Mt Todd Macroinvertebrate & Sediment Monitoring Report

2013-2014 Wet Season

Prepared for Vista Gold Australia Pty Ltd

Envirotech Monitoring Pty Ltd

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Front Cover: Early Morning upstream on the Edith River.

Table of Contents

EXECUTIVE SUMMARY

In June 2014 aquatic macroinvertebrate, sediment and water quality sampling was conducted along the Edith and Fergusson Rivers, nearby to the Mt. Todd mine site. The primary aim of these surveys and assessments were to enable Vista Gold to meet current regulatory obligations, and to identify and quantify any changes to the above measures of the downstream Edith River ecosystem as a result of licenced discharging activities. This report continues similar assessments conducted at the site since 2003.

Potential changes in overall macroinvertebrate community composition and other univariate measures of macroinvertebrate communities were investigated, as well as surface water quality and the chemical composition of sediments upstream and downstream of the mine. This report presents the results of these investigations.

Macroinvertebrates

In 2014 there was no statistically significant difference in the community composition of pelagic macroinvertebrates between reference sites located on the Edith River upstream of the mine, and sites downstream of discharge points. The composition of communities on the Fergusson River did differ significantly from both upstream and downstream Edith River sites, supporting past conclusions that the two river systems are inherently different with respect to their macroinvertebrate compositions.

Further targeted analyses confirmed that within the Edith River ecosystem, there was no significant impact of discharge activities on the downstream macroinvertebrate communities, with upstream and downstream Edith River sites showing similar macroinvertebrate compositions. Furthermore, temporal analyses showed the compositions of upstream and downstream sites on the Edith River have shown a steady increase in similarity over the last three years.

Analyses of other macroinvertebrate community measures showed that although taxa richness was marginally greater at reference compared with downstream sites, this was mostly attributed to a higher taxa richness of Fergusson river sites, with Edith upstream and downstream sites showing similar taxonomic richness. Differences in taxa between reference and downstream sites were not a reflection of mine discharge effects but rather chance sampling of rarely encountered taxa. Total macroinvertebrate abundance and the percentage of abundance comprised of pollution sensitive taxa also differed significantly; but did not reflect an impact of mine discharge with both variables greater at downstream sites.

A temporal analysis of macroinvertebrate community composition from 2003 to 2014 showed a statistical difference between reference and downstream sites that was dependant on year. In contrast to 2014, there was a significant difference in composition between reference and impact sites in 2012 and 2013. However, the detection of a statistical difference in community composition in 2012 and 2013 is most likely due to the increase in sampling sites and number of samples collected; and not as indicated by the temporal analysis, a result of compositional changes since 2011. Nevertheless, the magnitude of difference between reference and downstream sites is small and within the range of natural annual variability witnessed across sites within a similar treatment.

Sediments

This year's sampling program assessed sediment chemistry at five of the 17 sites previously sampled. The subset of results were used as indicators of any significant increased downstream impacts. There continued to be detectable and elevated levels of particular metals and ions downstream of the mine, but an absence of any further exacerbation of levels as a result of discharge activities. Concentrations in edge sediments continued to be higher than in benthic sediments for the majority of metals and ions, associated with the finer grain material held in place by riparian vegetation.

1. Introduction

Historically, assessments of the health of aquatic systems have relied on the measurement and monitoring of physical and chemical parameters (e.g. pH, turbidity, anolyte concentrations). However, such measures do not provide information on the actual biological condition of the aquatic environment. Understanding the latter is important, as impacts on an aquatic system can not only affect the physio-chemical parameters of water quality, but also the habitats of the fauna and flora that constitute the biological community of that water body. Thus significant changes in flora and fauna may indicate an effect of changes in water quality. Consequently an integrated approach encompassing physical, chemical and biological monitoring of river and stream health is often employed.

Aquatic macroinvertebrates are animals without backbones that are present in practically every freshwater system in the world. They are typically defined as animals retained by a 500 micron sieve and include organisms such as mayflies, aquatic mites, caddis flies, damselflies, worms and prawns. These organisms form an integral part of the aquatic food web as primary and secondary consumers and prey for larger predators. They are pivotal in the cycling of energy through the ecosystem by breaking down organic matter into finer material (‘shredders”) that serves as a food source for other filter-feeding biota; shredding course plant material and feeding on deposited material on the stream bed. They also harvest algae, feed on other macro- and micro-invertebrates and represent an important food source for larger vertebrates including fish, frogs and birds. Thus in their absence the functioning of an aquatic system may break down.

Aquatic macroinvertebrate assemblages are comprised of pelagic and benthic invertebrate communities. Pelagic invertebrates are those that reside in the water column, either in free-living form or attached to vegetation. Benthic invertebrates are those organisms that have an intimate relationship with the river bottom. These organisms are either permanently attached to the benthos or are intimately linked with the substrate bottom, and are the primary material exchangers across the sediment-water interface.

The negative effects of waters containing high heavy metal loads (e.g. zinc, lead, arsenic) on river and stream biota are well known, particularly on populations of metal-sensitive taxa such as mayflies. Impacts on aquatic biota as a consequence of metal pollution resulting from mining operations have been observed since 1932. The direct effects of contaminants on macroinvertebrates include changes in community composition and the relative abundances of aquatic taxa due to sensitivity differences across taxa and lifecycle stages. Indirect effects of metal pollution include changes in fecundity and to food webs, and the cascading effects caused by the loss or increased dominance of particular taxa.

Consequently, it is the ecological relevance and holistic response to environmental contaminants that makes aquatic macroinvertebrates an important tool for assessing the ecological health of aquatic ecosystems. They are recognised as one of the best biological indicators worldwide, for assessing the effects of metal pollution of the health of rivers and streams. This is also because they are (1) highly abundant and diverse, (2) sensitive to changes in water quality, given their limited ability to move away from an area of river being adversely impacted, and (3) their taxonomy is fairly well understood.

Vista Gold’s Mt Todd mine site operates under Waste Discharge Licence (WDL) 178-3. This licence is required due to the large volumes of water received by the mine during the wet season and the low retention capacity of key ponds on site. The licence permits the periodic controlled release of waste water from the mine site into the adjacent Edith River, during the wet season. Controlled releases aim to minimise uncontrolled overflow from ponds into the Edith River.

The success of the mine’s water management system is assessed against the licence criteria through the monitoring and analyses of water quality, sediments and aquatic macroinvertebrate data. Under the Beneficial Use Declaration Scheme within the Water Act (2000), the Edith River has an established aquatic ecosystem protection level and therefore monitoring is required to ensure discharges are not having any impacts on the downstream ecosystem. Under WDL 178-3 a biological macroinvertebrate and sediment sampling programme must be completed annually for the purposes of assessing potential impacts from licensed discharging activities.

This document reports on the aquatic macroinvertebrate monitoring conducted in 2014 after the 2013-2014 wet season at Mt Todd. Data and the outcomes of statistical and qualitative analyses on pelagic aquatic fauna, sediment chemistry and composition and water quality, collected at sites located on the Edith and Fergusson Rivers are presented.

2. Background and methodology

2.1. Mt Todd mine site

The Mt. Todd mine site is located approximately 37 km NW of Katherine and 320 km south-east of Darwin, in the Edith River catchment (Figure 1).

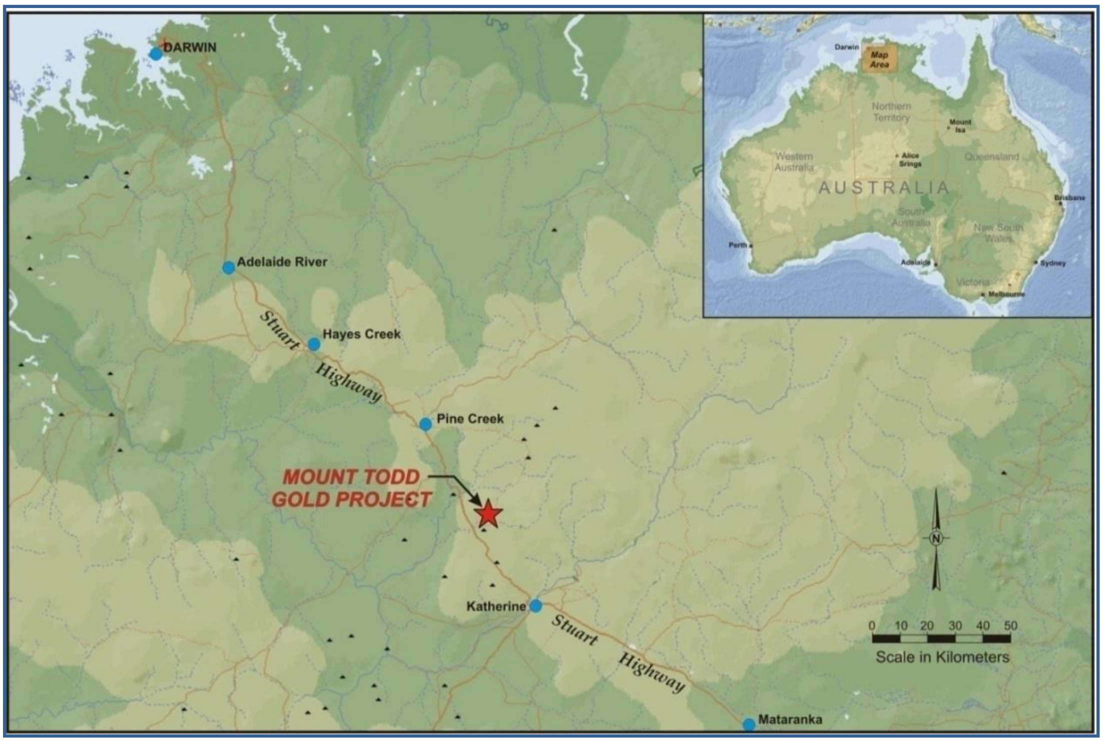

Figure 1. Location of the Mt Todd mine.

The climate is wet/dry monsoonal, with a wet season from November to April. Long-term average annual rainfall for Katherine is 1138 mm (www.bom.gov.au). Temperatures remain high throughout the year, with maximum and minimum temperatures in the dry season of 33 ºC and 17.0 ºC respectively, and 35 ºC and 24 ºC respectively, in the wet season.

For the period covered in this report, total wet season rainfall received at the mine site over the 2013-2014 wet season was 1207 mm which is slightly higher than the 37 year average of 1135mm recorded at Katherine. The last three years annual rainfall at Mt. Todd is illustrated in Figure 2. The mine sits on the northern bank of the Edith River with natural and anthropogenic drainage entering the Edith River at three locations: Stow Creek, RP1 discharge point and West Creek.

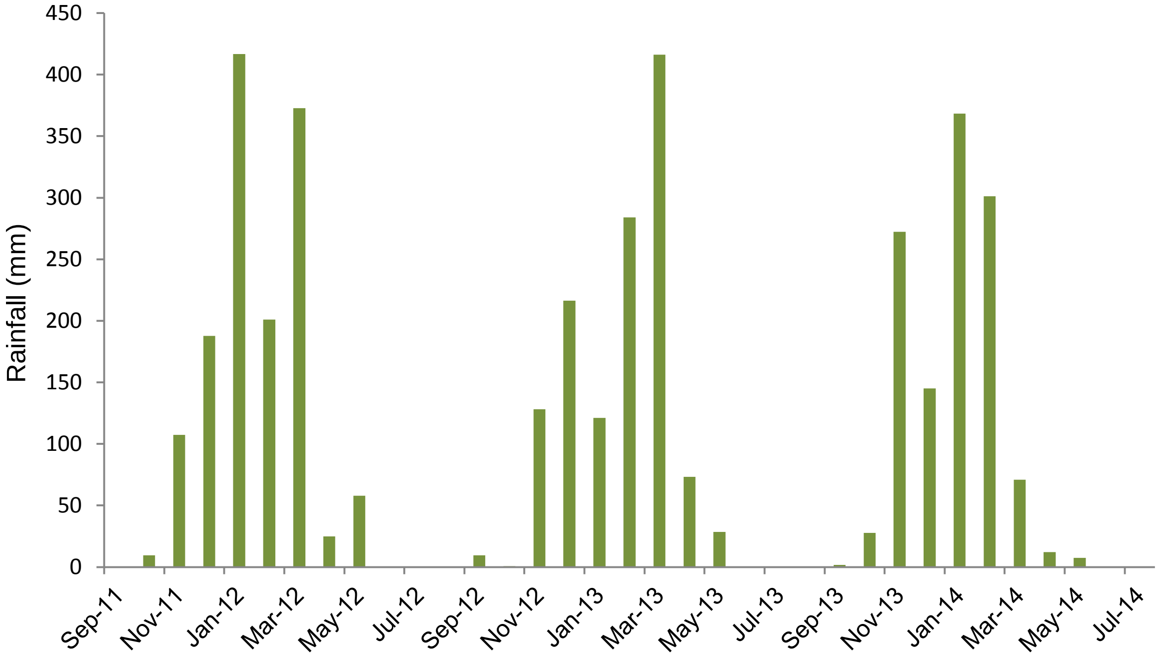

Figure 2. Three year rainfall totals for Mt Todd.

2.2. Historical assessments at Mt. Todd

2.2.1. *Macroinvertebrates*

At the Mt Todd mine site, pelagic macroinvertebrates have been monitored since 2003. From 2003 to 2010 five sites were monitored annually by the Northern Territory Department of Resources (DoR), with a single macroinvertebrate sample collected at each site. These sites were:

- Edith River Upstream (ERUS)
- Edith River Downstream (ERDS)
- Edith River Downstream of site SW4 (ERSW4)
- Fergusson River Upstream (FRUS)
- Fergusson River Downstream (FRDS)

The majority of mine water that enters the Edith River under controlled discharges occurs at the RP1 discharge point into Burrell Creek prior to entering the Edith River (Figure 3). Other potential sources of mine water include discharge from Batman Creek and Horseshoe Creek which pass water to Stow Creek prior to the Edith River and discharge from West Creek. Stow Creek receives seepage and pond overflow from RP7, RP2, RP5 and the Heap Leach. West Creek receives overflow from RP1. Anthropogenic discharge can occur from RP7 and as of 2013 from RP3.

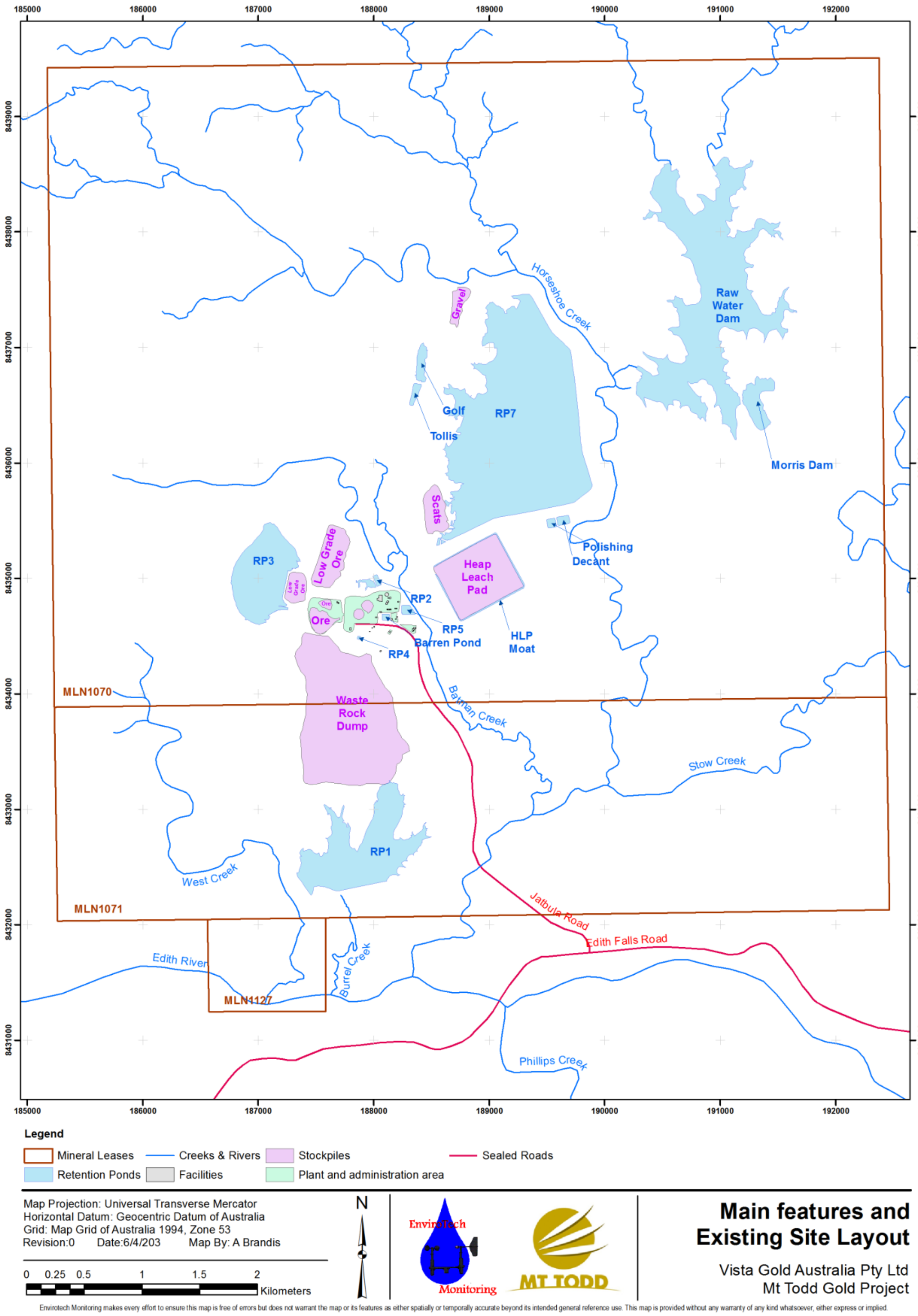

Figure 3. Key features of the Mt Todd Minesite.

From 2003 to 2010 the main focus of macroinvertebrate analyses was to use changes in pelagic macroinvertebrate community composition as an indicator of mine site wastewater impact. The analyses compared macroinvertebrate community composition at sites along a reference river (Fergusson River), with those upstream of the mine to those of sites along the potential 'impact zone' on the Edith River. If the community composition between sites on the "impacted" river were of equal or greater similarity compared to that observed between sites of the reference river, then no impact was said to be detected. Conclusions were based on the results of a Bray-Curtis similarity matrix each year, generated from the single macroinvertebrate sample collected at each site.

Results over this period concluded that there was no clear large impact from contaminant discharge on downstream pelagic macroinvertebrate fauna, within the area under assessment. An impact was reportedly detected once in 2003-2004, however this conclusion has since been shown to be incorrect. The data analyses and interpretation from this period was predominantly hampered by the lack of replication and sample size.

In 2011 Envirotech Monitoring Pty Ltd took over the macroinvertebrate monitoring program, and modified the experimental design and statistical approach. Since 2011 three replicate macroinvertebrate samples were collected at each of the above five sites (Envirotech Monitoring, 2012). Each replicate was represented by the site name (e.g. ERUS) followed by a number from 1 to 3 that represented the site sample replicate (e.g. ERUS1, ERUS2, ERUS3).

Since 2011 potential changes in other macroinvertebrate community variables have also been examined, in addition to community composition, these include total taxa richness, total macroinvertebrate abundance, percentage contribution of Ephemeroptera, Trichoptera and Odonata taxa (ETO taxa) and percentage of ETO abundance. ETO taxa are regarded as a reliable and commonly used biological indicator of water pollution worldwide. This is because these ETO taxa guilds contain species that are most sensitive to environmental pollution, and therefore act as a useful indicator for detecting impacts from water quality deterioration.

In 2012 the experimental design and statistical approach was further modified. An additional three sampling sites (ERBTM, ERTOP and FRBTM) were introduced to increase the statistical power of the analyses (Envirotech Monitoring, 2012). Envirotech Monitoring Pty Ltd also initiated sampling of the benthic macroinvertebrate fauna at one replicate sites for each of the five main sampling sites, to provide a more holistic approach to the measurement of potential pollutant effects on macroinvertebrate communities (Envirotech Monitoring, 2012).

The locations of the eight sampling sites are shown in green in Figure 4 and details of each presented in Table 1. Photos illustrating the variety of habitats represented across the eight sites are shown in Figure 5.In 2012 although there was no conclusive statistically significant impact of waste water discharge to downstream pelagic or benthic macroinvertebrate communities of the Edith River. However the analyses of pelagic macroinvertebrates did suggest that varying and more subtle impacts may be occurring.

In 2013 the macroinvertebrate sampling protocol and analyses employed in 2012 was again repeated. A temporal analysis of all pelagic macroinvertebrate data since 2003 was also undertaken in 2013 to quantify the between year changes and in an effort to evaluate compositional changes over time. Changes in any of these variables could also indicate a decline in river health in response to pollution, and can often occur independently of each other.

In 2013 there was a statistically significant difference in pelagic macroinvertebrate community composition between downstream Edith River sites and reference sites on the Edith and Fergusson rivers. This difference was not detected in benthic community composition analyses.

The macroinvertebrate sampling program conducted over the last two years has provided the most comprehensive results to date, for macroinvertebrate assessments of potential mine site impacts.

For both years, macroinvertebrate data showed no significant effect of mine discharge on the composition of the benthic macroinvertebrate community, or any of the other benthic community variables examined. This was despite the detection of a significant impact of mine discharge on pelagic macroinvertebrate community composition in 2013. Based on this and also taking into account the cost per unit effort for sampling, benthic macroinvertebrates were not assessed in 2014.

The detection of a statistical difference in community composition since 2012 was most likely due to the increase in site and sample number and not, as indicated by a temporal analysis, a result of compositional changes since 2011. It is also known that the Fergusson River macroinvertebrate compositions are statistically different from those of reference and downstream Edith sites, and despite compensating for this in the statistical approach, it is possible a biasing result remains.

Regardless of prior arguments qualifying the statistical differences, the magnitude of difference between reference and downstream sites was small and within the range of natural annual variability witnessed across sites within a similar treatment. An inference of a mining impact was valid by virtue of the experimental design; however such conclusions could not be made with certainty as the analyses to date have not isolated possible natural ecological factors which may be driving the statistical differences.

Table 1. Details of macroinvertebrate monitoring sites and locations.

Site code	Sample type	LAT (WGS84)	LONG (WGS84)	Description
ERTOP	Sweep 1	-14.1735	132.1433	Edith River farthest upstream site
	Sweep 2	-14.1766	132.1488	
	Sweep 3	-14.1787	132.1507	
ERUS	Sweep 1	-14.1713	132.1158	Edith River upstream of Stow Creek confluence.
	Sweep 2	-14.1713	132.1173	
	Sweep 3	-14.1703	132.1135	
ERDS	Sweep 1	-14.1714	132.1065	Edith River downstream of Stow Creek confluence.
	Sweep 2	-14.1718	132.1084	
	Sweep 3	-14.1715	132.1050	
ERSW4	Sweep 1	-14.1690	132.0919	Edith River downstream of site ERSW4
	Sweep 2	-14.1694	132.0961	
	Sweep 3	-14.1719	132.1004	
ERBTM	Sweep 1	-14.1692	132.0521	Edith River farthest downstream site
	Sweep 2	-14.1694	132.0572	
	Sweep 3	-14.1697	132.0590	
FRUS	Sweep 1	-13.9574	132.1778	Fergusson River upstream site (representative control for ERUS).
	Sweep 2	-13.9782	132.2213	
	Sweep 3	-13.9777	132.2208	
FRDS	Sweep 1	-13.9566	132.1786	Fergusson River downstream site (representative control for ERSW4).
	Sweep 2	-13.9543	132.1812	
	Sweep 3	-13.9539	132.1832	
FRBTM	Sweep 1	-13.9998	132.2262	Fergusson River farthest downstream site (representative control for ERBTM).
	Sweep 2	-13.9988	132.2254	
	Sweep 3	-13.9949	132.2247	

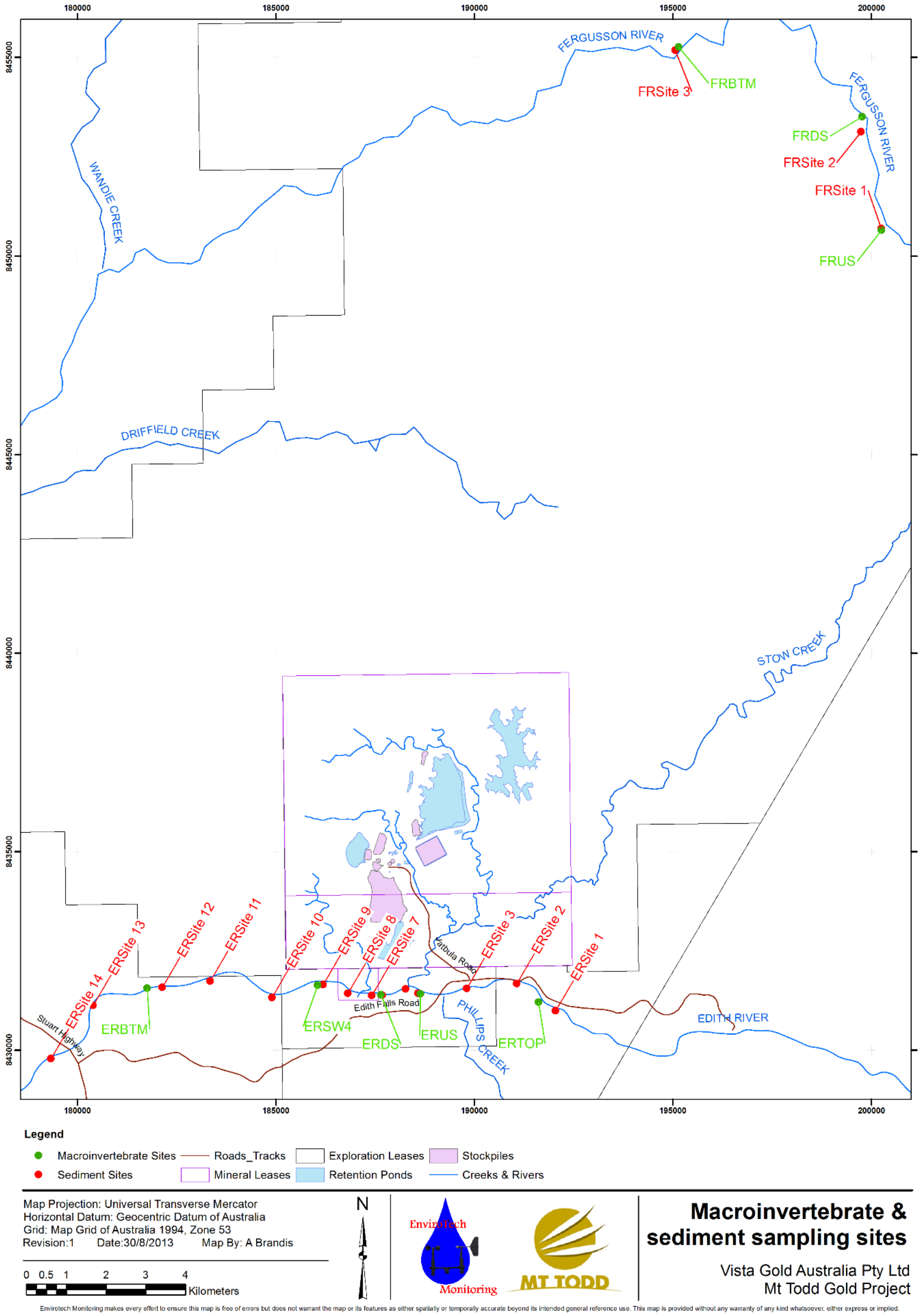

Figure 4. Location of sampling sites in reference to Mt Todd.

ERTOP

ERUS

ERDS

ERSW4

ERBTM

FRUS

FRBTM FRDS

Figure 5. Photos showing the variety of habitats represented across the eight main sampling sites at Mt Todd.

2.2.2. Sediments

Historical sediment sampling and analyses prior to 2012 indicated that metals were not being held locally in the sediments of the Edith River, but were being carried in suspension further downstream. However up until this point, sediment samples had only been collected from the river bottom within close proximity to the river edge (‘benthic edge samples’). A concern was that these sediment samples may not adequately represent the breadth of sediments across the river. It was not known whether released metals and other pollutants remain suspended in the water column as they flow downstream, or if they settle out and bind to the sediment of the river bottom.

In 2012 as well as collecting benthic edge samples, sediments were also collected from deeper riverine pool habitats characterised by slow water, where free or bound metals have the greatest potential for settlement (Figure 6) (‘benthic pool samples’). For each of these two sample types, three replicate samples were collected, pooled then subsampled for chemical and particle size analyses. This was conducted at one of the three replicate locations for each of the eight main sampling sites; the same location, and near to where, benthic macroinvertebrates were collected and water quality assessed.

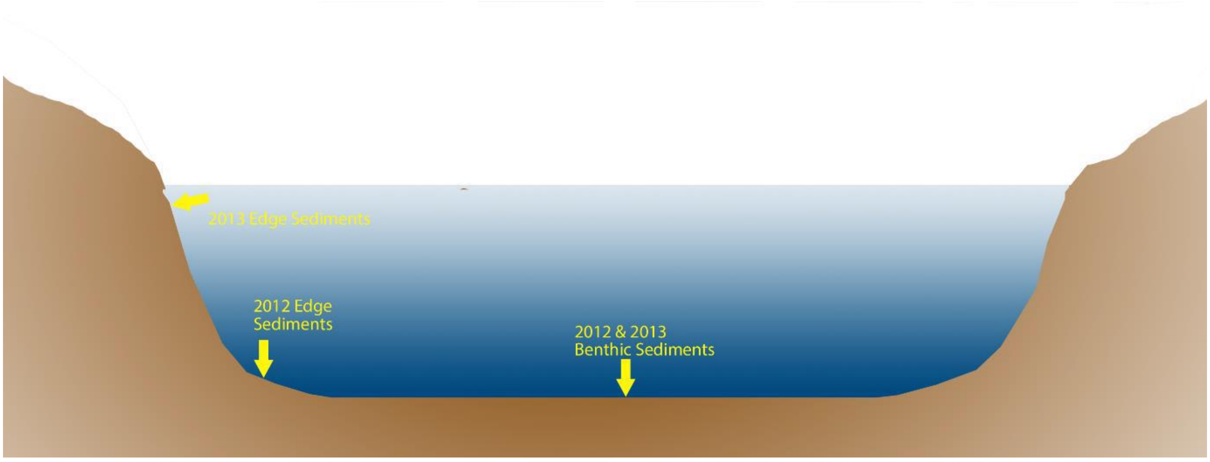

Figure 6. Cross sectional diagram of sediment sampling locations.

In 2012 the chemistry of benthic sediments from deeper pools and those taken close to river edges did not differ significantly in their chemistry. Both sediment sample types at the three downstream Edith river sites demonstrated statistically significant elevated concentrations of particular metals compared with reference upstream Edith River and Fergusson River sites. The ratios of sediment concentration increase were broadly consistent with the equivalent metal concentrations in waters discharged from the Mt Todd site. These findings have concluded that the velocities of the river in the sampled reach of the catchment are too high to permit accumulation of the finer colloidal particles holding heavy metals. However, both these sample types were collected only from the river bed which is largely composed of sand and coarser grained material.

In light of the 2012 results, the 2013 sediment sampling program was significantly increased to strengthen statistical assessments and respective conclusions. The three sediment sites on the Fergusson River remained the same, with the number of sediment sites on the Edith River increased to 14. The Edith River sediment sampling sites covered the spatial range from the upper most macroinvertebrate site (ERTOP) to the old Stuart Highway Bridge. The additional locations were distributed among the existing macroinvertebrate sites and spaced evenly where possible, or positioned to assist with the separation of the three main mine discharge confluences (Stow Creek, Burrell Creek and West Creek). This provides additional information as to whether any changes in chemistry may be occurring further downstream and if so, what distance from the mine and to what extent, are such effects occurring. To minimise confusion during analyses, sites were numbered from 1 to 14 with the former commencing at the ERTOP macroinvertebrate site.

The walls and broader river banks are composed of a very different sediment/soil structure compared with the river bed, being areas where finer particulates and organics are trapped and held in place by the riparian root structures. Benthic pool samples were collected as in 2012 at each of the 17 sites. However in 2013 the river edge samples were taken directly from the wetted zone of river bank in areas considered to be sediment deposition zones.

Figure 6 illustrates the relative cross sectional sampling positions. A stainless steel kitchen knife was used to cut and loosen the top 4-5 cm of sediment and root material prior to filling the sample jars via a stainless steel soup ladle.

In 2013 five elements (Mg, K, Zn, Pb, Cu) in sediment edge samples showed significant differences between reference and downstream sites, with all downstream samples reporting higher average concentrations. Seven elements (Mn, Pb, Zn, Cu, Co, Mg, SO_4) exhibited a spike in edge sample concentrations immediately below the points of discharge from the mine, and in general exhibited a reduction in concentrations with increased distance downstream. Of the three elements comparable to ANZECC published sediment guideline values (Zn, Pb, Cu), no samples were in exceedance (with the exception of the benthic copper sample below the Stuart Highway, attributed to the train derailment in 2011). The 2013 results from chemical analyses of benthic sediment material showed no significant changes in sediment chemistry downstream of the mine.

2.3. Macroinvertebrate methodology

As in previous years macroinvertebrate sampling was conducted towards the end of the wet season, specifically during the recessional flow period in the Edith and Fergusson Rivers. In 2014 macroinvertebrate sampling was carried out from the 2nd to the 5th June. The selection of this sampling period allowed for the minimum gestation and re-colonisation period of approximately six weeks following the final wet season flush. As in the past, water quality was also be assessed at the time of macroinvertebrate sampling to provide data to aid in the interpretation of macroinvertebrate results.

2.3.1. Pelagic macroinvertebrates

The three replicate pelagic macroinvertebrate samples at each of the eight macroinvertebrate sampling sites were collected and processed following standard Northern Territory AusRivAS field and laboratory protocols. At each site replicate, macroinvertebrates were collected from riverine edge habitat, one of the two most common habitats present in Northern Territory waterways (the other being sand bed). At each location, consistent suitable edge habitat was identified. These were areas where the edge was as vertical as possible, abundant root material was present and water velocity minimal (often also associated with a pool). Those edge areas characterised by Pandanas palm roots and undercut banks were avoided where possible.

Two operators sampled macroinvertebrates along the selected edge habitat for a distance of 10 m in an upstream direction. The procedure involves one operator using a 3-pronged cultivator rake to agitate the submerged root matter, by ‘scratching’ upwards from a depth of 0.3 m. The second operator then uses a standard long-handled net of 500µm mesh to continuously ‘sweep’ back and forth through the disturbed water to collect macroinvertebrates (Figure 7). In situations where a continuous 10 m stretch of edge habitat could not be found, separate lengths of edge habitat were sampled to total 10 m.

Figure 7. Sweeping edge habitat at ERUS for aquatic macroinvertebrates.

Figure 9. Transfer of sieved sample to jars for preservation and transport back to lab.

Figure 8. Sieving of sweep contents at FRBTM.

Figure 10. Macroinvertebrate sample ready for preservation.

The net contents were emptied into a bucket of water and the sample passed through a 10 cm sieve nested on top of a 500 µm sieve. Coarser vegetable matter is removed by the top sieve with the remainder of the sample captured on the sieve below. The coarser material was also rinsed and checked for macroinvertebrates before being discarded. The remainder of the sample was preserved in 70% ethanol for transport back to the laboratory for further sorting, counting and identification (Figure 7 through Figure 10).

2.3.2. Laboratory processing and identification

As in previous years, each of the pelagic macroinvertebrate sweep samples was subsampled following a similar methodology to that described by Marchant (1989). A sample was rinsed into a plastic box of dimensions 61 (L) x 40 (W) x 16 cm (D), the bottom of which was divided into 100 wells of equal size. Water was then added to just above the surface of the wells. The container was agitated to ensure even visual distribution of the sample across the base plate. A minimum 3% (i.e. 3 wells) of the sample was sorted, and if required additional 1% wells were sorted until the organism count reached 200. Wells were selected using a random numbers process. The percentage of the total sample sorted was recorded.

Using keys recommended by Hawking (1999), insects and crustaceans were identified to family level, with some to genus; with other non-insects to order or class. Information from other contaminant studies suggests identifications at such coarser taxonomic levels than species results in minimal loss of information. It also reduces processing time and associated costs. For each sample, the abundance of each taxon identified was recorded in a tally sheet.

2.4. Sediment Methodology

The similarity in chemistry of benthic pool and benthic edge sediments in 2012 suggested the benthic substrate of the rivers under examination is fairly homogenous with respect to the retention of metals and other pollutants. Based on this result and taking into account the greater time and logistics involved in collecting benthic samples from deep pools, benthic sediment samples were only taken from the river’s edge in 2014. As in 2013, sediment samples were also taken from the walls of the river bank at the river’s edge (edge sediment samples), where free or bound metals been shown so far to have the greatest potential for settlement.

The increased chemical concentrations found in edge sediment samples, particularly at sites downstream from the mine, are expected to be the result of accumulation over time and not related to a specific year of discharge. Therefore in 2014, the number of sites where sediments were collected was reduced to five to provide an initial comparative dataset with prior results. Further detailed sampling was planned following the identification of unexpected results. Three sites were sampled on the Edith River, ERTOP, ERBTM and ERSW4. On the Fergusson River, two of the three macroinvertebrate sampling sites were sampled for reference data (FRDS, FRBTM).

For the above five sites, sediments were collected at one of the three replicate locations; the same location at which water quality was sampled. For each sediment sample type, three samples were collected using procedures consistent with previous years.

All sediment samples were stored at 4 ºC prior to dispatch to a NATA accredited laboratory for analysis. These samples were analysed for:

- pH (in 1:5 soil to water ratio) and total organic carbon (combustion)
- Metals and other analytes (mg/kg): Al, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Ag, Zn, U SO_4, Cl, NO_2, NO_3, NH_4 CN, Ca, P, Mg, Na, As, Be, Cr, La, Mn, Pb

The selection of elements for analysis was based on those that have appeared in detectable concentrations within the discharge effluent.

2.5. Water Quality methodology

Water samples were collected as per Australian standards from the edge of the river, near to where pelagic macroinvertebrate sampling took place. Samples were taken to identify any significant chemical variations in the water at these sites, which may directly contribute to any observed variations in macroinvertebrate results. Samples were collected directly from the creek in flowing water where possible and prior to any disturbance of the waterway from macroinvertebrate or sediment sampling. Water samples were collected in pre-preserved bottles supplied by the laboratory. These samples were immediately stored in the dark at 4 ºC to reduce loss of volatiles and reduce bacterial activity. At each water sampling location, field parameters of water temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), turbidity and redox were recorded using a calibrated multi-parameter sonde.

2.6. Statistical analyses

Multivariate analyses were conducted using Primer 6.1.13 and PERMANOVA 1.0.3. (Clarke and Gorley 2001). Univariate analyses were performed using GenStat 17.1.0.13780 (VSN International Ltd, 2014).

2.6.1. Macroinvertebrates

The eight macroinvertebrate sampling sites consist of three sites on the Edith River that are potentially affected by mine discharge (referred to as 'impact' sites), two sites that are considered reference sites located above the mine on the Edith River, and three reference sites on the Fergusson River; thus representing three 'treatment' groups. The inference of the design is that the upstream Edith River sites and the Fergusson River sites are reference sites for the three sites downstream of the mine.

With this type of approach, the data are not from a true experimental design. That is, sites were not randomly allocated to be a reference or an impact site, and the three sites subject to mining impacts may be affected differently because they are at different points in the landscape relative to the mine. The design is further limited because none of the sites were sampled prior to the mine, so it is unknown as to whether the macroinvertebrate assemblages of sites within each treatment group were initially similar. Therefore the design relies heavily on the assumption that the reference sites and impact sites were similar before the mine, and that any present differences may be because of the mine.

The lack of true experiment design and pre-impact knowledge means that the sites are subject to several possible interpretations and that a number of statistical models could fit these data. The four models used to assess the data include:

(1) An 8 independent site model, where all 8 sites are treated as independent and compared with each other. This model enables detection of different effects from the mine on the affected sites.
(2) A reference v impact model, where there are simply two groups of sites, Reference and Impact. This model pools the Fergusson River sites and Upstream Edith Sites as Reference sites and assumes sites within the impact and reference categories behave similarly.
(3) A 'Three river reaches' model, where there are three groups of sites (Fergusson Reference, Edith Reference and Edith Impact). This model assumes sites within the "river reaches" are more like each other than the other reach.
(4) A reference v impact, river partitioned model. This model is similar to a Reference v Impact design (model 2), but where the differences between Fergusson sites are partitioned rather than pooled.

Akaike's Information Criteria (AIC, Akaike 1981) was used in 2012 to determine which specific model offers the simplest plausible explanation of the data when fitted to community composition, total taxa richness, percentage of ETO taxa, total macroinvertebrate abundance and percentage ETO abundance data sets, for pelagic macroinvertebrate data. Based on the similarity of AIC values and consistent treatment effects across the four models, no single model was a significantly better fit to the data than any other. Given the aim of the experimental design, as in 2013, this year the river partitioned model (4) was primarily used with outputs from models 3 and 1 used to further investigate the results from Model 4. Model 2 was generally excluded. This decision was primarily based on:

- the similarity in AIC values and consistency in interpretation of effects, across the four models in 2013,
- the direct applicability of model design to the aim of the monitoring study,
- known natural differences between the Fergusson River and the Edith River, and
- the greater statistical power of model 4 compared with model 3.

2.6.1.1. Community composition analyses

Models were applied to the macroinvertebrate community composition data which was analysed using PERMANOVA (Anderson 2001) on Bray-Curtis Similarities of 4th root transformed abundances. The statistical outputs are presented, and for any significant effects follow up pair-wise comparisons with 9999 possible permutations were conducted. The resultant Bray-Curtis similarity index, which is an association matrix that compares the percentage similarity in community composition for all pair-wise combinations of treatments under examination, is also presented. The P (permutations) value from the pair-wise tests were used to determine which treatments had significantly different community compositions, and in situations where the number of unique permutations were less than 50, the Monte-Carlo probabilities P(MC) were used for the comparison.

Non-metric multi-dimensional scaling ordination of the sites were performed in conjunction with Spearman's correlations of the macroinvertebrate data to the ordination axes, to interpret differences between sites and results of the PERMANOVA tests. These follow up 2D ordination plots provide a diagrammatic representation of the relative dissimilarity of sites based on the macroinvertebrate communities sampled.

For pelagic macroinvertebrate data prior to the community composition, total abundance and ETO abundance analyses, the raw abundance of each taxon identified was scaled up to a total abundance, using the percentage of the sample sorted and identified.

2.6.1.2. Richness and abundance

The rest of the macroinvertebrate data analyses included four univariate community measures:

1. total taxa richness (defined here as the number of different taxa present)
2. total macroinvertebrate abundance
3. percentage of ETO taxa, and
4. percentage of ETO macroinvertebrate abundance.

For all of these data the reference v impact, river partitioned model was applied and each variable individually analysed using ANOVA. Total abundance was $\log_e$ transformed and the residuals from all models were inspected to verify the assumptions of normality and homogeneity of variances. Separate analyses for univariate and multivariate measures were performed. A ± 1 standard deviation (SD) is presented in brackets for all means stated, with a (+ 1 SD) illustrated on graphs.

2.6.2. Temporal macroinvertebrate analyses

Annual assessments to date have largely focused on a comparison of upstream to downstream sites using data within the same year. A temporal analysis of pelagic macroinvertebrate communities was attempted to address the obvious knowledge gap in macroinvertebrate changes over time.

The macroinvertebrate sweep data from all sites from 2003 to 2014 were analysed using a 4 factor hierarchical PERMANOVA. In this model date was a fixed factor, subsamples were random factors within sites, and sites were random factors within the fixed factor site type (reference or impact). The analyses used sequential sums of squares which allowed testing of the site type × date interaction.

To moderate the effect of different abundances in samples from different sampling strategies, data were standardised first. The standardisation to a percentage gave each taxon a relative abundance of the site total (i.e. scale of 0 to 100). The analysis was then performed using Bray-Curtis similarities calculated on square root transformed relative macroinvertebrate abundances. The similarity measures from pairwise interactions of the ‘three river reach’ model over the subsequent years were plotted to identify any trends and longer term changes in the similarity numbers.

The Bray-Curtis similarity matrix was also used to generate a classification and an ordination to aid in interpretation of the inter-annual changes in macroinvertebrate community structure. The classification used UPGMA agglomeration and the ordination included axis correlations of macroinvertebrate taxa using Spearman’s correlation and taxa with an $r > 0.5$. A SIMPER analysis was also conducted to determine the taxa most responsible for any separation within and between reference and impact sites. Only species that contribute more than a random amount of variation were included.

Results and interpretations from the temporal data analysis were confounded because of changing personnel and sampling strategies (Table 2). Prior to 2010, the macroinvertebrate collection was conducted by the NT Government. The procedure at the time utilised a 250µm sweep net for collection and sieving of the sample via a 500µm sieve. All collection and sieving is now performed with 500µm mesh apparatus.

Table 2. Sampling variations from 2003 to 2014.

Agency	Habitat	Mesh	Date	Samples
NT Gov.	Pelagic	250	2003	5
NT Gov.	Pelagic	250	2004	5
NT Gov.	Pelagic	250	2005	5
NT Gov.	Pelagic	250	2006	5
NT Gov.	Pelagic	250	2007	5
NT Gov.	Pelagic	250	2008	5
NT Gov.	Pelagic	250	2009	5
Envirotech	Pelagic	250	2010	5
Envirotech	Pelagic	500	2011	15
Envirotech	Pelagic	500	2012	24
Envirotech	Benthic	500	2012	24
Envirotech	Pelagic	500	2013	24
Envirotech	Benthic	500	2013	24
Envirotech	Pelagic	500	2014	24

2.6.3. Water quality

No specific statistical analyses were performed on water quality data due to the low number of samples. Data were used to assist with interpretation of macroinvertebrate results where necessary. They were also compared with published ANZECC 95% species protection guidelines for fresh water.

2.6.4. Sediments

For each chemical parameter measured by the laboratory, graphs were generated for those either with a full set of detectable values or with more than two values above detection limits. Any parameters that were in greater concentration downstream were compared with ANZECC sediment guidelines. Qualitative analysis was used to identify any parameters that demonstrated a further increase in concentration downstream compared with 2013.

3. Results

3.1. Pelagic Macroinvertebrates

3.1.1. Community composition

The river partitioned model found no significant difference in pelagic macroinvertebrate community composition between reference and impact sites (Table 3, P=0.1826; Table 4). The Bray-Curtis similarities for this model showed the variability in community composition between these two site types was about 35% (Table 5).

Table 3. Summary of PERMANOVA results for pelagic macroinvertebrates sampled in 2014.

Model	Source	DF	SS	MS	Pseudo-F	P(perm)	Unique perms
Ref v Impact, River partitioned	River	1	3140.8	3140.8	6.0772	**0.0061**	560
	Ref / Impact	1	731.81	731.81	1.416	0.1826	9937
	Site(River)	5	2584.1	516.82	1.202	0.1959	9879
	Residual	16	6879.5	429.97			
	Total	23	13336				
'Three river reach'	Reach	2	3872.6	1936.3	3.7466	**0.0099**	280
	Site(Reach)	5	2584.1	516.82	1.202	0.1914	9868
	Residual	16	6879.5	429.97			
	Total	23	13336				
8 independent sites	Site	7	6456.7	922.39	2.1452	**0.0001**	9865
	Residual	16	6879.5	429.97			
	Total	23	13336				

Table 4. Summary of pair-wise tests for the different PERMANOVA models fitted to the pelagic macroinvertebrate community composition data for 2014.

Model	Groups	t	P(perm)	Unique perms	P(MC)
Ref v Impact, River partitioned	Reference, Impact	1.19	0.1846	9913	0.2099
'Three river reach'	Ferg Ref, Edith Ref	2.0128	0.1005	10	**0.0064**
	Ferg Ref, Edith Impact	2.3084	0.0998	10	**0.0015**
	Edith Ref, Edith Impact	1.1993	0.3022	10	0.2389
8 independent sites*	FRUS, ERSW4	1.6482	0.0938	10	0.082
	FRUS, ERDS	1.6335	0.095	10	0.0741
	FRUS, ERBTM	1.717	0.098	10	0.0585
	FRDS, ERTOP	1.6243	0.1028	10	0.0873
	FRDS, ERUS	1.6826	0.0999	10	0.073
	FRDS, ERSW4	1.887	0.1022	10	**0.0495**
	FRDS, ERDS	1.5652	0.1024	10	0.0994
	FRDS, ERBTM	1.9665	0.1017	10	**0.0352**
	FRBTM, ERTOP	1.5847	0.1023	10	0.0993
	FRBTM, ERUS	1.7477	0.1035	10	0.0675
	FRBTM, ERSW4	1.6737	0.1012	10	0.0774

FRBTM, ERBTM	1.9954	0.1	10	**0.0342**

**For this model, only those pair-wise comparisons significant to the 0.10 level are presented.*

Table 5. Average Bray-Curtis similarity between groups using the reference v impact, river partitioned PERMANOVA model for pelagic community composition. Diagonal values are within site similarities.

	REFERENCE	IMPACTED
REFERENCE	66.869	
IMPACTED	65.32	70.796

The river partitioned model did report a significant difference in community composition between the Edith and Fergusson Rivers (Table 3, P=0.0061). This can be seen in ordination space below (Figure 11), where in two dimensions the Fergusson River sites (black, shaded symbols) were scattered to the left in ordination space with the Edith River sites (grey and open symbols) scattered to the right. Fergusson River sites were particularly associated with the presence of the taxa Pleidae and *Berosus* and the Edith river sites with *Triaenodes*, *Tasmanocoenis* and Platycnemidae, and to a lesser extent Oribatida.

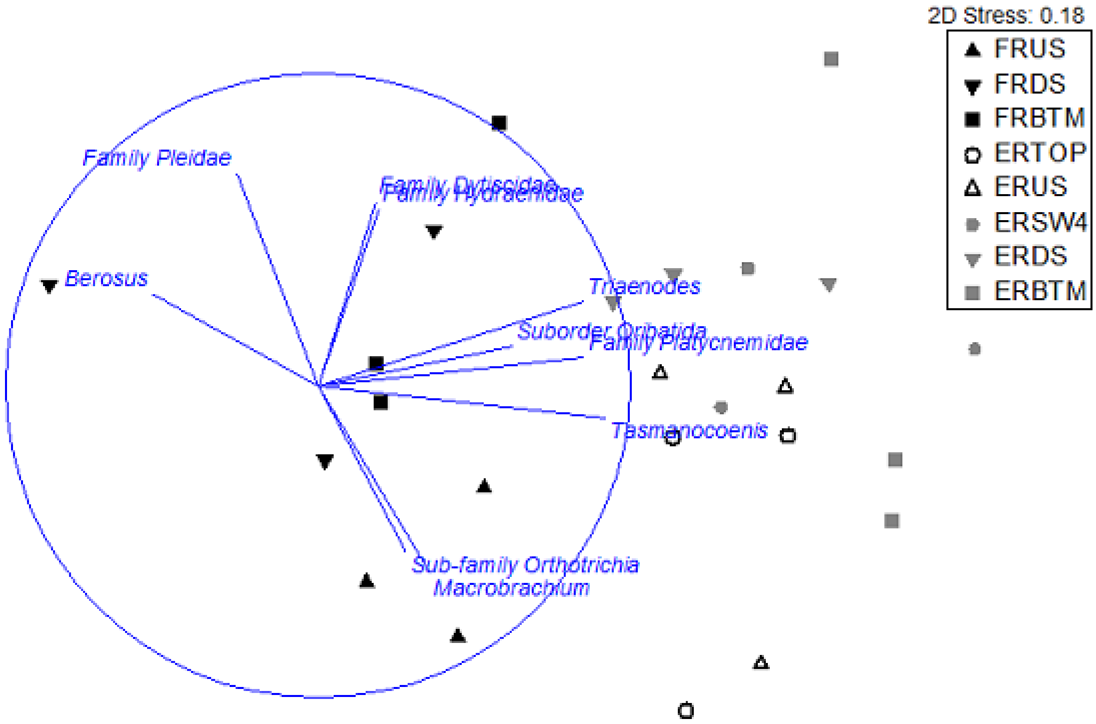

Figure 11. Ordination of macroinvertebrate community sites in 2014 based on Bray Curtis similarities of 4th root transformed data. Taxa with Spearman correlation coefficient > 0.6 are also shown. The length of the vector indicates correlation size and the circle indicates a correlation coefficient of 1. The position of the taxa should not be interpreted, just the size and direction of the vector.

The ‘three river reach’ analysis did show there was a significant difference in community composition between the Fergusson reference, Edith reference and Edith impact sites (Table 3, P=0.0099). However in terms of a potential impact of discharge on macroinvertebrates, follow-up pair-wise tests found no significant difference in community composition between Edith reference and Edith impact sites (Table 4, P=0.2389). This can be seen in ordination space where there was overlap of some sites from each of these two groups (Figure 11). Average similarity between the Edith reference and impact sites was 70% (Table 6).

The pair-wise tests showed the above overall significant effect in the ‘three river reach’ analysis could be attributed to a significant difference in macroinvertebrate community composition between the Fergusson River sites and the Edith River reference sites (Table 4, P= 0.0064) and between the Fergusson river sites and the Edith impact sites (Table 4, P=0.0015). These differences are represented in ordination space (Figure 11) where the Fergusson River sites were widespread but located to the left, whereas to the right the Edith River reference sites were generally located in the top right half and the Edith impact sites towards the bottom right half of ordination space. Average similarity between the Fergusson River sites and the Edith Reference and Edith Impact sites was 64% and 62% (Table 6).

Table 6. Average Bray-Curtis similarity between groups using the ‘three river reach’ PERMANOVA model for pelagic community composition. Orange and green shaded cells indicate a significant difference at the 0.05 and 0.10 level, respectively.

	FERG REF	EDITH REF	EDITH IMPACT
FERG REF	68.575		
EDITH REF	64.156	72.54	
EDITH IMPACT	61.939	70.391	70.796

Figure 12 shows the relative contributions of major taxonomic groups to the overall community composition at Fergusson reference, Edith reference and Edith impact sites. At the Fergusson River reference sites, Trichoptera (39.5%) and Coleoptera (26%) contributed most to the structure of the macroinvertebrate community, followed by Diptera (18%). By comparison, the contribution of Trichopteran taxa was even greater at Edith River reference (64%) and Edith impact (69.3%) sites, with Coleopteran and Dipteran taxa contributing to a lesser extent.

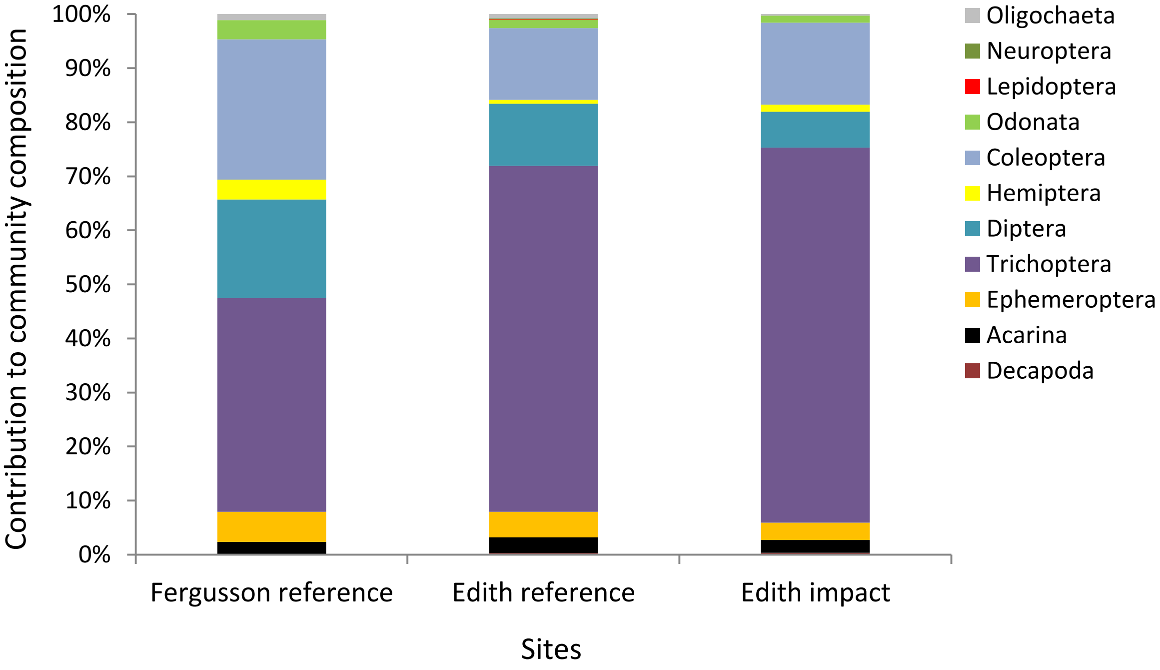

Figure 12. Relative community composition of the major pelagic macroinvertebrate groups sampled across Fergusson reference, Edith reference and Edith impact sites in 2014.

The significant variability in pelagic community composition found across treatment groups in the above analyses were reflected in the ‘eight sites’ model, where there was a significant difference in community composition across the eight sites (Table 3, P=0.0001). Amongst the eight sites, pair-wise tests and Bray-Curtis similarities showed the only significant differences in community composition occurred between a Fergusson River site and an Edith River site (Table 4).

Within the context of the results for the ‘three river reach’ model, the significant difference between Fergusson reference and Edith reference sites was more largely attributed to differences between FRDS and each of the Edith reference sites (ERTOP, ERUS) and FRBTM and each of the Edith reference sites. For FRDS these differences in composition were around 39%. For FRBTM these differences were around 35% (Table 7).

Spearman rank correlations showed that FRDS and FRBTM showed a greater association with Pleidae and *Berosus* than did FRUS, leading to the greater separation between the former two Fergusson reference sites and both of the Edith reference sites. This can be seen in Figure 11 where the FRDS and FRBTM sites are further away in ordination space to the Edith reference sites than are the FRUS sites.

The significant difference between Fergusson reference and Edith impact sites in the ‘three river reach’ model was more attributed to differences in composition between all of the Fergusson river reference sites (FRUS, FRDS, FRBTM) and ERBTM and all Fergusson sites and ERSW4 (Table 7, Figure 13). Of the three Fergusson River sites, FRDS and FRBTM showed a more significant difference in composition compared some of the Edith River impact sites, than did FRUS. This can be attributed to their greater correlation with the taxa Pleidae and *Berosus*, as mentioned above.

For ERBTM the differences in composition to Fergusson River sites ranged from 39% to 44%. For ERSW4 these differences ranged from 36% to 42% (Table 7). Spearman rank correlations showed that both ERBTM and ERSW4 showed a stronger association with the taxa *Tasmanocoenis*, Platycnemidae and *Triaenodes*, compared with ERDS. This can be seen in ordination space where there is a greater separation between ERBTM and ERSW4 sites (both groups further to the right in ordination space) to the Fergusson river sites (Figure 11).

Table 7. Average Bray-Curtis similarity between sites using the eight independent sites PERMANOVA model for the 2014 pelagic macroinvertebrate data. Orange and green shaded cells indicate a significant difference at the 0.05 and 0.10 level, respectively.

	FRUS	FRDS	FRBTM	ERTOP	ERUS	ERSW4	ERDS	ERBTM
FRUS	68.695							
FRDS	66.701	65.804						
FRBTM	69.699	69.204	71.587					
ERTOP	67.783	61.269	65.083	72.064				
ERUS	65.581	61.14	64.082	72.503	73.124			
ERSW4	62.944	57.862	64.356	71.697	71.544	72.044		
ERDS	63.921	63.205	68.087	69.936	72.361	73.849	73.887	
ERBTM	61.412	56.177	59.487	69.794	67.016	68.905	67.983	71.41

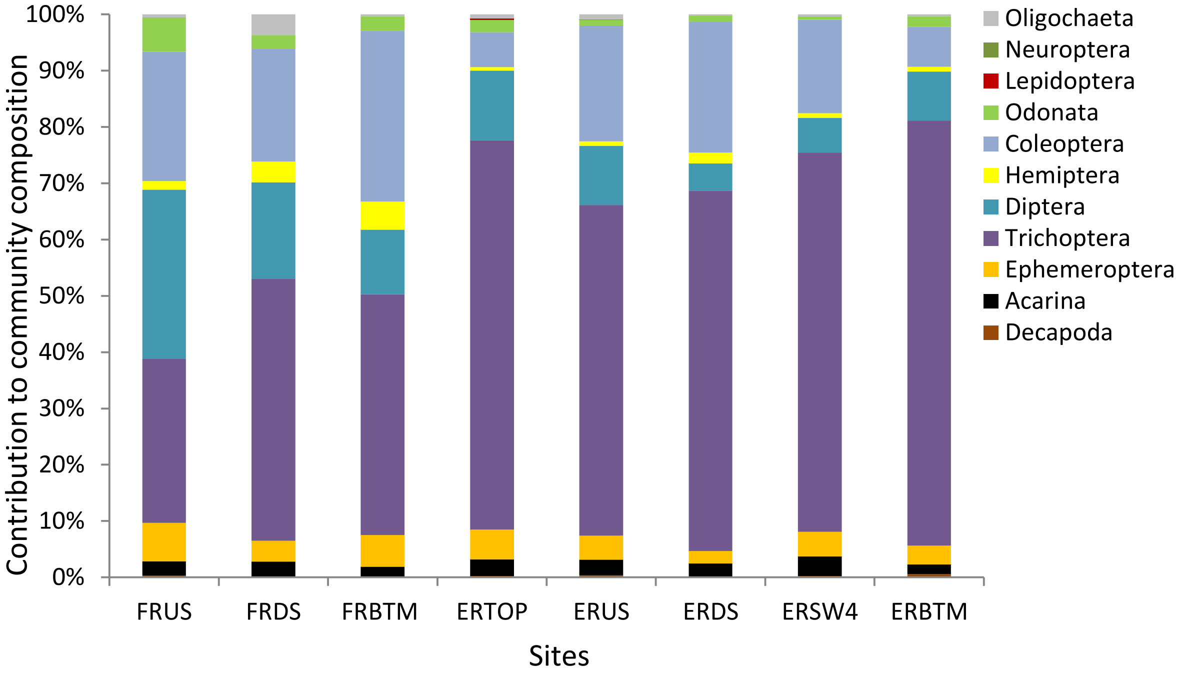

Figure 13. Relative community composition of major pelagic macroinvertebrate groups across the eight macroinvertebrate sampling sites in 2014.

Examination of similarities across sites within each of the 'three rivers reach' groupings, showed no significant difference in community composition between any of the Fergusson River sites. Here, between site similarities for the Fergusson River ranged from 66.7% to 69.7% (Table 7). The two Edith River reference sites also did not differ significantly from each other, sharing a compositional similarity of 72.5%. The three Edith River impact sites were also not significantly dissimilar from each other, with their similarities in macroinvertebrate composition ranging from 67.9% to 73.8%.

Examination of Bray-Curtis similarity indices at the individual site level showed that amongst replicate sweep samples, there was a degree of natural variation in pelagic community composition. In 2014 within-site differences ranged from 34.2% (FRDS) to 26.1% (ERDS). Summary data of the Bray-Curtis similarity coefficients since 2003 are presented in Appendix 1 through Appendix 3.

3.1.2. Richness and abundance

There was a significant difference between reference and impact sites in the overall richness of macroinvertebrate taxa sampled (Table 8, P=0.039). Mean taxa richness was slightly greater at reference sites (22.8 ± 2.7) than at impact sites (19.67 ± 2.8).

Mean taxa richness recorded for the Fergusson River and Edith River reference sites was 23.4 (± 2.7) and 21.8 (± 2.7) respectively, and 19.7 (± 2.1) for the impact sites (Figure 14). Data on the total taxa richness recorded for each site replicate in 2014 are presented in Appendix 4. Data on taxa richness for previous years are presented in Appendix 5 through Appendix 9.

A total of 49 taxa were identified across all sweep samples. Of these 14 taxa were rarely encountered, represented by less than three individuals when they were collected in a sample. Two taxa, Ochteridae (Hemiptera) and Sisyridae (Neuroptera) have not been previously recorded at Mt. Todd.

The Fergusson River sites and Edith reference sites recorded totals of 43 and 38 taxa, respectively. Edith impact sites recorded 37 taxa, with 30 of these common to all three groups. One taxon, *Wundacaenis*, was not collected at Edith impact sites. Two taxa *Chimarra* and Hydropsychidae were only collected at Edith reference sites. Three taxa *Berosus*, Notonectidae and Orthocladiinae, were recorded from the Fergusson River and Edith impact sites but not at Edith reference sites. The taxon Orthotrichia was only recorded from the Edith River.

Comparison of Edith reference and impact sites showed 32 taxa were common to both. In addition, Edith reference sites recorded *Wundacaenis*, Culicidae, Sisyridae, Lepidoptera, Hemicorduliidae and Isostictidae. Edith impact sites recorded *Anisocentropus*, Orthocladiinae, Notonectidae, *Berosus* and Coenagrionidae.

There was also a significant difference between reference and impact sites in total macroinvertebrate abundance (Table 8, P=0.009). Reference sites recorded an average macroinvertebrate abundance of 4242 (± 2700) individuals compared with an average of 9581 (± 3795) individuals at impact sites.

For total macroinvertebrate abundance there was also a significant river effect (Table 8, P=0.027). On average, fewer macroinvertebrate individuals were recorded in the Fergusson River (3168 ± 2351) than in the Edith River (8091 ± 3751).

Comparison of Edith River reference and impact sites showed average macroinvertebrate abundance was greater at Edith impact (9581 ± 3795) than at Edith reference sites 5855 (± 2523) (Figure 15). Data on the raw abundances of each taxon identified from each sweep sample are presented in Appendix 4. A summary of the scaled total abundances of macroinvertebrates based on the percentage of sample sorted, are presented in Appendix 10.

Table 8. Summary of ANOVA results for pelagic macroinvertebrate indicators from sweep samples collected in 2014. Bolded P values indicate a significance of < 0.05.

Indicator	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Taxa richness	Ref v impact	1	55.225	55.225	7.73	**0.039**
	River	1	9.344	9.344	1.25	0.280
	Site(river)	5	35.722	7.144	0.96	0.472
	Error	16	119.333	7.458		
	Total	23	219.625	9.549		
Total abundance	Ref v impact	1	5.1255	5.1255	17.27	**0.009**
	River	1	1.9709	1.9709	5.89	**0.027**
	Site(river)	5	1.4838	0.2968	0.89	0.512
	Error	16	5.3535	0.3346		
	Total	23	13.9338	0.6058		
% of ETO taxa	Ref v impact	1	11.33	11.33	0.24	0.645
	River	1	174.58	174.58	4.01	0.062
	Site(river)	5	240.23	48.05	1.10	0.396
	Error	16	695.89	43.49		
	Total	23	1122.03	48.78		
% ETO abundance	Ref v impact	1	1548.2	1548.2	9.84	**0.026**
	River	1	1954.5	1954.5	13.34	**0.002**
	Site(river)	5	786.9	157.4	1.07	0.411
	Error	16	2343.7	146.5		
	Total	23	6633.2	288.4		

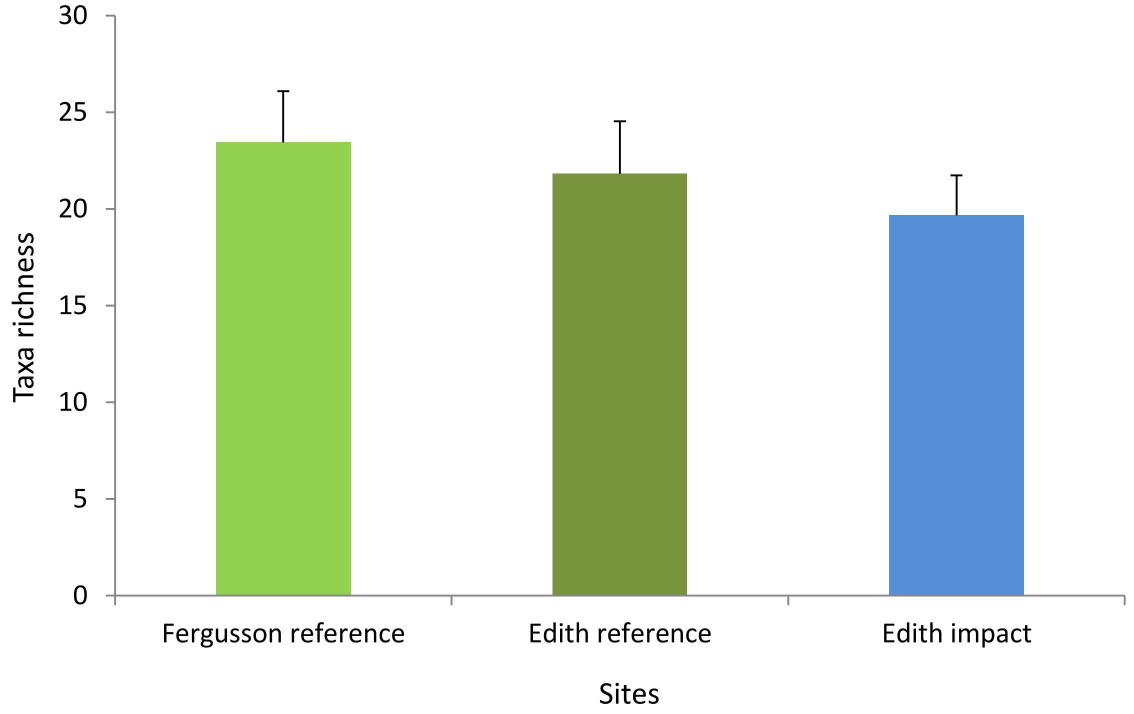

Figure 14. Mean (+SD) number of pelagic taxa sampled in Fergusson reference (n=5), Edith reference (n=2) and Edith impact (n=3) sites.

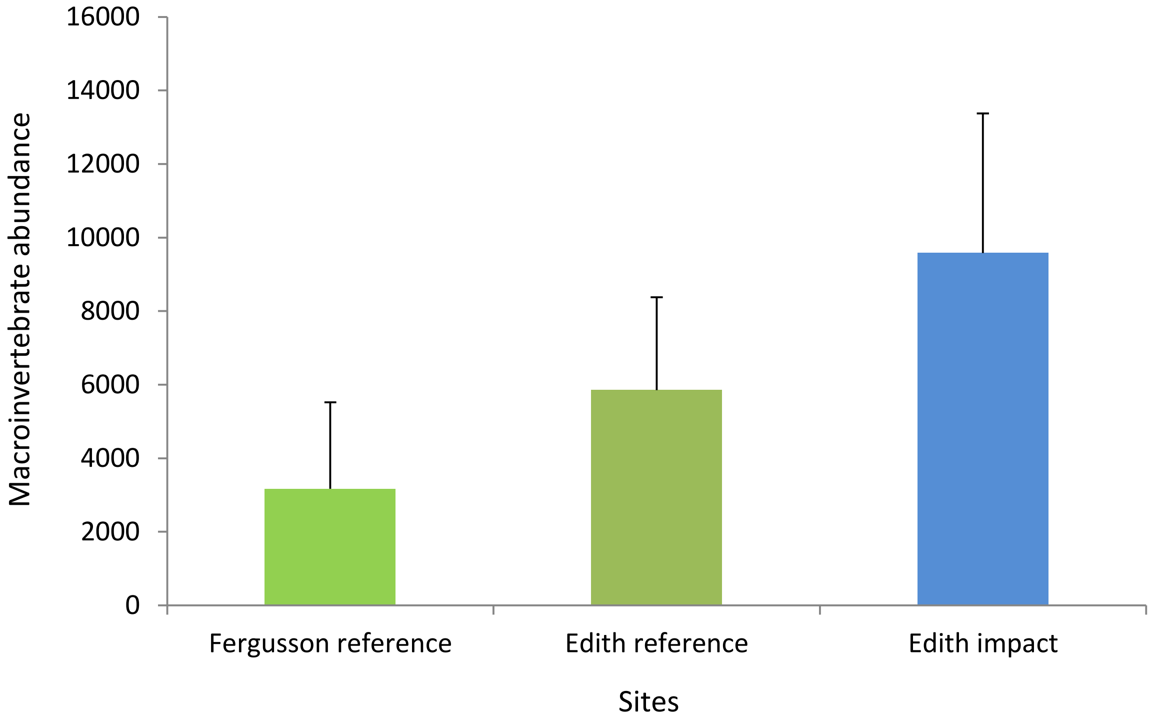

Figure 15. Mean (+SD) abundance of pelagic macroinvertebrates sampled in Fergusson reference (n=3), Edith reference (n=2) and Edith impact (n=3) sites.

The mean abundance of the major pelagic macroinvertebrate groups for reference and impact sites are shown in Figure 16 and Figure 17. Table 9 summarises the total abundances for each major taxonomic group as well as the breakdown of these totals across the reference and impact site groups.

As for last year, Trichopteran taxa dominated sweep samples (
Table 9, Figure 17). Within this group the genus *Triaenode*s was again the most abundant taxon, comprising 90% of the Trichopteran taxa. Coleoptera and Diptera were the second and third most abundant groups represented.

The higher macroinvertebrate abundances recorded for the Edith River compared with the Fergusson River, was largely attributed to the significantly greater abundance of Trichopteran taxa at Edith reference and Edith impact sites. Compared with the Fergusson River, average Trichopteran abundance was also significantly greater than that of Coleopteran and Dipteran taxa. At the Fergusson River, the abundances of these three groups were similar (Figure 17). Ephemeropteran and Acarina taxa were also in greater abundances in the Edith River (Figure 16).

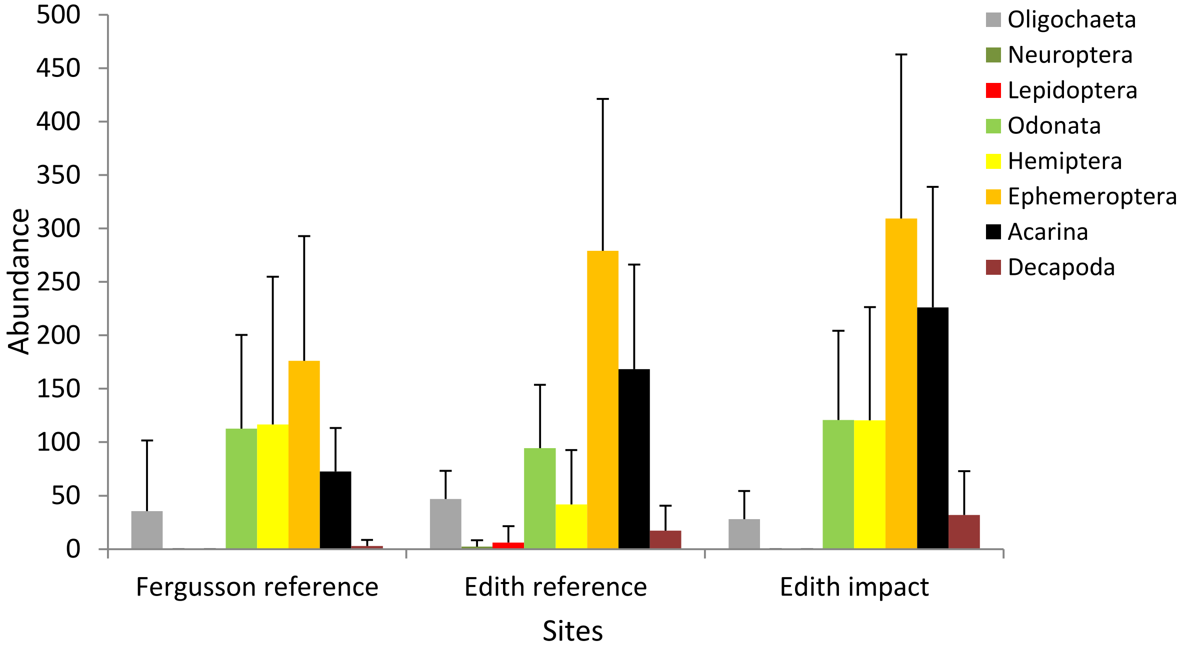

Figure 16. Mean (+SD) abundances of major taxonomic groups (excluding Coleoptera, Diptera and Trichoptera) identified from pelagic sweep samples at Fergusson reference (n=3), Edith reference (n=2).

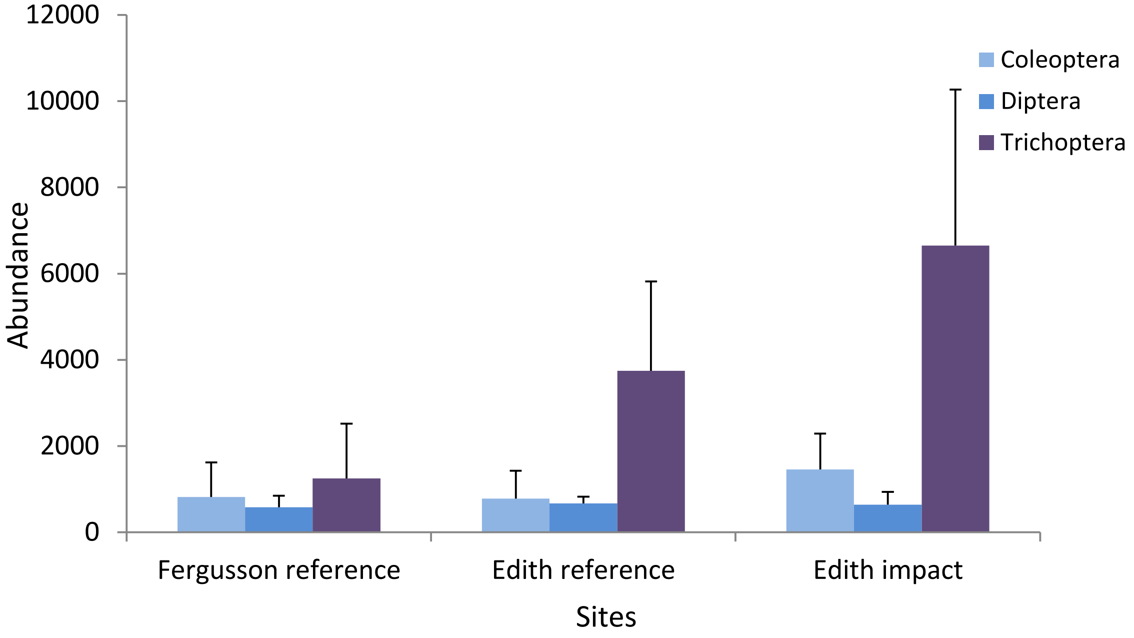

Figure 17. Mean (+SD) abundances of Coleoptera, Diptera and Trichoptera identified from pelagic sweep samples in Fergusson reference (n=3), Edith reference (n=2) and Edith impact (n=3) sites.

Table 9. Total scaled abundances of the eleven major taxonomic groups identified from sweep samples. The individual totals for each of the Fergusson reference, Edith reference and Edith impact sites also presented. Taxa are ordered from highest to lowest abundance according to total numbers counted.

Taxa	Total	Fergusson ref	Edith ref	Edith impact
Trichoptera	93571	11262	22484	59825
Coleoptera	25179	7391	4667	13122
Diptera	15000	5208	4037	5755
Ephemeroptera	6045	1585	1676	2785
Acarina	3699	653	1011	2035
Odonata	2669	1015	567	1087
Hemiptera	2385	1050	250	1085
Oligochaeta	854	319	282	253
Decapoda	415	25	103	287
Lepidoptera	38	0	38	0
Neuroptera	14	0	14	0

3.1.3. ETO macroinvertebrates

The percentage of total taxa represented by ETOs did not differ significantly between reference and impact sites (Table 8, P=0.645). Mean percentage of ETO taxa recorded for Fergusson and Edith reference sites was 38.7% (± 6.1%) and 45.7% (± 4.1%) respectively, and 42.9% (± 8.3%) for Edith impact sites (Figure 18).

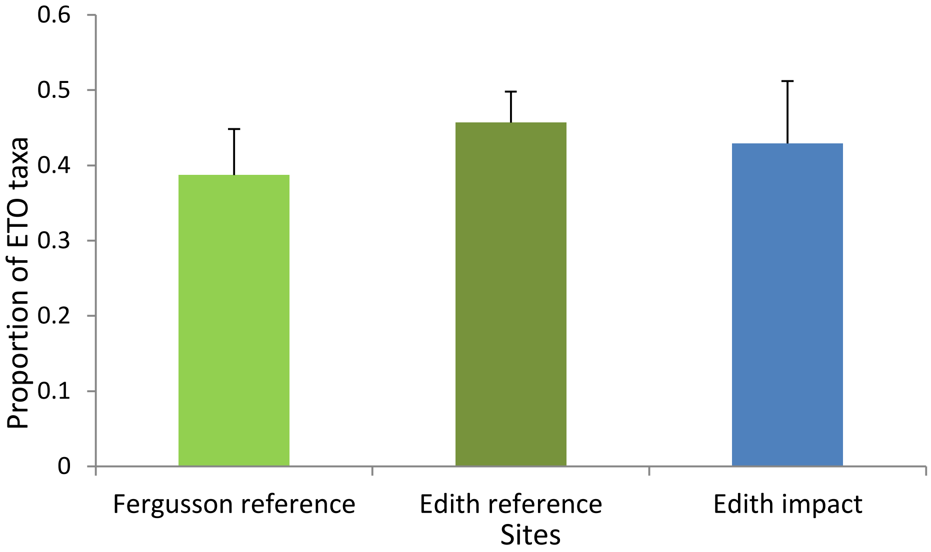

Figure 18. Mean (+SD) richness of ETO taxa as a proportion of total pelagic taxa richness sampled in Fergusson reference (n=3), Edith reference (n=2) and Edith impact (n=3) sites.

A total of 21 ETO taxa were identified from pelagic sweep samples across all sites. Fourteen ETO taxa were common to reference and impact sites. Fergusson and Edith reference sites recorded totals of 18 and 16 ETO taxa respectively, with 14 taxa common to both. Edith impact sites recorded 15 ETO taxa. Isostictidae were only recorded in Edith reference sites and *Anisocentropus* only recorded in impact sites. Comparisons of Edith reference and impact sites showed *Wundacaenis* and Hemicorduliidae were also only recorded at the former, whilst impact sites also recorded Coenagrionidae.

The river effect for the percentage of ETO taxa was close to significance. On average, there was a tendency for the Edith River to have a greater percentage of ETO taxa (44.0 ± 6.9%) than the Fergusson River (38.7 ± 2.0%) (Figure 19).

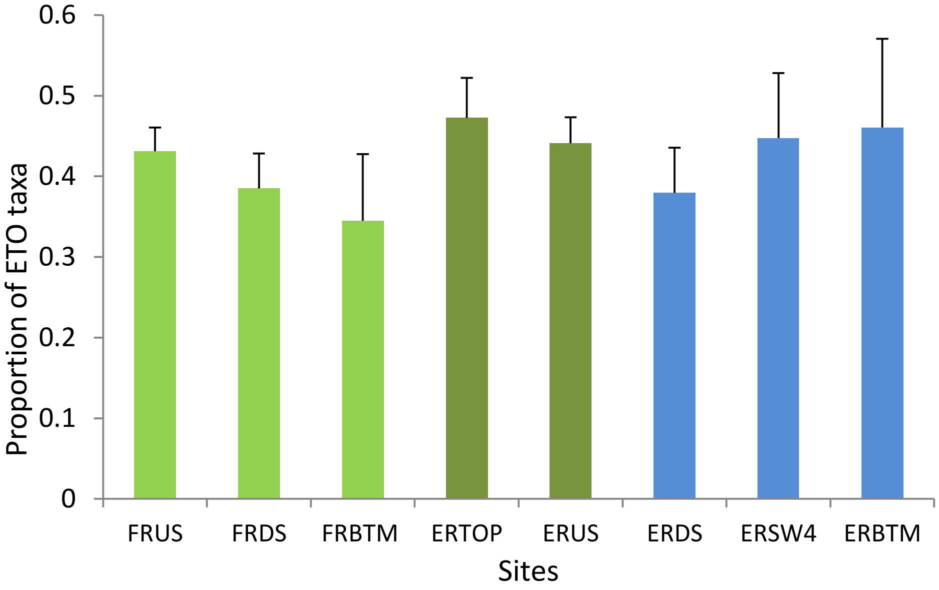

Figure 19. Mean (+SD) richness of ETO taxa as a proportion of total pelagic taxa richness sampled across the eight pelagic sweep sites in 2014.

There was a significant difference between reference and impact sites in the percentage contribution of ETO individuals to total macroinvertebrate abundance (Table 8, P=0.026). Average contribution of ETO individuals was greater at impact sites (70.8 ± 15.7) than at reference sites (54.2 ± 15.0). Within the Edith River, the average percentage of ETO individuals to total macroinvertebrate abundance was only slightly higher at the impact sites than that recorded for Edith reference sites (68.1 ± 9.7) (Figure 20). Both these site types recorded a greater percentage of ETO individuals than the Fergusson reference sites (44.8% ±9.3).

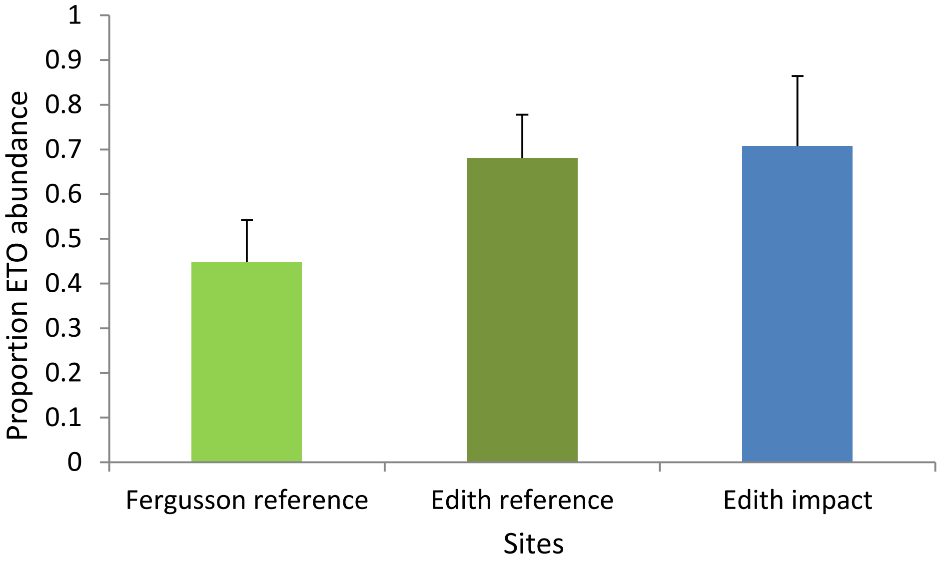

Figure 20. Mean (+SD) abundance of ETO taxa as a proportion of the total abundance of pelagic macroinvertebrates sampled in Fergusson reference (n=3), Edith reference (n=2) and Edith impact (n=3) sites.

There was also a significant river effect for the contribution of ETO individuals to total abundance (Table 8). On average the percentage of ETO individuals was higher in the Edith River (69.7% ± 13.2) than in the Fergusson river (44.8% ± 9.4) (Figure 21). This was primarily a result of a lower percentage contribution of Trichopteran taxa to total macroinvertebrate abundance within the Fergusson River sites (Table 9, Figure 21).

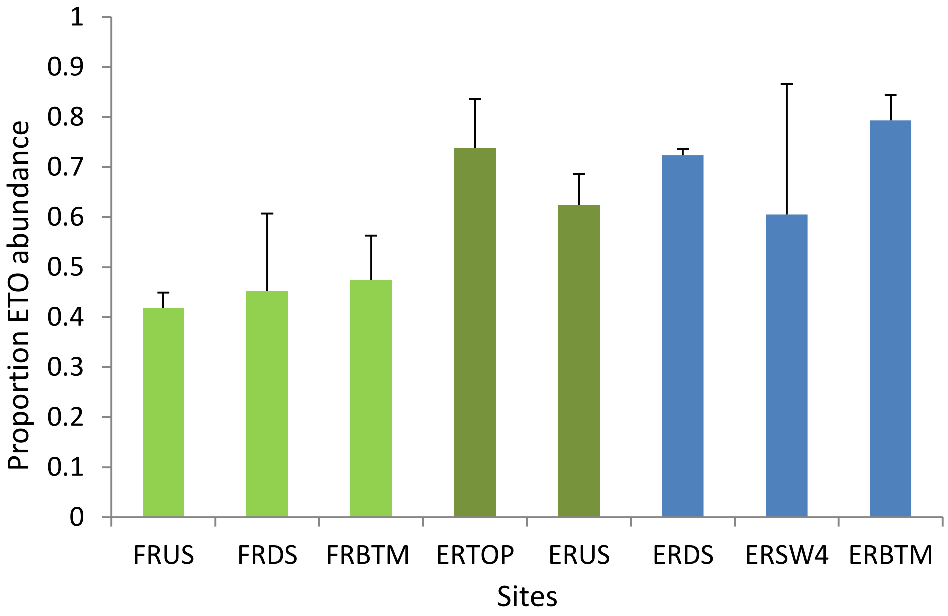

Figure 21. Mean (+SD) abundance of ETO taxa as a proportion of the total abundance of pelagic macroinvertebrates sampled across the eight sites in 2014.

3.1.4. Temporal analysis

When all sites were pooled together, overall pelagic community compositions showed significant natural variability through time (

Table 10, P=0.0001). Comparisons between reference and impact sites also showed a significant difference in composition (P=0.034), but that this difference was dependent on year (P=0.03).

Table 10. PERMANOVA results for pelagic macroinvertebrate community differences using Bray-Curtis similarity of square root relative abundances between years (Dates) and site types (Reference/Impact) at Mt. Todd.

Source	DF	Sum of squares	Mean square	Pseudo-F	P(permutation)
Date	11	37159	3378.1	7.0986	**0.0001**
Ref/Impact	1	7530.2	7530.2	2.6861	**0.0341**
Date x R/I	11	6961	632.81	1.1485	**0.0299**
Sites(R/I)	6	13964	2327.4	2.5537	**0.0003**
Sites(R/I) x date	39	16826	431.43	1.3326	**0.0017**
Subsamples(sites(sitetype))	16	10730	670.62	2.0715	**0.0001**
Residual	42	13597	323.74		
Total	126	106770			

Further statistical analyses of temporal data to interpret the nature of the above effects could not be conducted, due to insufficient replicates. However qualitative analyses were used to interpret the nature of the temporal interaction between site type (reference v impact) and year. The average Bray-Curtis similarity was graphed through time for the pair-wise combination of sites within and between each of the three groups: Fergusson reference, Edith reference and Edith impact sites (Figure 22). The following results and their interpretation are related to similarities and not actual species becoming more or less similar.

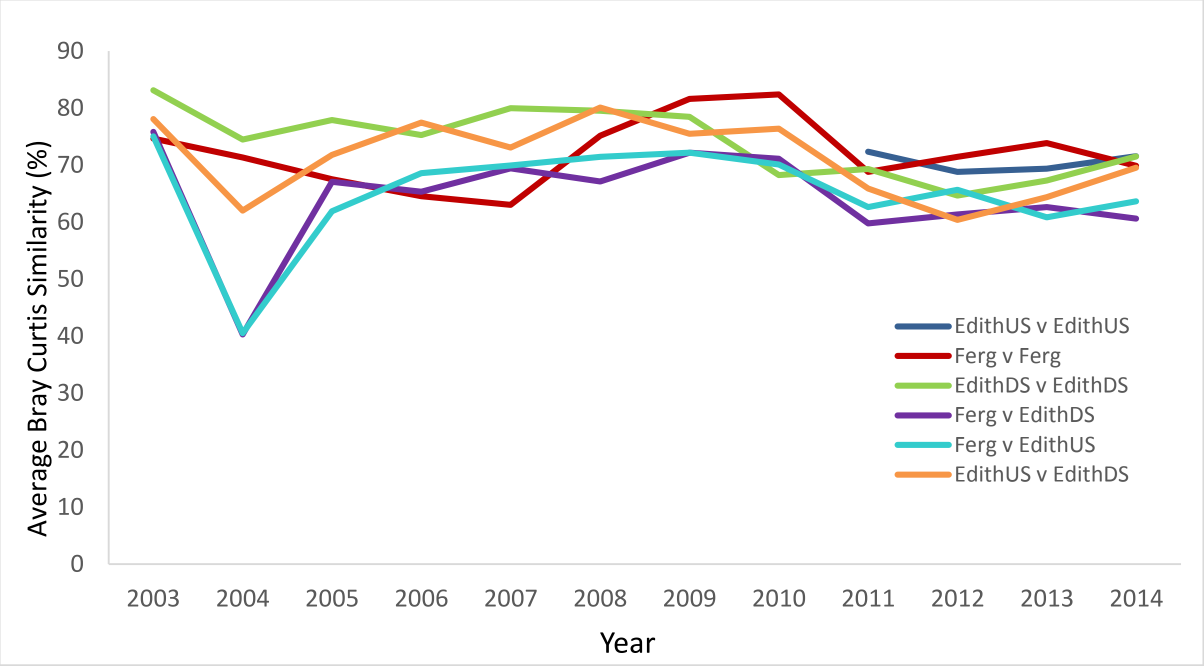

Figure 22. Average Bray-Curtis similarity on standardised then square root transformed data for different site types (that included separation according to river) from 2003 to 2014.

As shown in Figure 22 sites within each of the Fergusson reference (red line), Edith reference (dark blue) and Edith impact (light green) groups showed natural variability in their compositional similarity through time. This was supported at a broader level by the results of the temporal analysis where there was significant variation in similarity across sites within broader reference and impact groupings (

Table 10, P=0.0003).

The fluctuations in the similarity of Fergusson River sites to each other (red) tended to be slightly greater than that observed for impact sites (green) and Edith reference sites (dark blue). It should be noted that the absence of Edith reference data (blue line) prior to 2011 was a consequence of the lack of a second upstream site for comparison with ERUS. The sharp decline in trajectories from 2010 to 2011 is likely also an artefact of a changeover in personnel and sampling technique, as opposed to a real decline in pelagic compositional similarities.

Since 2012 the compositional similarity between Edith River reference and Edith impact sites has steadily increased, as evidenced by the upward trajectory of the orange line (Figure 22), and supported by the lack of a significant difference in community composition between these two groups over the last three years. In contrast, and in support of the analytical results, the macroinvertebrate composition of the Fergusson River shows greater dissimilarity to those of the Edith River reference sites (light blue line) and Edith River impact sites (purple). Any statistical differences between reference and impact sites prior to 2012 are largely unknown due to a lack of site and sample replication and consequent insufficient statistical power.

In 2004 there was a substantial decline in pelagic compositional similarity between Fergusson reference and Edith impact sites (Figure 22, purple line). However this decline, as well as it’s extent, was also observed between Fergusson reference and Edith reference sites (light blue line). In both cases communities only shared a similarity of around 40%.

Although Edith reference compared with Edith impact sites also showed a slight decline in this year (orange line), this decline still fell within the range of natural variability in composition for these two sites over time. The ordination of sites from 2003 to 2014 showed that in 2004, the Fergusson river samples were outliers to most other samples. They were also highly similar in their pelagic compositions, clustered together towards the far left in ordination space in Figure 23.

The impact of changing personnel and sampling methodology in 2011 is also evidenced by a large proportion of 2011 to 2014 samples tending to be more similar to each other than previous years samples. The latter are distributed more to the right in ordination space and the former to the left. However, some sites from these later years are scattered through the historical grouping.

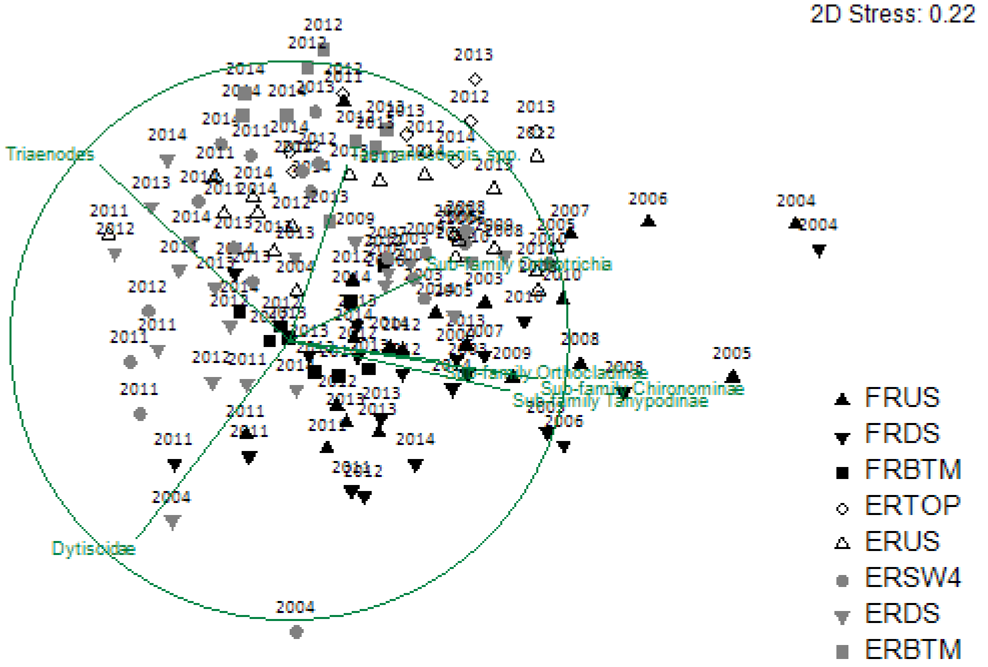

Figure 23. Ordination of sites defined by Bray-Curtis similarities of √standardised macroinvertebrate abundance in 2003-2014.

Figure 23 also shows a general separation of sites based on river (Fergusson, Edith) and site type (reference/impact). Fergusson river samples (shaded black symbols) were generally spread across the middle and to the left in 2D ordination space; with the Edith river samples (open symbols and shaded grey symbols) broadly spread across the upper half of the ordination and to the left. With respect to site type, reference sites (black symbols and open symbols) tended towards the upper right quarter in ordination space. However, the relationship of macroinvertebrate taxa to this discrimination was not simple to elucidate.

The results of the SIMPER analysis to determine those taxa that contributed most to the similarities within, and difference between, reference and impact sites are presented in Table 11. Only taxa that contributed more than a random amount of variation are included.

Table 11. Results of the SIMPER analysis showing taxa that contributed to similarities within and/or between reference (Edith and Fergusson pooled) and impact sites, as part of the temporal analysis of pelagic macroinvertebrate community structure from 2003 to 2014. The average abundance column is the average square root standardised abundance of sites in that group (reference or impact).

Species	Impact		Reference		% cont. diff. ref v impact
	Av. Abun.	% contrib.	Av. Abun.	% contrib.	
Dytiscidae	3.58	12.76	3.18	9.90	7.94
Triaenodes	4.80	17.81	5.53	24.84	7.19
Oribatida	1.32	2.45	1.13	2.73	5.07

Chironominae	3.53	10.18	3.25	9.41	4.94
Prostigmata	1.39	3.56	0.99	1.75	4.49
Tasmanocoenis spp.	1.41	2.66	1.43	4.66	3.66
Baetidae	1.91	5.65	1.75	5.08	3.59
Austrogomphus	1.15	3.89	1.02	3.07	3.38
Oecetis	1.89	6.79	1.77	6.67	3.25
Oligochaeta	1.13	2.72	1.04	2.31	3.24
Ceratopogonidae	1.41	3.89	1.36	4.18	3.20
Hydrochus	1.05	3.21	0.92	2.18	3.00
Hydraenidae	0.79	1.23	0.80	1.38	2.66
Tanypodinae	1.80	4.30	1.73	4.18	2.65
Corixidae	0.61	1.44			2.59
Elmidae	1.86	6.39	1.66	6.69	2.54
Hemicorduliidae					2.26
Wundacaenis			0.57	1.20	2.09
Ecnomus					2.08
Atyidae	0.41	1.54			1.79
Leptophlebiidae					1.77
Hellyethira					1.69
Triplectides					1.67
Macrobrachium					1.62
Berosus					1.58
Ecnomina					1.57
Pyralidae					1.49
Pleidae					1.49
Libellulidae					1.43
Orthocladinae					1.24
Isostictidae					1.19
Noteridae					1.13
Mesoveliidae					1.11

There were 33 taxa that significantly contributed to the difference between reference and impact sites. Dytiscidae, *Triaenodes* were most responsible for the difference in macroinvertebrate community composition between reference and impact sites since 2003. Fifteen of the 33 taxa significantly contributed to the compositional similarity both within reference and impact sites. Corixidae and Atyidae also contributed to the similarity within impact sites, and *Wundacaeni*s to the similarity within reference sites.

Over the period 2003 to 2014 the average similarity in macroinvertebrate community composition between reference and impact sites was 66.7% (± 7.8%). This is marginally lower than that seen within reference and impact site groups. Average similarity within reference sites was 67.8% (± 6.6) and within impact sites, 74.2% (± 6.0%).

Examination of the 10 taxa that showed a correlation > 0.5 with the ordination axes showed *Triaenodes* tended to align with Edith river samples collected since 2011 (Figure 23). Three taxa (Chironominae, Tanypodinae, and Orthocladiinae) showed a significant correlation in the opposite direction and tended to be associated with Fergusson River reference sites, particularly from 2003 to 2010.

Dytiscidae showed a correlation in a different direction to these first two groups; associated more with 2012 and 2013 Fergusson River reference sites. Orthotrichia tended to align with samples collected between 2003 and 2010. *Tasmanocoenis* spp. tended to be associated with Edith River reference sites for samples collected since 2011.

From 2012 to 2014 the significant compositional differences detected between Fergusson and Edith reference sites can be seen in ordination space (Figure 23). Fergusson river sites (solid black) sat within the lower half of the ordination with Edith reference sites (hollow symbols) towards the top. The former showed an association with Dytiscidae and whilst Edith reference sites showed an association with *Tasmanocoenis* spp. The significant difference in macroinvertebrate composition between Fergusson reference and Edith impact sites is also evident, with impact sites mostly scattered largely within the top centre of ordination space and associated with *Triaenodes* (Figure 23).

Despite post processing of samples through a consistently sized sieve, the change in sweep net mesh sizes in 2011 is likely to have contributed to different taxa showing high correlations with samples pre- and post-2011.

3.2. Water Quality

Physical water quality measurements taken at each of the sites are presented in Table 12. All readings are well within expected ranges of a typical tropical river system. None of the physical parameters recorded at downstream Edith River sites exhibited levels of marked difference to reference sites.

Table 12. Physical water quality measurements.

Site	Date	EC µS/cm	pH	Temp °C	DO (mg/L)	Turbidity NTU	ORP mV
FRUS	05-Jun-14	17.6	6.26	25.6	7.72	1.65	235.0
FRDS	05-Jun-14	20.2	6.54	27.3	7.76	1.8	277.7
FRBTM	06-Jun-14	21.7	6.71	25.0	7.35	2.44	250.4
ERTOP	03-Jun-14	13.81	6.51	26.4	7.32	0.56	287.7
ERUS	04-Jun-14	13.4	6.4	26.4	7.5	0.98	263.6
ERSW4	02-Jun-14						
ERDS	03-Jun-14	11.8	6.74	25.2	6.93	1.26	280
ERBTM	03-Jun-14	10.8		26.3			

For all sites where EC and pH were recorded, EC values were generally lower and pH values slightly higher, than those recorded for last year. Water temperatures were marginally higher over the last two years than in previous years. Dissolved oxygen levels at sites were similar to those recorded in previous years. Turbidity values were first recorded in 2010, with all sites characterised by low turbidity levels. *In situ* physical and chemical water quality measurements collected at the eight macroinvertebrate sampling sites from 2003 to 2013 are presented in Appendix 11.

Out of the 46 chemical parameters tested, 24 reported concentrations above laboratory detection limits from at least one site (Figure 24). Concentrations of metals and ions at downstream Edith River sites were generally higher than those recorded at Fergusson and Edith River reference sites; with concentrations recorded at the latter two locations closer to the limit of reporting (LOR) from the laboratory . Total cyanide was only recorded in Edith River reference samples, whereas Nitrate was not recorded from these sites. Zinc was not detected at upstream sites, with concentrations downstream similar to those recorded from Fergusson River samples.

As in 2013, Sulfate, Calcium, Potassium and Magnesium were only recorded at downstream sites; and Manganese and Zinc were again recorded in significantly greater concentrations in downstream Edith River samples. Sodium and Nitrate also showed elevated concentrations at downstream sites compared with reference sites. Unlike last year, elevated Aluminium concentrations were not detected in downstream Edith River samples. Complete laboratory results for chemical analyses of water quality samples for 2014 are presented in Appendix 12.

All detectable results were below published ANZECC 95% species protection guidelines for fresh water, with the exception Total Zn from FRBTM at 11 µg/L (guideline 8 µg/L). The protection values for Zinc are only a guide as they are influenced by water hardness ($CaCO_3$) and the corresponding level of dissolved Zinc was well below the ANZECC 95% guidelines and at the Limit of Reporting (1 µg/L). The Total Zn at FRBTM still falls within the 90% species protection guidelines with respect to Zinc concentration (guideline 15 µg/L).

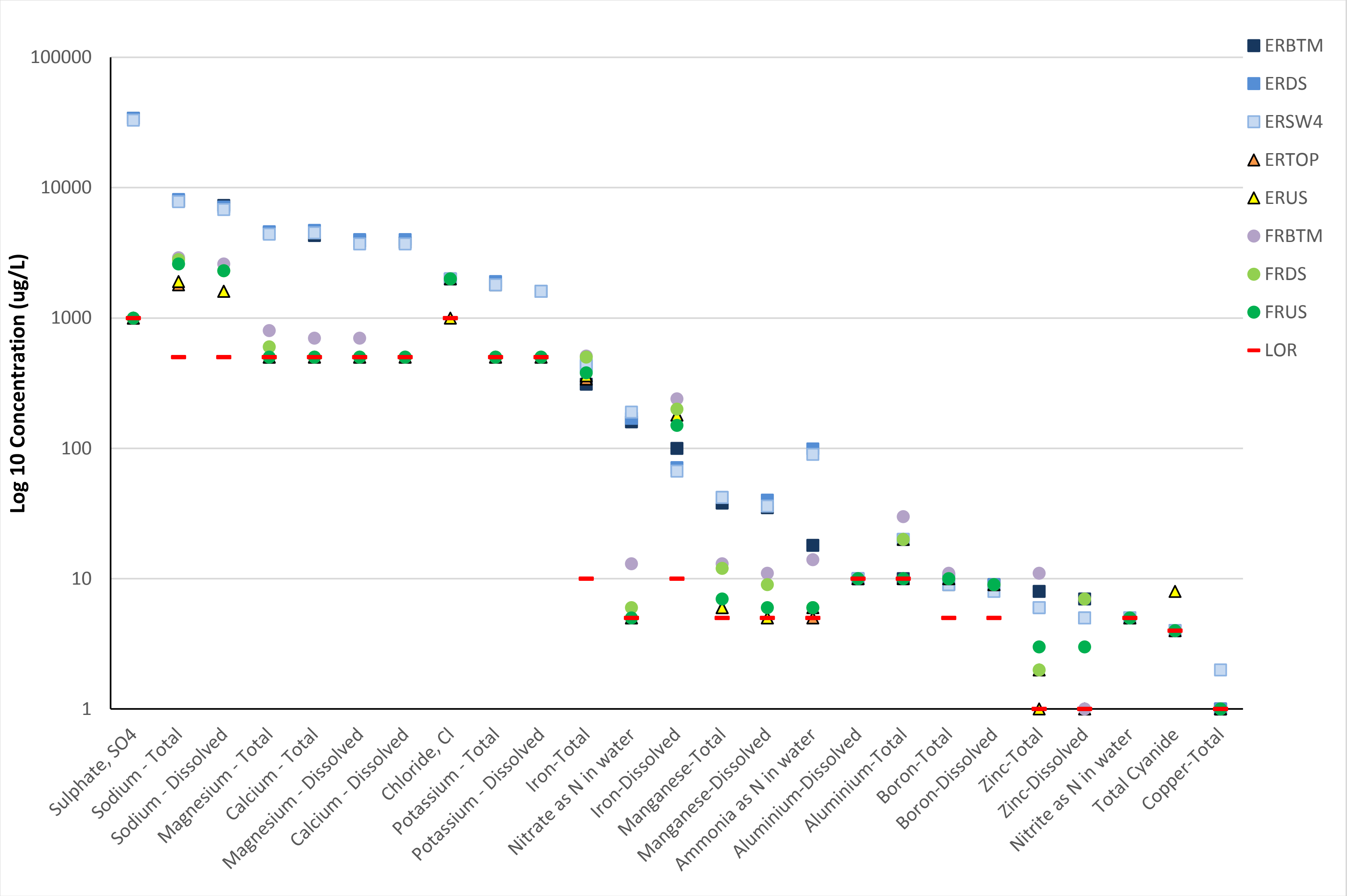

Figure 24. Concentration of chemical parameters measured from surface water samples at the eight macroinvertebrate sites, ranked highest to lowest. Only those parameters that recorded concentrations above the laboratory’s Limit of Reporting (LOR) are shown. LOR values represented in red.

3.3. Sediments

Out of the 27 elements tested, seven were below the LOR at all sites across edge and benthic samples. Eight elements reported some level of concentration above detection limits at all sites, and the remaining 11 varied with respect to their detection amongst sites sampled (Table 13).

Table 13. Summary of element detections and laboratory limits of reporting.

Not detected		**Detected in all samples**		**Detected in some samples (/9)**	
Element	LOR *(mg/Kg)*	Element	LOR *(mg/Kg)*	Element	LOR *(mg/Kg)*
Nitrate	0.5	TOC	100	Chromium (1)	1
Cyanide	0.5	Manganese	1	Nickel (2)	1
Beryllium	1	Iron	1	Nitrite (1)	0.1
Cadmium	0.4	Aluminium	1	Cobalt (6)	1
Mercury	0.1	Magnesium	5	Sodium (5)	10
Uranium	1	Calcium	5	Copper (7)	1
Lanthanum	1	Ammonia as N	0.5	Lead (8)	1
		Potassium	10	Zinc (7)	1
		pH		Sulfate (6)	10
				Chloride (4)	10
				Arsenic (1)	4

Compared with 2013, Lanthanum was not detected in any samples this year. Nitrite was not detected in 2013, but was detected this year at FRBTM in the sediment sample collected from the edge of the river bank. Complete laboratory results for chemical analyses of sediment samples are presented in Appendix 13. The absence of data for the benthic sediment sample collected at FRBTM was due to a breakage of the sample jar during transit.

Figure 25 through to Figure 29 illustrate the concentrations of each chemical parameter recorded in edge and sediment samples at the five sediment sampling locations. These figures exclude parameters that recorded ≤ 2 values above laboratory detection limits. A total of 13 parameters showed marked differences in concentration between edge and benthic samples (TOC, Ca, Mg, Fe, Al, NH3, pH, K, Cl, Zn, Na, Cu, SO_4), with all but pH showing increased concentrations in edge samples. These results are consistent with those found in 2013, with the exception of Cobalt that was also greater in concentration in edge samples in 2013.

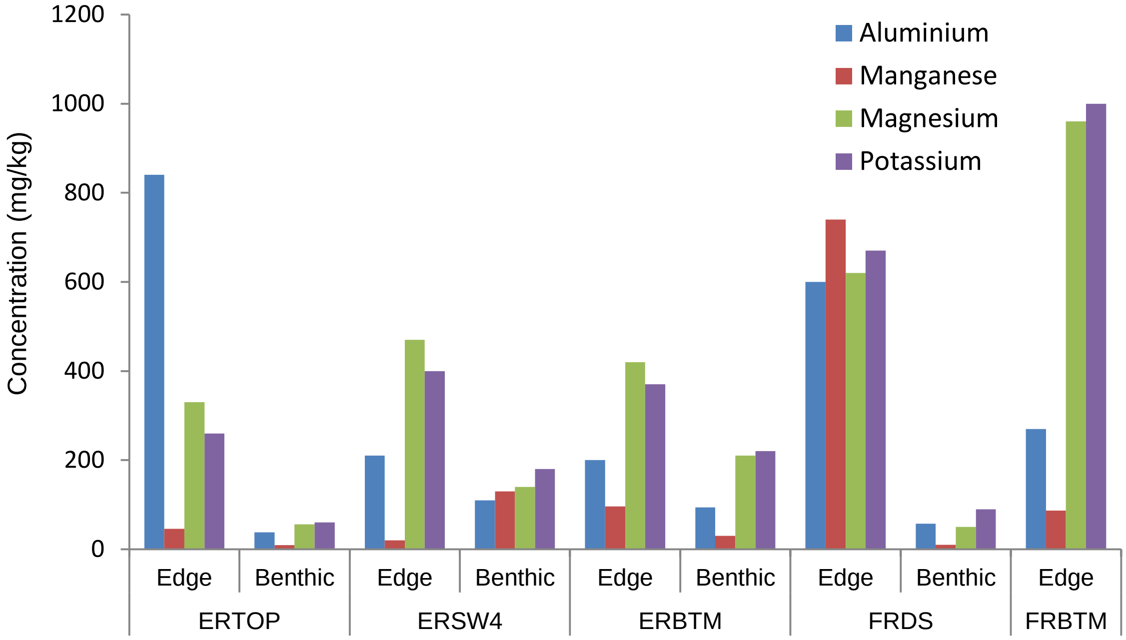

Figure 25. Concentration of Al, Mn, Mg and K in edge and benthic sediment samples at the five sites sampled for sediments in 2014.

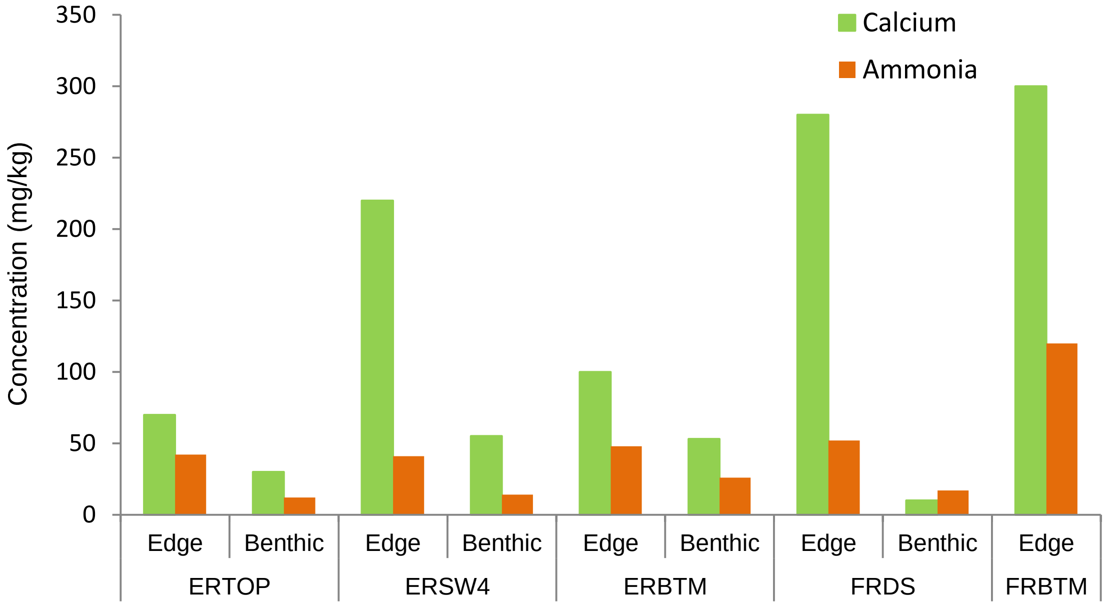

Figure 26. Concentration of Ca and NH3 in edge and benthic sediment samples at the five sites sampled for sediments in 2014.

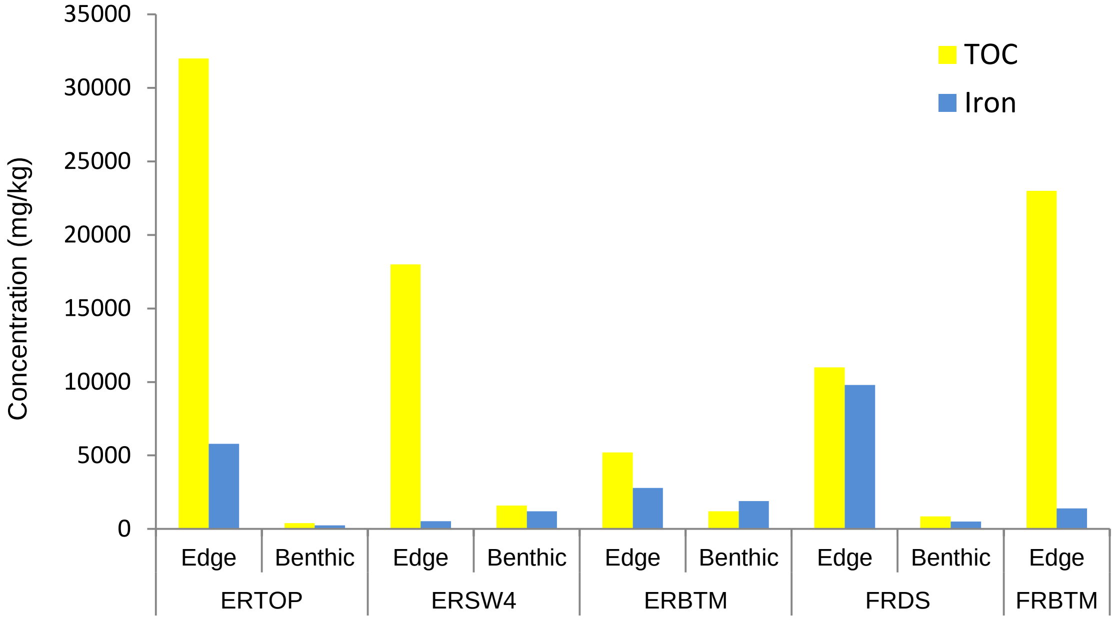

Figure 27. Concentration of TOC and Fe in edge and benthic sediment samples at the five sites sampled for sediments in 2014.

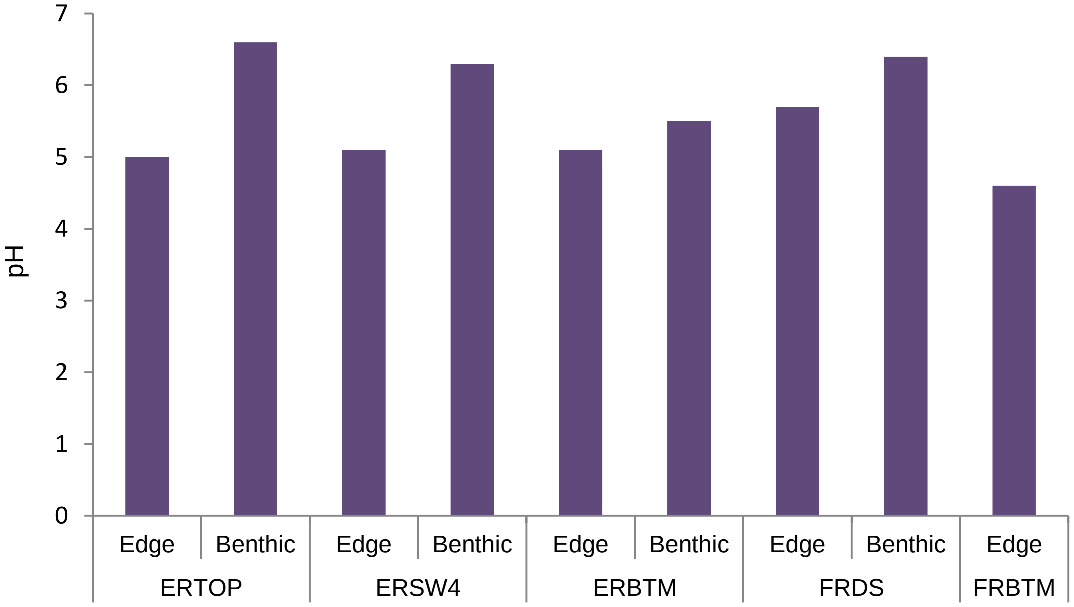

Figure 28. pH values in edge and benthic sediment samples at the five sites sampled for sediments in 2014.

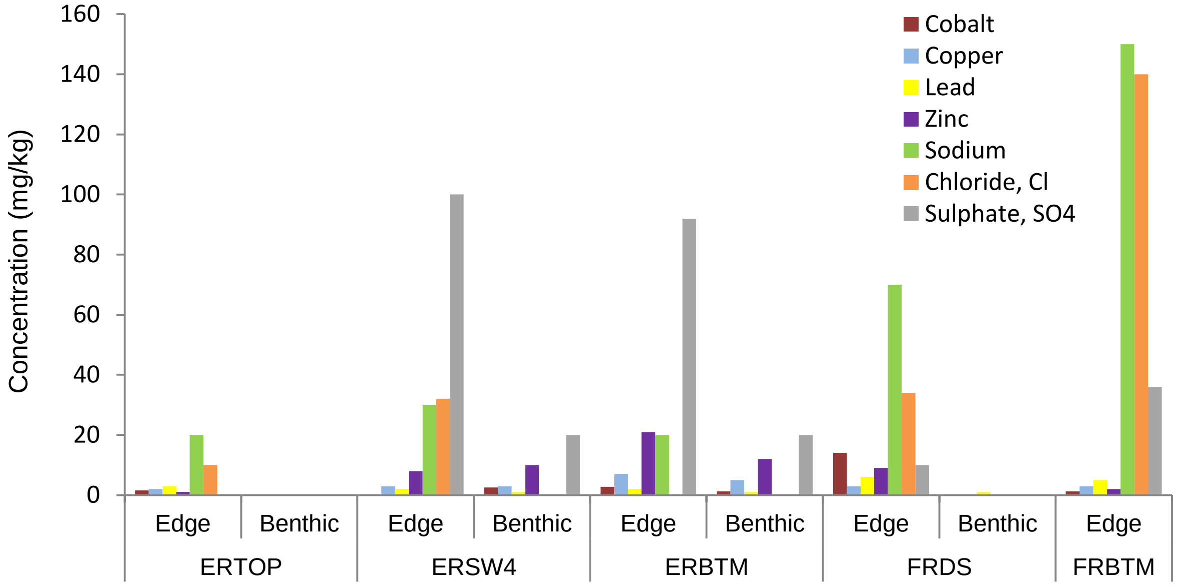

Figure 29. Concentration of Co, Cu, Pb, Zn, Na, Cl and SO_4 in edge and benthic sediment samples at the five sites sampled for sediments in 2014.

Comparison of reference and downstream sites on the Edith River showed seven chemical parameters showed distinct concentration increases in either benthic (Mg, K, Fe, Al) or benthic and edge sediments (Zn, Cu, SO_4) at one or both downstream sites. Mn and Co concentrations in benthic sediments also showed a significant spike in concentration immediately downstream (ERSW4) of the three mine confluence points (Stow, Burrell and West Creeks).

These results are largely consistent with those found in 2013, taking into account the values and natural fluctuations in concentrations of each chemical parameter recorded at reference sites. The exceptions are further increased concentrations of Fe and Al downstream, as well as K and SO_4. However, in contrast to 2013, Pb concentrations were no longer significantly higher at downstream sites (Table 14).

Table 14. Comparison of 2014 to 2013 sediment chemistry results for sites sampled in 2014. Parameters below detection limits are shaded in grey. Parameters that exhibited increased concentrations downstream compared with 2013 are highlighted in pink. Table excludes the six parameters below laboratory detection limits for both years.

Parameter (mg/kg)	ERTOP						ERSW4						ERBTM					
	Edge			Benthic			Edge			Benthic			Edge			Benthic		
	2014	2013	change	2014	2013	change	2014	2013	change	2014	2013	change	2014	2013	change	2014	2013	change
Aluminium*	840	1200	-30%	38	37	3%	210	245	-14%	110	75	47%	200	730	-73%	94	84	12%
Arsenic*	<4	<4		<4	<4		<4	<4		<4	<4		<4	<4		<4	<4	
Cobalt*	1.6	4	-60%	<1	<1		<1	<1		2.5	1	150%	2.7	2	35%	1.3	1	30%
Chromium*	1	1	0%	<1	<1		<1	<1		<1	<1		<1	<1		<1	<1	
Copper*	2	6	-67%	<1	<1		3	12	-75%	3	2	50%	7	45	-84%	5	4	25%
Iron*	5800	5700	2%	250	305	-18%	530	1350	-61%	1200	370	224%	2800	3700	-24%	1900	400	375%
Manganese*	46	80	-43%	9	9	0%	20	50	-60%	130	44	195%	96	14	586%	30	40	-25%
Nickel*	<1	2		<1	<1		<1	<1		<1	<1		1	2	-50%	<1	<1	
Lead*	3	4	-25%	<1	<1		2	3	-33%	1	1	0%	2	5	-60%	1	1	0%
Lanthanum*	<1	6		<1	<1		<1	2		<1	<1		<1	7		<1	<1	
Zinc*	1	6	-83%	<1	<1		8	10.5	-24%	10	5	100%	21	37	-43%	12	8	50%
Calcium	70	310	-77%	30	21	43%	220	200	10%	55	50	10%	100	26	285%	53	51	4%
Potassium	260	93	180%	60	10	500%	400	42	852%	180	20	800%	370	86	330%	220	21	948%
Magnesium	330	170	94%	56	13.5	315%	470	145	224%	140	32	338%	420	96	338%	210	37	468%
Sodium	20	52	-62%	<10	<10		30	23	30%	<10	<10		20	56	-64%	<10	<10	
pH^	5	4.6	9%	6.6	5.8	14%	5.1	5.6	-9%	6.3	6.1	3%	5.1	4.6	11%	5.5	5.9	-7%
Total Organic Carbon	32000	31000	3%	390	410	-5%	18000	8500	112%	1600	770	108%	5200	9000	-42%	1200	590	103%
Chloride, Cl	10	16	-38%	<10	<10		32	7.5	327%	<10	<10		<10	14		<10	<10	
Sulfate, SO4	<10	<10		<10	<10		100	10	900%	20	7	186%	92	54	70%	20	3	567%
Ammonia as N in soil	42	14.5	190%	12	1.6	650%	41	2.75	1391%	14	2.3	509%	48	5.4	789%	26	1.9	1268%
Nitrite as N in soil	<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1	

* = 1M HCL extract

^ = pH units

Table 14. continued.

Parameter (mg/kg)	FRDS						FRBTM		
	Edge			Benthic			Edge		
	2014	2013	change	2014	2013	change	2014	2013	change
Aluminium*	600	690	-13%	57	180	-68%	270	690	-61%
Arsenic*	5	4	25%	<4	<4		<4	<4	
Cobalt*	14	1	1300%	<1	<1		1.3	1.1	18%
Chromium*	<1	<1		<1	<1		<1	<1	
Copper*	3	3	0%	<1	<1		3	8	-63%
Iron*	9800	3400	188%	520	1300	-60%	1400	4100	-66%
Manganese*	740	12	6067%	10	16	-38%	87	45	93%
Nickel*	5	1	400%	<1	<1		<1	<1	
Lead*	6	5	20%	1	2	-50%	5	14	-64%
Lanthanum*	<1	<1		<1	<1		<1	<1	
Zinc*	9	2	350%	<1	<1		2	3	-33%
Calcium	280	30	833%	10	46	-78%	300	66	355%
Potassium	670	50	1240%	90	26	246%	1000	80	1150%
Magnesium	620	41	1412%	50	37	35%	960	130	638%
Sodium	70	29	141%	<10	<10		150	29	417%
pH^	5.7	5.1	12%	6.4	5.9	8%	4.6	5.2	-12%
Total Organic Carbon	11000	9200	20%	860	1800	-52%	23000	11000	109%
Chloride, Cl	34	17.5	94%	<10	<10		140	7	1900%
Sulfate, SO4	10	2.5	300%	<10	<10		36	3	1100%
Ammonia as N in soil	52	2.8	1757%	17	1.4	1114%	120	3.5	3329%
Nitrite as N in soil	<0.1	<0.1		<0.1	<0.1		0.2	0.1	100%

* = 1M HCL extract

^ = pH units

Zn, Pb and Cu were the only comparable elements to ANZECC sediment guidelines. All three elements reported low concentrations, falling well within the recommended concentrations (Table 15). A suggested method from ANZECC to assess concentrations of chemical parameters without published guidelines is to multiply reference concentrations by a factor of two or three and then compare these values with those from potential impact areas.

Table 15. Comparison of maximum concentrations of Zn, Pb and Cu recorded in edge and benthic sediment samples for 2014 against ANZECC sediment guidelines.

Parameter	ANZECC ISQG Low	ANZECC ISQG High	Benthic (mg/Kg)	Location	Edge (mg/Kg)	Location
Zinc	200	410	12	ERBTM	21	ERBTM
Lead	50	220	1	FRDS,ERSW4,ERBTM	6	FRDS
Copper	65	270	5	ERBTM	7	ERBTM

Table 16 presents the ratio of downstream to upstream concentrations for benthic and edge samples in the Edith River, for those parameters that showed increased concentrations at downstream sites. As only five sites were sampled for sediments this year, the maximum value recorded out of the two downstream Edith River sites (ERSW4 and ERBTM) was used for these calculations, as a conservative measure i.e. to provide the ‘worst case scenario’. As a further conservative measure a value of 1 was used for those parameters that recorded a LOR result <1.0. These results also need to be interpreted with caution as they are only based on a single upstream reference value from ERTOP.

As in 2013, Cu and Zn concentrations (both in benthic and edge sediment) again exceeded a 3x upstream multiplier, as did Potassium in benthic samples and SO4 in edge samples. In contrast to 2013, Fe, Mg and Mn exceeded a 3x upstream multiplier this year, with Al dropping below.

Table 16. Ratio of Edith River downstream to upstream concentrations for those parameters that recorded elevated concentrations at downstream sites. Those parameters potentially exceeding recommended levels (based on a 3x multiplier) are highlighted in orange.

Parameter	Maximum Concentration	
	Benthic Ratio	Edge Ratio
Aluminium *1M HCl extract*	2.89	0.25
Cobalt *1M HCl extract*	2.5*	1.7
Copper *1M HCl extract*	5.0*	3.5
Iron *1M HCl extract*	7.6	0.5
Magnesium *1M HCL extract*	3.7	1.4
Manganese *1M HCl extract*	14.4	2.1
Potassium *1M HCL extract*	3.7	1.5
Sulfate, SO4	2.0	10.0
Zinc *1M HCl extract*	12.0*	21.0

* True value for reference site below laboratory detection limit (<1); value of 1used.

4. Discussion

4.1. 2014 Macroinvertebrates

In 2014 there were no significant differences in the composition of the pelagic macroinvertebrate communities between reference and impact sites. At the broader level this contrasts to the two previous years, where significant compositional differences were detected. However, these past effects were attributed to significant differences in composition between Fergusson River reference sites and Edith River impact sites, and this was also observed in the 2014 results.

As observed for two years prior, this year, the pelagic macroinvertebrate communities of the Edith River sites downstream and upstream of discharge activities were not significantly different. In 2013 results at the individual site level suggested there could be some smaller level of mining impact. As two of the immediate downstream sites did differ significantly in composition compared with the upstream reference site ERTOP. However in 2014 data showed the greatest similarity in composition between Edith River upstream and downstream sites over the last three years. At the site level this is strongly supported by the lack of any significant differences in community composition between any pair-wise combination of an upstream Edith River reference site and a downstream impact site.

The inherent variation in macroinvertebrate community compositions between the two river systems that has been demonstrated in previous year's analyses was again shown in 2014.

In contrast to last year, reference and impact sites did differ significantly in their total macroinvertebrate abundances. However the direction of this effect implies this difference was not attributable to a negative impact of discharge on downstream communities, as impact sites on average recorded a greater number of macroinvertebrates. This is further supported by the results of the percentage of total abundance comprised of ETO taxa. As for last year, in 2014 the percentage contribution of ETO individuals to total abundance was also significantly greater at impact sites than at reference sites. As ETO taxa contain species that are most sensitive to environmental pollution, the direction of this effect suggests any mine discharge is not having a detrimental impact on downstream communities.

Within the Edith River the slightly higher taxa richness and lower macroinvertebrate and ETO abundances at reference sites, compared with downstream sites, is more likely a reflection of the changes in aquatic habitat along the reach. Differences between the two river systems in macroinvertebrate variables are likely also a reflection of the variability in the riverine structures. Further analyses that examine the interactions and relationships between macroinvertebrate assemblages and other data such as environmental habitat factors and contaminant deposition, may help elucidate the mechanism behind such observed effects.

Of all taxa sampled, some were either absent from last year's collections and encountered this year, or vice versa. Similarly, the presence of some varied between reference and impact sites. However, almost all these were recorded in very low abundances (i.e. less than 5 individuals), and could be considered rarer taxa. The presence or absence of these individuals, particularly when comparing reference and impact treatments, is likely a reflection of chance encounter as opposed to real site differences. Results to date suggest that there are occasional rare taxa still being encountered in macroinvertebrate samples at Mt. Todd and this was highlighted this year with two new Family level taxa recorded, namely Ochteridae (Hemiptera) and Sisyridae (Order Neuroptera).

The absence of any unusual water quality results correlate with the absence of an impact on downstream macroinvertebrate communities. All detectable results were below published ANZECC 95% species protection guidelines for fresh water, with the exception of the Zn (90%). No comparisons of macroinvertebrate results were made against the NT AusRivAS Darwin/Daly model nor were SIGNAL scores calculated, as the statistical strength and capacity of the current design significantly exceeds the ability of the former to identify discharge impacts.

4.2. Macroinvertebrate trends over time

Prior to 2012 only individual annual Bray-Curtis similarities were used to determine any significant differences in community composition between reference and impact sites. However isolated annual assessments alone are unable to quantify the significance of any variation between years nor account for potential subtle changes to community composition over time.

The temporal analysis of pelagic community composition from 2003 to 2014 showed a statistically significant difference between reference sites and impact sites but that this was dependent on year. Despite reference and downstream sites showing significant differences in composition at a broader level in 2012 and 2013, no associated decline in their similarities compared with previous years was observed.

Although annual analyses prior to 2012 concluded that there was no significant difference in composition between reference and downstream sites, this absence of annual differences is likely attributed to a lack of statistical power due to the sampling design during those years. Therefore, the detection of a statistical difference in community composition since 2012 is most likely due to the increase in sites and samples and not, as indicated by the temporal analysis, a result of compositional changes since 2011. Independent of whether reference and downstream sites differed in their composition prior to 2012, the flat to increased trajectories of similarity for the reference versus Edith downstream sites since 2012, confirm that the composition of downstream sites is not becoming more different over time.

This temporal conclusion is also supported by 2014 results which show no significant differences in macroinvertebrate composition between reference and impact sites. The follow-up ‘three river reach’ model for the last three years showed the major differences each year were between Fergusson reference sites and Edith impact sites and Fergusson reference and Edith reference sites. In contrast, the similarity in macroinvertebrate composition between the Edith reference and Edith impact sites has steadily increased in an upward trajectory over the last three years.

The severe decline in similarities between reference and impact sites in 2004 had previously been interpreted as a mining impact in that year. However the approach taken in the temporal analysis confirmed that this is not the case. The fact that the similarities across sites within the Fergusson River did not show any marked decline in similarity, but that the Fergusson River was markedly different from both upstream and downstream Edith river sites, suggests all Fergusson sites were affected in the same way to become less similar to the Edith River. The above may be attributed to either some environmental factor that only affected macroinvertebrate communities of the Fergusson River in this year, or human error during the post-sampling of this group of samples. Identification of reasons for observed trends over time is also hampered due to the earlier data sets lacking replication.

Provided replicate sampling continues at the macroinvertebrate sites into the future, the power of the temporal analysis to identify significant effects and the drivers of any effects will continue to improve.

4.3. Sediments

The aim of this year’s sampling program was to use chemistry data collected from a subset of last year’s sites, as indicators of any significant downstream impacts due to this year’s discharge activities.

There continues to be detectable and elevated levels of select metals and ions at downstream sites. Last year’s analyses along the spatial gradient showed a number of metals and ions in elevated levels downstream originated from the mine as they matched the chemistry of the discharge waters. Discharging activities are known to have been occurring from the mine since closure, with historical volumes of discharge being significantly larger than those of more recent times. Thus it is likely that more recent concentrations are a reflection of an accumulation over time, rather than related to a specific year of discharge.

This year only four parameters (Fe, Al, K and SO_4) showed further increases in concentration at downstream Edith River sites compared with last year. However, the increases in Fe and Al were not attributable to this year's discharge activities, as water chemistry data from RP3 discharge waters shows the concentration of these two metals was extremely low. The observed increases are more likely to have originated from passive sources, such as Horseshoe Creek whose catchment contains the tailings dam. Past surface and groundwater samples from this catchment indicate seepage from the Tailings Facility. Elevated levels of Al have also been measured in Philips Creek which confluences with the Edith River between the upstream and downstream sites. The influence of passive sources are likely to be particularly significant this year, as sampling was conducted later in the season than usual.

SO_4 and K were present in 2014 RP3 discharge waters, however, it is again likely the elevated SO_4 can be attributed to passive discharge from Horseshoe Creek rather than from the very small window of discharge from RP3. Potassium levels were also generally higher across all sites this year with groundwater as the likely contributor.

The higher edge than benthic concentrations for many chemical parameters across all sites was again observed this year. These edge zones are known to correlate with the finer particulate matter held in place by riparian vegetation, that act as absorption points for contaminants. The drivers for the increased edge concentrations are likely to be many, and may include factors such as physio-chemical adsorption from the water column, biological uptake (particularly by bacteria and algae), sedimentation and physical entrapment of enriched particulate matter.

In summary, an increase in only two of the 27 chemical parameters does not provide sufficient evidence of a further exacerbation of the downstream sediment concentrations from discharge activities. This is consistent with what was expected given there were less than 10 days of discharge of treated RP3 water during the wet season. This discharge also occurred a few months prior to sampling, with follow up freshwater flows likely to have had a flushing effect. In addition compared with historical discharges, the quantity of treated water was significantly lower and the water quality significantly higher.

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7. Appendices

Appendix 1. Bray-Curtis similarity matrices for 2012 and 2013 macroinvertebrate data.

Year	Site	FRUS	FRDS	FRBTM	ERTOP	ERUS	ERSW4	ERDS	ERBTM
2011-2012	FRUS	71.8							
	FRDS	72.1	73.3						
	FRBTM	69.5	72.6	73.7					
	ERTOP	70.3	68.0	67.3	79.5				
	ERUS	64.0	64.7	67.4	69.2	67.1			
	ERSW4	63.8	62.5	68.6	64.7	65.3	69.9		
	ERDS	64.6	60.5	65.1	60.4	60.8	69.8	68.5	
	ERBTM	61.8	61.4	65.6	67.5	59.4	67.9	59.5	69.5
2012-2013	FRUS	69.1							
	FRDS	76.906	77.948						
	FRBTM	73.03	74.379	76.748					
	ERTOP	58.536	60.742	58.608	74.354				
	ERUS	66.304	68.774	68.558	69.002	71.744			
	ERSW4	63.091	66.036	63.774	57.458	68.153	63.358		
	ERDS	64.432	70.744	65.722	55.324	64.646	65.41	65.615	
	ERBTM	64.542	67.636	63.116	69.977	72.185	65.232	62.409	71.084

Appendix 2. Bray Curtis similarity matrices for 2008 to 2011 macroinvertebrate data.

Year	Site	FRUS	ERUS	ERDS
2007-08	FRDS	71.0		
	ERDS		84.5	
	ERSW4		74.7	79.4
2008-09	FRDS	78.5		
	ERDS		70.6	
	ERSW4		77.7	74.5
2009-10	FRDS	81.1		
	ERDS		77.5	
	ERSW4		78.3	70.2
2010-11*	FRDS	79.5		
	ERDS		73.9	
	ERSW4		72.6	69.2

**Results generated from pooling data from the three samples at each site*

Appendix 3. Bray Curtis similarity matrices for 2003 to 2007 macroinvertebrate data.

Year	Site	FERIUS	ERUS	ERDS
2002-03	FERIDS	75.7		
	ERDS		78.2	
	ERSW4		72.2	79.8
2003-04	FERIDS	85.5		
	ERDS		72.0	
	ERSW4		66.8	70.7
2004-05	FERIDS	66.1		
	ERDS		72.9	
	ERSW4		69.8	74.4
2005-06	FERIDS	70.3		
	ERDS		77.0	
	ERSW4		80.0	70.8
2006-07	FERIDS	62.2		
	ERDS		78.7	
	ERSW4		72.6	75.9

Appendix 4. Macroinvertebrate raw abundance counts, total taxa and percentage of each sample sorted for 2014.

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
PHYLUM ARTHROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Atyidae	1	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0	1	0	1	0	0	2	0
Family Palaemonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Arachnida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Acariformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Oribatida	4	8	5	5	13	3	8	1	12	8	2	9	6	6	6	10	8	8	13	6	3	3	8	6
Suborder Prostigmata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Baetidae	7	11	15	9	7	6	16	12	15	2	13	6	12	2	0	4	4	4	4	2	9	0	1	2
Family Caenidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tasmanocoenis spp.	0	2	0	0	0	1	0	0	0	3	9	7	9	3	3	3	11	5	1	3	4	6	13	10
Wundacaenis	1	0	0	1	1	1	1	0	1	0	2	0	2	0	1	0	0	0	0	0	0	0	0	0
Family Leptophlebiidae	0	1	1	1	0	0	0	0	0	0	1	2	3	1	1	0	2	0	0	1	0	0	0	2
Order Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Orthotrichia	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	1
Sub-family Hellyethira	2	2	3	0	3	0	1	0	0	2	7	2	2	2	1	12	1	2	3	0	3	0	1	7
Family Ecnomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus	2	2	0	1	2	2	1	0	6	0	11	0	3	1	1	0	4	8	1	0	5	0	1	16
Ecnomina	1	17	3	5	16	15	1	2	2	3	1	1	0	1	0	3	5	0	1	1	1	0	1	0
Family Leptoceridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triaenodes	48	33	53	38	37	112	71	112	44	158	67	185	73	127	119	143	173	127	212	311	38	144	209	359
Triplectides	0	1	2	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Oecetis	8	8	3	3	2	5	11	14	10	12	19	10	8	2	12	9	3	13	13	4	6	2	12	11
Family Philopotamidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chimarra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Polycentropodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Calamoceratidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anisocentropus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydrobiosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Chironomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Aphrotenninae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphroteniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Chironominae	40	50	54	29	43	19	26	8	23	12	43	15	28	8	5	6	16	12	4	5	27	19	24	27

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Stenochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Tanypodinae	1	4	12	6	13	0	7	4	6	4	8	4	8	6	2	1	0	7	2	4	3	6	3	3
Sub-family Orthocladiinae	4	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Family Culicidae	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dolichopodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Ceratopogonidae	10	6	9	16	4	4	7	7	13	6	12	6	12	6	6	3	0	5	1	4	1	2	2	1
Family Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Tabanidae	1	0	0	0	1	0	0	0	1	0	1	0	3	0	0	0	0	0	0	1	0	0	0	0
FamilyTipulidae	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Simulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Belostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pleidae	0	0	2	1	2	5	0	9	5	0	0	0	0	1	0	1	0	0	3	1	0	1	0	0
Family Corixidae	1	0	1	6	0	4	5	2	3	1	0	2	0	1	0	0	2	4	4	0	5	0	0	6
Family Veliidae	1	0	1	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Family Mesoveliidae	0	2	0	0	0	0	1	2	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0
Family Naucoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Notonectidae	0	0	1	10	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	1	0
Family Gerridae	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Nepidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Ranatra	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Family Gelastocoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Ochteridae	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dytiscidae	39	41	15	11	27	33	36	48	57	5	7	7	6	23	22	34	38	9	41	37	106	16	10	19
Family Hydrochidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrochus	3	1	4	12	3	1	6	7	3	1	0	6	6	8	9	2	0	5	5	5	2	0	0	0
Family Hydrophilidae	0	0	0	3	0	1	1	0	0	0	0	3	1	1	1	0	1	0	2	1	1	0	0	0
Berosus	0	2	0	3	1	0	1	2	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Family Georissidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georissus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydraenidae	0	1	0	3	2	1	1	6	0	0	0	0	0	0	1	0	3	3	6	3	4	1	1	0
Family Noteridae	2	1	0	11	0	4	0	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Family Elmidae	13	6	14	4	2	9	10	21	5	4	3	5	14	16	14	3	14	7	8	14	4	4	12	9
Family Limnichidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Gyrinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Scirtidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Staphylinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Cuculionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Zygoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Family Platycnemidae	0	0	1	0	0	0	0	0	0	2	1	2	4	0	1	1	2	1	4	2	2	2	3	2
Family Isostictidae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Family Coenagrionidae	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Sub-order Anisoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Cordulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pentathemus sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hemicorduliidae	0	0	0	2	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Family Libellulidae	0	0	2	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	2	0
Family Gomphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrogomphus	12	12	9	10	5	2	3	8	1	5	3	1	0	0	2	0	0	0	1	0	0	4	2	3
Antipodogomphus	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ictinogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Macromiidae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Lepidoptera																								
Family Pyralidae	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Neuroptera																								
Family Sisyridae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PHYLUM ANNELIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Oligochaeta	0	3	1	1	25	1	1	1	0	2	1	2	6	1	1	0	2	1	1	1	0	0	2	1
PHYLUM NEMATODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**206**	**223**	**218**	**203**	**210**	**232**	**221**	**268**	**212**	**232**	**222**	**277**	**216**	**219**	**208**	**239**	**288**	**220**	**335**	**409**	**228**	**212**	**313**	**488**
# TAXA	**23**	**25**	**24**	**28**	**22**	**23**	**26**	**20**	**20**	**19**	**25**	**21**	**25**	**22**	**19**	**18**	**17**	**19**	**23**	**22**	**21**	**15**	**23**	**19**
% sorted	**7**	**9**	**7**	**36**	**12**	**6**	**10**	**3**	**8**	**4**	**8**	**3**	**7**	**3**	**3**	**3**	**3**	**5**	**3**	**3**	**4**	**3**	**3**	**3**

Appendix 5. Macroinvertebrate raw abundance counts, total taxa and percentage of each sample sorted for 2013.

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
PHYLUM ARTHROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Atyidae	2	0	2	1	3	0	1	1	5	1	0	4	1	1	1	0	4	3	0	1	0	2	3	0
Family Palaemonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chonchostraca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Arachnida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Acariformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Oribatida	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Prostigmata	5	10	7	10	10	22	0	10	0	9	4	2	3	9	2	11	0	3	2	3	13	4	6	6
Class Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Baetidae	16	12	15	10	9	3	9	12	13	2	14	14	10	3	11	9	10	6	3	1	17	4	4	0
Family Caenidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tasmanocoenis spp.	0	2	3	4	3	2	1	1	1	14	22	11	16	4	14	0	6	2	0	1	3	17	15	13
Wundacaenis	0	2	0	2	0	0	2	0	4	2	1	4	3	0	2	1	1	0	0	0	2	2	6	3
Family Leptophlebiidae	1	0	0	0	0	0	0	0	0	3	0	0	1	1	0	1	2	0	0	0	0	2	2	0
Order Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Orthotrichia	0	0	0	0	0	0	0	0	0	1	3	6	0	0	0	0	0	0	0	0	0	2	0	1
Sub-family Hellyethira	0	2	1	2	6	0	3	0	1	1	1	0	1	1	0	0	0	0	0	0	1	1	3	1
Family Ecnomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus	0	1	3	3	2	6	0	2	1	0	2	0	0	0	1	1	0	0	0	0	1	0	1	2
Ecnomina	2	1	1	2	3	1	0	0	0	0	0	0	1	0	0	4	2	0	1	1	1	0	1	0
Family Leptoceridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triaenodes	17	22	26	46	46	26	40	39	55	106	53	84	36	131	134	124	116	129	128	112	100	110	137	75
Triplectides	2	0	5	3	3	2	0	0	0	1	0	0	1	0	0	0	0	2	1	3	0	0	0	1
Oecetis	8	5	4	4	5	1	18	10	18	13	9	12	20	5	9	7	3	9	3	1	0	4	5	23
Family Philopotamidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chimarra	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Family Polycentropodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Calamoceratidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anisocentropus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Family Hydropsychidae	0	0	0	0	0	0	0	0	0	1	0	0	2	0	1	0	0	0	0	0	0	0	0	0
Family Hydrobiosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Chironomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Aphrotenninae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Aphroteniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Chironominae	54	82	35	30	14	29	30	31	13	26	50	34	71	13	27	10	5	19	9	11	11	27	21	16
Stenochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Tanypodinae	2	8	5	6	5	9	5	8	3	4	9	3	9	3	1	4	2	5	5	1	2	3	13	6
Sub-family Orthocladinae	0	0	0	0	0	0	0	1	0	1	0	2	1	0	1	0	3	0	0	0	2	0	0	0
Family Culicidae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Family Dolichopodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Ceratopogonidae	7	15	3	3	3	12	5	4	4	11	22	6	11	3	6	0	1	7	5	2	1	6	2	6
Family Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Tabanidae	0	2	0	0	0	1	2	0	0	0	0	0	4	0	0	1	0	1	0	0	1	0	2	0
FamilyTipulidae	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Simulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Belostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pleidae	1	0	3	2	2	0	2	1	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Family Corixidae	4	6	7	3	1	7	5	2	1	0	0	0	0	0	1	2	5	0	1	0	2	0	6	0
Family Veliidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Family Mesoveliidae	0	0	0	1	0	1	2	0	1	0	0	0	1	0	0	0	0	4	1	0	1	0	0	0
Family Naucoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Notonectidae	1	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
Family Gerridae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Nepidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Family Gelastocoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dytiscidae	82	22	72	49	72	51	54	58	67	8	0	0	4	46	3	43	44	4	22	18	25	7	1	30
Family Hydrochidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrochus	3	1	4	3	7	4	5	1	3	1	0	0	1	2	2	5	2	0	6	6	3	0	0	4
Family Hydrophilidae	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2	1	0	0	4	1	0	0	0
Berosus	1	2	1	3	0	1	1	1	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Family Georissidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georissus	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Family Hydraenidae	2	0	0	0	7	3	0	3	2	0	0	0	0	2	2	1	1	13	7	14	4	0	2	0
Family Noteridae	0	0	2	0	0	0	1	3	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0
Family Elmidae	11	9	7	9	3	7	4	5	5	8	3	2	21	12	20	9	14	8	2	19	3	6	8	13
Family Limnichidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Gyrinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Scirtidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Staphylinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Cuculionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Zygoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Family Protoneuridae	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0
Family Isostictidae	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0	1	1	3	0	0
Family Coenagrionidae	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sub-order Anisoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Cordulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pentathemus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Family Hemicorduliidae	1	2	0	2	2	0	3	3	3	0	0	1	2	0	2	0	0	1	1	0	0	2	0	0
Family Libellulidae	3	1	4	0	1	2	2	0	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0
Family Gomphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrogomphus	0	2	1	2	1	7	5	2	2	0	5	2	4	3	9	4	3	1	5	4	6	2	2	4
Antipodogomphus	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	2	0	0	0	0	0	0	0
Ictinogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pyralidae	0	0	0	0	2	0	0	0	0	6	13	11	0	0	2	0	0	0	0	0	0	0	0	0
PHYLUM ANNELIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Oligochaeta	2	5	0	3	1	2	1	7	2	1	7	6	5	1	6	1	2	2	1	0	2	6	3	1
PHYLUM NEMATODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dugesiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**231**	**215**	**215**	**203**	**212**	**201**	**203**	**210**	**211**	**221**	**220**	**204**	**232**	**242**	**258**	**241**	**234**	**224**	**207**	**205**	**204**	**213**	**243**	**205**
# TAXA	**26**	**23**	**25**	**24**	**25**	**24**	**25**	**26**	**24**	**22**	**18**	**17**	**27**	**19**	**23**	**20**	**25**	**22**	**22**	**20**	**24**	**21**	**21**	**17**
% sorted	**7**	**5**	**13**	**7**	**7**	**10**	**13**	**10**	**6**	**4**	**9**	**10**	**6**	**3**	**4**	**3**	**5**	**3**	**7**	**3**	**9**	**6**	**3**	**4**

Appendix 6. Macroinvertebrate raw abundance counts, total taxa and percentage of each sample sorted for 2012.

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
PHYLUM ARTHROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Atyidae	1	0	7	2	1	7	4	2	5	2	3	3	1	1	4	0	0	1	2	0	1	0	1	0
Family Palaemonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium	4	2	0	0	1	5	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	5	0	0
Chonchostraca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Arachnida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Acariformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Oribatida	5	8	4	10	4	1	1	2	1	15	3	3	0	5	0	4	2	2	15	10	23	1	2	3
Suborder Prostigmata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Baetidae	10	16	5	16	3	3	11	19	9	6	12	11	19	2	18	15	5	9	14	0	12	10	33	8
Family Caenidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tasmanocoenis spp.	0	2	0	0	1	0	4	1	0	13	25	5	7	3	6	11	2	8	4	6	4	16	15	9
Wundacaenis	0	1	0	1	0	1	3	2	1	0	1	3	3	4	0	1	1	4	1	0	1	1	1	2
Family Leptophlebiidae	1	0	1	0	0	0	0	0	0	2	1	1	4	3	0	5	0	0	1	0	0	1	0	0
Order Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Orthotrichia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Sub-family Hellyethira	0	0	0	0	0	0	2	0	1	0	2	0	4	0	0	0	0	1	0	0	1	0	1	0
Family Ecnomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus	3	2	0	0	5	0	3	0	0	0	0	1	0	0	1	3	2	0	1	0	3	9	4	6
Ecnomina	2	0	0	1	1	0	0	1	1	0	0	1	0	1	0	1	0	0	1	0	0	1	4	0
Family Leptoceridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triaenodes	28	30	55	45	49	32	60	64	60	68	40	112	16	107	54	128	75	65	78	115	47	125	125	124
Triplectides	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Oecetis	9	14	19	5	10	27	12	22	22	13	18	16	26	5	29	14	7	35	6	11	2	13	12	24
Family Philopotamidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Chimarra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Polycentropodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Calamoceratidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anisocentropus	0	0	0	2	0	1	0	0	0	1	0	1	1	0	0	0	0	5	0	0	2	1	2	0
Family Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydrobiosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Chironomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Aphrotenninae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphroteniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Chironominae	36	49	50	34	40	29	31	10	20	42	32	17	64	20	18	8	1	7	2	1	7	13	28	19
Stenochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Tanypodinae	2	2	9	3	16	1	14	8	2	5	2	1	6	7	3	2	0	1	2	0	0	3	5	1
Sub-family Orthocladinae	0	0	0	3	0	1	1	0	0	0	0	0	2	0	1	2	0	1	0	0	1	0	0	0
Family Culicidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dolichopodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Ceratopogonidae	2	6	1	2	18	3	8	3	3	23	29	12	15	5	11	3	2	7	2	1	1	7	2	5
Family Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Family Tabanidae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
FamilyTipulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Family Simulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Belostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pleidae	0	0	1	0	1	1	0	4	1	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
Family Corixidae	0	1	3	7	2	1	2	3	0	0	0	0	0	0	0	3	2	1	7	1	16	0	3	0
Family Veliidae	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Family Mesoveliidae	0	0	0	0	0	0	0	1	0	0	2	0	0	0	1	0	0	4	0	0	0	0	1	0
Family Naucoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Notonectidae	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Family Gerridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Family Gelastocoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Order Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dytiscidae	68	33	11	39	18	21	16	43	43	3	5	1	4	30	11	10	81	14	75	55	65	1	7	10
Family Hydrochidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrochus	2	0	6	4	3	2	1	7	0	2	0	0	1	3	7	1	3	2	6	5	0	1	0	0
Family Hydrophilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	1	0	0	0	0	0
Berosus	1	0	0	1	3	1	2	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0
Family Georissidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georissus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydraenidae	0	0	0	0	0	6	1	2	5	0	0	0	2	2	2	0	1	1	0	16	0	0	0	1
Family Noteridae	0	1	1	0	0	0	0	0	2	0	0	0	0	0	1	0	1	0	3	1	2	0	0	0
Family Elmidae	10	11	19	11	1	7	4	4	11	8	11	5	14	22	20	9	6	17	2	16	6	3	6	0
Family Limnichidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Gyrinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Scirtidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Staphylinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Cuculionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Zygoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Protoneuridae	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0
Family Isostictidae	0	1	1	0	0	1	1	0	0	0	0	0	0	4	0	1	8	0	1	1	2	2	2	0
Family Coenagrionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Anisoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Cordulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pentathemus sp.	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Family Hemicorduliidae	2	2	0	4	2	9	3	5	7	0	3	6	1	0	4	0	0	9	0	0	0	2	1	0
Family Libellulidae	0	0	0	1	2	2	1	0	1	0	2	0	0	0	0	0	0	1	0	0	0	1	1	0
Family Gomphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrogomphus	11	21	12	7	18	19	18	7	10	5	10	9	7	4	18	2	1	5	11	6	4	0	1	0
Antipodogomphus	2	1	0	0	2	1	0	0	1	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0
Ictinogomphus	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**FRBTM**			**ERTOP**			**ERUS**			**ERSW4**			**ERDS**			**ERBTM**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Family Pyralidae	0	0	1	1	0	1	0	0	0	4	7	2	8	1	1	0	0	0	0	0	0	0	0	0
PHYLUM ANNELIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Oligochaeta	2	10	3	3	5	16	3	0	0	2	12	1	9	0	5	0	0	1	1	0	1	0	2	0
PHYLUM NEMATODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dugesiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**203**	**213**	**209**	**203**	**206**	**204**	**209**	**212**	**206**	**215**	**222**	**211**	**221**	**231**	**221**	**224**	**202**	**203**	**237**	**249**	**203**	**217**	**261**	**213**
# TAXA	**22**	**20**	**19**	**23**	**23**	**30**	**26**	**22**	**20**	**18**	**21**	**20**	**26**	**21**	**25**	**20**	**18**	**25**	**23**	**17**	**22**	**21**	**25**	**13**
% sorted	**8**	**9**	**13**	**9**	**12**	**11**	**11**	**5**	**6**	**6**	**13**	**8**	**9**	**4**	**5**	**5**	**3**	**6**	**4**	**5**	**4**	**7**	**6**	**7**

Appendix 7. Macroinvertebrate raw abundance counts and total taxa of each sample sorted for 2011.

TAXA	**FRUS**			**FRDS**			**ERUS**			**ERDS**			**ERSW4**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
PHYLUM ARTHROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Atyidae	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Family Palaemonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium	3	4	2	4	1	8	8	2	4	1	2	0	0	0	1
Chonchostraca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Arachnida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Acariformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Oribatida	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Suborder Prostigmata	3	5	1	0	3	2	3	1	1	6	2	5	7	3	9
Class Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Baetidae	3	1	3	5	1	4	5	1	3	2	1	5	2	5	13
Family Caenidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tasmanocoenis spp.	0	1	2	0	0	0	18	6	7	3	1	4	1	4	8
Wundacaenis	7	1	3	2	0	1	2	0	1	0	0	0	0	0	2
Family Leptophlebiidae	0	0	0	0	1	0	2	1	2	1	4	3	0	0	0
Order Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Orthotrichia	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2
Sub-family Hellyethira	0	0	0	0	0	0	0	0	0	0	0	0	1	5	1
Family Ecnomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Ecnomina	1	1	0	1	1	0	0	1	0	0	0	1	0	0	0
Family Leptoceridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triaenodes	31	49	111	29	24	36	82	135	129	65	182	32	81	69	89
Triplectides	0	0	0	2	2	0	5	1	4	0	0	0	2	0	6
Oecetis	15	4	7	11	15	11	18	4	6	4	6	9	4	4	21
Family Philopotamidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chimarra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Polycentropodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Calamoceratidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anisocentropus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Family Hydropsychidae	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Family Hydrobiosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Chironomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Aphrotenninae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphroteniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**ERUS**			**ERDS**			**ERSW4**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Sub-family Chironominae	21	7	20	8	13	3	3	1	3	0	7	20	3	3	4
Stenochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Tanypodinae	3	1	2	3	3	0	1	0	1	1	3	0	0	0	0
Sub-family Orthocladinae	0	0	2	0	2	0	2	0	0	0	0	0	0	0	0
Family Culicidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dolichopodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Ceratopogonidae	6	5	3	1	9	0	0	1	3	1	1	1	2	0	2
Family Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Tabanidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FamilyTipulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Simulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Belostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pleidae	0	0	0	0	8	0	0	3	0	0	0	0	6	0	0
Family Corixidae	5	0	0	3	0	0	0	0	0	1	0	1	3	2	2
Family Veliidae	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0
Family Mesoveliidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Family Naucoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Notonectidae	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Family Gerridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dytiscidae	55	54	3	71	34	102	30	57	19	102	89	98	114	100	14
Family Hydrochidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrochus	1	1	0	7	9	2	7	2	3	6	5	12	31	11	8
Family Hydrophilidae	0	0	0	0	0	0	1	0	0	0	0	0	1	2	0
Berosus	4	4	3	2	2	1	0	1	0	0	0	0	1	0	0
Family Georissidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georissus	1	0	0	0	0	0	0	0	0	0	0	0	1	2	0
Family Hydraenidae	8	2	0	1	1	2	2	0	0	2	3	0	5	1	0
Family Noteridae	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0
Family Elmidae	10	5	11	3	15	8	13	20	14	7	11	8	5	5	8
Family Limnichidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Gyrinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Scirtidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Staphylinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Cuculionidae	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Order Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Zygoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Protoneuridae	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Family Isostictidae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Family Coenagrionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Anisoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**FRUS**			**FRDS**			**ERUS**			**ERDS**			**ERSW4**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Family Cordulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pentathemus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hemicorduliidae	1	7	0	6	0	5	4	0	0	0	0	0	0	0	1
Family Libellulidae	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0
Family Gomphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrogomphus	14	14	17	8	19	8	5	5	17	1	9	3	0	0	3
Antipodogomphus	1	2	1	0	13	0	0	0	0	0	0	0	0	0	0
Ictinogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pyralidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHYLUM ANNELIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Oligochaeta	19	32	7	30	21	4	3	0	3	1	5	0	3	1	1
PHYLUM NEMATODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dugesiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	214	200	199	200	201	205	216	246	220	205	331	203	276	218	203
# TAXA	23	20	18	22	25	19	22	21	17	17	16	15	22	16	22

Appendix 8. Macroinvertebrate raw abundance counts and total taxa of each sample sorted for 2008-2010.

TAXA	**2010**					**2009**					**2008**				
	FRUS	**FRDS**	**ERUS**	**ERDS**	**ERSW4**	**FRUS**	**FRDS**	**ERUS**	**ERDS**	**ERSW4**	**FRUS**	**FRDS**	**ERUS**	**ERDS**	**ERSW4**
PHYLUM ARTHROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Atyidae	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Family Palaemonidae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Macrobrachium	0	0	3	1	0	0	1	2	0	0	0	0	0	0	0
Chonchostraca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Arachnida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Acariformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Oribatida	34	42	49	14	40	19	37	38	22	53	53	52	17	4	28
Suborder Prostigmata	10	11	19	30	14	7	18	22	16	13	13	2	13	14	2
Class Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Baetidae	10	10	3	19	3	6	14	4	8	11	11	6	11	11	13
Family Caenidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*Tasmanocoenis*spp.	1	0	11	22	6	0	3	17	19	11	1	2	19	33	36
Wundacaenis	0	1	2	4	2	0	1	3	0	0	0	0	1	1	1
Family Leptophlebiidae	1	0	3	3	5	0	1	1	6	2	0	0	1	4	0
Order Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Orthotrichia	1	0	3	0	1	0	0	7	0	0	1	0	0	1	1
Sub-family Hellyethira	1	2	4	2	1	4	3	9	7	6	3	0	0	0	1
Family Ecnomidae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ecnomus	0	0	0	0	0	1	0	0	0	3	0	1	0	0	0
Ecnomina	1	1	1	0	1	7	1	1	0	1	0	1	1	2	5
Family Leptoceridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triaenodes	18	30	34	52	32	19	28	95	250	145	12	5	21	63	117
Triplectides	0	0	0	1	0	0	1	3	0	2	0	0	0	0	0
Oecetis	4	7	14	9	4	4	8	8	5	8	2	5	6	4	3
Family Philopotamidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	**2010**					**2009**					**2008**				
	FRUS	**FRDS**	**ERUS**	**ERDS**	**ERSW4**	**FRUS**	**FRDS**	**ERUS**	**ERDS**	**ERSW4**	**FRUS**	**FRDS**	**ERUS**	**ERDS**	**ERSW4**
Chimarra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Family Polycentropodidae	0	0	0	0	0	0	0	2	2	0	2	0	0	0	0
Family Calamoceratidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Anisocentropus	0	1	0	0	0	1	2	0	2	1	0	0	0	0	0
Family Hydropsychidae	0	0	1	2	0	0	0	1	0	0	0	0	0	0	0
Family Hydrobiosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Chironomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Aphrotenninae	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0
Aphroteniella	0	0	3	0	0	0	1	1	1	1	0	0	0	0	0
Sub-family Chironominae	59	38	21	18	71	42	44	93	51	74	59	62	68	76	84
Stenochironomus sp.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
Sub-family Tanypodinae	26	22	23	16	19	38	31	52	32	24	19	13	21	25	20
Sub-family Orthocladinae	4	2	3	2	1	5	8	9	0	4	3	8	2	1	7
Family Culicidae	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Family Dolichopodidae	0	0	0	0	0	0	0	0	0	0	3	5	9	9	8
Family Ceratopogonidae	7	2	2	0	9	12	14	8	15	21	0	0	0	0	0
Family Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Tabanidae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Family Tipulidae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Family Simulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Belostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pleidae	0	0	0	0	0	0	2	0	1	1	0	0	0	0	2
Family Corixidae	0	0	1	3	0	3	8	0	5	0	3	0	1	2	1
Family Veliidae	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Family Mesoveliidae	0	0	2	1	0	0	0	0	1	0	0	0	0	0	0
Family Naucoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Notonectidae	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0

TAXA	**2010**					**2009**					**2008**				
	FRUS	**FRDS**	**ERUS**	**ERDS**	**ERSW4**	**FRUS**	**FRDS**	**ERUS**	**ERDS**	**ERSW4**	**FRUS**	**FRDS**	**ERUS**	**ERDS**	**ERSW4**
Family Gerridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dytiscidae	6	15	10	18	9	30	78	15	65	31	16	12	6	8	20
Family Hydrochidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrochus	0	0	4	3	1	2	3	1	2	2	5	3	4	4	2
Family Hydrophilidae	0	0	0	0	0	0	1	1	0	1	1	0	1	0	2
Berosus	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Family Georissidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georissus	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0
Family Hydraenidae	0	1	12	5	6	4	6	10	3	5	3	4	2	8	3
Family Noteridae	0	0	1	0	0	0	0	1	1	1	0	1	1	0	0
Family Elmidae	9	16	21	12	10	1	6	19	24	13	2	0	10	4	15
Family Limnichidae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Family Gyrinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Scirtidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Family Staphylinidae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Order Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Zygoptera	0	0	0	0	0	1	3	0	0	0	1	0	1	1	1
Family Protoneuridae	0	1	0	0	2	1	0	2	3	1	1	1	0	0	0
Family Isostictidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Coenagrionidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Sub-order Anisoptera	0	0	0	0	0	0	3	0	0	0	2	6	0	1	4
Family Cordulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pentathemus sp.	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Family Hemicorduliidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Family Libellulidae	1	1	0	0	0	0	0	1	0	0	0	0	0	0	4
Family Gomphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrogomphus	3	0	1	0	0	1	1	7	7	0	2	1	0	0	0
Antipodogomphus	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Order Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pyralidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA	2010					2009					2008				
	FRUS	FRDS	ERUS	ERDS	ERSW4	FRUS	FRDS	ERUS	ERDS	ERSW4	FRUS	FRDS	ERUS	ERDS	ERSW4
PHYLUM ANNELIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Oligochaeta	6	6	0	4	0	9	23	1	5	3	0	13	4	2	3
PHYLUM NEMATODA	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Family Duesiidae	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0
TOTAL	205	211	254	242	240	219	350	439	561	442	224	208	224	279	389
# TAXA	21	20	28	23	23	24	29	35	29	30	26	23	26	23	28

Appendix 9. Macroinvertebrate raw abundance counts and total taxa of each sample sorted for 2003-2007.

TAXA	2007					2006					2005					2004					2003				
	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4
PHYLUM ARTHROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Atyidae	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Family Palaemonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium	0	0	0	0	0	0	1	0	0	0	1	1	1	1	0	0	2	0	0	1	1	0	0	0	0
Chonchostraca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Class Arachnida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Acariformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Oribatida	6	14	24	13	10	25	2	26	4	13	1	0	6	4	8	6	4	3	0	0	10	0	11	4	4
Suborder Prostigmata	3	8	8	16	11	6	10	14	8	9	6	9	15	12	11	4	11	4	15	9	12	9	7	15	10
Class Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Baetidae	20	11	10	38	19	14	3	48	8	17	61	13	11	17	10	36	15	9	4	0	30	3	5	8	10
Family Caenidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*Tasmanocoenis*spp.	4	0	32	24	13	18	3	31	14	13	1	1	17	8	5	2	4	38	1	0	12	3	12	13	3
Wundacaenis	7	0	1	3	4	16	8	13	2	1	0	0	1	1	0	4	11	0	0	0	0	1	3	1	0
Family Leptophlebiidae	0	1	2	4	2	1	0	4	2	3	0	1	0	3	4	0	0	1	0	0	0	7	3	7	5
Order Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydroptilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Orthotrichia	23	0	16	0	0	7	0	19	0	2	1	0	17	0	1	36	15	0	0	0	1	0	1	0	1
Sub-family Hellyethira	1	1	6	2	1	3	1	5	2	1	4	3	4	1	10	1	2	0	0	0	1	1	7	1	0
Family Ecnomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomus	0	1	3	1	1	2	4	5	2	1	2	0	0	2	1	2	4	0	1	2	1	0	1	1	0
Ecnomina	0	1	1	1	0	0	2	0	1	2	2	7	0	6	17	0	0	1	4	0	0	0	0	0	1
Family Leptoceridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triaenodes	25	22	67	135	155	10	4	77	70	64	2	4	20	33	127	21	18	61	49	35	30	14	38	103	51
Triplectides	0	0	0	0	2	0	0	2	0	1	1	0	0	1	0	0	0	1	1	2	0	2	2	2	0
Oecetis	4	9	7	10	1	1	1	10	1	2	0	5	4	5	4	7	13	10	8	3	3	9	10	5	7

TAXA	2007					2006					2005					2004					2003				
	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4
Family Philopotamidae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0
Chimarra	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Polycentropodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Calamoceratidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anisocentropus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Family Hydropsychidae	3	0	0	0	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Family Hydrobiosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Chironomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-family Aphrotenninae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphroteniella	0	1	0	0	0	0	0	1	0	1	0	0	0	0	2	0	0	1	0	2	0	0	0	0	0
Sub-family Chironominae	92	44	65	51	71	99	35	60	35	52	105	63	43	40	66	87	53	19	5	20	33	24	46	56	48
Stenochironomus sp.	0	0	0	0	1	1	1	0	0	0	0	3	1	0	3	1	0	0	2	1	1	8	1	3	2
Sub-family Tanypodinae	15	28	10	26	30	17	12	15	19	14	24	28	23	27	20	22	31	10	9	23	30	52	23	28	21
Sub-family Orthocladinae	0	0	6	1	2	5	4	4	0	2	9	1	4	4	3	0	0	1	0	0	3	1	2	1	0
Family Culicidae	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	1	1
Family Dolichopodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Ceratopogonidae	5	10	17	14	8	11	12	18	7	5	3	4	8	11	11	5	9	5	6	7	7	5	18	18	18
Family Empididae	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Family Tabanidae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Family Tipulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Simulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Belostomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pleidae	0	1	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	1	0	0	1	1	0	0	0
Family Corixidae	0	4	1	5	0	0	0	1	2	1	1	12	0	1	1	0	0	1	11	5	3	2	0	7	2
Family Veliidae	0	1	0	1	0	2	2	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0
Family Mesoveliidae	0	1	0	2	0	1	12	1	0	1	0	0	0	0	1	1	0	1	1	0	1	1	1	0	0

TAXA	2007					2006					2005					2004					2003				
	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4	FERIUS	FERIDS	ERUS	ERDS	ERSW4
Family Naucoridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Notonectidae	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Gerridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Dytiscidae	4	27	10	68	89	4	23	16	45	15	8	24	4	33	49	3	0	41	92	64	22	29	12	33	28
Family Hydrochidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrochus	1	0	1	6	1	0	4	5	4	0	0	3	2	5	6	0	0	11	4	9	0	5	12	1	5
Family Hydrophilidae	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	0
Berosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Georissidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georissus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Family Hydraenidae	1	1	2	1	5	0	26	7	3	0	0	3	3	8	3	0	0	12	2	4	6	9	5	8	6
Family Noteridae	1	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
Family Elmidae	5	2	18	8	13	3	1	15	3	9	0	0	11	6	7	1	8	7	5	4	7	5	7	11	6
Family Limnichidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	1
Family Gyrinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Scirtidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Staphylinidae	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Order Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Zygoptera	0	0	2	7	1	0	1	1	3	0	0	2	1	2	0	0	0	1	2	0	1	1	0	2	0
Family Protoneuridae	0	1	0	0	7	0	0	2	2	0	0	0	0	3	0	0	0	2	0	2	0	0	0	2	1
Family Isostictidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Family Coenagrionidae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-order Anisoptera	4	3	3	0	1	8	11	7	1	1	3	5	2	0	2	9	10	0	0	0	9	3	0	2	1
Family Cordulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pentathemus sp.	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Family Hemicorduliidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Libellulidae	1	0	0	0	1	1	0	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0
Family Gomphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrogomphus	1	3	7	6	5	0	4	8	3	0	0	1	0	0	0	2	2	8	3	0	1	1	3	4	1

TAXA	**2007**					**2006**					**2005**					**2004**					**2003**				
	FERIUS	**FERIDS**	**ERUS**	**ERDS**	**ERSW4**	**FERIUS**	**FERIDS**	**ERUS**	**ERDS**	**ERSW4**	**FERIUS**	**FERIDS**	**ERUS**	**ERDS**	**ERSW4**	**FERIUS**	**FERIDS**	**ERUS**	**ERDS**	**ERSW4**	**FERIUS**	**FERIDS**	**ERUS**	**ERDS**	**ERSW4**
Antipodogomphus	0	1	0	0	0	0	4	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Order Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Pyralidae	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHYLUM ANNELIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class Oligochaeta	6	14	4	8	0	8	18	3	2	2	6	6	2	8	7	7	4	2	1	4	6	5	2	6	3
PHYLUM NEMATODA	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Family Duesiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	235	210	328	455	457	268	214	418	250	236	243	206	203	247	385	259	217	258	228	199	234	203	236	346	237
# TAXA	25	25	27	28	28	25	30	28	30	28	21	27	24	28	30	21	19	31	23	20	27	27	28	30	25

Appendix 10. Scaled aquatic macroinvertebrate abundance data for 2003-2014.

Year	FRUS			FRDS			ERUS			ERSW4			ERDS		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
2014	2943	2478	3114	564	1750	3867	3086	7300	6933	7967	9600	4400	11167	13633	5700
2013	3300	4300	1654	2900	3029	2010	3867	8067	6450	8033	4680	7467	2957	6833	2267
2012	2538	2367	1608	2256	1717	1855	2456	5775	4420	4480	6733	3383	5925	4980	5075
2011	3567	2857	2488	3333	1340	1367	3600	6150	3143	5520	5450	2538	6833	11033	5075
2010	6833			3571			8467			8000			8067		
2009	5475			11667			14633			14733			18700		
2008	4480			6933			5600			19450			9300		
2007	4700			4200			10933			15233			15167		
2006	4467			1529			13933			7867			8333		
2005	4050			1873			6767			12833			8233		
2004	4317			2170			6450			2488			3800		
2003	7800			5075			7867			7900			11533		

Year	FRBTM			ERTOP			ERBTM		
	1	2	3	1	2	3	1	2	3
2014	2210	8933	2650	5800	2775	9233	7067	10433	16267
2013	1562	2100	3517	5525	2444	2040	3550	8100	5125
2012	1900	4240	3433	3583	1708	2638	3100	4350	3043

Appendix 11. *In situ* physical and chemical water quality parameters measured at the macroinvertebrate sampling sites from 2003 to 2013.

YEAR	SITE CODE	DATE	EC uS/cm	pH	Temp ^{0}C	DO (mg/L)	Turb_fd NTU
2003	FERIUS	30-Apr-03	15.7	6.85	28.1		
	FERIDS	30-Apr-03	16.1	6.68	29.2		
	EDRIUSST	01-May-03	13.2	6.74	27.2		
	EDRIDSST	01-May-03	45.4	6.37	28.2		
	EDRIDSSW4	02-May-03	41.5	6.56	27.5		
2004	FERIUS	27-Apr-04	10	6.66	26.5		
	FERIDS	27-Apr-04	0	6.58	28.7		
	EDRIUSST	28-Apr-04	10	6.67	25.5		
	EDRIDSST	28-Apr-04	10	6.51	28		
	EDRIDSSW4	28-Apr-04	40	6.51	29		
2005	FERIUS	27-Apr-05	28.5	6.43	26.7		
	FERIDS	28-Apr-05	37.3	6.94	29.4		
	EDRIUSST	29-Apr-05	18.8	6.31	26		
	EDRIDSST	29-Apr-05	32.2	6.32	27.1		
	EDRIDSSW4	29-Apr-05	35.5	6.61	28.4		
2006	FERIUS	25-May-06	22.5	6.15	24.3		
	FERIDS	25-May-06	21.7	6.17	25.5		
	EDRIUSST	24-May-06	24.3	6.3	23.9		
	EDRIDSST	24-May-06	32.3	6.2	24.6		
	EDRIDSSW4	24-May-06	37.5	6.25	25.1		
2007	FERIUS	25-May-06	20.5	6.7	26.9		
	FRDS	25-May-06	36.9	5.55	29.4		
	EDRIUSST	24-May-06	28.7	7	27.3		
	EDRIDSST	24-May-06	31.9	6.98	26.9		
	EDRIDSSW4	24-May-06	37.2	6.62	25.8		
2008	FRUS	16-Apr-08	20.7	6.26	27		
	FRDS	17-Apr-08	19.6	6.36	24.6		
	ERUS	18-Apr-08	17.2	5.76	23.3		
	ERDS	15-Apr-08	33.8	6.98	26.4		
	ERSW4	18-Apr-08	27.6	6.27	24.9		
2009	FRUS	29-Apr-09	16.8	6.48	26.4		
	FRDS	29-Apr-09	16.2	6.23	24.5		
	ERUS	28-Apr-09	19.3	6.75	27.3		
	ERDS	30-Apr-09	14.7	5.73	23.7		
	ERSW4	30-Apr-09	16.4	6.02	25		
2010	FRUS	14-Apr-10	26.9	5.95	30.7		1.41
	FRDS	14-Apr-10	22.3	6.02	28.7		1.96
	ERUS	13-Apr-10	22.8	5.46	29.4		0.74
	ERDS	13-Apr-10	28.7	6.01	29.7		1.02
	ERSW4	13-Apr-10	31	5.81	30.1		0.63
2011	FRUS	12-May-11	16.8	5.62	25.7		3.5
	FRDS	10-May-11	17.0	5.46	24.3		2.4
	ERUS	13-May-11	15.2	5.93	22.4		0.2
	ERDS	13-May-11	27.0	6.02	22.4		1.0
	ERSW4	11-May-11	29.3	6.14	23.2		1.4

YEAR	SITE CODE	DATE	EC uS/cm	pH	Temp ^{0}C	DO (mg/L)	Turb_fd NTU	ORP (mV)	Alkalinity (mg CaCO$_3$)
2012	FRUS	26-May-12	16.0	6.51	21.5	7.39	**		
	FRDS	25-May-12	17.2	6.39	24.14	8.02			
	FRBTM	24-May-12	19.9	6.73	24.43	7.77			
	ERTOP	14-Jun-12	10.8	6.68	19.37	8.37			
	ERUS	27-May-12	14.7	6.61	21.06	8.31			
	ERSW4	17-May-12	30.3	6.80	23.02	7.92			
	ERDS	19-May-12	28.0	7.0	22.49	7.65			
	ERBTM	19-May-12	31.0	6.8	24.44	Log			
2013	FRUS	06-Jun-13	25.2	5.98	24.8	7.68	1.18	174.3	
	FRDS	04-Jun-13	25.7	5.68	24.0	7.25	0	198.6	29.5
	FRBTM	05-Jun-13	34.0	6.27	24.6	8.19	0.35	174.8	22.5
	ERTOP	29-May-13	31.6	6.41	25.7	7.31	0	278.6	16.0
	ERUS	28-May-13	20.7	6.22	25.2	7.61	0	204.6	
	ERSW4	28-May-13	37.9	6.08	23.6	7.4	0	194.2	17.6
	ERDS	31-May-13	34.9	5.98	24.0	7.0	0	246.6	18.0
	ERBTM	30-May-13	39.6	6.65	26.4	8.06	0	143.8	

** Lack of turbidity data due to equipment failure.

Appendix 12. Results for surface water quality samples collected at macroinvertebrate sampling sites in 2014.

Site	**Replicate**	**Date sampled**	**Date analyzed**	**Ammonia** *as N in water*	**Total Cyanide**	**Nitrate** *as N in water*	**Nitrite** *as N in water*	**Chloride, Cl**	**Sulfate, SO4**	**Sodium - Total**	**Potassium - Total**	**Calcium - Total**	**Magnesium - Total**	**Sodium - Dissolved**
				mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
FRUS	0	5/06/2014	12/06/2014	0.006	<0.004	<0.005	<0.005	2	<1	2.6	<0.5	<0.5	0.5	2.3
FRDS	0	5/06/2014	12/06/2014	0.006	<0.004	0.006	<0.005	2	<1	2.8	<0.5	<0.5	0.6	2.3
FRBTM	0	6/06/2014	12/06/2014	0.014	<0.004	0.013	<0.005			2.9	<0.5	0.7	0.8	2.6
ERTOP	0	3/06/2014	12/06/2014	<0.005	0.004	<0.005	<0.005	2	<1	1.8	<0.5	<0.5	<0.5	1.6
ERTOP	1	3/06/2014	12/06/2014	<0.005	0.004	<0.005	<0.005	2	<1	1.8	<0.5	<0.5	<0.5	
ERUS	0	4/06/2014	12/06/2014	0.006	0.008	<0.005	<0.005	1	<1	1.9	<0.5	<0.5	<0.5	1.6
ERUS	1	4/06/2014												1.6
ERDS	0	3/06/2014	12/06/2014	0.099	<0.004	0.17	<0.005	2	34	8.1	1.9	4.7	4.6	7.1
ERSW4	0	2/06/2014	12/06/2014	0.09	<0.004	0.19	<0.005	2	33	7.8	1.8	4.5	4.4	6.8
ERBTM	0	3/06/2014	12/06/2014	0.018	<0.004	0.16	<0.005	2	34	7.9	1.8	4.3	4.5	7.3

Site	**Replicate**	**Date sampled**	**Date analyzed**	**Potassium - Dissolved**	**Calcium - Dissolved**	**Magnesium - Dissolved**	**Aluminium-Dissolved**	**Arsenic-Dissolved**	**Beryllium-Dissolved**	**Boron-Dissolved**	**Cadmium-Dissolved**	**Chromium-Dissolved**	**Cobalt-Dissolved**
				mg/L	*mg/L*	*mg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*
FRUS	0	5/06/2014	12/06/2014	<0.5	<0.5	<0.5	<10	<1	<0.5	9	<0.1	<1	<1
FRDS	0	5/06/2014	12/06/2014	<0.5	<0.5	<0.5	<10	<1	<0.5	9	<0.1	<1	<1
FRBTM	0	6/06/2014	12/06/2014	<0.5	<0.5	0.7	<10	<1	<0.5	9	<0.1	<1	<1
ERTOP	0	3/06/2014	12/06/2014	<0.5	<0.5	<0.5	<10	<1	<0.5	9	<0.1	<1	<1
ERTOP	1	3/06/2014	12/06/2014				[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
ERUS	0	4/06/2014	12/06/2014	<0.5	<0.5	<0.5	<10	<1	<0.5	9	<0.1	<1	<1
ERUS	1	4/06/2014		<0.5	<0.5	<0.5	<10	<1	<0.5	9	<0.1	<1	<1
ERDS	0	3/06/2014	12/06/2014	1.6	4	4	<10	<1	<0.5	9	<0.1	<1	<1
ERSW4	0	2/06/2014	12/06/2014	1.6	3.7	3.7	<10	<1	<0.5	8	<0.1	<1	<1
ERBTM	0	3/06/2014	12/06/2014	1.6	3.8	3.9	<10	<1	<0.5	9	<0.1	<1	<1

Site	**Replicate**	**Date sampled**	**Date analyzed**	**Copper-Dissolved**	**Iron-Dissolved**	**Mercury-Dissolved**	**Lanthanum-Dissolved**	**Lead-Dissolved**	**Manganese-Dissolved**	**Nickel-Dissolved**	**Uranium-Dissolved**	**Zinc-Dissolved**	**Aluminium-Total**
				µg/L	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*
FRUS	0	5/06/2014	12/06/2014	<1	150	<0.05	<1	<1	6	<1	<0.5	3	10
FRDS	0	5/06/2014	12/06/2014	<1	200	<0.05	<1	<1	9	<1	<0.5	7	20
FRBTM	0	6/06/2014	12/06/2014	<1	240	<0.05	<1	<1	11	<1	<0.5	<1	30
ERTOP	0	3/06/2014	12/06/2014	<1	180	<0.05	<1	<1	<5	<1	<0.5	<1	20
ERTOP	1	3/06/2014	12/06/2014	[NT]	[NT]	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	20
ERUS	0	4/06/2014	12/06/2014	<1	180	<0.05	<1	<1	5	<1	<0.5	<1	10
ERUS	1	4/06/2014		<1	180	[NT]	<1	<1	5	<1	<0.5	<1	
ERDS	0	3/06/2014	12/06/2014	<1	71	<0.05	<1	<1	40	<1	<0.5	5	20
ERSW4	0	2/06/2014	12/06/2014	<1	67	<0.05	<1	<1	36	<1	<0.5	5	20
ERBTM	0	3/06/2014	12/06/2014	1	100	<0.05	<1	<1	35	<1	<0.5	7	10

Site	**Replicate**	**Date sampled**	**Date analyzed**	**Arsenic -Total**	**Beryllium -Total**	**Boron-Total**	**Cadmium -Total**	**Chromium-Total**	**Cobalt-Total**	**Copper-Total**	**Iron-Total**	**Mercury -Total**	**Lanthanum-Total**	**Lead-Total**
				µg/L	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*	*µg/L*
FRUS	0	5/06/2014	12/06/2014	<1	<0.5	10	<0.1	<1	<1	<1	380	<0.05	<1	<1
FRDS	0	5/06/2014	12/06/2014	<1	<0.5	10	<0.1	<1	<1	<1	500	<0.05	<1	<1
FRBTM	0	6/06/2014	12/06/2014	<1	<0.5	11	<0.1	<1	<1	<1	510	<0.05	<1	<1
ERTOP	0	3/06/2014	12/06/2014	<1	<0.5	10	<0.1	<1	<1	<1	330	<0.05	<1	<1
ERTOP	1	3/06/2014	12/06/2014	<1	<0.5	10	<0.1	<1	<1	<1	340	[NT]	<1	<1
ERUS	0	4/06/2014	12/06/2014	<1	<0.5	10	<0.1	<1	<1	<1	360	<0.05	<1	<1
ERUS	1	4/06/2014												
ERDS	0	3/06/2014	12/06/2014	<1	<0.5	10	<0.1	<1	<1	1	430	<0.05	<1	<1
ERSW4	0	2/06/2014	12/06/2014	<1	<0.5	9	<0.1	<1	<1	2	440	<0.05	<1	<1
ERBTM	0	3/06/2014	12/06/2014	<1	<0.5	9	<0.1	<1	<1	1	310	<0.05	<1	<1

Site	**Replicate**	**Date sampled**	**Date analyzed**	**Manganese -Total**	**Nickel-Total**	**Uranium-Total**	**Zinc-Total**
				µg/L	*µg/L*	*µg/L*	*µg/L*
FRUS	0	5/06/2014	12/06/2014	7	<1	<0.5	3
FRDS	0	5/06/2014	12/06/2014	12	<1	<0.5	2
FRBTM	0	6/06/2014	12/06/2014	13	<1	<0.5	11
ERTOP	0	3/06/2014	12/06/2014	6	<1	<0.5	2
ERTOP	1	3/06/2014	12/06/2014	6	<1	<0.5	1
ERUS	0	4/06/2014	12/06/2014	6	<1	<0.5	1
ERUS	1	4/06/2014					
ERDS	0	3/06/2014	12/06/2014	42	<1	<0.5	6
ERSW4	0	2/06/2014	12/06/2014	42	<1	<0.5	6
ERBTM	0	3/06/2014	12/06/2014	38	<1	<0.5	8

Appendix 13. Sediment chemistry results for selected macroinvertebrate sites in 2014.

Site	**Position**	**Replicate**	**Date sampled**	**Date analyzed**	**Aluminium** *1M HCl extract*	**Arsenic** *1M HCl extract*	**Beryllium**	**Cadmium** *1M HCl extract*	**Cobalt** *1M HCl extract*	**Chromium** *1M HCl extract*	**Copper** *1M HCl extract*
					mg/kg	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
FRDS	Edge	0	5/06/2014	17/06/2014	600	5	<1	<0.4	14	<1	3
FRDS	Edge	1	5/06/2014								
FRDS	Benthic	0	5/06/2014	17/06/2014	57	<4	<1	<0.4	<1	<1	<1
ERTOP	Edge	0	3/06/2014	17/06/2014	840	<4	<1	<0.4	1.6	1	2
ERTOP	Edge	1	3/06/2014		640	<4	<1	<0.4	2	1	2
ERTOP	Benthic	0	3/06/2014	17/06/2014	38	<4	<1	<0.4	<1	<1	<1
ERTOP	Benthic	1	3/06/2014	17/06/2014							
ERSW4	Edge	0	2/06/2014	17/06/2014	210	<4	<1	<0.4	<1	<1	3
ERSW4	Benthic	0	2/06/2014	17/06/2014	110	<4	<1	<0.4	2.5	<1	3
ERBTM	Edge	0	3/06/2014	17/06/2014	200	<4	<1	<0.4	2.7	<1	7
ERBTM	Benthic	0	6/06/2014	17/06/2014	94	<4	<1	<0.4	1.3	<1	5
FRBTM	Edge	0	6/06/2014	17/06/2014	270	<4	<1	<0.4	1.3	<1	3

Site	**Position**	**Replicate**	**Date sampled**	**Date analyzed**	**Iron** *1M HCl extract*	**Mercury** *1M HCl extract*	**Lanthanum**	**Manganese** *1M HCl extract*	**Nickel** *1M HCl extract*	**Lead** *1M HCl extract*	**Uranium** *1M HCl extract*
					mg/kg	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
FRDS	Edge	0	5/06/2014	17/06/2014	9800	<0.1	<1	740	5	6	<1
FRDS	Edge	1	5/06/2014								
FRDS	Benthic	0	5/06/2014	17/06/2014	520	<0.1	<1	10	<1	1	<1
ERTOP	Edge	0	3/06/2014	17/06/2014	5800	<0.1	<1	46	<1	3	<1
ERTOP	Edge	1	3/06/2014		5000	<0.1	<1	38	<1	2	<1
ERTOP	Benthic	0	3/06/2014	17/06/2014	250	<0.1	<1	9	<1	<1	<1
ERTOP	Benthic	1	3/06/2014	17/06/2014							
ERSW4	Edge	0	2/06/2014	17/06/2014	530	<0.1	<1	20	<1	2	<1
ERSW4	Benthic	0	2/06/2014	17/06/2014	1200	<0.1	<1	130	<1	1	<1
ERBTM	Edge	0	3/06/2014	17/06/2014	2800	<0.1	<1	96	1	2	<1
ERBTM	Benthic	0	6/06/2014	17/06/2014	1900	<0.1	<1	30	<1	1	<1
FRBTM	Edge	0	6/06/2014	17/06/2014	1400	<0.1	<1	87	<1	5	<1

Site	**Position**	**Replicate**	**Date sampled**	**Date analyzed**	**Zinc** *1M HCl extract*	**Calcium**	**Potassium**	**Magnesium**	**Sodium**
					mg/kg	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
FRDS	Edge	0	5/06/2014	17/06/2014	9	280	670	620	70
FRDS	Edge	1	5/06/2014						
FRDS	Benthic	0	5/06/2014	17/06/2014	<1	10	90	50	<10
ERTOP	Edge	0	3/06/2014	17/06/2014	1	70	260	330	20
ERTOP	Edge	1	3/06/2014		8				
ERTOP	Benthic	0	3/06/2014	17/06/2014	<1	30	60	56	<10
ERTOP	Benthic	1	3/06/2014	17/06/2014		20	60	72	<10
ERSW4	Edge	0	2/06/2014	17/06/2014	8	220	400	470	30
ERSW4	Benthic	0	2/06/2014	17/06/2014	10	55	180	140	<10
ERBTM	Edge	0	3/06/2014	17/06/2014	21	100	370	420	20
ERBTM	Benthic	0	6/06/2014	17/06/2014	12	53	220	210	<10
FRBTM	Edge	0	6/06/2014	17/06/2014	2	300	1000	960	150

Site	**Position**	**Replicate**	**Date analyzed**	**pH**	**Total Organic Carbon**	**Chloride, Cl**	**Sulfate, SO4**	**Ammonia as N in soil**	**Nitrate as N in soil**	**Nitrite as N in soil**	**Total Cyanide**
				1:5 soil:water	*(Combustion)*	*1:5 soil:water*	*1:5 soil:water*				
				pH Units	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
FRDS	Edge	0	13/06/2014	5.7	11000	34	10	52	<0.5	<0.1	<0.5
FRDS	Edge	1	13/06/2014	5.7	9700	35	10	51	<0.5	<0.1	<0.5
FRDS	Benthic	0	13/06/2014	6.4	860	<10	<10	17	<0.5	<0.1	<0.5
ERTOP	Edge	0	13/06/2014	5	32000	10	<10	42	<0.5	<0.1	<0.5
ERTOP	Edge	1									
ERTOP	Benthic	0	13/06/2014	6.6	390	<10	<10	12	<0.5	<0.1	<0.5
ERTOP	Benthic	1									
ERSW4	Edge	0	13/06/2014	5.1	18000	32	100	41	<0.5	<0.1	<0.5
ERSW4	Benthic	0	13/06/2014	6.3	1600	<10	20	14	<0.5	<0.1	<0.5
ERBTM	Edge	0	13/06/2014	5.1	5200	<10	92	48	<0.5	<0.1	<0.5
ERBTM	Benthic	0	13/06/2014	5.5	1200	<10	20	26	<0.5	<0.1	<0.5
FRBTM	Edge	0	13/06/2014	4.6	23000	140	36	120	<0.5	0.2	<0.5