, the cast net success will be determined by the depth of the water, silt and presence of snags. Cast nets consist of a hand rope attached to the centre of a circular net. The edges of cast nets are weighted with a series of small weights. This net is thrown in such a manner as to splay out across the surface of the water. The net then sinks to the substrate, at which time the hand rope can be gently pulled in – gathering the weights together and trapping fish within the pockets and folds of the net. Replicated casts were undertaken at each site. Cast netting was used in deep pools where backpack electrofishing was unable to be carried out.

All caught fish were identified in the field using appropriate keys (e.g. Allen *et al.* 2003) and counts for each species captured were recorded. The total number of fish captured at each site was derived from that information. All macrocrustaceans (Palaemonidae and Atyidae) caught at a site were also counted. Notes were also taken of any evidence of external lesions, parasites or deformities among the fish specimens collected at each of the study sites.

3.4.2 Data analysis

Fish data collected in 2015 was tabulated along with data from 2017 to understand if there are any differences in the data compared with that in 2015, which may be accounted for by environmental differences between the two years of sampling.

3.5 Water Monitors

3.5.1 Overview

The Mertens’ Water Monitor (*Varanus mertensi*) and the Mitchell’s Water Monitor (*Varanus mitchelli*) are considered Vulnerable under the *Territory Parks and Wildlife Conservation Act (2009)*, and both species are considered culturally significant within the NT. The study aimed to gather information on the presence of both species of water monitor within the study area, specifically downstream, so that the effect of mine operations on habitat may be established. The threatening process for both species, which is seen as the most acute, is the presence of cane toads (*Rhinella marina*). Cane toads are likely to be eaten by both species and cause death as attempts are made to ingest the prey item, and are responsible for the depletion of food sources for juvenile water monitors (Doody *et al.* 2006).

There have been three sightings of *V. mertensi* within 20 km of the Toms Gully Mine site (Figure 3-1), and no sightings of *V. mitchelli* within the same distance. Camera trapping for water monitors was undertaken for the first time in May 2017. In addition to camera trapping, general observations were made at each aquatic ecology site visited in relation to the suitability of habitat for water monitors. Evidence of scratches and scats were also noted if present.

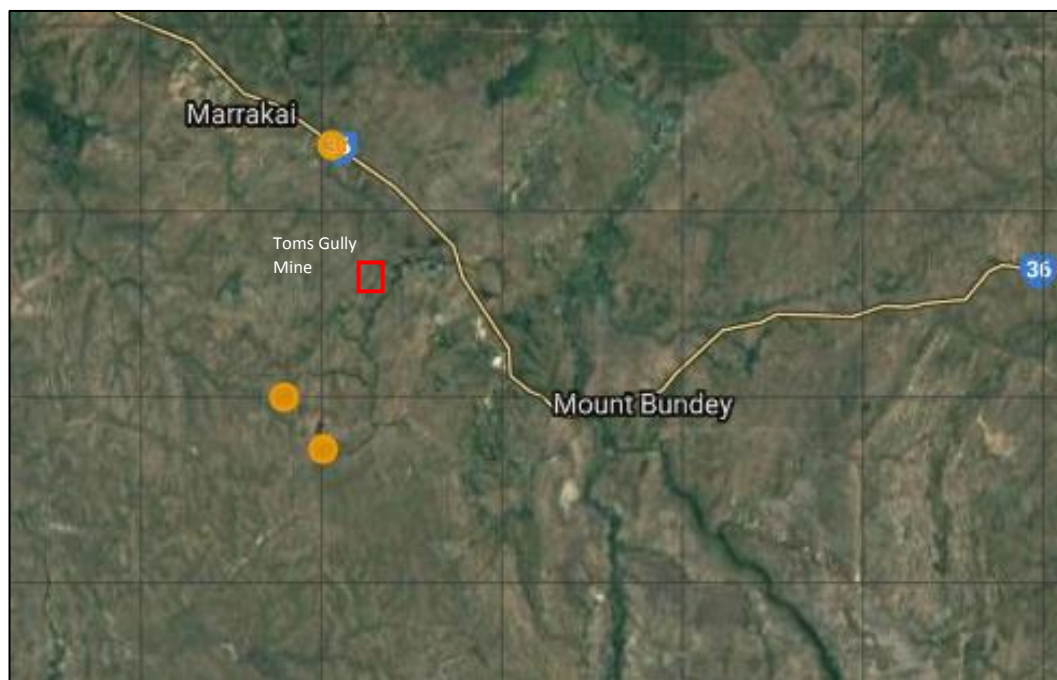


Figure 3-1 Sightings of Mertens Water Monitors (yellow markers) within 20 km of the Toms Gully mine site (Wildwatch 2017).

3.5.2 Remote camera trapping

Remote camera trapping was undertaken at six locations on Mount Bunday Creek in May 2017. Sites were co-located with aquatic ecology monitoring locations where appropriate habitat for water monitors was found. Five cameras were located downstream of Toms Gully Mine, and one was located upstream. The camera upstream was set up to check for the presence of water monitors outside of the influence of the mine. All remote cameras were set up with guidance from Gillespie *et al.* (2005). Cameras were attached to trees approximately 0.5 m from the ground, with a bait placed in front of the camera (Photo 3-1). Cameras were positioned where possible to include areas likely to be used for basking by water monitors, such as banks close to the water and logs. The Cameras remained operational between 18 May and 8 July 2017.



Photo 3-1 Camera trap set upstream of site SWTG2.

3.6 Summary of Sampling Tasks

Due to water availability, not all sites were subject to the full spectrum of sampling as described in Sections 3.1 to 3.5. However habitat assessment and macroinvertebrate and water quality sampling was undertaken at all sites. Table 3-4 summarises the sampling tasks carried out at each site.

Table 3-4 Summary of sampling carried out at each site in May 2017.

Site	Macroinvertebrate Sampling	Fish Sampling	Habitat Assessment	Water Quality	Remote Camera
SWTG1A	✓	✓	✓	✓	✓
SWTG1	✓	✓	✓	✓	
SWTG2	✓	✓	✓	✓	✓
SWTG3	✓	✓	✓	✓	✓
SWTG09	✓		✓	✓	
MBC01	✓	✓	✓	✓	
MBC03	✓	✓	✓	✓	
MBC06	✓		✓	✓	
MBC0	✓	✓	✓	✓	
CC01	✓	✓	✓	✓	
CC02	✓	✓	✓	✓	

Site	Macroinvertebrate Sampling	Fish Sampling	Habitat Assessment	Water Quality	Remote Camera
CC03	✓	✓	✓	✓	
CK7	✓	✓	✓	✓	
M1					✓
M4					✓
M6					✓

3.7 Quality Assurance / Quality Control

The following Quality Assurance / Quality Control (QA/QC) measures were undertaken as part of this project:

3.7.1 General

- One team member checked that all field sheet fields were completed correctly, all required site photographs were taken and that all necessary sampling completed before leaving site.
- Data entry was checked and verified by one team member not involved in data entry to ensure it was correct before data analysis was carried out.
- All report outputs were reviewed by a senior GHD staff member prior to their release to Primary Gold Limited.

3.7.2 Water and sediment quality

- To reduce the potential for sample contamination of *in-situ physical and chemical* readings, water quality measurements and water samples were taken before any other sampling (for this program samples were collected on the first day of the study).
- The water quality meters used were calibrated in accordance with the manufacturer's specifications prior to sampling.
- QA/QC samples were taken and results compared to those of the primary samples.
- Nitrile gloves were used during sampling of water and sediment to reduce the risk of contamination.

3.7.3 Macroinvertebrate Sampling

- Sample cross-contamination was prevented by thoroughly rinsing dip nets and sieves between samples and sites.
- New sample containers were used for each sample collected. Watertight containers were used to hold samples to reduce the risk of loss of animals during transport.
- Each sample was clearly labelled, with a waterproof label placed inside the sample container as well as sample details written on the sample container lid in permanent marker to ensure streamlined sample tracking when samples were sent to the laboratory for processing.
- Once samples arrived at GHD's macroinvertebrate laboratory, they were entered into GHD's sample registration system and allocated a unique identifying number so that they are easily traced.
- A senior taxonomist cross-checked 5% of all samples to assess the accuracy of identification and enumeration.

3.7.4 Remote Cameras

All remote cameras were tested when deployed by setting up before moving an object in front of the camera. The camera was then shut off, and the photos taken reviewed immediately to ensure the camera was working and that the focal point of the camera was on the baited area of ground.

4. Results

4.1 Site Conditions

A description of habitat characteristics associated with monitoring sites sampled in May 2017 is presented below in Table 4-1. The majority of sites were not flowing at the time of sampling, with Coulter Creek reduced to smaller isolated pools. Evidence that flows had recently ceased at most sites on Mount Bunday Creek was observed, with those furthest downstream still flowing while sampling took place.

Table 4-1 Habitat descriptions at locations sampled in May 2017.

Site / Habitat Description	Site Photo
Reference/Control Sites	
SWTG1A The site is located upstream of historical Toms Gully mining operations on Mount Bunday Creek, and was characterised by two large deep pools extending for the length of the reach. The pools were divided by a deposit of sand and gravel. Both pools were lined by a thick strip of native vegetation and had steep banks approximately 4 m high. For safety reasons, the site could not be sampled using electrofishing, but bait traps were deployed and an edge macroinvertebrate sample was taken. The substrate in the pools was difficult to see, as the pools were deep, and the surface was mostly covered in a slick and detritus. A large amount of woody debris was found at the site, and most of the banks contained exposed roots and undercut banks. The pools were approximately 6 m wide through most of the reach, and riparian vegetation was close to being a closed canopy, with the majority of the creek being shaded.	

Site / Habitat Description	Site Photo
CC01 The site is located close to cattle yards of Mount Bunday Creek Station, and contained a ford intersecting the creek. The reach extended from the ford downstream. The site was characterised by a meandering run with some deeper pools. Shading was lower in the downstream parts of the creek, with signs of regular cattle access to the creek. In the downstream section of the reach, large patches of filamentous algae were observed, and banks were eroded close to areas where cattle have been accessing the creek. A representative from Mount Bunday Creek Station advised that cattle were regularly herded through this section of the creek and over the ford. The upstream section of the reach was shaded and had a riparian strip around 5 m wide. The banks were more intact than the downstream section, and exposed roots and large woody debris were in each of the pools.	
CC02 This is the furthest upstream site on Coulter Creek, and is intersected by a ford made of large cobbles. Upstream of the ford was a large, deep pool containing large woody debris. The pool was considered unsafe to enter, and bait traps were set in it. Downstream of the ford was a series of pools connected by shallow runs and was 3 m wide for the majority of the reach. The creek was shaded by a dense, 5 m wide, native riparian strip on both banks. Beyond the riparian zone was cleared and the land used for grazing. An oil slick was observed directly downstream of the ford. Electrofishing and macroinvertebrate sampling were undertaken downstream of the ford.	

Site / Habitat Description	Site Photo
CK7 The site is an existing monitoring point for Tom’s Gully Mine, located on the downstream side of the crossing of Coulter Creek with the Arnhem Highway. It was characterised as a series of isolated pools ranging in depth from 0.2-1 m and two deeper pools directly downstream of the highway crossing that were more shaded than the remainder of the reach. The creek was 5 m wide and had steep, eroded banks with very little overhanging vegetation and native grasses. The substrate was mostly bedrock, with some sand and clay deposits. Evidence of cattle and pig access to the creek from both banks was observed. Some undercut banks and exposed roots and shade were found in the deeper pools.	
CC03 The site is located approximately 1.7 km downstream of the Arnhem Highway and is a large isolated pool 50 m in length, upstream and downstream of the pool was a dry creek bed. The pool has a very small amount of shade, but its banks were heavily eroded with very little vegetation outside of native grasses. The substrate was mostly bedrock, with some deposition of clay and silt in the downstream end of the pool. A crocodile slide and footprint were found in the clay, and it was therefore deemed a safety risk to enter the water (Figure 4 13). Bait taps were deployed, but no electrofishing or macroinvertebrate sampling was undertaken. The site contained some exposed roots where a small amount of native shrubs were growing along the left bank, but there was little available habitat for fish. Olive Hymenacne (<i>Hymenachne amplexicaulis</i>) was observed growing at the downstream end of the pool.	

Site / Habitat Description	Site Photo
Potentially Impacted Sites	
SWG09 The site is located on a small tributary ~200m upstream of the confluence with Mount Bunday Creek. a small number of isolated pools were present, separated by a section of bedrock. The site was characterised by vertical and undercut banks, with exposed roots lining much of the pools. The substrate was a mix of cobbles, pebbles and sand with several large leaf packs. The water level at the time of sampling was too low to undertake fish sampling. Macroinvertebrate sampling was completed in the remaining wetted sections of the reach. Evidence of access to the creek by pigs and cattle was observed, with the remaining pools possibly being used as wallows for pigs.	
SWG1 The site was a long shallow run connecting two large, deep pools. The wetted width was approximately 1.5 m wide and one third of the full channel width. Some small isolated pools remained in the left section of the channel. Substrate comprised of cobbles and pebbles embedded in gravel and sand. Large woody debris was found through the extent of the reach and the right bank was undercut, exposing roots from riparian vegetation. Banks were approximately 3.5 m high and were very steep. Riparian vegetation was thick, extending at least 20 m from each bank and shading most of the creek. A small, deep gully entered the creek on the right side towards the top of the reach. Bait traps were placed in it, and in both of the large pools at either end of the reach. Both deeper pools were the entire width of the creek and the channel opened out in these areas to ~8 m in width. Large trees lined the banks, with their roots exposed, creating good habitat for larger fish. An edge macroinvertebrate sample was collected along the right bank in undercut sections of the creek and in the small isolated pools.	

Site / Habitat Description	Site Photo
Electrofishing was undertaken along the length of the reach excluding the large pools for safety reasons.	
MBC0 The site is located approximately 100 m upstream of the confluence between a small, unnamed tributary containing site MBC06 and Mount Bunday Creek. Flow was recorded at the site at the time of sampling, and the reach was well shaded due to a continuous riparian zone. The presence of trees along banks allowed for exposed roots, large woody debris and leaf packs to be common through the site. There was some evidence of siltation in slower flowing areas, but the majority of substrate at the site was made up of sand and pebbles. A number of long, gliding pools were found within the reach, which contained boulders surrounded by sand. Freshwater crocodiles were observed at the site.	
MBC06 The site is located on a small tributary of Mount Bunday Creek draining away from EP2. The site was reduced to small isolated pools no more than 3 m in length, with an average width of 2 m. The substrate was a mixture of bedrock, cobbles, silt and clay with some pools having small amounts of woody debris and leaf packs. The largest pool was found in the furthest upstream point of the reach and was 0.5 m deep, containing a slick of oil on the surface. When sampling macroinvertebrates, an anoxic odour was released from sediment. Electrofishing and bait trapping were undertaken in the entire length of the reach where water was present.	

Site / Habitat Description	Site Photo
MBC01 A large deep pool covered the length of the site and extended beyond the 100 m reach at both ends. Large woody debris and overhanging River Pandanus dominated the site, with the remaining riparian vegetation made up of bamboo and native riparian trees. Banks at the site were vertical and approximately 1.5 m high above the water surface. The large pool was an average of 5 m wide and slightly turbid. The surface was covered in detritus and there was an oil slick observed in some sections that appeared to be caused by oil or fuel. The source of this could not be confirmed. Bait traps were deployed at the site, but no electrofishing was undertaken due to inaccessibility. An edge habitat macroinvertebrate sample was collected along the right bank where safety allowed. The creek was heavily shaded, the roots of many of the trees were exposed, and undercut banks were present. The site was close to a tailings dam.	
SWG2 The site is intersected by a causeway, with upstream sections of the creek being made up of a series of deep pools connected by runs. Downstream of the causeway, the site was a wide, shallow pool. Substrate along the entire reach was a mixture of cobbles, pebbles and sand, and banks were made of clay. Continuous riparian vegetation was observed at the site (except through the causeway path) and this had resulted in heavy deposition of detritus and large woody debris within the creek. Exposed roots were common in deeper pools.	

Site / Habitat Description	Site Photo
MBC03 The site is located on a bend and was characterised by a long shallow run connecting deep pools at either end of the reach. The majority of the run was 0.1 m deep and 3 m wide with some deeper sections adjacent to banks. Large woody debris was found through the reach as were leaf packs. Substrate was made up mainly of sand and gravel with some silty deposits in deeper areas. Macroinvertebrates were sampled along the right bank and electrofishing was undertaken along the extent of the reach. The creek was highly shaded in this area and the riparian zone extended for 20 m on the right bank and >30 m on the left bank. The right bank was very steep and 3.5 m high, whereas the left bank was a gentle slope reaching a similar height.	
SWTG3 The site is the furthest downstream on Mount Bunday Creek, upstream of its confluence with Coulter Creek. The site was characterised by a long pool and run with large woody debris and undercut banks. Substrate was clay and silt, which suspended easily into the water column, the substrate was covered for most of the reach by detritus. Bait traps were deployed into a deep pool upstream that was considered unsafe to enter. An oil slick was observed on the surface of the water, as was a large amount of detritus. The site was heavily shaded by thick stands of bamboo and native vegetation. Very little understory vegetation was present. There was evidence of access by livestock, and buffalo 'lay downs' were also seen in the grass near the creek. There was a small tributary flowing into the creek downstream of the site, which appeared to be a groundwater intrusion, as the main channel of the creek was not flowing at the time, and there had been little rain in the previous week.	

4.2 Water Quality

4.2.1 *In situ*

Table 4-2 presents the *in situ* water quality results for May 2017. The key results from the *in situ* water quality monitoring were:

- There was little variability in water temperature, which ranged from 22.1 to 25.5 degrees Celsius.
- pH exceeded the upper SSTV at sites SWTG1A, SWTG1, SWTG09, MBC03, CC01, CC02 and CC03. pH was below the lower SSTV at site MBC01.
- EC values were below the SSTV at all sites except SWTG2, MBC01 and CC02. The most saline site was MBC01, as indicated by the EC at this site being the highest.
- DO saturations were below the lower SSTV at all sites in May 2017.
- Turbidity was low at all sites except CK7, where it exceeded the SSTV.

Table 4-2 *In-situ* water quality results (May 2017)

Site	Time	Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO (%)	Turbidity (NTU)
SSTV (GHD 2015)	NA	NA	5.8–8.0	250	NA	85-120	60
SWTG1A	11:24	23.1	8.75	49.8	5.26	61.5	2.3
SWTG1	15:51	25.3	9.18	53.7	5.69	69.3	3.5
SWTG2	07:25	24.8	6.51	279.0	5.21	62.9	1.3
SWTG3	15:00	24.7	7.78	122.9	3.88	46.7	6.6
SWTG09	13:50	25.3	8.71	155.6	1.75	21.3	12.3
MBC01	13:23	24.9	5.46	472.1	4.47	54.1	2.9
MBC03	16:20	25.3	8.15	190.5	4.96	60.1	6.6
MBC06	11:48	24.4	7.04	236.4	1.17	14.0	18.2
MBC0	13:13	25.2	6.97	35.6	4.28	52.1	8.3
CC01	16:25	25.5	8.36	154.2	1.62	19.7	11.1
CC02	14:27	22.1	8.39	423.8	0.26	3.2	6.9
CC03	11:03	24.0	8.48	165.4	1.90	22.6	35.6
CK7	10:14	24.6	7.93	203.6	2.05	24.7	747.1

Notes:

Values in **bold highlight** indicate exceedances of the SSTVs.

NA: Not applicable - no SSTV applies.

4.2.2 Laboratory analysis

Table 4-3 presents the results of the laboratory analysis of the water samples taken in May 2017. Comparison of the *in situ* and laboratory results for pH indicated that the multi-parameter water

quality meter may have misrepresented the pH results in May 2017, which were all higher than those reported by the laboratory. Some increased acidity can be observed in laboratory results due to the oxidation and precipitation of iron and manganese in the bulk sample (from which pH is measured). However, it is noted that lower pH values were reported by the laboratory for samples with low total iron and manganese concentrations, suggesting that the difference was more likely to be associated with the pH probe used for the *in situ* measurements. For this reason, the laboratory pH results were considered more reliable for interpretive purposes.

The following key results from laboratory analysis were observed:

- There were no exceedances of the upper SSTV for pH. There were two low pH values observed, at SWTG2 and MBC01, which were below the lower SSTV value.
- The laboratory measurements of EC agreed with the *in situ* measurements well, with the values at SWTG2, MBC01 and CC02 exceeding the SSTV.
- Sites in the Mount Bunday Creek and Coulter Creek catchments had low alkalinities. The highest alkalinity in the Mount Bunday Creek catchment was observed at SWTG09, whereas CC02 had the highest alkalinity in the Coulter Creek catchment.
- Chloride concentrations were low at all sites, ranging between 3 and 6 mg/L.
- Sulfate concentrations were variable, ranging from 2 to 201 mg/L. The latter concentration, which was observed at MBC01, exceeded the SSTV. Sulfate was the dominant anion at SWTG2, SWTG3, MBC01, MBC03, MBC06, CC02 and CK7. At all other sites sampled in May 2017, bicarbonate was the dominant anion.
- In terms of cations, all sites were dominated by calcium and magnesium except SWTG1A, SWTG1, and MBC0, which were ionically dilute and exhibited balanced cation chemistry.
- Concentrations of dissolved arsenic, chromium and lead were all below the respective laboratory limits of reporting (LORs).
- The concentration of dissolved aluminium at MBC01 exceeded the SSTV. At all other sites the dissolved aluminium concentration was either below or at the LOR.
- Concentrations of dissolved cadmium were all below the laboratory LOR except for the concentration observed at MBC01. The laboratory LOR exceeded the SSTV, as such, all of the dissolved cadmium results in Table 4-3 are reported as exceedances.
- Concentrations of dissolved cobalt and copper were below the respective LORs at all sites except SWTG2 and MBC01. The LORs for both of these metals exceeded the respective SSTVs, meaning that all results for cobalt and copper were presented as exceedances.
- Dissolved iron concentrations exceeded the SSTV at SWTG1A, SWTG3, SWTG09, MBC01, MBC06, CC01, CC02 and CC03. The highest dissolved iron concentration was observed at MBC01.
- Dissolved manganese concentrations were below the SSTV at all sites except CC02.
- The laboratory LOR for dissolved nickel exceeded the SSTV, resulting in each of the concentrations in Table 4-3 being presented as exceedances. All dissolved nickel concentrations were below the LOR except those observed at SWTG2, MBC01, and MBC03. The highest of these concentrations was observed at MBC01.
- All dissolved uranium concentrations were below the LOR except for the concentration observed at MBC01.
- Dissolved zinc concentrations at SWTG2, MBC01 and MBC03 exceeded the SSTV. All other dissolved zinc concentrations were below the LOR.

- Total metal concentrations agreed well with the dissolved metal results. There was no indication of any sample contamination associated with field filtering, as can be shown by dissolved metal concentrations exceeding total metal concentrations.
- There was no cyanide detected in any of the samples, all free cyanide, WAD cyanide and total cyanide results were below the respective LORs.

Table 4-3 Laboratory water quality results, May 2017. All units are mg/L except where specified.

Suite/analyte	LOR	SWTG1A	SWTG1	SWTG2	SWTG3	SWTG09	MBC01	MBC03	MBC06	MBC0	CC01	CC02	CC03	CK7	SSTV
Physico-chemical parameters															
pH	0.1	6.9	7	5.7	6.7	7.1	4.7	6.2	6.1	6.7	6.8	7.4	7	7	5.8-8.0
EC (µS/cm)	1	53	47	270	120	89	440	180	210	34	150	440	160	200	250
TDS	5	32	28	160	71	53	270	110	130	20	90	260	94	120	NA
Turbidity (NTU)	0.1	4.2	2.6	1.7	11	13	14	3.9	18	8.1	14	3	7.4	5.9	60
Major anions															
Hydroxide as CaCO ₃	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NA
Carbonate as CaCO ₃	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NA
Bicarbonate as CaCO ₃	5	31	27	<5	25	37	<5	<5	19	19	43	89	37	34	NA
Total alkalinity as CaCO ₃	5	31	27	<5	25	37	<5	7	19	19	43	89	37	34	NA
Chloride	1	4	3	3	4	5	4	3	4	4	6	5	5	5	NA
Sulfate	1	3	2	120	30	2	210	71	75	2	24	130	32	55	129
Major cations															
Calcium	0.5	2.4	2.2	20	7.4	8.4	35	13	12	1.6	8.2	31	9.4	11	NA
Magnesium	0.5	1.8	1.6	12	5	3.5	22	8.4	12	1.1	7.4	24	8.2	10	NA
Sodium	0.5	4.8	4.5	6.4	5.5	3.9	7.9	5.8	7.2	2.8	5.3	12	6.6	7.9	NA
Potassium	0.5	1	1.2	2.1	1.9	1.9	3	1.8	0.9	0.6	2.2	5.6	3.3	3.2	NA
Hardness as CaCO ₃	3	13	12	100	39	36	180	68	79	9	51	180	57	71	NA
Dissolved metals															
Arsenic	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.140
Aluminium	0.1	<0.1	<0.1	0.1	<0.1	<0.1	1.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.260
Cadmium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.0008
Cobalt	0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.0014

Suite/analyte	LOR	SWTG1A	SWTG1	SWTG2	SWTG3	SWTG09	MBC01	MBC03	MBC06	MBC0	CC01	CC02	CC03	CK7	SSTV
Chromium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.040
Copper	0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.0025
Iron	0.02	0.48	0.14	<0.02	0.58	1.4	3.9	0.1	0.51	0.23	0.44	0.37	0.53	0.07	0.300
Lead	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.0094
Manganese	0.01	0.02	<0.01	1.8	0.25	<0.01	3.3	0.77	0.16	0.02	2.8	8.9	0.89	0.38	3.600
Nickel	0.02	<0.02	<0.02	0.07	<0.02	<0.02	0.14	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.017
Uranium	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.003	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NA
Zinc	0.02	<0.02	<0.02	0.31	<0.02	<0.02	0.65	0.18	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.031
Total metals															
Arsenic	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	NA
Aluminium	0.1	<0.1	<0.1	0.2	<0.1	<0.1	1.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NA
Cadmium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA
Cobalt	0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA
Chromium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA
Copper	0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA
Iron	0.02	0.73	0.16	0.26	1.5	2	5.5	0.69	3.6	0.49	2.1	1.1	1.3	0.18	NA
Lead	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	NA
Manganese	0.01	0.12	0.03	1.9	0.41	0.14	3.2	0.81	0.17	0.06	3.2	9.1	2.1	0.45	NA
Nickel	0.02	<0.02	<0.02	0.07	<0.02	<0.02	0.13	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NA
Uranium	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.003	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NA
Zinc	0.02	<0.02	<0.02	0.31	0.02	<0.02	0.63	0.19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NA
Cyanide															
Free cyanide	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	NA
WAD cyanide	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	NA
Total cyanide	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.018

Notes:

Values in **orange bold highlight** indicate exceedances of the SSTVs. Values in **green bold highlight** indicate where the LOR is such that an exceedance of the SSTV cannot be confirmed.

NA: Not Available - no SSTV applies

4.3 Macroinvertebrate Community

The results of macroinvertebrate sampling in May 2017 are presented below. Where historical data from Crocodile Gold was available (sites SWTG1A, SWTG1, SWTG2, SWTG3), this has been utilised in understanding the health of Mount Bunday Creek over time. Results collected by GHD in 2015 have also been included to understand the differences in the macroinvertebrate community that may be linked to environmental factors, such as rainfall.

4.3.1 Relative abundance

The relative abundance of macroinvertebrates collected in May 2017 is presented below in Figure 4-1. Coulter Creek contained consistently higher numbers of macroinvertebrates across samples collected in May 2017, with CC03 recording the highest abundance of any site. Sites SWTG1A and SWTG1 had the highest relative abundances of any sites sampled on Mount Bunday Creek. All other sites were generally similar across both replicates collected, except MBC06, which varied markedly. MBC01 and MBC03 contained the lowest numbers of macroinvertebrates collected in May 2017.

Results were compared against those from sites sampled in previous years (Figure 4-2). Sites located furthest upstream on Mount Bunday Creek recorded much higher relative abundances in 2017 than from any previous sampling event, whereas those towards the downstream end of the study area were relatively similar. Site MBC03 recorded consistently low relative abundances in both sampling events that it was visited. Sites on Coulter Creek recorded far higher relative abundances in 2017 to those in samples collected in 2015.

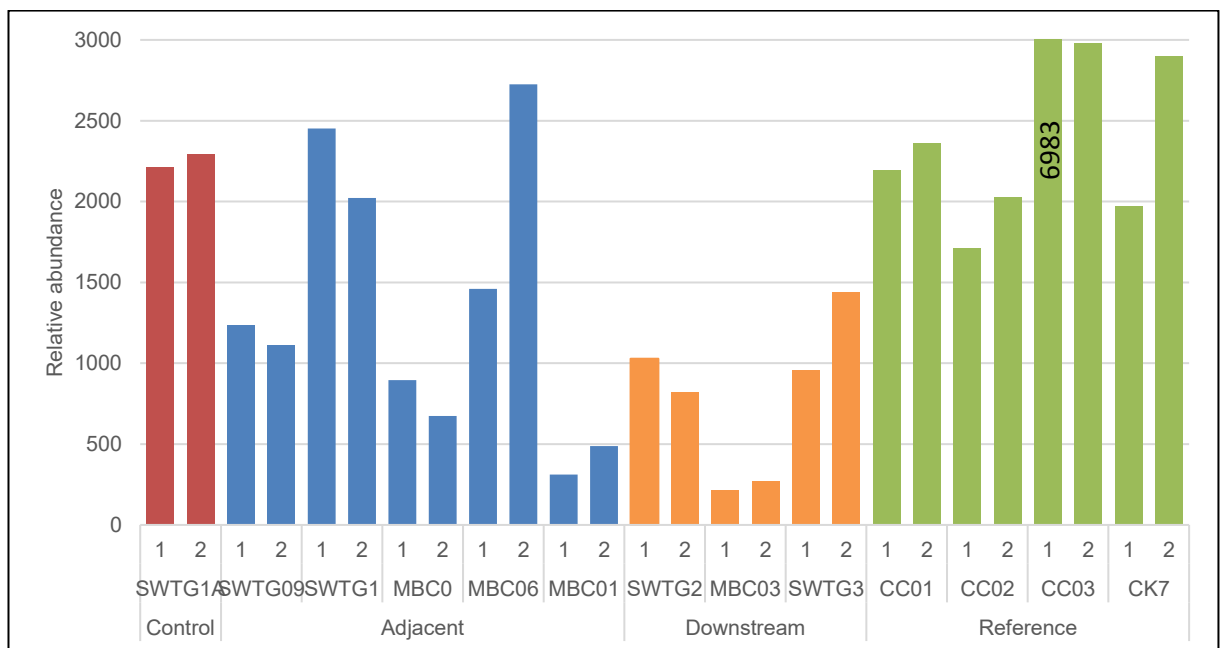


Figure 4-1 Relative abundance of samples collected in May 2017.

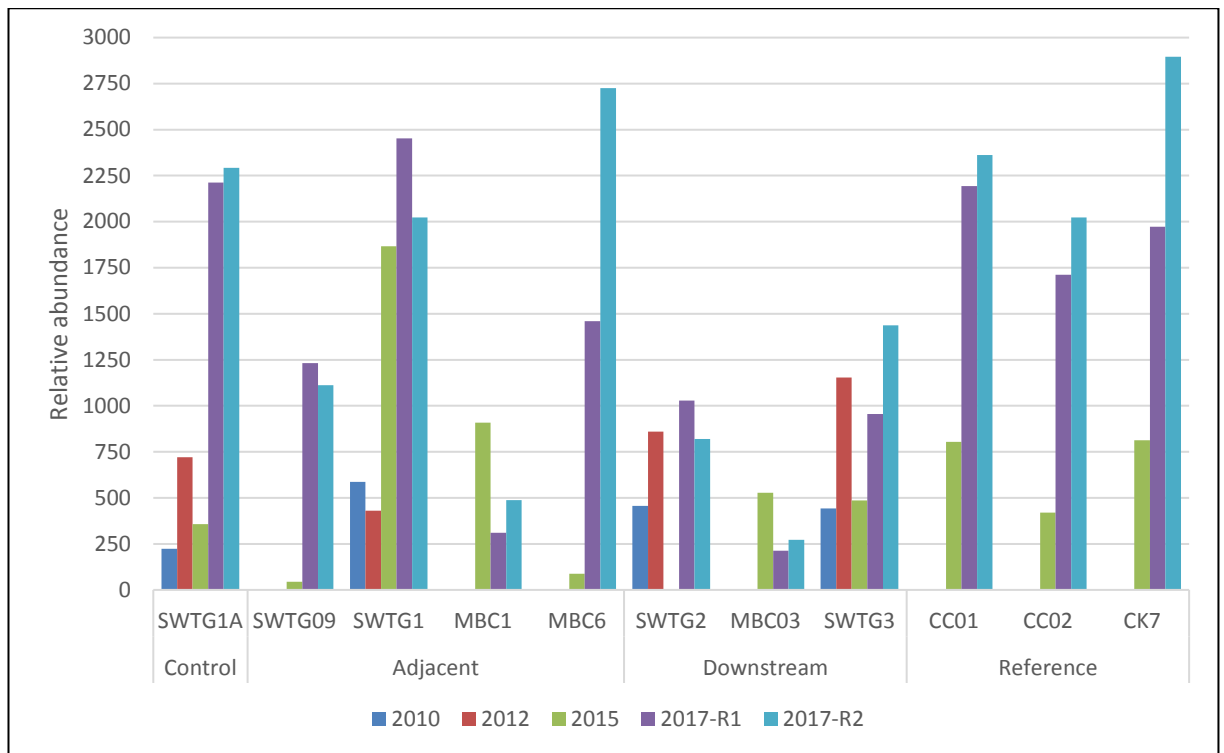


Figure 4-2 Relative abundance results from sites sampled historically at Toms Gully Mine.

4.3.2 Taxa richness

Taxa richness results from sites visited in May 2017 are presented in Figure 4-3, and are compared with results of monitoring undertaken previously in Figure 4-4. In 2017, sites on Mount Bunday Creek varied in taxa richness between sites, with samples at MBC06 and SWTG2 adjacent and downstream of the mine site containing the highest number of taxa. While other sites downstream of Toms Gully Mine recorded the lowest taxa richness of all samples. Sites on Coulter Creek contained similar numbers of taxa across all samples and sites.

Variable taxa richness results have been recorded at SWTG1A over time, whereas those at SWTG1 have remained relatively similar. SWTG09, MB06 and SWTG2 have all recorded increases in taxa richness in 2017 compared to sampling in previous years. All sites on Coulter Creek remained relatively similar over both sampling events.

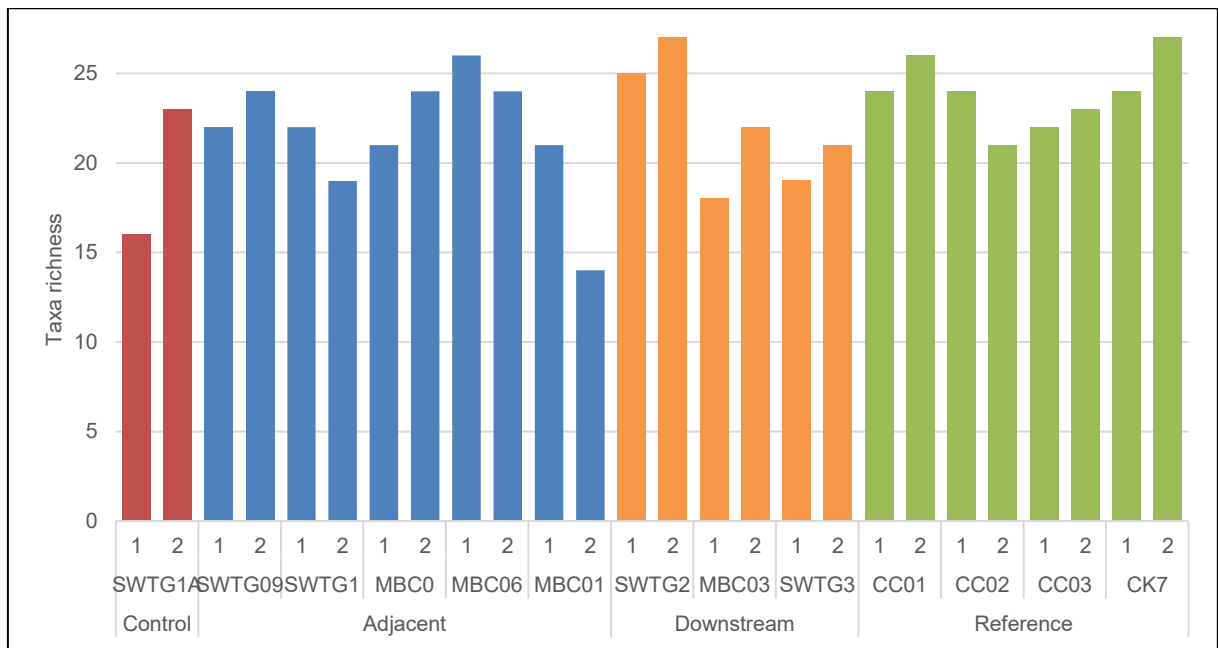


Figure 4-3 Taxa richness results from sites sampled in May 2017.

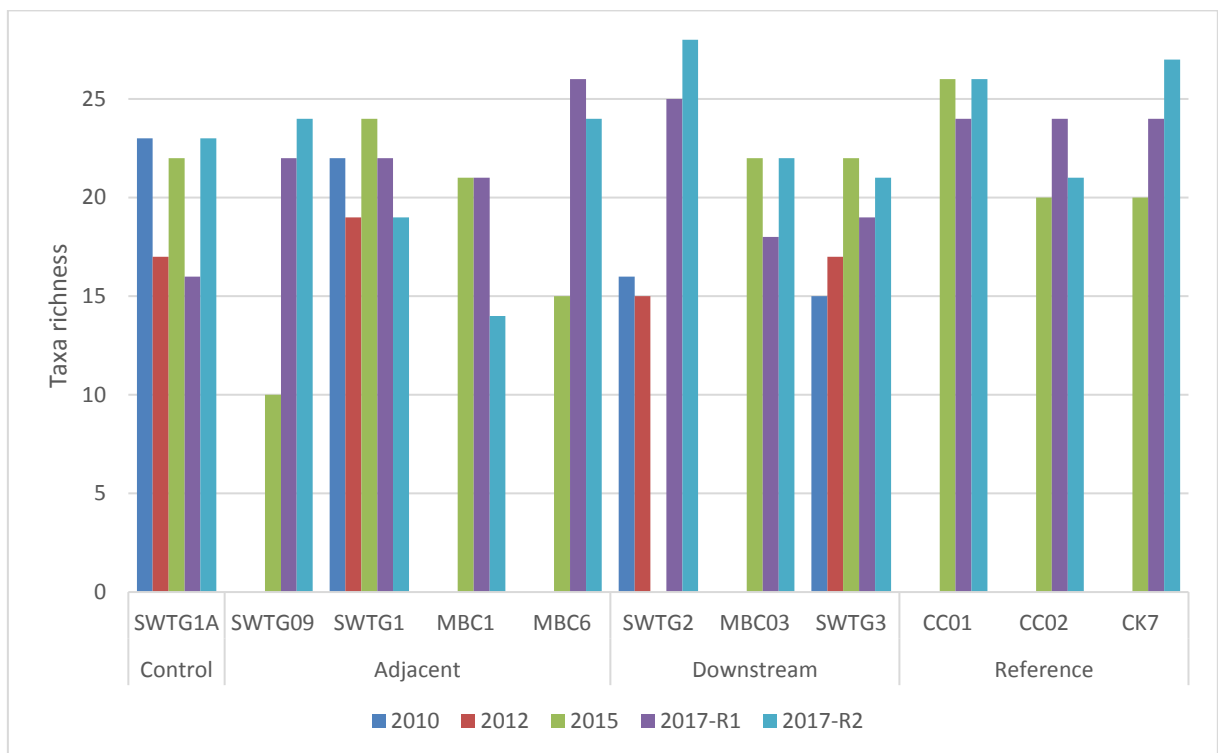


Figure 4-4 Taxa richness results from sites sampled historically at **Toms** Gully Mine.

4.3.3 PET richness

PET richness results from sites sampled in 2017 are presented in Figure 4-5, with these results compared with those from previous sampling events in Figure 4-6. Sites furthest upstream on Mount Bunday Creek showed no intra-site variability, and were dominated by Ephemeroptera families. Sites adjacent to and downstream of Tom's Gully Mine, on the other hand, showed a greater amount of variability in PET richness between samples at a given site. The greatest variability found at MBC01 and MBC03. All sites on Coulter Creek were generally similar.

Historically, PET richness at compliance sites SWTG1A and SWTG1 have been higher than that recorded in samples in 2017. Furthest downstream site SWTG3 appeared to show the opposite trend, where higher PET richness values were found in 2015 and 2017 than in previous sampling events. Sites MBC01 and MBC03 recorded variable PET richness results in both sampling events. Sites on Coulter Creek were similar across both sampling events, with CC01 being slightly higher in 2017 than 2015. Although not sampled in 2015, PET richness at SWTG2 was relatively similar over time.

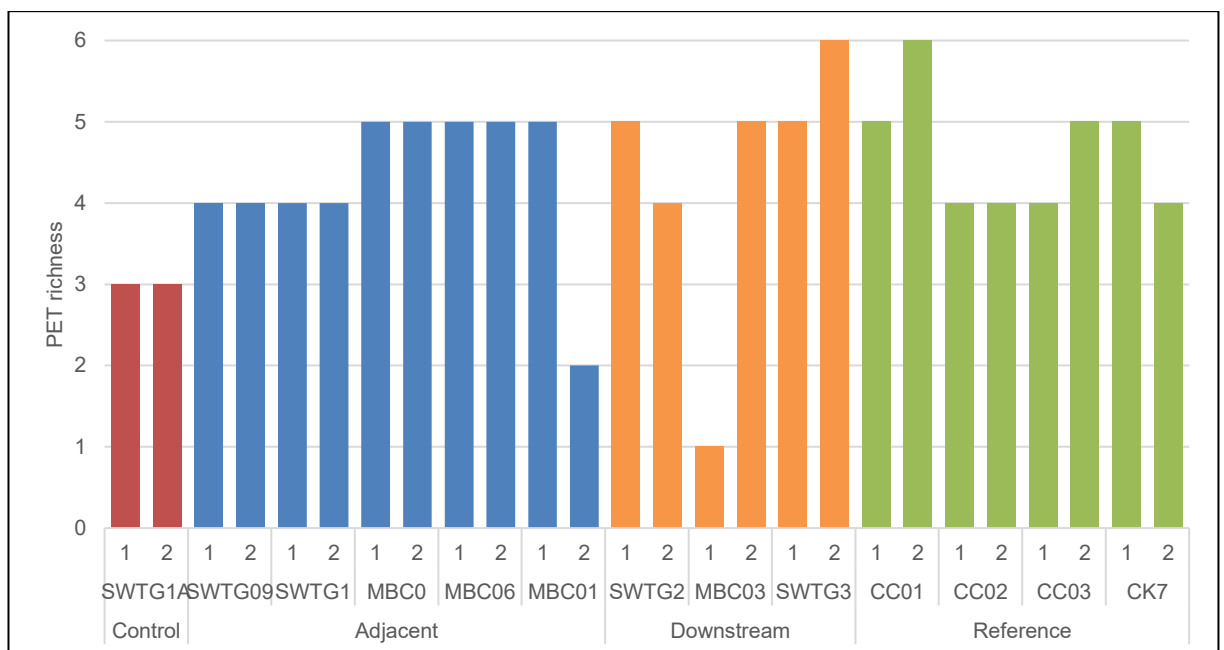


Figure 4-5 PET richness results from sites sampled in May 2017.

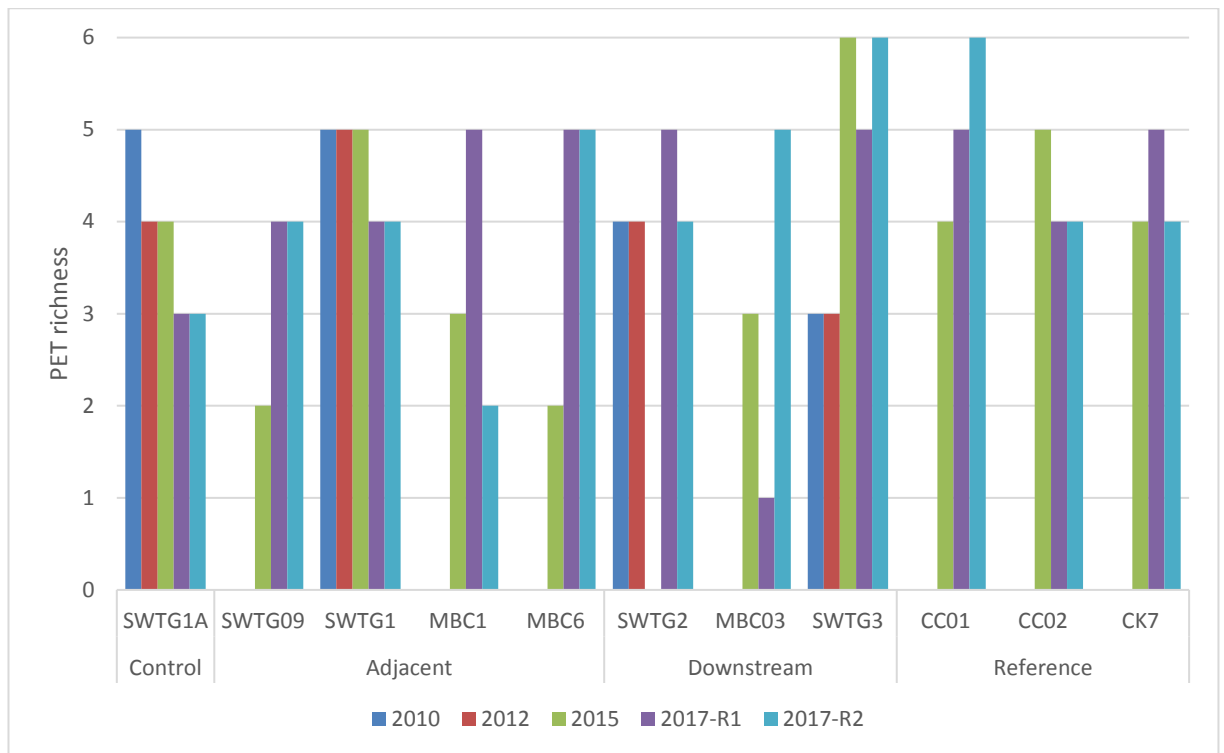


Figure 4-6 PET richness results from sites sampled historically at Toms Gully Mine.

4.3.4 SIGNAL-2

SIGNAL-2 results for sites sampled in May 2017 are presented in Figure 4-7, these results are compared with those from sites sampled historically in Figure 4-8. There was very little variability in SIGNAL-2 scores between sites on Mt Bunday Creek in 2017. There was even less variability between samples from sites on Coulter Creek. The watercourses showed variance between replicates of 0.9 and 0.33 respectively.

Historically, there has also been very little variance in sites sampled on Coulter Creek. Mount Bunday Creek has shown slightly more variability over time, but this is mostly restricted to sites where only two sampling events have been undertaken. Site SWTG3 recorded higher SIGNAL-2 scores in 2015 and 2017 compared with previous sampling events.

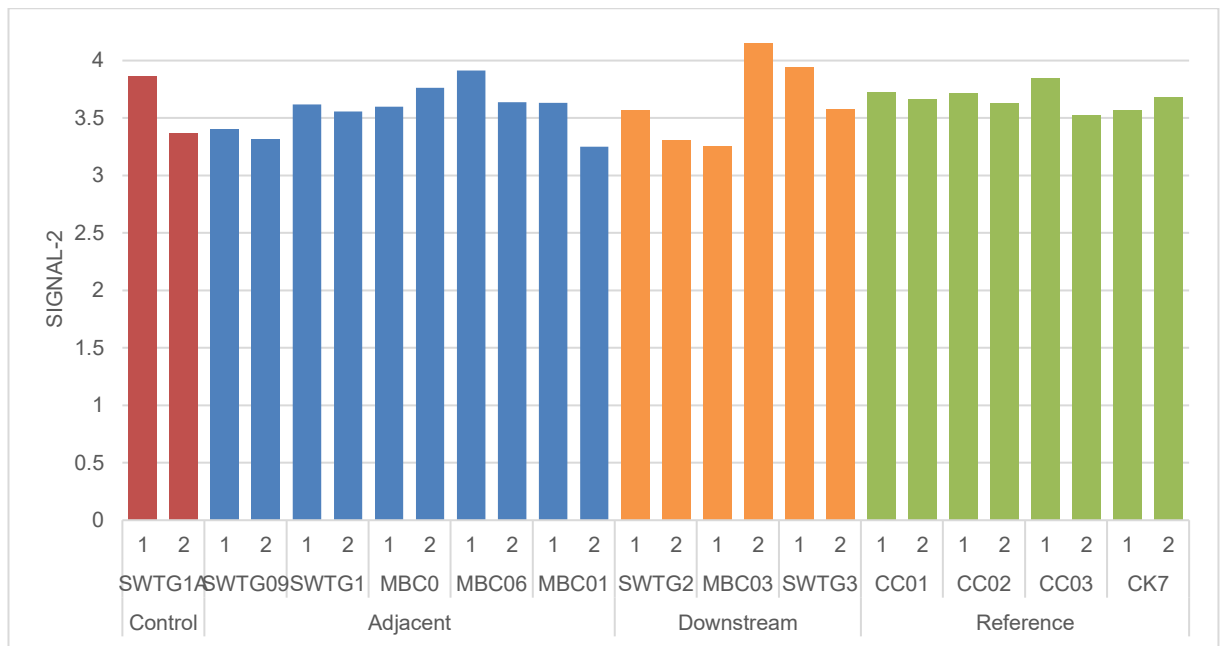


Figure 4-7 SIGNAL-2 results from sites sampled in May 2017.

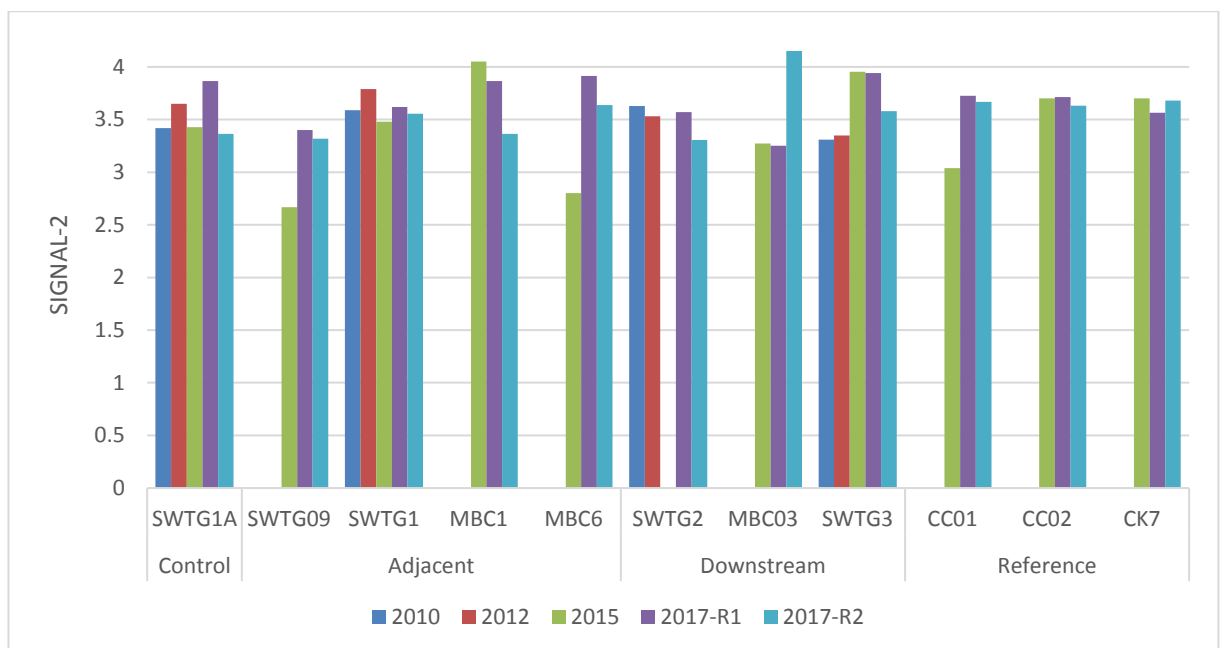


Figure 4-8 SIGNAL-2 results from sites sampled historically at Toms Gully Mine.

4.3.5 AUSRIVAS

The results of the Darwin-Daly AUSRIVAS model are presented in Figure 4-9, and these results have been compared to those from sites monitored historically (Figure 4-10). Most sites on Mount Bunday Creek returned a Band A rating, which indicate that they were similar to reference condition, with three sites (SWG09, MBC01 and MBC03) returning a Band B rating (significantly impaired). Sites on Coulter Creek were for the most part found to be significantly impaired (Band B), except for CC01, which was similar to reference condition (Band A).

Historically, sites on Mount Bunday Creek have had variable AUSRIVAS outputs. The sampling event in 2015 yielded particularly poor results, with most sites across both watercourses being categorised as Band B. SWTG2 was the most stable across all sampling events, but was not sampled in 2015. SWTG1 has consistently returned results similar to reference condition (Band A). Smaller tributaries of Mount Bunday Creek and Coulter Creek were variable in 2015 and 2017.

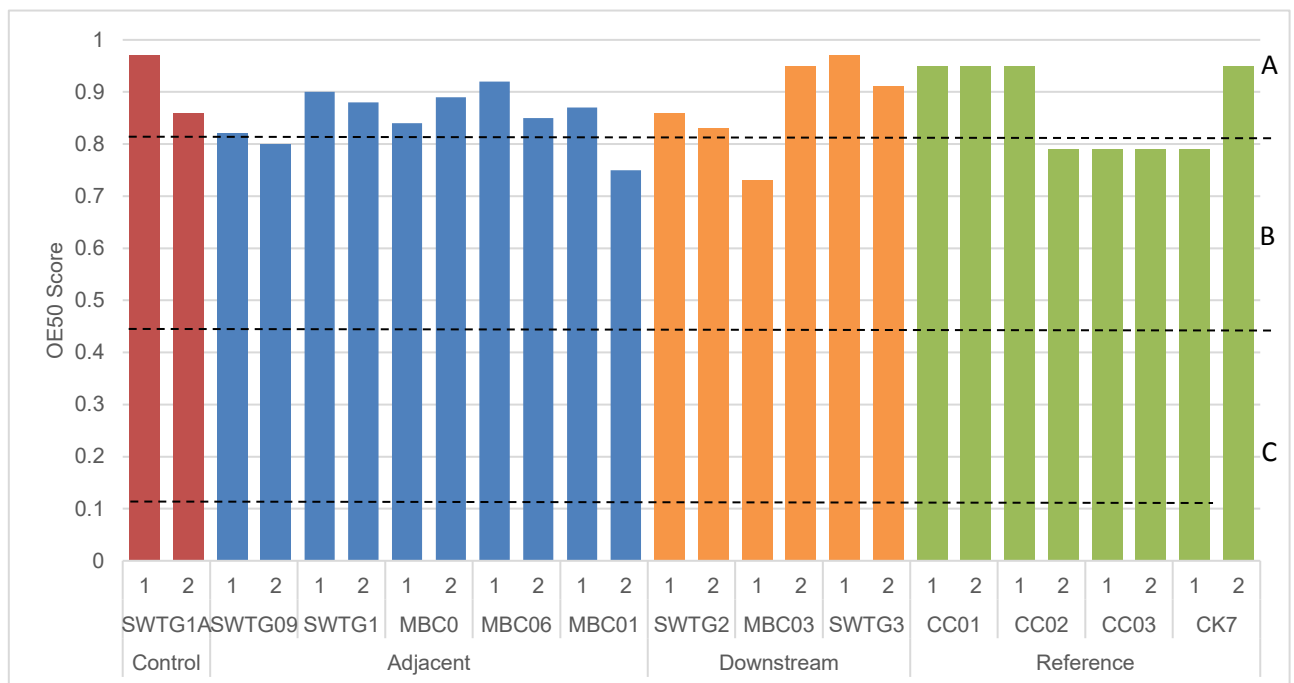


Figure 4-9 AUSRIVAS OE50 results and bandings from sites sampled in May 2017.

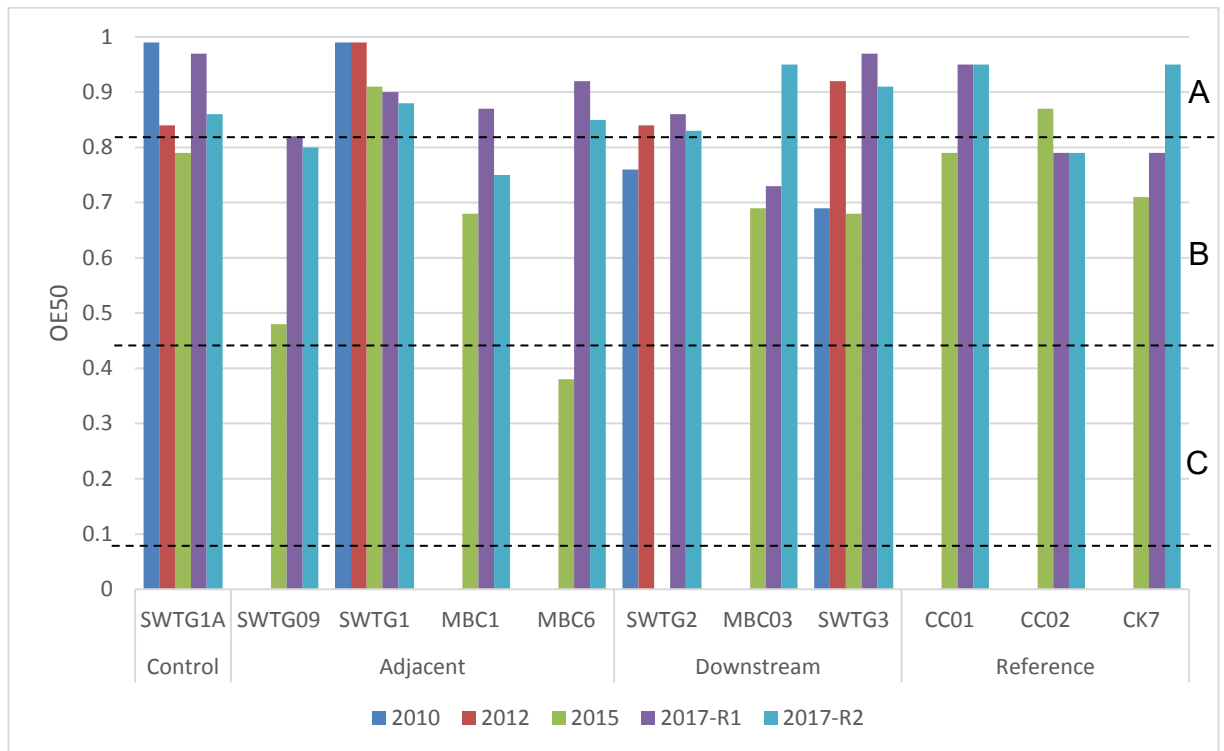


Figure 4-10 AUSRIVAS results from sites sampled historically at Toms Gully Mine.

4.3.6 Community composition - 2017

A total of 55 families were collected during the 2017 sampling event. The distribution of those taxa across 14 Orders is presented in Figure 4-11.

Taxa at sites in both Mount Bunday Creek and Coulter Creek were dominated by Diptera (flies) and Ephemeroptera (mayflies). Coleoptera (beetles) and Trichoptera (caddisflies) were also common across all sites. A noticeable difference in the community at MBC01 could be seen, where the samples were lacking Ephemeroptera, as was a sample from MBC03. A sample from MBC06 followed a similar pattern. Site SWTG9 displayed relatively greater abundances of Gastropoda (snails).

Overall, community composition of samples was similar for sites across Coulter Creek and Mount Bunday Creek with some exceptions. A NMDS plot (Figure 4-12) demonstrates that the majority of sites sampled in May 2017 were more than 65% similar to each other. The outlying samples that did not cluster with the majority were consistent with those that did not follow the pattern of samples mentioned in the previous paragraph (MBC01, MBC03, MBC06 and SWTG09).

A full list of taxa collected during the May 2017 sampling event can be found in Appendix C.

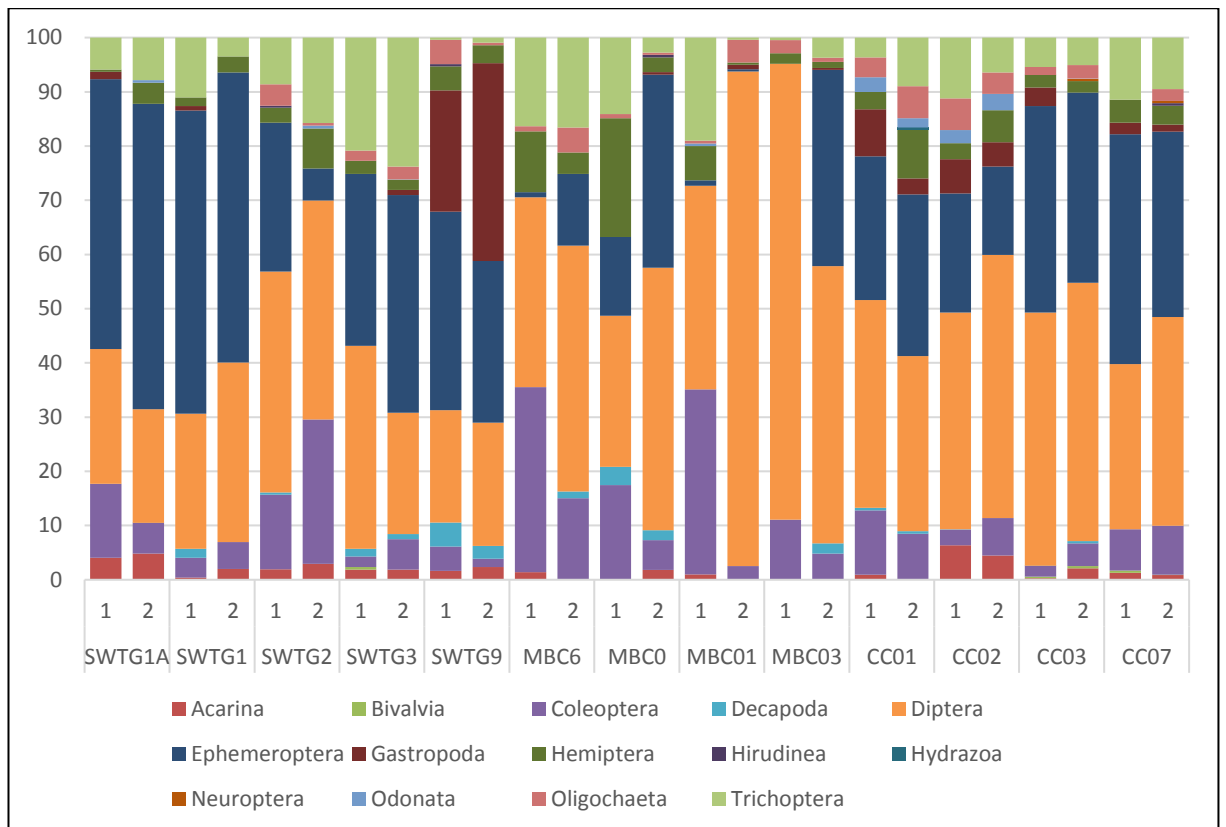


Figure 4-11 Composition of Orders from each site sampled in May 2017.

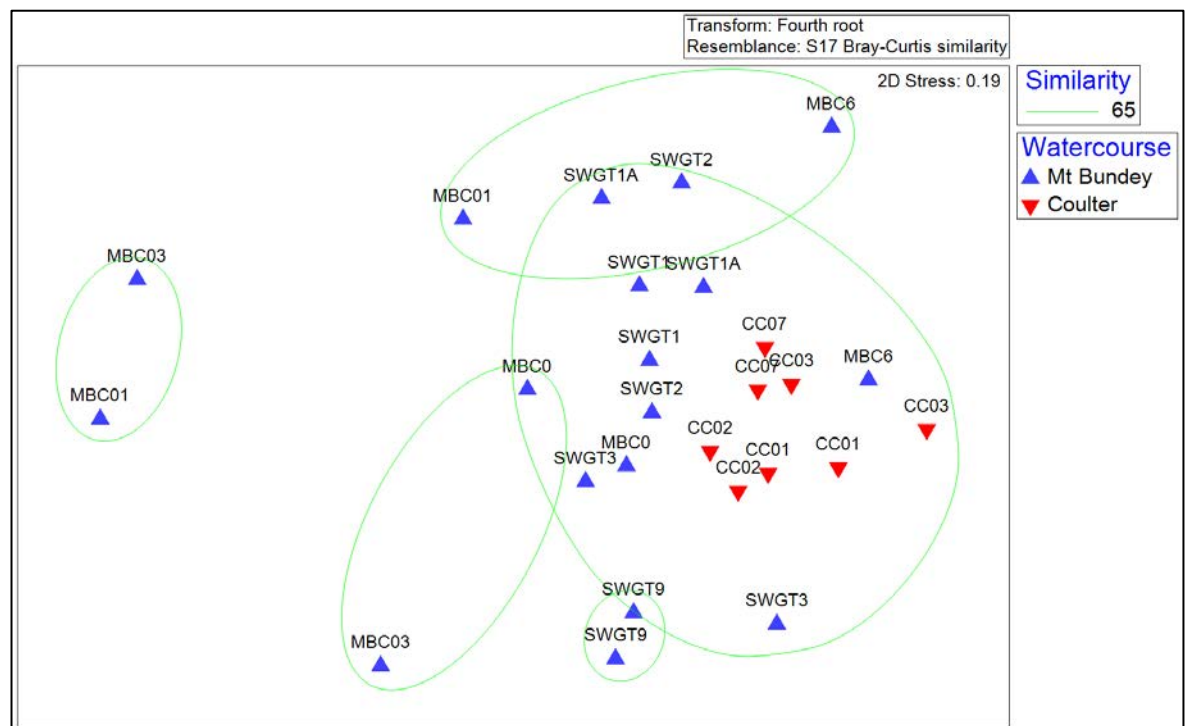


Figure 4-12 NMDS plot showing similarities in the macroinvertebrate community in 2017 grouped by watercourse.

4.3.7 Community composition – 2015 & 2017

The NMDS plot of data available from two sampling events undertaken by GHD (2015 and 2017) is presented below in Figure 4-13. There were few discernible patterns in the data, but Coulter Creek samples from 2017 grouped together more so than other sampling events and years. As could be seen in Figure 4-13 samples from 2017 were similar, with much more variability seen in samples from 2015 in both watercourses. Individual samples from MBC01 and MBC03 in 2017 grouped together, but were not similar to other samples from those sites or any others. The same was the case for samples from SWTG09 and MBC06 in 2015, when only a single sample was taken.

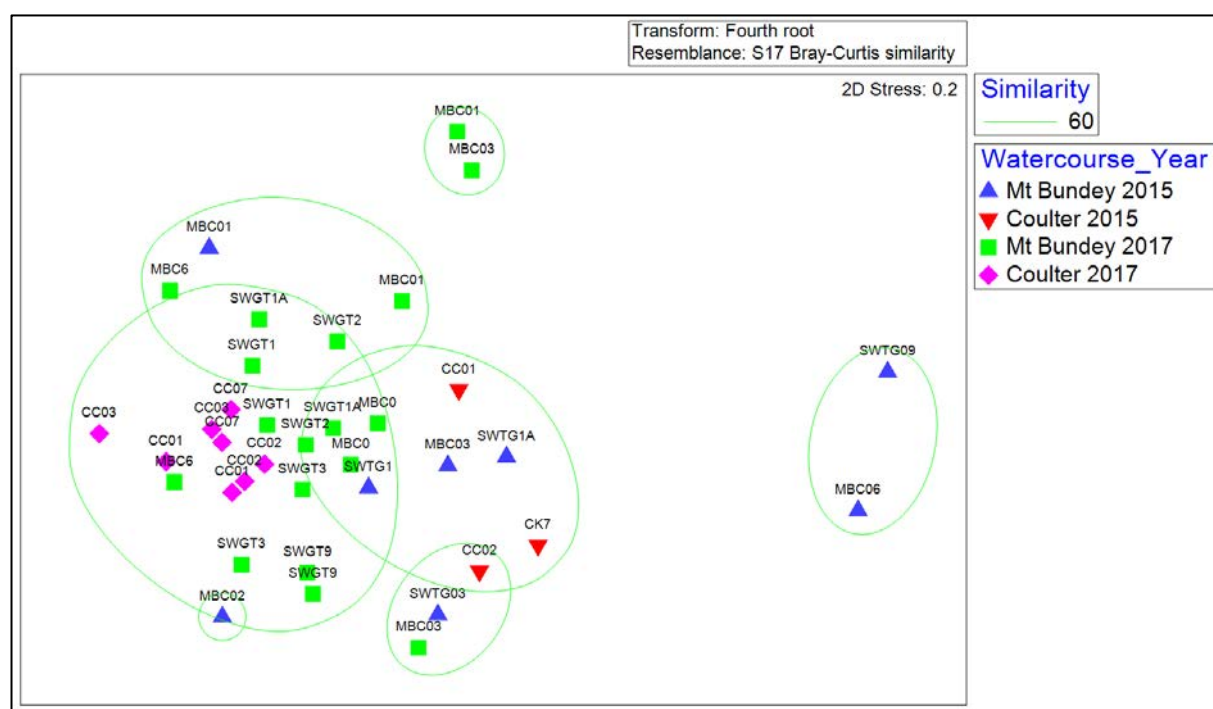


Figure 4-13 NMDS plot demonstrating similarities in the macroinvertebrate community by sampling event and watercourse.

4.4 Fish Community

4.4.1 Fish known to occur in the study area

There is limited publically available data on the freshwater fish community known to the Mary River however data is available for the neighbouring Daly River catchment, which incorporates the upper reaches of the Mary River immediately adjacent to the Toms Gully Mine. A total of 38 fish species belonging to 17 families are known to inhabit the Daly River catchment, giving some indication of the number of species that could potentially inhabit the Mary River catchment. Information cited from WWF (2005) for the Daly River freshwater fish community is presented below in Table 4-4.

Table 4-4 Freshwater Fish species known to occur within the Daly River catchment (WWF 2005).

Family	Scientific Name	Common Name	Conservation Status
Apogonidae	<i>Glossamia aprion</i>	Mouth Almighty	Not-threatened
Ariidae	<i>Arius graeffei</i>	Salmon Catfish	Non-threatened

Family	Scientific Name	Common Name	Conservation Status
	<i>Arius leptaspis</i>	Shovel nosed Catfish	Non-threatened
	<i>Arius midgleyi</i>	Triangular Shield Catfish	Non-threatened
Atherinidae	<i>Craterocephalus stercusmuscarum</i>	Fly-specked Hardyhead	Non-threatened
	<i>Quirichthys stramineus</i>	Strawman	Non-threatened
Belonidae	<i>Strongylura krefftii</i>	Long Tom	Non-threatened
Centropomidae	<i>Lates calcarifer</i>	Barramundi	Non-threatened
Chandidae	<i>Ambassis agrammus</i>	Sailfin Glassfish	Non-threatened
	<i>Ambassis macleayi</i>	Macleays Glassfish	Non-threatened
	<i>Ambassis sp.2</i>	North-western Glassfish	Non-threatened
	<i>Denariusa bandata</i>	Pennyfish	Non-threatened
Clupeidae	<i>Nematolosa erebi</i>	Bony Bream	Non-threatened
Eleotridae	<i>Hypseleotris compressa</i>	Empire Gudgeon	Non-threatened
	<i>Hypseleotris sp.</i>	Katherine River Gudgeon	Data deficient
	<i>Mogurnda mogurnda</i>	Northern Trout Gudgeon	Non-threatened
	<i>Oxyeleotris lineolatus</i>	Sleepycod	Non-threatened
	<i>Oxyeleotris selheimi</i>	Northern Sleepycod	Non-threatened
Gobiidae	<i>Glossogobius aureus</i>	Golden Goby	Non-threatened
	<i>Glossogobius giuris</i>	Flathead Goby	Non-threatened
Kurtidae	<i>Kurtus gulliveri</i>	Nursery Fish	Non-threatened
Megalopidae	<i>Megalops cyprinoides</i>	Tarpon	Non-threatened
Melanotaeniidae	<i>Melanotaenia splendida</i>	Eastern Rainbowfish	Non-threatened
	<i>Melanotaenia exquisita</i>	Exquisite Rainbowfish	Non-threatened
Plotosidae	<i>Anodontoglanis dahli</i>	Toothless Catfish	Non-threatened
	<i>Neosilurus ater</i>	Black Catfish	Non-threatened
	<i>Neosilurus hyrtlii</i>	Hyrtles tandan	Non-threatened
	<i>Neosilurus pseudospinosus</i>	False-spine Catfish	Non-threatened
	<i>Porochilus obbesi</i>	Obbes Catfish	Non-threatened
Pseudomugilidae	<i>Pseudomugil tenellus</i>	Delicate Blue-eye	Non-threatened
Soleidae	<i>Aseraggodes klunzingeri</i>	Freshwater Sole	Non-threatened
Terapontidae	<i>Amniataba percoides</i>	Barred Grunter	Non-threatened
	<i>Hephaestus fuliginosus</i>	Sooty Grunter	Non-threatened

Family	Scientific Name	Common Name	Conservation Status
	<i>Leiopotherapon unicolor</i>	Spangled Perch	Non-threatened
	<i>Pingalla midgleyi</i>	Midgley's Grunter	Low risk-near threatened
	<i>Syncomistes butleri</i>	Butler's Grunter	Non-threatened
Toxotidae	<i>Toxotes chatareus</i>	Archerfish	Non-threatened
	<i>Toxotes lorentzi</i>	Primitive Archerfish	Non-threatened

4.4.2 Fish community composition and distribution

A total of 471 individuals belonging to 13 species of fish were recorded during the May 2017 sampling event (Table 4-5). Additionally, 6 freshwater crabs and 12 freshwater yabbies were collected from bait traps. Flow was present at most sites along Mount Bunday Creek, which aided in the use of backpack electrofishing as an efficient capture method where conditions allowed entry to the water. Seine netting was also used successfully. Conductivity of waters within both Coulter Creek and Mount Bunday Creek were variable, and through alterations in settings, backpack electrofishing was effective wherever utilised. Turbidity was an issue, in terms of being able to locate stunned fish at CC03 where evidence of cattle was present. In this case, seine netting and bait traps were used. Conditions were such that cast-netting was not required at any site in 2017, as methods previously mentioned were able to be used at all sites. Insufficient water was present to undertake fish sampling at SWTG09 and MBC06.

Of the thirteen identifiable species of fish recorded in May 2017, Eastern Rainbowfish made up the largest number of those collected during sampling, followed by Sailfin Glassfish. Spangled Perch and Eastern Rainbowfish were the most widely distributed fish, being found at nine and eight sites across the study area respectively. SWTG3 recorded the highest number of fish species in May 2017, closely followed by the farthest upstream sites on Mt Bunday Creek (SWTG1A and SWTG1).

Mount Bunday Creek sites recorded a higher diversity of fish species compared with Coulter Creek. There was little difference between the control site, and sites adjacent and downstream of the mine area on Mount Bunday Creek. Diversity was generally low on Coulter Creek, and sites upstream of the Arnhem Highway recorded the lowest diversity of any sites on that watercourse, with only one species being caught at both sites. Fish found in both watercourses included Sailfin Glassfish, Spangled Perch, Eastern Rainbowfish, Northern Trout Gudgeon and Seven-spotted Archerfish, the remaining eight species were found exclusively in Mount Bunday Creek in May 2017.

A Short-finned Eel was caught at MBC01 in May 2017, eels are not identified as being previously recorded in the Daly River (Table 4-4), although Pollard (1974) has collected Short-finned Eels from a nearby catchment, the East Alligator River. The eel caught during surveys in May 2017 could not be identified beyond *Anguilla sp.*, which was the case for eels previously caught in the nearby catchment (Pollard 1974).

4.4.3 Fish physical condition

Fish caught in Coulter Creek did not show any signs of stress or external damage and appeared to be in good health. Within Mount Bunday Creek, fish collected were for the most part in good condition, with no signs of stress or parasites noted. At site MBC01, several Spangled Perch were recorded as having lesions identified as most likely being Tropical Ulcerative Syndrome (red spot disease) (Photo 4-1). A number of Seven-spot Archerfish were observed swimming sluggishly at the site, which could be collected using a dip net without using the electrofishing unit.



Photo 4-1 Suspected red spot disease found on Spangled Perch at MBC01.

Table 4-5 Fish caught during May 2017 sampling event.

Species	Common Name	SWG1A	SWG1	SWG3	MBC0	MBC01	SWG2	MBC03	CC01	CC02	CC03	CK7	TOTAL
<i>Ambassis agrammus</i>	Sailfin Glassfish	17	61				1	7			47	3	136
<i>Anguilla sp.</i>	Short-finned Eel					1							1
<i>Anodontoglanis dahli</i>	Toothless Catfish		1										1
<i>Hephaestus fuliginosus</i>	Sooty Grunter	9					1						10
<i>Leiopotherapon unicolor</i>	Spangled Perch	1	2	4	1	3	5	2			2		20
<i>Melanotaenia exquisita</i>	Exquisite Rainbowfish	1											1
<i>Melanotaenia splendida</i>	Eastern Rainbowfish	34	12	8	3		94	33	2	2	29		217
<i>Mogurnda mogurnda</i>	Northern Trout Gudgeon	11	2	11	11						1	5	41
<i>Nemelatosia erebi</i>	Boney Bream			3									3
<i>Neosilurus ater</i>	Black Catfish		1	3	2								6
<i>Neosilurus hyrtlui</i>	Hytrles Tandan		1	3	2								6
<i>Oxyleotris lineolatus</i>	Sleepycod		2	4	2			1					9
<i>Toxotes chatareus</i>	Seven-Spotted Archerfish			1		3						20	24
<i>Austrothelphusa sp.</i>	Freshwater Crab	1	2	1	1		1						6
<i>Cherax quadricarinatus</i>	Red Claw	2		2		3	4	1					12
Total Number Observed		76	84	40	22	10	106	44	2	2	79	28	491
Total Number of Species		8	9	10	7	4	6	5	1	1	4	3	15

4.4.4 Established preference ranges/tolerances for water quality

Water quality preference/tolerance ranges presented in Pusey *et al* (2004) were referred to as a guide to determine whether these might explain the distribution patterns of fish recorded in May 2017 (Table 4-6). These preferences are based on fish collected within the Alligator Rivers Region, which is the closest geographically relevant location from which data is available. As these values are known as ‘preferences’, they are not seen as absolute values outside of which any given fish species would not be found. Further, data on tolerances/preferences for fish of the Mary River Floodplain are not readily available, and so those from the Alligator River act as a surrogate as it is located closest to the study site from the data available. Laboratory results for pH have been utilised during the interpretation of these results (see Section 5.1 for more detail).

The following observations were made in regards to fish species recorded during the May 2017 survey compared with known tolerances/preferences:

- The absence of many species from site MBC01 may be explained by the lower pH and high EC recorded at the site relative to other sites on Mount Bunday Creek.
- Similarly, lower pH and relatively high EC at SWTG2 may have precluded a number of species found elsewhere on Mount Bunday Creek from being present.
- *A. agrammus* were found at SWTG2, even though EC was recorded above the known tolerance range for the species.
- Although tolerance/preference ranges for most species were recorded at sites on Coulter Creek, those species were not recorded.
- Similarly, conditions thought favourable from a water quality perspective at sites on Mount Bunday Creek did not necessarily result in a fish species being found at that location.

Table 4-6 Environmental preferences and tolerances of fish observed in Mount Bunday Creek and Coulter Creek.

Species	Temp (°C)	DO (mg/L)	pH	EC (µS/cm)	Turbidity (Secchi)
<i>Ambassis agrammus</i>	24 - 38	2.5 – 6.8	4.5 – 6.7	4 -220	1 - 360
<i>Anguilla sp.</i>	N/A				
<i>Anodontoglanis dahli</i>	N/A				
<i>Hephaestus fuliginosus</i>	23 - 34	5.3 – 7.4	5.13 – 8.0	56-790 ¹	5 -80
<i>Leiopotherapon unicolor</i>	7.3 - 37.5 ²	≥ 0.4	4.0 – 8.6	≤ 30 ²	1.5 – 260
<i>Melanotaenia splendida</i>	21.0 -29.5	1.1 -11.6	5.13 – 8.47	6.0 - 790	0.1 – 16.0
<i>Melanotaenia exquisita</i>	N/A				
<i>Mogurnda mogurnda</i>	11.9 -31.7	0.6 -12.8	4.9 -10.0	72 -2495	0.1 -200
<i>Nematelosa erebi</i>	23-38	2.7-9.7	5.1-8.6	2-198	1-360
<i>Neosilurus ater</i>	23-32	0.6-6.2	4.5-6.8	2-70	2-360
<i>Neosilurus hyrtlui</i>	23 - 36	1.0 – 9.7	5.2 – 7.3	4- 620	1 -170

<i>Oxyleotris lineolatus</i>	26 - 38	1.0 – 9.1	4.80 – 9.1	4 - 480	1 - 100
<i>Toxotes chatareus</i>	26 - 36	4.3 – 9.7	4.6 – 7.2	2 -420	0.6 -20.8

¹ Data from Burdekin River, QLD

² Experimentally derived value

4.4.5 Temporal comparison of fish data

Over the two sampling events in which fish have been surveyed at Toms Gully Mine, 17 species of fish have been recorded. Table 4-7 shows the similarity in both numbers and diversity of fish collected between the two sampling events. A number of fish caught in 2015 were not caught in 2017 and vice versa. Species that have been found in a particular year and not in the other were not recorded in high numbers where found. Higher numbers of *M. splendida* and *A. agrammus* were recorded in 2017, whereas a much larger number of *O. lineolatus* were recorded in 2015.

Figure 4-14 demonstrates the similarity between fish communities at sites visited during the April 2015 and May 2017 sampling events. Multiple sites on Coulter Creek were found to be less than 40% similar to those that grouped together, as was Mount Bunday Creek site MBC01.

Table 4-7 Fish recorded at Toms Gully Mine in 2015 and 2017

Species	Common Name	2015	2017	Total
<i>Ambassis agrammus</i>	Sailfin Glassfish	26	136	162
<i>Ambassis macleayi</i>	Macleay's Glassfish	2	0	2
<i>Amniataba percoides</i>	Barred Grunter	1	0	1
<i>Anguilla sp.</i>	Indian Short-finned Eel	0	1	1
<i>Anodontoglanis dahli</i>	Toothless Catfish	0	1	1
<i>Glossamia aprion</i>	Mouth Almighty	7	0	7
<i>Hephaestus fuliginosus</i>	Sooty Grunter	1	10	11
<i>Leiopotherapon unicolor</i>	Spangled Perch	18	20	38
<i>Melanotaenia exquisita</i>	Exquisite Rainbowfish	6	1	7
<i>Melanotaenia sp.</i>	Unidentified Rainbowfish	33	0	33
<i>Melanotaenia splendida</i>	Eastern Rainbowfish	126	217	343
<i>Mogurnda mogurnda</i>	Northern Trout Gudgeon	51	41	92
<i>Nemelatosia erebi</i>	Bony Bream	0	3	3
<i>Neosilurus ater</i>	Black Catfish	0	6	6
<i>Neosilurus hyrtlii</i>	Hyrtles Tandan	4	6	10
<i>Oxyleotris lineolatus</i>	Sleepy Cod	134	9	143
<i>Toxotes chatareus</i>	Seven-Spotted Archerfish	13	22	35
TOTAL Number Observed		422	473	895
TOTAL Number of Species		13	13	17

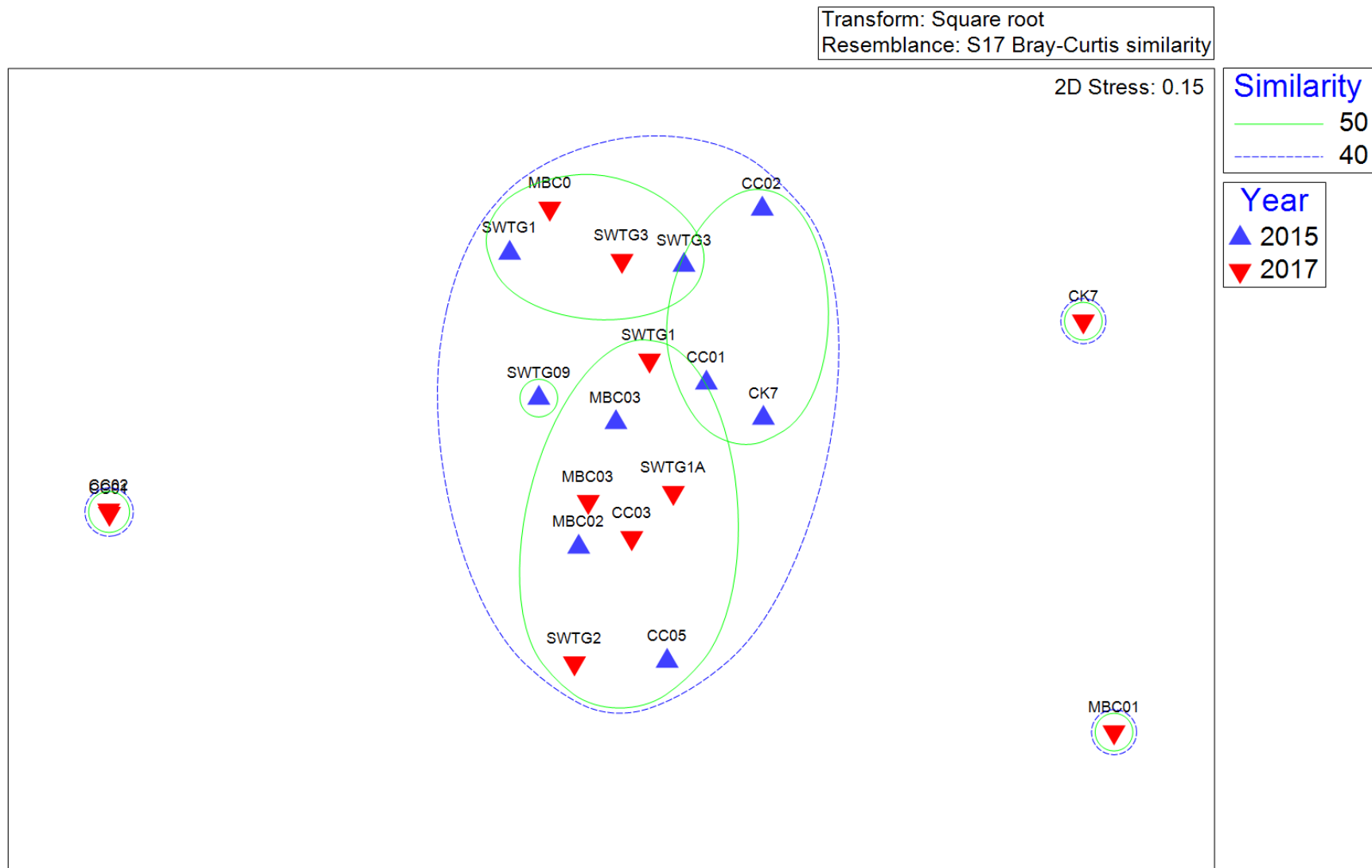


Figure 4-14 NMDS plot showing similarities between fish communities at sites surveyed in 2015 and 2017.

4.5 Water Monitors

4.5.1 Sampling effort

Camera units were deployed at six sites across the study area and were active between 47 and 50 days, depending on deployment date (Table 4-8). Photos taken indicated that all cameras were working effectively for the length of deployment.

Table 4-8 Remote camera locations and deployment.

Site	Easting	Northing	Camera in	Camera out	Deployed days
M1	778691	8580427	20/5/17	8/7/17	49
M2	780604	8580044	21/5/17	8/7/17	48
M3	776351	8580503	19/5/17	8/7/17	50
M4	780126	8580212	21/5/17	8/7/17	48
M5	779453	8580428	21/5/17	8/7/17	48
M6	779377	8580450	22/5/17	8/7/17	47

4.5.2 Target species

A single individual species of Mertens' Water Monitor (*Varanus mertensi*) was recorded within the study area on camera unit M3, located upstream of the mine on Mt Bundey Creek (Photo 4-2). There were no sightings of *V. mitchelli* on any of the remote camera units. A large number of non-target species were recorded on cameras during deployment.



Photo 4-2 Mertens Water Monitor (*Varanus. mertensi*) photographed on camera unit M3.

4.5.3 Non-target species

Seventeen additional species were recorded on remote cameras across the study area. A number of introduced species were recorded on all camera units, notably cane toads were found at all sites (Photo 4-3), as were large groups of pigs at a number of sites (Photo 4-4). A feral cat was also recorded on camera unit M3. The most common native species recorded was the Agile Wallaby (Photo 4-5), and one species listed as Vulnerable under the *Territory Parks and Wildlife Conservation Act (2009)* (*Rattus Tunneyi*) was recorded on several cameras (M2, M4, M5 and M6). A number of small mammals could not be identified due to their size or age. A full list of species that could be positively identified can be found in Appendix D.



Photo 4-3 Cane toads recorded on camera unit M3.



Photo 4-4 A group of pigs recorded on camera unit M2.



Photo 4-5 Agile Wallaby (*Macropus agilis*) recorded on camera unit M5.

5. Discussion

5.1 Water Quality

The water quality was poorer downstream of Tailings Dam 2 (TSF2) and this was evidenced by EC results, which indicated that water in Mount Bunday Creek had an increased salinity at sites downstream of the tributary draining the TSF2 area. A similarly elevated EC was also observed at Coulter Creek site CC02, indicating a potential impact of land use practices in the upper reaches of the Coulter Creek catchment. The most acidic water was observed at MBC01, indicating that the TSF2 may be a source of acid metalliferous drainage (AMD). The pH observed at SWTG2 was also low, indicating that the water quality remained lower for approximately 1.3 km downstream of MBC01. pH was within the SSTV range at SWTG3, demonstrating reduced acidity further downstream on Mount Bunday Creek.

Low DO saturations were observed at all sites sampled in May 2017. This was likely the result of the low flows and the consumption of DO associated with the breakdown of instream organic material. This is supported by the generally lower DO saturations in Coulter Creek, where lower water levels were observed. It should however be noted that diurnal changes in DO may also affect measurements. These results should therefore be considered a snapshot of existing conditions that highlight potential poor water quality at these sites.

Turbidity was generally low, with no impact of the site on Mount Bunday Creek evident. Considerable turbidity was observed at CK7 and there was evidence of pig and cattle crossings of the creek, as such, the turbidity observed *in situ* is considered accurate.

The potential impact of the site on the ionic composition of Mount Bunday Creek is evidenced by increased concentrations of sulfate, calcium and magnesium, which were highest at MBC01. MBC01 also had the highest concentrations of dissolved aluminium, cadmium, cobalt, copper, iron, nickel and zinc, which all exceeded the relevant SSTVs. This indicates the potential impact of runoff from the New Tailings Dam, as all of these metals are potentially ecotoxic. At downstream site SWTG2, dissolved concentrations of cobalt, nickel and zinc were elevated, though substantially lower than those observed at MBC01, indicating the ameliorative effects of dilution, adsorption and precipitation between the two sites.

Approximately 600 metres downstream of SWTG2, at site MBC03, nickel and zinc were the only metals observed at elevated concentrations. At the furthest downstream site SWTG3, the concentrations of all metals except iron and manganese were below the respective LORs, indicating that any impact is unlikely to be observed at this location on Mount Bunday Creek.

Elevated concentrations of iron and manganese were observed in both the Mount Bunday Creek and Coulter Creek catchments, suggesting the impact of the local lithology and land uses. Apart from iron and manganese, all dissolved metal concentrations in the Coulter Creek Catchment were below the respective LORs in May 2017.

The laboratory LORs for the metals cadmium, cobalt, copper and nickel were not of a sufficient precision to detect concentrations of these metals below the SSTVs described in GHD (2015). Subsequently, the May 2017 sampling results for these metals were reported as unable to confirm if exceedances of the SSTVs had occurred. To avoid the reporting of (potentially insignificant) results as such, a recommendation concerning future monitoring has been made below in Section 6.

5.2 Macroinvertebrate community

In May 2017, the macroinvertebrate community of the study area was characterised by low-sensitivity taxa, often in high abundances. The majority of macroinvertebrate families collected had low sensitivity grades and had very little preference for habitat. There was no clear pattern in macroinvertebrate metrics between control and adjacent to mine sites on Mount Bunday Creek, although there was more intra-site variability of sensitivity metrics in samples downstream of the tributary on which site MBC06 is located. In general, lower relative abundances were also recorded at these sites. Results of AUSRIVAS modelling followed a similar trend to other metrics, with sites MBC01 and MBC03 deemed as significantly impaired, whereas compliance points SWTG2 and SWTG3 were both similar to reference condition.

Results from MBC01 and MBC03 were variable between samples, with a number of expected taxa missing from one of the two samples from the sites according to results of the AUSRIVAS model outputs. The majority of these had SIGNAL-2 scores of 4 or below, which would not have markedly increased the overall SIGNAL-2 score for samples from the sites should they have been present. Three of the missing families from both samples were PET taxa. The protocol for interpretation of AUSRIVAS model outputs stipulates that where two samples from the same site are found to be in different bandwidths, the lower bandwidth be assigned for that site. In the case of sites on Mount Bunday Creek and its tributaries that were classified as significantly impaired, one of two samples were allocated to the Band A or reference condition bandwidth.

Water chemistry results from MBC01, SWTG2 and MBC03 showed there is degradation of water quality in proximity to TSF2. The high pollution tolerance of the macroinvertebrate community present at all sites along Mount Bunday Creek denotes that results were less likely to be affected by changes in water quality at sites MBC01 and MBC03. This is evidenced when noting the Band A (similar to reference condition) result of the AUSRIVAS model and higher taxa richness values at SWTG2. The above results suggest that more diverse habitat was likely available at SWTG2 compared with the other sites, and that habitat is a greater driver of the macroinvertebrate community across Mount Bunday Creek compared with water quality. In general, SIGNAL analyses tend to be a reflection of water quality, whilst AUSRIVAS outputs are more related to habitat quality.

In 2017, the macroinvertebrate community at all but one site on Coulter Creek was considered significantly impaired as a result of the AUSRIVAS model. Other metrics were somewhat variable, but with water quality results being relatively similar, besides elevated EC and manganese at CC02, it is thought that habitat availability may be more influential at sites on Coulter Creek. As the watercourse is of a lower order, more ephemeral and receives much more impact by the way of cattle access, that the creek is not likely to support a diverse and pollution-sensitive macroinvertebrate community. Interestingly, the composition of the macroinvertebrate community at sites on Coulter Creek was more similar to that of sites on Mount Bunday Creek. This may be the result of consistently lower quality habitat across all sites and that all sites were reduced to standing pools at the time of sampling.

5.3 Fish community

The fish community of the study area was similar in 2015 and 2017 and an additional four species were added to the overall list of fish caught during both years. Rainfall recorded in the 2016/2017 wet season was much higher than the 2014/2015 wet season, which resulted in higher and longer lasting flows through Mount Bunday Creek and Coulter Creek. Backpack electrofishing was found to be very successful in most circumstances during the May 2017 sampling event. The addition of seine netting and angling resulted in greater catches of some species, but did not increase the overall diversity of fish recorded at each site.

As Coulter Creek was again reduced to isolated pools, as in 2015, and additional capture techniques were employed at sites, it was thought that additional species or higher numbers of fish may be caught in that system in 2017. The opposite was the case, with a lower diversity and abundance of fish found. The adjoining Old Mount Bunday Station was purchased by new owners in 2016, who have intensified the use of the land to the east of Coulter Creek, re-establishing plantations of mangoes, and utilising the paddocks with access to the creek for grazing and holding of cattle (Tony Harrower, Old Mount Bunday Station *per comms.*). These actions may have resulted in poorer quality conditions for fish, such as increased erosion and turbidity as well as some nutrient enrichment. As there was no analysis for nutrients undertaken in 2017, this cannot be confirmed.

The fish community of Mount Bunday Creek appeared to be less diverse at sites in close proximity to the TSF2 in May 2017. Two species caught at the site closest to the TSF2 were recorded as being in poor condition. *L. unicolor* were found with lesions, and *T. chatareus* were observed swimming slowly. Pusey *et al.* (2004) noted the visual acuity and vigilant nature of *T. chatareus* made it difficult to collect using backpack electrofishing methods, yet individuals were observed to be swimming sluggishly at MBC01 and were extremely easy to collect with dip nets, without the aid of an electrofishing unit. This may indicate that those individuals seen were affected in some way by water quality, regardless of their broad tolerance range for pH, EC and dissolved oxygen. *L. unicolor* affected by red spot disease were recorded at MBC01, but at no other sites. Low pH has been noted as a catalyst for the infection of red-spot disease, by creating small perforations in the skin and scales that can be colonised by the disease (Oidtmann 2012). Often fish that are affected by red spot disease are in some way impaired, be that by injury or exposure to poor water quality e.g. high dissolved aluminium concentrations have been attributed to the susceptibility of fish to the disease (Virgona 1992). Low pH and dissolved aluminium above the SSTV were recorded at MBC01, which may have attributed to the poor condition of *L. unicolor* at the site. Given that *L. unicolor* are able to move large distances, and all sites were connected by flow, it is possible that individuals affected at the site were exposed to contaminants at a different location and were simply caught at the site. This is less likely to be the case, as there were more than one individual caught that was affected by the disease. *L. unicolor* was recorded at a number of sites where pH values were circum-neutral and the disease was not noted. The small number of individuals caught that were affected by the disease is not cause for immediate concern, but the water quality issues need to be investigated and where required, should be addressed, and fish monitoring should continue to understand if this is an isolated incident.

Besides fish condition at MBC01, sites downstream of the Toms Gully recorded a lower diversity and abundance of fish, with the exception of a large number of *M. splendida* being recorded from SWTG2. Availability of woody debris, pool and run sequences and riparian vegetation was present at all sites along Mount Bunday Creek, and surface flow was recorded at almost all sites. As fish habitat was not found to be markedly different at each site and connectivity was not an issue at the time of sample, or before it given the prior wet season, water quality is a likely contributor to the presence of fish. The connectivity of sites denotes that fish may have been capable of moving upstream or downstream of the waters having higher concentrations of metals, as well as high EC or low pH conditions. The site located furthest downstream (SWG3) recorded a number of fish, which were also present at sites upstream of the TSF2, as well as similar water quality attributes to upstream sites, except EC, which was slightly elevated. This denotes some recovery in water quality and fish communities downstream with distance from the area of poorer water quality.

5.4 Water Monitors

Camera trapping undertaken at Toms Gully Mine yielded a variety of native and introduced fauna inhabiting the riparian zone of Mount Bunday Creek. Water monitors of either species were not recorded at sites downstream of or adjacent to Toms Gully Mine and only a single individual Mertens Water Monitor (*Varanus mertensi*) was captured on a camera unit upstream. All sites recorded cane toads, which are known to be a threatening process to both *V. mertensi* and *V. mitchelli* (Griffiths and Mackenzie 2005; Smith and Phillips 2006). Impacts on the presence of water monitors within the study area, and likely on the region in general are the presence of large numbers of cane toads (ingestion), feral pigs (predation of eggs) and a feral cat (predation of young).

In saying this, management of water on site and any influence it may have on the riparian communities downstream of the mine will be important to the ongoing survival of water monitors in the area. Conservation objectives for *V. mertensi* and *V. mitchelli* do not suggest that removal of cane toads is a viable option, but that there is some value in supporting surviving populations of water monitors that remain after the arrival of cane toads and an initial population crash occurs (Ward *et al.* 2006; Ward 2012). According to local residents, cane toads have been present in the area for more than ten years (Linda Francis *per comms.*). Therefore, the riparian habitat available for remnant water monitors will assist with the survival and overall resilience of populations of both species in the study area, helping to meet objectives for their conservation.

Although there were no water monitors recorded on remote cameras downstream or adjacent to Toms Gully Mine, this does not mean they are not present, albeit likely in low numbers. Further surveys (deploying additional cameras) would require a much more comprehensive study to ascertain their presence, due to their apparent low abundance.

6. Conclusions and Recommendations

6.1 Water quality

The results from the May 2017 sampling indicated that water quality in Mount Bunday Creek is of poorest quality around TSF2. Results for the site at the confluence of Mount Bunday Creek and the tributary which receives discharges from the TSF area, indicated that the runoff is acidic and moderately saline, with elevated concentrations of metals. The impact of this runoff on water quality in Mount Bunday Creek is observed to a lesser extent at the compliance monitoring point at the Arnhem Highway crossing. Further downstream, at a monitoring site 300 metres upstream of the confluence between Mount Bunday Creek and Coulter Creek, these impacts are no longer observed.

To improve the ability to compare future water quality monitoring results to the SSTVs presented in GHD (2015), it is recommended that laboratory methods be chosen so that their precision allows for the detection of metal concentrations at or below the relevant SSTVs.

6.2 Macroinvertebrate Community

The macroinvertebrate community of the study area is characterised by pollution tolerant families that are more likely being influenced by habitat availability at a given site, rather than by water quality in Mount Bunday Creek. Sites closest to the TSF2 showed more intra-site variability than those upstream of it, yet the furthest downstream site showed consistent results that indicated recovery from any impairment, should it have been detected downstream of Toms Gully Mine.

Future monitoring should continue to incorporate replicate sampling, but in order to improve statistical power, an additional site upstream of mining activities is recommended. Coulter Creek has provided a good baseline of reference data from a nearby watercourse, yet the continued use of this creek for comparison may be diminished by ongoing changes to land use associated with the operation of Old Mount Bunday Station. The establishment of additional control sites upstream of SWTG1A is therefore important to the assessment of impacts associated with Toms Gully Mine during its maintenance and operational phases.

6.3 Fish Community

The fish community of Coulter Creek is of low diversity and abundance, which is not surprising, given that it is ephemeral and impacted by the access of cattle. The watercourse recorded lower numbers of fish in 2017, which was not expected, given the high rainfall associated with the previous wet season, but this may be associated with the increased activity at Old Mount Bunday Station. Mount Bunday Creek, on the other hand recorded slightly more fish than the sampling event in 2015, but these were in the most part restricted to sites upstream of, or furthest downstream from Toms Gully. Fish data for the study area is limited, and so the result of the sampling event in 2017 is not sufficient to draw strong conclusions about the associations between fish presence and water quality. Poor fish condition, as well as low abundance and diversity appeared to be related to water quality parameters that are potentially ecotoxic; therefore, long-term water quality data should be investigated. Ongoing monitoring of fish communities is recommended, should results of the water quality investigation lead to the conclusion that mining infrastructure is contributing to water quality deterioration.

6.4 Water Monitors

The current monitoring effort represents a pilot program, which was able to establish that Mertens Water Monitors are present in the study area, albeit in low numbers. Preferable habitat is present for both the Mitchell's and Mertens Water Monitor species at sites downstream of Toms Gully Mine. As both species are likely to be sparsely distributed across the study area due to the presence of introduced species, survey effort to capture their occurrence would need to be much greater.

Future monitoring programs should employ the use of a greater number of cameras, including multiple at each site. To increase the likelihood of recorded water monitors, cameras should be deployed for at least three months during the dry season to coincide with the breeding season.

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Appendices

Appendix A - Disclaimer

This report: has been prepared by GHD for Primary Gold Limited and may only be used and relied on by Primary Gold Limited for the purpose agreed between GHD and the Primary Gold Limited as set out in section 1.2 of this report.

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The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.2. of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

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The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

Appendix B – Certificate of Analysis – water quality



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Envirolab Services (WA) Pty Ltd trading as
MPL Laboratories | ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 196288

Client:

GHD Services Pty Ltd
PO Box Y3106
Perth
WA 6000

Attention: Tara Steele

Sample log in details:

Your Reference:	TG17
No. of samples:	14 Water
Date/Time samples received:	30/05/2017 / 10:20
Date completed instructions received:	30/05/2017
Location:	

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	6/06/17
Date of Preliminary Report:	Not issued
Issue Date:	6/06/17

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Accredited for compliance with ISO/IEC 17025 - Testing
Tests not covered by NATA are denoted with *.

Results Approved By:

Todd Lee
Laboratory Manager

MPL Reference: 196288
Revision No: R 00



Miscellaneous Inorganics Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-1 MBC0 24/05/2017 Water	196288-2 MBC1 24/05/2017 Water	196288-3 MBC3 23/05/2017 Water	196288-4 MBC6 25/05/2017 Water	196288-5 SWTG1A 25/05/2017 Water
Date prepared	-	01/06/2017	01/06/2017	01/06/2017	01/06/2017	01/06/2017
Date analysed	-	01/06/2017	01/06/2017	01/06/2017	01/06/2017	01/06/2017
pH	pH Units	6.7	4.7	6.2	6.1	6.9
Electrical Conductivity (EC)	µS/cm	34	440	180	210	53
Acidity as CaCO ₃	mg/L	<5	25	<5	13	<5
Total Dissolved Solids (grav)	mg/L	20	270	110	130	32
Turbidity	NTU	8.1	14	3.9	18	4.2

Miscellaneous Inorganics Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-6 SWTG1 25/05/2017 Water	196288-7 SWTG2 24/05/2017 Water	196288-8 SWTG3 23/05/2017 Water	196288-9 SWTG9 23/05/2017 Water	196288-10 CC03 23/05/2017 Water
Date prepared	-	01/06/2017	01/06/2017	01/06/2017	01/06/2017	01/06/2017
Date analysed	-	01/06/2017	01/06/2017	01/06/2017	01/06/2017	01/06/2017
pH	pH Units	7.0	5.7	6.7	7.1	7.0
Electrical Conductivity (EC)	µS/cm	47	270	120	89	160
Acidity as CaCO ₃	mg/L	<5	5	<5	<5	<5
Total Dissolved Solids (grav)	mg/L	28	160	71	53	94
Turbidity	NTU	2.6	1.7	11	13	7.4

Miscellaneous Inorganics Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-11 CC02 25/05/2017 Water	196288-12 CC01 25/05/2017 Water	196288-13 DS12 25/05/2017 Water	196288-14 CK7 25/05/2017 Water
Date prepared	-	01/06/2017	01/06/2017	01/06/2017	01/06/2017
Date analysed	-	01/06/2017	01/06/2017	01/06/2017	01/06/2017
pH	pH Units	7.4	6.8	6.8	7.0
Electrical Conductivity (EC)	µS/cm	440	150	53	200
Acidity as CaCO ₃	mg/L	<5	5	<5	<5
Total Dissolved Solids (grav)	mg/L	260	90	32	120
Turbidity	NTU	3.0	14	4.8	5.9

Ionic Balance Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-1 MBC0 24/05/2017 Water	196288-2 MBC1 24/05/2017 Water	196288-3 MBC3 23/05/2017 Water	196288-4 MBC6 25/05/2017 Water	196288-5 SWTG1A 25/05/2017 Water
Date prepared	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Calcium - Dissolved	mg/L	1.6	35	13	12	2.4
Potassium - Dissolved	mg/L	0.6	3.0	1.8	0.9	1.0
Magnesium - Dissolved	mg/L	1.1	22	8.4	12	1.8
Sodium - Dissolved	mg/L	2.8	7.9	5.8	7.2	4.8
Bicarbonate HCO ₃ as CaCO ₃	mg/L	19	<5	<5	19	31
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	<5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	19	<5	7	19	31
Chloride	mg/L	4	4	3	4	4
Sulphate	mg/L	2	210	71	75	3
Ionic Balance	%	-27	-5.2	-1.8	-3.5	-21
Hardness as CaCO ₃	mg/L	9	180	68	79	13

Ionic Balance Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-6 SWTG1 25/05/2017 Water	196288-7 SWTG2 24/05/2017 Water	196288-8 SWTG3 23/05/2017 Water	196288-9 SWTG9 23/05/2017 Water	196288-10 CC03 23/05/2017 Water
Date prepared	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Calcium - Dissolved	mg/L	2.2	20	7.4	8.4	9.4
Potassium - Dissolved	mg/L	1.2	2.1	1.9	1.9	3.3
Magnesium - Dissolved	mg/L	1.6	12	5.0	3.5	8.2
Sodium - Dissolved	mg/L	4.5	6.4	5.5	3.9	6.6
Bicarbonate HCO ₃ as CaCO ₃	mg/L	27	<5	25	37	37
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	<5	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	27	<5	25	37	37
Chloride	mg/L	3	3	4	5	5
Sulphate	mg/L	2	120	30	2	32
Ionic Balance	%	-19	-2.8	-7.0	0.31	-0.90
Hardness as CaCO ₃	mg/L	12	100	39	36	57

Ionic Balance					
Our Reference:	UNITS	196288-11	196288-12	196288-13	196288-14
Your Reference	-----	CC02	CC01	DS12	CK7
Date Sampled	-----	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Type of sample		Water	Water	Water	Water
Date prepared	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Calcium - Dissolved	mg/L	31	8.2	2.4	11
Potassium - Dissolved	mg/L	5.6	2.2	1.3	3.2
Magnesium - Dissolved	mg/L	24	7.4	1.9	10
Sodium - Dissolved	mg/L	12	5.3	5.1	7.9
Bicarbonate HCO ₃ as CaCO ₃	mg/L	89	43	27	34
Carbonate CO ₃ ²⁻ as CaCO ₃	mg/L	<5	<5	<5	<5
Hydroxide OH ⁻ as CaCO ₃	mg/L	<5	<5	<5	<5
Total Alkalinity as CaCO ₃	mg/L	89	43	27	34
Chloride	mg/L	5	6	4	5
Sulphate	mg/L	130	24	3	55
Ionic Balance	%	-5.1	-7.3	-13	-3.0
Hardness as CaCO ₃	mg/L	180	51	14	71

Dissolved Metals in Water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-1 MBC0 24/05/2017 Water	196288-2 MBC1 24/05/2017 Water	196288-3 MBC3 23/05/2017 Water	196288-4 MBC6 25/05/2017 Water	196288-5 SWTG1A 25/05/2017 Water
Date prepared	-	1/06/2017	1/06/2017	1/06/2017	1/06/2017	1/06/2017
Date analysed	-	1/06/2017	1/06/2017	1/06/2017	1/06/2017	1/06/2017
Arsenic - Dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Aluminium - Dissolved	mg/L	<0.1	1.4	<0.1	<0.1	<0.1
Cadmium - Dissolved	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
Cobalt - Dissolved	mg/L	<0.01	0.08	<0.01	<0.01	<0.01
Chromium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper - Dissolved	mg/L	<0.01	0.11	<0.01	<0.01	<0.01
Iron - Dissolved	mg/L	0.23	3.9	0.1	0.51	0.48
Lead - Dissolved	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Manganese - Dissolved	mg/L	0.02	3.3	0.77	0.16	0.02
Nickel - Dissolved	mg/L	<0.02	0.14	0.04	<0.02	<0.02
Uranium - Dissolved	mg/L	<0.0005	0.0030	<0.0005	0.0006	<0.0005
Zinc - Dissolved	mg/L	<0.02	0.65	0.18	<0.02	<0.02

Dissolved Metals in Water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-6 SWTG1 25/05/2017 Water	196288-7 SWTG2 24/05/2017 Water	196288-8 SWTG3 23/05/2017 Water	196288-9 SWTG9 23/05/2017 Water	196288-10 CC03 23/05/2017 Water
Date prepared	-	1/06/2017	1/06/2017	1/06/2017	1/06/2017	1/06/2017
Date analysed	-	1/06/2017	1/06/2017	1/06/2017	1/06/2017	1/06/2017
Arsenic - Dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Aluminium - Dissolved	mg/L	<0.1	0.1	<0.1	<0.1	<0.1
Cadmium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt - Dissolved	mg/L	<0.01	0.03	<0.01	<0.01	<0.01
Chromium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper - Dissolved	mg/L	<0.01	0.02	<0.01	<0.01	<0.01
Iron - Dissolved	mg/L	0.14	<0.02	0.58	1.4	0.53
Lead - Dissolved	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Manganese - Dissolved	mg/L	<0.01	1.8	0.25	<0.01	0.89
Nickel - Dissolved	mg/L	<0.02	0.07	<0.02	<0.02	<0.02
Uranium - Dissolved	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc - Dissolved	mg/L	<0.02	0.31	<0.02	<0.02	<0.02

Dissolved Metals in Water					
Our Reference:	UNITS	196288-11	196288-12	196288-13	196288-14
Your Reference	-----	CC02	CC01	DS12	CK7
Date Sampled	-----	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Type of sample		Water	Water	Water	Water
Date prepared	-	1/06/2017	1/06/2017	1/06/2017	1/06/2017
Date analysed	-	1/06/2017	1/06/2017	1/06/2017	1/06/2017
Arsenic - Dissolved	mg/L	<0.05	<0.05	<0.05	<0.05
Aluminium - Dissolved	mg/L	<0.1	<0.1	<0.1	<0.1
Cadmium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Cobalt - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Chromium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Copper - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Iron - Dissolved	mg/L	0.37	0.44	0.45	0.07
Lead - Dissolved	mg/L	<0.03	<0.03	<0.03	<0.03
Manganese - Dissolved	mg/L	8.9	2.8	0.02	0.38
Nickel - Dissolved	mg/L	<0.02	<0.02	<0.02	<0.02
Uranium - Dissolved	mg/L	<0.0005	<0.0005	<0.0005	<0.0005
Zinc - Dissolved	mg/L	<0.02	<0.02	<0.02	<0.02

Total Metals in water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-1 MBC0 24/05/2017 Water	196288-2 MBC1 24/05/2017 Water	196288-3 MBC3 23/05/2017 Water	196288-4 MBC6 25/05/2017 Water	196288-5 SWTG1A 25/05/2017 Water
Date digested	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Aluminium - Total	mg/L	<0.1	1.7	<0.1	<0.1	<0.1
Arsenic-Total	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium - Total	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
Cobalt - Total	mg/L	<0.01	0.07	<0.01	<0.01	<0.01
Chromium - Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper - Total	mg/L	<0.01	0.11	<0.01	<0.01	<0.01
Iron - Total	mg/L	0.49	5.5	0.69	3.6	0.73
Lead-Total	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Manganese - Total	mg/L	0.06	3.2	0.81	0.17	0.12
Nickel - Total	mg/L	<0.02	0.13	0.04	<0.02	<0.02
Uranium - Total	mg/L	<0.0005	0.0030	<0.0005	0.0006	<0.0005
Zinc - Total	mg/L	<0.02	0.63	0.19	<0.02	<0.02

Total Metals in water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-6 SWTG1 25/05/2017 Water	196288-7 SWTG2 24/05/2017 Water	196288-8 SWTG3 23/05/2017 Water	196288-9 SWTG9 23/05/2017 Water	196288-10 CC03 23/05/2017 Water
Date digested	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Aluminium - Total	mg/L	<0.1	0.2	<0.1	<0.1	<0.1
Arsenic-Total	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium - Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt - Total	mg/L	<0.01	0.03	<0.01	<0.01	<0.01
Chromium - Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper - Total	mg/L	<0.01	0.02	<0.01	<0.01	<0.01
Iron - Total	mg/L	0.16	0.26	1.5	2.0	1.3
Lead-Total	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Manganese - Total	mg/L	0.03	1.9	0.41	0.14	2.1
Nickel - Total	mg/L	<0.02	0.07	<0.02	<0.02	<0.02
Uranium - Total	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc - Total	mg/L	<0.02	0.31	0.02	<0.02	<0.02

Total Metals in water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-11 CC02 25/05/2017 Water	196288-12 CC01 25/05/2017 Water	196288-13 DS12 25/05/2017 Water	196288-14 CK7 25/05/2017 Water
Date digested	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Aluminium - Total	mg/L	<0.1	<0.1	<0.1	<0.1
Arsenic - Total	mg/L	<0.05	<0.05	<0.05	<0.05
Cadmium - Total	mg/L	<0.01	<0.01	<0.01	<0.01
Cobalt - Total	mg/L	<0.01	<0.01	<0.01	<0.01
Chromium - Total	mg/L	<0.01	<0.01	<0.01	<0.01
Copper - Total	mg/L	<0.01	<0.01	<0.01	<0.01
Iron - Total	mg/L	1.1	2.1	0.65	0.18
Lead - Total	mg/L	<0.03	<0.03	<0.03	<0.03
Manganese - Total	mg/L	9.1	3.2	0.11	0.45
Nickel - Total	mg/L	<0.02	<0.02	<0.02	<0.02
Uranium - Total	mg/L	<0.0005	<0.0005	<0.0005	<0.0005
Zinc - Total	mg/L	<0.02	<0.02	<0.02	<0.02

Cyanides in Water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-1 MBC0 24/05/2017 Water	196288-2 MBC1 24/05/2017 Water	196288-3 MBC3 23/05/2017 Water	196288-4 MBC6 25/05/2017 Water	196288-5 SWTG1A 25/05/2017 Water
Date prepared	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Free Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004

Cyanides in Water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-6 SWTG1 25/05/2017 Water	196288-7 SWTG2 24/05/2017 Water	196288-8 SWTG3 23/05/2017 Water	196288-9 SWTG9 23/05/2017 Water	196288-10 CC03 23/05/2017 Water
Date prepared	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Free Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004

Cyanides in Water Our Reference: Your Reference Date Sampled Type of sample	UNITS ----- -----	196288-11 CC02 25/05/2017 Water	196288-12 CC01 25/05/2017 Water	196288-13 DS12 25/05/2017 Water	196288-14 CK7 25/05/2017 Water
Date prepared	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Date analysed	-	31/05/2017	31/05/2017	31/05/2017	31/05/2017
Free Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004
WAD Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004
Total Cyanide	mg/L	<0.004	<0.004	<0.004	<0.004

Method ID	Methodology Summary
INORG-001	pH - Measured using pH meter and electrode base on APHA latest edition, Method 4500-H+. Please note that the results for water analyses may be indicative only, as analysis can be completed outside of the APHA recommended holding times. Soils are reported from a 1:5 water extract unless otherwise specified.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C based on APHA latest edition Method 2510. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-005	Acidity - determined by titration based on APHA latest edition, Method 2310 B. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180±5°C
INORG-022	Turbidity - measured nephelometrically using a turbidimeter, in accordance with APHA latest edition, 2130 B.
METALS-020	Metals in soil and water by ICP-OES.
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition, Method 2320-B. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110 -B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
INORG-040	Ion Balance Calculation: Cations in water by ICP-OES; Anions in water by IC; Alkalinity in water by Titration using APHA methods.
METALS-008	Hardness calculated from Calcium and Magnesium as per APHA latest edition 2340B.
METALS-022	Determination of various metals by ICP-MS.
INORG-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids are extracted in a caustic media prior to analysis.

Client Reference: TG17

QUALITYCONTROL	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results	Spike Sm#	Spike % Recovery
Miscellaneous Inorganics						Base II Duplicate II %RPD		
Date prepared	-			01/06/2017	196288-11	01/06/2017 01/06/2017	LCS-1	01/06/2017
Date analysed	-			01/06/2017	196288-11	01/06/2017 01/06/2017	LCS-1	01/06/2017
pH	pH Units		INORG-001	[NT]	196288-11	7.4 7.4 RPD: 0	LCS-1	101%
Electrical Conductivity (EC)	µS/cm	1	INORG-002	<1	196288-11	440 440 RPD: 0	LCS-1	100%
Acidity as CaCO ₃	mg/L	5	INORG-005	<5	196288-11	<5 5	LCS-1	99%
Total Dissolved Solids (grav)	mg/L	5	INORG-018	<5	196288-11	260 260 RPD: 0	LCS-1	97%
Turbidity	NTU	0.1	INORG-022	<0.1	196288-11	3.0 [N/T]	[NR]	[NR]
QUALITYCONTROL	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results	Spike Sm#	Spike % Recovery
Ionic Balance						Base II Duplicate II %RPD		
Date prepared	-			31/05/2017	196288-11	31/05/2017 31/05/2017	LCS-1	31/05/2017
Date analysed	-			31/05/2017	196288-11	31/05/2017 31/05/2017	LCS-1	31/05/2017
Calcium - Dissolved	mg/L	0.5	METALS-020	<0.5	196288-11	31 30 RPD: 3	LCS-1	99%
Potassium - Dissolved	mg/L	0.5	METALS-020	<0.5	196288-11	5.6 5.4 RPD: 4	LCS-1	102%
Magnesium - Dissolved	mg/L	0.5	METALS-020	<0.5	196288-11	24 24 RPD: 0	LCS-1	100%
Sodium - Dissolved	mg/L	0.5	METALS-020	<0.5	196288-11	12 12 RPD: 0	LCS-1	103%
Bicarbonate HCO ₃ as CaCO ₃	mg/L	5	INORG-006	<5	196288-11	89 90 RPD: 1	LCS-1	101%
Carbonate CO ₃ ²⁻ - as CaCO ₃	mg/L	5	INORG-006	<5	196288-11	<5 <5	LCS-1	101%
Total Alkalinity as CaCO ₃	mg/L	5	INORG-006	<5	196288-11	89 90 RPD: 1	LCS-1	101%
Chloride	mg/L	1	INORG-081	<1	196288-11	5 5 RPD: 0	LCS-1	98%
Sulphate	mg/L	1	INORG-081	<1	196288-11	130 130 RPD: 0	LCS-1	105%
Hardness as CaCO ₃	mg/L	3	METALS-008	<3	196288-11	180 [N/T]	[NR]	[NR]

Client Reference: TG17

QUALITY CONTROL	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results	Spike Sm#	Spike % Recovery
Dissolved Metals in Water						Base II Duplicate II %RPD		
Date prepared	-			1/06/2017	196288-11	1/06/2017 1/06/2017	LCS-1	1/06/2017
Date analysed	-			1/06/2017	196288-11	1/06/2017 1/06/2017	LCS-1	1/06/2017
Arsenic - Dissolved	mg/L	0.05	METALS-020	<0.05	196288-11	<0.05 <0.05	LCS-1	105%
Aluminium - Dissolved	mg/L	0.1	METALS-020	<0.1	196288-11	<0.1 <0.1	LCS-1	103%
Cadmium - Dissolved	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	104%
Cobalt - Dissolved	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	105%
Chromium - Dissolved	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	104%
Copper - Dissolved	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	103%
Iron - Dissolved	mg/L	0.02	METALS-020	<0.02	196288-11	0.37 0.36 RPD: 3	LCS-1	105%
Lead - Dissolved	mg/L	0.03	METALS-020	<0.03	196288-11	<0.03 <0.03	LCS-1	100%
Manganese - Dissolved	mg/L	0.01	METALS-020	<0.01	196288-11	8.9 8.8 RPD: 1	LCS-1	100%
Nickel - Dissolved	mg/L	0.02	METALS-020	<0.02	196288-11	<0.02 <0.02	LCS-1	101%
Uranium - Dissolved	mg/L	0.0005	METALS-022	<0.0005	196288-11	<0.0005 <0.0005	LCS-1	99%
Zinc - Dissolved	mg/L	0.02	METALS-020	<0.02	196288-11	<0.02 <0.02	LCS-1	101%

Client Reference: TG17

QUALITYCONTROL	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results	Spike Sm#	Spike % Recovery
Total Metals in water						Base Duplicate %RPD		
Date digested	-			31/05/2017	196288-11	31/05/2017 31/05/2017	LCS-1	31/05/2017
Date analysed	-			31/05/2017	196288-11	31/05/2017 31/05/2017	LCS-1	31/05/2017
Aluminium - Total	mg/L	0.1	METALS-020	<0.1	196288-11	<0.1 <0.1	LCS-1	105%
Arsenic-Total	mg/L	0.05	METALS-020	<0.05	196288-11	<0.05 <0.05	LCS-1	100%
Cadmium - Total	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	99%
Cobalt - Total	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	100%
Chromium - Total	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	99%
Copper - Total	mg/L	0.01	METALS-020	<0.01	196288-11	<0.01 <0.01	LCS-1	108%
Iron - Total	mg/L	0.02	METALS-020	<0.02	196288-11	1.1 1.2 RPD: 9	LCS-1	101%
Lead-Total	mg/L	0.03	METALS-020	<0.03	196288-11	<0.03 <0.03	LCS-1	104%
Manganese - Total	mg/L	0.01	METALS-020	<0.01	196288-11	9.1 10 RPD: 9	LCS-1	104%
Nickel - Total	mg/L	0.02	METALS-020	<0.02	196288-11	<0.02 <0.02	LCS-1	105%
Uranium - Total	mg/L	0.0005	METALS-022	<0.0005	196288-11	<0.0005 <0.0005	LCS-1	106%
Zinc - Total	mg/L	0.02	METALS-020	<0.02	196288-11	<0.02 <0.02	LCS-1	105%

Client Reference: TG17

QUALITY CONTROL	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results	Spike Sm#	Spike % Recovery
Cyanides in Water						Base Duplicate %RPD		
Date prepared	-			31/05/2017	196288-11	31/05/2017 31/05/2017	[NR]	[NR]
Date analysed	-			31/05/2017	196288-11	31/05/2017 31/05/2017	[NR]	[NR]
Free Cyanide	mg/L	0.004	INORG-014	<0.004	196288-11	<0.004 <0.004	[NR]	[NR]
WAD Cyanide	mg/L	0.004	INORG-014	<0.004	196288-11	<0.004 <0.004	[NR]	[NR]
Total Cyanide	mg/L	0.004	INORG-014	<0.004	196288-11	<0.004 <0.004	[NR]	[NR]
QUALITY CONTROL Miscellaneous Inorganics		UNITS	Dup. Sm#		Duplicate Base + Duplicate + %RPD			
Date prepared		-	196288-10		01/06/2017 31/05/2017			
Date analysed		-	196288-10		01/06/2017 31/05/2017			
Turbidity		NTU	196288-10		7.4 7.4 RPD: 0			
QUALITY CONTROL Total Metals in water		UNITS	Dup. Sm#		Duplicate Base + Duplicate + %RPD		Spike Sm#	Spike % Recovery
Date digested		-	[NT]		[NT]		196288-12	31/05/2017
Date analysed		-	[NT]		[NT]		196288-12	31/05/2017
Aluminium - Total		mg/L	[NT]		[NT]		196288-12	113%
Arsenic-Total		mg/L	[NT]		[NT]		196288-12	103%
Cadmium - Total		mg/L	[NT]		[NT]		196288-12	102%
Cobalt - Total		mg/L	[NT]		[NT]		196288-12	104%
Chromium - Total		mg/L	[NT]		[NT]		196288-12	103%
Copper - Total		mg/L	[NT]		[NT]		196288-12	112%
Iron - Total		mg/L	[NT]		[NT]		196288-12	100%
Lead-Total		mg/L	[NT]		[NT]		196288-12	106%
Manganese - Total		mg/L	[NT]		[NT]		196288-12	96%
Nickel - Total		mg/L	[NT]		[NT]		196288-12	108%
Uranium - Total		mg/L	[NT]		[NT]		196288-12	104%
Zinc - Total		mg/L	[NT]		[NT]		196288-12	107%

Client Reference: TG17

QUALITYCONTROL Miscellaneous Inorganics	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD		
Date prepared	-	196288-1	01/06/2017 01/06/2017		
Date analysed	-	196288-1	01/06/2017 01/06/2017		
Acidity as CaCO ₃	mg/L	196288-1	<5 <5		
QUALITYCONTROL Ionic Balance	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	196288-1	31/05/2017 31/05/2017	196288-2	31/05/2017
Date analysed	-	196288-1	31/05/2017 31/05/2017	196288-2	31/05/2017
Calcium - Dissolved	mg/L	196288-1	1.6 1.6 RPD: 0	196288-2	83%
Potassium - Dissolved	mg/L	196288-1	0.6 0.6 RPD: 0	196288-2	102%
Magnesium - Dissolved	mg/L	196288-1	1.1 1.2 RPD: 9	196288-2	101%
Sodium - Dissolved	mg/L	196288-1	2.8 2.9 RPD: 4	196288-2	106%
Chloride	mg/L	196288-1	4 4 RPD: 0	196288-2	97%
Sulphate	mg/L	196288-1	2 3 RPD: 40	196288-2	101%
QUALITYCONTROL Dissolved Metals in Water	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	196288-1	1/06/2017 1/06/2017	196288-2	1/06/2017
Date analysed	-	196288-1	1/06/2017 1/06/2017	196288-2	1/06/2017
Arsenic - Dissolved	mg/L	196288-1	<0.05 <0.05	196288-2	107%
Aluminium - Dissolved	mg/L	196288-1	<0.1 <0.1	196288-2	104%
Cadmium - Dissolved	mg/L	196288-1	<0.01 <0.01	196288-2	106%
Cobalt - Dissolved	mg/L	196288-1	<0.01 <0.01	196288-2	106%
Chromium - Dissolved	mg/L	196288-1	<0.01 <0.01	196288-2	105%
Copper - Dissolved	mg/L	196288-1	<0.01 <0.01	196288-2	104%
Iron - Dissolved	mg/L	196288-1	0.23 0.24 RPD: 4	196288-2	111%
Lead - Dissolved	mg/L	196288-1	<0.03 <0.03	196288-2	100%
Manganese - Dissolved	mg/L	196288-1	0.02 0.02 RPD: 0	196288-2	99%
Nickel - Dissolved	mg/L	196288-1	<0.02 <0.02	196288-2	103%
Uranium - Dissolved	mg/L	196288-1	<0.0005 [N/T]	196288-2	104%
Zinc - Dissolved	mg/L	196288-1	<0.02 <0.02	196288-2	101%

Client Reference: TG17

QUALITYCONTROL Cyanides in Water	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	196288-1	31/05/2017 31/05/2017	196288-2	31/05/2017
Date analysed	-	196288-1	31/05/2017 31/05/2017	[NR]	[NR]
Free Cyanide	mg/L	196288-1	<0.004 <0.004	196288-2	108%
WAD Cyanide	mg/L	196288-1	<0.004 <0.004	196288-2	105%
Total Cyanide	mg/L	196288-1	<0.004 <0.004	196288-2	103%

Report Comments:

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike: A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample): This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Appendix C – Raw Macroinvertebrate Data

Class/Order	Family/Sub-family	SWTG1	SWTG1	SWTG1A	SWTG1A	SWTG2	SWTG2	SWTG3	SWTG3	MBC0	MBC0
Replicate		1	2	1	2	1	2	1	2	1	2
Acarina		10	40	90	110	20	24	18	27	0	12
Bivalvia	Hyriidae	0	0	0	0	0	0	5	0	0	0
Coleoptera	Dytiscidae	20	20	1	70	72	36	9	80	100	9
Coleoptera	Elmidae	10	0	50	10	0	4	0	0	0	3
Coleoptera	Gyrinidae	0	0	1	10	0	12	0	0	0	0
Coleoptera	Hydraenidae	10	30	10	0	16	20	0	0	0	0
Coleoptera	Hydrochidae	50	50	220	20	52	112	5	0	30	21
Coleoptera	Hydrophilidae	0	0	20	20	0	32	5	0	27	3
Decapoda	Atyidae	20	0	0	1	0	0	5	13	17	0
Decapoda	Palaemonidae	20	0	0	0	4	0	9	0	13	12
Diptera	Ceratopogonidae	50	20	10	60	48	164	55	33	30	24
Diptera	Chaoboridae	0	20	0	0	0	0	5	0	0	0
Diptera	Chironominae	410	350	230	140	180	76	132	107	63	197
Diptera	Culicidae	30	0	0	30	20	12	0	7	53	3
Diptera	Dolichopodidae	0	0	0	0	0	0	0	0	0	0
Diptera	Empididae	0	0	0	0	0	0	0	0	0	0
Diptera	Muscidae	0	0	0	0	0	0	0	0	0	0
Diptera	Orthoclaadiinae	0	10	0	20	0	0	5	7	0	0
Diptera	Simuliidae	0	0	0	0	0	0	0	0	0	0
Diptera	Stratiomyidae	0	0	0	0	0	0	0	0	0	0
Diptera	Tabanidae	0	0	0	0	0	20	0	0	0	0
Diptera	Tanypodinae	120	270	310	230	168	56	164	167	103	97
Diptera	Tipulidae	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae	170	70	10	10	32	0	14	7	23	18
Ephemeroptera	Caenidae	1180	990	1090	1280	216	44	282	533	103	212
Ephemeroptera	Leptophlebiidae	20	20	0	0	32	4	9	33	3	6
Gastropoda	Ancylidae	20	0	30	0	0	0	0	0	0	3
Gastropoda	Planorbidae	0	0	0	0	0	0	0	13	0	0
Hemiptera	Belostomatidae	0	0	0	0	0	0	0	0	0	0
Hemiptera	Gelastocoridae	0	0	0	0	0	0	0	0	0	0
Hemiptera	Gerridae	0	0	0	10	8	0	0	0	60	3
Hemiptera	Hydrometridae	0	0	0	0	0	12	0	0	77	3
Hemiptera	Mesoveliidae	10	10	0	20	4	8	0	7	3	0
Hemiptera	Micronectidae	0	0	0	40	4	4	18	20	10	0
Hemiptera	Nepidae	0	0	0	0	0	0	0	0	0	0
Hemiptera	Notonectidae	10	20	0	0	4	4	0	0	3	0
Hemiptera	Ochteridae	0	0	0	0	0	0	0	0	0	0
Hemiptera	Pleidae	10	10	0	10	4	4	0	0	0	3
Hemiptera	Veliidae	10	20	10	10	4	28	5	0	43	9
Hirudinea	Arhynchobdellida	0	0	0	0	4	0	0	0	0	0
Hirudinea	Glossiphoniidae	0	0	0	0	0	0	0	0	0	0
Hirudinea		0	0	0	0	0	0	0	0	0	3
Hydrazoa	Hydridae	0	0	0	0	0	0	0	0	0	0
Neuroptera	Sisyridae	0	0	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0	0	0	0	0

Class/Order	Family/Sub-family	SWG1	SWG1	SWG1A	SWG1A	SWG2	SWG2	SWG3	SWG3	MBC0	MBC0
Odonata	Corduliidae	0	0	0	0	0	0	0	0	0	0
Odonata	Epiprocta sp.	0	0	0	0	4	0	0	0	0	3
Odonata	Libellulidae	0	0	0	10	0	4	0	0	0	0
Odonata	Lindenidae	0	0	0	0	0	0	0	1	0	0
Odonata	Platycnemidae	0	0	0	0	0	0	0	0	0	0
Odonata	Zygoptera sp.	0	0	0	0	0	4	0	7	0	0
Oligochaeta		0	0	0	0	40	4	18	33	7	3
Trichoptera	Calamoceratidae	0	0	0	0	4	0	14	27	13	0
Trichoptera	Ecnomidae	0	0	0	0	0	8	0	0	0	3
Trichoptera	Hydroptilidae	0	0	0	0	0	0	0	7	0	0
Trichoptera	Leptoceridae	270	70	130	180	84	120	186	307	113	15

Class/Order	Family/Sub-family	SWG9	SWG9	MBC01	MBC01	MBC03	MBC03	MBC06	MBC06
Replicate		1	2	1	2	1	2	1	2
Acarina		20	26	3	0	0	0	20	0
Bivalvia	Hyriidae	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	5	5	50	0	4	0	180	117
Coleoptera	Elmidae	0	0	2	0	0	6	40	0
Coleoptera	Gyrinidae	0	1	0	0	0	2	0	0
Coleoptera	Hydraenidae	35	11	3	6	3	0	7	0
Coleoptera	Hydrochidae	10	0	47	2	13	5	240	50
Coleoptera	Hydrophilidae	5	0	5	4	3	0	20	242
Decapoda	Atyidae	55	21	0	0	0	2	0	8
Decapoda	Palaemonidae	0	5	0	0	0	3	0	25
Diptera	Ceratopogonidae	20	5	17	30	25	2	253	242
Diptera	Chaoboridae	15	16	0	22	6	0	0	0
Diptera	Chironominae	30	47	88	266	95	88	187	458
Diptera	Culicidae	45	5	2	20	14	1	0	75
Diptera	Dolichopodidae	0	0	0	0	0	0	0	8
Diptera	Empididae	0	0	0	0	0	0	7	0
Diptera	Muscidae	0	5	0	0	0	0	0	0
Diptera	Orthocladinae	0	0	0	0	1	1	0	8
Diptera	Simuliidae	0	0	0	0	0	0	0	0
Diptera	Stratiomyidae	0	0	0	0	0	0	0	0
Diptera	Tabanidae	0	0	0	0	0	0	7	0
Diptera	Tanypodinae	140	174	11	98	32	45	47	442
Diptera	Tipulidae	5	0	0	0	1	0	0	0
Ephemeroptera	Baetidae	50	68	2	0	0	19	7	8
Ephemeroptera	Caenidae	390	216	2	2	0	76	0	275
Ephemeroptera	Leptophlebiidae	10	47	0	0	0	2	7	75
Gastropoda	Ancylidae	275	405	0	4	0	1	0	0
Gastropoda	Planorbidae	0	0	0	0	0	0	0	0
Hemiptera	Belostomatidae	0	0	0	0	0	0	0	0
Hemiptera	Gelastocoridae	0	0	0	0	0	0	7	0
Hemiptera	Gerridae	5	5	0	0	0	1	13	17
Hemiptera	Hydrometridae	0	0	0	0	0	0	13	25

Class/Order	Family/Sub-family	SWTG9	SWTG9	MBC01	MBC01	MBC03	MBC03	MBC06	MBC06
Hemiptera	Mesoveliidae	0	5	11	0	2	1	20	33
Hemiptera	Micronectidae	50	16	2	0	0	1	7	0
Hemiptera	Nepidae	0	0	0	0	0	0	7	0
Hemiptera	Notonectidae	0	5	0	0	0	0	7	8
Hemiptera	Ochteridae	0	0	0	2	0	0	0	0
Hemiptera	Pleidae	0	0	2	0	0	0	0	0
Hemiptera	Veliidae	0	5	6	0	2	0	87	25
Hirudinea	Arhynchobdellida	0	0	0	0	0	0	0	0
Hirudinea	Glossiphoniidae	5	0	0	0	0	0	0	0
Hirudinea		0	0	0	0	0	0	0	0
Hydrazoa	Hydridae	0	0	0	0	0	0	0	0
Neuroptera	Sisyridae	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0	0	0
Odonata	Corduliidae	0	0	0	0	0	0	0	0
Odonata	Epiprocta sp.	0	0	0	10	2	1	33	8
Odonata	Libellulidae	0	0	0	0	0	0	0	0
Odonata	Lindeniidae	0	0	0	0	0	0	0	0
Odonata	Platycnemidae	0	0	2	0	0	0	0	0
Odonata	Zygoptera sp.	0	0	0	0	0	0	0	0
Oligochaeta		55	5	2	20	5	2	13	125
Trichoptera	Calamoceratidae	0	0	3	0	0	1	27	58
Trichoptera	Ecnomidae	5	0	2	0	0	0	13	0
Trichoptera	Hydroptilidae	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	0	11	55	2	1	9	193	392

Class/Order	Family/Sub-family	CC01	CC01	CC02	CC02	CC03	CC03	CC07	CC07
Replicate		1	2	1	2	1	2	1	2
Acarina		20	0	108	90	20	62.5	25	25
Bivalvia	Hyriidae	0	0	0	0	20	13	8	1
Coleoptera	Dytiscidae	50	0	17	30	20	63	58	13
Coleoptera	Elmidae	0	0	0	0	0	0	0	13
Coleoptera	Gyrinidae	0	0	0	0	0	0	0	0
Coleoptera	Hydraenidae	70	50	0	30	100	38	42	50
Coleoptera	Hydrochidae	130	140	25	80	20	25	50	63
Coleoptera	Hydrophilidae	10	10	8	0	1	1	0	125
Decapoda	Atyidae	0	0	0	0	0	13	0	0
Decapoda	Palaemonidae	10	10	1	0	1	0	0	0
Diptera	Ceratopogonidae	10	160	67	110	160	200	67	113
Diptera	Chaoboridae	0	0	0	0	0	0	0	0
Diptera	Chironominae	200	200	275	110	1080	300	200	413
Diptera	Culicidae	170	120	58	10	240	113	67	113
Diptera	Dolichopodidae	0	0	0	0	0	0	0	0
Diptera	Empididae	0	0	0	0	0	0	0	0
Diptera	Muscidae	0	0	0	10	0	0	0	0
Diptera	Orthocladiinae	0	10	8	0	0	0	0	13
Diptera	Simuliidae	0	0	8	0	0	0	0	0
Diptera	Stratiomyidae	0	0	0	0	20	0	0	0
Diptera	Tabanidae	0	0	0	0	0	0	0	0

Class/Order	Family/Sub-family	CC01	CC01	CC02	CC02	CC03	CC03	CC07	CC07
Diptera	Tanypodinae	460	270	267	740	1760	813	267	463
Diptera	Tipulidae	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae	50	10	67	100	0	13	42	38
Ephemeroptera	Caenidae	490	670	300	220	2460	1025	792	925
Ephemeroptera	Leptophlebiidae	40	20	8	10	200	13	0	25
Gastropoda	Ancylidae	190	70	108	90	240	0	42	38
Gastropoda	Planorbidae	0	0	0	0	0	0	0	0
Hemiptera	Belostomatidae	0	0	0	0	0	1	0	0
Hemiptera	Gelastocoridae	0	0	0	0	0	0	0	0
Hemiptera	Gerridae	30	0	0	10	20	0	17	1
Hemiptera	Hydrometridae	0	10	0	0	0	0	8	0
Hemiptera	Mesoveliidae	20	10	17	0	60	0	8	38
Hemiptera	Micronectidae	20	170	25	100	0	13	42	38
Hemiptera	Nepidae	0	0	0	0	0	0	0	0
Hemiptera	Notonectidae	0	0	0	0	0	13	1	0
Hemiptera	Ochteridae	0	0	0	0	0	0	0	0
Hemiptera	Pleidae	0	0	0	0	0	0	0	0
Hemiptera	Veliidae	0	20	8	10	80	38	8	25
Hirudinea	Arhynchobdellida	0	0	0	0	0	0	0	0
Hirudinea	Glossiphoniidae	0	0	0	0	0	0	0	13
Hirudinea		0	0	0	0	0	0	0	0
Hydrazoa	Hydridae	0	10	0	0	0	0	0	0
Neuroptera	Sisyridae	0	0	0	0	0	13	0	13
Odonata	Coenagrionidae	50	40	0	0	0	0	0	0
Odonata	Corduliidae	0	0	0	0	1	1	0	0
Odonata	Epiprocta sp.	10	10	8	0	0	0	0	0
Odonata	Libellulidae	10	0	42	60	0	0	0	0
Odonata	Lindenidae	0	0	0	0	0	0	0	0
Odonata	Platycnemidae	0	0	0	0	0	0	0	0
Odonata	Zygoptera sp.	0	0	0	0	0	0	0	0
Oligochaeta		80	140	100	80	100	75	0	63
Trichoptera	Calamoceratidae	10	20	0	0	40	1	25	0
Trichoptera	Ecnomidae	0	0	0	0	0	0	8	0
Trichoptera	Hydroptilidae	0	20	0	0	0	0	0	0
Trichoptera	Leptoceridae	70	170	192	130	340	150	192	275

Appendix D – Remote Cameras Species List

Scientific Name	Common Name	Listing		Camera Unit					
		EPBC	NT	M1	M2	M3	M4	M5	M6
<i>Ardea pacifica</i>	White-necked Heron			✓					
<i>Butorides striata</i>	Striated Heron					✓			
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo					✓			
<i>Centropus phasianinus</i>	Pheasant Coucal						✓		
<i>Corvus orru</i>	Torresian Crow						✓		
<i>Felis catus</i>	Cat					✓			
<i>Geopelia humeralis</i>	Bar-shouldered Dove				✓	✓			
<i>Haliastur sphenurus</i>	Whistling Kite					✓			
<i>Hydromys chrysogaster</i>	Water Rat				✓	✓			✓
<i>Macropus agilis</i>	Agile Wallaby			✓	✓	✓	✓	✓	✓
<i>Nycticorax caledonicus</i>	Nankeen Night Heron				✓		✓	✓	
<i>Pitta iris</i>	Rainbow Pitta								✓
<i>Rattus tunneyi</i>	Pale Field Rat		VU		✓		✓	✓	✓
<i>Rhinella marina</i>	Cane Toad			✓	✓	✓	✓	✓	✓
<i>Sus scrofa</i>	Pig			✓	✓	✓	✓	✓	✓
<i>Threskiornis moluccus</i>	Australian White Ibis				✓	✓		✓	✓
<i>Threskiornis spinicollis</i>	Straw-necked Ibis				✓	✓	✓		
<i>Varanus mertensi</i>	Mertens Water Monitor		VU			✓			

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OfficeAddressLine1

OfficeAddressLine2

T: OfficeTelephone F: OfficeFax E: OfficeEmail

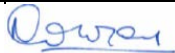
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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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