Vista Gold Australia Pty Ltd

Mt Todd Mine Biological Monitoring Program

Aquatic Ecology Monitoring 2017

November 2017

Executive summary

In May 2017, GHD undertook sampling in the Edith River and Stow Creek as part of the Mt Todd Biological Monitoring Program on behalf of Vista Gold, as required under WDL 178-5.

The Edith River was assessed for aquatic ecological health to determine if treated mine water discharged through the licenced discharge point RP3 is having an adverse impact on the downstream ecology of the river. This assessment was undertaken through sampling of water and sediment quality and macroinvertebrates.

Overall, the results from the 2017 monitoring round were consistent with the previous year's monitoring event, showing no discernible impact from treated mine water discharged from RP3 on the aquatic ecosystem of the Edith River. Water quality in the Edith River was found to be relatively benign in terms of toxicity potential; with no analytes being found above the site-specific trigger values. Sediment quality along the Edith River showed no elevation of parameters above guideline levels. Macroinvertebrate results were similar to the previous year's monitoring event, with samples from the Edith River showing no significant community change as a result of the RP3 discharge, and that habitat was a greater driver of macroinvertebrate community composition in 2017.

The results from the survey show that Vista Gold remain compliant with licence requirements under WDL 178-5.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

1.1 Background

The Mt Todd Gold Mine site is located approximately 55 km north-west of Katherine and 250 km south of Darwin in the Northern Territory (NT). The Mt Todd Gold Mine site is a brownfield site that was previously mined for gold in the 1990's until the year 2000. Mining infrastructure such as tailing dams, waste rock dumps and the remanent processing facilities remain on site.

The current owner of the site is Vista Gold Australia Pty Ltd, a wholly owned subsidiary of Vista Gold Corporation.

Vista Gold Corporation is an international gold mining company with more than 20 years of history in gold exploration, project development and operations. In addition to the Mt Todd Gold Project (the Project), Vista Gold Corporation have ventures in the United States, Mexico and Indonesia.

Vista Gold purchased the rights to the Mt Todd property on 1 March 2006. Under the terms of an agreement between Vista Gold and the NT Government (Agreement D92226), Vista Gold would initiate a comprehensive review of the Project to evaluate current site conditions and develop programs to stabilise legacy issues associated with the Project to minimise offsite migration of potential contaminants. Vista Gold was additionally required to examine all technical, economic and environmental issues, estimate costs to rehabilitate the site, explore and evaluate the potential of the Project, and prepare a technical and economic feasibility study for the potential development and recommencement of the Project.

Operating conditions at Mt Todd Mine are subject to regulatory obligations, including waste discharge licence WDL 178-5. Mt Todd mine is currently discharging treated wastewater from RP3 according to WDL 178-5 requirements.

1.2 Scope and limitations

The scope of works for the Mt Todd Aquatic Monitoring Program (the Program) are based on the scope detailed in the 2015-16 Wet Season Macroinvertebrate and Sediment Report undertaken by GHD, and GHD's determination of the requirements to meet the aims of the Biological Monitoring Program contained within WDL 178-5.

The Program includes the following key components:

- The collection of three replicate macroinvertebrate samples from eight sites using the NT AUSRIVAS sampling methodology.
- Process macroinvertebrate samples to family level as per the NT AUSRIVAS method
- Water quality sampling at each of the macroinvertebrate monitoring sites, including in-situ measurements and grab samples for laboratory analysis. Sampling includes the collection of a duplicate sample at one location and a field blank sample for QA/QC purposes. Samples are tested for the analytes outlined in Envirotech (2014).
- Sediment quality sampling at each of the macroinvertebrate monitoring sites for laboratory analysis. Sampling includes the collection of a duplicate sample for QA/QC purposes. Samples were tested for the analytes outlined in Envirotech (2014).
- Carry out analysis on macroinvertebrate, sediment and water quality data to determine if there is any evidence of impacts associated with the discharge of treated mine water from the Mt Todd Mine site.

- Analysis of macroinvertebrate data to include:
  - Univariate and multivariate statistical analysis
  - Calculation of SIGNAL-2 sensitivity ratings based on Chessman (2003) to assess whether or not spatial or temporal trends in community composition relate to the prescribed pollution sensitivity of taxa.
- Provide an annual report with appropriate statistical analysis and interpretation

The limitations of this report are detailed in Appendix A.

1.3 Purpose of this report

The purpose of this report is to provide the results for the 2017 Aquatic Monitoring event undertaken on behalf of Vista Gold, as required under WDL 178-5 and described in the Scope in Section 1.2.

1.4 Assumptions

GHD assumes the following:

- All licencing is current and up to date.
- Data received from Northern Territory Department of Land Resource Management (DLRM) that relates to AUSRIVAS modelling variables has been verified by DLRM.

2. Study Area

2.1 Mine and Bioregion Location

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

Land types of the Pine Creek bioregion are mainly hilly to rugged ridges with undulating plains. Vegetation communities include eucalypt woodlands, patches of monsoon forests, Melaleuca woodlands, riparian vegetation and tussock grasslands (DOTE 2008). The major vegetation types are eucalypt tall open forests typically dominated by Darwin Woollybutt (*Eucalyptus miniata*) and Darwin Stringybark (*E. tetradonta*), and woodlands (dominated by a range of Eucalyptus species); with smaller areas of monsoon rainforest.

2.2 The Edith River Catchment

The study area is located on the Edith River, located in the Daly River catchment. The Edith River flows to the Fergusson River before joining the Daly River. The Daly River is one of the Northern Territory's largest rivers with a catchment area of 52,577 km^2, and is one of the few catchments in the Northern Territory that has perennial flows. The Edith River is an important tributary of the Daly River, with a catchment of 1,057 km^2.

The Edith River rises at an elevation of 257 m and ends at an elevation of 81.8 m where it merges with the Fergusson River, dropping around 175 m over its 69.1 km length. The Edith River is the largest waterway in the immediate vicinity of the mine and has been the recipient of mine overflow waters via Stow Creek and West Creek. In the past, it has received licensed discharge from the mines RP1 waste-rock retention pond. Currently, the Edith River receives treated mine water from RP3 through Batman Creek and Stow Creek. The river has been intensively sampled because it is the receiving environment for the majority of the Mt Todd Mine Site catchment.

Watercourses of the Edith River Catchment are ephemeral and cease to flow during the late dry season, but have regular flows during the wet season, with some of the major watercourses remaining inundated into the early dry season. Some seasonal and semi-permanent waterholes exist along the Edith River. These are likely to be ecologically important and serve as a refuge for fish and aquatic reptiles during the dry season.

2.3 Regional Climate

The climate in the Katherine Region is characterised by hot, humid wet seasons lasting from November to March followed by a hot dry season from April to October. Transition periods occur between the wet and dry seasons. The region has an average rainfall of approximately 1100 mm, which is highly seasonal.

Rainfall recorded for 12 months prior to sampling in 2017 are shown in Figure 2-1. Above average rainfall was recorded in the 2016/2-17 wet season, with January and February contributing more than double the average rainfall for those months. March and April recorded below average rainfall, and there were no rain events in the two weeks leading up to sampling.

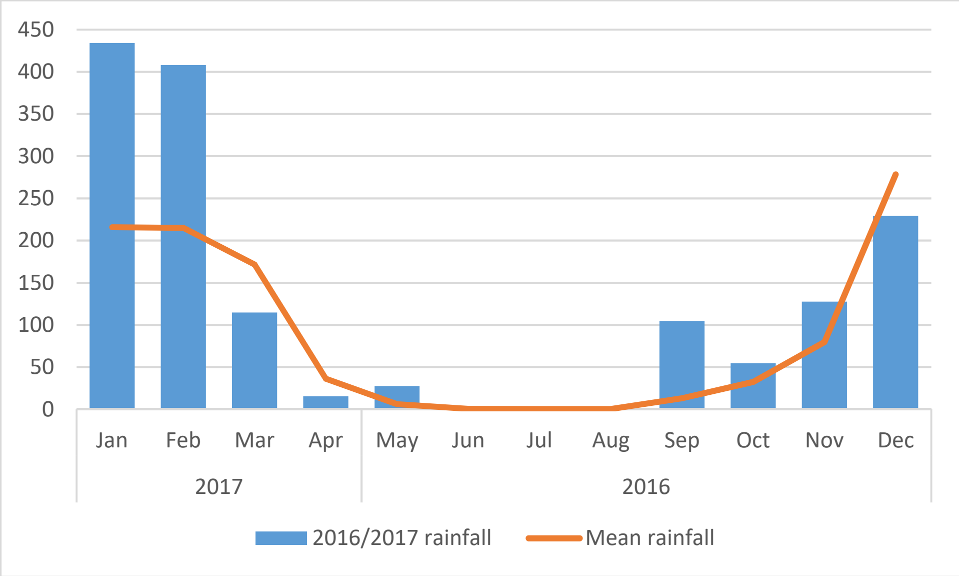

Figure 2-1 Rainfall recorded at Nitmuluk Ridge compared with mean rainfall (BOM 2017).

3. Methods

3.1 Study Design

The primary aim of the study is to detect whether or not there are impacts on the aquatic environment in the Edith River from mine water released from discharge point RP3, in accordance with the discharge licence. The study design for the 2017 focusses on the comparison of the aquatic environments between the sites upstream and downstream of the discharge location.

As a secondary objective of the study, sites were assessed on Stow Creek which receives the treated mine water through Horseshoe Creek. Sites have been located upstream and downstream of the confluence of Horseshoe Creek and Stow Creek to provide an indication of any potential impacts that the discharge may be having on the receiving environment.

3.2 Survey Timing

Previous aquatic sampling has taken place in the early dry season, and most often in April, when flows in the Edith River are steady following recession of flows. The above average rainfall recorded in the wet season prior to sampling required a small delay in sampling to allow flow conditions to be appropriate for sampling as per AUSRIVAS protocols.

Sampling was undertaken between 3 and 4 May 2017. Flows were receding at the time, with all sites having visible flow, often being made up of pools connected by riffles or runs.

3.3 Survey Sites

Sites for water, sediment, and macroinvertebrate sampling were chosen to provide an assessment of the state of the aquatic environment in the footprint of the mineral leases and adjacent waterways. Sites were positioned to efficiently quantify existing conditions and allow for detection of impacts from potential pollutant sources. Sites nominated for sampling included historic monitoring locations used by Vista Gold since 2008, and are detailed in Table 3-1 and Figure 3-1.

There was no direct discharge from RP3 into the Edith River at the time of the survey, nor during the immediate period leading up to the survey.

Table 3-1 Site location details, 2017 sampling event.

Site Code	Easting	Northing	Site Description	Site Type
ERTOP	191545	8431259	Edith River farthest upstream site	Upstream
ERUS	188476	8431460	Edith River upstream of Stow Creek confluence.	Upstream
ERDS	187685	8431369	Edith River downstream of Stow Creek confluence.	Downstream
ERSW4	186750	8431478	Edith River downstream of site ERSW4	Downstream
ERBTM	180080	8430235	Edith River farthest downstream site	Downstream
SCTOP	53019005	8433207	Stow Creek upstream site	Upstream
SCDS	53018895	8432524	Stow Creek downstream site	Downstream
SCBTM	53018836	8431616	Stow Creek farthest downstream site	Downstream

Figure 3-1 Survey sites sampled in the 2017 sampling event.

3.4 Macroinvertebrate sampling

3.4.1 Sampling Methods

Macroinvertebrate sampling and processing followed procedures outlined in the Northern Territory AUSRIVAS Manual for the Darwin-Daly Region (Lamche, 2007). Sampling involved scraping the edge habitat of a site to agitate and suspend macroinvertebrates into the water column whilst a dip net was swept through the water downstream. Areas of riffle or fast flowing habitat, Pandanus roots and severe bank undercuts were avoided where possible when collecting edge habitat samples.

Once collected, the samples were washed through 10 mm and 250 µm mesh sieves. The course mesh sieve was examined for large, conspicuous taxa, and these were placed in a labelled sample container along with the contents of the fine mesh sieve; the container was then preserved with 70% ethanol. Samples were subsequently sent to the GHD macroinvertebrate laboratory for further processing and identification.

Three replicate samples were taken at each site to increase statistical power to detect potential impacts.

3.4.2 Laboratory processing

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

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

Taxa were identified to family level where possible, with the exception of key taxa identified in Lamche (2007) as either requiring identification to sub-family level (e.g. Chironomidae) or only to order level (e.g. Acarina). All taxa were identified using keys specified in Hawking (2000). Following identification, taxa counts were recorded in a database and samples preserved and archived by GHD.

3.4.3 Data analysis

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

The macroinvertebrate data collected as part of this study were analysed using a combination of univariate and multivariate statistical techniques. Univariate metrics provided an indication of 'health', while multivariate analysis focusses on variability in community composition between sites and sampling occasions. This is described in more detail in the section below. Upstream and Downstream sites were compared to each other to understand the impacts (if any) of treated mine water discharge on downstream environments at Mt Todd Mine. The differences between Stow Creek and the Edith River were also tested to ensure if significant differences were caused by interactions between the site type and watercourse, these are acknowledged and further investigated.

Univariate analysis

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

Long-term medians have been calculated for sites where multiple sampling occasions have been undertaken, and for those sites that have been sampled for the first time, a median of the two replicate samples from 2017 have been calculated. The use of median values allows for a simpler assessment of results from 2017, whilst allowing for consideration of the overall performance of metrics at a particular site over previous years. Once generated, metrics and medians were graphed so that results could be compared between sites. Using these visual aids, temporal trends were assessed qualitatively

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

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

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

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

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

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

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

In addition to qualitative assessments of macroinvertebrate metrics, a factorial ANOVA was used to understand if there were significant differences between sites upstream and downstream of the discharge location as well as if there were any differences between the two watercourses sampled as part of this study. The factorial ANOVA allows for interactions between watercourses and site types to be tested. Where a significant interaction is found, means plots were generated to display the differences in watercourses and site types more clearly.

Multivariate techniques

As was the case for univariate metrics, statistical analysis comparing control and impact site types focussed only on 2017 data.

The multivariate analysis methods used to assess macroinvertebrate data included:

- Non-metric Multi-Dimensional Scaling (NMDS) Ordination
- Analysis of Similarities (ANOSIM)

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

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

In previous years, ANOSIM (ANalysis Of SIMilarity) has been applied on the similarity matrix for each ordination analysis to determine if the differences between sites observed within the ordination plots were significantly different. In 2017, the results of the NMDS ordination did not suggest that performing this test on the data would yield a result that would be of any value to explaining any differences in the data. Therefore this analysis was not performed.

3.5 Habitat assessment

Descriptions of habitat conditions were recorded at each site following the criteria listed in the Northern Territory AUSRIVAS “Darwin-Daly Region Model” field sheets (Lamche, 2007). Habitat assessments included the whole reach sampled (100 m longitudinal section of the river) and included:

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

- Sketches of the site, including a cross-section of the reach.

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

Photos were taken of upstream and downstream portions of the reach sampled, as well as bank habitat and other key habitat features to further characterise 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.

3.6 Water and sediment quality

3.6.1 *In-situ* water quality

The following *in situ* physico-chemical parameters were measured at each sampling site using a calibrated YSI ProDSS multi-parameter water quality meter:

- pH
- Electrical conductivity (EC) (µS/cm)
- Temperature (ºC)
- Turbidity (nephelometric turbidity units – NTU)
- Dissolved oxygen (DO) (mg/L and percent saturation)

3.6.2 Chemical analysis

One water sample was collected at each site prior to the collection of sediment and macroinvertebrate samples. Samples requiring analysis of dissolved metals were field filtered using a dedicated high volume 45 µm filter prior to collection in the sample bottle. Water samples were analysed for the parameters in Table 3-4 by a NATA accredited laboratory.

The laboratory certificate of analysis is presented in Appendix B.

Table 3-4 Analytical schedule - water samples.

Suite	Analytes
Physico-chemical	Total suspended solids (TSS), total dissolved solids (TDS)
Major anions	Alkalinity, chloride, sulfate
Major cations	Sodium, potassium, calcium, magnesium.
Metals (dissolved and total)	Arsenic, beryllium, boron, cadmium, cobalt, copper, chromium, iron, lead, manganese, nickel, uranium, zinc, mercury
Nutrients	Ammonia, nitrite, nitrate, total Kjeldahl nitrogen (TKN), total nitrogen.
Other	Dissolved hexavalent chromium, total cyanide

Sediment grab samples were collected following the sediment-water interface hand corer methods as outlined in the Sediment Quality Assessment (Simpson and Batley 2016) guide. Sediment samples were collected at each of the monitoring sites using a 100 mm diameter corer. The corer was pushed 200 mm deep into the sediment where the substrate was soft enough. If the sediment had a higher percentage of coarse particles which prevented sampling by corer, sediment was collected using a plastic trowel. Two samples were collected from each site and homogenised to produce one composite sediment sample.

The sediment samples were analysed for the parameters in Table 3-5 by a NATA accredited laboratory. The laboratory certificate of analysis is presented in Appendix B.

Table 3-5 Analytical schedule - sediment samples.

Suite	Analytes
Metals (totals and 1M HCl extractable where possible)	Antimony, arsenic, boron, barium, beryllium, cadmium, chromium, cobalt, copper, manganese, nickel, lead, selenium, vanadium, zinc, mercury, silver, iron, aluminium
Anions	Flouride, sulfate
Nutrients	Total nitrogen, nitrate, nitrite, TKN, ammonia
Hydrocarbons	Total recoverable hydrocarbons
Particle sizing	2000 µm – 63 µm

3.6.3 Data analysis

Water quality results were compared against the Site Specific Trigger Values (SSTVs) derived for the Edith River at ERSW4 (GHD 2015).

Sediment quality results were compared to Table 2 of the revised ANZECC/ARMCANZ Sediment Quality Guideline Values (SQGVs) (Simpson *et al*. 2013). The SQGVs represent the thresholds above which biological effects are possible. SQGV-high are also outlined, which are the thresholds above which there is a high probability of biological effects.

Although there are no GVs for ammonia or nutrients in aquatic ecosystem sediments, these analytes are important to collect, in order to observe any temporal changes and identify any accumulation in sediments.

3.7 Quality Assurance / Quality Control

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

3.7.1 General

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

3.7.2 Water and sediment quality

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

3.7.3 Macroinvertebrate Sampling

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

4. Results

4.1 Site conditions

A description of habitat conditions associated with monitoring sites sampled at Mt Todd in May 2017 is given in Table 4-1. All sites were flowing at the time of sampling, but showed signs of water level recession. Evidence of high flows from the 2016/2017 wet season evident along levee banks and floodplain areas at all sites.

Table 4-1 Habitat conditions at Mt Todd Sampling locations visited in May 2017.

Site / Habitat Description	Site Photo
Control Sites	
ERTOP The site is located upstream of historical Mt Todd mining operations on the Edith River, and was characterised by large deep pools, with a short riffle at the downstream end, extending for the length of the reach. The substrate in the pools consisted of gravel, sand and cobbles. A large amount of woody debris was found at the site, and the majority of the banks upstream of the riffle contained exposed roots and angled banks. The river was approximately 20 m wide through most of the reach, and riparian vegetation was almost a closed canopy, shading the majority of the river, consisting largely of Pandanas aquaticus.	
ERUS This site was located on the Edith River upstream of its confluence with Stow Creek. The flow channel was approximately 10 m wide. The river was characterised by angled banks, with exposed roots lining much of the larger sections. The substrate was a mix of cobbles, pebbles and sand with several large leaf packs and macrophytes. The entire reach was shaded.	

Site / Habitat Description	Site Photo
SCTOP The site is located on Stow Creek, just upstream of the Horseshoe Creek confluence with Stow Creek. Horseshoe Creek receives treated mine water discharge from RP3. This site is characterised by a shallow riffle run that flows into a deep, slow flowing pool. The substrate consisted of sand and silt, with an abundance of snags. The banks were approximately 4 m high and were very steep. Riparian vegetation consisted of riparian shrubland and grassland.	
Impact Sites	
ERDS This site is located downstream of the Edith River confluence with Stow Creek which receives flow from RP1. This site was characterised by a long deep (>1.5 m) pool. The substrate at this site appeared to mostly consist of sand/silt and detritus, however, it was difficult to determine due to the depth and turbidity. The channel at this site was shaded, with continuous longitudinal coverage of large trees along both banks. The length of this section was characterised by vertical undercut banks, with exposed roots lining much of the larger pools. There was a fresh crocodile indicator installed at this site on the day of sampling, as the previous one had been destroyed, (presumably by a crocodile).	
ERSW4 This site was characterised by shallow run and pool sequences. Courser sediments such as sand and gravel were dominant at the site, with bedrock and cobbles lining the banks. Upper levees contained riparian woodland, with lower banks made up of grasses and small trees as well as areas of bare sand and cobbles. Filamentous algae was noted growing in runs and in the deeper sections of pools. The site is located at SW4 monitoring point that is also one of the WDL compliance monitoring points. There is a small weir at this section of the Edith River. Upstream of the weir is a pool (>1.5 m deep at the time of sampling).	

Site / Habitat Description	Site Photo
ERBTM The site was located just upstream of the Edith River rail bridge approximately 10 km downstream from the mine site and was characterised by a large open channel. The water at this site was restricted to a series of isolated pools and riffles. There was visible flow within these pools likely through hyporheic flows. The substrate consisted of sand and silt, macrophytes and snags. The banks were approximately 3.5 m high and were very steep. Riparian vegetation was thick. Large trees lined the banks, with their roots exposed. This site contains copper contamination from the train derailment in December 2011, which has the potential to confound any results.	
SCDS The site is located upstream of the Mt Todd Mine road bridge on Jatbula Road and was characterised by a shallow run with a series of vegetated bar islands in the channel. There was visible flow within this section with areas of high flow between the vegetated bar islands. The substrate consisted of sand and there were areas of macrophytes and snags. The banks were steep and approximately 2 m high on the left bank and 1 m on the right. Riparian vegetation consisted of riparian woodland and grassland, with Pandanas groves along the water's edge.	
SCBTM The site is located upstream of the confluence of Stow Creek and the Edoth River. Flow was observed at the time of sampling, and the site was characterised by sandy, gently sloping banks with dense riparian vegetation and high shading. The creek had some braiding and sand bar formation throughout the reach. Exposed roots and leaf packs were features of slower moving sections of the site. vegetation was dominated by Melaleuca sp and Pandanus.	

4.2 Water Quality

4.2.1 *In-situ* water quality

In-situ water quality results collected during the May 2017 sampling event are presented in Table 4-2. These have been compared to the SSTVs listed in WDL 178-05. The following key results were observed:

- Temperature varied little between sites, ranging between 25.0 and 27.8 °C.
- Turbidity was low at all sites. The highest turbidities were observed at the Stow Creek sites, with turbidity increasing slightly with distance downstream.
- pH was slightly above the SSTV range at ERTOP, whereas all other sites recorded pH values within the SSTV range.
- EC was very low at the upstream sites on the Edith River, and was approximately 50 µS/cm higher at the downstream sites. A similar increase was observed between the upstream and downstream sites on Stow Creek, where EC was higher, though remained below the SSTV.
- Observed values for dissolved oxygen were relatively similar across sites upstream and downstream of the discharge on both waterways. A dissolved oxygen saturation below the SSTV range was observed at ERTOP. All other sites recorded values within the SSTV range.

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

Site	Site Type	Time	Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO (% sat.)	Turbidity (NTU)
SSTV			-	6.0-8.0	250	-	85-120	-
ERTOP	Upstream	09:42	25.0	**8.07**	16.5	6.92	**83.7**	0.4
ERUS	Upstream	13:40	26.4	8.00	16.7	7.45	92.6	1.0
ERDS	Downstream	15:15	26.4	7.96	67.4	7.24	89.9	1.2
ERSW4	Downstream	09:34	25.2	7.76	67.6	7.13	86.6	1.1
ERBTM	Downstream	11:04	25.9	7.71	67.1	7.97	98.0	1.2
SCTOP	Upstream	11:07	26.5	7.90	198.5	7.51	93.1	2.3
SCDS	Downstream	13:03	26.7	7.90	246.4	7.12	88.8	2.6
SCBTM	Downstream	14:17	27.8	7.60	247.2	7.52	95.8	3.9

Text in Bold denotes an exceedance of the SSTVs for the Mt Todd Mine Site.

4.2.2 Laboratory Water Quality Data

Results of laboratory analysis are presented in Table 4-3, which also presents the laboratory limits of reporting (LORs) and the relevant SSTVs. The following key results were observed:

- TSS concentrations were low at all sites, in agreement with the turbidity data presented in Section 4.2.1.
- All sites were of low ionic strength, though the downstream sites had higher TDS concentrations than the upstream sites.
- The upstream sites were dominated by sodium and chloride, whereas the downstream sites were dominated by sodium and sulfate. Sulfate concentrations were highest at the Stow Creek downstream sites, though they did not exceed the SSTV for sulfate. The were no exceedances of the SSTVs for the other anions, chloride and bicarbonate.

- There were no exceedances of the SSTVs for dissolved metals. Dissolved metal concentrations were below the laboratory LORs at all sites except for arsenic, iron, manganese, nickel and zinc.
- Dissolved arsenic concentrations were below the LOR at all sites except the Stow Creek downstream sites, where low concentrations were observed.
- Dissolved iron concentrations showed little spatial variation, though the highest concentrations in 2017 were observed at ERSW4 and ERBTM.
- Dissolved manganese concentrations were below the LOR at ERTOP and ERUS, and were low at all other sites. The highest concentrations were observed at the Stow Creek downstream sites, though these concentrations were less than one tenth that of the SSTV.
- All dissolved nickel concentrations were below the LOR, except those observed at the Stow Creek downstream sites, which were at the LOR.
- Low concentrations of dissolved zinc were observed at all sites except ERTOP, where the concentration was below the LOR. The highest dissolved zinc concentration was observed at ERUS.
- The total metals concentrations observed in 2017 were reflective of the dissolved metals results, and were not indicative of any substantial quantity of suspended particulate metals.
- Concentrations of ammonia and nitrate were highest at the Stow Creek downstream sites, and low concentrations of these nitrogenous nutrients were observed at the Edith River downstream sites. TKN and total nitrogen concentrations at the Stow Creek downstream sites indicated that ammonia and nitrate were the dominant nitrogen species, with little organic nitrogen present.
- All dissolved hexavalent chromium and cyanide concentrations were below the laboratory LORs.

4.2.3 QA/QC Samples

Analysis of a field blank and a duplicate sample was undertaken, with results provided in Appendix B. The laboratory certificate of analysis is provided in Appendix C.

There was good agreement between the results for the primary sample (ERTOP) and the duplicate, indicating that the results a suitably reliable for interpretation. The chloride result for the duplicate sample indicated that that which was reported for the primary sample was a typographical error (a missing decimal point). As such, the duplicate chlorine concentration was presented in Table 4-3.

The results for the field blank indicated that the rinsate water used was not completely deionised, as low concentrations of sodium, chloride and copper were detected. This has had no apparent impact on the sampling results however, as the site water was used for the rinsing of sampling equipment.

Table 4-3 Laboratory water quality results (May 2017). All units are mg/L.

Analyte	LOR	ERTOP	ERUS	ERDS	ERSW4	ERBTM	SCTOP	SCDS	SCBTM	SSTV
Physico-chemical parameters										
TSS	1	1.6	2.2	3.9	3.3	2.9	4	3.3	5.4	-
TDS	10	10	20	28	24	33	<10	140	120	-
Major anions										
Chloride	1	1.8	3.8	2.2	2.1	2.2	1.9	3.6	4.2	64
Sulfate as SO_4	5	<5	<5	19	18	18	<5	99	100	129
Bicarbonate alkalinity as $CaCO_3$	20	<20	<20	<20	<20	<20	<20	<20	<20	319
Total alkalinity as $CaCO_3$	20	<20	<20	<20	<20	<20	<20	<20	<20	-
Major cations										
Calcium	0.5	<0.5	<0.5	2.1	2.1	2.2	0.6	9.3	9.2	-
Magnesium	0.5	0.8	0.7	3.2	3.2	3.2	1	13	13	-
Potassium	0.5	<0.5	<0.5	0.8	0.8	0.8	<0.5	3.6	3.5	-
Sodium	0.5	2.1	1.7	4.1	4.3	4.4	2.4	14	14	-
Dissolved metals										
Arsenic	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	-
Beryllium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Boron	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
Cadmium	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0008
Chromium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Cobalt	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.0025
Copper	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0025
Iron	0.05	0.22	0.25	0.27	0.29	0.29	0.17	0.23	0.25	0.3
Lead	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0094
Manganese	0.005	<0.005	<0.005	0.038	0.036	0.019	0.017	0.21	0.17	3.6
Mercury	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-
Nickel	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.017
Uranium	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-
Zinc	0.005	<0.005	0.012	0.006	0.007	0.007	0.008	0.011	0.011	0.031
Total metals										
Arsenic	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.004	-

Analyte	LOR	ERTOP	ERUS	ERDS	ERSW4	ERBTM	SCTOP	SCDS	SCBTM	SSTV
Beryllium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Boron	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
Cadmium	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-
Chromium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Cobalt	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	-
Copper	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	-
Iron	0.05	0.49	0.75	0.71	0.75	0.6	0.44	0.84	0.96	-
Lead	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Manganese	0.005	0.008	0.008	0.045	0.043	0.022	0.024	0.23	0.2	-
Mercury	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-
Nickel	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	-
Uranium	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-
Zinc	0.005	<0.005	<0.005	0.006	0.007	<0.005	<0.005	0.008	0.011	-
Nutrients										
Ammonia as N	0.01	<0.01	<0.01	0.06	0.06	0.03	0.02	0.36	0.3	-
Nitrite as N	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Nitrate as N	0.02	<0.02	<0.02	0.06	0.05	0.04	<0.02	0.14	0.17	-
Nitrite and nitrate as N	0.02	<0.05	<0.05	0.07	0.06	<0.05	<0.05	0.15	0.18	-
TKN as N	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	0.3	-
Total nitrogen as N	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.6	0.5	-
Other										
Dissolved hexavalent chromium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Total cyanide	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-

Text in Bold denotes an exceedance of the SSTVs for the Mt Todd Mine Site.

4.3 Sediment Quality

4.3.1 Laboratory sediment quality data

Sediment particle size distribution results for May 2017 are presented in Figure 4-1, and Sediment quality results are presented in Table 4-4. Historical sediment quality results are provided in Appendix D and the laboratory certificate of analysis for the 2017 results is provided in Appendix E.

The particle size distribution results show that site ERDS had the largest proportion of fine sediments, including fine sands, silt and clay. Generally, the sites were dominated by fine to medium sands, with the exceptions of ERUS and SCBTM, which had larger proportions of coarse materials.

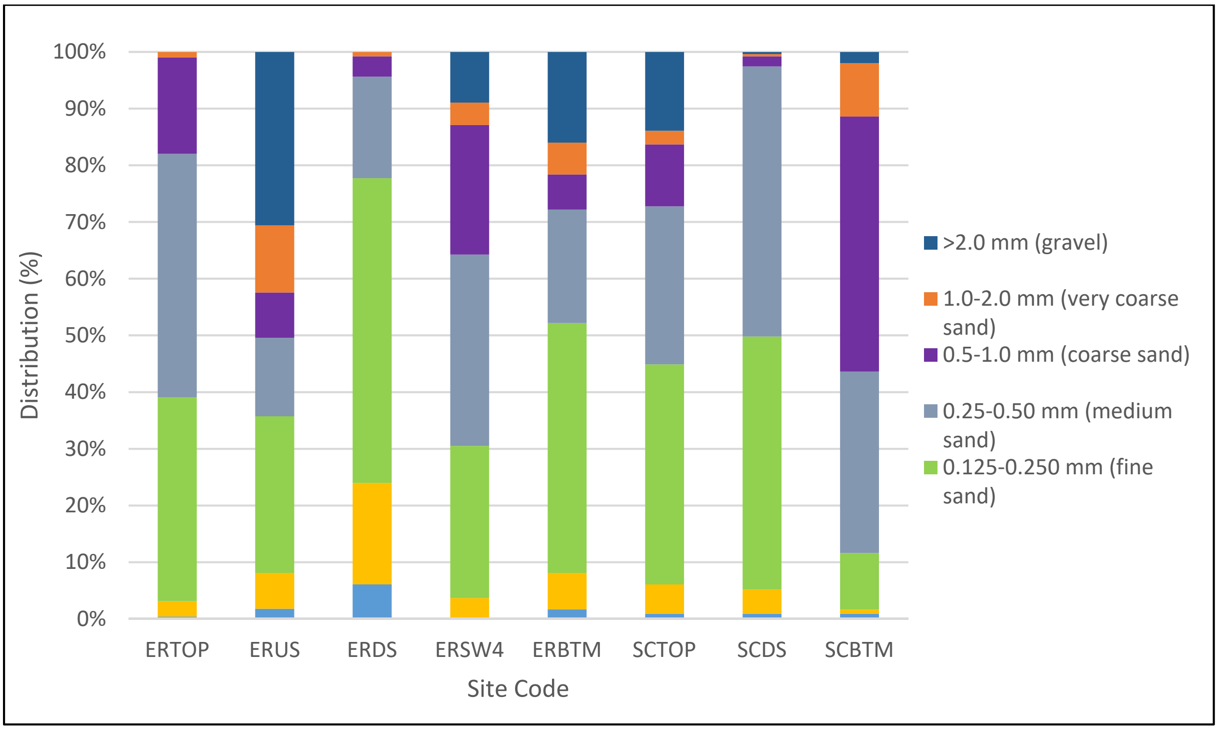

Figure 4-1 Sediment particle size distribution, May 2017.

Key findings from the sediment quality results (Table 4-4) include:

- Low percentages of total organic carbon were observed at all sites, with the highest being observed at ERDS, where the particle size distribution results suggest that the organic carbon was mainly fine detritus.
- The aqueous extract results for chloride and sulfate did not indicate any spatial trend between the upstream and downstream sites. Cyanide concentrations were below the LOR at all sites.
- Concentrations of 1 M HCl extractable metals were generally low, with all concentrations of arsenic, boron, cadmium, chromium, cobalt, lead, mercury, nickel, silver and uranium being below the respective LORs.
- The LORs for 1 M HCl extractable mercury and silver were above the respective SQGV-high and SQGV-low. In the case of silver, the total concentrations were all below the (lower) LOR, and as such, no exceedance was observed.
- A low concentration of 1 M HCl extractable copper was observed at ERBTM. All other sites had 1 M HCl extractable copper concentrations below the LOR

- 1 M HCl extractable iron concentrations were generally lower at the Stow Creek sites. In Edith River, the highest 1 M HCl extractable iron concentration was observed at ERDS.
- The highest 1 M HCl extractable manganese concentration was observed at SCBTM. There was no apparent impact on manganese concentrations at the Edith River downstream sites.
- Low concentrations of 1 M HCl extractable zinc were observed at the downstream sites, whereas concentrations were below the LOR at the upstream sites.
- Total metals concentrations were generally reflective of the acid extractable results, though it is noted that some above-LOR results were observed for arsenic, chromium and lead.
- Ammonia and nitrite were below the respective LORs at all sites. Low concentrations of nitrate were observed at the Stow Creek downstream sites. At these sites, nitrate contributed less than ten percent of the total nitrogen concentration, with the remainder of the nitrogen present as organic nitrogen. At all other sites organic nitrogen comprised 100 percent of the nitrogen present in the sediments.

4.3.2 QA/QC Samples

Analysis of a duplicate sample was undertaken, with results provided in Appendix E. The laboratory certificate of analysis is provided in Appendix F. Results for the primary and duplicate samples showed good agreement with the exceptions of the iron concentrations and the nitrogenous nutrient concentrations, which indicated a moderate level of variability, which is usually encountered with sediment analyses.

Table 4-4 Laboratory water quality results (May 2017). All units are mg/kg except where indicated.

Analyte	LOR	ERTOP	ERUS	ERDS	ERSW4	ERBTM	SCTOP	SCDS	SCBTM	SQGV-low	SQGV-high
Moisture content (%)	1	22	18	24	19	21	20	21	18	-	-
Total organic carbon (%)	0.1	<0.1	0.1	1.3	<0.1	0.5	<0.1	<0.1	<0.1	-	-
Chloride (1:5 aqueous extract)	5	-	210	99	120	<5	<5	<5	180	-	-
Sulfate (1:5 aqueous extract)	10	<30	<10	<10	<10	18	14	42	19	-	-
Total cyanide (1:5 aqueous extract)	5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
1 M HCl extractable metals											
Arsenic	2	<2	<2	<2	<2	<2	<2	<2	<2	20	70
Boron	2	<2	<2	<2	<2	<2	<2	<2	<2	-	-
Cadmium	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5	10
Chromium	5	<5	<5	<5	<5	<5	<5	<5	<5	80	370
Cobalt	5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Copper	5	<5	<5	<5	<5	5.1	<5	<5	<5	65	270
Iron	20	790	2500	3400	1200	1200	600	860	460	-	-
Lead	5	<5	<5	<5	<5	<5	<5	<5	<5	50	220
Manganese	10	<10	37	34	53	19	11	45	63	-	-
Mercury	2	<2	<2	<2	<2	<2	<2	<2	<2	0.15	1.0
Nickel	5	<5	<5	<5	<5	<5	<5	<5	<5	21	52
Silver	2	<2	<2	<2	<2	<2	<2	<2	<2	1.0	4.0
Uranium	10	<10	<10	<10	<10	<10	<10	<10	<10	-	-
Zinc	5	<5	<5	10	9.8	12	<5	11	6.2	200	410
Total metals											
Arsenic	2	<2	6.3	6.3	6.2	5.1	4.1	5.3	9.6	-	-
Beryllium	2	<10	<2	<2	<2	<2	<2	<2	<2	-	-
Boron	10	<10	<10	<10	<10	<10	<10	<10	<10	-	-
Cadmium	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	-	-
Chromium	5	<5	15	6.7	6.3	<5	6.4	<5	9.3	-	-
Cobalt	5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Copper	5	<5	<5	5.2	<5	8.8	<5	<5	<5	-	-

Iron	20	3200	36000	12000	9200	8300	9400	6600	9200	-	-
Lead	5	<5	<5	5.3	6.4	<5	<5	<5	<5	-	-
Manganese	5	14	55	44	49	41	15	40	70	-	-
Nickel	5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Silver	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-
Uranium	10	<10	<10	<10	<10	<10	<10	<10	<10	-	-
Zinc	5	<5	8.5	16	16	20	<5	14	15	-	-
Nutrients											
Ammonia as N	5	-	<5	<5	<5	<5	<5	<5	<5	-	-
Nitrite as N	5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
Nitrate as N	5	<5	<5	<5	<5	<5	<5	5	5.2	-	-
Nitrite and nitrate as N	5	<5	<5	<5	<5	<5	<5	5	5.3	-	-
TKN as N	10	120	260	320	80	200	48	110	51	-	-
Organic nitrogen as N	5	-	260	320	80	200	48	110	51	-	-
Total nitrogen as N	10	120	260	320	80	200	48	120	56	-	-

4.4 Macroinvertebrates

4.4.1 Relative abundance

The relative abundance of macroinvertebrates collected at each site in May 2017 are presented below in Figure 4-2. Variability in relative abundance was found between replicates at each site, as well as between sites in both upstream and downstream site types. At least one replicate at each site recorded a relative abundance above or equal to the long-term median for that site. Downstream sites on Stow creek had higher relative abundances than the upstream site on that watercourse. The Edith River did not show a discernible pattern in relative abundance according to site type.

The results of a one-way ANOVA showed a significant difference ($p < 0.05$) between site types, whereas there was no significant difference ($p > 0.05$) between sites from Stow Creek compared with those from the Edith River (Table 4-5). Differences between site types is further explained in the means plot presented in Figure 4-3, demonstrating the higher abundance at downstream sites compared with upstream sites.

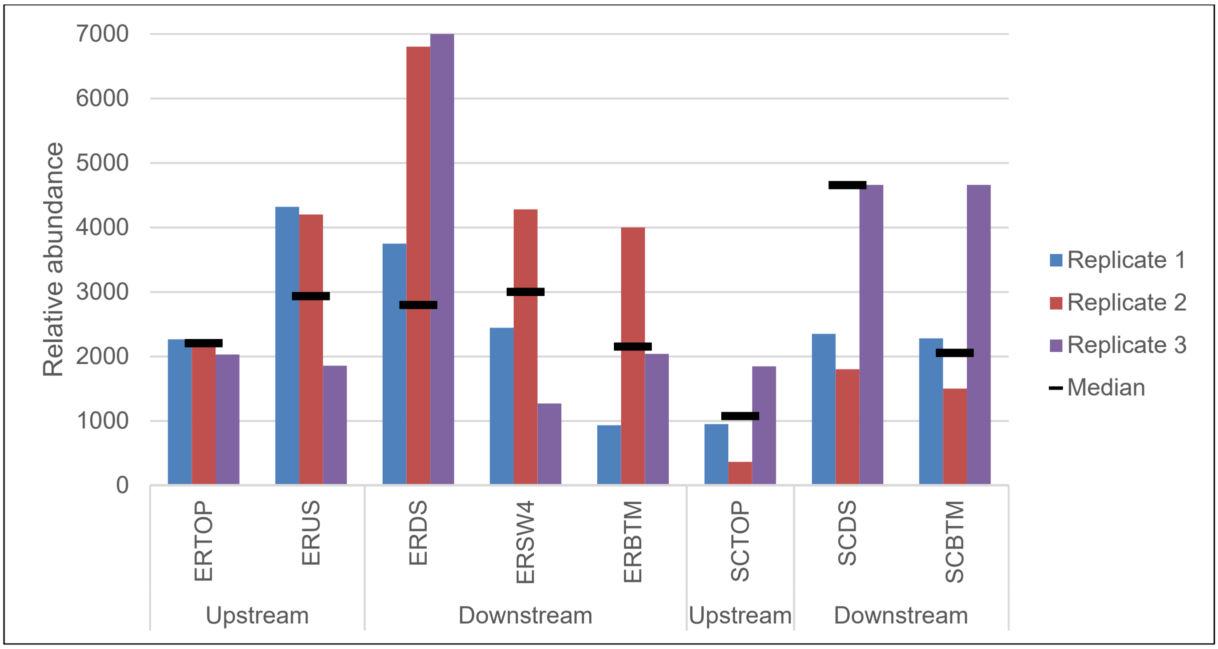

Figure 4-2 Relative abundances and long-term medians for sites sampled in May 2017.

Table 4-5 Results of factorial ANOVAs performed on relative abundance data from sampling in May 2017. Significant values indicate by bold text.

Effect	SS	Degr. of Freedom	MS	F	*p*
Intercept	132607852	1	132607852	55.6376	0.000000
Watercourse	6794270	1	6794270	2.8506	0.106870
Site Type	16449242	1	16449242	6.9015	**0.016151**
Watercourse*Site Type	5631	1	5631	0.0023	0.961714
Error	47668432	20	2383422		

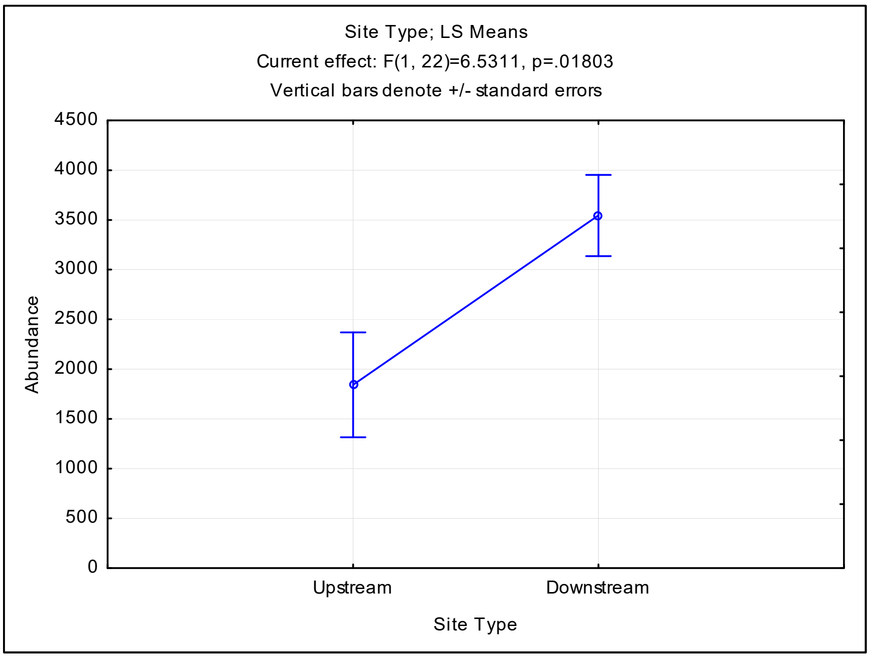

Figure 4-3 Means plot indicating differences in relative abundance between site types in May 2017.

4.4.2 Taxa richness

Taxa richness results for sites collected at each site in May 2017 are presented below in Figure 4-4. Samples from upstream sites on the Edith River contained a greater number of taxa to the long-term median for those sites, whereas downstream sites were more variable and generally lower. All samples collected at ERTOP, ERUS and ERBTM were above the long-term median. Sites on Stow Creek contained similar numbers of taxa across all three sites, with those located downstream generally containing higher numbers of taxa than long-term medians for that site.

The result of a one-way ANOVA showed no significant differences (p >0.05) between site types or watercourses and is presented in Appendix H.

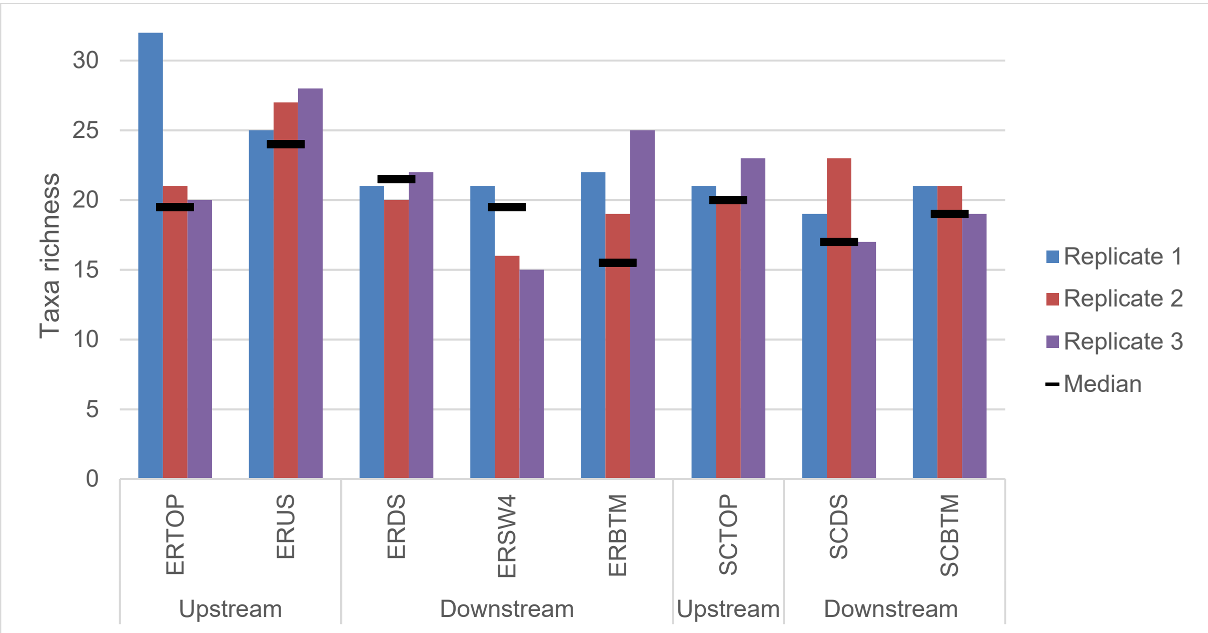

Figure 4-4 Taxa richness and long-term medians of sites samples in May 2017.

4.4.3 PET Richness

PET richness results of samples collected in May 2017 are presented in Figure 4-5. PET richness was higher at upstream sites compared with downstream sites on the Edith River, whereas sites on Stow Creek were relatively similar. ERTOP recorded the highest number of PET taxa, and all samples at the site were far higher than the long-term median. All other sites on the Edith River recorded PET richness values similar to long-term medians. Samples from downstream sites on Stow Creek were either equal to or higher than the long-term median, however samples from SCTOP were equal to or lower than the long term median. Samples from SCTOP also generally contained lower numbers of PET taxa than those from downstream sites on Stow Creek.

The results of a factorial ANOVA indicated a significant difference ($p < 0.05$) between PET richness values from the Edith River and Stow Creek (Table 4-6). There was also a significant interaction ($p < 0.05$) between site types and watercourses detected. The differences between site types on the two watercourses is demonstrated in the means plot presented in Figure 4-6. The means plot further demonstrates that the Edith River sites contained lower numbers of PET taxa at downstream sites, whereas Stow Creek sites contained higher numbers of PET taxa at upstream sites. Notably, both watercourses contained similar PET richness values at downstream sites.

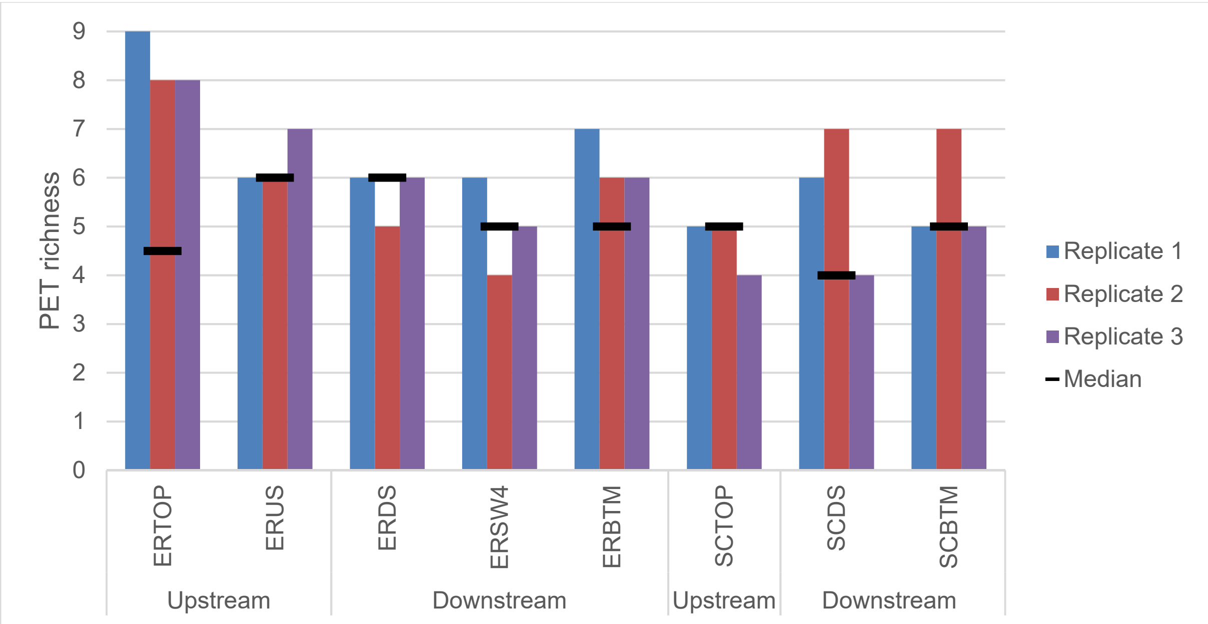

Figure 4-5 PET richness and long-term medians of sites samples in May 2017.

Table 4-6 Results of factorial ANOVA performed on PET richness data from May 2017. Significant values indicated by bold text.

Effect	SS	Degr. Of Freedom	MS	F	*p*
Intercept	700	1	700	656.25	0
Watercourse	9.1429	1	9.1429	8.5714	**0.008323**
Site Type	0.5714	1	0.5714	0.5357	0.472705
Watercourse*Site Type	9.1429	1	9.1429	8.5714	**0.008323**
Error	21.3333	20	1.0667		

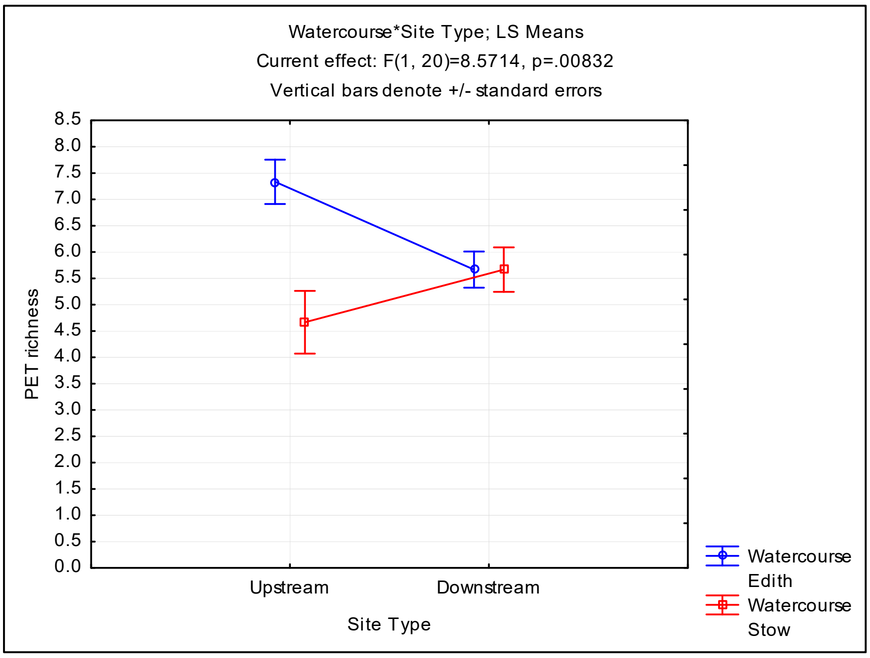

Figure 4-6 Means plot indicating differences between site types and watercourses in PET richness data from May 2017.

4.4.4 SIGNAL-2

The SIGNAL-2 scores calculated for samples collected in May 2017 along with long-term medians for each site are presented in Figure 4-7. Edith River sites showed some variability within each site type, but there was very little difference between sites overall (range of 1.06). Similarly, there was little variability between samples at all sites on Stow Creek, but there was a trend of higher SIGNAL-2 scores at downstream sites.

The results of ANOVA found a significant difference (p <0.05) in SIGNAL-2 results between watercourses, and a significant interaction (p <0.05) between site types and watercourses (Table 4-7). Figure 4-8 demonstrates that the difference between SIGNAL-2 scores at upstream sites on both watercourses contributes most to the significant interaction. The means plot shows opposing trends in sensitivity of the macroinvertebrate community within each watercourse. As with PET richness, SIGNAL-2 scores were on average higher at downstream sites compared with upstream sites on Stow Creek, and lower at upstream sites compared with downstream sites on the Edith River.

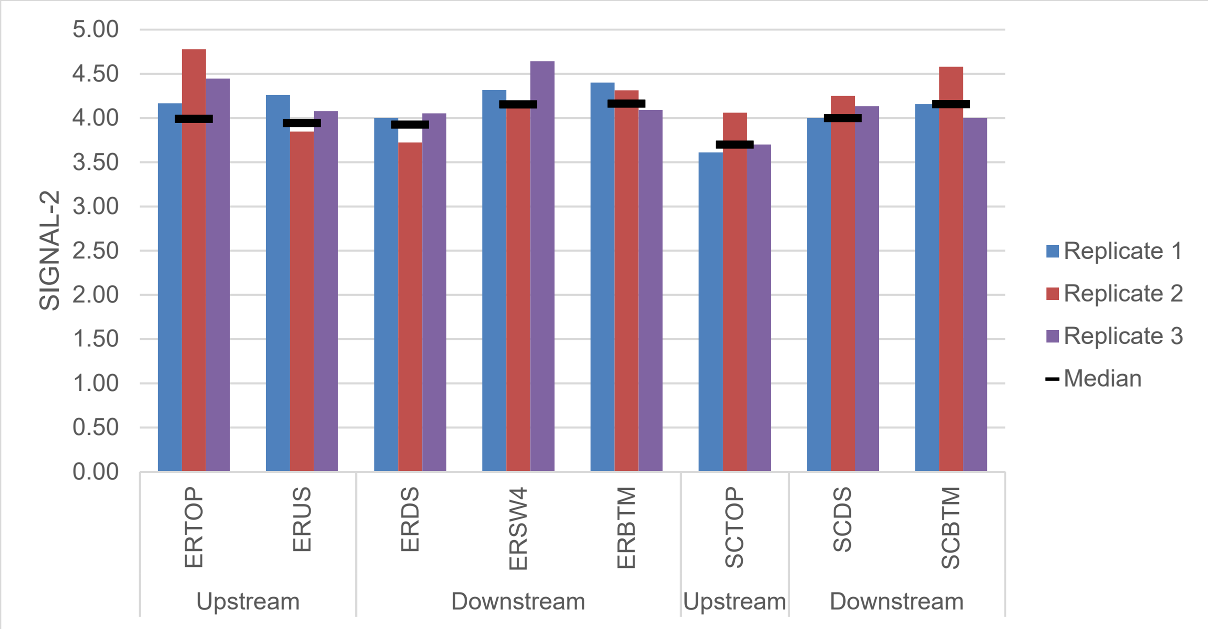

Figure 4-7 SIGNAL-2 results and long-term medians of sites samples in May 2017.

Table 4-7 Results of factorial ANOVA performed on SIGNAL-2 data from May 2017. Significant values indicated by bold text.

Effect	SS	Degr. Of Freedom	MS	F	*p*
Intercept	348.3351	1	348.3351	5687.973	0
Watercourse	0.3299	1	0.3299	5.386	**0.030976**
Site Type	0.0286	1	0.0286	0.467	0.502205
Watercourse*Site Type	0.5337	1	0.5337	8.715	**0.00788**
Error	1.2248	20	0.0612		

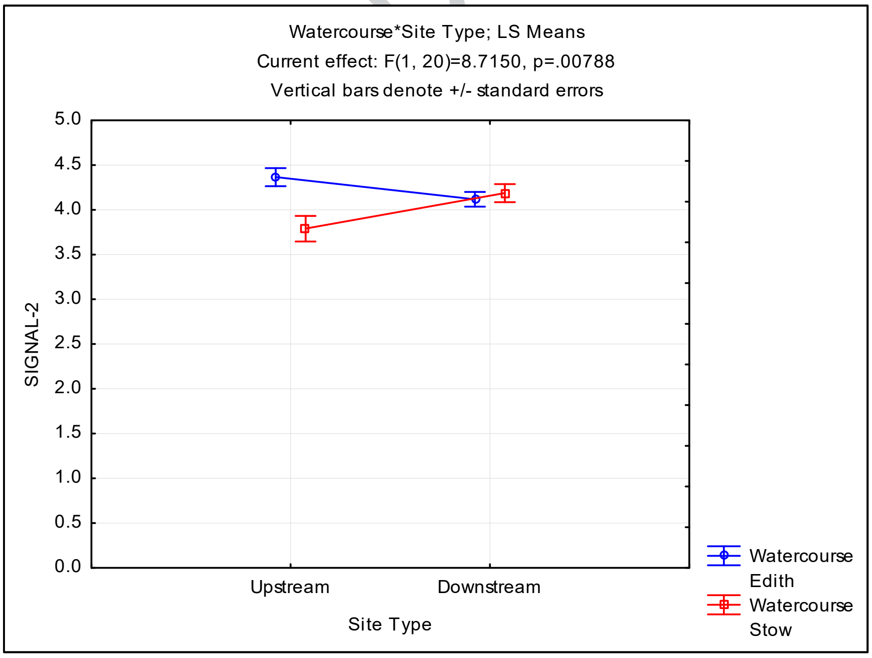

Figure 4-8 Means plot indicating the significant difference in SIGNAL-2 scores between watercourses.

4.4.5 AUSRIVAS

The results of the AUSRIVAS Darwin-Daly model are presented in Table 4-8. Regardless of site type or watercourse, all sites returned a Band A rating (similar to reference condition). A sample from sites ERTOP and ERDS returned a Band X result (more diverse than reference condition), but overall, the sites were classified as Band A due to the results of other samples at those sites. Samples at all sites returned OE50 scores similar to long-term medians.

Results on a one-way ANOVA showed no significant differences (p >0.05) and are presented in Appendix H.

Table 4-8 AUSRIVAS Darwin-Daly model outputs and long-term medians.

Site	Replicate	Site Type	OE50	Band	Median
ERTOP	1	Upstream	1.19	A	1.03
	2		1.03		
	3		1.03		
ERUS	1	Upstream	0.99	A	1.03
	2		0.91		
	3		1.15		
ERDS	1	Downstream	1.03	A	1.09
	2		1.11		
	3		1.19		
ERSW4	1	Downstream	1.07	A	0.99
	2		0.99		
	3		0.82		
ERBTM	1	Downstream	0.98	A	0.87
	2		1.13		
	3		1.2		
SCTOP	1	Upstream	1.07	A	0.99
	2		0.99		
	3		0.99		
SCDS	1	Downstream	0.99	A	0.91
	2		1.07		
	3		0.82		
SCBTM	1	Downstream	0.99	A	0.99
	2		0.99		
	3		0.99		

4.4.6 Community Composition

The results of univariate analyses showed differences in the macroinvertebrate community that are in many cases related to the watercourse in which a sample was taken. Initial NMDS scaling indicated similar differences. For this reason, individual NMDS plots were generated for each watercourse, which are presented below in Figure 4-9 and Figure 4-10.

Similarity between upstream and downstream sites on the Edith River was higher than among sites of the same site type (Figure 4-9). ERDS was the only site where all three replicate samples grouped together. All samples from all sites, excepting the second replicate from ERUS, were found to have 60% similarity to each other regardless of site type.

As with most samples collected from the Edith River, samples from sites on Stow Creek had a 60% similarity to each other regardless of the site type. There were no discernible grouping patterns of samples according to site type, or even according to site.

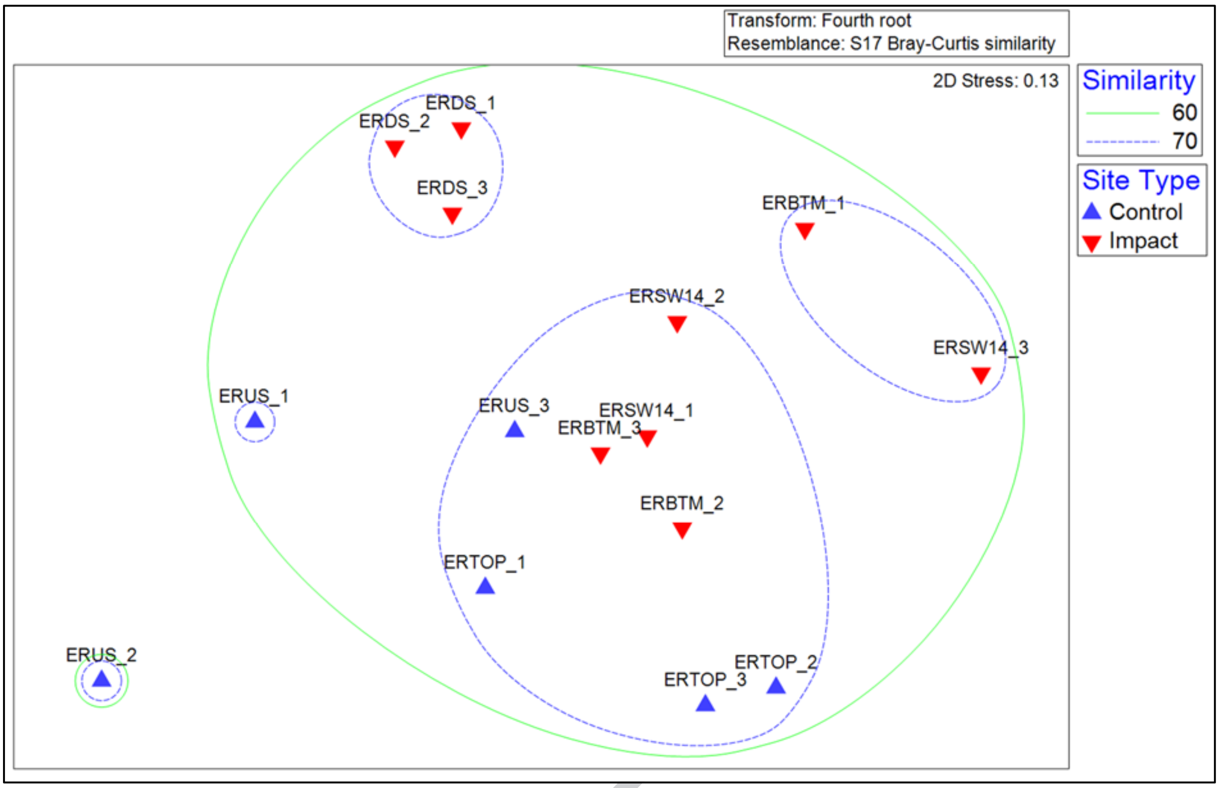

Figure 4-9 NMDS Plot showing differences in community composition between sites on the Edith River in May 2017.

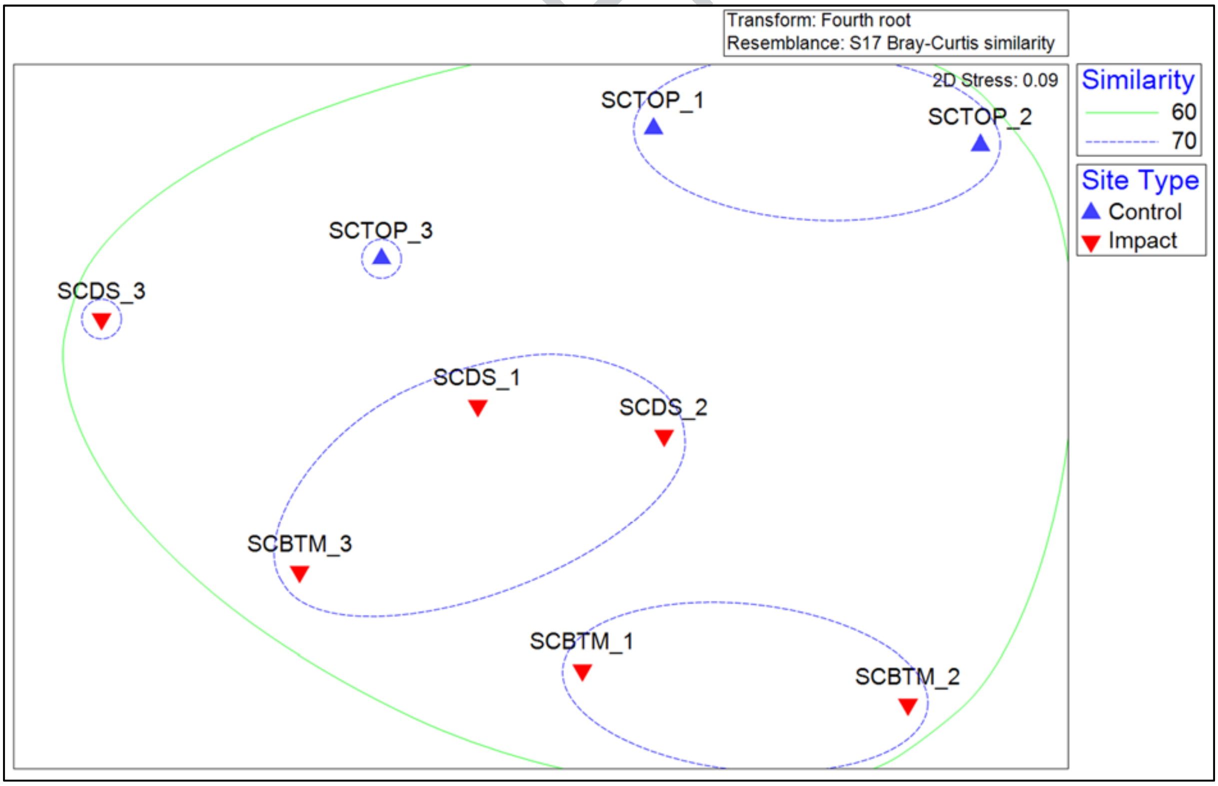

Figure 4-10 NMDS Plot showing differences in community composition between sites on Stow Creek in May 2017.

5. Discussion

The macroinvertebrate community was found to be in good condition within the Edith River and Stow Creek in 2017. There were significant differences found between watercourses in pollution sensitivity-related metrics (SIGNAL-2 and PET richness), yet a significant interaction between watercourse and site type was also found. The interaction is the result of differences between metric values at upstream sites on the Edith River and Stow Creek. Mean values for sensitivity metrics were similar at downstream sites on both watercourses, yet the significant interaction indicates they should be interpreted separately and in a qualitative manner.

5.1 Edith River

Water quality in the Edith River in May 2017 was ionically dilute, with no toxicant concentrations that were likely to result in adverse biological effects. There were no exceedances of the SSTVs, with the exception of exceedances for pH and DO at ERTOP, which cannot be attributed to the discharge of treated mine water. Indicators of this discharge were limited to EC, sulfate, ammonia, and nitrate, which were all slightly elevated at Edith River downstream sites.

Sediments in the Edith River were generally comprised of moderate to fine-grained sands, which did not contain any metal concentrations likely to result in adverse biological effects. A low concentration of acid extractable copper was observed at the farthest downstream site, which may be indicative of a long term impact of the 2011 train derailment (ATSB 2012), though this concentration is no longer of concern in terms of its potential effect of aquatic biota. The only apparent influence of the discharge of treated mine water on sediments in Edith River was suggested by the zinc concentrations, which were higher at downstream sites, though these concentrations were far below the threshold for possible biological effects (SQGV-low).

There was a decline in taxa richness, PET richness and SIGNAL-2 at sites on the Edith River downstream of the confluence with Stow Creek. These declines did not, however, result in a change in the AUSRIVAS model outputs, with all sites regardless of site type receiving a Band A rating. The clustering of sites based on their community composition further evidenced the similarities among sites irrespective of site type, and often irrespective of site. Given the negligible differences in water and sediment quality between upstream and downstream sites on the Edith River, habitat quality and diversity is likely to be a stronger driver of the health indicators at a particular site.

Downstream site ERDS was the only site where all three replicates clustered with any similarity based on community composition. The site is a large pool with a gentle glide, much different to other sites, which are shallow and possess a greater level of habitat heterogeneity. As ERDS is a deeper pool, the risk of estuarine crocodile attack is higher. The indicator buoy at that site was replaced on the day of sampling, having been completely removed, signifying the likely presence of a crocodile. Sampling could therefore only be undertaken in locations deemed safe, which may have influenced the results by not allowing for the full range of habitats to be sampled at the site.

5.2 Stow Creek

Stow Creek is more saline than Edith River, and in May 2017, the EC downstream of the Horseshoe Creek confluence was approximately 50 µS/cm higher than the upstream site. Concentrations of sulfate, calcium, magnesium, sodium, ammonia, and nitrate increase markedly at these downstream sites, however there were no exceedances of the SSTVs at any Stow Creek site. There were no bioavailable metal concentrations, which were likely to have an adverse effect on aquatic species.

There were no exceedances of the SQGVs at Stow Creek sites in May 2017. As was observed in the Edith River, zinc concentrations were slightly elevated at the downstream sites, indicating a potential influence of the discharge of treated mine water. Another potential impact was suggested by the sediment nitrate concentrations, which were only observed at concentrations above the laboratory LOR at sites downstream of the Horseshoe Creek confluence. While the zinc and nitrate concentrations at the downstream sites suggested the influence of the treated mine water discharge, neither parameter was observed at a concentration that could have any impact on aquatic biota.

The relative abundance of macroinvertebrates appeared to increase with distance downstream on Stow Creek, as did PET richness and SIGNAL-2, yet there was no overall difference in AUSRIVAS model outputs. All sites received a Band A rating, and the similarities in community composition regardless of site type were also evident. As there were no major differences in water and sediment quality between sites, habitat is the most likely driver of community composition on Stow Creek.

5.3 Conclusions

There were no exceedances of the water quality SSTVs at sites downstream of the discharge location on Stow Creek or the Edith River. There were low concentration signatures of the discharge observed in both watercourses in water and sediments, but these were not at concentrations likely to be detrimental to aquatic biota. This is reflected in the macroinvertebrate community within Stow Creek and the Edith River. Sites on both watercourses were found to have macroinvertebrate communities in good condition regardless of their site type. There were some declines observed in univariate metrics on the Edith River downstream of Stow Creek, but these are more likely related to habitat than treated mine discharge given the results of water and sediment quality monitoring.

6. References

Australian Transport Safety Bureau (2012). Derailment of freight train 7AD1 at Edith River near Katherine, Northern Territory, 27 December 2011. Report No. RO-2011-019.

Bureau of Meteorology (2017). Monthly Rainfall for Nitmuluk Ridge. Retrieved 14 July 2017 from: http://www.bom.gov.au/jsp/ncc/cdio/wData/wdata?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=014062

Chessman (2003). SIGNAL-2 - A scoring system for macroinvertebrates ('water bugs') in Australian rivers: User manual, September 2003. National River Health Initiative Technical Report Number 3.

Envirotech (2014). 2013-14 Mt Todd Mine Wet Season Macroinvertebrate and Sediment Report.

GHD (2015). Mt Todd Project Site Specific Trigger Values. Report prepared for Vista Gold, April 2015. pp. 79

Hawking, J.H. (2000). Key to Keys. A guide to keys and zoological information to identify invertebrates from Australian inland waters.

Lamche, G. (2007). The Darwin-Daly Regional AUSRIVAS Models –Northern Territory: User Manual. Aquatic Health Unit –Department of Natural Resources, Environment and the Arts. Report 06/2007D.

Marchant, R (1989). A sub-sampler for samples of benthic invertebrates. Bull. Aust. Soc. Limnol. 2 49-52.

Simpson SL, Batley GB and Chariton AA (2013) Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines. CSIRO Land and Water Science Report 08/07. CSIRO Land and Water.

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

Appendices

Appendix A – Limitations of this report

This report: has been prepared by GHD for Vista Gold Australia Pty Ltd and may only be used and relied on by Vista Gold Australia Pty Ltd for the purpose agreed between GHD and the Vista Gold Australia Pty Ltd as set out in section 1.3 of this report.

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

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

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

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

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

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

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

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

Appendix B - Water quality QA/QC

Analyte	LOR	ERTOP	ERD (ERTOP duplicate)	ERFB (field blank)
Physico-chemical parameters				
TSS	1	1.6	1.8	<1
TDS	10	10	14	13
Major anions				
Chloride	1	11	1.8	4.4
Sulfate as SO_4	5	<5	<5	<5
Bicarbonate alkalinity as $CaCO_3$	20	<20	<20	<20
Total alkalinity as $CaCO_3$	20	<20	<20	<20
Major cations				
Calcium	0.5	<0.5	<0.5	<0.5
Magnesium	0.5	0.8	0.7	<0.5
Potassium	0.5	<0.5	<0.5	<0.5
Sodium	0.5	2.1	1.9	3.8
Dissolved metals				
Arsenic	0.001	<0.001	<0.001	<0.001
Beryllium	0.001	<0.001	<0.001	<0.001
Boron	0.05	<0.05	<0.05	<0.05
Cadmium	0.0002	<0.0002	<0.0002	<0.0002
Chromium	0.001	<0.001	<0.001	<0.001
Cobalt	0.001	<0.001	<0.001	<0.001
Copper	0.001	<0.001	<0.001	<0.001
Iron	0.05	0.22	0.28	<0.05
Lead	0.001	<0.001	<0.001	<0.001
Manganese	0.005	<0.005	<0.005	<0.005
Mercury	0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	<0.001	<0.001	<0.001
Uranium	0.005	<0.005	<0.005	<0.005
Zinc	0.005	<0.005	0.006	<0.005
Total metals				
Arsenic	0.001	<0.001	<0.001	<0.001
Beryllium	0.001	<0.001	<0.001	<0.001
Boron	0.05	<0.05	<0.05	<0.05
Cadmium	0.0002	<0.0002	<0.0002	<0.0002
Chromium	0.001	<0.001	<0.001	<0.001
Cobalt	0.001	<0.001	<0.001	<0.001
Copper	0.001	<0.001	<0.001	0.001
Iron	0.05	0.49	0.49	<0.05
Lead	0.001	<0.001	<0.001	<0.001
Manganese	0.005	0.008	0.008	<0.005
Mercury	0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	<0.001	<0.001	<0.001
Uranium	0.005	<0.005	<0.005	<0.005
Zinc	0.005	<0.005	0.006	<0.005
Nutrients				
Ammonia as N	0.01	<0.01	<0.01	<0.01

Analyte	LOR	ERTOP	ERD (ERTOP duplicate)	ERFB (field blank)
Nitrite as N	0.02	<0.02	<0.02	<0.02
Nitrate as N	0.02	<0.02	<0.02	<0.02
Nitrite and nitrate as N	0.02	<0.05	<0.05	<0.05
TKN as N	0.2	<0.2	<0.2	<0.2
Total nitrogen as N	0.2	<0.2	<0.2	<0.2
Other				
Dissolved hexavalent chromium	0.001	<0.001	<0.001	<0.001
Total cyanide	0.005	<0.005	<0.005	<0.005

Appendix C - Water Quality Laboratory Reports

Appendix D - Sediment Chemistry Summary Table

Site	Date	Aluminium (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)	Cobalt (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Nickel (mg/kg)	Silver (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)
SQG (low & high trigger values)			20 - 70	1.5 - 10	N/A	80 - 370	65 - 270	N/A	50 - 220	N/A	21 - 52	1		200 - 410
ERSW4	2011	1200	NT	<0.5	<5	<5	26	7200	<5	79	<5	<5	NT	24
	2012	1200	NT	<0.5	<5	<5	26	7200	<5	79	<5	<5	NT	24
	2013	245	<4	NT	<1	<1	12	1350	3	50	<1	NT	NT	<1
	2014	210	<4	<0.4	<1	<1	3	530	2	20	<1	NT	<1	<1
	2015	660	7	NT	6	<5	13	4500	6	180	NT	NT	NT	30
	2016	NT	3	<0.4	<2	<5	9	1900	<5	61	<4	<2	<5	7
	2017	NT	<2	<0.4	<5	<5	<5	1200	<5	53	<5	<2	<10	9.8
ERUS	2011	990	NT	<0.5	<5	<5	<5	12000	<5	20	<5	<5	NT	<5
	2012	990	NT	<0.5	<5	<5	<5	12000	<5	20	<5	<5	NT	<5
	2013	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
	2014	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
	2015	810	<2	NT	<2	<5	<5	5000	<5	120	NT	NT	NT	<5
	2016	NT	<2	<0.4	<2	<5	<5	1900	<5	42	<4	<2	<5	<5
	2017	NT	<2	<0.4	<5	<5	<5	2500	<5	37	<5	<2	<10	<5
ERDS	2011	940	NT	<0.5	<5	5.4	<5	8500	<5	130	<5	<5	NT	9.2
	2012	940	NT	<0.5	<5	5.4	<5	8500	<5	130	<5	<5	NT	9.2
	2013	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
	2014	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
	2015	1200	2	NT	4	5	6	8900	5	110	NT	NT	NT	15
	2016	NT	2	<0.4	3	<5	6	4200	<5	130	<4	<2	<5	9
	2017	NT	<2	<0.4	<5	<5	<5	3400	<5	34	<5	<2	<10	10

Site	Date	Aluminium (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)	Cobalt (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Nickel (mg/kg)	Silver (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)
SQG (low & high trigger values)			20 - 70	1.5 - 10	N/A	80 - 370	65 - 270	N/A	50 - 220	N/A	21 - 52	1		200 - 410
ERTOP	2013	1200	<4	NT	4	1	6	5700	4	80	2	NT	NT	6
	2014	840	<4	<0.4	1.6	1	2	5800	3	46	<1	NT	<1	NT
	2015	710	<2	NT	2	5	<5	8600	<5	160	NT	NT	NT	<5
	2016	NT	<2	<0.4	<2	<5	<5	1800	<5	20	<4	<2	<5	<5
ERBTM	2013	730	<4	NT	2	<1	45	3700	5	14	2	NT	NT	37
	2014	200	<4	<0.4	2.7	<1	7	2800	2	96	1	NT	<1	21
	2015	1000	<2	NT	4	<5	10	4600	<5	99	NT	NT	NT	17
	2016	NT	<2	<0.4	<2	<5	<5	1100	<5	42	<4	<2	<5	<5
	2017	NT	<2	<0.4	<5	<5	<5	1200	<5	19	<5	<2	<10	12
SCTOP	2016	NT	<2	<0.4	<2	<5	<5	1100	<5	19	<4	<2	<5	<5
	2017	NT	<2	<0.4	<5	<5	<5	600	<5	11	<5	<2	<10	<5
SCDS	2016	NT	<2	<0.4	<2	<5	<5	1400	<5	76	<4	<2	<5	6
	2017	NT	<2	<0.4	<5	<5	<5	860	<5	45	<5	<2	<10	11
SCBTM	2016	NT	<2	<0.4	<2	<5	<5	1300	<5	44	<4	<2	<5	<5
	2017	NT	<2	<0.4	<5	<5	<5	460	<5	63	<5	<2	<10	6.2
QA	2017		<2	<0.4	<5	<5	<5	1000	<5	11	<5	<2	<10	<5

Appendix E – Sediment quality QA/QC

Analyte	LOR	ERTOP	ERD
Moisture content (%)	1	22	20
Total organic carbon (%)	0.1	<0.1	<0.1
Chloride (1:5 aqueous extract)	5	-	<5
Sulfate (1:5 aqueous extract)	10	<30	<10
Total cyanide (1:5 aqueous extract)	5	<5	<5
1 M HCl extractable metals			
Arsenic	2	<2	<2
Boron	2	<2	<2
Cadmium	0.4	<0.4	<0.4
Chromium	5	<5	<5
Cobalt	5	<5	<5
Copper	5	<5	<5
Iron	20	790	1000
Lead	5	<5	<5
Manganese	10	<10	11
Mercury	2	<2	<2
Nickel	5	<5	<5
Silver	2	<2	<2
Uranium	10	<10	<10
Zinc	5	<5	<5
Total metals			
Arsenic	2	<2	<2
Beryllium	2	<10	<2
Boron	10	<10	<10
Cadmium	0.4	<0.4	<0.4
Chromium	5	<5	<5
Cobalt	5	<5	<5
Copper	5	<5	<5
Iron	20	3200	3500
Lead	5	<5	<5
Manganese	5	14	11
Nickel	5	<5	<5
Silver	0.2	<0.2	<0.2
Uranium	10	<10	<10
Zinc	5	<5	<5
Nutrients			
Ammonia as N	5	-	<5
Nitrite as N	5	<5	<5
Nitrate as N	5	<5	<5
Nitrite and nitrate as N	5	<5	<5
TKN as N	10	120	26
Organic nitrogen as N	5	-	26
Total nitrogen as N	10	120	26

Appendix F - Sediment Quality Laboratory Reports

Appendix G – Macroinvertebrate Raw Data

Class/Order	Family/Sub-family	ERTOP	ERTOP	ERTOP	ERBTM	ERBTM	ERBTM	SCTOP	SCTOP	SCTOP
		1	2	3	1	2	3	1	2	3
Acarina		190	220	180	82	140	210	55	32	91
Coleoptera	Dytiscidae	30	0	30	14	20	20	5	7	55
Coleoptera	Elmidae	40	20	0	14	100	20	0	2	9
Coleoptera	Gyrinidae	1	0	0	0	0	0	0	0	0
Coleoptera	Hydraenidae	20	0	10	0	0	10	5	0	45
Coleoptera	Hydrochidae	20	0	0	9	0	10	0	0	27
Coleoptera	Hydrophilidae	0	0	0	5	0	0	0	0	9
Decapoda	Palaemonidae	20	20	10	0	40	20	27	3	9
Decapoda	Parathelphusidae	0	0	0	0	0	0	0	0	0
Diptera	Aphroteniinae	0	10	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	150	130	90	68	120	50	32	27	82
Diptera	Chironominae	430	520	600	305	1480	440	214	73	273
Diptera	Culicidae	0	10	0	0	0	0	0	2	9
Diptera	Empididae	0	0	0	5	0	10	0	0	9
Diptera	Orthocladiinae	80	130	100	14	120	30	5	2	0
Diptera	Simuliidae	30	0	0	0	0	10	0	0	0
Diptera	Tabanidae	10	0	0	0	0	0	0	0	0
Diptera	Tanypodinae	100	170	100	77	320	160	205	110	573
Diptera	Tipulidae	1	0	0	14	0	0	5	0	18
Ephemeroptera	Baetidae	160	90	170	5	140	150	86	15	73
Ephemeroptera	Caenidae	530	330	290	59	320	330	86	20	336
Ephemeroptera	Leptophlebiidae	20	40	10	5	0	0	0	2	0
Gastropoda	Ancylidae	0	10	10	0	0	0	0	0	0
Gastropoda	Hydrobiidae	10	0	0	0	0	0	0	0	0
Hemiptera	Belostomatidae	1	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	0	0	0	0	0	0	0	0	0
Hemiptera	Gerridae	0	0	0	0	0	0	0	0	0

Class/Order	Family/Sub-family	ERTOP	ERTOP	ERTOP	ERBTM	ERBTM	ERBTM	SCTOP	SCTOP	SCTOP
Hemiptera	Hebridae	0	0	0	0	0	0	0	2	0
Hemiptera	Mesoveliidae	10	0	0	0	0	0	5	0	9
Hemiptera	Micronectidae	0	0	0	123	0	80	64	28	127
Hemiptera	Nepidae	0	0	0	0	0	0	0	3	0
Hemiptera	Notonectidae	0	0	0	0	0	0	5	0	0
Hemiptera	Ochteridae	0	0	0	0	0	0	0	0	9
Hemiptera	Veliidae	0	0	0	0	0	0	5	0	0
Hirudinea		0	0	0	0	0	30	0	0	0
Lepidoptera	Crambidae	40	10	10	0	200	20	0	0	0
Neuroptera	Sisyridae	0	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	10	0	0	0	0	0	0	0	0
Odonata	Corduliidae	0	0	0	0	0	0	0	0	9
Odonata	Gomphidae	10	0	0	41	120	20	14	2	0
Odonata	Libellulidae	1	0	0	5	40	10	0	0	0
Odonata	Macromiidae	0	0	0	0	0	0	0	0	0
Oligochaeta		50	40	70	5	160	80	5	2	9
Trichoptera	Calamoceratidae	10	10	20	0	0	10	0	0	0
Trichoptera	Ecnomidae	10	20	0	14	60	40	9	0	0
Trichoptera	Hydropsychidae	10	20	10	5	100	0	0	0	0
Trichoptera	Hydroptilidae	90	270	120	23	300	90	41	17	9
Trichoptera	Leptoceridae	120	70	170	45	200	170	64	15	27
Trichoptera	Philopotamidae	50	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	0	0	10	0	0	0	0	0	0
Turbellaria	Dugesiidae	0	0	20	0	0	0	0	0	0

Class/Order	Family/Sub-family	SCDS	SCDS	SCDS	SCBTM	SCBTM	SCBTM	ERUS	ERUS	ERUS
		1	2	3	1	2	3	1	2	3
Acarina		80	8	100	150	78	20	40	80	100
Coleoptera	Dytiscidae	10	25	20	30	6	0	200	880	127
Coleoptera	Elmidae	0	17	0	40	39	0	40	0	145
Coleoptera	Gyrinidae	0	0	0	0	0	0	0	40	0
Coleoptera	Hydraenidae	10	0	120	0	0	40	440	20	18
Coleoptera	Hydrochidae	10	8	180	20	0	40	160	20	36
Coleoptera	Hydrophilidae	0	8	0	40	0	0	0	200	18
Decapoda	Palaemonidae	20	8	20	30	6	20	40	40	9
Decapoda	Parathelphusidae	0	0	0	0	0	0	0	0	9
Diptera	Aphroteniinae	0	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	40	42	400	30	72	80	180	80	73
Diptera	Chironominae	1400	892	1680	410	156	2260	1080	800	236
Diptera	Culicidae	0	0	0	30	0	80	0	0	0
Diptera	Empididae	0	0	40	0	0	0	0	20	9
Diptera	Orthocladiinae	40	42	180	80	100	60	60	220	73
Diptera	Simuliidae	0	0	0	20	33	0	160	160	9
Diptera	Tabanidae	0	0	0	0	0	0	0	0	0
Diptera	Tanypodinae	350	208	960	100	11	740	360	520	127
Diptera	Tipulidae	0	0	0	0	6	0	20	0	9
Ephemeroptera	Baetidae	70	75	80	630	450	140	220	300	336
Ephemeroptera	Caenidae	80	133	280	230	100	320	500	480	182
Ephemeroptera	Leptophlebiidae	10	17	0	10	11	40	0	20	9
Gastropoda	Ancylidae	0	0	0	0	6	40	0	20	0
Gastropoda	Hydrobiidae	0	0	0	0	0	0	0	0	0
Hemiptera	Belostomatidae	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	0	0	0	0	0	0	0	40	0
Hemiptera	Gerridae	0	8	0	0	0	0	20	0	1
Hemiptera	Hebridae	0	0	0	0	0	0	20	0	0
Hemiptera	Mesoveliidae	10	0	0	0	0	0	40	20	0

Class/Order	Family/Sub-family	SCDS	SCDS	SCDS	SCBTM	SCBTM	SCBTM	ERUS	ERUS	ERUS
Hemiptera	Micronectidae	30	83	280	10	6	160	20	40	27
Hemiptera	Nepidae	0	0	0	0	0	0	0	0	0
Hemiptera	Notonectidae	0	0	0	0	0	0	0	40	0
Hemiptera	Ochteridae	0	0	0	10	0	0	0	0	0
Hemiptera	Veliidae	0	0	0	0	0	0	0	40	0
Hirudinea		0	0	0	0	0	0	0	0	0
Lepidoptera	Crambidae	0	8	0	0	11	0	0	0	45
Neuroptera	Sisyridae	0	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0	0	0	0
Odonata	Corduliidae	0	0	0	0	0	0	0	20	0
Odonata	Gomphidae	0	0	140	0	0	0	180	0	9
Odonata	Libellulidae	0	8	0	0	0	0	20	20	0
Odonata	Macromiidae	0	0	0	10	0	0	0	0	0
Oligochaeta		10	8	0	20	178	20	0	0	9
Trichoptera	Calamoceratidae	10	8	20	0	6	0	0	0	0
Trichoptera	Ecnomidae	70	50	0	0	0	80	0	20	9
Trichoptera	Hydropsychidae	0	0	0	0	6	0	200	20	18
Trichoptera	Hydroptilidae	50	17	0	170	128	0	60	0	64
Trichoptera	Leptoceridae	0	8	120	210	94	60	180	40	136
Trichoptera	Philopotamidae	0	0	0	0	0	0	60	0	0
Trichoptera	Polycentropodidae	0	0	0	0	0	0	0	0	0
Turbellaria	Dugesiidae	0	0	0	0	0	0	0	0	0

Class/Order	Family/Sub-family	ERSW14	ERSW14	ERSW14	ERDS	ERDS	ERDS
		1	2	3	1	2	3
Acarina		111	260	150	283	167	280
Coleoptera	Dytiscidae	11	40	0	217	167	980
Coleoptera	Elmidae	111	180	56	117	233	360
Coleoptera	Gyrinidae	11	0	1	0	0	0
Coleoptera	Hydraenidae	11	0	0	117	33	480
Coleoptera	Hydrochidae	22	20	0	33	0	60
Coleoptera	Hydrophilidae	0	0	0	17	1	40
Decapoda	Palaemonidae	22	0	0	0	67	20
Decapoda	Parathelphusidae	0	0	0	0	0	0
Diptera	Aphroteniinae	0	0	0	0	0	0
Diptera	Ceratopogonidae	133	220	25	167	133	240
Diptera	Chironominae	500	680	194	433	933	1160
Diptera	Culicidae	0	0	0	0	0	0
Diptera	Empididae	0	0	6	0	0	0
Diptera	Orthocladiinae	22	60	6	0	0	20
Diptera	Simuliidae	0	0	0	0	0	0
Diptera	Tabanidae	0	0	0	0	0	0
Diptera	Tanypodinae	33	140	75	133	167	480
Diptera	Tipulidae	0	0	0	17	0	0
Ephemeroptera	Baetidae	456	1200	356	67	133	120
Ephemeroptera	Caenidae	289	720	231	100	67	60
Ephemeroptera	Leptophlebiidae	11	0	6	0	0	0
Gastropoda	Ancylidae	0	0	0	0	0	0
Gastropoda	Hydrobiidae	0	0	0	0	0	0
Hemiptera	Belostomatidae	0	0	0	0	0	0
Hemiptera	Corixidae	0	0	0	0	0	0
Hemiptera	Gerridae	0	0	0	0	0	0
Hemiptera	Hebridae	0	0	0	0	33	0
Hemiptera	Mesoveliidae	0	0	0	17	33	0
Hemiptera	Micronectidae	11	20	13	17	33	40
Hemiptera	Nepidae	0	0	0	0	0	0

Class/Order	Family/Sub-family	ERSW14	ERSW14	ERSW14	ERDS	ERDS	ERDS
Hemiptera	Notonectidae	0	0	0	0	0	0
Hemiptera	Ochteridae	0	0	0	0	0	0
Hemiptera	Veliidae	0	0	0	17	0	0
Hirudinea		0	0	0	0	0	0
Lepidoptera	Crambidae	11	0	0	0	0	0
Neuroptera	Sisyridae	0	0	0	0	33	20
Odonata	Coenagrionidae	0	0	0	0	0	0
Odonata	Corduliidae	0	0	0	0	0	0
Odonata	Gomphidae	44	80	6	117	1	40
Odonata	Libellulidae	0	20	0	0	0	0
Odonata	Macromiidae	0	0	0	0	0	0
Oligochaeta		67	140	0	33	100	80
Trichoptera	Calamoceratidae	0	0	0	0	0	20
Trichoptera	Ecnomidae	0	0	0	83	33	80
Trichoptera	Hydropsychidae	11	0	0	0	0	0
Trichoptera	Hydroptilidae	78	60	69	33	33	60
Trichoptera	Leptoceridae	478	440	75	1717	4400	2320
Trichoptera	Philopotamidae	0	0	0	0	0	0
Trichoptera	Polycentropodidae	0	0	0	17	0	0
Turbellaria	Dugesiidae	0	0	0	0	0	0

Appendix H – ANOVA Results

Univariate Tests of Significance for Relative abundance (Macroinvertebrate Metrics Vista Mt Todd) Sigma-restricted parameterization Effective hypothesis decomposition					
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	132607852	1	132607852	55.6376	0
Watercourse	6794270	1	6794270	2.85064	0.10687
Site Type	16449242	1	16449242	6.90152	0.016151
Watercourse*Site Type	5631	1	5631	0.00236	0.961714
Error	47668432	20	2383422		

Univariate Tests of Significance for Taxa richness (Macroinvertebrate Metrics Vista Mt Todd) Sigma-restricted parameterization Effective hypothesis decomposition					
Effect	SS	Degr. Of Freedom	MS	F	p
Intercept	9546.036	1	9546.036	633.2362	0
Watercourse	15.75	1	15.75	1.0448	0.318919
Site Type	10.321	1	10.321	0.6847	0.417747
Watercourse*Site Type	0.036	1	0.036	0.0024	0.961662
Error	301.5	20	15.075		

Univariate Tests of Significance for PET richness (Macroinvertebrate Metrics Vista Mt Todd) Sigma-restricted parameterization Effective hypothesis decomposition					
Effect	SS	Degr. Of Freedom	MS	F	p
Intercept	700	1	700	656.25	0
Watercourse	9.1429	1	9.1429	8.5714	0.008323
Site Type	0.5714	1	0.5714	0.5357	0.472705
Watercourse*Site Type	9.1429	1	9.1429	8.5714	0.008323
Error	21.3333	20	1.0667		

Univariate Tests of Significance for SIGNAL-2 (Macroinvertebrate Metrics Vista Mt Todd) Sigma-restricted parameterization Effective hypothesis decomposition					
Effect	SS	Degr. Of Freedom	MS	F	p
Intercept	348.3351	1	348.3351	5687.973	0
Watercourse	0.3299	1	0.3299	5.386	0.030976
Site Type	0.0286	1	0.0286	0.467	0.502205
Watercourse*Site Type	0.5337	1	0.5337	8.715	0.00788

Error	1.2248	20	0.0612		

Univariate Tests of Significance for OE50 (Macroinvertebrate Metrics Vista Mt Todd) Sigma-restricted parameterization Effective hypothesis decomposition					
Effect	SS	Degr. Of Freedom	MS	F	p
Intercept	21.75953	1	21.75953	2280.409	0.000000
Watercourse	0.02191	1	0.02191	2.297	0.145298
Site Type	0.01448	1	0.01448	1.517	0.232337
Watercourse*Site Type	0.00067	1	0.00067	0.070	0.794176
Error	0.19084	20	0.00954		

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