PRIMARY GOLD

Appendix Q - Macroinvertebrate and Sediment Monitoring

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Sediment and macroinvertebrate results April 2021

Rustlers Roost

Primary Gold Pty Ltd

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ACRONYMS

ADP	Authorised discharge point
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2018
BOM	Bureau of Meteorology
DGV	Default Guideline Values
DO	Dissolved oxygen
EC	Electrical conductivity
EPA	Environment Protection Authority
LOR	Limit of reporting
NATA	National Association of Testing Authorities
NT	Northern Territory
PET	Plecoptera, Ephemeroptera, Trichoptera
RRPA	Rustlers Roost Project Area
SOCS	Sites of Conservation Significance
TOC	Total organic carbon
WDL	Waste Discharge License

1 INTRODUCTION

The Rustlers Roost Project Area (RRPA) is located approximately 100 km south-east of Darwin. The mine is in care and maintenance and has not been operational since 1997, but is currently undergoing the process to recommence mining.

EcOz Environmental Consultants (EcOz) was engaged by Primary Gold Pty Ltd (PGO) to conduct sediment and macroinvertebrate sampling at the RRPA, which is required annually according to the Sediment and Macroinvertebrate monitoring plan Rustlers Roost (EcOz 2021) and in fulfilment of the Water Discharge License (WDL247).

1.1 Background

The RRPA is licensed to conduct controlled discharge of pit water in accordance with WDL247 issued by the Northern Territory (NT) Environment Protection Authority (EPA) under the NT *Water Act* on 22 June 2021. As per WDL247, Primary Gold Pty Ltd (PG) are required to comply with the following levels of protection to the receiving environment:

- 95% species protection for freshwater ecosystems (Australian and New Zealand Guideline for Fresh and Marine Water Quality ANZG, 2018)
- Minimal change in water/sediment chemical and physical properties beyond natural variation
- Biological communities remain in a healthy condition and ecosystem integrity is largely retained.

The area surrounding the site includes numerous unnamed small creeks, Mt Bundey Creek which feed into the Mary River as well as Marrakai Creek which terminates into the Adelaide River. The Mary River coastal floodplain is listed as a site of conservation significance (SOCS) (NT GOV) as it provides habitat to 12 threatened species and a large number of bird species. The Adelaide River is also listed as a SOCS and is home to possibly the largest colony of egrets in Australia as well as providing habitat to 14 threatened species.

WDL247 authorises discharge of pit water through two Authorised Discharge Points ADP1 and ADP2 into Marrakai Creek and Mount Bundey Creek respectively.

1.2 Purpose and Scope

Primary Gold Limited (PGO) engaged EcOz Environmental Consultants (EcOz) to conduct sediment and macroinvertebrate sampling on the Rustlers Roost mineral lease prior to the dewatering of the Rustlers Roost pit. This will form a baseline data range to compare data to collected during the dewatering process, in order to assess whether dewatering activities conducted on site might have caused environmental harm downstream.

This report presents the following information:

- Sediment and macroinvertebrate sampling methods for field work undertaken in April 2021
- Field and laboratory results from the April 2021 sampling
- An assessment of the sediment and macroinvertebrate monitoring program to adequately meet the requirements of WDL247.

2 SEDIMENT AND MACROINVERTEBRATE SAMPLING PROGRAM

2.1 Sample sites

According to the *Sediment and Macroinvertebrate Monitoring Plan* (EcOz 2021), sediment samples require collection from five sites that are located along streams and creeks to the east and west of the Rustlers Roost pit lake with macroinvertebrate samples being collected from four of these sites (all except RRSW2). These locations are shown in Figure 2-1, with the location's coordinates and descriptions provided in Table 2-1 below.

Table 2-1. Sediment and macroinvertebrate monitoring locations and descriptions

Site ID	Latitude	Longitude	Description	Purpose	Monitoring
RRMCUS	12.9196239°S	131.4809763°E	Marrakai creek upstream site	Control	Sediment and macroinvertebrate
RRMCDS	12.9049505°S	131.4695765°E	Marrakai creek downstream site	Impact	Sediment and macroinvertebrate
RRSW2	12.92867°S	131.50156°E	Upper Mount Bundey Creek tributary upstream, adjacent to leach heap pad	Impact	Sediment
RRSW23	12.930765°S	131.50637°E	Upper Mount Bunt Creek tributary upstream	Impact	Sediment and macroinvertebrate
Q29SW2	12.914634°S	131.52644°E	Upper Mount Bundey Creek tributary downstream	Impact	Sediment and macroinvertebrate

2.2 Water Quality

In-situ water quality was measured at each site where macroinvertebrate samples were taken (four sites). Measurements were taken for pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), and Temperature using a pre-calibrated Pro DSS instrument.

2.3 Sediment sampling method

All sampling complied with Simpson & Batley (2016). This method was developed to ensure that all sampling events are repeatable and produce comparable data. The sampling method is as follows:

- Sediment samples are taken from reasonably straight river reaches and from the primary or low flow channel when multiple channels are present.
- Nitrile gloves are worn while sampling with new gloves for each sampling site to avoid cross contamination.
- Sediments are either collected with a grab sampler or trowel/shovel (stainless steel or plastic).
- Five sub-samples are collected (approximately 1 kg in total) from a cross section of the stream bed between the surface and a depth of 1-100 mm.
- Sub-sampling locations are evenly spaced across the stream bed at the sampling site.
- Sub-samples are combined and mixed thoroughly in a clean decontaminated bucket to homogenise.

- A sample is taken from the bucket and placed into a laboratory supplied sample jar or plastic zip-lock bag without air gap that is labelled accordingly.
- Samples are kept refrigerated until submitted to the analysing laboratory.
- Field observations are recorded for each sampling location on a sediment sampling field data sheet.

2.4 Sediment analysis parameters

Sediment samples were analysed by a NATA accredited laboratory for the following parameters:

- Particle sizing
- Moisture content
- Metals (Al, Sb, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Pb, Mn, Ni, Ag, V, Zn, B, Mo, Sr, Se, U, Hg)
- Cyanide
- Total organic Carbon (TOC)

2.5 Sediment assessment guidelines

EcOz adopted the ANZG (2018) recommended default guideline values (DVGs) for toxicants in sediment (low to high). These consist of the upper and lower DVGs for metals and metalloids, which are presented in Table 2-2.

Table 2-2. Assessment guideline values for sediment samples

Metals	Units	DVG-low	DVG-high
Antimony	mg/kg	2.0	25
Cadmium	mg/kg	1.5	10
Chromium	mg/kg	80	370
Copper	mg/kg	65	270
Lead	mg/kg	50	220
Mercury	mg/kg	0.15	1.0
Nickel	mg/kg	21	52
Silver	mg/kg	1.0	4.0
Zinc	mg/kg	200	410
Arsenic	mg/kg	20	70

DGV: default guideline value

Macroinvertebrate sampling method

Macroinvertebrate samples were collected following the method from the *User Manual for the Darwin-Daly Regional AUSRIVAS Models – Northern Territory* (Lamche 2007). The key steps are:

- Disturbance of a 5-10m straight creek section in a low flow area by the first person using a three pronged rake.
- Passing of a 500µm mesh net (D-shaped with 35cm opening) in a sweeping motion immediately behind the rake by a second operator to collect all disturbed matter before contents are deposited in a bucket and net is thoroughly rinsed to remove all remaining debris and macroinvertebrates.

- Stirring of collected material in bucket to separate inorganic sediments from organic material before slowly pouring through nested 10mm and 500µm sieves. Coarse fraction inspected for any macroinvertebrates before being discarded.
- Contents of fine sieve is gently washed into 500ml plastic wide mouth sample jar and preserved with ethanol.
- Muslin cloth is placed in sample jar prior to sealing to prevent jostling and potential damage to samples in transit to laboratory.
- Sample jars are labelled and stored in eskies before being shipped to an accredited taxonomist, who then sends five percent of identified samples to a second independent accredited taxonomist for quality assurance and control.

In addition to photographs taken at each site, information on habitats sampled and surrounding in-stream and riparian areas was recorded, including the following (see Appendix A):

- Stream width (i.e. at water level)
- Bank full widths and depths (i.e. levy banks)
- Water depth at sample location
- Stream discharge (estimated visually)
- Flow at sample location (estimated visually)
- Dominant substrates at sample location
- Riparian canopy cover (estimated visually)
- Riparian disturbance (i.e. weeds, feral animals, fire).

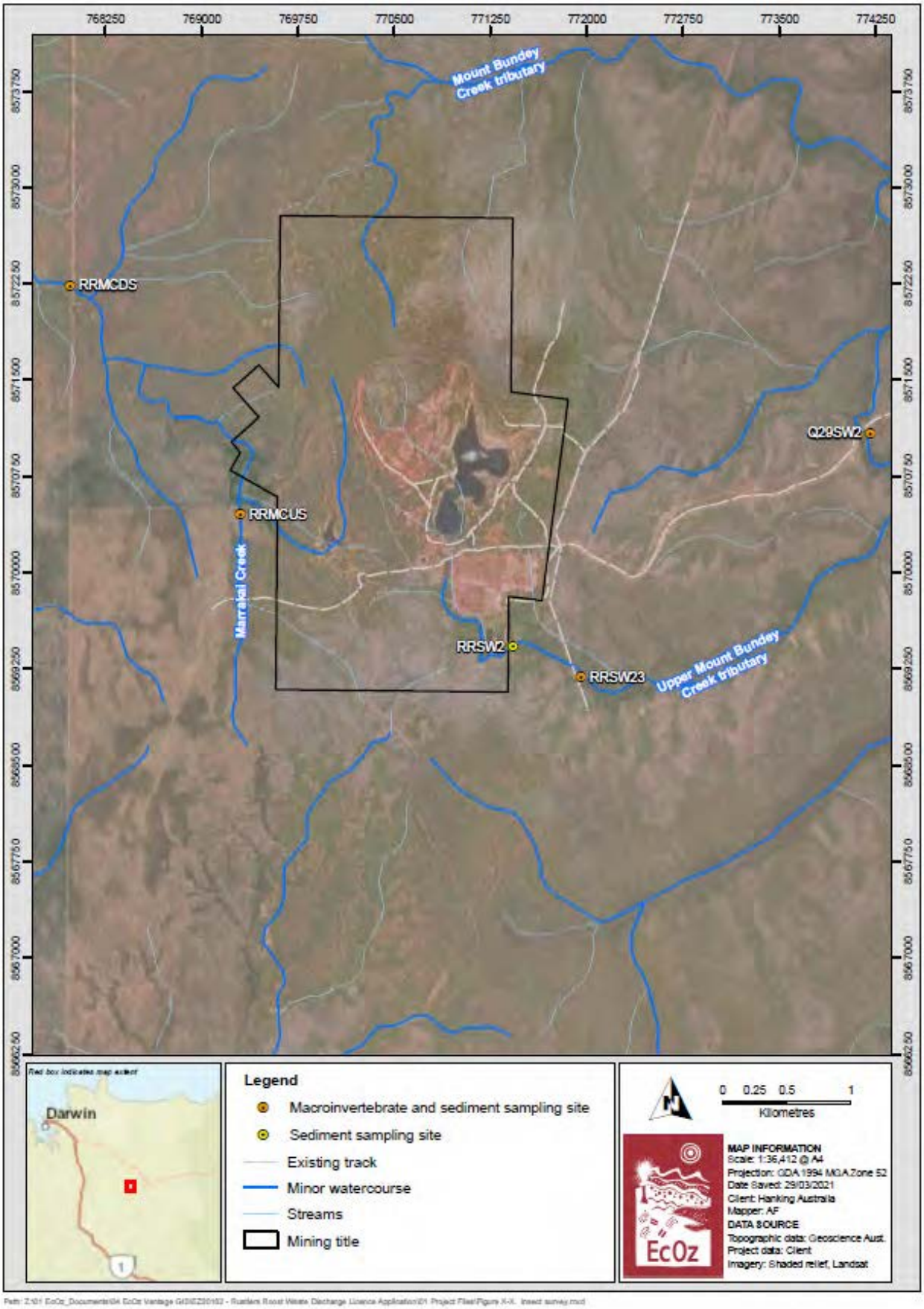

Figure 2-1. Rustlers Roost Project Area sample locations

3 RESULTS AND DISCUSSION

All field work was undertaken on 14 +15 April 2021. All sites were flowing at time of sampling. At all sites access by cattle was apparent.

3.1 Description of macroinvertebrate sampling locations

RRMCUS:

The site was characterised by grassy edges with few scrubs and trees. The water was flowing with some apparent turbidity.

RRMCDS:

The riparian vegetation consisted of paperbark trees and other shrubs and trees with few grasses. The water was flowing and slightly turbid.

	RRSW23: The site was characterised by mostly shrubs and trees lining the creek, providing shade and ample edge habitat for macroinvertebrates. The water was flowing and relatively turbid.
	Q29SW2: This site was the furthest downstream with well-established riparian tree and scrub vegetation shading the creek. The water was flowing and relatively turbid.

Figure 3-1. Photos of sampling locations

3.2 Water quality

Physical water quality parameters were recorded at each macroinvertebrate site and compared with the ANZECC (2000) guidelines for upland rivers of tropical Australia (Table 3-1).

Table 3-1. Physical water parameters

Site ID	Date	pH	Temperature	EC	DO	Turbidity
			°C	µS/cm	%	NTU
ANZECC (2000) – tropical Australia, upland rivers		**6-7.5**	**-**	**20-250**	**90-120**	**15**
RRMCUS	**15-04-21**	6.19	27.3	21.9	87.6	24.5
RRMCDS	**15-04-21**	6.31	30.5	21.7	101.5	9.2
RRSW23	**14-04-21**	7.32	30.7	124.3	116.5	14.2
Q29SW2	**14-04-21**	6.6	27.3	44.6	80.6	21

Two sites, RRMCUS and Q29SW2, recorded DO saturation below the guideline and exceeded the turbidity guidelines. These low DO concentrations were similar to the ones recorded at Q29SW2 between January and May 2021, whilst turbidity was often much higher than the values recorded between January and May 2021.

The two sites on the tributary to Marrakai Creek have not been sampled prior and thus no comparison data are available. The reason for the low DO and high turbidity could be from recent access of cattle to the area, traces of which was observed at all sites.

3.3 Sediment sampling results

All analytes with a default guideline value (DGV) recorded concentrations far below those guidelines with the large majority of results being below the laboratory's limit of reporting (LOR). Laboratory results for dissolved metals covered by sediment toxicity DGV are provided in Table 3-2 below. One sample container from Q29SW2 was damaged in transit, thus samples were analysed for particle size only.

The concentrations for dissolved metals were generally greatest at RRSW2 and RRSW23. This was largely for metals without a DGV, such as aluminium, which recorded the highest concentration of 400 mg/kg at RRMCUS, and iron, with a concentration recorded at RRSW2 and RRSW23 of 1830 mg/kg and 1120 mg/kg respectively.

The remainder of analytes providing background information on particle size, moisture content and total organic carbon (TOC) are listed in Table 3-4 and Table 3-5. The concentrations of cyanide were below LOR at all sites.

3.3.1 Discussion of sediment data 2021

The concentrations for iron were highest at the downstream locations from the Heap Leach Pad (RRSW2 and RRSW23) (see Figure 2-1). Other metals where concentrations were higher at these sites compared to RRMDCS and RRMCUS were Arsenic, Barium, Cobalt, Copper, Lead, Manganese, Vanadium and to a lesser extent Zinc and Nickel (only recorded at RRSW2). While these analytes have no applicable DGVs, the concentrations indicate a potential impact from the pre-existing mine site. Aluminium recorded a maximum concentration of 400 mg/kg at RRMCDS, the only occurrence of a site recording a greater concentration than that found at RRSW2 and RRSW23. All metals not discussed in this section recorded concentrations below the laboratory's limit of reporting (LOR) (Table 3-3).

No exceedances as per the DGV and the fact that cyanide was below LOR indicate that there are no concerns in regards to sediment toxicity at present.

Table 3-2. Laboratory results summary for Sediment toxicant DGV* covered dissolved metals

Site ID	Date	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc	Mercury
Sediment Toxicant DGV*		**2-25**	**20-70**	**1.5-10**	**80-130**	**65-270**	**50-220**	**21-52**	**1-4**	**200-410**	**0.15-1**
RRMCUS	15-04-21	<1.0	<1.0	<0.1	<1.0	<1.0	1.4	<1.0	<1.0	<1.0	<0.01
RRMCDS	15-04-21	<1.0	<1.0	<0.1	<1.0	<1.0	1.6	<1.0	<1.0	<1.0	<0.01
RRSW2	14-04-21	<1.0	5.8	<0.1	1.1	9.9.	2.7	1.2	<1.0	1.8	0.01
RRSW23	14-04-21	<1.0	2.4	<0.1	<1.0	3.1	3	<1.0	<1.0	1	0.01

**Sediment Toxicant DGV: Toxicant default guideline values for sediment quality* (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants, *ANZG (2018) as per Table 2-2.*

Table 3-3. Dissolved Metals results (without toxicant default guideline values)

Site ID	Date	Aluminium	Barium	Beryllium	Boron	Cobalt	Iron	Manganese	Molybdenum	Selenium	Strontium	Uranium	Vanadium
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
RRMCDS	15-04-2021	190	18.7	<1.0	<50	0.7	960	62	<5	<0.5	<5	<1.0	<2.0
RRMCUS	15-04-2021	400	15.6	<1.0	<50	1.4	750	38	<5	<0.5	<5	<1.0	<2.0
RRWS2	15-04-2021	290	30.4	<1.0	<50	2.2	1830	88	<5	<0.5	<5	<1.0	4.7
RRSW23	15-04-2021	310	30.5	<1.0	<50	2.4	1120	91	<5	<0.5	<5	<1.0-	2.5

Table 3-4. Particle sizing results

Site ID	Date	+75µm	+150µm	+300µm	+425µm	+600µm	+1180µm	+2.36mm	+4.75mm	+9.5mm	+19.0mm	+37.5mm	+75mm
		%	%	%	%	%	%	%	%	%	%	%	%
RRMCDS	15-04-2021	68	56	38	29	25	22	18	12	6	<1	<1	<1
RRMCUS	15-04-2021	72	60	31	20	16	13	11	8	<1	<1	<1	<1
RRWS2	15-04-2021	66	62	54	49	45	42	37	30	18	6	<1	<1
RRSW23	15-04-2021	58	48	33	25	22	19	16	11	3	<1	<1	<1
Q29SW2	15-04-2021	63	51	44	42	41	38	34	28	22	11	<1	<1

Table 3-5. Particle sizing results continued, moisture content, cyanide and total organic carbon results

Site ID	Date	Clay (<2 µm)	Silt (2-60 µm)	Sand (0.06-2.00 mm)	Gravel (>2mm)	Cobbles (>6cm)	Moisture content	Total Cyanide	Total Organic Carbon
		%	%	%	%		%	%	%
RRMCDS	15-04-2021	15	14	52	19	<1	21.8	<1	1.24
RRMCUS	15-04-2021	13	11	64	12	<1	16.6	<1	0.19
RRWS2	15-04-2021	20	14	28	38	<1	26.2	<1	0.44
RRSW23	15-04-2021	19	22	42	17	<1	24.3	<1	2.65
Q29SW2	15-04-2021	15	22	27	36	<1			

3.4 Macroinvertebrate sampling

The taxonomic specialist engaged to identify and analyse samples, Aquatic Ecology Services, provided a macroinvertebrate report to EcOz, which is provided in Appendix C.

3.4.1 Macroinvertebrate sampling results

Macroinvertebrate sampling was undertaken at four sites located to the east and west of the proposed mine expansion area (Figure 2-1).

The relative abundance of macroinvertebrates was greatest at RRMCDS and RRSW23 with both sites recording values over fourteen hundred (Aquatic Ecology Services 2021). RRMCUS recorded the next highest value, exceeding 600, while Q29SW2, with slightly above 400, recorded the lowest value.

Taxa richness was lowest at RRMCUS, with lower than twenty taxa, and highest at Q29SW2 with thirty taxa identified. Both RRMCDS and RRSW23 recorded over twenty taxa each.

PET richness, an indicator including taxa from the groups of Plecoptera (stone flies), Ephemeroptera (mayflies) and Trichoptera (caddis flies) was very similar at all sites, with RRMCUS recording just one fewer PET taxa (five) than the other three sites (six each).

Signal-2 results varied from slightly greater than 3.5 to just over 4, showing minimal variation between sites, with RRMCDS and Q29SW2 recording the lowest and greatest score respectively.

There is an observable difference in community composition between the upstream site on Marrakai Creek and all other sites. True flies (Diptera) dominate the community at the upstream site, compared with other sites, which do contain a high proportion of true flies, but their abundance is offset by mayflies (Ephemeroptera). There was a great amount of variability in community composition.

3.4.2 Discussion of macroinvertebrate results

The relative abundance results may be explained by differences in habitat at each sample location. In the photos provided in Figure 3-1 it is apparent that both RRMCDS and RRSW23 have a greater number of trees lining the bank, the roots of which provide habitat for macroinvertebrates. Conversely RRMCUS has fewer trees and more grasses lining the bank, perhaps providing different habitat which may have contributed to the overall lower abundance.

The high taxa richness at Q29SW2 may be due to its location three kilometres downstream, in a section of the creek that seasonally flows for a longer time period then further upstream, providing a greater opportunity for habitation and maturation of macroinvertebrates. This may be relevant given that the two wet seasons immediately preceding the 2020-2021 wet season were some of the poorest on record, potentially reducing the taxa richness through shortened periods of water flow (BoM 2021a, b).

The PET richness was almost identical at all sites, varying from 5 to 6, which describes the habitats sampled at the four sites of similar quality with regards to the presence of Ephemeroptera and Trichoptera families (there are no Plecoptera in the NT).

The SIGNAL-2 results demonstrate a high proportion of non-pollution tolerant taxa at all sites. The comparison of data post discharge will assess any potential environmental impacts, as the pollution tolerant taxa might increase proportionally to the non-pollution tolerant taxa. Lamche (2007) discourages the use of Signal scores in the NT due to lack of comparison data. However, the use of this score at the same site over time will allow to assess whether trends might be apparent.

Differences in community composition are likely to be associated with differences in habitat characteristics of sites. The higher number of taxa collected at Q29SW2 is contributed to by a greater diversity of true bugs (Hemiptera) at the site.

Given that water quality differences do not appear to be driving any differences in community composition, habitat characteristics are likely playing a major role in the presence or absence of macroinvertebrate families in each sampling site.

Results show a similarity of 60% between all sites, with both downstream sites recording a further 10% similarity between each other. The results from RRMCUS were substantially different from the three other sites, with a significantly larger proportion of true flies (Diptera) and smaller of mayflies (Ephemeroptera). The variation in habitat likely played a significant role in the differences between macroinvertebrate communities at all sites.

Q29SW2 provides a good opportunity for impact monitoring given the presence of taxa that are not pollution tolerant, although results seem to indicate that the communities at all sites are relatively pollution tolerant due to the nature of the habitat in a wet/dry season climate.

The differences in the macroinvertebrate community between sites highlights the importance of sampling prior to mining/dewatering activities recommencing at the RRPA, as it provides site-level baseline data for future comparison. Ongoing monitoring of the receiving environment will be the most effective tool in adaptive management of the discharge strategy, should negative impacts be observed.

3.5 Sediment and macroinvertebrate monitoring program assessment

3.5.1 Review of sample site locations

The current design sets out four sites for macroinvertebrate and sediment monitoring and one site (RRSW2) for sediment for a total of five monitoring sites. ADP1 discharges into Marrakai Creek, with an upstream (RRMCUS) and a downstream (RRMCDS) sample point, while the three sample points along the Upper Mount Bundey Creek tributary (RRSW2, RRSW23 and Q29SW2) will all be downstream of ADP2. Ideally, the sampling design would encompass several sites upstream of the mined area as control sites and a similar number of sites downstream as impacted sites. However, the RRPA is in the headwaters of both the Mount Bundey Creek and the Marrakai Creek catchments and only one control location was available: Marrakai upstream (RRMCUS, Table 2-1).

To increase statistical power, future monitoring rounds could explore the use of replicate sampling, and the addition of a sampling site in a tributary of Mount Bundey Creek that is not currently in the receiving environment of the RRPA. It is acknowledged that access to additional sites may be limited due to the prevailing terrain and available tributaries.

RRSW2 and RRSW23 may have been impacted by prior activities, given that both sites are downstream of the heap leach pad which appears to have slowly eroded over its bund wall. The placement of these points is unavoidable due to the location of the creek and discharge point. This will provide the program with one control site and four impact sites and the addition of a second control site as discussed above is recommended.

As per WDL247 - issued in June 2021 after this annual sampling in April 2021 - the number of sampling sites increases in the forthcoming years to include an additional control site (RRSW25) and several further downstream sites. Sediment sampling will now occur at nine, and macroinvertebrate monitoring at eight sites.

3.5.2 Review of timing of sampling and parameters investigated

The sampling was conducted in the late wet season (i.e. April) with all sites still flowing. This is considered adequate sampling time for both sediments and macroinvertebrates.

The field and laboratory parameters measured in the sediment monitoring program are consistent with the guideline values with the exception of turbidity and dissolved oxygen at RRMCUS and Q29SW2.

Macroinvertebrate samples were largely identified to family level, with key taxa being identified to order or subfamily as per Lamche (2007). This is considered adequate for requirements.

4 CONCLUSION

This first collection of sediment and macroinvertebrate data for the RRPA found the following:

The results of the April sediment sampling event all recorded concentrations below the ANZG 2018 DGVs.

The highest dissolved metal concentrations were generally recorded in sediments at those sites located downstream and in close proximity to the heap leach pad, which could be the result of previous mining activities, but could also represent an anomaly or a longer term trend. Forthcoming sediment data will allow for better assessment of causes for these higher dissolved metal concentrations.

The macroinvertebrate data provide an indication of community size and composition, and this baseline information will be a potential a key indicator of contamination causing environmental degradation.

It is recommended that sediment and macroinvertebrate sampling be undertaken annually for the duration of discharge operations and the life of the mine as per the Sediment and Macroinvertebrate Monitoring Plan Rustlers Roost (EcOz 2021).

These sediment and macroinvertebrate results provide a baseline against which all future results will be compared to ascertain the effects of the discharge on the receiving water courses.

5 REFERENCES

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APPENDIX A FIELD SHEETS

FIELD SHEETS

FIELD SHEETS

AUSRIVAS - Darwin Daly regional Models

Date	Site Code	Site Name	Field Team
15-4-21	RRMCUS		AL + BD

GPS coordinates: (*predictor variables family level model*):

Zone (UTM)	~~Easting~~ Lat	~~Northing~~ long	Datum
~~52~~	12.918623925°S	131.480976302°E	

Landholders and contact details

Mt Burdey station

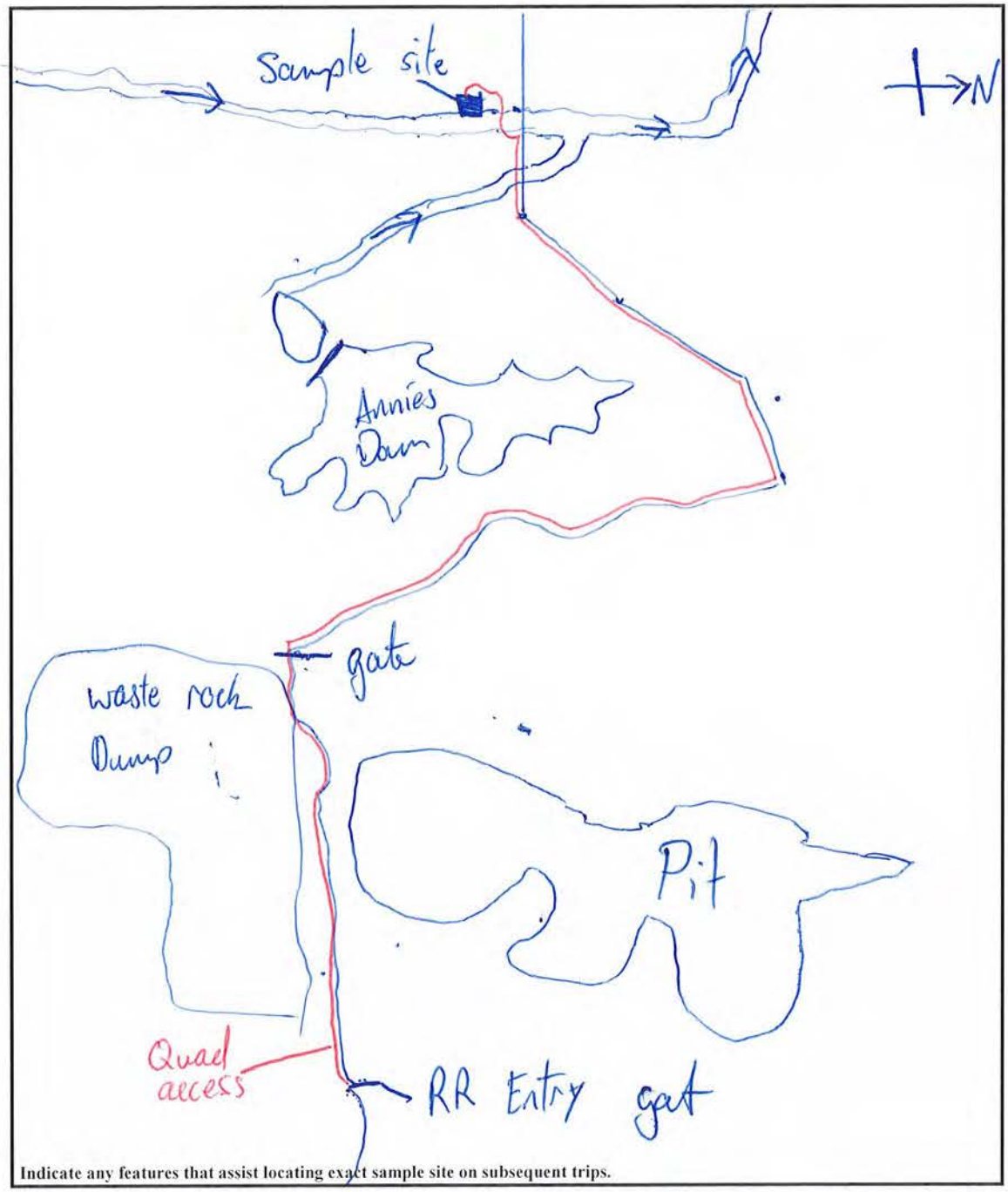
Site comments, observations

Small pool 100m upstream from junction of ~~creek~~ annies dam creek

ACCESS SKETCH

SITE NAME Rustlers Roost Marrahai Creek upstream

SITE CODE RRMCCUS



Indicate any features that assist locating exact sample site on subsequent trips.

WATER QUALITY

Time 1030 **Instrument** YSI Pro DSS **Instrument Serial No.**

pH 6.19 **units** **E.C.** 21.9 **µS/cm**

D.O. 87.6 **mg/L** **Water Temperature** 27.3 **°C**

Turbidity 24.5 **NTUs** **Instrument and serial number**

Water samples for laboratory water quality analysis

(ALKALINITY is a *predictor variable for genus level model*)

Bottle lable	**Analysis**
	Alkalinity

Observations relating to water quality (e.g. water oil, scum, foam, sediment odours)

Som algae on surface

MACROINVERTEBRATE SAMPLING

EDGE

Length sampled 10 m

Collected by AL + BD

No. of containers used 2

Edge description

- ☐ Vertical 90°
- ☒ Angled 45-90°
- ☐ Undercut

Edge habitat mainly composed of roots from

- ☐ Paperbark / Melaleuca
- ☒ shrub
- ☒ other common riparian trees
- ☒ grass

Edge habitat

- ☒ roots covered by algae
- ☒ overhanging vegetation

Habitat velocity & depth **Flow meter serial no.** _____ **Fan set no.**____

(*predictor variable genus level model*)

Meter Reading (Revolutions per 40s)				Habitat depth (cm)		
1	2	3	Fan details	1	2	3
1 m/sec	0.1 m/sec	0.3 m/sec		50 mm	1 m	0.5

Stream Width (at water level) (*predictor variable genus and family level models*): six measurements or estimations are taken in a 100m reach upstream of the macroinvertebrate sampling site.

Number	1	2	3	4	5	6
Width (m)	4	1	0.5	2	1	1.5

☒ measured ☐ estimate only

Comments

Stream width varying from small fast riffles to pools with little movement, lots of macrophytes in pool.

4x shrimp

DESCRIPTION OF THE REACH (reach 100 m upstream of sample site)

Habitats within 100 m reach

Sand/Silt bed	☒	Riffle	☒
Gravel/Rock bed	☐	Run	☐
Macrophytes	☒	Pool	☒
Snags	☐		

Description of stream characteristics

Width between top of levee banks (bankfull width) 6 m

Other levees ☐

Height of levee bank from water surface 1 m

Flow observable ☑

RIPARIAN ZONE (within 100 m reach)

Riparian zone width -left bank (facing downstream) 3-4 m

-right bank 3 m

Riparian vegetation type

Monsoon-vine forest/Rainforest	☐	Riparian shrubland	☐
Riparian forest	☐	Riparian grassland	☑
Riparian woodland	☑	Other:	

Weeds ☑ Gamba

Evidence of fire Riparian Zone ☐

Beyond Levee Banks ☐

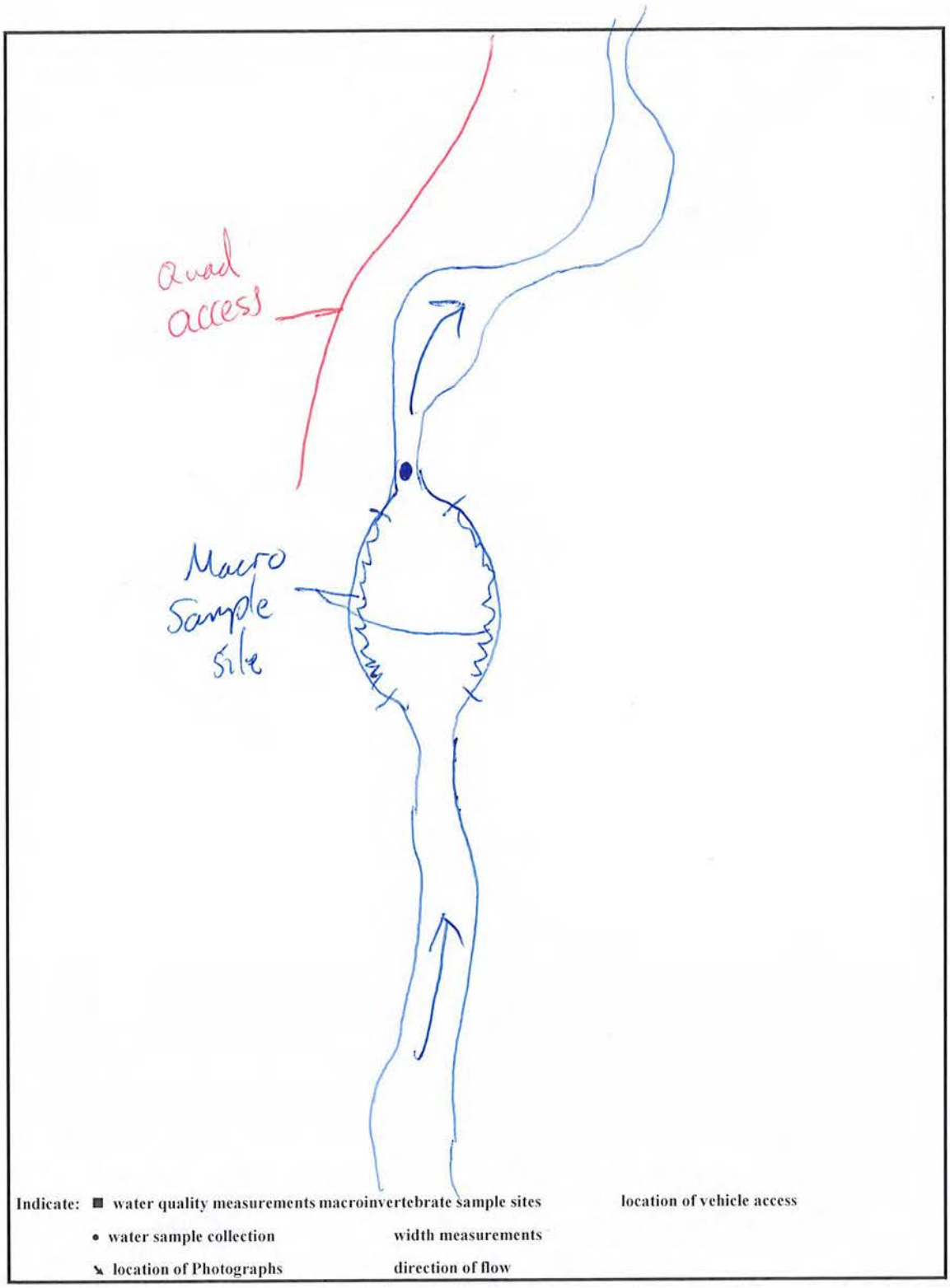
Cattle access ☑

Comments

stream flow observable in riffles

25% vegetation cover with densiometer

SKETCH OF 100 M REACH



FIELD SHEETS

FIELD SHEETS

AUSRIVAS - Darwin Daly regional Models

Date	Site Code	Site Name	Field Team
15-4-21	NRMCDS	Rustlers Roost Mamrekai Creek Downstream	AL - BD

GPS coordinates: (*predictor variables family level model*):

Zone (UTM)	Easting	Northing	Datum
12	904950473°S	131.469576510°E	

Landholders and contact details

MT Burdey Station

Site comments, observations

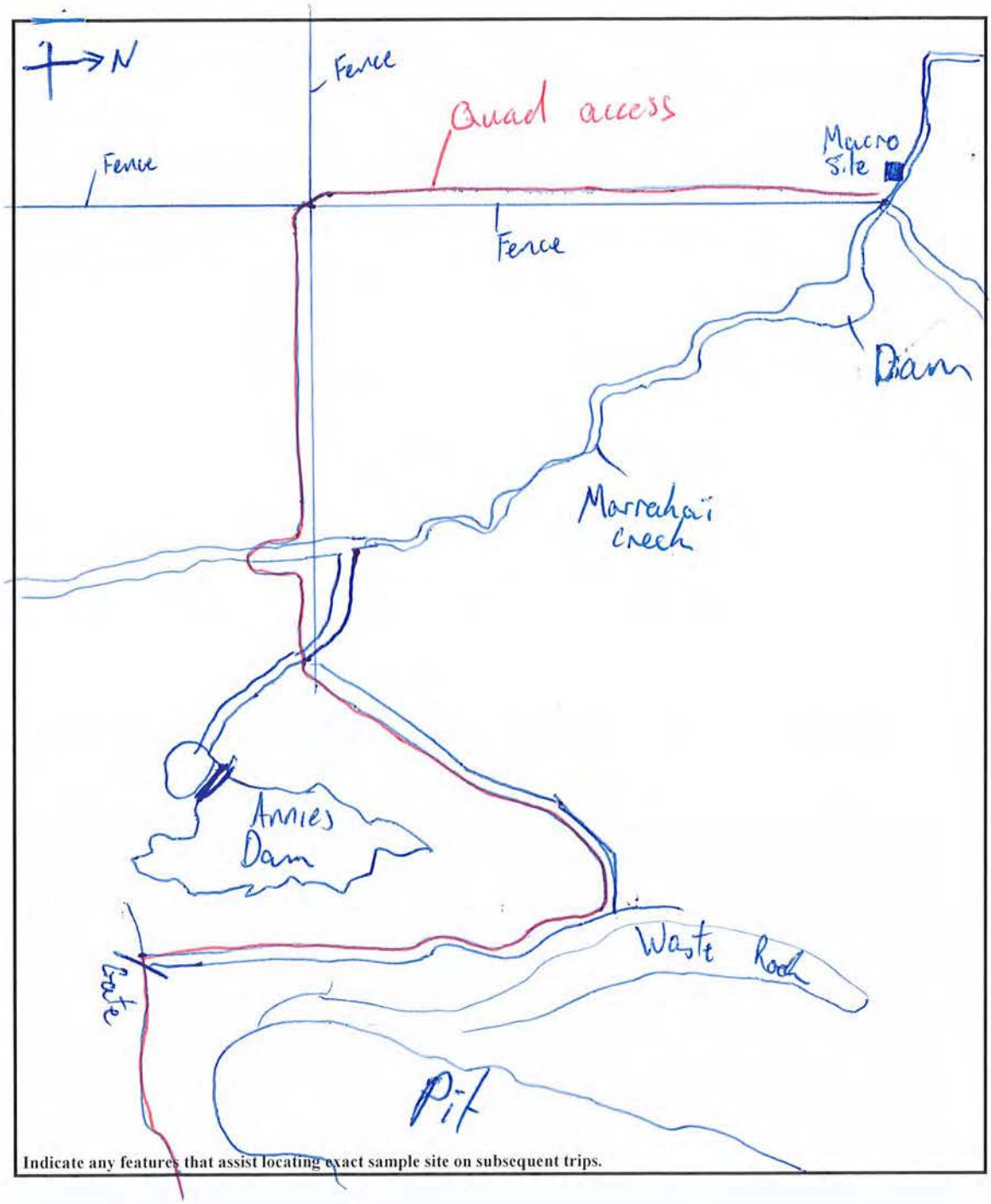
~~Downstream of Junctions and fence line.~~

Creek winds across access track several times. Sample site downstream of all creek junctions and fence line. large man made dam 150m upstream

ACCESS SKETCH

SITE NAME **SITE CODE**

Rustlers Roost Marrakai creek Downstream RRMCDS



Indicate any features that assist locating exact sample site on subsequent trips.

WATER QUALITY

Time 1220	**Instrument**	**Instrument Serial No.**		
pH 6.31	**units**	**E.C.** 21.7		**µS/cm**
D.O. 101.5	**mg/L**	**Water Temperature** 30.5		**°C**
Turbidity 9.2	**NTUs**	**Instrument and serial number**		

Water samples for laboratory water quality analysis

(ALKALINITY is a *predictor variable for genus level model*)

Bottle lable	**Analysis**
	Alkalinity

Observations relating to water quality (e.g. water oil, scum, foam, sediment odours)

Clear water

MACROINVERTEBRATE SAMPLING

EDGE

Length sampled 10 m

Collected by AL + BD

No. of containers used 2

Edge description

- ☐ Vertical 90°
- ☒ Angled 45-90°
- ☐ Undercut

Edge habitat mainly composed of roots from

- ☑ Paperbark / Melaleuca
- ☑ other common riparian trees
- ☑ shrub
- ☑ grass

Edge habitat

- ☑ roots covered by algae
- ☑ overhanging vegetation

Habitat velocity & depth **Flow meter serial no.** _____ **Fan set no.**____

(*predictor variable genus level model*)

Meter Reading (Revolutions per 40s)				Habitat depth (cm)		
1	2	3	Fan details	1	2	3
0-1m/sec	0.3m/sec	0.5m/sec		1m	0.3m	0.2m

Stream Width (at water level) (*predictor variable genus and family level models*): six measurements or estimations are taken in a 100m reach upstream of the macroinvertebrate sampling site.

Number	1	2	3	4	5	6
Width (m)	1	2	0.5	4	3	1.5

☑ measured ☐ estimate only

Comments

sneaking small creek, some snags, root mass on edge, leaf litter

2x rainbowfish

2x crab 5x shrimp

DESCRIPTION OF THE REACH (reach 100 m upstream of sample site)

Habitats within 100 m reach

Sand/Silt bed	☑	Riffle	☑
Gravel/Rock bed	☑	Run	☐
Macrophytes	☑	Pool	☑
Snags	☑		

Description of stream characteristics

Width between top of levee banks (bankfull width) 30 m

Other levees ☐

Height of levee bank from water surface 2 m

Flow observable ☑

RIPARIAN ZONE (within 100 m reach)

Riparian zone width -left bank (facing downstream) 10 m

-right bank 20 m

Riparian vegetation type

Monsoon-vine forest/Rainforest	☐	Riparian shrubland	☒
Riparian forest	☐	Riparian grassland	☒
Riparian woodland	☒	Other:	

Weeds ☒

Evidence of fire Riparian Zone ☐

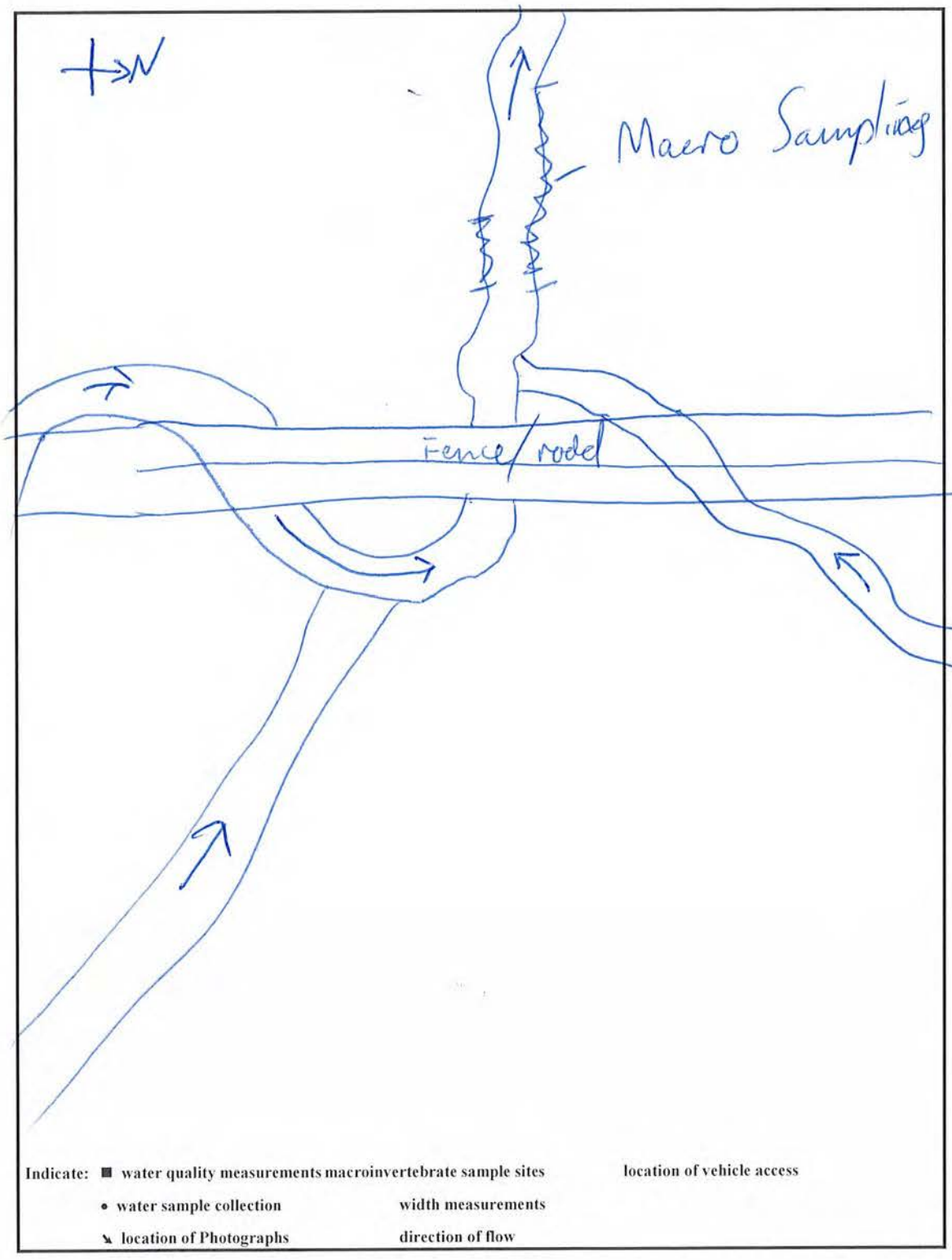
Beyond Levee Banks ☐

Cattle access ☑

Comments

no evidence of fire, creek has several channels upstream that converge just upstream from sample site

SKETCH OF 100 M REACH



Indicate: ■ water quality measurements macroinvertebrate sample sites location of vehicle access
• water sample collection width measurements
↘ location of Photographs direction of flow

FIELD SHEETS

FIELD SHEETS

AUSRIVAS - Darwin Daly regional Models

Date	Site Code	Site Name	Field Team
14.4.21	RRSW23	Rustlers Roost surface water 23	AL + BD

GPS coordinates: (*predictor variables family level model*):

Zone (UTM)	Easting	Northing	Datum
12.930765 S		131.50657 E	

Landholders and contact details

NT Bundey station

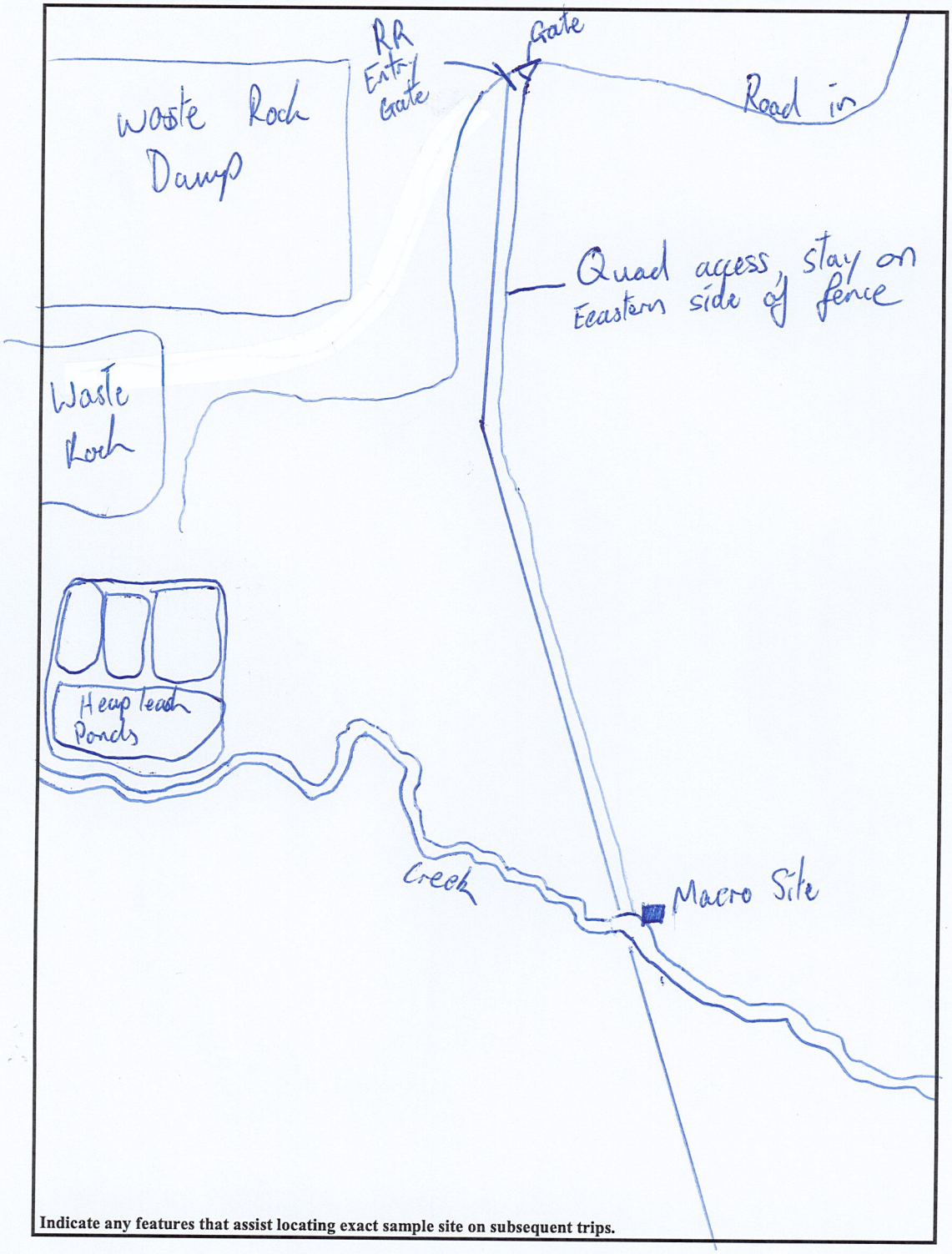
Site comments, observations

Site located 1 km South of Rustlers Roost entry gate along Eastern side of fenceline, stay ouside of fence.

AUSRIVAS NT

ACCESS SKETCH

SITE NAME **SITE CODE**



Indicate any features that assist locating exact sample site on subsequent trips.

WATER QUALITY

Time 1235 **Instrument** Pro DSS **Instrument Serial No.**

pH 7.32 **units** **E.C.** 124.3 **µS/cm**

D.O. 116.5 % ~~mg/L~~ **Water Temperature** 30.7 **°C**

Turbidity 14.2 **NTUs** **Instrument and serial number**

Water samples for laboratory water quality analysis

(ALKALINITY is a *predictor variable for genus level model*)

Bottle lable	Analysis
	Alkalinity

Observations relating to water quality (e.g. water oil, scum, foam, sediment odours)

water opaque brown, no other visible obs, some flow

MACROINVERTEBRATE SAMPLING

EDGE Length sampled 10 m

Collected by AL+BD

No. of containers used 2

Edge description

- ☐ Vertical 90°
- ☒ Angled 45-90°
- ☐ Undercut

Edge habitat mainly composed of roots from

- ☐ Paperbark / Melaleuca
- ☑ shrub
- ☑ other common riparian trees
- ☑ grass

Edge habitat

- ☑ roots covered by algae
- ☑ overhanging vegetation

Habitat velocity & depth **Flow meter serial no.** _____ **Fan set no.**____

(*predictor variable genus level model*)

Meter Reading (Revolutions per 40s)				Habitat depth (cm)		
1	2	3	Fan details	1	2	3
0.1m/sec	0.2m/sec	0.8m/sec		1m	0.5m	0.1m

Stream Width (at water level) (*predictor variable genus and family level models*): six measurements or estimations are taken in a 100m reach upstream of the macroinvertebrate sampling site.

Number	1	2	3	4	5	6
Width (m)	1.5	6	2	4	3	5

☑ measured ☑ estimate only

Comments

stream width varys, riffle 80m upstream, sample site in still pool, mostly gravel bottom, sandstone/laterite edges

5 x freshwater crab

DESCRIPTION OF THE REACH (reach 100 m upstream of sample site)

Habitats within 100 m reach

Sand/Silt bed	☑	Riffle	☑
Gravel/Rock bed	☑	Run	☐
Macrophytes	☐	Pool	☑
Snags	☑		

Description of stream characteristics

Width between top of levee banks (bankfull width) 15 m

Other levees ☑

Height of levee bank from water surface 2 m

Flow observable ☑

RIPARIAN ZONE (within 100 m reach)

Riparian zone width -left bank (facing downstream) 18 m

-right bank 12 m

Riparian vegetation type

Monsoon-vine forest/Rainforest	☐	Riparian shrubland	☑
Riparian forest	☑	Riparian grassland	☑
Riparian woodland	☐	Other:	

Weeds ☑ Lantana

Evidence of fire Riparian Zone ☐

Beyond Levee Banks ☐

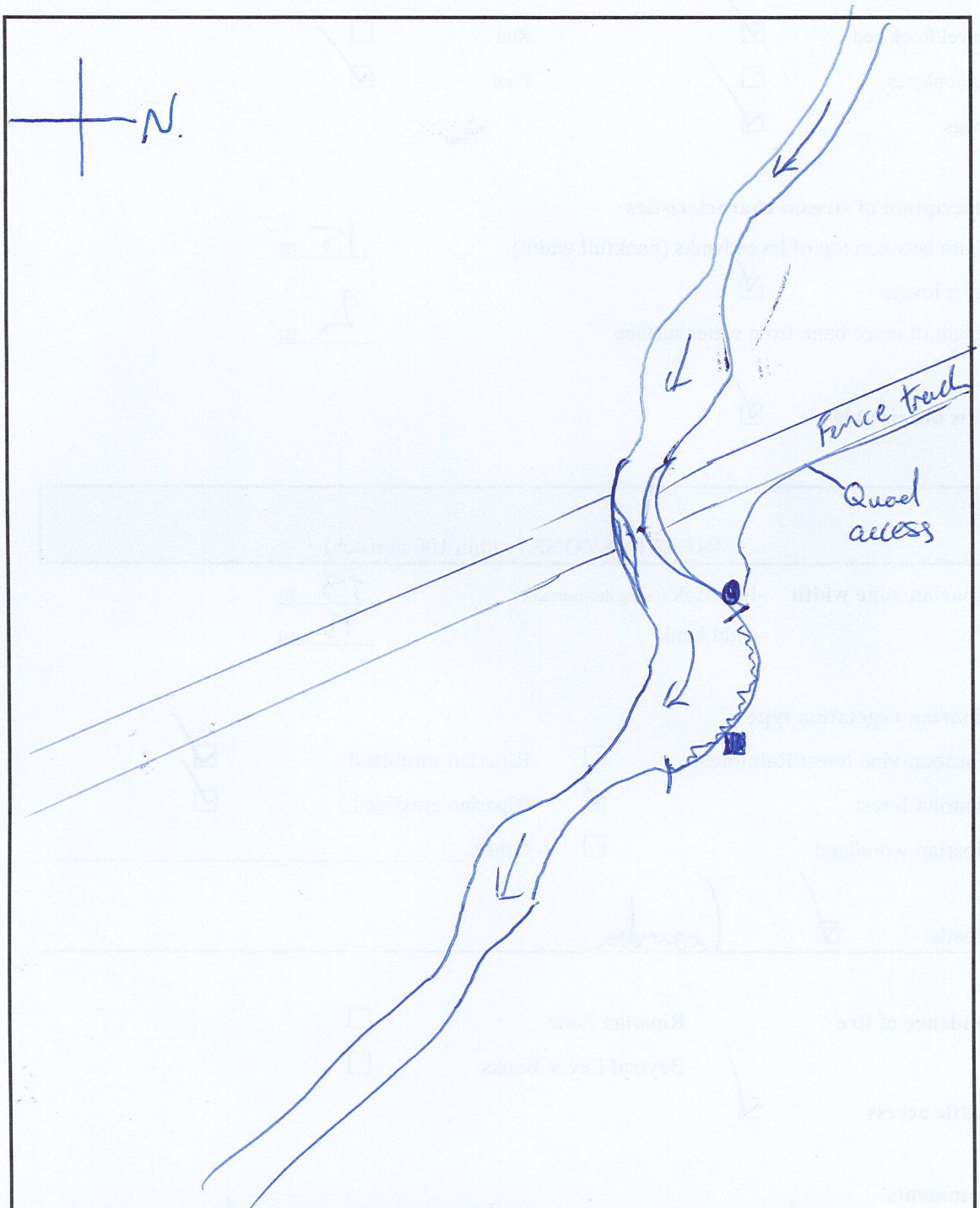
Cattle access ☑

Comments

~~Riffle 3 Stns upstream Sample St~~

84% vegetation cover using Densiometer

SKETCH OF 100 M REACH



Indicate: ■ water quality measurements macroinvertebrate sample sites location of vehicle access

• water sample collection width measurements

↘ location of Photographs direction of flow

FIELD SHEETS

FIELD SHEETS

AUSRIVAS - Darwin Daly regional Models

Date	Site Code	Site Name	Field Team
14-4-21	Q295W2	Quest 29 Surface Water 2	AL + BD

GPS coordinates: (*predictor variables family level model*):

Zone (UTM)	Easting	Northing	Datum
52S	774142	8570971	
12.914634 S		131.52644 E	

Landholders and contact details

MT Bundey station

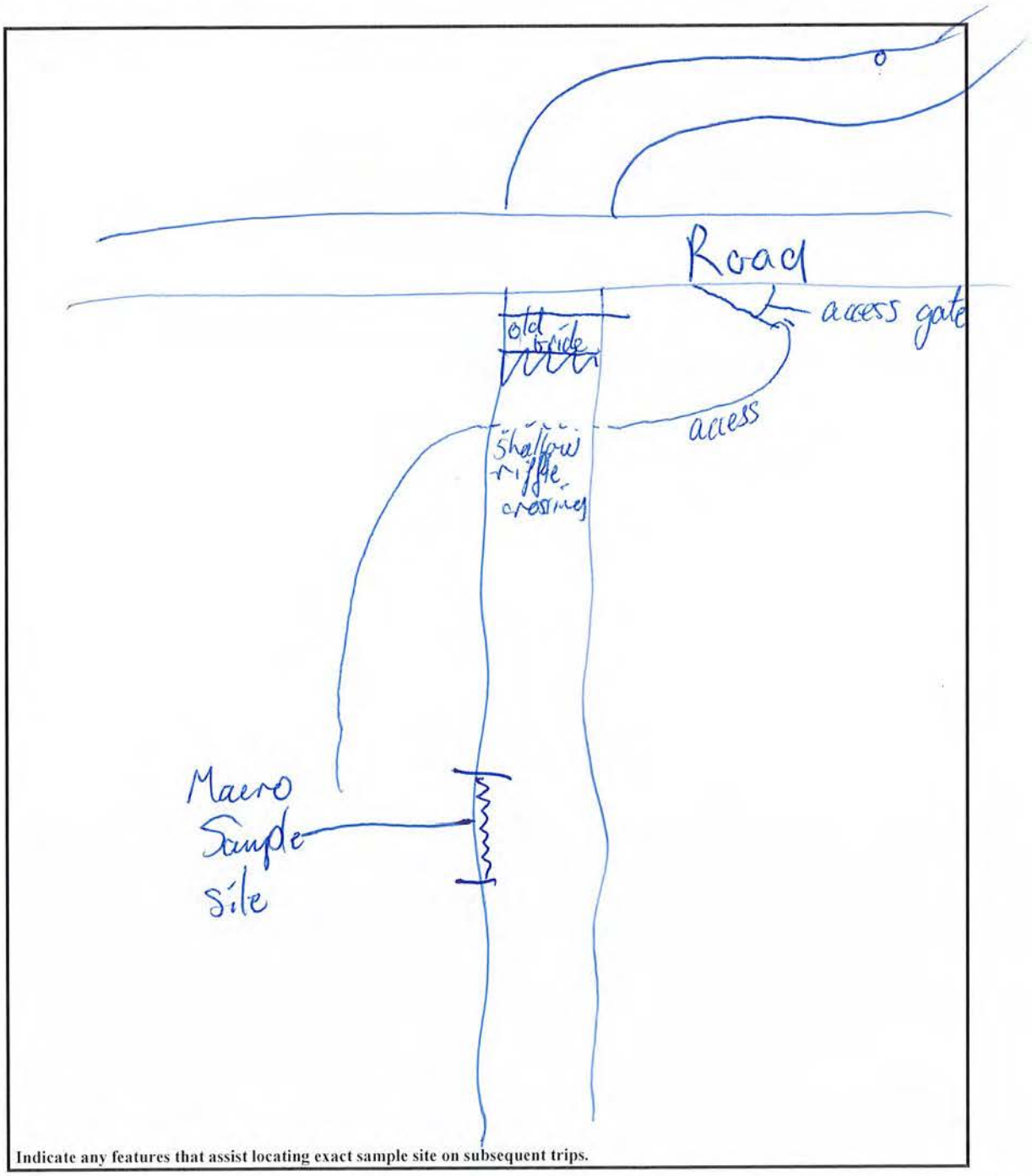
Site comments, observations

Macro Site located 150m upstream of road crossing, on other side of ~~gate~~ fence. Sampled on west side of creek. Deep run section, very crocy.

ACCESS SKETCH

SITE NAME **SITE CODE**

Q295W2



Indicate any features that assist locating exact sample site on subsequent trips.

WATER QUALITY

Time 1030 **Instrument** YSI Pro DSS **Instrument Serial No.**

pH 6.60 **units** **E.C.** 44.6 **µS/cm**

D.O. 80.6 ~~or mg/L~~ **Water Temperature** 27.3 **°C**

Turbidity 21 **NTUs** **Instrument and serial number**

Water samples for laboratory water quality analysis

(ALKALINITY is a *predictor variable for genus level model*)

Bottle lable	Analysis
	Alkalinity

Observations relating to water quality (e.g. water oil, scum, foam, sediment odours)

Slightly opaque, looks clean otherwise no visible observations (scum, sheen, foam etc). Some leaf litter on surface

MACROINVERTEBRATE SAMPLING

EDGE

Length sampled 10 m

Collected by AL

No. of containers used 2

Edge description

- [x] Vertical 90°
- [ ] Angled 45-90°
- [ ] Undercut slightly

Edge habitat mainly composed of roots from

- [ ] Paperbark / Melaleuca
- [x] shrub
- [x] other common riparian trees
- [x] grass

Edge habitat

- [x] roots covered by algae
- [x] overhanging vegetation

Habitat velocity & depth **Flow meter serial no.** _____ **Fan set no.**____

(*predictor variable genus level model*)

Meter Reading ~~(Revolutions per 40s)~~				Habitat depth (cm)		
1	2	3	Fan details	1	2	3
50mm/sec	50mm/sec	0.5m/sec		~1.5m	~2m	20cm

Stream Width (at water level) (*predictor variable genus and family level models*): six measurements or estimations are taken in a 100m reach upstream of the macroinvertebrate sampling site.

Number	1	2	3	4	5	6
Width (m)	6	4	5	7	4	6

- [ ] measured
- [x] estimate only

cant cross

Comments

stream width fairly consistent, flow hardly observable till creek narrows near road, Bank mostly vertical, some root mass, leaf litter

DESCRIPTION OF THE REACH (reach 100 m upstream of sample site)

Habitats within 100 m reach

Sand/Silt bed	☒	Riffle	☒
Gravel/Rock bed	☒	Run	☒
Macrophytes	☐	Pool	☒
Snags	☒		

Description of stream characteristics

Width between top of levee banks (bankfull width) 20 m

Other levees ☐

Height of levee bank from water surface 3.5 m

Flow observable ☒ just

RIPARIAN ZONE (within 100 m reach)

Riparian zone width -left bank (facing downstream) 20 m

-right bank 10 m

Riparian vegetation type

Monsoon-vine forest/Rainforest	☒	Riparian shrubland	☒
Riparian forest	☐	Riparian grassland	☒
Riparian woodland	☒	Other:	

Weeds ☒ Gamba

Evidence of fire Riparian Zone ☐

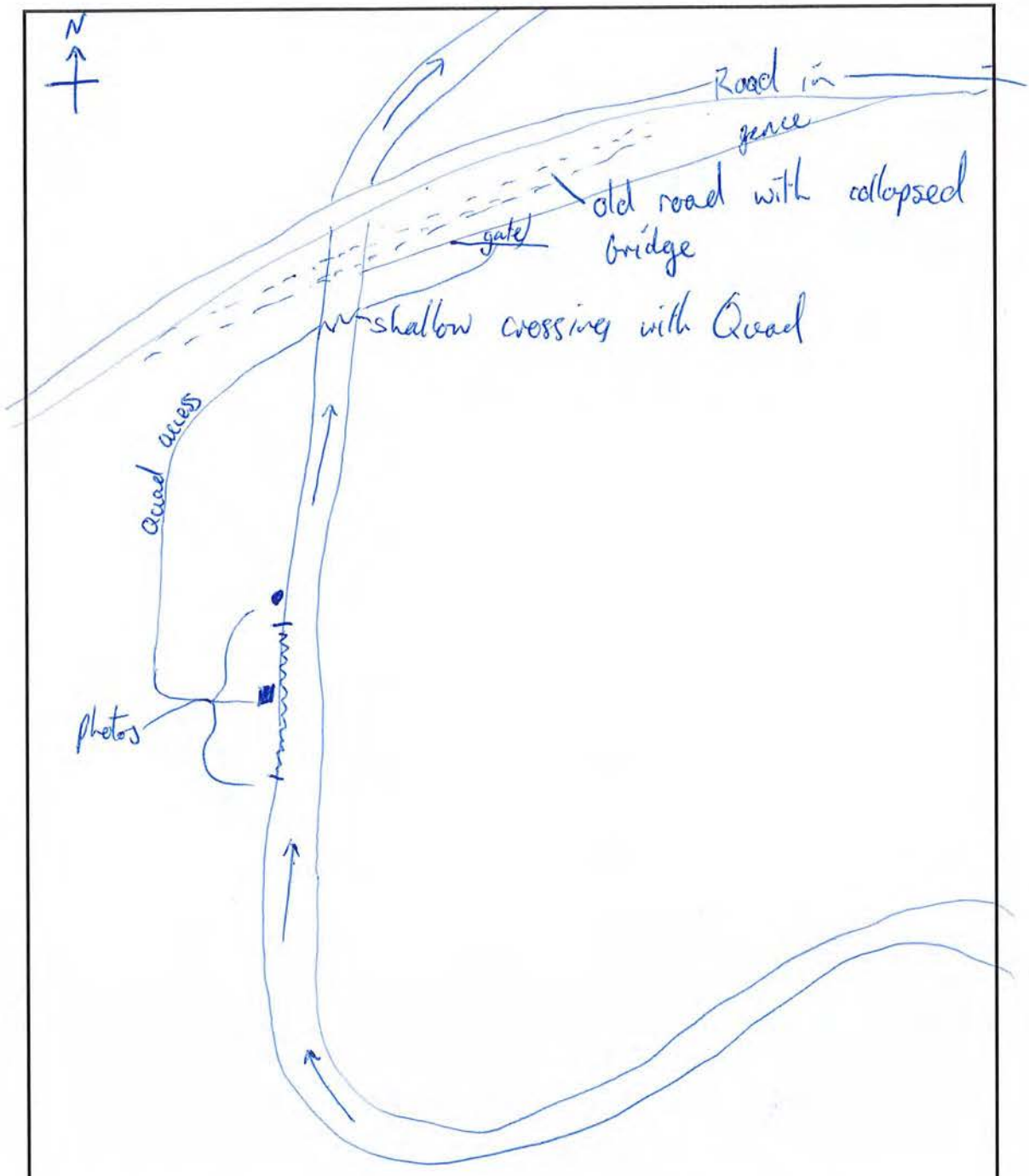
Beyond Levee Banks ☐

Cattle access ☒

Comments

95% Vegetation cover overhead using Densiometer, no recent fire

SKETCH OF 100 M REACH



Indicate: ■ water quality measurements macroinvertebrate sample sites location of vehicle access
• water sample collection width measurements
↘ location of Photographs direction of flow

APPENDIX B LABORATORY RESULTS

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **ES2114313**

Client	: **ECOZ ENVIRONMENTAL SERVICES**	Laboratory	: Environmental Division Sydney
Contact	: Gisela Lamche	Contact	: Customer Services ES
Address	: PO BOX 381 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: Gisela.Lamche@ecoz.com.au	E-mail	: ALSEnviro.Sydney@ALSGlobal.com
Telephone	: ----	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: EZ21047 Hnaking sediment monitoring	Page	: 1 of 2
Order number	: EZ21047	Quote number	: EB2017ECOZENV0001 (EN/222)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: AL		

Dates

Date Samples Received	: 20-Apr-2021 08:30	Issue Date	: 20-Apr-2021
Client Requested Due Date	: 28-Apr-2021	Scheduled Reporting Date	: **28-Apr-2021**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Not Available
No. of coolers/boxes	: 1	Temperature	: 18.1
Receipt Detail	:	No. of samples received / analysed	: 5 / 5

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Sample #5: Soil Jar was received as broken, only PSA will be analysed**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please direct any queries you have regarding this work order to the above ALS laboratory contact.
- Analytical work for this work order will be conducted at ALS Sydney.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Sampling date / time	Sample ID	SOIL - EA055-103 Moisture Content	SOIL - EA150H Particle Size Analysis by Hydrometer: AS1289	SOIL - EG005-SDH 1M HCl Extractable Metals	SOIL - EG020-SDH 1M HCl Extractable Se in Sediments by ICPMS	SOIL - EG035T-LL Total Mercury by FIMS - Low Level (SOLID)	SOIL - EK025SF (Solids) Free CN by Segmented Flow Analyser	SOIL - EP003 Total Organic Carbon (TOC) in Soil
ES2114313-001	15-Apr-2021 00:00	RRMCDS	✓	✓	✓	✓	✓	✓	✓
ES2114313-002	15-Apr-2021 00:00	RRMCUS	✓	✓	✓	✓	✓	✓	✓
ES2114313-003	14-Apr-2021 00:00	RRSW2	✓	✓	✓	✓	✓	✓	✓
ES2114313-004	14-Apr-2021 00:00	RRSW23	✓	✓	✓	✓	✓	✓	✓
ES2114313-005	14-Apr-2021 00:00	Q29SW2		✓					

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ANDREW LEWIS

- *AU Certificate of Analysis - NATA (COA)	Email	andrew.lewis@ecoz.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	andrew.lewis@ecoz.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	andrew.lewis@ecoz.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	andrew.lewis@ecoz.com.au
- Attachment - Report (SUBCO)	Email	andrew.lewis@ecoz.com.au
- Chain of Custody (CoC) (COC)	Email	andrew.lewis@ecoz.com.au
- EDI Format - ENMRG (ENMRG)	Email	andrew.lewis@ecoz.com.au
- EDI Format - ESDAT (ESDAT)	Email	andrew.lewis@ecoz.com.au

Gisela Lamche

- *AU Certificate of Analysis - NATA (COA)	Email	Gisela.Lamche@ecoz.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Gisela.Lamche@ecoz.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Gisela.Lamche@ecoz.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	Gisela.Lamche@ecoz.com.au
- A4 - AU Tax Invoice (INV)	Email	Gisela.Lamche@ecoz.com.au
- Attachment - Report (SUBCO)	Email	Gisela.Lamche@ecoz.com.au
- Chain of Custody (CoC) (COC)	Email	Gisela.Lamche@ecoz.com.au
- EDI Format - ENMRG (ENMRG)	Email	Gisela.Lamche@ecoz.com.au
- EDI Format - ESDAT (ESDAT)	Email	Gisela.Lamche@ecoz.com.au

INVOICE ADDRESS

- A4 - AU Tax Invoice (INV)	Email	ecoz@ecoz.com.au

CHAIN OF CUSTODY

ALS Laboratory: please tick →

ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com

BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com

GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com

MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com

MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com

MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

NEWCASTLE 5 Rosa Gum Road Warabrook NSW 2304 Ph: 02 4968 8448 E: samples.newcastle@alsglobal.com

NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com

PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com

SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: EcOz Environmental Consultants	TURNAROUND REQUIREMENTS: (Standard TAT may be longer for some tests e.g. Ultra Trace Organics) ☐ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):	FOR LABORATORY USE ONLY (Circle): Custody Seal Intact?	Yes No (N/A)
OFFICE: Darwin		Free ice / frozen ice blocks present upon receipt?	(Yes) No N/A
PROJECT: Hanking sediment monitoring	ALS QUOTE NO.: EN/222/20	Random Sample Temperature on Receipt:	15.1 °C
PROJECT NUMBER: EZ21047	COC SEQUENCE NUMBER (Circle) COC: 1 2 3 4 5 6 7	Other comment:	
PROJECT MANAGER: Gisela Lamche	CONTACT PH: 89811100 OF: 1 2 3 4 5 6 7		
SAMPLER: AL	SAMPLER MOBILE: 0419478875	RELINQUISHED BY: Alewis DATE/TIME: 19-4-21	RECEIVED BY: Vishal Patel DATE/TIME: 19/04/2021 1400
COC emailed to ALS? (YES/NO)	EDD FORMAT:	RELINQUISHED BY: DATE/TIME:	RECEIVED BY: Acc-Sydney DATE/TIME: 20/4/21 AM
Email Reports to: andrew.lewis@ecoz.com.au, Gisela.lamche@ecoz.com.au			
Email Invoice to: ecoz@ecoz.com.au, Gisela.lamche@ecoz.com.au			

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: 0.5

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).							Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	EG005-SDH plus Uranium and Selenium	EG035T-LL	EK026	EA150H	EP003	EA055		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	RRMCDS	15-4-21	S		2	x	x	x	x	x	x		
2	RRMCUS	15-4-21	S		2	x	x	x	x	x	x		
3	RRSW2	14-4-21	S		2	x	x	x	x	x	x		
4	RRSW23	↓	S		2	x	x	x	x	x	x		
5	Q29SW2		S		2	x	x	x	x	x	x		
				TOTAL	10								

AB OF ORIC DARWIN

Environmental Division Sydney

Work Order Reference ES2114313

Telephone : 61-2-8784 8555

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2114313**	Page	: 1 of 4
Client	: **ECOZ ENVIRONMENTAL SERVICES**	Laboratory	: Environmental Division Sydney
Contact	: Gisela Lamche	Contact	: Customer Services ES
Address	: PO BOX 381 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: EZ21047 Hnaking sediment monitoring	Date Samples Received	: 20-Apr-2021 08:30
Order number	: EZ21047	Date Analysis Commenced	: 23-Apr-2021
C-O-C number	: ----	Issue Date	: 28-Apr-2021 16:00
Sampler	: AL		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 5		
No. of samples analysed	: 5		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. 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*
Aleksandar Vujkovic	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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.

- EA150H: Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1 2006 was not requested by the client. Typical sediment SPD values used for calculations and consequently NATA endorsement does not apply to hydrometer results.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	RRMCDS	RRMCUS	RRSW2	RRSW23	Q29SW2
			Sampling date / time	15-Apr-2021 00:00	15-Apr-2021 00:00	14-Apr-2021 00:00	14-Apr-2021 00:00	14-Apr-2021 00:00
Compound	CAS Number	LOR	Unit	ES2114313-001	ES2114313-002	ES2114313-003	ES2114313-004	ES2114313-005
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	21.8	16.6	26.2	24.3	----
EA150: Particle Sizing								
+75µm	----	1	%	68	72	66	58	63
+150µm	----	1	%	56	60	62	48	51
+300µm	----	1	%	38	31	54	33	44
+425µm	----	1	%	29	20	49	25	42
+600µm	----	1	%	25	16	45	22	41
+1180µm	----	1	%	22	13	42	19	38
+2.36mm	----	1	%	18	11	37	16	34
+4.75mm	----	1	%	12	8	30	11	28
+9.5mm	----	1	%	6	<1	18	3	22
+19.0mm	----	1	%	<1	<1	6	<1	11
+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	%	15	13	20	19	15
Silt (2-60 µm)	----	1	%	14	11	14	22	22
Sand (0.06-2.00 mm)	----	1	%	52	64	28	42	27
Gravel (>2mm)	----	1	%	19	12	38	17	36
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	190	400	290	310	----
Antimony	7440-36-0	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg	<1.0	<1.0	5.8	2.4	----
Barium	7440-39-3	1.0	mg/kg	18.7	15.6	30.4	30.5	----
Beryllium	7440-41-7	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Cobalt	7440-48-4	0.5	mg/kg	0.7	1.4	2.2	2.4	----
Chromium	7440-47-3	1.0	mg/kg	<1.0	<1.0	1.1	<1.0	----
Copper	7440-50-8	1.0	mg/kg	<1.0	<1.0	9.9	3.1	----
Iron	7439-89-6	50	mg/kg	960	750	1830	1120	----
Lead	7439-92-1	1.0	mg/kg	1.6	1.4	2.7	3.0	----
Manganese	7439-96-5	10	mg/kg	62	38	88	91	----
Nickel	7440-02-0	1.0	mg/kg	<1.0	<1.0	1.2	<1.0	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	RRMCDS	RRMCUS	RRSW2	RRSW23	Q29SW2
				Sampling date / time	15-Apr-2021 00:00	15-Apr-2021 00:00	14-Apr-2021 00:00	14-Apr-2021 00:00	14-Apr-2021 00:00
Compound	CAS Number	LOR	Unit		ES2114313-001	ES2114313-002	ES2114313-003	ES2114313-004	ES2114313-005
					Result	Result	Result	Result	Result
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES - Continued									
Silver	7440-22-4	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
Vanadium	7440-62-2	2.0	mg/kg		<2.0	<2.0	**4.7**	**2.5**	----
Zinc	7440-66-6	1.0	mg/kg		<1.0	<1.0	**1.8**	**1.0**	----
Boron	7440-42-8	50	mg/kg		<50	<50	<50	<50	----
Molybdenum	7439-98-7	5	mg/kg		<5	<5	<5	<5	----
Strontium	7440-24-6	5	mg/kg		<5	<5	<5	<5	----
EG020-SDH: 1M HCl Extractable metals by ICPMS									
Selenium	7782-49-2	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	----
Uranium	7440-61-1	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
EG035T: Total Recoverable Mercury by FIMS (Low Level)									
Mercury	7439-97-6	0.01	mg/kg		<0.01	<0.01	**0.01**	**0.01**	----
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	1	mg/kg		<1	<1	<1	<1	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**1.24**	**0.19**	**0.44**	**2.65**	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

Analysis conducted by ALS Newcastle, NATA accreditation no. 825, site no. 1656 (Chemistry) 9854 (Biology).

(SOIL) EA150: Soil Classification based on Particle Size

(SOIL) EA150: Particle Sizing

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **ES2114313**	Page	: 1 of 5
Client	: **ECOZ ENVIRONMENTAL SERVICES**	Laboratory	: Environmental Division Sydney
Contact	: Gisela Lamche	Contact	: Customer Services ES
Address	: PO BOX 381 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: EZ21047 Hnaking sediment monitoring	Date Samples Received	: 20-Apr-2021
Order number	: EZ21047	Date Analysis Commenced	: 23-Apr-2021
C-O-C number	: ----	Issue Date	: 28-Apr-2021
Sampler	: AL		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 5		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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*
Aleksandar Vujkovic	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QC Lot: 3646238)									
ES2114313-001	RRMCDS	EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	0.7	0.8	0.00	No Limit
		EG005-SDH: Antimony	7440-36-0	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Arsenic	7440-38-2	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Barium	7440-39-3	1	mg/kg	18.7	19.6	5.02	0% - 50%
		EG005-SDH: Beryllium	7440-41-7	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Chromium	7440-47-3	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Copper	7440-50-8	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Lead	7439-92-1	1	mg/kg	1.6	1.5	0.00	No Limit
		EG005-SDH: Nickel	7440-02-0	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Silver	7440-22-4	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Zinc	7440-66-6	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Manganese	7439-96-5	10	mg/kg	62	65	5.58	No Limit
		EG005-SDH: Vanadium	7440-62-2	2	mg/kg	<2.0	<2.0	0.00	No Limit
		EG005-SDH: Molybdenum	7439-98-7	5	mg/kg	<5	<5	0.00	No Limit
		EG005-SDH: Strontium	7440-24-6	5	mg/kg	<5	<5	0.00	No Limit
		EG005-SDH: Aluminium	7429-90-5	50	mg/kg	190	180	0.00	No Limit
		EG005-SDH: Iron	7439-89-6	50	mg/kg	960	920	4.42	0% - 50%
		EG005-SDH: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 3642458)									
ES2114313-001	RRMCDS	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 3639755)									
ES2114313-001	RRMCDS	EA055: Moisture Content	----	0.1	%	21.8	22.8	4.18	0% - 20%
EG020-SDH: 1M HCl Extractable metals by ICPMS (QC Lot: 3646237)									

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EG020-SDH: 1M HCl Extractable metals by ICPMS (QC Lot: 3646237) - continued									
ES2114313-001	RRMCDS	EG020-SDH: Selenium	7782-49-2	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EG020-SDH: Uranium	7440-61-1	1	mg/kg	<1.0	<1.0	0.00	No Limit
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 3639752)									
ES2114355-008	Anonymous	EK026SF: Total Cyanide	57-12-5	1	mg/kg	<1	<1	0.00	No Limit
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 3643589)									
EB2104867-001	Anonymous	EP003: Total Organic Carbon	----	0.02	%	5.30	5.94	11.3	0% - 20%
EB2110616-005	Anonymous	EP003: Total Organic Carbon	----	0.02	%	1.83	1.81	1.10	0% - 20%

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 3646238)								
EG005-SDH: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SDH: Antimony	7440-36-0	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Arsenic	7440-38-2	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Barium	7440-39-3	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Beryllium	7440-41-7	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.1	----	----	----	----
EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	<0.5	----	----	----	----
EG005-SDH: Chromium	7440-47-3	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Copper	7440-50-8	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005-SDH: Lead	7439-92-1	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Manganese	7439-96-5	10	mg/kg	<10	----	----	----	----
EG005-SDH: Nickel	7440-02-0	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Silver	7440-22-4	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Vanadium	7440-62-2	2	mg/kg	<2.0	----	----	----	----
EG005-SDH: Zinc	7440-66-6	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005-SDH: Molybdenum	7439-98-7	5	mg/kg	<5	----	----	----	----
EG005-SDH: Strontium	7440-24-6	5	mg/kg	<5	40.95 mg/kg	95.0	94.0	106
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 3642458)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	0.073 mg/kg	112	72.0	116
EG020-SDH: 1M HCl Extractable metals by ICPMS (QCLot: 3646237)								
EG020-SDH: Selenium	7782-49-2	0.5	mg/kg	<0.5	0.5 mg/kg	104	86.0	114
EG020-SDH: Uranium	7440-61-1	1	mg/kg	<1.0	----	----	----	----
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 3639752)								
EK026SF: Total Cyanide	57-12-5	1	mg/kg	<1	40 mg/kg	114	81.0	129
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 3643589)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	8.16 %	103	70.0	130
				<0.02	0.48 %	88.5	70.0	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 3646238)							
ES2114313-001	RRMCDS	EG005-SDH: Arsenic	7440-38-2	50 mg/kg	85.4	70.0	130
		EG005-SDH: Barium	7440-39-3	50 mg/kg	92.3	70.0	130
		EG005-SDH: Beryllium	7440-41-7	50 mg/kg	103	70.0	130
		EG005-SDH: Cadmium	7440-43-9	12.5 mg/kg	96.3	70.0	130
		EG005-SDH: Cobalt	7440-48-4	50 mg/kg	97.5	70.0	130
		EG005-SDH: Chromium	7440-47-3	50 mg/kg	95.7	70.0	130
		EG005-SDH: Copper	7440-50-8	50 mg/kg	92.6	70.0	130
		EG005-SDH: Lead	7439-92-1	50 mg/kg	99.4	70.0	130
		EG005-SDH: Manganese	7439-96-5	50 mg/kg	87.6	70.0	130
		EG005-SDH: Nickel	7440-02-0	50 mg/kg	97.8	70.0	130
		EG005-SDH: Vanadium	7440-62-2	50 mg/kg	96.3	70.0	130
		EG005-SDH: Zinc	7440-66-6	50 mg/kg	109	70.0	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 3642458)							
ES2114313-001	RRMCDS	EG035T-LL: Mercury	7439-97-6	0.05 mg/kg	98.0	70.0	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 3639752)							
ES2114355-008	Anonymous	EK026SF: Total Cyanide	57-12-5	40 mg/kg	125	70.0	130

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES2114313**	Page	: 1 of 6
Client	: **ECOZ ENVIRONMENTAL SERVICES**	Laboratory	: Environmental Division Sydney
Contact	: Gisela Lamche	Telephone	: +61-2-8784 8555
Project	: EZ21047 Hnaking sediment monitoring	Date Samples Received	: 20-Apr-2021
Site	: ----	Issue Date	: 28-Apr-2021
Sampler	: AL	No. of samples received	: 5
Order number	: EZ21047	No. of samples analysed	: 5

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

Matrix: **SOIL**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Matrix Spikes (MS)					
1M HCl Extractable Metals by ICPMS	0	4	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / *Container* / Client Sample ID(s)		*Sample Date*	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA055: Moisture Content (Dried @ 105-110°C)								
Soil Glass Jar - Unpreserved (EA055)								
RRSW2,	RRSW23	**14-Apr-2021**	**----**	----	----	**23-Apr-2021**	28-Apr-2021	✓
Soil Glass Jar - Unpreserved (EA055)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**----**	----	----	**23-Apr-2021**	29-Apr-2021	✓
EA150: Particle Sizing								
Snap Lock Bag (EA150H)								
RRSW2, Q29SW2	RRSW23,	**14-Apr-2021**	**----**	----	----	**28-Apr-2021**	11-Oct-2021	✓
Snap Lock Bag (EA150H)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**----**	----	----	**28-Apr-2021**	12-Oct-2021	✓
EA150: Soil Classification based on Particle Size								
Snap Lock Bag (EA150H)								
RRSW2, Q29SW2	RRSW23,	**14-Apr-2021**	**----**	----	----	**28-Apr-2021**	11-Oct-2021	✓
Snap Lock Bag (EA150H)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**----**	----	----	**28-Apr-2021**	12-Oct-2021	✓
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Soil Glass Jar - Unpreserved (EG005-SDH)								
RRSW2,	RRSW23	**14-Apr-2021**	**28-Apr-2021**	11-Oct-2021	✓	**28-Apr-2021**	11-Oct-2021	✓
Soil Glass Jar - Unpreserved (EG005-SDH)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**28-Apr-2021**	12-Oct-2021	✓	**28-Apr-2021**	12-Oct-2021	✓
EG020-SDH: 1M HCl Extractable metals by ICPMS								
Soil Glass Jar - Unpreserved (EG020-SDH)								
RRSW2,	RRSW23	**14-Apr-2021**	**28-Apr-2021**	11-Oct-2021	✓	**28-Apr-2021**	11-Oct-2021	✓
Soil Glass Jar - Unpreserved (EG020-SDH)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**28-Apr-2021**	12-Oct-2021	✓	**28-Apr-2021**	12-Oct-2021	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035T: Total Recoverable Mercury by FIMS (Low Level)								
Soil Glass Jar - Unpreserved (EG035T-LL)								
RRSW2,	RRSW23	**14-Apr-2021**	**27-Apr-2021**	12-May-2021	✓	**28-Apr-2021**	12-May-2021	✓
Soil Glass Jar - Unpreserved (EG035T-LL)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**27-Apr-2021**	13-May-2021	✓	**28-Apr-2021**	13-May-2021	✓
EK026SF: Total CN by Segmented Flow Analyser								
Soil Glass Jar - Unpreserved (EK026SF)								
RRSW2,	RRSW23	**14-Apr-2021**	**23-Apr-2021**	28-Apr-2021	✓	**26-Apr-2021**	07-May-2021	✓
Soil Glass Jar - Unpreserved (EK026SF)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**23-Apr-2021**	29-Apr-2021	✓	**26-Apr-2021**	07-May-2021	✓
EP003: Total Organic Carbon (TOC) in Soil								
Pulp Bag (EP003)								
RRSW2,	RRSW23	**14-Apr-2021**	**27-Apr-2021**	12-May-2021	✓	**27-Apr-2021**	12-May-2021	✓
Pulp Bag (EP003)								
RRMCDS,	RRMCUS	**15-Apr-2021**	**27-Apr-2021**	13-May-2021	✓	**27-Apr-2021**	13-May-2021	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
1M HCl Extractable Metals	EG005-SDH	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals by ICPMS	EG020-SDH	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
1M HCl Extractable Metals	EG005-SDH	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals by ICPMS	EG020-SDH	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	6	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
1M HCl Extractable Metals	EG005-SDH	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals by ICPMS	EG020-SDH	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
1M HCl Extractable Metals	EG005-SDH	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals by ICPMS	EG020-SDH	0	4	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM Schedule B(3).
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3
1M HCl Extractable Metals	EG005-SDH	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined via ICPAES following weak acid extraction. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM Schedule B(3). LORs per NAGD. ALS is not NATA accredited for the analysis of Barium, Boron, Molybdenum and Strontium by this method.
1M HCl Extractable Metals by ICPMS	EG020-SDH	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020. Metals are determined via ICPMS following weak acid extraction. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector. Analyte list and LORs per NAGD. ALS is not NATA accredited for the analysis of Tin, Uranium, Barium, Boron and Strontium by this method.
Total Mercury by FIMS (Low Level)	EG035T-LL	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM Schedule B(3)
Total Cyanide by Segmented Flow Analyser	EK026SF	SOIL	In house: Referenced to APHA 4500-CN C / ASTM D7511 / ISO 14403. Caustic leachates of soil samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM Schedule B(3).
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO2) is automatically measured by infra-red detector.

Preparation Methods	Method	Matrix	Method Descriptions
NaOH leach for CN in Soils	CN-PR	SOIL	In house: APHA 4500 CN. Samples are extracted by end-over-end tumbling with NaOH.

Preparation Methods	Method	Matrix	Method Descriptions
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM Schedule B(3).
1M HCl Extraction for Metals in Sediments (1 hour)	EN71	SOIL	In house: Referenced to In house, Allen (1993). 1g of sample is leached at room temperature for 1 hour in 10% hydrochloric acid. The resultant extract is filtered and bulked for analysis of extracted metals.
Dry and Pulverise (up to 100g)	GEO30	SOIL	#

Certificate of Analysis

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pH 02 4014 2500
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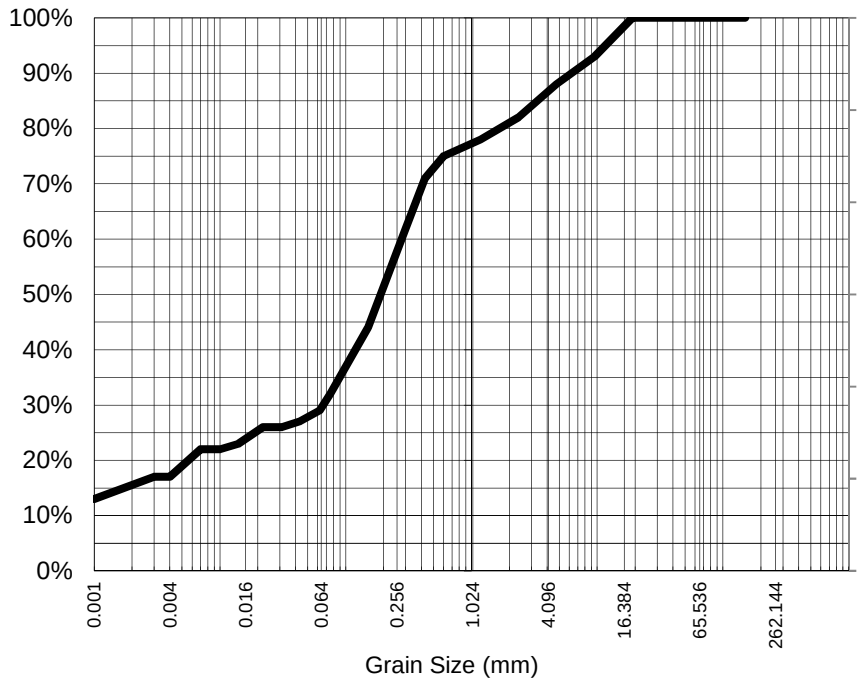
ALS Environmental

Newcastle, NSW

CLIENT:	Gisela Lamche	**DATE REPORTED:**	28-Apr-2021
COMPANY:	ECOZ ENVIRONMENTAL SERVICES	**DATE RECEIVED:**	20-Apr-2021
ADDRESS:	Po Box 381 Darwin Nt, Australia	**REPORT NO:**	ES2114313-001 / PSD
PROJECT:	EZ21047 Hnaking sediment monitoring	**SAMPLE ID:**	RRMCDS

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	93%
4.75	88%
2.36	82%
1.18	78%
0.600	75%
0.425	71%
0.300	62%
0.150	44%
0.075	32%
Particle Size (microns)	
43	27%
31	26%
22	26%
14	23%
10	22%
7	22%
5	19%
4	17%
1	13%

Median Particle Size (mm)*	0.200

Analysis Notes

Samples analysed as received.

**** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results***

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 23-Apr-21

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND,FINES,GRAVEL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) #N/A

NATA Accreditation: 825 Site: Newcastle
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WORLD RECOGNISED ACCREDITATION

Aleksandar Vujkovic
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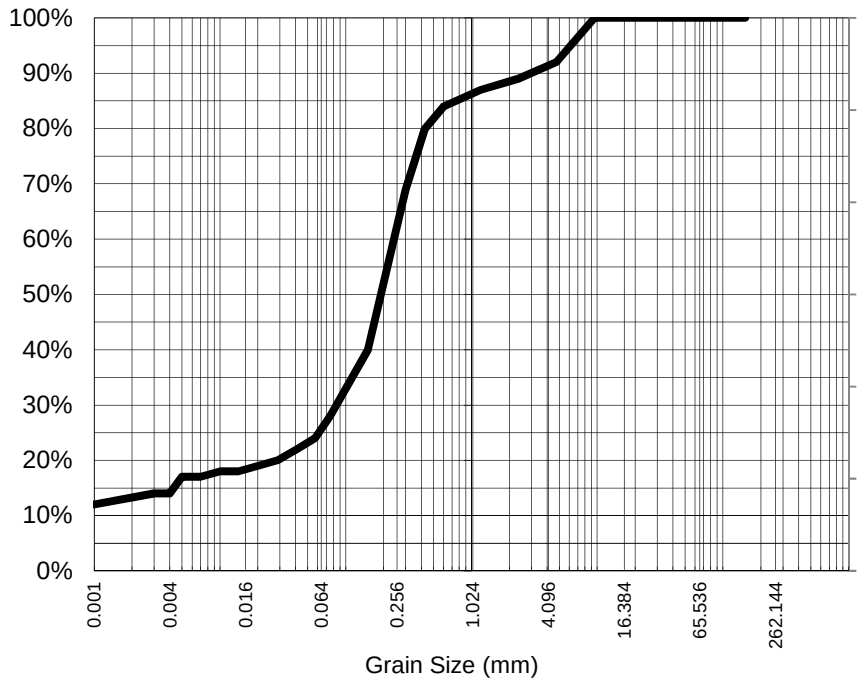
Newcastle, NSW

CLIENT:	Gisela Lamche	**DATE REPORTED:**	28-Apr-2021
COMPANY:	ECOZ ENVIRONMENTAL SERVICES	**DATE RECEIVED:**	20-Apr-2021
ADDRESS:	Po Box 381 Darwin Nt, Australia	**REPORT NO:**	ES2114313-002 / PSD
PROJECT:	EZ21047 Hnaking sediment monitoring	**SAMPLE ID:**	RRMCUS

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	92%
2.36	89%
1.18	87%
0.600	84%
0.425	80%
0.300	69%
0.150	40%
0.075	28%
Particle Size (microns)	
41	22%
29	20%
20	19%
14	18%
10	18%
7	17%
5	17%
4	14%
1	12%

Median Particle Size (mm)*	0.202

Analysis Notes

Samples analysed as received.

**** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results***

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 23-Apr-21

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND,FINES,GRAVEL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) #N/A

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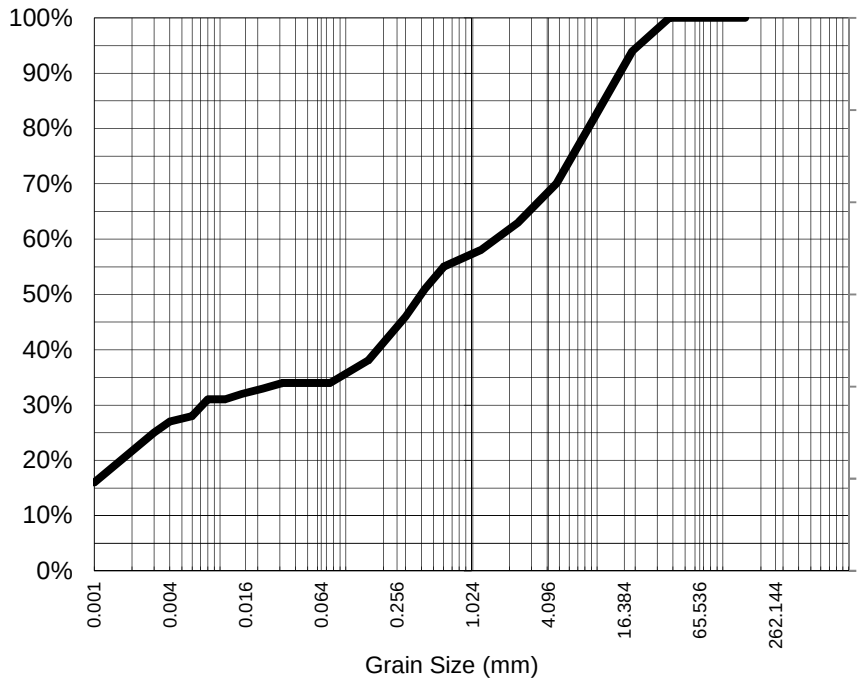
Newcastle, NSW

CLIENT:	Gisela Lamche	**DATE REPORTED:**	28-Apr-2021
COMPANY:	ECOZ ENVIRONMENTAL SERVICES	**DATE RECEIVED:**	20-Apr-2021
ADDRESS:	Po Box 381 Darwin Nt, Australia	**REPORT NO:**	ES2114313-003 / PSD
PROJECT:	EZ21047 Hnaking sediment monitoring	**SAMPLE ID:**	RRSW2

Particle Size Distribution



Particle Size (mm)	% Passing
37.5	100%
19.0	94%
9.50	82%
4.75	70%
2.36	63%
1.18	58%
0.600	55%
0.425	51%
0.300	46%
0.150	38%
0.075	34%
Particle Size (microns)	
43	34%
31	34%
22	33%
15	32%
11	31%
8	31%
6	28%
4	27%
1	16%

Median Particle Size (mm)*	0.400

Analysis Notes

Samples analysed as received.

**** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results***

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 23-Apr-21

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: GRAVEL,FINES,SAND

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) #N/A

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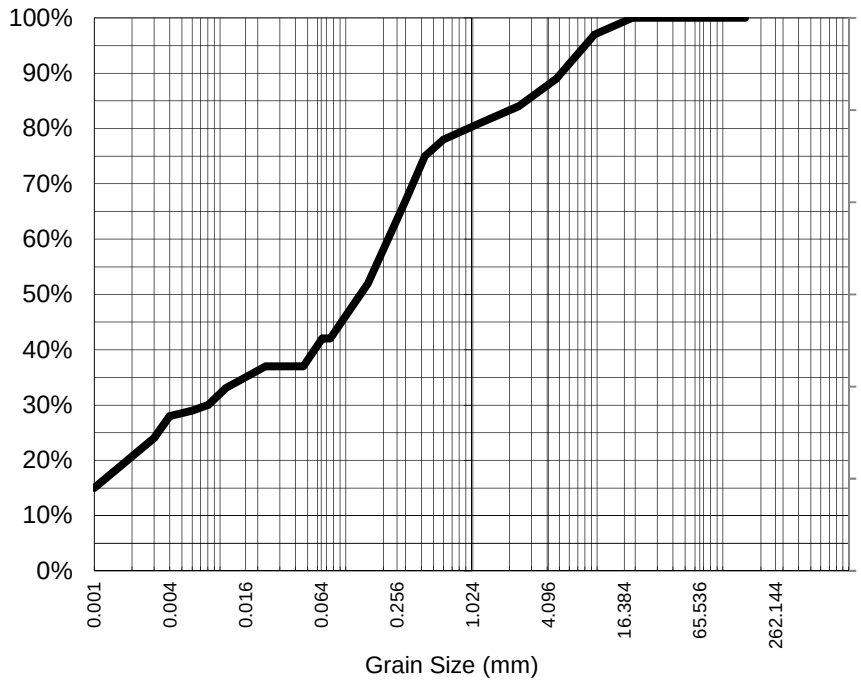
CLIENT:	Gisela Lamche	**DATE REPORTED:**	28-Apr-2021
COMPANY:	ECOZ ENVIRONMENTAL SERVICES	**DATE RECEIVED:**	20-Apr-2021
ADDRESS:	Po Box 381 Darwin Nt, Australia	**REPORT NO:**	ES2114313-004 / PSD
PROJECT:	EZ21047 Hnaking sediment monitoring	**SAMPLE ID:**	RRSW23

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	97%
4.75	89%
2.36	84%
1.18	81%
0.600	78%
0.425	75%
0.300	67%
0.150	52%
0.075	42%
Particle Size (microns)	
46	37%
33	37%
23	37%
16	35%
11	33%
8	30%
6	29%
4	28%
1	15%

Median Particle Size (mm)*	0.135

Analysis Notes

Samples analysed as received.

**** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results***

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 23-Apr-21

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND,FINES,GRAVEL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) #N/A

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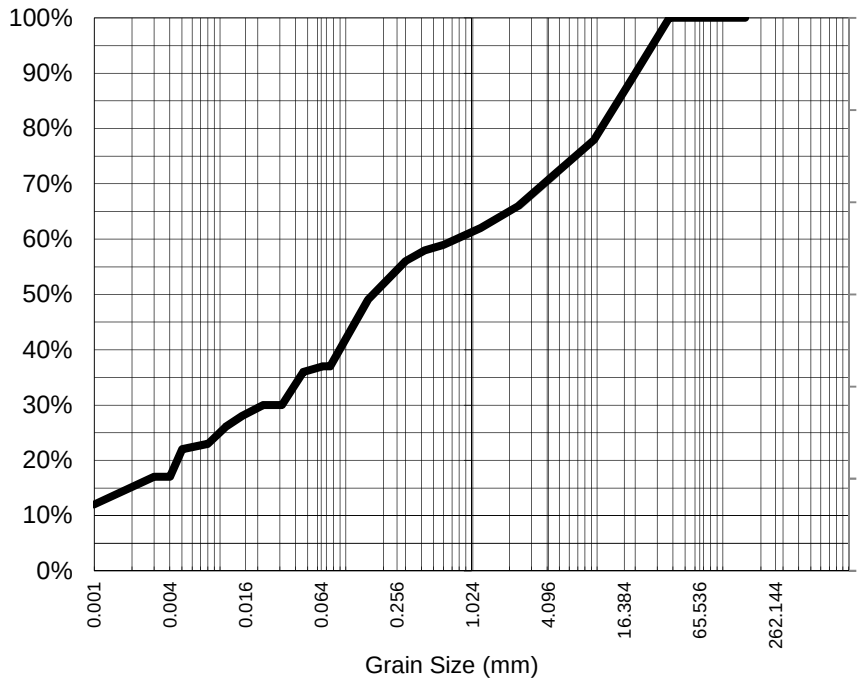
CLIENT:	Gisela Lamche	**DATE REPORTED:**	28-Apr-2021
COMPANY:	ECOZ ENVIRONMENTAL SERVICES	**DATE RECEIVED:**	20-Apr-2021
ADDRESS:	Po Box 381 Darwin Nt, Australia	**REPORT NO:**	ES2114313-005 / PSD
PROJECT:	EZ21047 Hnaking sediment monitoring	**SAMPLE ID:**	Q29SW2

Particle Size Distribution



Particle Size (mm)	% Passing
37.5	100%
19.0	89%
9.50	78%
4.75	72%
2.36	66%
1.18	62%
0.600	59%
0.425	58%
0.300	56%
0.150	49%
0.075	37%
Particle Size (microns)	
46	36%
31	30%
22	30%
15	28%
11	26%
8	23%
5	22%
4	17%
1	12%

Median Particle Size (mm)*	0.171

Analysis Notes

Samples analysed as received.

**** Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results***

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 23-Apr-21

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, GRAVEL, SAND

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) #N/A

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APPENDIX C MACROINVERTEBRATE REPORT

Rustlers Roost Mine

Biological Monitoring 2021

Draft Report

Aquatic Ecology Services

This report has been prepared for Ecoz as a technical document. 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.

Field data and macroinvertebrate samples were obtained from Ecoz. Aquatic Ecology Services has made the assumption that all data has been validated and is correct, and that standard protocols were followed during sampling.

Version	Prepared by	Reviewed by	Review Date
Draft 1.0	T Steele	G. Lamche	19 July 2021
Final 2.0	T Steele		

Table of Contents

Figures

Tables

1. Background

1.1 Catchment

Rustlers Roost Mine is located at the headwaters of two catchments. To the west, Marrakai Creek flows to the Adelaide River, approximately 35km downstream. To the east, Mount Bundey Creek flows into Hardies Creek, a tributary of the Mary River Floodplain. The catchment to the east of Rustlers Roost is located within the Mary River Surface Water Beneficial Use and Objectives Area, which identifies all tributaries that enter the Mary River as having environmental, riparian and cultural beneficial uses. The Rustlers Roost Project Area (RRPA) is located on Old Mount Bundy Station, and the surrounding land use is predominantly cattle grazing.

1.2 Monitoring Program

Primary Gold Limited have recently received approval for a Waste Discharge Licence (WDL) with the Northern Territory Environmental Protection Authority, to dewater the historic mining pit at RRPA, with the objective to recommence mining.

In early 2021, a Sediment and Macroinvertebrate Monitoring Program (Ecoz 2021) was developed for the RRPA. Although the WDL application does not include details on ecosystem monitoring to validate environmental harm, a biological and sediment monitoring program has been implemented to gather data before and during pit dewatering in the receiving environment of the RRPA.

1.3 Scope

Aquatic Ecology Services was engaged by Ecoz to complete sample processing, data analysis and reporting for the biological monitoring component of the macroinvertebrate monitoring program. This report details the outcome of macroinvertebrate sampling completed in the early dry season, 2021.

2. Study Design

2.1 Sampling sites

Four sites were visited during macroinvertebrate sampling in 2021 (Table 1). This included one upstream and one downstream site on Marrakai Creek, and two downstream sites on Upper Mount Bundey Creek.

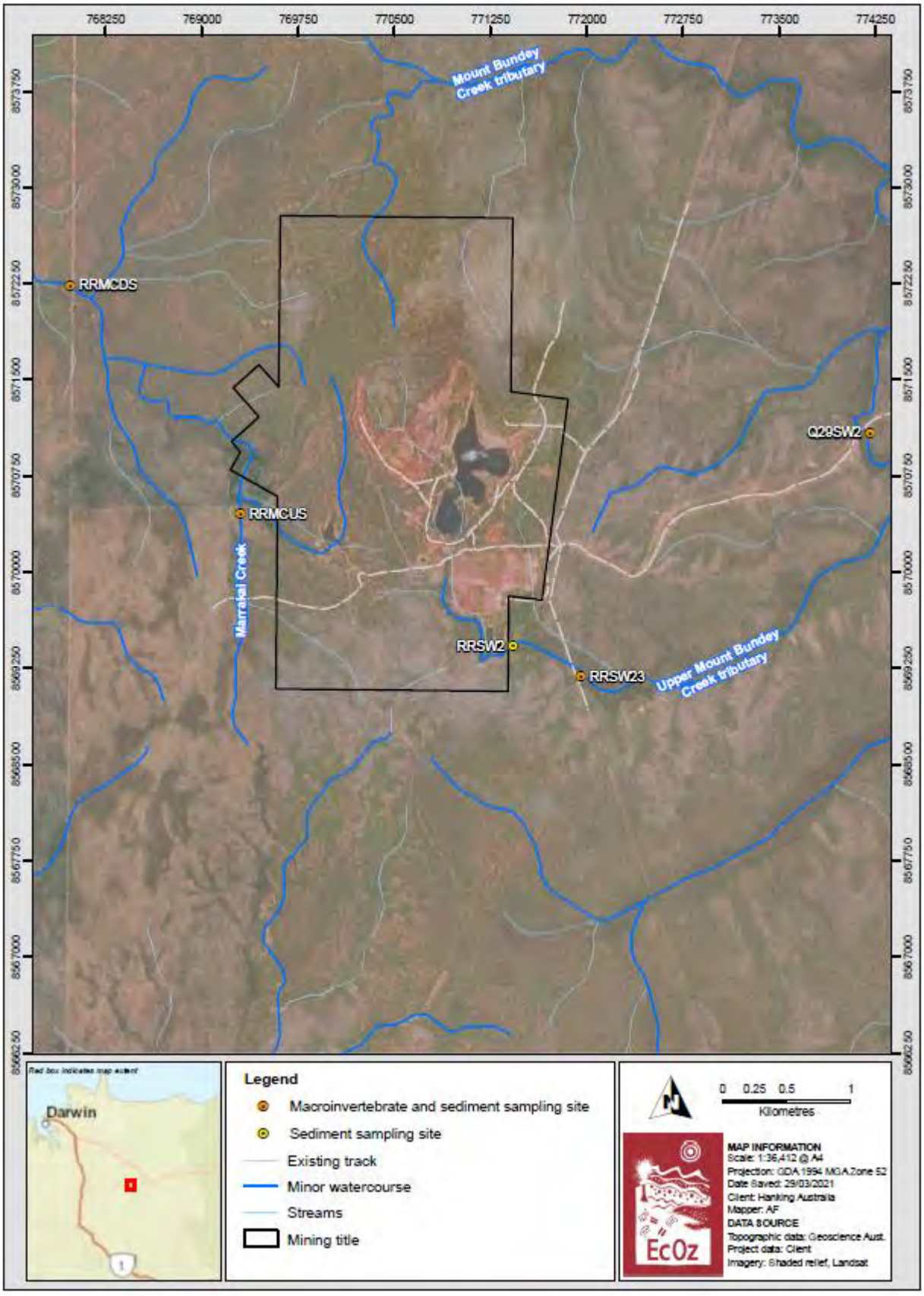
Table 1 – Sampling sites at the RRPA

Site Code	Site type	Description	Easting	Northing
RRMCUS	Upstream	Marrakai Creek upstream of inflow from Annie's Dam	769206	8570823
RRMCDS	Downstream	Marrakai Creek downstream of inflows from the RRPA	767981	8572085
RRSW23	Downstream	Upper Mount Bundey Creek tributary downstream of proposed authorised discharge point	771900	8569190
Q29SW2	Downstream	Mount Bundey Creek tributary crossing on RRPA access road	774154	8571092

2.2 Timing

To meet the protocols outlined in the Darwin-Daly AUSRIVAS sampling manual (Lamche 2007), sampling was conducted in the post-wet season during the recessional flow period. Sampling was undertaken in April to target adequate water availability at all sites.

Figure 1 – Macroinvertebrate sampling site locations (Ecoz 2021)



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. 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 quality

The physico-chemical parameters of the water at each site were 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

The results were compared to guideline values (ANZECC 2000).

3.3 Macroinvertebrates

3.3.1 Field sampling

Macroinvertebrate sampling and field processing was completed by Ecoz, and 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 10mm and 250µm 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 macroinvertebrate laboratory for further processing and identification.

3.3.2 Laboratory processing

Samples were washed through a series of sieves (10mm, 500µm and 250µm 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 500µm mesh sieve were retained for macroinvertebrate identification and enumeration, while the 250µm fraction was retained as sample residue for quality assurance purposes. The contents of the 500µm 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 genus 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.

3.4 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. 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:

- Relative abundance – Total number of individual taxa collected at a site. This information is calculated based on processing requirements in the laboratory (% of sample processed).
- Taxa richness (Family) – Total number of taxa present at the site used as a measure of diversity of families (used for long-term data analysis).
- Taxa Richness (Genus) - Total number of taxa present at the site used as a measure of diversity of genera.
- 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 order to further understand this metric, the tolerant taxa index was calculated from SIGNAL grade numbers. Taxa with SIGNAL grade numbers of 3 or less are designated as tolerant (Marshall et al. 2001), and the number of these tolerant taxa are compared to the overall taxa count and expressed as a percentage. This approach allows for a more nuanced assessment of any impacts associated with active discharge from the RRPA in the future, and provides background data on the overall tolerance of taxa in the catchments.

Prior to 2021, biological monitoring programs commonly utilised the NT AUSRIVAS Darwin-Daly Early (dry season) Family level Edge habitat model. New guidance on the use of these models in the NT to understand impacts of point source pollution have been published (ANZG 2021). The updated guidance states that the models are not useful in understanding aquatic ecosystem health outside of the large rivers where macroinvertebrates have been collects, and therefore the use of AUSRIVAS modelling has not been undertaken on the data collected for this project.

In addition to univariate analysis of metrics, an assessment of differences in the macroinvertebrate community composition was 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. 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 (Upstream and Downstream) and catchments (Marrakai and Mt Bundey). 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).

Sample data was fourth-root transformed prior to multivariate analysis.

4. Results and Discussion

4.1 Site conditions

4.1.1 Rainfall

Rainfall recorded at the closest available weather station (Middle Point, Station no. 14041) is presented in Figure 2. Rainfall data was recorded approximately 40km from the Rustlers Roost site, and is indicative of rainfall at the RRPA. A total of 1747mm of rain was recorded in the 2020/2021 wet season, which was greater than the long-term average for the area (1373mm) and rainfall was above average in the months of December, January and March.

It is acknowledged that rainfall in the NT can be patchy, and rainfall recorded at Middle point is indicative of climate, but may not accurately represent conditions on site at the RRPA. The establishment of a weather station on site is advised, given that data is not available reliably from other stations in the area.

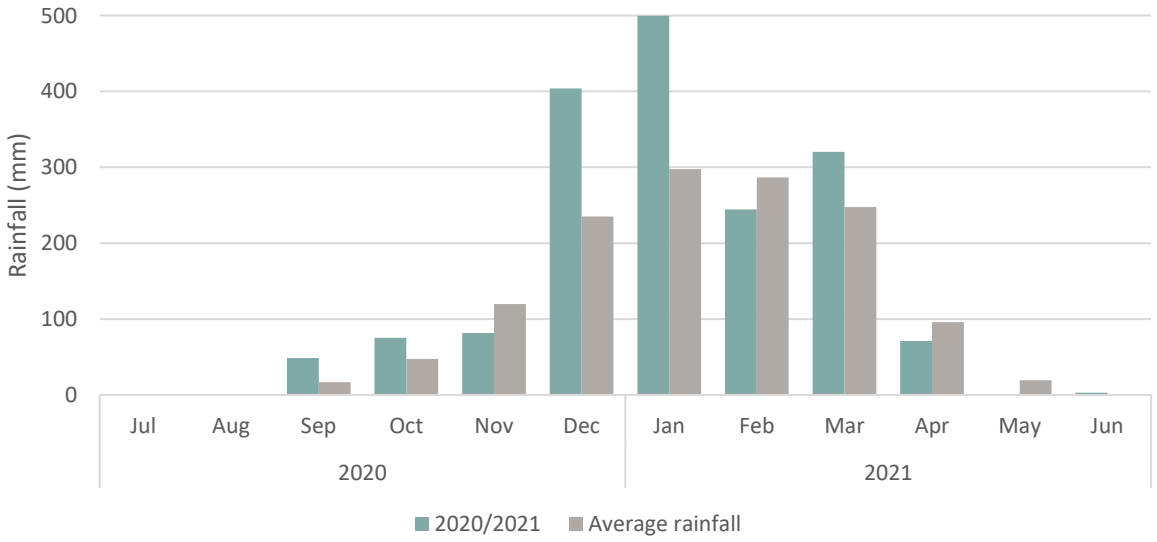


Figure 2 – Monthly Rainfall recorded at Middle Point July 2020-June 2021 (BOM 2021)

4.1.2 Habitat characteristics

Habitat characteristics of each site are detailed below in Table 2. All sites were flowing at the time of sampling. Sufficient water was present for sampling to take place at each site, and sample timing was considered appropriate. Evidence of cattle access to all sites was observed.

Table 2 – BMP site descriptions, April 2021

Site description	Site photo
RRMCUS – Upstream The site was located around 100m upstream of the confluence of Annie's Dam Creek. Flow was observable at the site over shallow areas. The sampling site was a pool with vertical banks and sparse trees. Vegetation was mainly pasture grasses with some trees. The pool sampled was turbid, and macrophytes were present.	
RRMCDS – Downstream The site is located downstream of a large dam constructed across Marrakai Creek. The site is characterised by a narrow, meandering creek line through Paperbark and Pandanus which lined the banks. Water was slightly turbid, and shading was high. Leaf packs and branches were common throughout.	
RRSW23 -Downstream The site is located on a tributary of Mount Bundey Creek and consisted of a large, deep pool between riffles and runs. Substrate in shallow habitats was a mixture of sand and pebbles, and the pool contained sand with bedrock covered by detritus. Riparian vegetation was made up of shrubs, with some trailing into the water.	
Q29SW2 – Downstream The site was located upstream of the access road to the RRPA. Flow was observable, but very slow. The site was highly shaded by riparian vegetation overhanging the creek. The sampling site was mainly pool habitat with undercut banks, exposed roots and detritus. Water was turbid, and the substrate was a mixture of sand and clay.	

4.2 Water quality

In situ water quality data collected at sampling sites is presented below in Table 3. The following observations can be made about water parameters at sites associated with the RRPA:

- Water temperatures were similar at all sites.
- Dissolved oxygen was recorded outside of the guideline value range at Q29SW2, which is likely to be related to shading and turbidity, limiting light penetration and primary productivity. A reading above 80% saturation is not considered to be hypoxic and does not indicate any form of impact at the site.
- Conductivity was lowest at sites on Marrakai Creek, with very little difference between sites upstream and downstream. The highest conductivity was recorded at the site closest to the RRPA in the Mt Bundey Creek catchment (RRSW23), but was reduced by more than half downstream. The higher conductivity result directly downstream of the RRPA may indicate some influence associated with passive discharges from the RRPA. Higher conductivity on the tributary appeared to be ameliorated by fresher waters from Mt Bundey Creek.
- pH was highest at RRSW23, with the remainder of sites recording similar results. Waters at all sites were circumneutral.
- Turbidity was variable across sites, and above the guideline value at RRMCUS and Q29SW2. Low water clarity was not related to position in the catchment and was likely to be related to cattle access, which was noted at all sites.

Table 3 – In situ water quality results from sites visited in April 2021

Site Code	Date	Time	Temp (°C)	DO (%)	EC (µS/cm)	pH	Turbidity (NTU)
Guideline Value			-	85-110	20-250	6-8	15
RRMCUS	15/04/2021	10:30	27.3	87.6	21.9	6.19	24.5
RRMCDS	15/04/2021	12:20	21.7	101.5	21.7	6.31	9.2
RRSW23	14/04/2021	12:35	30.7	116.5	124.3	7.32	14.2
Q29SW2	14/04/2021	10:30	27.3	80.6	44.6	6.60	21.0

4.3 Macroinvertebrates

The following sections summarise the findings of results from 2021, which represents the first year that sampling was completed. Raw data is attached in Appendix A and QA results in Appendix B

4.3.1 Relative abundance

The relative abundance of macroinvertebrates collected at the RRPA in 2021 is presented in Figure 3. A greater number of individuals were collected at the downstream site on Marrakai Creek and the tributary of Mt Bundey Creek. The relative abundance of the sample collected at the upstream site were similar to that furthest downstream on Mt Bundey Creek.

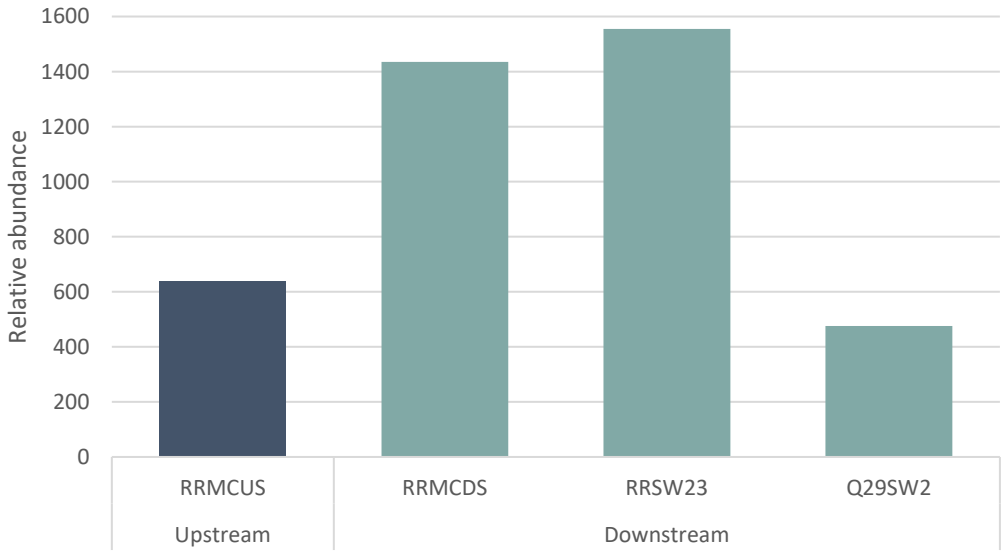


Figure 3 – Relative abundance of samples collected in 2021

4.3.2 Taxa richness

Taxa richness of samples collected in 2021 are presented in Figure 4. The lowest diversity of all samples was recorded at the upstream site, and the highest at the site farthest downstream on Mt Bundey Creek. Taxa richness was similar at the upstream site to downstream sites closest to the RRPA.

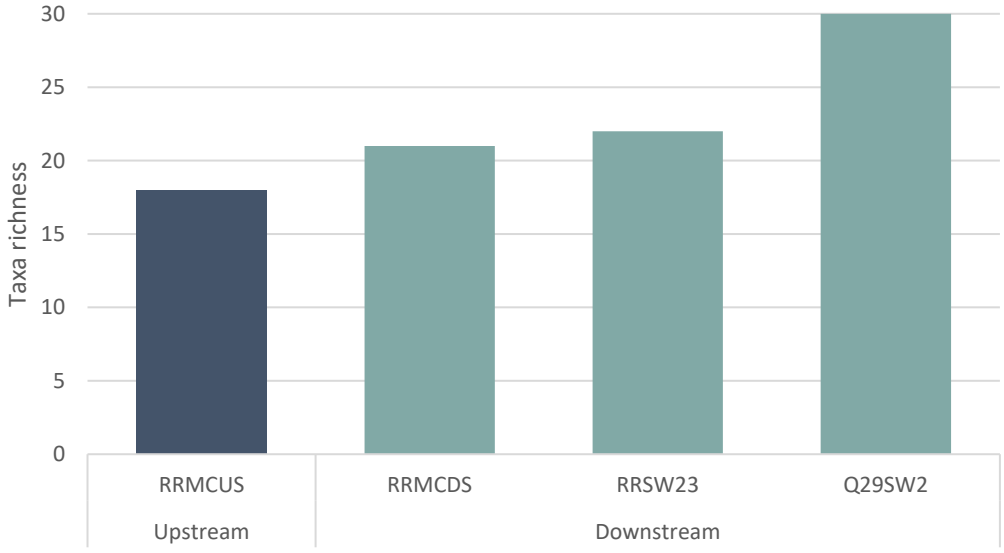


Figure 4 -Family taxa richness from sites at the RRPA sampled in 2021

4.3.3 PET richness

PET richness results for samples collected in 2021 are presented in Figure 5. There was very little difference between results for any site, with all three sites downstream returning the same result, and a single PET taxon (Hydroptilidae) not present in the sample upstream.

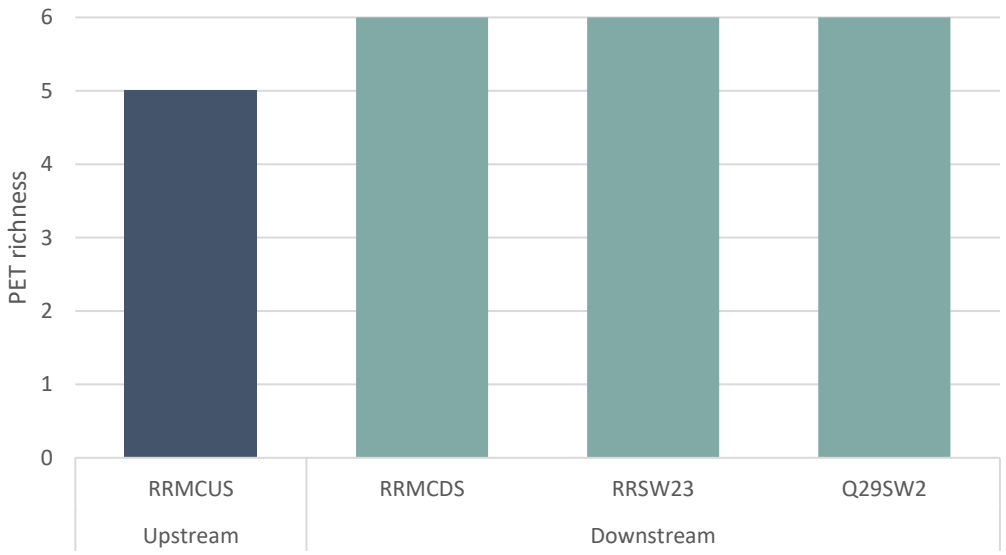


Figure 5 – PET richness from sites at the RRPA sampled in 2021

4.3.4 SIGNAL-2

SIGNAL-2 scores calculated for samples collected in 2021 are presented in Figure 6. Results were similar, regardless of the catchment in which samples were collected and their position relative to the RRPA. The proportion of sensitive taxa for each sample followed a similar trend to SIGNAL-2 results (Figure 7), but a slightly lower result for Q29SW2 was observed. Both metrics indicate that the macroinvertebrate community is pollution tolerant, which is expected, given the ephemeral nature of the sampled watercourses.

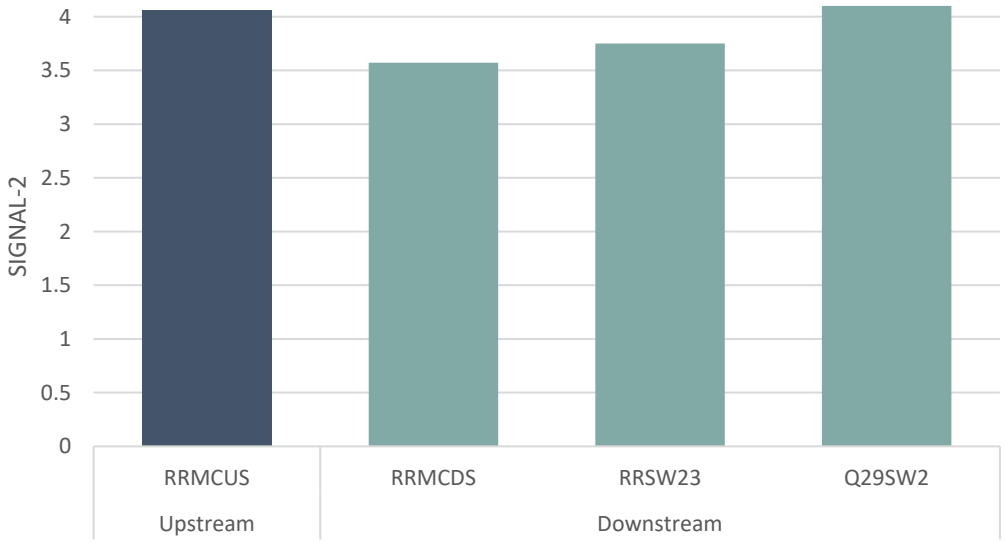


Figure 6 – SIGNAL-2 scores for samples collected at the RRPA in 2021

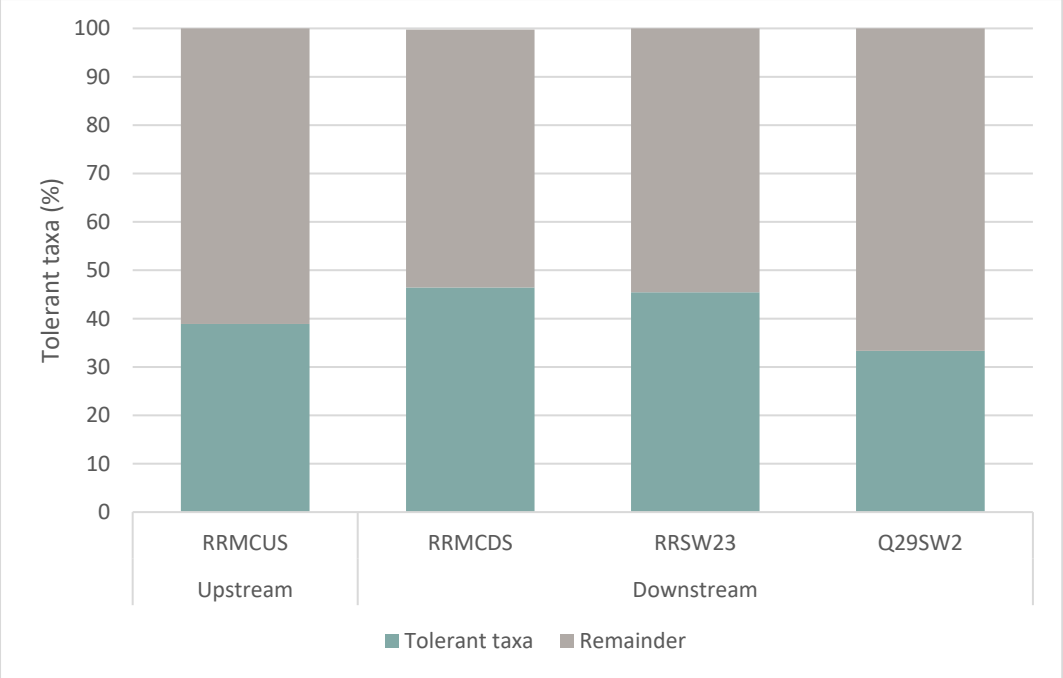


Figure 7 - Percentage of tolerant taxa found at each site

4.3.5 Community composition

The proportion of each macroinvertebrate order in samples is presented in Figure 8. There is an observable difference in community composition between the upstream site on Marrakai Creek and all other sites. True flies (Diptera) dominate the community at the upstream site, compared with other sites, which do contain a high proportion of true flies, but their abundance is offset by mayflies (Ephemeroptera). Variation in the composition of the macroinvertebrate community across sites is further demonstrated in Figure 9. There was a great amount of variability in composition. The most observable similarity was approximately 10% greater similarity between downstream sites closest to the RRPA, as opposed to a 60% similarity between all sites. Differences in community composition are likely to be associated with differences in habitat characteristics of sites. The higher number of taxa collected at Q29SW2 is contributed to by a greater diversity of true bugs (Hemiptera) at the site.

Given that water quality differences do not appear to be driving any differences in community composition, habitat characteristics are likely playing a major role in the presence or absence of macroinvertebrate families in each sampling site.

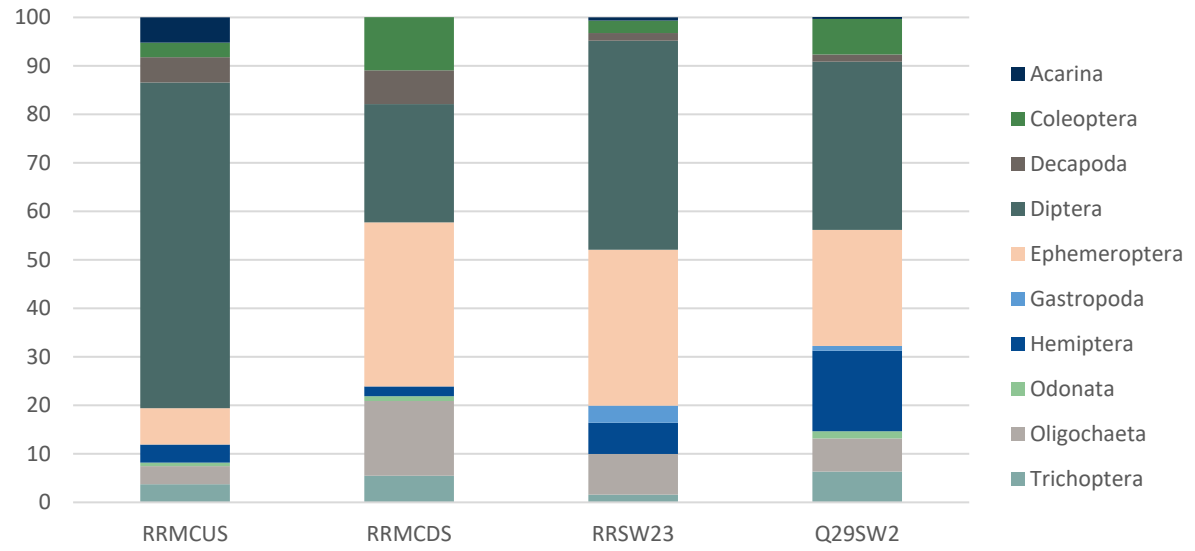


Figure 8 – Proportional abundance of macroinvertebrate orders collected in 2021

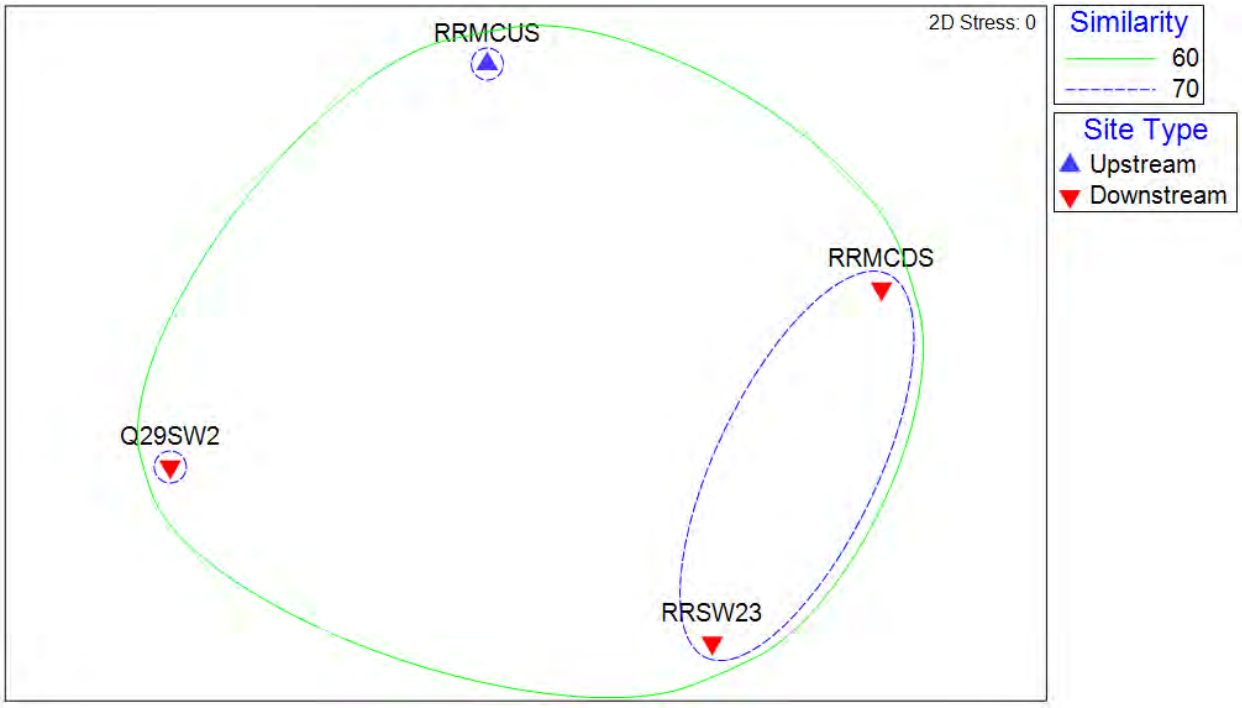


Figure 9 - NMDS plot showing variation in community composition between sites

4.4 Discussion

Biological monitoring conducted at the RRPA in 2021 has demonstrated that the macroinvertebrate community of Marrakai Creek and upper Mount Bundey Creek catchments are tolerant of pollution and highly influenced by habitat availability. The habitat characteristics of the upstream site on Marrakai Creek were quite different to its downstream counterpart, and were also unlike those found in the Mount Bundey Creek catchment. The riparian zone at RRMCUS lacked understorey vegetation, besides grasses, and trees were sparse. This is likely to have resulted in lower shading, and a lower likelihood of detritus being deposited in the creek bed. The upstream site also contained submerged macrophytes, which provide

structural habitat not found downstream. The habitat available at the two downstream sites closest to the RRPA was similar, and resulted in similar macroinvertebrate metrics and community composition, despite differences in water quality.

Water quality results suggest influence associated with the RRPA are likely to be occurring at RRSW23, due to higher conductivity results. This report does not include the detailed analysis of water quality results which is assumed to be undertaken separately. Should any impact associated with passive discharge from the RRPA be occurring, the implementation of the sediment monitoring program will be a fundamental component of understanding any changes to the macroinvertebrate community that may occur over time as a result of mining activity at the RRPA.

Macroinvertebrate metrics suggest that the community at Q29SW2 is of the highest quality, even though it contained similar habitat to that of the remaining downstream sites. The site is located on a higher order stream, and therefore differentiated from others by its position in the catchment. The catchment area of the Q29SW2 is greater than those on Marrakai Creek and the tributary of Mount Bundey Creek, and it is therefore likely to contain water for a much longer time period (extending water availability at the beginning and end of the wet season). The water quality at the site was similar to that of the upstream site, suggesting recovery and dilution associated with catchment position that makes the site an appropriate recovery site for the RRPA. In addition, its low proportion of tolerant taxa may provide an early indicator of changes in the macroinvertebrate community if influences from the RRPA are detected in water quality at the site.

The sampling design for this monitoring program cannot strictly follow the before, after, control impact (BACI) design, due to the location of RRPA infrastructure at the headwaters of the catchments. In spite of this, the study has utilised the most practical sampling locations and begun the process of baseline data collection. To increase statistical power, future monitoring rounds could explore the use of replicate sampling, and the addition of a sampling site in a tributary of Mount Bundey Creek that is not currently in the receiving environment of the RRPA. It is acknowledged that access to additional sites may be limited due to the prevailing terrain and available tributaries.

The differences in the macroinvertebrate community between sites highlights the importance of sampling prior to mining/dewatering activities recommencing at the RRPA, as it provides site-level baseline data for future comparison. Ongoing monitoring of the receiving environment will be the most effective tool in adaptive management of the discharge strategy, should negative impacts be observed.

5. References

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Appendix A. Raw Macroinvertebrate Data

Order	Family/Sub-family	RRMCUS	RRMCDS	RRSW23	Q29SW2
Acarina		33	0	10	2
Coleoptera	Dytiscidae	10	21	5	9
Coleoptera	Hydrochidae	0	0	0	12
Coleoptera	Hydrophilidae	10	121	35	14
Coleoptera	Noteridae	0	7	0	0
Coleoptera	Scirtidae	0	7	0	0
Decapoda	Palaemonidae	33	86	0	7
Decapoda	Parathelphusidae	0	14	25	0
Diptera	Ceratopogonidae	10	29	100	16
Diptera	Chironominae	324	229	305	86
Diptera	Culicidae	0	0	0	5
Diptera	Empididae	5	0	0	0
Diptera	Muscidae	0	0	0	5
Diptera	Orthocladiinae	0	14	10	0
Diptera	Tabanidae	0	0	5	0
Diptera	Tanyderidae	10	7	5	7
Diptera	Tanypodinae	81	71	245	47
Ephemeroptera	Baetidae	19	57	105	44
Ephemeroptera	Caenidae	14	379	370	58
Ephemeroptera	Leptophlebiidae	14	50	25	12
Gastropoda	Planorbidae	0	0	55	5
Hemiptera	Gerridae	0	0	40	9
Hemiptera	Hydrometridae	0	0	0	2
Hemiptera	Mesoveliidae	0	0	5	0
Hemiptera	Micronectidae	14	29	50	47
Hemiptera	Notonectidae	0	0	5	2
Hemiptera	Pleidae	10	0	0	12
Hemiptera	Veliidae	0	0	0	7
Odonata	Coenagrionidae	0	0	0	2
Odonata	Corduliidae	0	0	0	2
Odonata	Gomphidae	0	0	0	2
Odonata	Isostictidae	0	7	0	0
Odonata	Libellulidae	5	7	0	0
Oligochaeta		24	221	130	33
Trichoptera	Ecnomidae	14	7	5	2
Trichoptera	Hydroptilidae	0	50	10	2
Trichoptera	Leptoceridae	10	21	10	26

Appendix B. Macroinvertebrate QA

Aquatic Ecology Services

Macroinvertebrate Identification
Quality Assurance Certificate

Site Code: Q29SW2
Replicate: 1 of 1
Habitat: Edge
Identification Date: 20/06/2021
Identifier: T Steele
Identification Level: Family
QA Date: 28/06/2021
Senior Taxonomist: S Jones
Percentage Correct: 100%
QA Result: Pass

Taxonomy	Original Count	QA Count	Comment
Acarina	1	1	
Dytiscidae	3	3	
Hydrochidae	5	5	
Hydrophilidae	6	6	
Noteridae	1	1	
Atyidae	1	1	
Palaemonidae	2	2	
Ceratopogonidae	7	7	
Chironominae	37	35	
Culicidae	2	2	
Muscidae	2	2	
Tanyderidae	3	3	
Tanypodinae	20	20	
Baetidae	19	19	
Caenidae	25	25	
Leptophlebiidae	5	5	
Planorbidae	2	2	
Gerridae	4	4	
Hydrometridae	1	1	
Micronectidae	20	20	
Notonectidae	1	1	
Pleidae	5	5	
Veliidae	3	3	
Coenagrionidae	1	1	
Corduliidae	1	1	
Gomphidae	1	1	
Oligochaeta	14	10	
Ecnomidae	1	1	
Hydroptilidae	1	1	
Leptoceridae	11	11	

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