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ACTEW Water

Murrumbidgee Ecological Monitoring Program

Part 4: Tantangara to Burrinjuck

Autumn 2012

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List of Abbreviations

ACT	– Australian Capital Territory
ACTEW	– ACTEW Water (previously ACTEW Corporation Ltd and ActewAGL Dist. Pty Ltd)
ANZECC	– Australian and New Zealand Environment and conservation Council
ANOSIM	– Analysis of Similarities (statistics)
ANOVA	– Analysis of Variance (statistics)
ARI	– Annual Recurrence Interval
ARMCANZ	- Agriculture and Resource Management Council Of Australia and New Zealand
AUSRIVAS	– Australian River Assessment System
CPOM	– Coarse Particulate Organic Matter
CRCFE	– Cooperative Research Centre for Freshwater Ecology
EC	– Electrical Conductivity
ECD	– Enlarged Cotter Dam
EIS	– Environmental Impact Statement
EPA	– Environmental Protection Authority
EPT	– Ephemeroptera, Plecoptera, Trichoptera
D.O.	– Dissolved Oxygen
GL/a	– Gigalitres per annum
GPS	– Global Positioning System
LMWQCC	– Lower Molonglo Water Quality Control Centre
LWD	– Large Woody Debris
M2G	– Murrumbidgee to Googong water transfer project
MEMP	– Murrumbidgee Ecological Monitoring Program
ML/d	– Megalitres per day
NATA	– National Association of Testing Authorities
NMDS	– Non-metric Multidimensional Scaling (statistics)
O/E Family	– Observed to Expected ratio of macroinvertebrate families
PCA	– Principal Components Analysis
Q	– Daily flow rate (ML/d)
QA	– Quality Assurance
QC	– Quality Control
RBA	– Rapid BioAssessment
SIGNAL	– Stream Invertebrate Grade Number – Average Level
SIMPER	– Similarity Percentage (statistics)
TN	– Total Nitrogen
TP	– Total Phosphorus
Temp.	- Water temperature (°C)
WAE	– Water Allocation Entitlement
WL	– Water Level

Executive Summary

In light of the recent drought in the ACT region (2000-2010), ACTEW Water (previously ACTEW Corporation), the water utility company for the ACT, developed a water supply security program that encompassed the development of new infrastructure in order to secure long term water supply for the ACT. One of the project options put forward was the "Tantangara transfer" which involves transferring water from the Tantangara Reservoir on the upper Murrumbidgee River to the ACT via run of river flow, and then abstracting the water at Angle Crossing and transferring it to the Googong Reservoir. This provides a source of water that is less dependent on rainfall within the ACT.

The Murrumbidgee Ecological Monitoring Program was set up by ACTEW Water to evaluate the potential impacts of water abstraction from the Murrumbidgee River. It is designed to address concerns raised by both Government and non-Government stakeholders; and to provide ACTEW Water with relevant information regarding any beneficial and/or detrimental ecological effects of the abstraction. The MEMP was set up to be implemented prior to the commencement of the Murrumbidgee to Googong transfer project (M2G), allowing ACTEW to collect pre-abstraction baseline data to compare against post-abstraction data once the M2G project is in operation. The MEMP study has undertaken pre-abstraction sampling in spring and autumn since spring 2008.

There are four component areas that have been established for the MEMP. This report focuses on Part 4: Tantangara to Burrinjuck. In particular, it focuses on results of the autumn 2012 macroinvertebrate sampling run.

The key aim of this sampling run was to collect water quality and macroinvertebrate information and establish baseline conditions against which future monitoring results can be assessed.

Autumn 2012 sampling was conducted between the 1st and 11th of May. Sampling occurred approximately eight weeks after a major high flow event that affected several river catchments in the greater ACT/NSW region. Peak flows at the Hall's Crossing gauging station reached 200,000 ML /d, while further upstream data collected from the Mount MacDonald gauging station indicated this to be approximately a 1 in 10 year Average Recurrence Interval (ARI) flood event for that site. The following is a summary of the water quality and biological assessments for that period.

The physico-chemical water quality parameters were, for the most part, within the ANZECC and ARMCANZ guidelines for upland river ecosystem health. In the upper reaches in Zone 1, electrical conductivity (EC) and turbidity were low, and at two of the sites in that Zone (MUR 1 and 2), these values were below the recommended minimum value. Exceedances in pH occurred at all sites downstream of Angle Crossing, however the recorded values were either on the cusp of the upper limit or between 0.1 and 0.2 units above the recommended value of 8.0. These exceedances are not thought to be related to the M2G project since they represent a continuum of increasing pH down the system.

Nutrients (total phosphorus and total nitrogen) exceeded the guideline concentrations at most sites downstream of the Bredbo river confluence suggesting significant nutrient inputs from the Numeralla and Bredbo Rivers which both flow into the Murrumbidgee River between MUR 9 and MUR 12.

Continuous water quality data shows typical responses to high flow events, and there is no indication from the monitoring sites of any impact from the new ACTEW projects in the catchment. The gauging station at Hall's Crossing was damaged by the March 2012 flood and there is no water data available from that station during the autumn period.

AUSRIVAS results fluctuated between Band A and Band B throughout the catchment and there were obvious patterns in these results other than the Band A assessments dominating the edge habitat at sites MUR 1-9. Band B assessments were more common in Zones 2-4, which is consistent with previous sampling periods. This is attributed to changes in landuse in these sections of the Murrumbidgee River, but in this sampling run the impact of the March flood cannot be ruled out as a contributing factor, since the high flows encountered farther downstream are likely to have had a significant impact on the macroinvertebrate communities. Furthermore, there was a noticeable increase in Simuliidae (black fly larvae), which tended to dominate the riffle communities at some sites. This is probably due to the influence of the prolonged high flows down the Cotter River and the operation of the Bendora Main scour valve increasing flows downstream of the Cotter River confluence; offering ideal conditions for Simuliidae to thrive.

The indication from the macroinvertebrate community data is that the influence of high flow events such as the one seen in March can reduce macroinvertebrate abundances and most likely diversity. After eight weeks of recovery time, there is evidence to suggest that taxa richness has returned to its pre-flood state although abundances are still considerably lower suggesting that recovery in diversity (composition) can be fairly rapid after such events, but abundances (and secondary production) may take longer to establish because of limited food sources, competition and other factors.

The current programme should continue in order to capture a wider range of hydrological conditions. This will facilitate better predictive power over various scenarios prior to the operation of the Tantangara Transfer project. Currently the MEMP has captured various stages of succession following high flow events, medium sized events and an extended environmental flow releases from Tantangara Reservoir. The knowledge gap in this project is how river health is affected under various low-flow scenarios typical of when water abstraction would be anticipated. While this is beyond control, future monitoring runs may benefit from "targeting" low flow periods within a given season.

1. Introduction

The drought in the ACT, which began in the year 2000, progressively caused declines in the ACT's dam storage volumes to unprecedented levels. ACTEW Water (formally ACTEW Corporation), the major water utility company in the ACT, developed a water security program that encompassed upgrading the existing Cotter Dam, and development of new infrastructure to pump water from the Murrumbidgee River in order to secure water for the Australian Capital Territory (ACT). One of the new water security projects put forward was the "Tantangara transfer" which would involve transferring water from the Tantangara Reservoir in the upper Murrumbidgee River to the ACT via run of river flow, with the aim of providing a source of water that is less dependent on rainfall within the ACT.

In order to use water from the Tantangara Reservoir, ACTEW Water has constructed a river off- take pumping structure, with a pipeline from Angle Crossing (southern border of the ACT) to the Googong catchment. The pumping system will transfer water from Angle Crossing through a 1m diameter underground pipeline into Burra Creek, and then transfer the water by run of river flow into the Googong Reservoir. The system is designed to enable pumping of up to 100 ML/d. Abstraction will be dictated by the storage level in Googong reservoir, the level of demand for the water, the availability of water in the Murrumbidgee River allowing for environmental flow requirements, and by the water quality trigger values. The abstraction infrastructure is referred to as the Murrumbidgee to Googong project (M2G). A schematic overview of how the ACT Water Supply system fits within the Tantangara to Burrinjuck catchment is given in Appendix A.

Required base flows to be maintained in the Murrumbidgee River will be regulated through the ACT Environmental Flow Guidelines (ACT Government, 2011) and associated water abstraction licence. ACT and NSW Government agencies, and recreational and rural users in the regional Murrumbidgee River reach (both upstream and downstream of the ACT), are key stakeholders in the ACT water supply projects.

The Murrumbidgee Ecological Monitoring Program (MEMP) was set up by ACTEW Water to evaluate the potential impacts of water abstraction from the Murrumbidgee River. It was designed to address concerns raised by both Government and non-Government stakeholders; and to provide ACTEW Water with relevant information regarding any beneficial and/or detrimental ecological effects of the project. The MEMP was implemented prior to the commencement of the M2G project, allowing ACTEW Water to collect pre-abstraction baseline data to compare against the post-abstraction data once the M2G project is in operation. Pre-operational sampling has been conducted in spring and autumn each year since 2008.

There are four component areas covered as part of the MEMP:

- Part 1: Angle Crossing;
- Part 2: Burra Creek (discharge point for Angle Crossing abstraction);
- Part 3: Murrumbidgee Pump Station; and
- **Part 4: Tantangara to Burrinjuck**

This report focuses on Part 4: Tantangara to Burrinjuck.

1.1 Objectives

The overall objectives of Part 4 of the MEMP are to monitor the physical, biological and water quality indicators along the length of the upper Murrumbidgee River from Tantangara to Burrinjuck reservoirs. The intention of the seasonal sampling is to establish baseline macroinvertebrate data for key sites along the Murrumbidgee River and, in doing so, establish a data base of the existing condition prior to any releases from Tantangara Reservoir. The baseline monitoring incorporates water quality monitoring (including nutrient analysis) and macroinvertebrate monitoring based on the Australian River Assessment System (AUSRIVAS) sampling and assessment framework.

With these procedures in place, GHD will be able to provide ACTEW with appropriate information to further develop knowledge and understanding of environmental flows and ecosystem thresholds. The information derived from this program will also support ACTEW's adaptive management approach to water abstraction and environmental flow provision in the ACT. Frequent review of the MEMP will ensure that the monitoring has the capacity to adapt to changing environmental, social and economic conditions, with regard to ACTEW Water's operational requirements.

1.2 Scope of Work

The works outlined in the proposal (ALS, 2011, GHD, 2012) included the following:

- Bi-annual sampling, in spring and autumn;
- Macroinvertebrate sampling of both the riffle and edge habitats as per ACT AUSRIVAS protocols;
- Macroinvertebrates to be identified to the taxonomic level of family;
- In-situ water quality measurements to be collected and analysed for physico-chemical parameters and nutrients; and
- Water quality analysis to be conducted in Australian Laboratory Services (ALS) NATA accredited laboratory in Canberra.
- The purpose of this biannual seasonal report is to convey the results of the macroinvertebrate and water quality sampling from Tantangara Reservoir to Burrinjuck Reservoir in autumn 2012. Several sites within this report are also key components of the three main sub-sections of the MEMP, including monitoring for the Murrumbidgee Pump Station (MPS) upgrade operation and the impact assessment of the construction and operation of the Angle Crossing pump station and pipeline, which includes the eventual discharge into Burra Creek. The sampling regime for these sub-sections differs slightly to those reported here, mainly in that replicate macroinvertebrate samples were collected for ecological assessment in the other sub-sections and a higher level (Genus) of identification was sometimes applied. This means that a more comprehensive list of macroinvertebrate taxa is likely to be captured for those sub-sections. For the Tantangara to Burrinjuck component of the MEMP, only one macroinvertebrate sample was included for each habitat type at each site and identification was only to Family level. In order to compare data from the Tantangara to Burrinjuck study to those collected as part of other study components, the first sub-sample from the first replicate macroinvertebrate sample taken at each site from those other studies was selected for inclusion in the data analysis. As a result of this process, it should be recognised that there are small discrepancies between the taxonomic inventories, taxonomic richness measurements and presence / absence of taxa reported here and those reported in relation to other sub-sections of the MEMP.

2. Materials and Methods

2.1 Study Sites

As stated in the objectives of this program, macroinvertebrate community composition and water quality is to be monitored along the Murrumbidgee River between the Tantangara and Burrinjuck reservoirs, with the aim of obtaining current information about ecological condition. Ecological monitoring was conducted in accordance with AUSRIVAS sampling protocols.

The upper Murrumbidgee River is impacted by a range of landuse practices throughout the catchment. Consequently, it was important to sample a sufficiently large number of sites to provide a realistic snap-shot of the current macroinvertebrate community across all existing landuse impacts. Both riffle and edge habitats were sampled, where possible, to provide a more complete picture of the macroinvertebrate community at each site.

Sites are the same as previous sampling runs and were chosen based on several criteria including:

1. Accessibility – safe and with approvals from land owners;
2. Sites which have representative habitats (i.e. riffle / pool sequences). If both habitats were not present then riffle zones took priority as the they are the most likely to be affected by water abstractions; and
3. Sites which have historical ecological data sets (e.g. Keen (2001)) took precedence over "new sites" – thus allowing comparisons through time to help assess natural variability through the system.

Potential sites were identified initially from topographic maps and then visited prior to sampling to assess suitability. In total, 23 sites fulfilled the above criteria. These sites include 10 sites upstream and 13 sites downstream of Angle Crossing (ACT), locations upstream and downstream of the Lower Molonglo Water Quality Control Centre (LMWQCC) and several of the Murrumbidgee River's major tributaries (Table 1 Figure 1).

The sites were divided up into four macro-reaches (zones) which represent geographic or hydrological changes (Allan and Castillo, 2008) throughout the system; and obvious changes in terms of landuse, erosional processes and/or other potential anthropogenic impacts. These classifications are to some extent subjective, but are based on previous frameworks which have suggested methods for such classifications (e.g. Frissell et al., 1986; Hynes, 1970; Allan and Castillo, 2008). Details of the four zones are provided in Table 2.

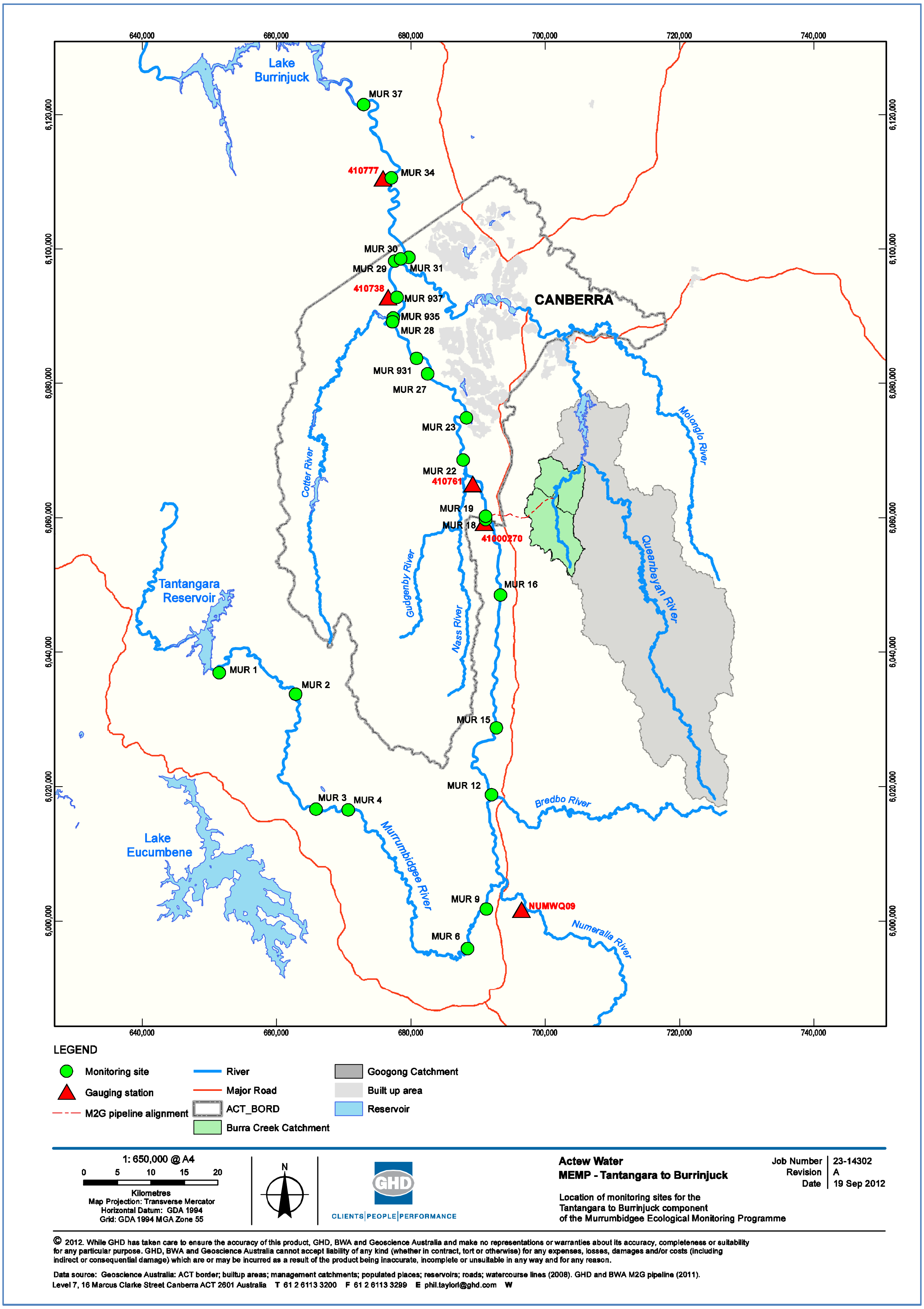

Figure 1 Location of macroinvertebrate sampling sites and continuous monitoring stations on the Murrumbidgee River

Table 1 Sampling site locations and details

Site Code	Location	Alt. (m)	Landuse	Habitat sampled
MUR 1	D/S Tantangara Reservoir	1200	Native	Riffle and Edge
MUR 2	Yaouk Bridge	1070	Grazing	Riffle and Edge
MUR 3	Bobeyan Road Bridge	968	Grazing	Riffle and Edge
MUR 4	Camp ground off Bobyon Road	968	Recreation / Grazing	Riffle and Edge
MUR 6	D/S STP Pilot Creek Road	743	Native / Residential	Riffle and Edge
MUR 9	Murrells Crossing	723	Grazing	Riffle and Edge
MUR 12	Through Bredbo township	698	Grazing / Residential / Recreation	Riffle and Edge
MUR 15	Near Colinton - Bumbalong Road	658	Grazing / Recreation	Riffle and Edge
MUR 16	The Willows - Near Michelago	646	Grazing / Recreation	Riffle and Edge
MUR 18	U/S Angle Crossing	608	Grazing	Riffle and Edge
MUR 19	D/S Angle Crossing	608	Grazing / Recreation	Riffle and Edge
MUR 22	Tharwa Bridge	572	Recreation / Grazing / Residential	Riffle and Edge
MUR 23	Point Hut Crossing	561	Recreation / Residential	Riffle and Edge
MUR 27	Kambah Pool	519	Recreation / Residential	Riffle and Edge
MUR 931	“Fairvale” ~4km U/S of the Cotter Confluence	480	Grazing	Riffle and Edge
MUR 28	U/S Cotter River confluence	468	Grazing	Riffle and Edge
MUR 935	Casuarina sands	471	Grazing	Riffle and Edge
MUR 937	Mt. MacDonald ~5km D/S of the Cotter Confluence	460	Grazing / ex-forestry/ Recreation	Riffle and Edge
MUR 29	Uriarra Crossing	445	Grazing	Riffle and Edge
MUR 30	U/S Molonglo Confluence	445	Grazing	Riffle and Edge
MUR 31	D/S Molonglo Confluence	443	Grazing	Riffle and Edge
MUR 34	Halls Crossing	393	Grazing	Riffle and Edge
MUR 37	Boambolo Road	370	Grazing	Edge

Note: U/S – upstream, D/S – downstream

Table 2 Zone structure of sites along the Murrumbidgee River

Macro-reach	Zone	Sites included	Land use
Tantangara - Cooma	1	MUR 1 - 4	Native. Reservoir within national park. Recreation. Agricultural land downstream of Yaouk
Cooma – Angle Crossing	2	MUR 6 - 18	Agriculture dominant. Some urbanization. STP present upstream of MUR 6.
Angle Crossing - LMWQCC	3	MUR 19 - 30	Residential and residential / urban development increases. Less grazing than in the Tantangara – Cooma and LMWQCC – Taemas Bridge macro-reaches
LMWQCC – Taemas bridge	4	MUR 31 - 37	Intensive agricultural landuse. Downstream of LMWQCC. Previous work has shown a marked change in water quality downstream of the treatment plant

2.1.1 Hydrology and Rainfall

River flows and rainfall for the sampling period were recorded at ALS operated gauging stations located: upstream of Angle Crossing (41000270); at Lobb's Hole (downstream of Angle Crossing: 410761); at Mount MacDonald (downstream of the Cotter River confluence: 410738) and at Halls Crossing (at MUR 34: 410777). A list of parameters measured at each station is given in Table 3. Stations were calibrated monthly and data were downloaded and verified before quality coding and storage in the ALS database. Water level data was manually verified by comparing the logger value to the physical staff gauge value and adjusted if required. Rain gauges were also calibrated and adjusted as required. Records were stored using the HYDSTRA© database management system.

Table 3 River flow monitoring locations and parameters

Site	Site Code	Location/Notes	Parameters*	Latitude	Longitude
1	41000270	M'bidgee River, upstream of Angle Crossing	WL, Q, pH, EC, DO, Temp, Turb, Rainfall	S 35.59070˚	E 149.1179˚
2	410761	M'bidgee River @ Lobb's Hole (D/S of Angle Crossing)	WL, Q, pH, EC, DO, Temp, Turb, Rainfall	S 35.53980˚	E 149.1015˚
3	410738	M'bidgee River @ Mt. MacDonald	WL, Q	S 35.29170˚	E 148.9565˚
4	410777	M'bidgee River @ Hall's Crossing	WL, Q, pH, EC, DO, Temp, Turb, Rainfall	S 35.13277˚	E 148.9425˚

** WL = Water Level; Q = Rated Discharge; EC = Electrical Conductivity; DO = Dissolved Oxygen; Temp = Temperature; Turb = Turbidity; Rainfall = Rainfall (min. 0.2 mm); D/S = downstream.*

2.2 Water Quality

In-situ physico-chemical parameters including temperature, pH, electrical conductivity, turbidity and dissolved oxygen were recorded using a multiprobe HYDROLAB® Minisonde 5 and Surveyor meter. The Minisonde and Surveyor unit were calibrated in accordance with QA procedures and the manufactures requirements prior to sampling.

From each site, grab samples were taken in accordance with the AUSRIVAS protocols (Nichols et al., 2000)and used for HYDROLAB® verification and nutrient analysis. Water samples were placed on ice, returned to the ALS Canberra laboratory and analysed for various water quality parameters in accordance with the protocols outlined in A.P.H.A (2005). Collectively, this information on the water quality parameters will assist with the interpretation of biological data and provide a basis to gauge changes that can potentially be linked to flow reductions at these key sites following water abstractions.

2.3 Macroinvertebrate Sampling

2.3.1 Sample collection

Macroinvertebrate samples were collected and analysed in accordance with the ACT AUSRIVAS protocols for riffle and edge habitats (Nichols et al., 2000). Samples were collected using a framed net (350 mm wide) with 250 µm mesh. Riffle habitat (flowing broken water over gravel, pebble, cobble or boulder, with a depth greater than 10cm (Nichols et al., 2000) sampling began at the downstream end of each riffle. The net was held perpendicular to the substrate with the opening facing upstream. The stream directly upstream of the net opening was disturbed by vigorously kicking and agitating the stream bed, allowing any dislodged material to be carried into the net. The process continued, working upstream over 10 metres of riffle habitat. Edge habitat (backwaters or areas of low flow within 0.5m of the bank) was sampled by sweeping the collection net along the edge habitat at the sampling site with the operator working systematically over a ten metre section and sampling where there was overhanging vegetation, submerged snags, macrophyte beds, overhanging banks and areas with trailing vegetation. The samples were then preserved in the field using 80% ethanol in clearly labelled containers showing site codes, habitat and date information.

2.3.2 Sample Processing

In the laboratory, the preserved macroinvertebrate samples were placed in a sub-sampler, comprising of 100 (10 X 10) cells (Marchant, 1989). The sub-sampler was then agitated to evenly distribute the sample. The contents of randomly selected cells were extracted, one at a time. Macroinvertebrates were examined under a microscope until a total of 200 animals were collected. If 200 animals were identified before a cell had been completely analysed, identification continued until all animals within the cell were identified. Macroinvertebrates present in each sample were identified to family level except for select groups such as Chironomidae (identified to sub-family), Oligochaeta (identified to class) and Acarina (identified to order). Macroinvertebrate identification was undertaken using a range of published and working keys. Upon the completion of macroinvertebrate identification, the samples were transferred to vials for long-term archiving. Samples can be re-examined at a later date if required (e.g. if the taxonomy changes significantly during the course of a long term monitoring program).

2.3.3 Macroinvertebrate quality control procedures

A number of Quality Control procedures were undertaken during the identification phase of this program including:

- Attempts were made to obtain significantly more than 200 organisms, to overcome losses associated with damage to intact organisms during vial transfer;
- Identification was performed by qualified and experienced aquatic biologists who had more than 100 hours of identification experience;
- When required, taxonomic experts performed confirmations of identification. Voucher specimens were also used when required;
- ACT AUSRIVAS QA/QC protocols were followed;
- 10% of samples were re-identified by another senior taxonomist;
- Very small, immature, or damaged animals or pupae that could not be positively identified were not included in the dataset (i.e. data that were not identified past Order level); and

2.4 Data analysis

2.4.1 Water quality

Principal Components Analysis (PCA), based on Euclidean distances, was used to determine which physico–chemical variables were most strongly associated with differences among sites. PCA is a multivariate analysis technique that is commonly used on environmental data as an exploratory procedure. It condenses a set of variables, in this case water quality, into a smaller number of derived variables (components). These components are linear combinations of the original variables that capture as much of the variation in the data matrix as possible (Quinn and Keough, 2002); PCA summarises the data in a way which best explains the variance within the data set, and in this way it is similar to a multivariate extension of linear regression.

The output from the PCA includes a two or three dimensional plot, similar to those produced by non-metric multidimensional scaling (NMDS), and a list of eigenvalues and eigenvectors. The eigenvalues represent the amount of the original variance explained by each new component and the eigenvectors are coefficients or weights that show how much each original variable contributes to each new, derived variable, or component.

Principal Components Analysis was performed in PRIMER version 6 (Clarke and Gorley, 2006) using normalised water quality variables collected in autumn 2012. The analysis began with 14 variables however nitrate and nitrite records were removed from the analysis because they did not provide any information beyond that available from NO_X. Dissolved Oxygen (mg/L) was also removed in favour of Dissolved Oxygen (% saturation) and TSS was removed in favour of turbidity. Some values for ammonia are censored (i.e. they could not be differentiated beyond the LOR, and not appropriate in this case to halve the LOR value). Thus, care must be taken when interpreting the results of the PCA in regards to differences in ammonia. However, ammonia values were included in the analysis as the raw data indicated key differences between sites. Prior to multivariate analysis, turbidity, alkalinity and electrical conductivity were log (x+1) transformed and values of NO_X, total phosphorus and total nitrogen and ammonia were fourth root transformed.

Water quality parameters were also examined for compliance with ANZECC water guidelines for healthy ecosystems in upland streams of temperate Australia (ANZECC and ARMCANZ, 2000).

2.4.2 AUSRIVAS assessment

AUSRIVAS is a prediction system that uses macroinvertebrates to assess the biological health of rivers and streams. The model uses site-specific information to predict the macroinvertebrate fauna expected (E) in the absence of environmental stressors. The expected fauna from sites with similar sets of predictor variables (physical and chemical characteristics which cannot be influenced by human activities e.g. altitude) are then compared to the observed fauna (O) and the ratio derived is used to indicate the extent of any impact (O/E). The ratios derived from this analysis are converted to Bandwidths (i.e. X, A-D; Table 4) which indicate the overall health of each site (Coysh et al., 2000). Data are presented using the AUSRIVAS O/E 50 ratio (Observed/Expected score for taxa with a >50% probability of occurrence base on site location and habitat conditions) and the previously mentioned rating bands (Table 4). The site assessments are based on the results from both the riffle and edge samples. The overall site assessment is based on the furthest band from reference condition from the two habitats. For example, a site that had an A assessment in the edge and a B Band in the riffle would be given an overall site assessment of B (Coysh et al., 2000)This approach accords with the precautionary principle.

Table 4 AUSRIVAS Band-widths and interpretations for the ACT autumn edge and rifflemodels

Band	O/E Band Width		Explanation
	RIFFLE	EDGE	
X	> 1.12	> 1.17	More diverse than expected. Potential enrichment or naturally biologically rich.
A	0.88 - 1.12	0.83 - 1.17	Similar to reference. Water quality and / or habitat in good condition.
B	0.64 - 0.87	0.49 - 0.82	Significantly impaired. Water quality and/ or habitat potentially impacted resulting in loss of taxa.
C	0.40 - 0.63	0.15 - 0.48	Severely impaired. Water quality and/or habitat compromised significantly, resulting in a loss of biodiversity.
D	< 0.40	< 0.15	Extremely impaired. Highly degraded. Water and /or habitat quality is very low and very few of the expected taxa remain.

2.4.3 Univariate indices

Several additional metrics to the AUSRIVAS were utilised. This included: taxa abundance (the total number of animals collected); taxa richness (the number of taxa recorded in a sample – based on the applied taxonomic resolution level); EPT richness (number of Ephemeroptera, Plecoptera and Trichoptera families in a given sample); EPT relative abundance (the proportion of total abundance made up of EPT taxa); relative abundance of tolerant taxa (the proportion of total abundance made up of less sensitive taxa from the Oligochaeta, Chironomidae and Diptera groups) and the Stream Invertebrate Grade Number – Average Level (SIGNAL-2) index.

SIGNAL-2 is a biotic index based on pollution sensitivity values (grade numbers) assigned to aquatic macroinvertebrate families. The sensitivity values for each family have been determined from published and unpublished information on their tolerance to pollutants, such as sewage and nitrification (Chessman, 2003). Each family in a sample is assigned a grade between 1 (most tolerant) and 10 (most sensitive). Sensitivity grades are also given in the AUSRIVAS output which can then be used as complimentary information to these assigned bandwidths to aid the interpretation of each site assessment.

Preliminary Experimental Data Analysis (EDA) determined that the distribution of some indices appeared to deviate from a normal distribution. This means that the parametric ANOVA technique may produce erroneous results (Zar, 1999) and was, thus, abandoned in favour of more conservative non-parametric equivalents. For consistency, non-parametric tests were used for analysis of all univariate indices. A Mann-Whitney test was used to examine differences between two independent samples (e.g. habitats) and a Kruskal-Wallis test was used to determine differences between more than two independent samples (e.g. zones). As no suitable non-parametric multiple-comparisons technique was available, differences between groups were assessed using a modified version of Tukey's HSD (honestly significant differenced) test for factors with $k \geq 3$ levels with uneven sample sizes.

Univariate statistics were performed using STATISTICA version 9 (StatSoft Inc, 1984-2010).

2.4.4 Macroinvertebrate communities

All multivariate analyses were performed using PRIMER version 6 (Clarke and Gorley, 2006).

Non-metric multidimensional scaling (NMDS)

Non-metric multidimensional scaling (NMDS) was performed on the macroinvertebrate community data following the initial cluster analysis. NMDS is a multivariate procedure that reduces the dimensionality of multivariate data and simplifies its interpretation. It reduces the dimensionality of the data by describing trends in the joint occurrence of taxa. The initial step in this process was to calculate a similarity matrix for all pairs of samples based on the Bray-Curtis similarity coefficient (Clarke and Warwick, 2001). The number of dimensions (axes) used in the NMDS procedure was based on the resultant Stress levels. Stress is a measure of the distortion produced by compressing multidimensional data into a reduced set of dimensions (i.e. it is a measure of goodness of fit of the ordination plot relative to patterns in the original data matrix) and will increase as the number of dimensions is reduced (Kruskal, 1964).

Classification

Classification or cluster analysis is a mathematical method of grouping entities according to the relative similarity of their attributes. In an ecological setting these techniques can be used to group sites according to how similar their macroinvertebrate community is. The key to this technique is the Bray-Curtis similarity matrix which is constructed from the individual similarities between all possible pairs of sites (Bray and Curtis, 1957). From this matrix, a classification using Hierarchical Agglomerative Clustering is obtained and represented visually as a dendrogram. The dendrogram displays sites in groups of varying size according to the similarities between them. In other words, sites which are similar in macroinvertebrate assemblage will be grouped together on the dendrogram.

Cluster analysis can be useful in detecting patterns within complex data sets but it is not without limitations. The nature of this technique is such that linkages will often be made between sites based on chance similarities. The SIMPROF test (described below) can be used in conjunction with the cluster analysis to prevent misinterpretation of random similarities as "true" patterns.

SIMPROF (SIMilarity PROFile)

The SIMPROF test determines whether a dataset contains a "multivariate structure. It can be used as a safeguard against misinterpreting chance similarities as meaningful patterns. SIMPROF works by rearranging observations (i.e. taxa counts) across the samples to simulate random data and then recalculating the similarities between the samples. The similarities from the 'random' data are then compared to the similarities from the observed data. This process is replicated several times, each time with the observed data being compared to a different 'random' set of data. If the similarities calculated from the actual observations are found to be significantly different from those calculated from the simulated 'random' data then it is concluded that any pattern detected is 'real' and not just a chance occurrence (Clarke and Warwick, 2001). When used in conjunction with cluster analysis, the SIMPROF test will indicate meaningful clusters within the dendrogram by outlining them in red.

PERMANOVA (Permutational MANOVA)

PERMANOVA is an extension to the PRIMER multivariate software package for biological and environmental data. The PERMANOVA procedure is based on the principals of a MANOVA (multivariate analysis of variance) with some differences. The key to PERMANOVA is the use of permutation to determine differences between categorical groups. This is done by randomly rearranging the observations to different sample labels and reanalysing the data to obtain the distribution of data that may be expected "by chance" if no multivariate patterns exist. This distribution of permuted data replaces the theoretical distribution which is generally utilised by parametric statistics such as MANOVA. The calculated test statistic (pseudo *F*) is compared to the permutational distribution in order to determine whether the observed pattern is likely to have occurred by chance or whether there are "true multivariate patterns" within it. The use of permutation to create the null distribution means that many of the assumptions which exist for MANOVA are avoided. For example, there is no assumption that the test data follows a normal distribution. Also, there is no necessity for data cells to be equal as long as an appropriate Sum of Squares (SS) calculation method is used. PERMANOVA was used to test for differences in the macroinvertebrate communities between groups (Zones).

SIMPER (SIMilarity PERcentages)

The SIMPER routine was used to identify taxa that contributed strongly to the average dissimilarity between site groups identified from the cluster analysis (classification). SIMPER computes the average dissimilarity (Bray-Curtis) between all pairs of inter-group samples (every sample in Group 1 with every sample in Group 2 etc.) and then breaks this average down into the separate contributions from each taxon. In addition to calculating the average dissimilarity between groups, SIMPER also calculates the average similarity within a group.

2.5 Licences and permits

All sampling was carried out with current NSW scientific research permits under section 37 of the Fisheries Management Act 1994 (permit number P01/0081(C))-03.

GHD field staff maintain current AUSRIVAS accreditation.

3. Results

3.1 Hydrology and rainfall

The plot in Figure 2 shows the flow during the autumn period at the four monitoring stations on the Murrumbidgee River. The rainfall recorded at Lobb's Hole (410761) is also shown and is considered to be representative of the region (rainfall at all other sites can be found in Appendix B).

There was a large high flow event at the beginning of March which passed through all sites with the peak at Hall's Crossing (410777) exceeding 200,000 ML/d (Plates 1 and 2). This event included multiple peaks and was the result of heavy rainfall days, which started during the last few days of February. After the March event, flows generally decreased towards mid-April where there was a smaller peak in response to a number of small consecutive rainfall events. Flows then decreased for the rest of the period, with the exception of a small peak towards the end of May at Mt. MacDonald (410738) and Hall's Crossing (410777) in response to a small isolated rainfall event. The monthly flow and rainfall summaries for autumn can be found in Table 5. Quick reference site summaries can be found in Appendix C.

Plate 1. The Murrumbidgee River at Halls Crossing near its peak of > 200,000 ML/d on the 4th of March 2012

Plate 2. The Murrumbidgee River on 4th of March looking upstream

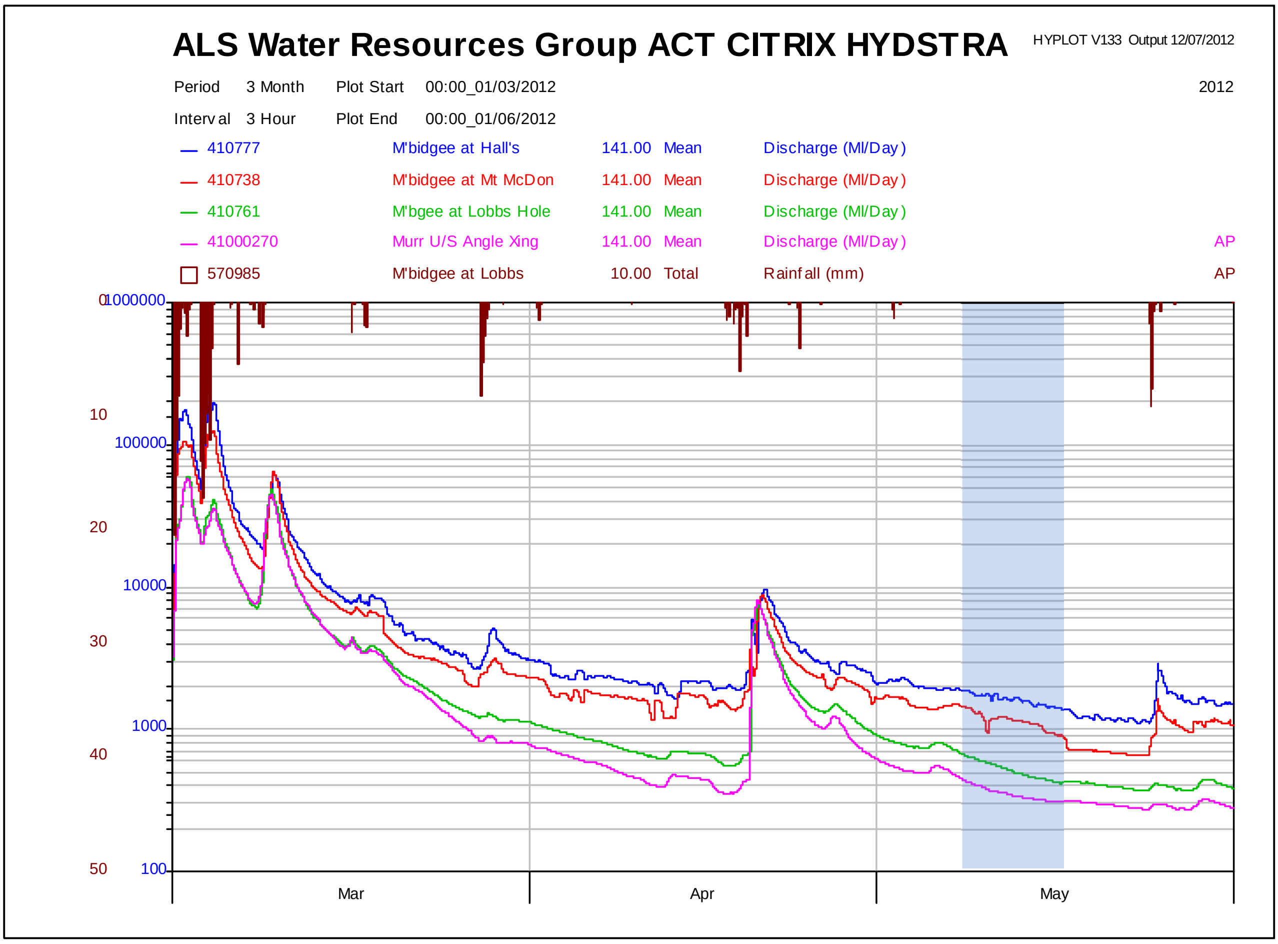

Figure 2 **Autumn hydrograph of the Murrumbidgee River flows and rainfall**

Flow is on a log scale, rainfall in mm per hour from top down. Shaded area indicates sampling period

Table 5 Average monthly flow and rainfall statistics for autumn 2012

Site Location	March Average flow (ML/d)	April Average flow (ML/d)	May Average flow (ML/d)	Rainfall (mm) (autumn total)
Upstream of Angle Crossing (41000270)	9,810	1,100	367	238.6
Lobb's Hole (410761)	10,400	1,330	527	251.2
Mt. MacDonald (410738)	20,300	2,240	1,120	-
Hall's Crossing (410777)	28,100	2,880	1,630	284.8

3.2 Water Quality

3.2.1 *In-situ* and grab samples

The water quality parameters measured during the autumn sampling period are found in Table 6. There was a relatively low temperature range across all sites from 8.3°C at MUR 1 to 13.0°C at MUR 31. Most of the electrical conductivity (EC), turbidity and dissolved oxygen (DO) readings were within the ANZECC and ARMCANZ (2000) guidelines but there were some exceptions. Electrical conductivity and turbidity were both slightly lower than the minimum ANZECC and ARMCANZ (2000) guideline value at furthest upstream sites MUR 1 and MUR 2. Dissolved oxygen (% saturation) was slightly higher than recommended at MUR 6, MUR 937, MUR 30 and MUR 31. Levels of pH were measured at or slightly above the recommended ANZECC and ARMCANZ (2000) maximum trigger value at all sites downstream of MUR 18 (exclusive).

Total Phosphorous and NOx concentrations peak at MUR 15, after which, there is a slow but steady decline moving downstream to MUR 23. Total nitrogen (TN) however, remains above the guideline levels at all sites downstream of and including MUR 12, except at MUR 937 and MUR 29 where TP is below the upper limits of the guideline value.

There is evidence of a large increase in nutrient levels upstream of MUR 31 also, likely from the Molonglo River, with levels of NO_X, TP and TN exceeding the guideline values all sites within Zone 4; although it should be noted that TP is lower than many of the sites in zones 2 and 3. NO_X guidelines are also exceeded at MUR 1.

The PCA plot in Figure 3 shows the results of the first two principal components which account for approximately 73.8% of the variation in the data. Principal Component 1 (PC1) is most strongly characterised by temperature, dissolved oxygen, turbidity, pH, alkalinity, total nitrogen and total phosphorus. PC2 is most strongly characterised by high dissolved oxygen and reduced levels of ammonia. The PCA plot indicates a weak separation in the water quality results between zones. The zones with the strongest intra-zone similarity were Zone 1 and Zone 4. The water quality from these two zones appeared to be the most strongly separated along PC1 with samples from Zone 1 sites being positioned at the far left and samples from Zone 4 sites falling furthest to the right along this axis. This indicates that sites in Zone 1 generally had lower temperatures, EC, turbidity, pH , alkalinity, total phosphorus and total nitrogen compared to sites in other zones and that the highest levels of these parameters were generally observed at Zone 4 sites. There is no clear pattern in the sites or zones with regards to PC2. To view the PCA output refer to Appendix D.

Table 6 In-situ and grab sample water quality results for autumn 2012

ANZECC and ARMCANZ (2000) guidelines are in red bold. Values outside recommended guideline levels are highlighted yellow. Borderline values are highlighted in orange.

Zone	Site	Date	Time	Temp. (°C)	EC (µs/cm) (30-350)	Turbidity (NTU) (2-25)	TSS mg/L	pH (6.5-8)	D.O.(% Sat.) (90-110)	D.O. (mg/L)	Alkalinity	NO_x (mg/L) (0.015)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L) (0.02)	TN (mg/L) (0.25)
Tantangara –Cooma	MUR 1	8/5	11.10	8.3	29	1.2	18	7.0	102.5	10.4	16	0.050	0.048	<0.002	0.009	0.015	0.16
	MUR 2	8/5	13.20	8.4	27	1.6	<2	7.1	107.8	11.0	16	0.009	0.007	<0.002	0.006	0.005	0.08
	MUR 3	8/5	15.00	10.1	33	4.2	2	7.3	109.6	10.8	18	0.004	0.002	<0.002	0.004	0.012	0.16
	MUR 4	8/5	16.00	9.8	43	5.3	4	7.4	108.1	10.8	22	0.003	0.001	<0.002	0.002	0.015	0.18
Cooma – Angle Crossing	MUR 6	11/5	10.10	10.2	96	5.3	3	7.6	110.9	10.2	37	0.003	0.001	<0.002	<0.002	0.016	0.21
	MUR 9	11/5	11.40	10.3	99	4.4	2	7.7	99.5	10.1	38	0.002	<0.001	<0.002	0.006	0.017	0.23
	MUR 12	11/5	12.55	12.1	170	8.9	10	7.7	98.3	9.4	65	0.036	0.034	0.002	0.006	0.034	0.35
	MUR 15	1/5	10.00	11.7	160	8.4	7	7.8	110.0	11.4	60	0.068	0.066	<0.002	0.011	0.041	0.50
	MUR 16	1/5	13.00	12.0	160	8.0	5	7.9	102.6	10.3	60	0.064	0.062	<0.002	0.008	0.037	0.49
	MUR 18	1/5	15.10	12.6	150	8.5	6	7.9	101.0	11.1	59	0.061	0.059	<0.002	0.009	0.037	0.49
Angle Crossing – LMWQCC	MUR 19	2/5	10.30	11.5	160	7.9	6	8.1	102.1	11.4	60	0.061	0.059	<0.002	0.007	0.036	0.48
	MUR 22	2/5	15.00	11.4	150	6.9	4	8.1	102.9	11.6	57	0.047	0.045	<0.002	0.006	0.032	0.41
	MUR 23	2/5	12.15	11.4	150	9.9	7	8.0	99.5	9.9	58	0.046	0.044	<0.002	0.004	0.034	0.44
	MUR 27	7/5	15.50	10.7	160	5.5	3	8.0	105.5	10.7	63	0.011	0.009	<0.002	0.007	0.027	0.37
	MUR 931	7/5	10.15	10.7	160	5.6	4	8.0	103.7	10.8	65	0.008	0.006	<0.002	0.006	0.026	0.34
	MUR 28	9/5	10.00	10.2	160	4.3	3	8.1	105.7	11.0	64	0.004	0.002	<0.002	0.005	0.022	0.33
	MUR 935	9/5	11.40	10.9	160	4.3	3	8.1	109.1	11.5	62	0.004	0.002	0.002	0.006	0.021	0.32
	MUR 937	9/5	14.10	12.0	130	4.4	2	8.2	113.5	11.4	55	0.003	0.001	<0.002	0.003	0.018	0.29
	MUR 29	7/5	13.15	11.0	130	4.6	<2	8.0	109.1	11.2	53	0.004	0.004	<0.002	0.004	0.019	0.28
	MUR 30	10/5	15.10	12.6	130	3.9	4	8.1	111.3	10.8	56	0.003	0.001	<0.002	0.003	0.020	0.28
LMWQCC – Burrinjuck	MUR 31	10/5	13.45	13.0	170	5.8	4	8.2	111.5	10.6	62	0.91	0.908	0.002	0.004	0.029	1.3
	MUR 34	10/5	09.30	11.6	170	4.2	3	8.1	106.3	10.7	61	0.91	0.908	0.002	0.005	0.023	1.3
	MUR 37	10/5	11.45	12.4	180	5.1	4	8.2	99.8	11.1	64	0.72	0.718	0.002	0.004	0.022	1.1

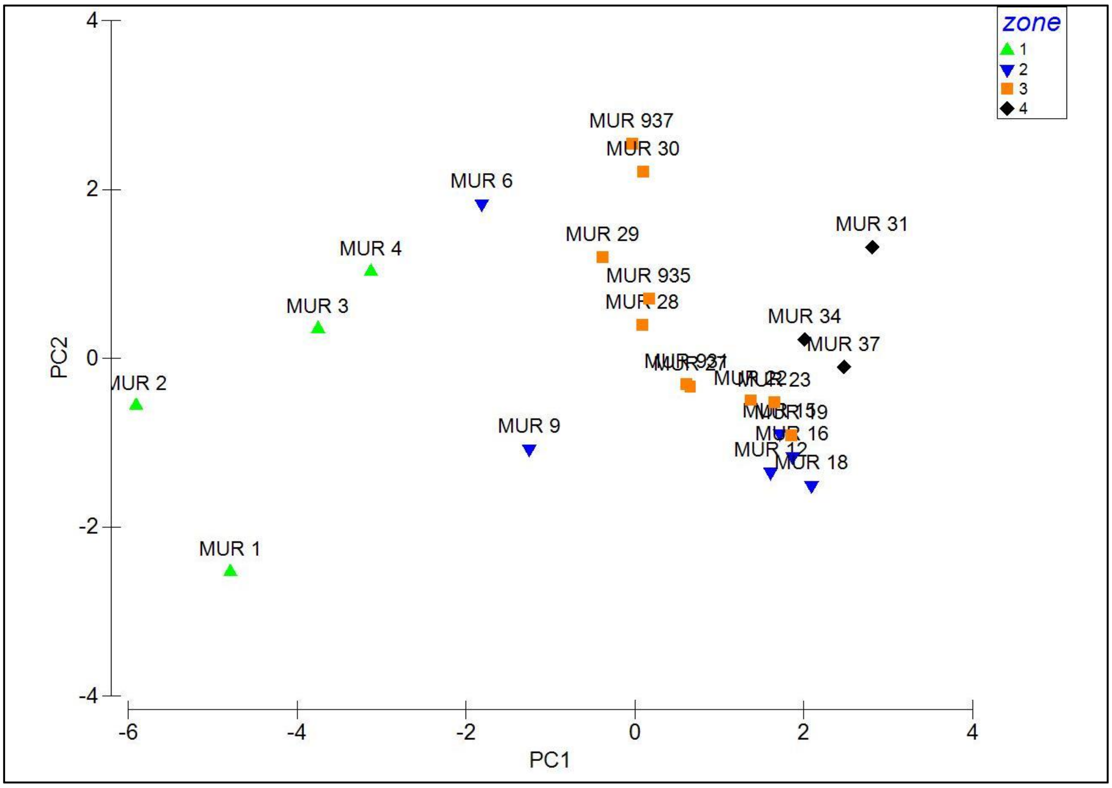

Figure 3 Correlation based Principal Components Analysis on water quality data collected in autumn 2012

3.2.2 Continuous water quality

The Hall's Crossing gauging station (410777) was damaged during the March high flow event and was not operational during the autumn period for the measurement of any water quality parameters, however flow was still logged.

The upstream Angle Crossing gauging station showed similar patterns to that of Lobb's Hole with large variations during the first half of March and smaller variations during mid-April relating to the high-flow events (Figure 4). DO and pH parameters were below the ANZECC and ARMCANZ (2000) minimum trigger value for a large portion of the season, while EC was only outside guideline levels at the beginning of March due to the large volume of water (rainfall inputs) in the river

From March to the beginning of April the pH sensor at Lobb's Hole (410761) was not operation and could not be repaired due to the high river level. During March all other parameters were operational and logging correctly (Figure 5).

At the beginning of March turbidity, electrical conductivity (EC), temperature and dissolved oxygen (DO) % saturation were all variable as a result of multiple rainfall events, however most readings were still found to be within the ANZECC and ARMCANZ (2000) guidelines. Smaller variations were also present in mid-April during the small increased flow event. Dissolved oxygen fluctuated diurnally, while water temperature decreased throughout the season, corresponding to decreasing ambient temperatures towards the beginning of winter. EC remained within the guidelines for the whole period while turbidity was stable after the high flow conditions with all but two daily means within the guidelines. Once the pH sensor was repaired and logging it was stable, however only 15 of the remaining 59 days during the autumn period logged daily means within the ANZECC and ARMCANZ (2000) guidelines..

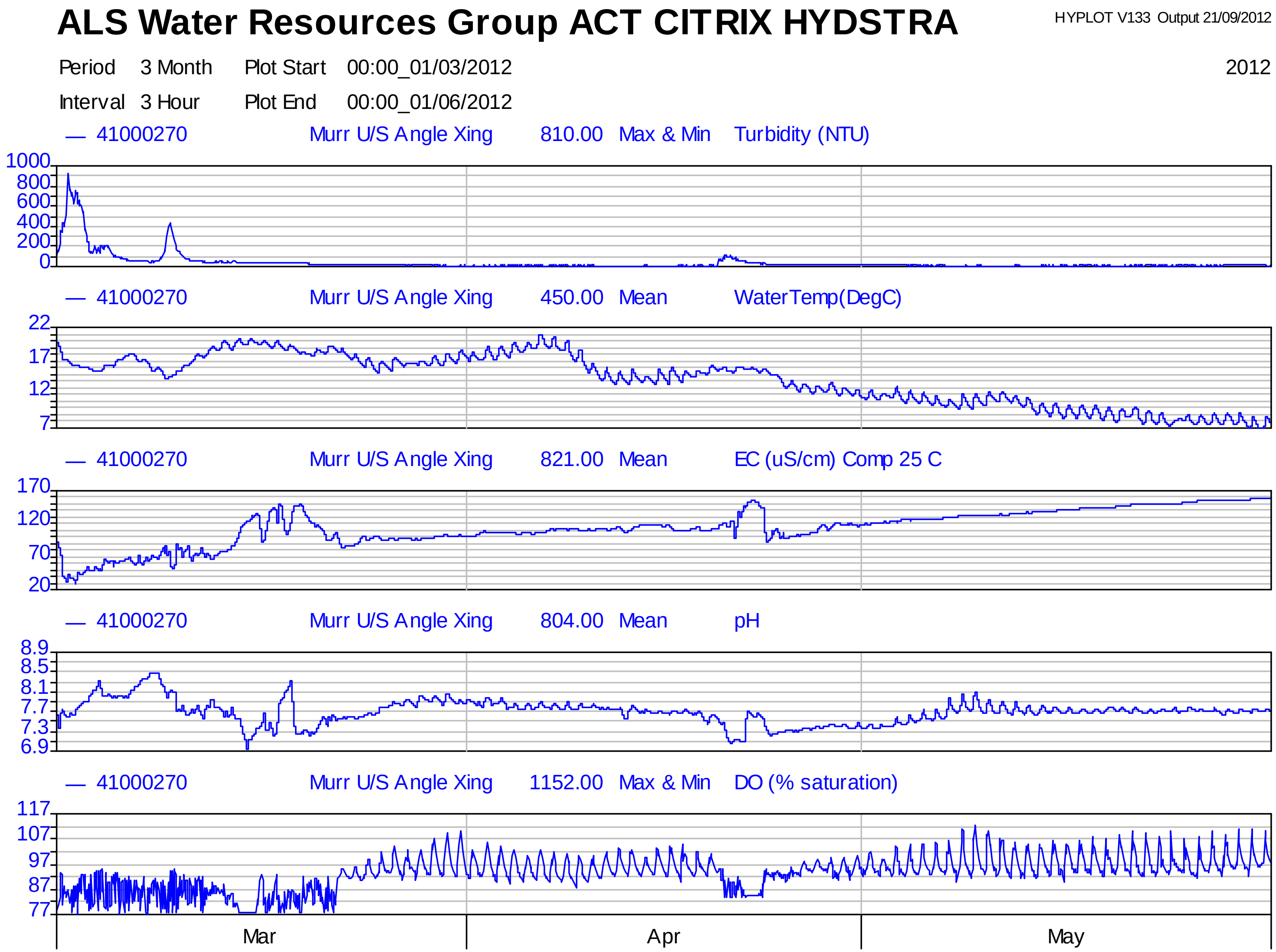

Figure 4 Continuous water quality results recorded upstream of Angle Crossing in autumn 2012 (41000270)

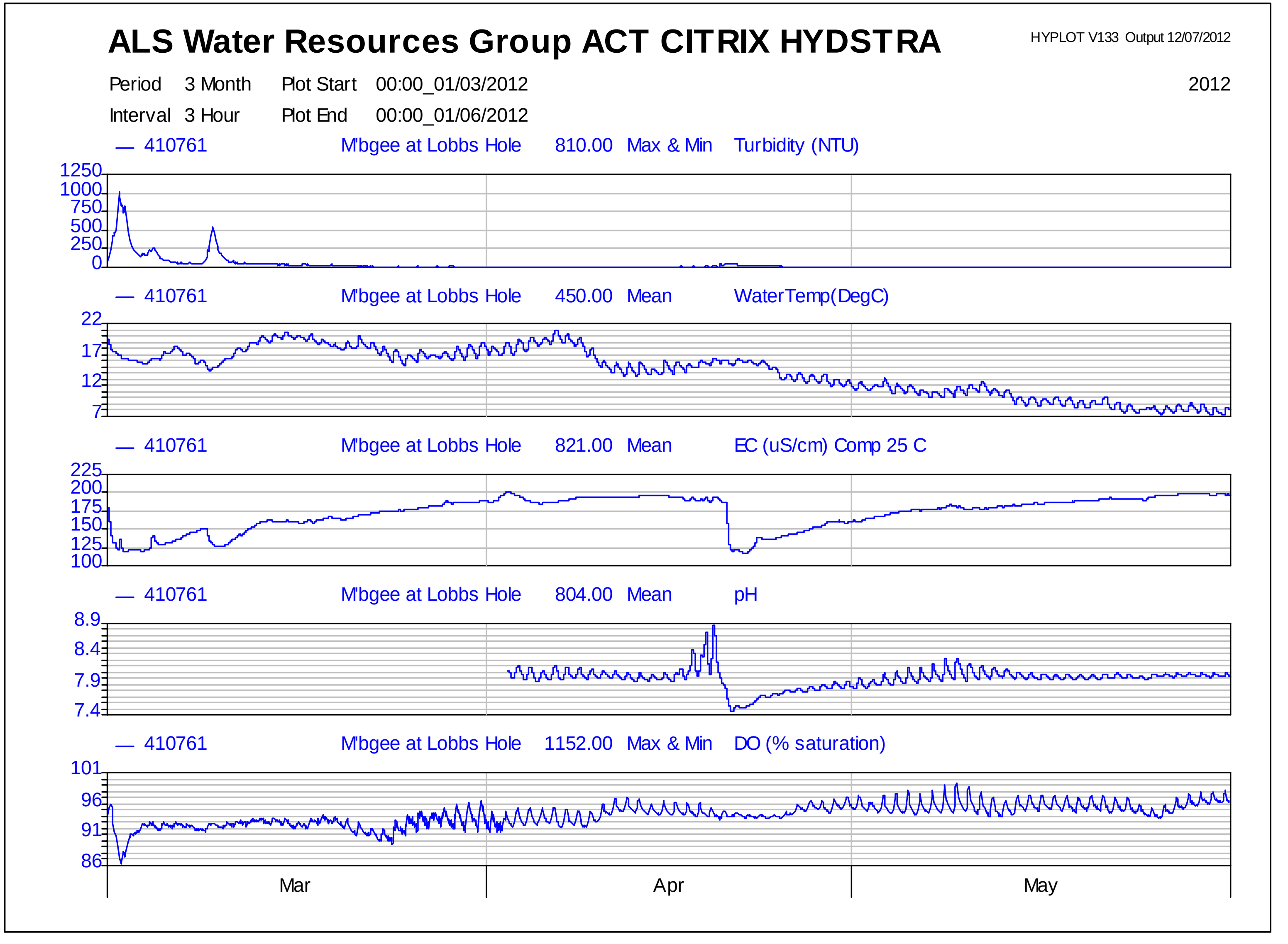

Figure 5 Continuous water quality results for Lobb's Hole in autumn 2012 (410761)

3.3 Macroinvertebrate Communities

The NMDS plot in Figure 6 indicates the relative similarity of the macroinvertebrate community of riffle habitat between sites and zones. The stress is relatively low (i.e. < 0.2) indicating that the multivariate pattern is being portrayed adequately by the 2 dimensional plot. The riffle communities at sites 1-3 showed a distinct separation from all other sites. MUR 4 was more similar to MUR 6 and MUR 9 (in Zone 2) than other sites in Zone 1 (Figure 7). There was no clear separation in the macroinvertebrate community of riffle samples from other zones.

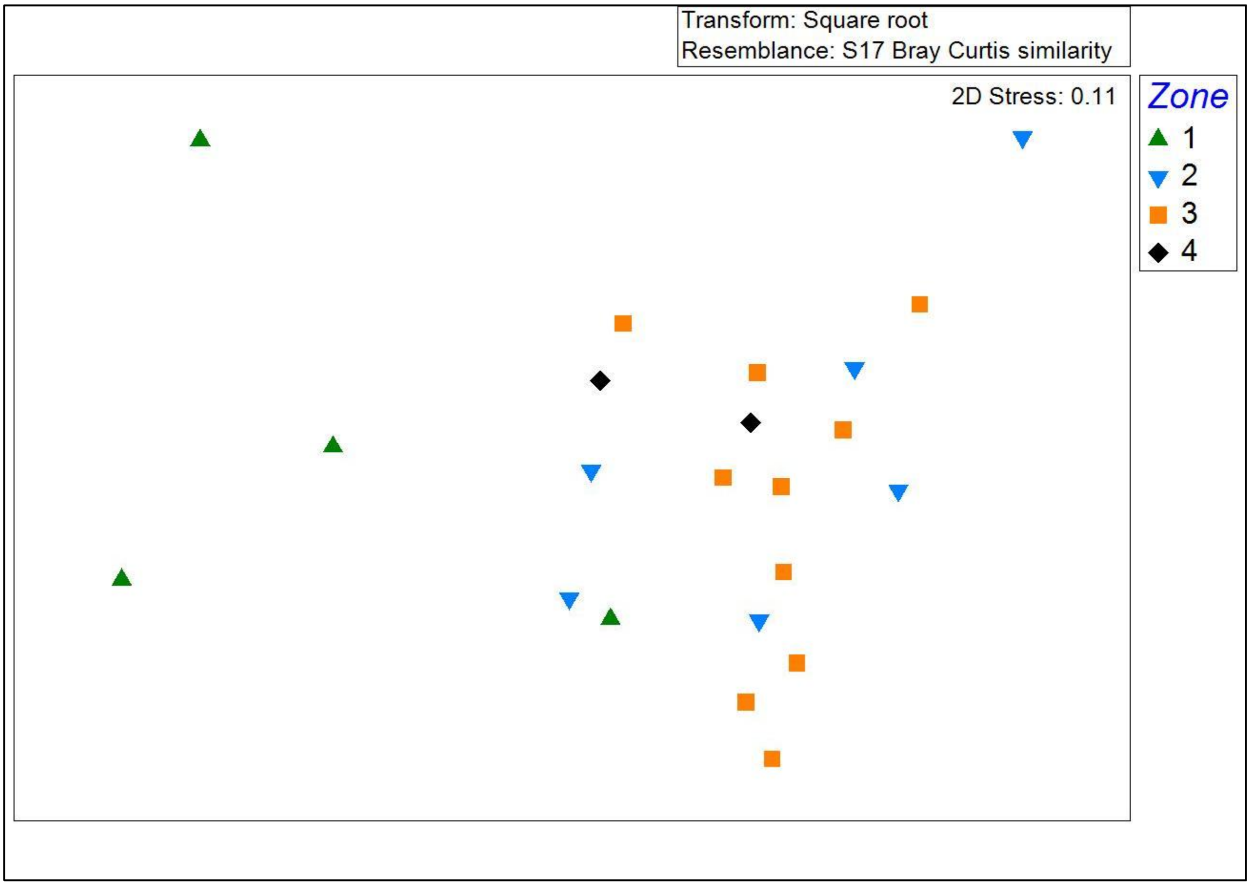

Figure 6 Non-metric multidimensional scaling of family level data for the autumn 2012 riffle samples

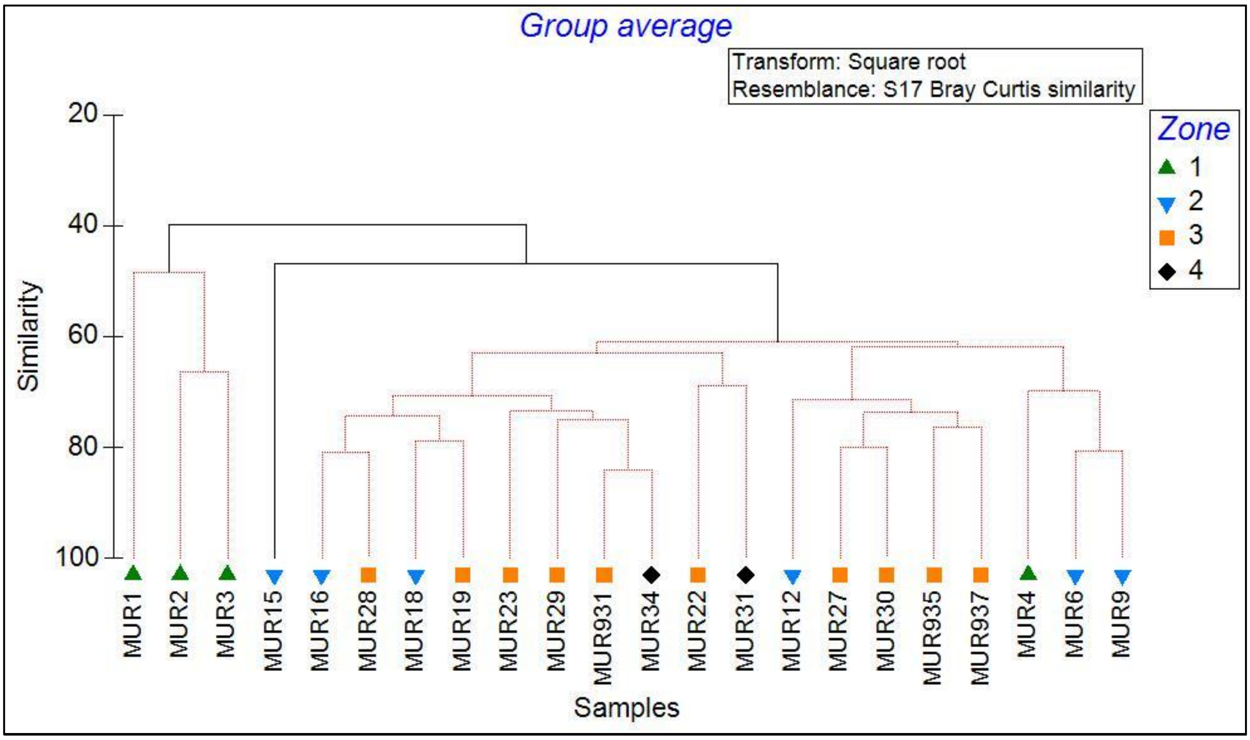

Figure 7 Cluster analysis of family level data for the autumn riffle samples

Branches marked in red denote significant groupings based on SIMPROF

PERMANOVA analysis determined that there was a significant difference (*p*<0.05) in the autumn samples collected from riffle habitat between some zones. The results of multiple comparisons testing (Table 7) indicate that riffle samples collected from zone 1 sites were significantly different to those collected from Zone 2 or Zone 3 sites. These *p*-values were determined using permutation. To view the PERMANOVA output refer to Appendix E.

Table 7 *p*-values for multiple comparisons between Zones for riffle macroinvertebrates

Significant p-values are highlighted in red (*p*<0.05)

Zone	1	2	3
1			
2	**0.021**		
3	**0.003**	0.529	
4	0.19	0.607	0.781

SIMPER was used to determine the average similarity in the macroinvertebrate community between and within zones (Table 8). The similarity in community composition of riffle samples was generally not much higher than between zones. Similarity was generally fairly low, with no similarity (either inter-zone or intra-zone) being higher than 64.67% (Zone 3). The lowest intra-zone similarity was between riffle samples from Zone 3 and Zone 4.

Table 8 Average similarity in riffle macroinvertebrate samples between and within zone groups

Zone	1	2	3	4
1	50.3			
2	55.4	58.0		
3	56.1	38.1	64.6	
4	51.4	38.6	33.2	64.0

The key taxa leading to significant differences between Zone 1 and Zone 2 were Simuliidae, Gripopterygidiae, Leptophlebiidae, Baetidae and Conoesucidae in order of importance (Table 9). These same taxa were identified as the most influential in the differences between Zone 1 and Zone three although the last two taxa were transposed (Table 10).

Numbers of Simuliidae were lower in Zone 1 compared to either Zone 2 or Zone 3. Higher numbers of Gripopterygidae, Leptophlebiidae, Baetidae and Conoesucidae were observed in riffle samples from Zone 1 compared to those collected from Zone 2 and Zone 3 sites. The bubble plot in Figure 8 shows that while the average number of Simuliidae was lower in Zone 1, there was a lot of variation in Simuliid abundance between Zone 1 samples. The bubble plots in Figure 9 and Figure 10 indicate a more consistently high number of Gripopterygidae and Leptophlebiidae across all Zone 1 sites compared to Zones 2 and 3.

Table 9 Major differentiating taxa between Zone 1 and Zone 2 riffle samples

Family	Av abundance		Contribution to group differences (%)
	Zone 1	Zone 2	
Simuliidae	28.6	55.1	13.5
Gripopterygidae	33.9	6.9	10.1
Leptophlebiidae	28.9	6.6	8.7
Baetidae	26.6	22.3	8.2
Conoesucidae	18.6	2.6	6.1

Table 10 Major differentiating taxa between Zone 1 and Zone 3 riffle samples

Family	Av abundance		Contribution to group differences (%)
	Zone 1	Zone 3	
Simuliidae	28.6	61.0	14.9
Gripopterygidae	33.9	1.2	11.6
Leptophlebiidae	28.9	6.2	8.3
Conoesucidae	18.6	0	6.5
Baetidae	26.6	19.9	6.3

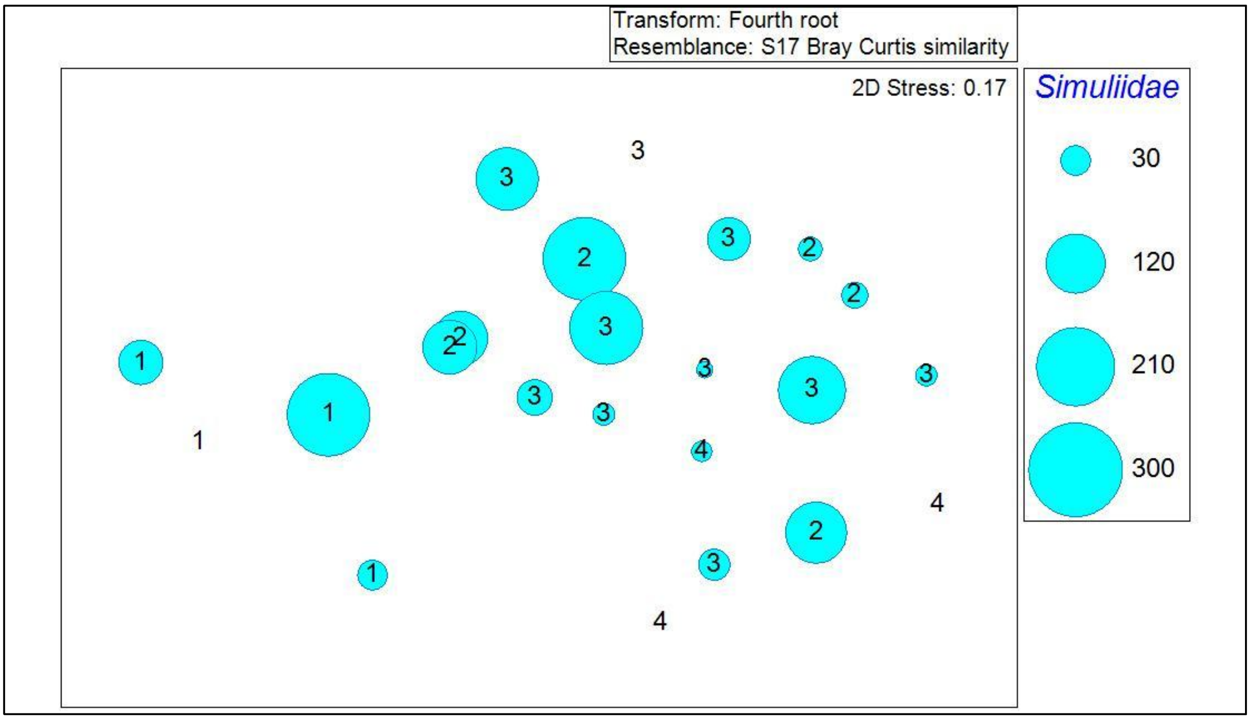

Figure 8 Bubble plot indicating relative abundance of Simuliidae between riffle samples

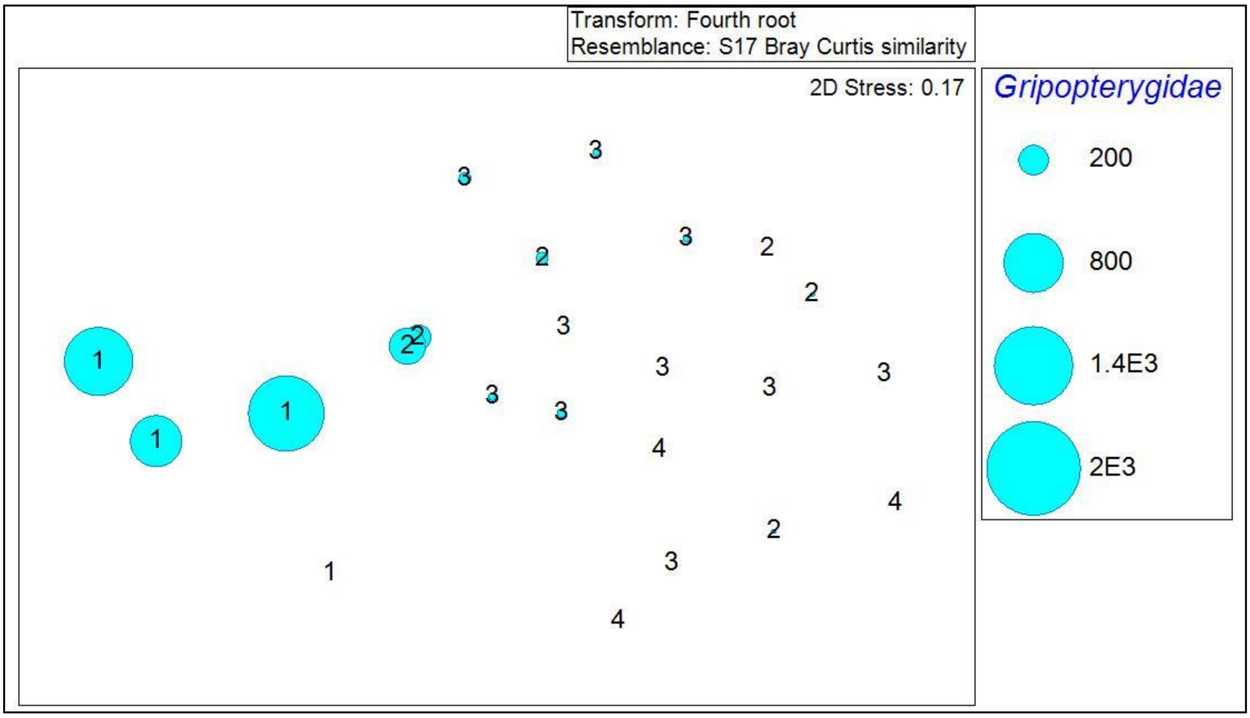

Figure 9 Bubble plot indicating relative abundance of Gripopterygidae between riffle samples

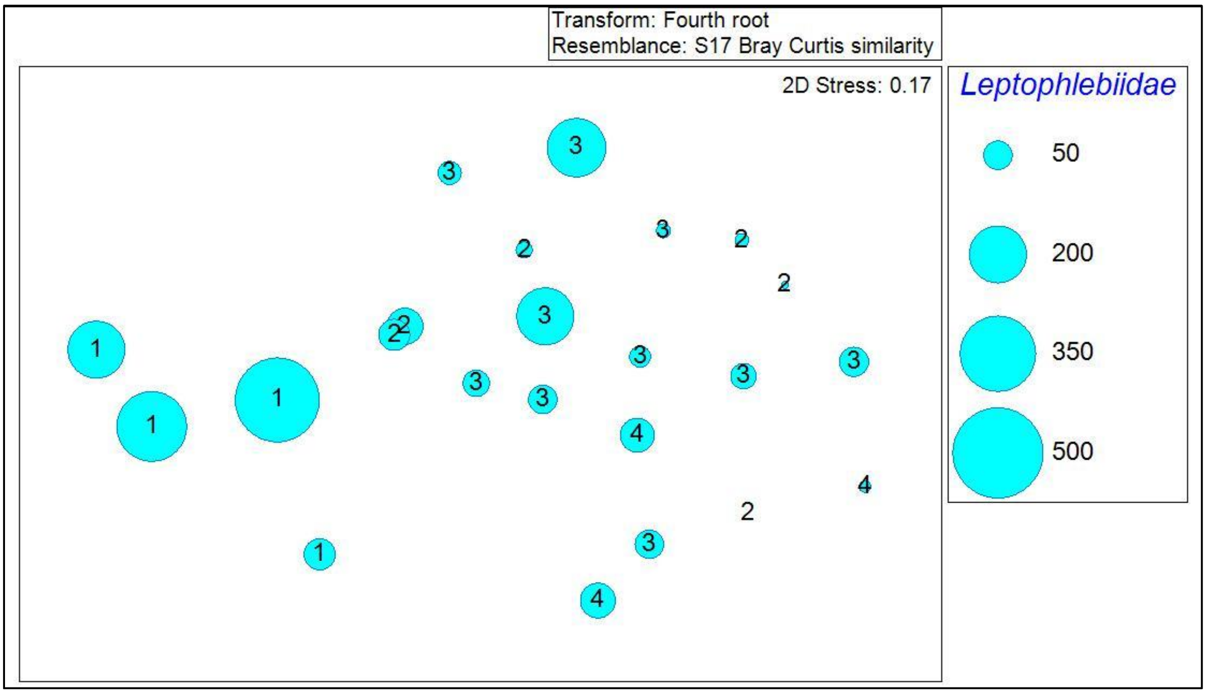

Figure 10 Bubble plot indicating relative abundance of Leptophlebiidae between riffle samples

The MDS in Figure 11 indicates the relative similarity in the community composition of edge habitat between sites and zones. The stress levels for the MDS indicate that the data were adequately displayed within the 2-D plot. As was observed for the riffle samples, the samples from Zone 1 are the only ones that are clearly separated into their zone group.

The cluster diagram for edge samples (Figure 12) mirrors the results of the MDS with the Zone 1 samples being separated from other zones. However, samples from Zone 1 were no more than 70% similar to each other. The other samples were not separated in zone groups although some of the samples from adjacent sites were clustered together in the dendrogram. These pairs were MUR 22 and MUR 23 as well as MUR 6 and MUR 9. Even the most closely linked samples were no more than 80% similar.

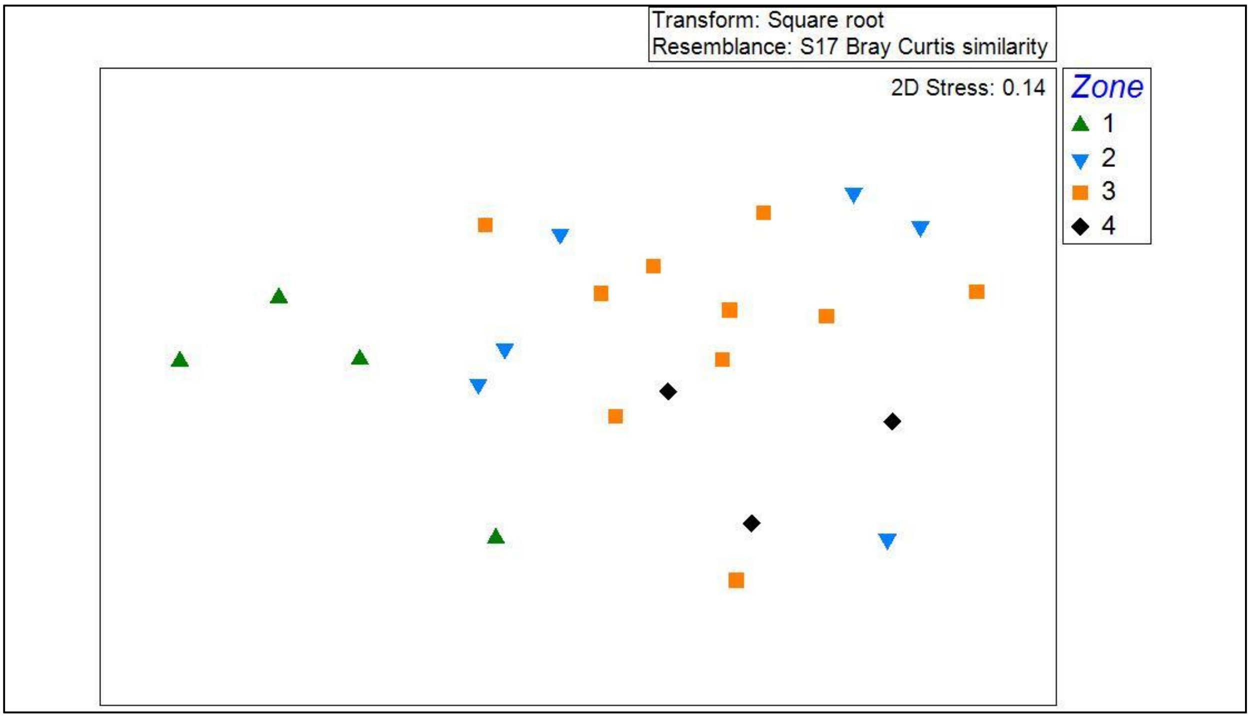

Figure 11 **Non-metric multidimensional scaling of family level data for the autumn edge samples**

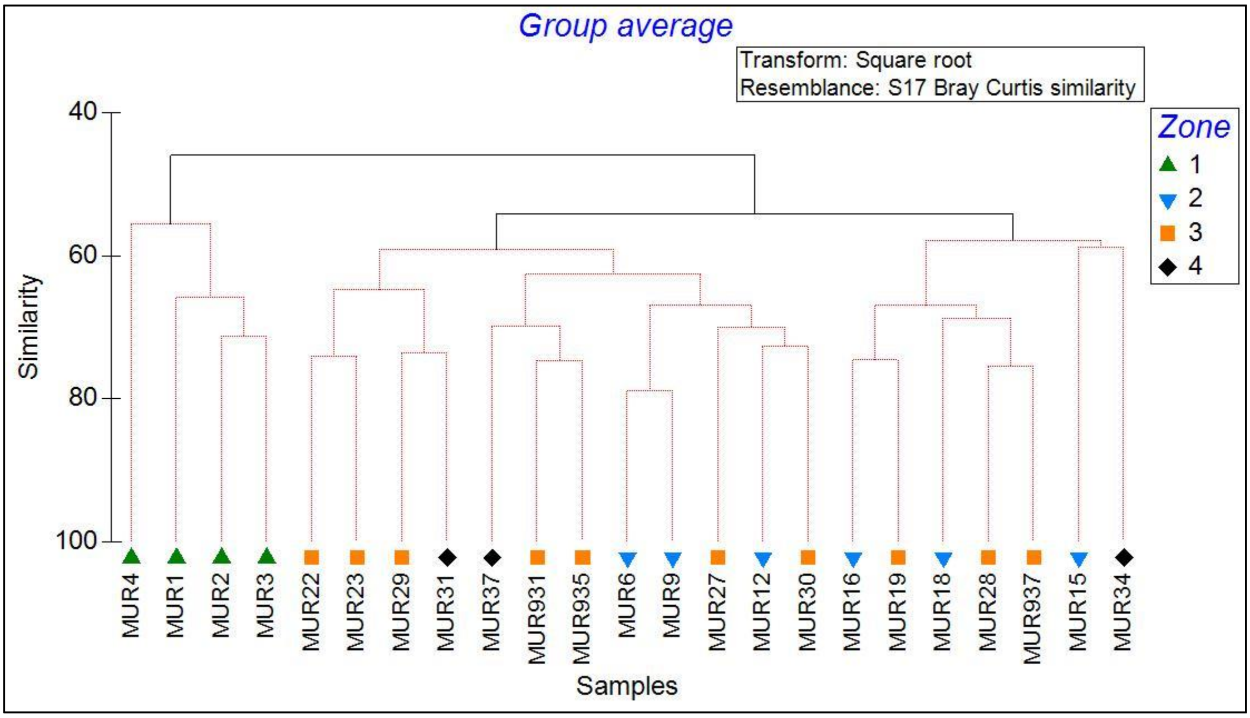

Figure 12 Cluster analysis of family level data for the autumn edge samples

Branches marked in red denote significant groupings based on SIMPROF

PERMANOVA analysis identified significant (*p*<0.05) differences in the multivariate macroinvertebrate community of edge habitat between some zones. The results of multiple comparisons testing are provided in Table 11. This table indicates significant differences (*p*<0.05) in the macroinvertebrate edge community between Zone 1 and the other three zones.

The average intra-zone similarity was lowest within Zone 2 and highest in Zone 1 (

Table 12). Inter-zone similarity was between 40% and 50%.

Table 11 ***p*-values for multiple comparisons between Zones for edge macroinvertebrates**

Significant p-values are highlighted in red (p<0.05)

Zone	1	2	3
1			
2	0.031		
3	0.001	0.25	
4	0.030	0.40	0.18

Table 12 **Average similarity in edge macroinvertebrate samples between and within zone groups**

Zone	1	2	3	4
1	61.			
2	51.7	55.3		
3	54.8	42.2	61.4	
4	55.8	43.6	40.9	59.7

The results of SIMPER analysis are provided in Table 13, 14 and 15. The two taxa most influential in determining differences between Zone 1 and the other sites were Oligochaeta and Gripopterygidae. On average the abundance of Oligochaeta and Gripopterygidae was higher in Zone 1 than all other sites. However, the bubble plot in Figure 13 shows that Oligochaeta were variable in number between Zone 1 samples. The numbers of Gripopterygidae were consistently higher in three of the four Zone 1 samples than the other zones (Figure 14). Average numbers of Orthocladiinae and Baetidae were also higher at Zone 1 sites than the other three zones.

Table 13 **Major differentiating taxa between Zone 1 and Zone 2 edge samples**

Family	Av abundance		Contribution to group differences (%)
	Zone 1	Zone 2	
Oligochaeta	32.6	20.6	9.9
Gripopterygidae	23.3	6.5	9.8
Orthocladiinae	33.7	19.3	8.7
Baetidae	21.8	12.6	7.8
Leptophlebiidae	15.0	4.3	5.5

Table 14 Major differentiating taxa between Zone 1 and Zone 3 edge samples

Family	Av abundance		Contribution to group differences (%)
	Zone 1	Zone 3	
Gripopterygidae	23.3	2.05	9.9
Oligochaeta	32.6	18.5	9.5
Caenidae	2.9	21.9	9.1
Orthocladiinae	33.7	17.1	8.8
Baetidae	21.8	17.0	6.7

Table 15 Major differentiating taxa between Zone 1 and Zone 4 edge samples

Family	Av abundance		Contribution to group differences (%)
	Zone 1	Zone 4	
Oligochaeta	32.6	14.6	11.1
Gripopterygidae	23.3	0	10.5
Baetidae	21.8	9.7	7.9
Orthocladiinae	33.7	20.3	7.4
Hydroptilidae	14.1	0	6.7

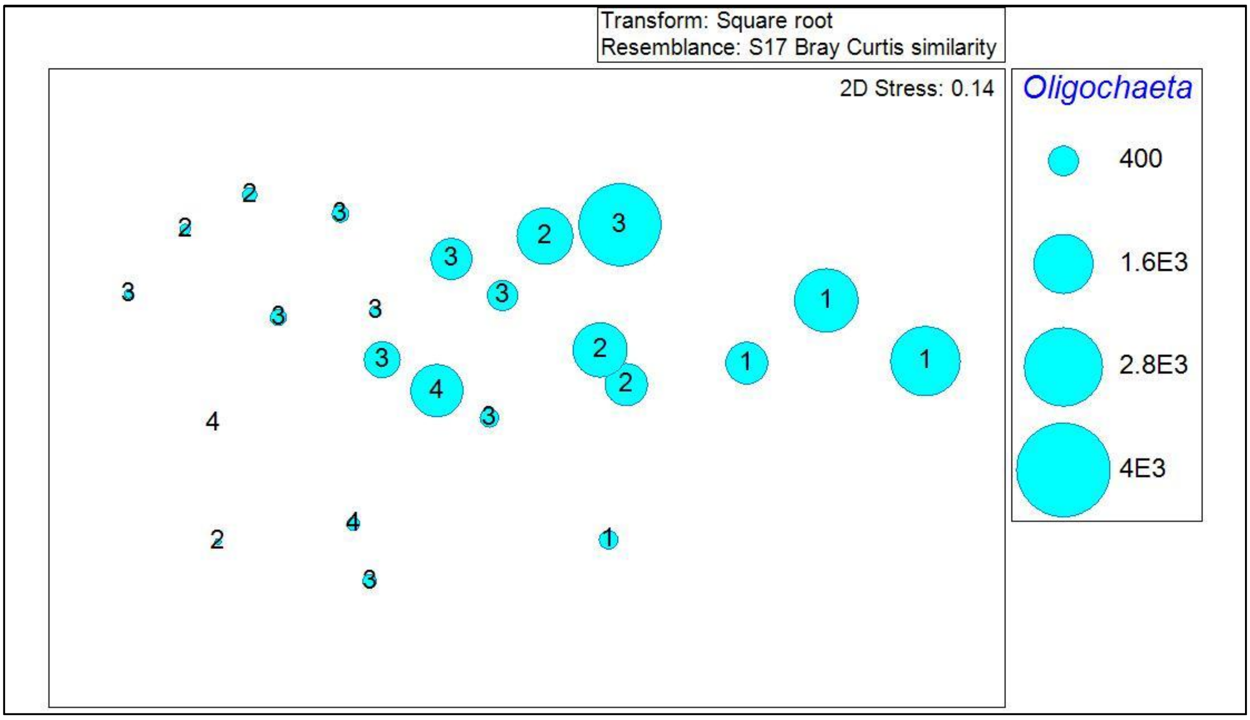

Figure 13 Bubble plot indicating relative abundance of Oligochaeta between edge samples

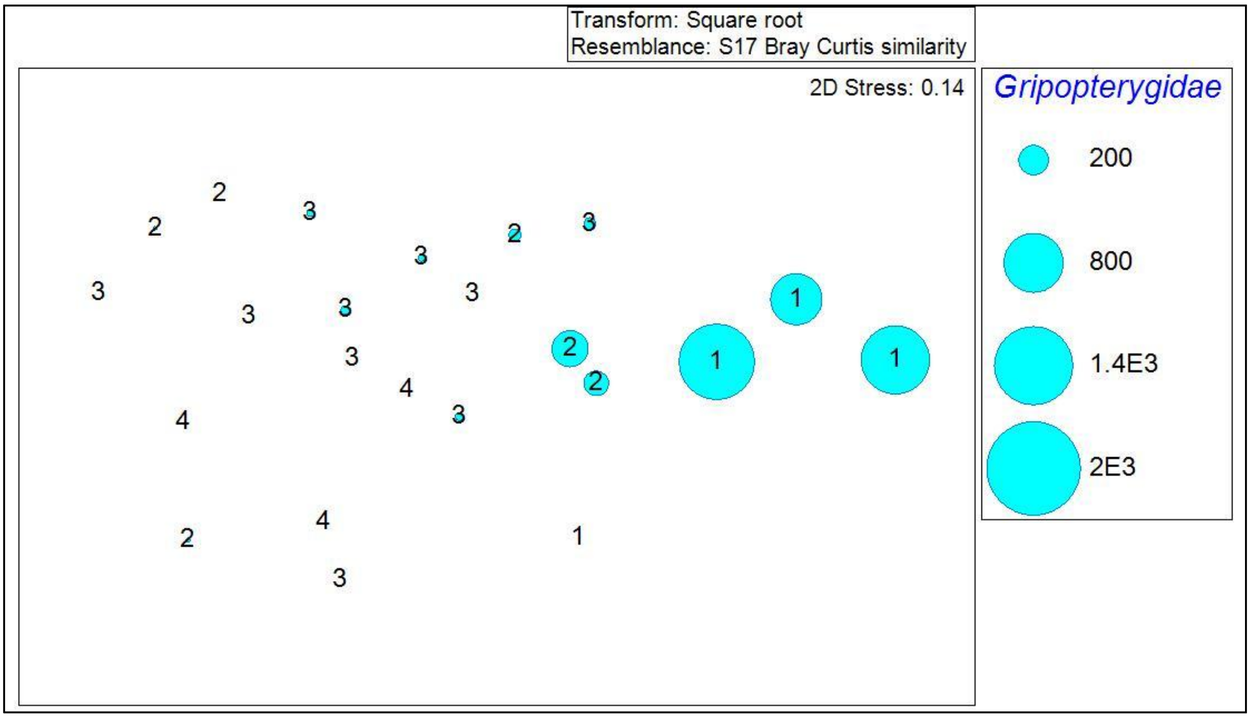

Figure 14 Bubble plot indicating relative abundance of Gripopterygidae between edge samples

BEST was not conducted as there was no clear separation of the macroinvertebrate edge samples into zone groups.

3.4 Univariate Indices

Taxa richness, abundance and AUSRIVAS scores for the 23 sites are provided in Table 16. Taxa richness represents the number of different macroinvertebrate families present in the sample. Non-parametric analysis determined that there is a significant ($p<0.05$; Appendix F) difference in the number of taxa observed in riffle samples between some zones. The multiple comparisons test indicates that taxa richness is only significantly different between Zone 1 and Zone 2. Figure 15 shows that taxa richness was much higher in riffle samples collected from Zone 1 than from Zone 2, with similar results for the EPT taxa (Figure 16). No significant different in taxa richness was found in edge samples between zones.

Total abundance was estimated based on the proportions observed from the identification of 200 (minimum) animals. No significant difference was found in taxa abundance from riffle samples between the four zones. No significant different in total abundance was found in edge samples between zones.

AUSRIVAS banding was either A or B for all sites indicating that the “health” of the Murrumbidgee River throughout the study area was either in line with or slightly poorer than reference condition. Most sites achieved at least an A except for Zone 3 sites downstream of MUR 23 (exclusive) which were awarded a B rating for both habitats. The O/E50 scores, on which the bands were based, were not found to differ significantly between zones for either riffle or edge samples.

Indices related to taxon sensitivity are summarised in Table 17. EPT richness indicates the number of families collected in each sample from the Orders of Ephemeroptera, Plecoptera and Trichoptera.

Generally EPT richness was fairly consistent between the two habitats for each site but there was variation between sites. Minimum EPT richness was 3 at MUR 15 (riffle sample) and the maximum was 11 at MUR 4 (riffle sample). Non-parametric tests found significant differences in the EPT richness of riffle samples between the four zones. EPT richness of riffle samples was found to be significantly higher in Zone 1 than in Zone 3 (Table 19; Figure 17). There was no significant difference found in EPT richness of edge samples between zones (Table 17).

The relative abundance of tolerant taxa is the proportion of total abundance made up of taxa from the Oligochaeta, Chironomidae and other Diptera groups. The proportion of abundance comprised of EPT taxa appeared to be higher than tolerant taxa abundance for most Zone 1 sites but the reverse was true for many Zone 2 and Zone 3 sites. However, statistical analysis detected no significant difference in EPT or relative abundance of tolerant taxa between zones for either edge or riffle samples.

SIGNAL-2 provides another measure of health by focusing on the tolerance the macroinvertebrate community to pollution. The averaged SIGNAL-2 score provides an overall estimate of taxa sensitivity for each sample based. All samples received a moderate SIGNAL-2 score with values ranging from 4.06 at MUR 37 (edge sample) and 5.90 at MUR 2 (riffle sample). No significant difference was detected in SIGNAL-2 between the zones for either edge or riffle samples.

The graphs in Figure 17 and Figure 18 display the proportion of overall richness comprised of EPT taxa. For most sites the proportion of EPT taxa is quite high and fairly consistent across samples and habitats. The overall number of taxa and EPT taxa does vary greatly between sites but as was discussed above, the greatest differences richness between zones were for riffle samples.

Table 16 Taxa richness, abundance and AUSRIVAS Bands for autumn 2012

Zone	Site	Location	AUSRIVAS O/E score		AUSRIVAS band		Overall Site Assessment
			Riffle	Edge	Riffle	Edge	
Zone 1	MUR 1	D/S Tantangara	0.87	0.89	B	A	B
	MUR 2	Yaouk Bridge	1.02	0.9	A	A	A
	MUR 3	Bobeyan Road Bridge	0.8	1.01	B	A	B
	MUR 4	Bobeyan Road Camp Ground	0.96	0.86	A	A	A
Zone 2	MUR 6	D/S STP, Pilot Creek Road	0.7	1.01	B	A	B
	MUR 9	Murrells Crossing	0.88	1.02	A	A	A
	MUR 12	Bredbo	0.89	0.71	A	B	B
	MUR 15	Bumbalong Road, near Colinton	0.78	0.86	B	A	B
	MUR 16	The Willows, near Michelago	0.78	0.7	B	B	B
	MUR 18	U/S Angle Crossing	0.78	0.78	B	B	B
Zone 3	MUR 19	D/S Angle Crossing	0.89	0.78	A	B	B
	MUR 22	Tharwa Bridge	1	0.93	A	A	A
	MUR 23	Point Hut Crossing	1	0.98	A	A	A
	MUR 27	Kambah Pool	0.67	0.78	B	B	B
	MUR 931	Fairvale – 4km U/S of the Cotter River Confluence	1	0.62	A	B	B
	MUR 28	U/S Cotter River Confluence	0.78	0.78	B	B	B
	MUR 935	Casuarina Sands	0.78	0.7	B	B	B
	MUR 937	Mt. MacDonald – 5km D/S of the Cotter River Confluence	0.67	0.7	B	B	B
	MUR 29	Uriarra Crossing	0.78	0.78	B	B	B
	MUR 30	U/S Molonglo River Confluence	0.78	0.78	B	B	B
Zone 4	MUR 31	D/S Molonglo River Confluence	0.89	0.85	A	A	A
	MUR 34	Hall's Crossing	1.11	0.54	A	B	B
	MUR 37	Boambolo Road	N/A	0.7	N/A	B	B

Table 17 Tukey's HSD post-hoc pairwise comparisons of pairwise comparisons of taxa richness in edge samples between Zones

Text in red indicates significant differences (*p*<0.05)

Zone	1	2	3
1			
2	0.04		
3	0.05	0.99	
4	0.67	0.82	0.85

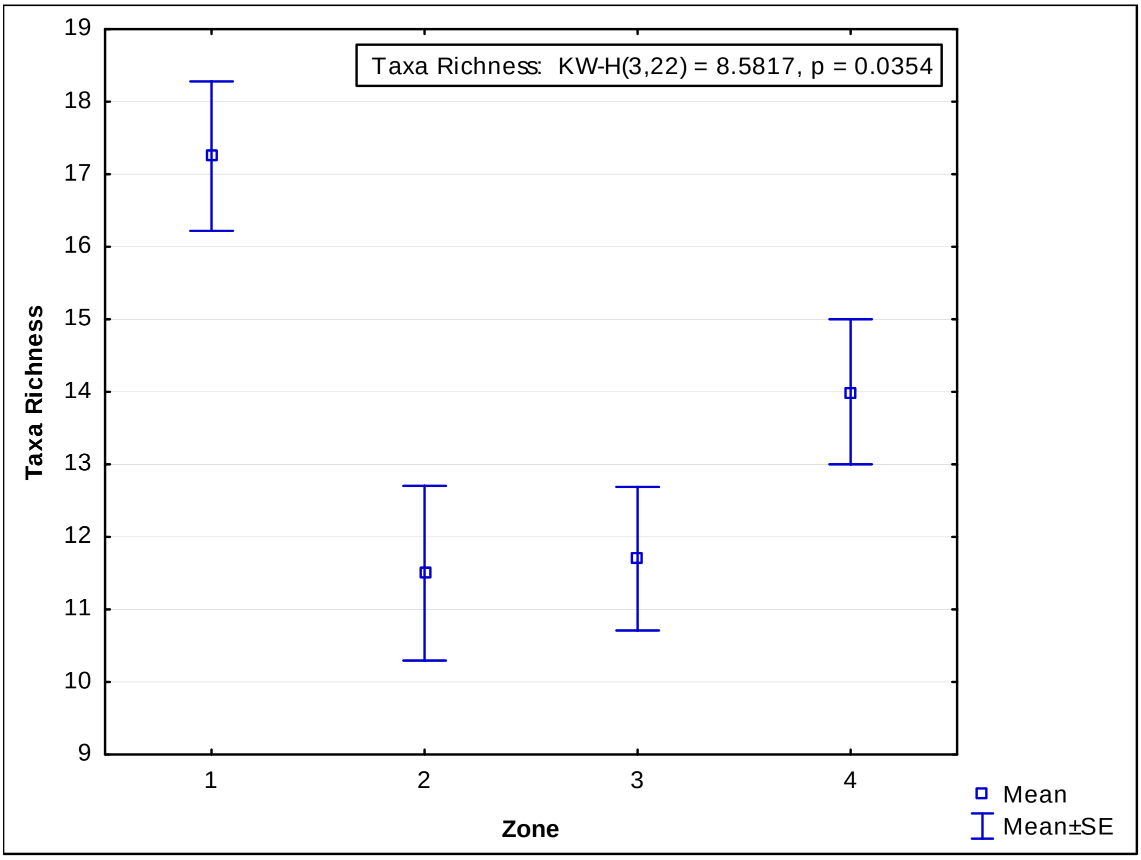

Figure 15 Means plot showing differences in Taxa richness of riffle samples between Zones

Table 18 EPT richness, relative abundance of tolerant taxa and SIGNAL-2 scores for autumn 2012

Zone	Site	EPT Relative Abundance		Relative Abundance of Tolerant Taxa		SIGNAL-2	
		Riffle	Edge	Riffle	Edge	Riffle	Edge
Zone 1	MUR 1	65	45	33	52	5.12	4.33
	MUR 2	86	29	9	67	5.90	5.00
	MUR 3	69	62	29	35	5.53	4.28
	MUR 4	21	28	79	55	5.47	4.11
Zone 2	MUR 6	44	25	56	63	5.38	4.76
	MUR 9	25	35	75	60	5.20	4.84
	MUR 12	7	22	91	75	5.42	4.77
	MUR 15	4	15	96	65	4.57	4.31
	MUR 16	14	71	86	28	5.11	4.79
	MUR 18	31	37	68	60	4.92	4.29
Zone 3	MUR 19	17	69	83	31	5.55	5.00
	MUR 22	38	55	60	25	5.13	4.68
	MUR 23	21	71	77	24	4.50	4.31
	MUR 27	18	27	81	72	5.56	5.13
	MUR 931	27	40	69	57	5.20	4.36
	MUR 28	14	41	86	57	4.91	4.63
	MUR 935	15	46	85	53	4.13	4.71
	MUR 937	17	41	83	56	4.50	4.62
	MUR 29	23	22	76	44	5.38	4.07
	MUR 30	31	44	69	55	4.70	4.38
Zone 4	MUR 31	73	34	27	36	5.38	4.33
	MUR 34	17	17	81	79	5.33	4.45
	MUR 37	N/A	19	N/A	76	N/A	4.06

Table 19 Tukey's HSD post-hoc pairwise comparisons of pairwise comparisons of EPT richness in riffle samples between Zones

Text in red indicates significant differences (*p*<0.05)

Zone	1	2	3
1			
2	**0.39**		
3	**0.04**	1	
4	**1**	1	**1**

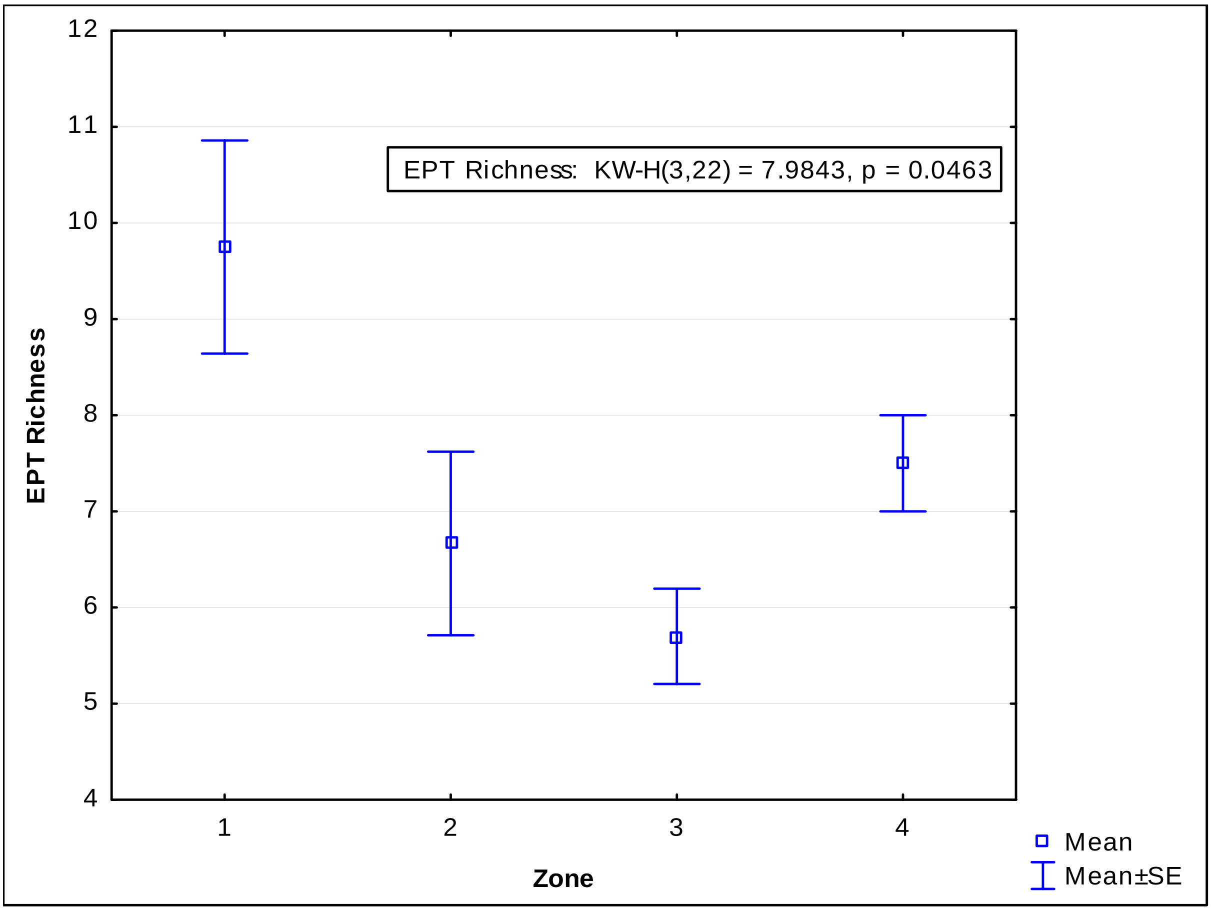

Figure 16 Means plot showing differences in EPT richness of riffle samples between Zones

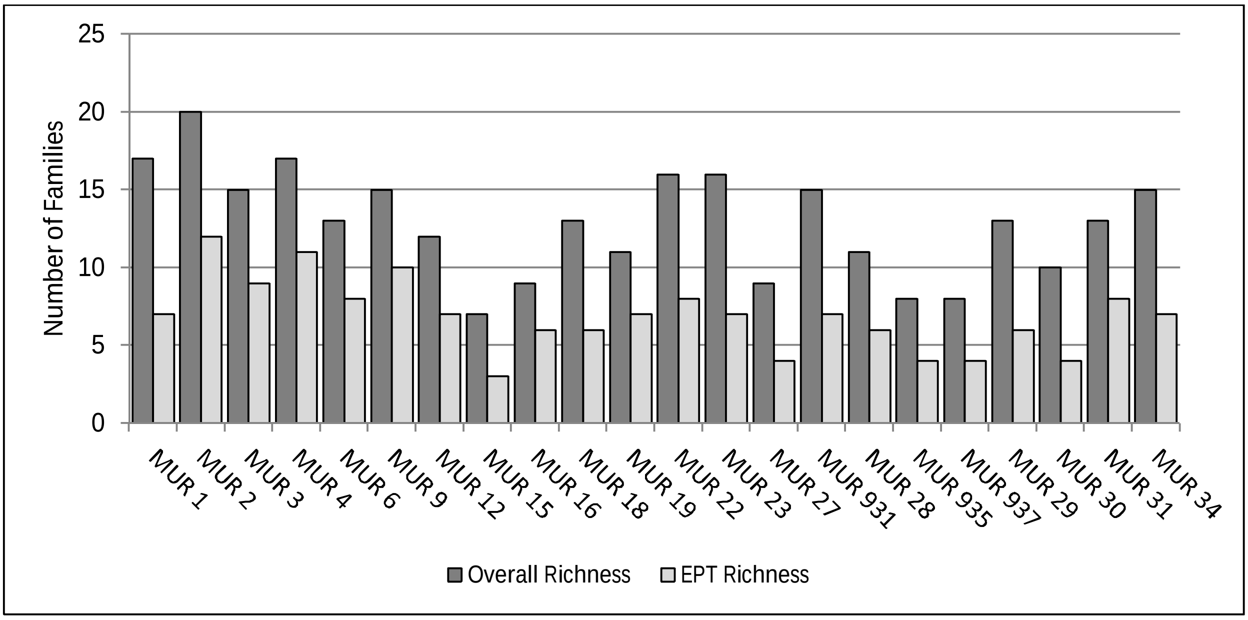

Figure 17 Number of EPT taxa compared to overall richness within riffle samples

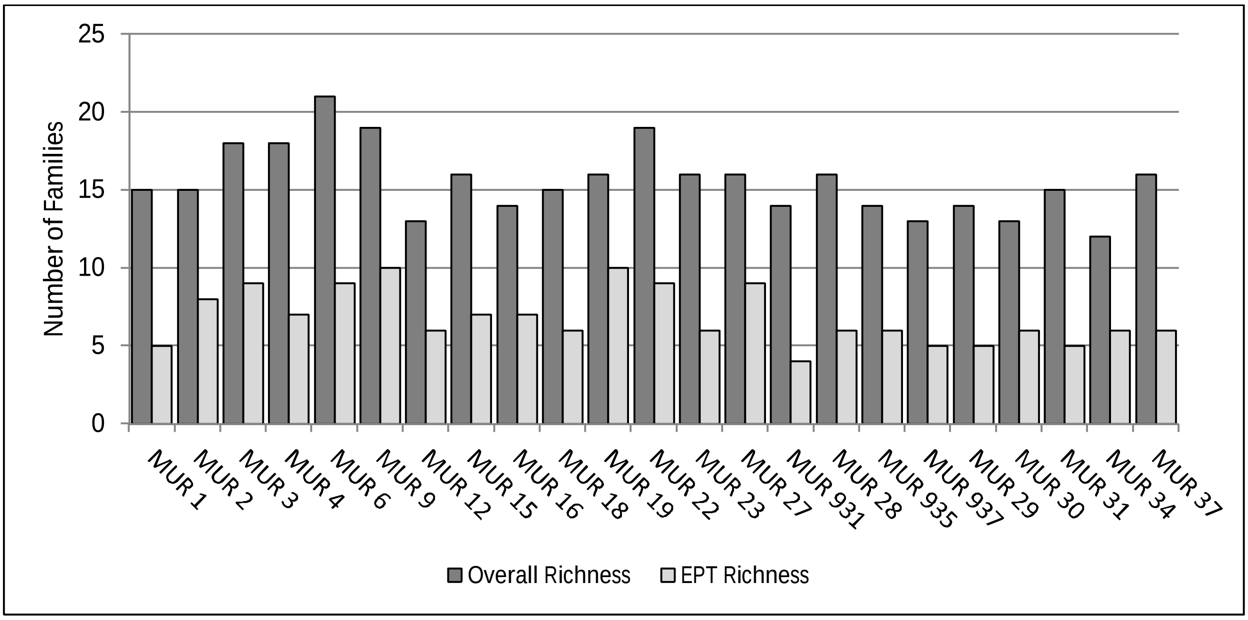

Figure 18 Number of EPT taxa compared to overall richness within edge samples

4. Discussion

4.1 Water Quality

All continuously gauged water quality parameters were affected by the high flows occurring at the beginning of autumn. Hall's Crossing was inundated during the high flows and was not operational for the autumn period, with the exception of water level. On the 1st of June after repairs, the water quality monitoring was calibrated and re-installed.

There was a slight elevation of pH levels at all sites within Zone 3 and Zone 4 which are all either on the cusp of, or exceeding the ANZECC and ARMCANZ (2000) guidelines. This does not appear to be related to activities connected to the M2G project, as it is consistent with the pattern present at all sites regardless of location. This pattern shows an increase in pH values the further downstream a site is located.

NO_x concentrations exceeded the ANZECC and ARMCANZ (2000) guidelines at MUR 1. This has only occurred on one previous sampling round (spring 2010) for this particular site (downstream of the Tantangara dam wall). It is proposed that the source of these increased nutrient levels was rainfall during 2010, however due to the lack of rainfall immediately prior to autumn 2012, this cannot be the case for the current study; rather, we attribute this to the groundwater input. The groundwater input in the upstream sections of the Murrumbidgee River, directly downstream of Tantangara Dam is minimal and usually diluted by water releases from the dam. However, during the autumn 2012 sampling period no water was released from Tantangara Dam, resulting in a higher proportion of groundwater contributing to the surface flow component. Higher groundwater contributions may be carrying nutrients to the surface water bodies (Ouyang, 2012).

The elevated nutrient levels which are present at a majority of sites downstream from MUR 12 exceed the guideline levels. These excess nutrient levels of total nitrogen, total phosphorus and NO_X show a distinct pattern that indicates the source of these nutrients is between MUR 9 and 12, with a further increase downstream between MUR 12 and 15 (within Zone 2). The source of these nutrients could be a number of factors, such as tributary inputs, a build up from agricultural sources or some other point source. The continuing trend throughout Zone 2 and 3 indicates that the nutrients are being taken up by the system slowly as they move downstream, with NO_X and total phosphorus falling below guideline levels at MUR 27 and MUR 937, respectively. Although total nitrogen does not return to an acceptable level downstream of this point, the levels do continue to reduce. These results suggest that, within Zones 2 and 3, there is no other significant input of nutrients downstream of MUR 23.

However, in Zone 4 nutrient levels increase markedly with NO_X levels increasing to sixty times the ANZECC and ARMCANZ (2000) guidelines. The source of these increased nutrient levels is the Molonglo River, with the Lower Molonglo Water Quality Control Centre (LMWQCC) discharge point approximately two kilometres upstream of the confluence.

4.2 Patterns in macroinvertebrate communities

Despite high nutrient concentrations in Zone 4, the macroinvertebrate communities collected from sites within this zone were not separated from others in the multivariate analyses. The only significant differences were observed between Zone 1 sites compared to Zones 2 and 3 for the riffle communities and between Zone 1 and Zones 2-4 for the edge communities. Results were similar to those seen in spring 2011 which indicates that a good baseline is being established despite differences in flow and season. The most consistent trends were increasing numbers of Simuliidae (Diptera; riffle only) and decreasing numbers of Gripopterygidae (Ephemeroptera; edge and riffle), Leptophlebiidae (Ephemeroptera; riffle only) and Oligochaeta (edge only) between Zone 1 and the zones further downstream.

The decreasing trend with distance downstream in Gripopterygidae and subsequent increase in Simuliidae abundance was also noted in spring 2011. Reduced abundances of Gripopterygidae (Plecoptera) have been linked to nutrient enrichment,(Lenat, 1984, cited in Maul *et al.* 2004). Thus, the increased presence of Gripopterygidae in the further upstream sites is most likely due to the reduced intensity of agricultural practices in this area and the associated quality of the surface water. This is also likely to be the reason behind a higher number of Leptophlebiidae being observed at Zone 1 sites. This family has a SIGNAL-2 grade of 8 indicating that these animals are highly sensitive to pollutants (Chessman, 2003).

Given the low nutrient levels at Zone 1 sites, it is surprising that the highest numbers of Oligochaetes were collected in this zone. Oligochaeta are highly tolerant taxa which are often associated with very disturbed environments, but their tolerance for disturbed systems does not preclude their presence in pristine environments (Gooderham and Tsyrlin, 2002). Increased numbers of Simuliidae at downstream sites are more likely to be due to differences in flow as Simuliidae prefer to live in faster-flowing water (Gooderham and Tsyrlin, 2002; William, 1980). This increased flow is a result of the persistent increased flow down the Cotter River, as a result of the high rainfall at the beginning of the period. The continual operation of the Bendora Main scour valve at the Murrumbidgee River just prior to the collection of macroinvertebrate samples is also likely to have favoured flow – dependant taxa such as the Simuliidae, and provides another, but not mutually exclusive explanation for the increased estimated abundances in this section of the Murrumbidgee River.

The only differences in the univariate measures between zones were in overall richness and EPT richness of Zone 1 riffle samples. Richness and EPT richness was higher on average within Zone 1 riffle samples than Zone 2. The raw data indicates that the taxa which occurred in large numbers within these samples were mostly from the EPT groups. Thus, the increased richness within the riffle habitat of Zone 1 sites can be attributed to improved water quality rather than any pollutants which may cause clumping of opportunistic species. However, some changes were also evident as a result of differing levels of flow. A similar study into the impact of flow regimes noted that changes in flow lead to differences in richness without influencing O/E 50 scores (Chessman et al., 2010). The impact on richness was considered to be related to the flow itself but also differing temperature. Although less noticeable than in previous events, the water temperature was generally lower within Zone 1 sites compared to other zones. Chessman et al. (2010) also discuss the limitations of AUSRIVAS for identifying the impacts of hydrological alterations given that many of the reference sites for dryland rivers are already subject to some hydrological variation. This highlights the importance of the baseline data collection for the identification of impacts resulting from hydrological modification to the system.

As with the multivariate community, there was no indication of changes in the univariate indices within Zone 4 as a result of increased nutrients downstream of Molonglo River confluence. Zone 4 sites generally have higher relative abundance's of tolerant taxa compared to EPT taxa, perhaps due to higher nutrient levels which tend to promote opportunistic species by increasing food sources. However, given the extremely high levels of nitrogen at Zone 4 sites, the macroinvertebrate community was still in remarkably good health.

The AUSRIVAS score was either an A or B for all sites including those in Zone 4. This indicates that all 23 sites were only missing a small number, if any, of the expected taxa (Appendix G). Refer to Appendix H for a complete list of collected taxa. The good and fairly consistent AUSRIVAS results across the Murrumbidgee River sites may reflect the fact that all sites were impacted by the March high flow event and at the time of sampling were still in a state of recovery. Very high rainfall was received at the start of the season, which provided approximately 8 weeks for sites to recover before sampling was conducted. These results indicate that this length of time was adequate for the recovery of community diversity for the magnitude of flow which occurred, to levels which were reasonably consistent with previous sampling runs. However, it is also evident that longer is needed for the relative abundances of macroinvertebrates to reach pre-disturbance levels, with some changes in dominant taxa apparent during recovery periods.

5. Conclusions

High nutrient levels were recorded in autumn 2012, particularly in Zone 2 and 4 and at the upstream sites in Zone 3. Levels of total phosphorus and nitrogen were above the ANZECC guideline levels at several sites. This is not surprising given that the land-use in the region is predominantly agriculture; however, there was indication of a specific source of nutrient input between MUR 9 and MUR 12. These higher nutrient levels have been linked to the absence of some more sensitive taxa in the downstream zones where nutrient levels are higher.

Overall site assessments determined that all sites were either BAND A or BAND B indicating that they were either 'similar to reference' of 'significantly impaired' respectively. The macroinvertebrate communities, although still reflecting moderate to high levels of intra-zone variation, exhibited fewer differences between zones than were seen in some of the previous sampling events. This limited variability has been attributed to the high flow event at the beginning of the period resulting in all sites being in a state of recovery. It has been shown that recovery time for diversity to return to pre-disturbance levels is reduced in comparison to that of abundance.

Within the downstream reaches of the study area there was a noticeable increase in Simuliidae, which were highly dominant in the riffle habitats at some sites. This is due to the influence of the prolonged high flows down the Cotter River and the operation of the Bendora Main scour valve increasing flows downstream of the Cotter Confluence. This is presenting ideal conditions for Simuliidae to dominate in conditions it finds favourable during this period of recovery when space and resources are available. This demonstrates the potential for environmental hydrological changes to temporarily alter the structure of the macroinvertebrate community, and its resilience to these large scale flow events.

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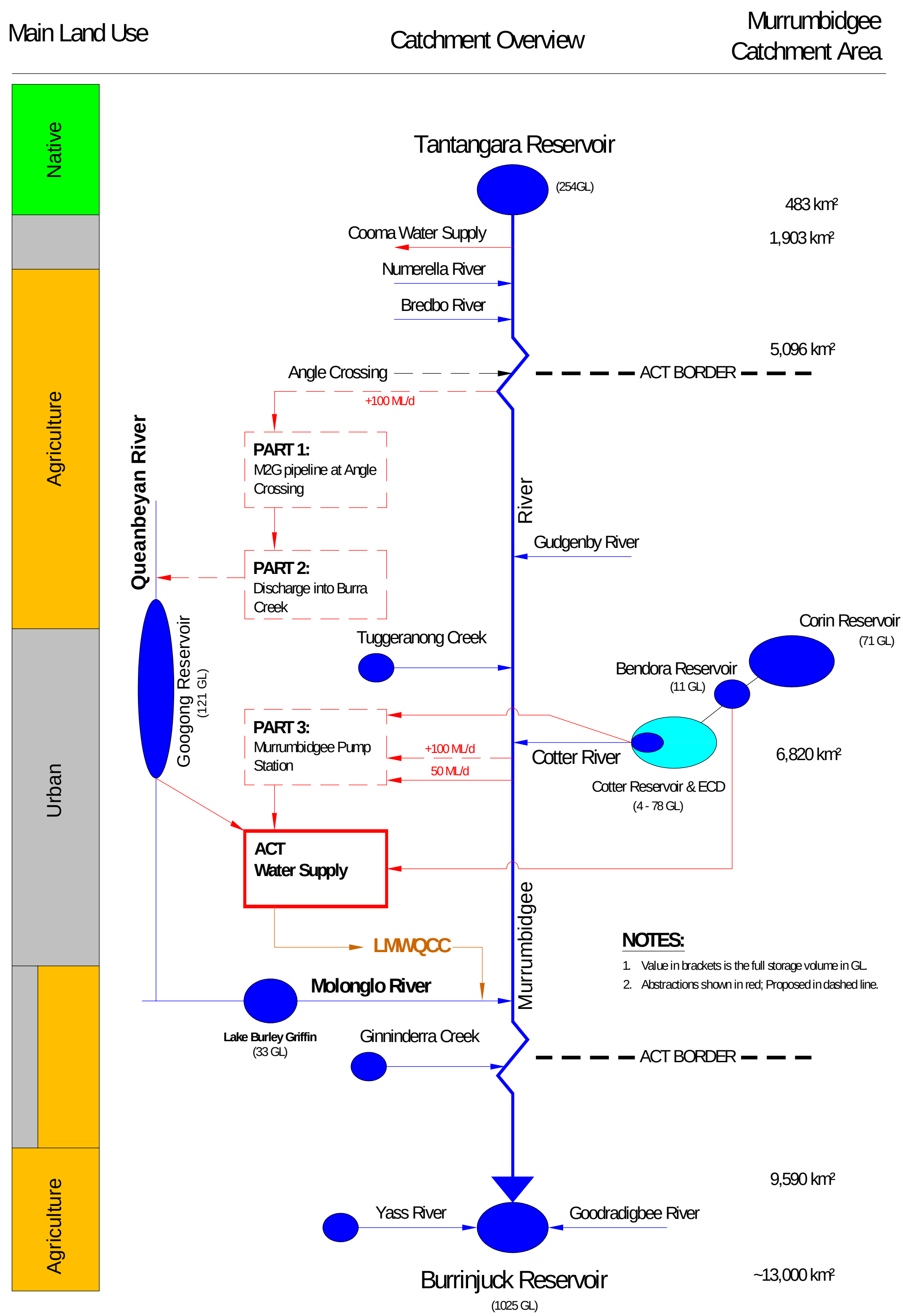
Appendix A

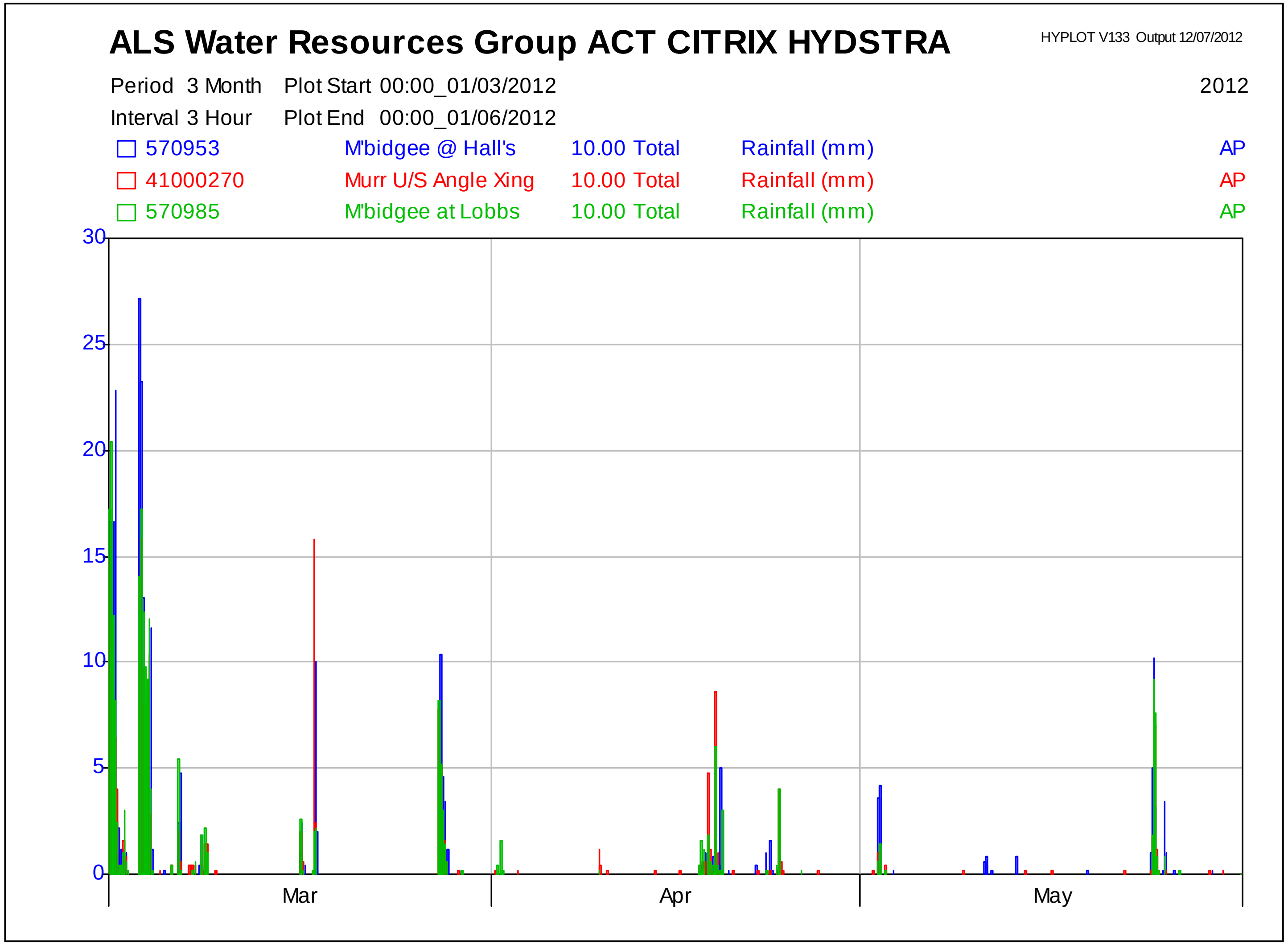
Schematic representation of the Murrumbidgee Catchment and ACTEW's major water projects



Appendix A. Murrumbidgee Catchment overview including ACTEW's major water projects

Appendix B

Rainfall summary from upstream Angle Crossing Lobb's Hole and Halls Crossing for autumn 2012



Appendix B. Rainfall totals during the spring period at Halls Crossing (570953), upstream Angle Crossing (41000270) and Lobb's Hole (570985)

Appendix C
Site Summaries

MUR1

Downstream Tantangara Reservoir
Zone 1: Tantangara - Cooma
8/5/2012 11:10am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
8.3	29	1.2	18	7.0	102.5	10.4

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
16	0.050	0.048	< 0.002	0.009	0.015	0.16

Daily Flow: 140 ML/day

Recorded at the closest station (41000260), located on the Murrumbidgee River at Yaouk. (Source: www.water.nsw.gov.au)

Compared to current level:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	B	B	B
Edge Habitat	A	A	A
Overall Site Assessment	B	B	B

Riffle Habitat

- Highly silted
- Only present in small sections, these were compiled together to create a single sample
- Dominant substrate was silt

Dominant Taxa

- Chironomidae
- Leptophlebiidae
- Gripopterygidae
- Conoesucidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Coloburiscidae
- Leptophlebiidae
- Gripopterygidae
- Hydrobiosidae

Additional Comments

- Very little flow, no water currently being released from Tantangara Dam
- Woody debris throughout site
- Iron bacteria seepage present

Edge Habitat

- Highly silted
- Dominant trailing bank vegetation was macrophytes
- Mountain Galaxias (*Galaxias olidus*) caught in the sample, subsequently released

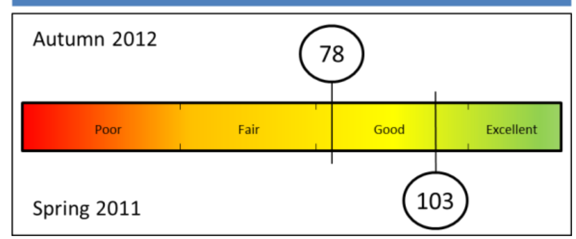
Dominant Taxa

- Baetidae
- Corixidae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Dixidae
- Leptophlebiidae

Site Quality Assessment



MUR2

Yaouk Bridge
Zone 1: Tantangara - Cooma
8/5/2012 1:30pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
8.4	27	1.6	< 2	7.1	107.8	11.0

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
16	0.009	0.007	< 0.002	0.006	0.005	0.08

Daily Flow: 140 ML/day

Recorded at the closest station (41000260), located on the Murrumbidgee River at Yaouk. (Source: www.water.nsw.gov.au)

Compared to current level:

Spring 2011: ↑ Autumn 2011: ↓

AUSRIVAS Results	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	A
Edge Habitat	A	X	A
Overall Site Assessment	A	A	A

Riffle Habitat

- Large riffle zone
- Dominant substrate was cobble

Dominant Taxa

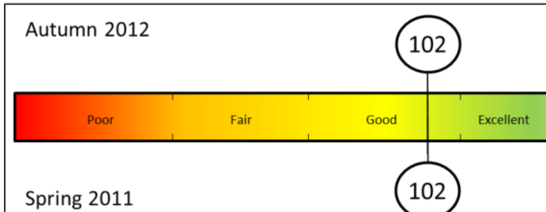
- Chironomidae
- Coloburiscidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Coloburiscidae
- Leptophlebiidae
- Telephlebiidae
- Gripopterygidae
- Hydrobiosidae
- Philopotamidae

Site Quality Assessment

Autumn 2012



Spring 2011

Edge Habitat

- Restricted access to edge zone due to restriction by private property access
- Dominant trailing bank vegetation was macrophytes

Dominant Taxa

- Amphipoda
- Chironomidae
- Baetidae
- Corixidae
- Veliidae
- Leptoceridae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae
- Gripopterygidae
- Hydrobiosidae

Additional Comments

- Dense areas of filamentous algae along the margins of the channel

MUR3

Bobeyan Road Bridge
Zone 1: Tantangara - Cooma
8/5/2012 3:00pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
10.1	33	4.2	2	7.3	109.6	10.8

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
18	0.004	0.002	< 0.002	0.004	0.012	0.16

Daily Flow: 140 ML/day

Recorded at the closest station (41000260), located on the Murrumbidgee River at Yaouk. (Source: www.water.nsw.gov.au)

Compared to current level:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	C	A	B
Edge Habitat	B	A	A
Overall Site Assessment	C	A	B

Riffle Habitat

- Mountain Galaxias (*Galaxias olidus*) caught in the sample, subsequently released
- Dominant substrate was cobble

Dominant Taxa

- None

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Coloburiscidae
- Leptophlebiidae
- Glossosomatidae
- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was macrophytes

Dominant Taxa

- Chironomidae
- Leptophlebiidae
- Corixidae

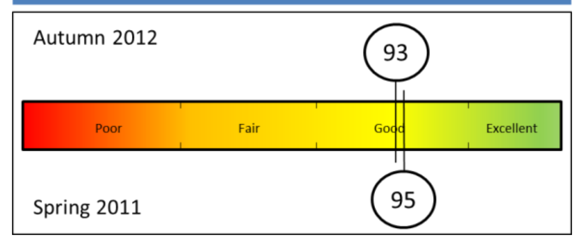
Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae
- Synlestidae

Additional Comments

- Sections of dead macrophytes
- Iron bacteria seepage present
- Direct stock access to river channel, has resulted in a high level of trampling along the edges

Site Quality Assessment



MUR4

Bobeyan Road Camp Ground
Zone 1: Tantangara - Cooma
8/5/2012 4:00pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
9.8	43	5.3	4	7.4	108.1	10.8

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
22	0.003	0.001	< 0.002	0.002	0.015	0.18

Daily Flow: 140 ML/day

Recorded at the closest station (41000260), located on the Murrumbidgee River at Yaouk. (Source: www.water.nsw.gov.au)

Compared to current level:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	A
Edge Habitat	B	X	A
Overall Site Assessment	B	A	A

Riffle Habitat

- Dominant substrate was boulder

Dominant Taxa

- Chironomidae
- Simuliidae
- Coloburiscidae
- Leptophlebiida
- Hydrobiosidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Coloburiscidae
- Leptophlebiidae
- Gripopterygidae
- Hydrobiosidae
- Philopotamidae

Additional Comments

- Clumps of filamentous algae in areas of slower moving water
- Large willow and other scrub pushed over by high flows, debris left in the tree's approximately 2m above current water level

Edge Habitat

- Highly silted
- Dominant trailing bank vegetation was macrophytes (*Phragmites australis*) and native shrubs

Dominant Taxa

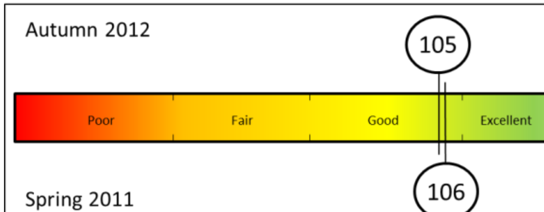
- Chironomidae
- Leptophlebiidae
- Corixidae
- Notonectidae
- Leptoceridae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae

Site Quality Assessment

Autumn 2012



Spring 2011

MUR6

D/S Cooma STP, Pilot Creek Road
Zone 2: Cooma – Angle Crossing
11/5/2012 10:10am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
10.2	96	5.3	3	7.6	110.9	10.2

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
37	0.003	0.001	< 0.002	< 0.002	0.016	0.21

Daily Flow: 150 ML/day

Recorded at the closest station (410033), located on the Murrumbidgee River at Mittagang. (Source: www.water.nsw.gov.au)

Compared to current flow:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	B
Edge Habitat	A	A	A
Overall Site Assessment	A	A	B

Riffle Habitat

- Larger riffle zone
- Dominant substrate was cobble

Dominant Taxa

- Chironomidae
- Coloburiscidae
- Leptophlebiidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Coloburiscidae
- Hydrobiosidae
- Leptophlebiidae

Edge Habitat

- Dominant trailing bank vegetation was macrophytes

Dominant Taxa

- Amphipoda
- Atyidae
- Corixidae
- Chironomidae

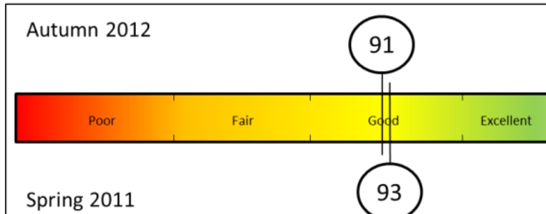
Sensitive Taxa (SIGNAL-2 ≥ 7)

- Hydrobiosidae
- Gripopterygidae

Additional Comments

- Periphyton dense, but only in patches
- Filamentous algae dense along the margins of the channel in the slower moving water
- Areas of erosion on the right hand bank
- Patches of dead grasses and shrubs from inundation during high flows
- Scrub pushed over by high flows

Site Quality Assessment



MUR9

Murrells Crossing
Zone 2: Cooma – Angle Crossing
11/5/2012 11:40am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
10.3	99	4.4	2	7.7	99.5	10.1

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
38	0.002	< 0.001	< 0.002	0.006	0.017	0.23

Daily Flow: 150 ML/day

Recorded at the closest station (410033), located on the Murrumbidgee River at Mittagang. (Source: www.water.nsw.gov.au)

Compared to current flow:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results			
	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	A
Edge Habitat	A	A	A
Overall Site Assessment	A	A	A

Riffle Habitat

- Larger riffle zone due to bridge being removed
- Dominant substrate was cobble

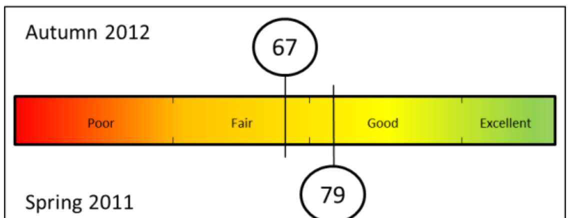
Dominant Taxa

- Chironomidae
- Leptophlebiidae
- Simuliidae
- Baetidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Coloburiscidae
- Leptophlebiidae

Site Quality Assessment



Edge Habitat

- Highly silted
- Dominant trailing bank vegetation was macrophytes

Dominant Taxa

- Chironomidae
- Corixidae
- Hydrobiosidae
- Leptoceridae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Hydrobiosidae
- Gripopterygidae
- Leptophlebiidae

Additional Comments

- Small bridge has been destroyed by high flows with remnants strewn across the site
- High levels of erosion on the left hand bank
- Some channelisation forming upstream of the riffle zone
- Wood debris remains from high flows

MUR12

Bredbo
Zone 2: Cooma – Angle Crossing
11/5/2012   1:00pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
12.1	170	8.9	10	7.7	98.3	9.4

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
65	0.036	0.034	0.002	0.006	0.034	0.35

Daily Flow: 510 ML/day

Recorded at the closest station (410050), located on the Murrumbidgee River at Billilingra. (Source: www.water.nsw.gov.au)

Compared to current flow:

Spring 2011:    Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	X	A
Edge Habitat	B	A	B
Overall Site Assessment	B	A	B

Riffle Habitat

- Larger riffle zone
- *Gambusia sp.* caught in sample, subsequently released
- Dominant substrate was cobble and pebble

Dominant Taxa

- Baetidae
- Hydrobiosidae
- Simulidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was macrophytes and willow

Dominant Taxa

- Chironomidae
- Corixidae
- Gyrinidae
- Simulidae

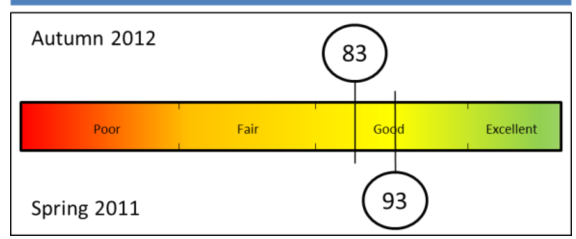
Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae
- Hydrobiosidae

Additional Comments

- Slower moving areas are highly silted
- Cobble material has been deposited on the right hand bank
- Patches of dead macrophytes and grasses due to inundation
- Island has had a large portion of sand eroded

Site Quality Assessment



MUR15

Bumbalong Road
Zone 2: Cooma – Angle Crossing
1/5/2012 10:00am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
11.7	160	8.4	7	7.8	110.0	11.4

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
60	0.068	0.066	< 0.002	0.011	0.041	0.50

Daily Flow: 770 ML/day

Recorded at the closest station (410050), located on the Murrumbidgee River at Billilingra. (Source: www.water.nsw.gov.au)

Compared to current flow:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	B
Edge Habitat	B	A	A
Overall Site Assessment	B	A	B

Riffle Habitat

- Sampled upstream of usual riffle due to site alteration by high flows
- Dominant substrate was sand

Dominant Taxa

- Simuliidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- None

Edge Habitat

- Dominant trailing bank vegetation was blackberry and wood

Dominant Taxa

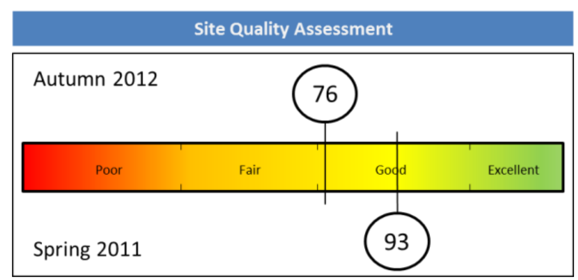
- Baetidae
- Corixidae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebidae

Additional Comments

- Sections of dead vegetation along the banks due to inundation
- Periphyton coverage limited due to the unstable nature of the sediment, although abundant on the small sections of stable substrate
- High levels of sand deposited on the site since Spring



MUR16

The Willows – Near Michelago
Zone 2: Cooma – Angle Crossing
1/5/2012 10:00am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
12.0	160	8.0	5	7.9	102.6	10.3

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
60	0.064	0.062	< 0.002	0.008	0.037	0.49

Daily Flow: 770 ML/day

Recorded at the closest station (410050), located on the Murrumbidgee River at Billilingra. (Source: www.water.nsw.gov.au)

Compared to current flow:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	B
Edge Habitat	B	A	B
Overall Site Assessment	B	A	B

Riffle Habitat

- Restricted riffle zone due to high flows
- Dominant substrate was cobble

Dominant Taxa

- Simuliidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Coloburiscidae
- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was native shrubs and tree's

Dominant Taxa

- Caenidae

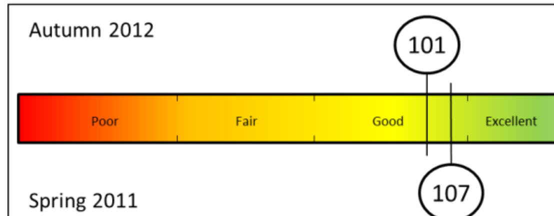
Sensitive Taxa (SIGNAL-2 ≥ 7)

- None

Additional Comments

- High level of periphyton coverage, however it is only a thin (young) layer due to scour from higher flows
- Evident lack of macrophytes which are usually present at this site, specifically *Myriophyllum sp.*

Site Quality Assessment



MUR18

Upstream Angle Crossing
Zone 2: Cooma – Angle Crossing
1/5/2012 10:00am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
12.4	150	8.5	6	7.9	101.0	11.1

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
59	0.061	0.059	< 0.002	0.009	0.037	0.49

Daily Flow: 570 ML/day

Recorded at the closest station (41000270), located on the Murrumbidgee River at upstream Angle Crossing.

Compared to current flow:

Spring 2011: ↓ Autumn 2011: ↓

Riffle Habitat

- Restricted riffle zone due to high flows
- Dominant substrate was cobble

Dominant Taxa

- Baetidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was macrophytes (mainly *Phragmites australis*) native shrubs

Dominant Taxa

- None

Sensitive Taxa (SIGNAL-2 ≥ 7)

- None

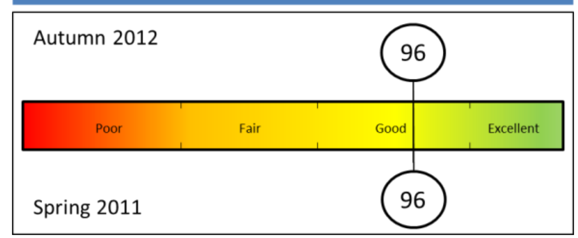
AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	B	B	B
Edge Habitat	A	B	B
Overall Site Assessment	B	B	B

Additional Comments

- Sections of erosion on the left hand bank
- New braid cut through providing a new riffle section on the far side of the channel (not sampled)

Site Quality Assessment



MUR19

Downstream Angle Crossing
Zone 3: Angle Crossing - LMWQCC
2/5/2012 10:30am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
11.5	160	7.9	6	8.1	102.1	11.4

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
60	0.061	0.059	< 0.002	0.007	0.036	0.48

Daily Flow: 520 ML/day

Recorded at the closest station (41000270), located on the Murrumbidgee River at upstream Angle Crossing.

Compared to current flow:

Spring 2011: ↓ Autumn 2011: ↓

Riffle Habitat

- Some deposition of sand in riffle zone
- Dominant substrate was cobble

Dominant Taxa

- Simuliidae
- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Some deposition of cobble and pebble material around the edge habitat
- Dominant trailing bank vegetation was native shrubs

Dominant Taxa

- Baetidae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae

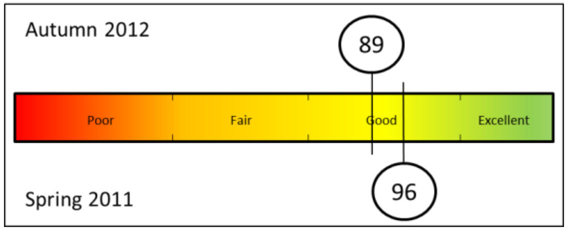
AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	A
Edge Habitat	A	A	B
Overall Site Assessment	A	A	B

Additional Comments

- New *Myriophyllum sp.* Growth
- Periphyton coverage approximately 70%, however reduced directly downstream of the crossing
- Areas of erosion on the right hand bank
- Large levels of sand and a concrete pillar deposited on left hand bank during the March event but was cleaned up by Bulk Water Alliance prior to sampling
- Iron bacteria seepage present
- Construction of the M2G uptake nearing completion with the removal of the coffer dam

Site Quality Assessment



MUR22

Tharwa Bridge
Zone 3: Angle Crossing - LMWQCC
2/5/2012 3:00pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
11.4	150	6.9	4	8.1	102.9	11.6

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
57	0.047	0.045	< 0.002	0.006	0.032	0.41

Daily Flow: 810 ML/day

Recorded at the closest station (410761), located on the Murrumbidgee River at Lobb's Hole.

Compared to current flow:

Spring 2011: ↓ Autumn 2011: ↓

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	A
Edge Habitat	B	A	A
Overall Site Assessment	B	A	A

Riffle Habitat

- Dominant substrate was sand

Dominant Taxa

- Simuliidae
- Oligochaeta
- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was macrophytes and shrubbery

Dominant Taxa

- Gyrinidae
- Corixidae
- Leptoceridae

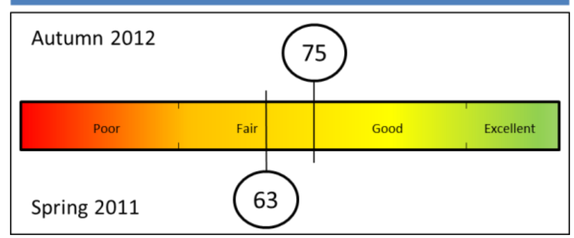
Sensitive Taxa (SIGNAL-2 ≥ 7)

- Hydrobiosidae

Additional Comments

- Re-construction of bridge finished since Spring sampling, removing the blockage of half the river width
- Some small areas of erosion on both banks
- Some scour present in the channel, directly upstream of the bridge

Site Quality Assessment



MUR23

Point Hut Crossing
Zone 3: Angle Crossing - LMWQCC
2/5/2012 12:15pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
11.4	150	9.9	7	8.0	99.5	9.9

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
58	0.046	0.044	< 0.002	0.004	0.034	0.44

Daily Flow: 810 ML/day

Recorded at the closest station (410761), located on the Murrumbidgee River at Lobb's Hole.

Compared to current flow:

Spring 2011: ↓ Autumn 2011: ↓

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	B	A	A
Edge Habitat	B	A	A
Overall Site Assessment	B	A	A

Riffle Habitat

- Dominant substrate was cobble

Dominant Taxa

- Simuliidae
- Baetidae
- Hydrobiosidae
- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Colobuiscidae
- Leptophlebiidae
- Gripopterygidae
- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was macrophytes, wood and shrubs

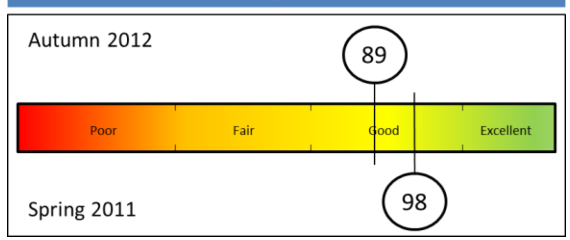
Dominant Taxa

- Baetidae
- Corixidae
- Leptoceridae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae
- Gripopterygidae
- Hydrobiosidae

Site Quality Assessment



Additional Comments

- Small areas of erosion on the left hand bank
- Large amounts of sand deposited around the site and within the channel
- Tree's pushed over from high flows
- Iron bacteria seepage present
- High level of material scoured from the car park area

MUR27

Kambah Pool
Zone 3: Angle Crossing - LMWQCC
7/5/2012 3:50pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
10.7	160	5.5	3	8.0	105.5	10.7

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
63	0.011	0.009	< 0.002	0.007	0.027	0.37

Daily Flow: 750 ML/day

Recorded at the closest station (410761), located on the Murrumbidgee River at Lobb's Hole.

Compared to current flow:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	B	B
Edge Habitat	B	B	B
Overall Site Assessment	B	B	B

Riffle Habitat

- Dominant substrate was bedrock

Dominant Taxa

- Chironomidae
- Simuliidae
- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Limited edge habitat available
- Dominant trailing bank vegetation was macrophytes and wood

Dominant Taxa

- Baetidae
- Corixidae
- Leptoceridae

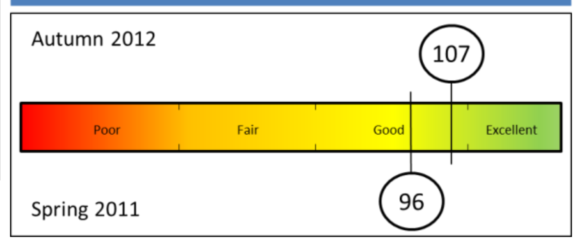
Sensitive Taxa (SIGNAL-2 ≥ 7)

- None

Additional Comments

- Scour on right hand bank
- Woody debris remaining from March event
- Murray River Crayfish (*Euastacus armatus*) was caught at the site, not in a sample, and released

Site Quality Assessment



MUR931

Fairvale
Zone 3: Angle Crossing - LMWQCC
7/5/2012 10:15am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
10.7	160	5.6	4	8.0	103.7	10.8

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
65	0.008	0.006	< 0.002	0.006	0.026	0.34

Daily Flow: 750 ML/day

Recorded at the closest station (410761), located on the Murrumbidgee River at Lobb's Hole.

Compared to current flow:

Spring 2011: ↓

Autumn 2011: ↓

Riffle Habitat

- Dominant substrate was cobble

Dominant Taxa

- Simuliidae
- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was wood, blackberries and native tree's and shrubs

Dominant Taxa

- None

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae
- Gripopterygidae

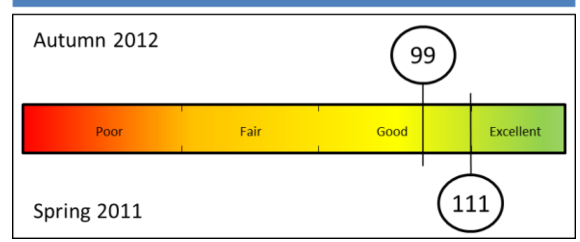
AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	B	A
Edge Habitat	B	B	B
Overall Site Assessment	B	B	B

Additional Comments

- New periphyton growth
- Filamentous algae in thick mats, but patchy
- Very few macrophytes
- Some small isolated areas of erosion
- A number of tree's have been pushed over by the March event
- Large amounts of logs and wood debris deposited along the right hand bank
- Upstream riffle was sampled due to better looking habitat

Site Quality Assessment



MUR28

Upstream Cotter River Confluence
Zone 3: Angle Crossing - LMWQCC
9/5/2012 10:00am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
10.2	160	4.3	3	8.1	105.7	11.0

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
64	0.004	0.002	< 0.002	0.005	0.022	0.33

Daily Flow:

750 ML/day
Recorded at station 410761, located on the Murrumbidgee River at Lobb's Hole.

1200 ML/day
Recorded at station 410738, located on the Murrumbidgee River at Mt. MacDonald.

250 ML/day
Recorded at station 410700, located on the Cotter River at Cotter Kiosk (below the Enlarged Cotter Dam).

The high flows down the Cotter River limit the comparability of this seasons flow to that of other seasons, which is further complicated by the operation of the Bendora Scour Valve.

Riffle Habitat

- Dominant substrate was bedrock and boulder

Dominant Taxa

- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Gripopterygidae
- Hydrobiosidae

Edge Habitat

- Limited edge habitat available due to scour valve, resulting in a single edge sample
- Dominant trailing bank vegetation was wood

Dominant Taxa

- Chironomidae
- Baetidae
- Leptoceridae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae

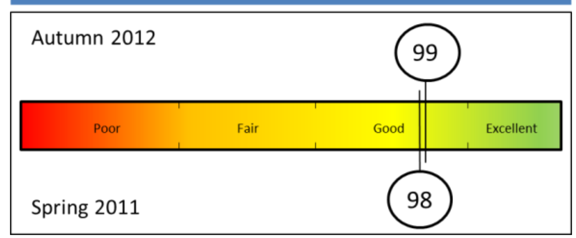
AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	B	B
Edge Habitat	B	B	B
Overall Site Assessment	B	B	B

Additional Comments

- Bendora Scour Valve has been on for over a week, was turned down, but not completely off, for sampling
- The Murrumbidgee Pump Station is currently recirculating water down the Cotter River, downstream of the Enlarged Cotter Dam

Site Quality Assessment



MUR935

Casuarina Sands
Zone 3: Angle Crossing - LMWQCC
9/5/2012   11:40am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
10.9	160	4.3	3	8.1	109.1	11.5

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
62	0.004	0.002	0.002	0.006	0.021	0.32

Daily Flow:

750 ML/day
Recorded at station 410761, located on the Murrumbidgee River at Lobb's Hole.

1200 ML/day
Recorded at station 410738, located on the Murrumbidgee River at Mt. MacDonald.

250 ML/day
Recorded at station 410700, located on the Cotter River at Cotter Kiosk (below the Enlarged Cotter Dam).

The high flows down the Cotter River limit the comparability of this seasons flow to that of other seasons, which is further complicated by the operation of the Bendora Scour Valve.

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	B	B
Edge Habitat	B	B	B
Overall Site Assessment	B	B	B

Riffle Habitat

- Dominant substrate was boulder

Dominant Taxa

- Chironomidae
- Simuliidae
- Baetidae
- Hydrobiosidae
- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae
- Philopotamidae

Edge Habitat

- Limited edge habitat due to inability to cross the channel
- Dominant trailing bank vegetation was wood and *Casuarina sp.*

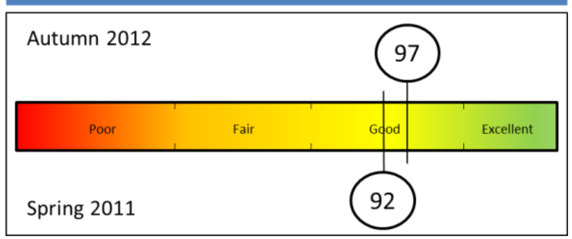
Dominant Taxa

- Baetidae
- Leptophlebiidae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae
- Gripopterygidae

Site Quality Assessment



Additional Comments

- Large dense mats of filamentous algae along the edges of the channel in the slower moving waters
- Some erosion on the left hand bank
- Sand has been scoured out from the edge of the riffle section
- Deposition of wood debris on the left hand bank
- Large amounts of sand and cobble material deposited on the right hand bank, possible shifting of some material also

MUR937

Mt. MacDonald
Zone 3: Angle Crossing - LMWQCC
9/5/2012 2:10pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
12.0	130	4.4	2	8.2	113.5	11.4

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
55	0.003	0.001	< 0.002	0.003	0.018	0.29

Daily Flow: 1200 ML/day

Recorded at the closest station (410738), located on the Murrumbidgee River at Mt. MacDonald.

Compared to current flow:

Spring 2011: ↓ Autumn 2011: ↓

Riffle Habitat

- Dominant substrate was cobble

Dominant Taxa

- Chironomidae
- Simuliidae
- Baetidae
- Hydrobiosidae
- Hydropsychidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Dominant trailing bank vegetation was wood and shrubs

Dominant Taxa

- Baetidae
- Corixidae
- Leptoceridae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae
- Gripopterygidae
- Hydrobiosidae

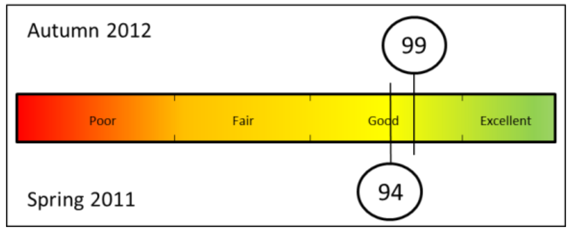
AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	B	B
Edge Habitat	B	B	B
Overall Site Assessment	B	B	B

Additional Comments

- Substrate is reasonably clean with some dense patches of periphyton
- Periphyton and filamentous algae is much more abundant in slow flowing areas
- Small areas of erosion on the left hand bank
- Wood debris is strewn throughout the edges of the channel
- Areas of dead grass and weeds along both banks due to inundation during higher flows

Site Quality Assessment



MUR29

Uriarra Crossing
Zone 3: Angle Crossing - LMWQCC
7/5/2012 1:15pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
11.0	130	4.6	< 2	8.0	109.1	11.2

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
53	0.004	0.004	< 0.002	0.004	0.019	0.28

Daily Flow: 1400 ML/day

Recorded at the closest station (410738), located on the Murrumbidgee River at Mt. MacDonald.

Compared to current flow:

Spring 2011: ↓

Autumn 2011: ↓

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	B	B
Edge Habitat	B	B	B
Overall Site Assessment	B	B	B

Riffle Habitat

- Dominant substrate was cobble

Dominant Taxa

- Chironomidae
- Baetidae
- Oligochaeta

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Hydrobiosidae

Edge Habitat

- Limited edge habitat available
- Dominant trailing bank vegetation was wood and *Casuarina sp.*

Dominant Taxa

- Corixidae
- Leptoceridae

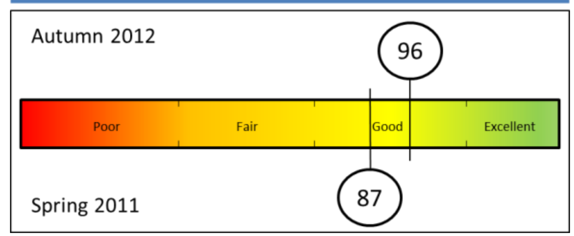
Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae

Additional Comments

- Iron bacteria seepage present
- Tree's have been pushed over by high flows (mainly *Casuarina sp.*)
- Large dense mats of filamentous algae in shallow pooling areas
- Grasses and weeds have been scoured off the left hand bank leaving bare patches

Site Quality Assessment



MUR30

Camp Sturt
Zone 3: Angle Crossing - LMWQCC
10/5/2012 3:10pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
12.6	130	3.9	4	8.1	111.3	10.8

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
56	0.003	0.001	< 0.002	0.003	0.020	0.28

Daily Flow: 1000 ML/day

Recorded at the closest station (410738), located on the Murrumbidgee River at Mt. MacDonald.

Compared to current flow:

Spring 2011:  Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	B
Edge Habitat	A	B	B
Overall Site Assessment	A	B	B

Riffle Habitat

- More extensive riffle zone than during Spring
- Dominant substrate was cobble

Dominant Taxa

- Simuliidae
- Baetidae
- Hydrobiosidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Additional Comments

- Iron bacteria seepage present
- Some erosion and slumping present on the left hand bank
- Sections of dead grasses and weeds from inundation during higher flows
- Large amounts od sand deposited on the right hand bank
- Large sections of large wood debris and logs have been deposited throughout the reach

Edge Habitat

- Limited edge habitat available due to inability to cross the channel
- Dominant trailing bank vegetation was macrophytes

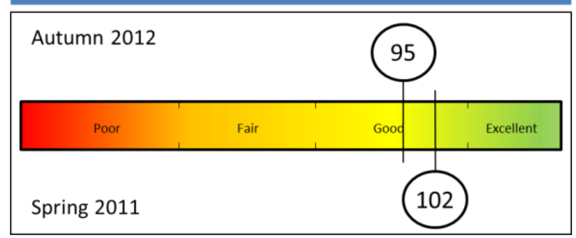
Dominant Taxa

- Chironomidae
- Baetidae
- Corixidae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae

Site Quality Assessment



MUR31

D/S Molonglo River Confluence
Zone 4: LMWQCC - Burrinjuck
10/5/2012 1:45pm

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
13.0	170	5.8	4	8.2	111.5	10.6

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
62	0.91	0.908	0.002	0.004	0.029	1.3

Daily Flow: 1700 ML/day

Recorded at the closest station (410777), located on the Murrumbidgee River at Hall's Crossing.

Compared to current flow:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	B	A
Edge Habitat	A	B	A
Overall Site Assessment	A	B	A

Riffle Habitat

- More extensive riffle zone due to scouring of sand from the riffle area
- Dominant substrate was cobble

Dominant Taxa

- Oligochaeta
- Simuliidae
- Hydrobiosidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Hydrobiosidae

Edge Habitat

- Sediment is anaerobic/sewage
- Sediment deposition in edge zone
- Dominant trailing bank vegetation was wood and *Casuarina sp.*

Dominant Taxa

- Chironomidae
- Corixidae
- Leptoceridae

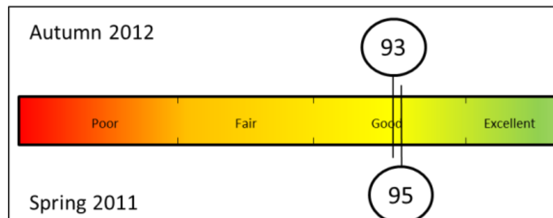
Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae

Additional Comments

- Large sediment deposits on the inside of the bend directly upstream of the site
- Some erosion on the right hand bank
- More tree's have been pushed over by high flows

Site Quality Assessment



MUR34

Halls Crossing
Zone 4: LMWQCC - Burrinjuck
10/5/2012 9:30am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
11.6	170	4.2	3	8.1	106.3	10.7

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
61	0.91	0.908	0.002	0.005	0.023	1.3

Daily Flow: 1700 ML/day

Recorded at the closest station (410777), located on the Murrumbidgee River at Hall's Crossing.

Compared to current flow:

Spring 2011: 

Autumn 2011: 

Riffle Habitat

- Higher proportion of sand in the riffle zone than expected
- Dominant substrate was cobble

Dominant Taxa

- Gomphidae
- Hydrobiosidae

Sensitive Taxa (SIGNAL-2 ≥ 8)

- Leptophlebiidae
- Hydrobiosidae

Edge Habitat

- Thick periphyton on infrequent stable habitat
- Dominant trailing bank vegetation was wood and pushed over *Casuarina sp.*

Dominant Taxa

- Gyrinidae

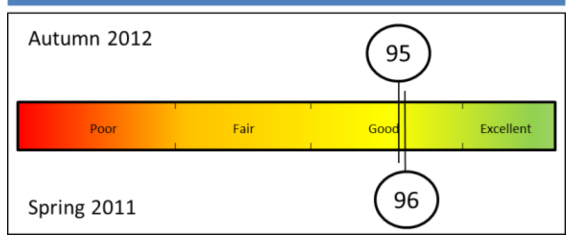
Sensitive Taxa (SIGNAL-2 ≥ 7)

- None

AUSRIVAS Results

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	A	A	A
Edge Habitat	B	C	B
Overall Site Assessment	B	N	B

Site Quality Assessment



Additional Comments

- Some erosion on right hand bank
- Tree's have been pushed over during high flow event
- Deposition of sand and cobble material on the inside of the bend on the left hand bank
- Wood debris remaining along the banks, deposited after high flows

MUR37

Boambolo Road
Zone 4: LMWQCC - Burrinjuck
10/5/2012 11:45am

Temp. (°C)	EC (µs/cm)	Turb. (NTU)	TSS (mg/L)	pH	D.O. (% Sat.)	D.O. (mg/L)
12.4	180	5.1	4	8.2	99.8	11.1

Alkalinity	NO_x (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	TN (mg/L)
64	0.72	0.718	0.002	0.004	0.022	1.1

Daily Flow: 1700 ML/day

Recorded at the closest station (410777), located on the Murrumbidgee River at Hall's Crossing.

Compared to current flow:

Spring 2011: 

Autumn 2011: 

AUSRIVAS Band Scores

	Autumn 2011	Spring 2011	Autumn 2012
Riffle Habitat	NS	B	NS
Edge Habitat	B	C	B
Overall Site Assessment	B	C	B

Riffle Habitat

- No riffle zone present
- Inundated by high water level

Additional Comments

- Water quality data collected in edge habitat under *Causarina sp.*
- Site inundated by combination of backed up dam water from Burrinjuck Reservoir and high flows
- Very little flow, if any
- Whole reach is highly silted with large sand deposits throughout
- Large areas of wood debris along banks and within channel

Edge Habitat

- Edge sample may not represent river, as it could be dam water
- Dominant trailing bank vegetation was wood and *Casuarina sp.*

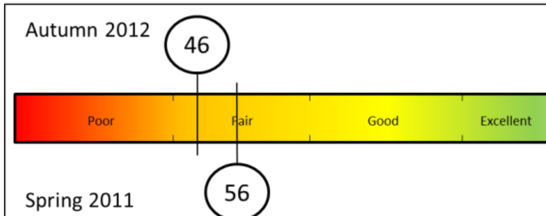
Dominant Taxa

- Chironomidae
- Corixidae

Sensitive Taxa (SIGNAL-2 ≥ 7)

- Leptophlebiidae

Site Quality Assessment



Appendix D

Principal Components Analysis of water quality variables

PCA
Principal Component Analysis

Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	5.77	57.7	57.7
2	1.61	16.1	73.8
3	1.21	12.1	86.0
4	0.627	6.3	92.3
5	0.472	4.7	97.0

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4	PC5
Temperature	0.368	0.182	0.036	0.083	0.264
EC	0.394	0.089	-0.146	-0.152	-0.263
Turbidity	0.321	-0.051	-0.362	0.424	0.455
pH	0.359	0.287	-0.051	-0.184	-0.378
D.O %	-0.108	0.617	0.078	-0.516	0.537
Alkalinity	0.390	0.101	-0.171	-0.196	-0.271
Nox	0.226	-0.150	0.731	0.107	0.112
TP	0.365	-0.221	-0.205	-0.008	0.330
TN	0.350	0.010	0.479	0.029	0.004
Ammonia	0.078	-0.641	-0.048	-0.663	0.167

Outputs
Plot: Graph5
Worksheet: Data2

Appendix E

PERMANOVA output

PERMANOVA – Riffle (main test)

Permutational MANOVA

Resemblance worksheet
Name: Resem3
Data type: Similarity
Selection: All
Transform: Square root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Zone	Fixed	4
Site	Random	22

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Zone	3	6257.7	2085.9	2.463	0.0048	9891
Site(Zone)	18	15244	846.89	No test		
Total	21	21502				

Details of the expected mean squares (EMS) for the model

Source	EMS
Zone	1*V(Site(Zone)) + 4.9697*S(Zone)
Site(Zone)	1*V(Site(Zone))

Construction of Pseudo-F ratio(s) from mean squares

Source	Numerator	Denominator	Num.df	Den.df
Zone	1*Zone	1*Site(Zone)	3	18
Site(Zone)			0	0

PERMANOVA – Riffle (multiple comparisons)

Permutational MANOVA

Resemblance worksheet
Name: Resem3
Data type: Similarity
Selection: All
Transform: Square root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Zone	Fixed	4
Site	Random	22

PAIR-WISE TESTS

Term 'Zone'

Groups	t	P(perm)	Unique perms
1, 2	1.8611	0.0201	210
1, 3	2.4489	0.0031	1001
1, 4	1.3133	0.1961	15
2, 3	0.90646	0.5298	5692
2, 4	0.85601	0.607	28
3, 4	0.76162	0.7811	66

Denominators

Groups	Denominator	Den.df
1, 2	1*Site(Zone)	8
1, 3	1*Site(Zone)	12
1, 4	1*Site(Zone)	4
2, 3	1*Site(Zone)	14
2, 4	1*Site(Zone)	6
3, 4	1*Site(Zone)	10

Average Similarity between/within groups

	1	2	3	4
1	50.361			
2	44.573	58.026		
3	43.878	61.913	64.665	
4	48.607	61.362	66.832	64.021

PERMANOVA – Edge (main test)

Permutational MANOVA

Resemblance worksheet
Name: Resem2
Data type: Similarity
Selection: All
Transform: Square root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Zone	Fixed	4
Site	Random	23

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Zone	3	7513	2504.3	2.9419	0.0005	9892
Site(Zone)	19	16174	851.25	No test		
Total	22	23687				

Details of the expected mean squares (EMS) for the model

Source	EMS
Zone	1*V(Site(Zone)) + 5.3333*S(Zone)
Site(Zone)	1*V(Site(Zone))

Construction of Pseudo-F ratio(s) from mean squares

Source	Numerator	Denominator	Num.df	Den.df
Zone	1*Zone	1*Site(Zone)	3	19
Site(Zone)			0	0

PERMANOVA – Edge (multiple comparisons)
Permutational MANOVA

Resemblance worksheet
Name: Resem3
Data type: Similarity
Selection: All
Transform: Square root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Zone	Fixed	4
Site	Random	22

PAIR-WISE TESTS

Term 'Zone'

Groups	t	P(perm)	Unique perms
1, 2	1.8611	0.0201	210
1, 3	2.4489	0.0031	1001
1, 4	1.3133	0.1961	15
2, 3	0.90646	0.5298	5692
2, 4	0.85601	0.607	28
3, 4	0.76162	0.7811	66

Denominators

Groups	Denominator	Den.df
1, 2	1*Site(Zone)	8
1, 3	1*Site(Zone)	12
1, 4	1*Site(Zone)	4
2, 3	1*Site(Zone)	14
2, 4	1*Site(Zone)	6
3, 4	1*Site(Zone)	10

Average Similarity between/within groups

	1	2	3	4
1	50.361			
2	44.573	58.026		
3	43.878	61.913	64.665	
4	48.607	61.362	66.832	64.021

Appendix F

Kruskal-Wallis output

Kruskal-Wallis ANOVA by Ranks; EPT Richness
Independent (grouping) variable: Zone
Kruskal-Wallis test: H (3, N= 22) =7.984273 p =.0463

	Code	Valid - N	Sum of - Ranks	Mean - Rank
1	1	4	74.50000	18.62500
2	2	6	65.50000	10.91667
3	3	10	83.50000	8.35000
4	4	2	29.50000	14.75000

Kruskal-Wallis ANOVA by Ranks; Taxa Richness
Independent (grouping) variable: Zone
Kruskal-Wallis test: H (3, N= 22) =8.581715 p =.0354

	Code	Valid - N	Sum of - Ranks	Mean - Rank
1	1	4	78.50000	19.62500
2	2	6	53.00000	8.83333
3	3	10	94.50000	9.45000
4	4	2	27.00000	13.50000

Appendix G

Predicted taxa for riffle and edge habitats but not collected: Autumn 2012

Appendix G. Taxa expected, but not collected in the riffle habitat. The number in each cell is the probability of collection np = not predicted

Taxa	Hydrobiidae	Ancylidae	Oligochaeta	Amphipoda	Scritidae	Elmidae	Psephenidae	Tipulidae	Podonominae	Tanypodinae	Chironominae	Baetidae	Caenidae	Corydalidae	Gomphidae	Gripopterygidae	Hydrobiosidae	Glossosomatidae	Hydroptilidae	Philopotamidae	Leptoceridae	Total number of missing taxa
SIGNAL-2	4	4	2	3	6	7	6	5	6	4	3	5	4	7	5	8	8	9	4	8	6	
MUR1	*np*	*np*		0.80	0.69		*np*	*np*	0.65			0.92	*np*	*np*	*np*			*np*		*np*	0.82	5
MUR2	*np*	*np*	0.97	*np*				*np*	0.59						0.53			0.52				4
MUR3	0.56	0.56		*np*	*np*		*np*	*np*	0.57	0.70			0.93	*np*	*np*		0.85	*np*		*np*		6
MUR4	*np*	*np*		*np*	*np*	0.98	0.65		0.58					*np*	0.57			*np*			*np*	4
MUR6	*np*	*np*		*np*	*np*	0.96	0.84	*np*	0.59	0.51				0.56	0.63			0.61	0.60	0.65	*np*	9
MUR9	*np*	*np*		*np*	*np*	0.97	0.70	*np*	0.58	0.57				*np*	0.59			*np*		*np*	*np*	5
MUR12	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*	*np*			*np*	*np*		*np*	2
MUR15	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*		0.80		*np*	*np*		np	*np*	*np*	*np*	*np*	3
MUR16	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*	1.00			*np*	*np*		np	*np*	*np*	*np*	*np*	3
MUR18	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*	*np*	0.60		*np*		*np*	*np*	3
MUR19	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*	*np*			*np*	*np*		*np*	2
MUR22	*np*	*np*		*np*	*np*		*np*	0.80	*np*	*np*				*np*				*np*		*np*	*np*	1
MUR23	*np*	*np*		*np*	*np*		*np*	0.80	*np*	*np*				*np*	*np*			*np*		*np*	*np*	1
MUR27	*np*	*np*		*np*	*np*		*np*	0.80	*np*	*np*	1.00		1.00	*np*	*np*	0.60		*np*	*np*	*np*	*np*	4
MUR931	*np*	*np*		*np*	*np*		*np*		*np*	*np*					*np*	0.60		*np*		*np*	*np*	1
MUR28	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*	*np*	0.60		*np*	*np*	*np*	*np*	3
MUR935	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*	*np*	0.60	np	*np*	*np*	*np*	*np*	3
MUR937	*np*	*np*	0.80	*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*	*np*	0.60	np	*np*		*np*	*np*	4
MUR29	*np*	*np*		*np*		1.00	*np*	0.80	*np*	*np*				*np*	*np*	0.60		*np*	*np*	*np*	*np*	3
MUR30	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*		0.60	np	*np*	*np*	*np*	*np*	3
MUR31	*np*	*np*		*np*	*np*	1.00	*np*	0.80	*np*	*np*				*np*	*np*			*np*	*np*	*np*	*np*	2
MUR34	*np*	*np*		*np*	*np*		*np*		*np*	*np*				*np*				*np*		*np*	*np*	0

Appendix G (cntd.). Taxa expected, but not collected in the edge habitat. The number in each cell is the probability of collection np = not predicted

Taxa	Ancylidae	Planorbidae	Oligochaeta	Amphipoda	Hydrophilidae	Scirtidae	Elmidae	Tipulidae	Simuliidae	Podonominae	Tanypodinae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Synlestidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Leptoceridae	Total number of missing taxa
SIGNAL-2	4	2	2	3	2	6	7	5	5	6	4	5	8	4	2	7	8	4	4	7	6	
MUR1	*np*	*np*		0.89	*np*	0.79	0.79			0.53		0.74		*np*		*np*			*np*			
MUR2	*np*	*np*		0.83	*np*		0.78	0.59	0.61	0.50				*np*		*np*			*np*			
MUR3	*np*	0.50		0.56	*np*	0.54	0.72	*np*		*np*						*np*						
MUR4	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*				0.99		0.64	0.69					
MUR6	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*						0.65						
MUR9	*np*	0.54		*np*	*np*	*np*	0.63	*np*		*np*						0.61						
MUR12	*np*	0.54		*np*	*np*	*np*	0.64	*np*		*np*	0.90					0.58		0.86	0.55	0.57		
MUR15	*np*	0.55		*np*	*np*	*np*	0.63			*np*			0.96			0.64				0.58		
MUR16	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*	0.90				0.62	0.66			0.59	0.59		
MUR18	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*						0.66	0.69		0.59	0.59		
MUR19	*np*	0.55		*np*	*np*	*np*	0.62			*np*	0.90				0.62	0.66				0.59		
MUR22	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*						0.65				0.58		
MUR23	0.50	*np*		*np*	0.82	*np*	0.74	*np*		*np*						*np*				*np*		
MUR27	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*	0.90				0.62	0.65				0.59		
MUR931	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*	0.90					0.65	0.69	0.93	0.58	0.59		
MUR28	*np*	0.55		*np*	*np*	*np*				*np*					0.62	0.65	0.69	0.93		0.59		
MUR935	*np*	0.55		*np*	*np*	*np*	0.62	*np*	*np*	*np*					0.62	0.66		0.93		0.59	0.97	
MUR937	*np*	0.55		*np*	*np*	*np*				*np*	0.90					0.66	0.69	0.93	0.59	0.59		
MUR29	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*						0.65	0.69	0.93		0.59		
MUR30	*np*	0.55		*np*	*np*	*np*	0.62	*np*		*np*						0.65	0.69		0.59	0.59		
MUR31	*np*	0.55		*np*	*np*	*np*		*np*	*np*	*np*						0.66	0.69	0.93		0.59		
MUR34	*np*	0.55	0.97	*np*	*np*	*np*	0.62		*np*	*np*	0.90					0.65	0.69	0.93	0.59	0.59		
MUR37	*np*	0.55		*np*	*np*	*np*	0.62			*np*	0.90					0.65	0.69	0.93		0.59		

Appendix H

Taxonomic Inventory

Appendix H. Taxonomic inventory of the macroinvertebrate taxa collected for the riffle habitat

CLASS / Order	Family / Subfamily	MUR1	MUR2	MUR3	MUR4	MUR6	MUR9	MUR12	MUR15	MUR16	MUR18	MUR19	MUR22	MUR23	MUR27	MUR931	MUR28	MUR935	MUR937	MUR29	MUR30	MUR31	MUR34
ACARINA		■		■		■					■					■				■		■	■
Coleoptera	Dytiscidae													■									
	Elmidae	■	■	■									■	■	■	■							■
	Gyrinidae							■			■												
	Hydrophilidae													■									
	Psephenidae		■																				
	Scirtidae		■																	■			
Decapoda	Palaemonidae												■										
Diptera	Ceratopogonidae	■																					
	Chironominae	■	■	■	■	■	■	■	■		■	■	■	■		■	■	■	■	■	■	■	■
	Empididae	■									■		■		■		■		■	■	■		
	Orthocladiinae	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Simuliidae	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Tanypodinae	■	■		■																		
	Tipulidae				■											■							■
Ephemeroptera	Baetidae		■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Caenidae		■		■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
	Coloburiscidae		■	■	■		■													■			
	Leptophlebiidae	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■			■	■	■	■
Hemiptera	Corixidae	■					■							■									
Megaloptera	Corydalidae		■													■							
Odonata	Gomphidae												■								■		■
OLIGOCHAETA		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■
Plecoptera	Gripopterygidae	■	■	■	■	■	■	■	■	■		■	■	■								■	■
Trichoptera	Conoesucidae	■	■	■	■	■	■															■	
	Ecnomidae	■	■	■	■	■	■			■			■			■	■	■				■	
	Hydrobiosidae	■	■		■	■	■	■			■	■	■	■	■	■	■			■		■	■
	Hydropsychidae	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Hydroptilidae	■	■	■	■		■				■		■	■		■			■				■
	Leptoceridae		■	■																			
	Philopotamidae		■		■			■				■											
Turbellaria	Dugesiidae													■									

Appendix H (cont). Taxonomic inventory of the macroinvertebrate taxa collected for the edge habitat

CLASS / Order	Family / Subfamily	MUR1	MUR2	MUR3	MUR4	MUR6	MUR9	MUR12	MUR15	MUR16	MUR18	MUR19	MUR22	MUR23	MUR27	MUR931	MUR28	MUR935	MUR937	MUR29	MUR30	MUR31	MUR34	MUR37
ACARINA					■	■	■	■		■			■	■	■	■		■				■		
Bivalvia	Corbiculidae															■								■
Coleoptera	Dytiscidae			■																				
	Elmidae																■		■			■		
	Gyrinidae								■		■													
	Hydraenidae					■		■														■		
	Scirtidae		■																					
Decapoda	Atyidae					■				■				■		■	■	■	■	■			■	■
	Palaemonidae										■		■		■							■		
	Parastacidae																			■	■			
Diptera	Ceratopogonidae	■				■	■							■		■								
	Chironominae	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Empididae					■					■		■		■	■	■	■						
	Orthocladiinae	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Psychodidae								■	■		■					■			■		■	■	■
	Simuliidae	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■			■
	Tanypodinae	■	■	■	■	■	■		■		■		■	■			■	■		■	■	■		
	Tipulidae	■							■			■					■		■				■	■
Ephemeroptera	Baetidae		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Caenidae			■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Leptophlebiidae	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	sp.																						■	
GASTROPODA	Lymnaeidae			■																				
Gastropoda	Physidae	■	■	■	■								■	■										■
Hemiptera	Corixidae	■	■	■	■	■	■	■	■		■		■	■		■			■	■	■	■	■	■
	Gerridae																	■						
	Notonectidae				■																			
	Veliidae				■																			
Megaloptera	Corydalidae					■																		
OLIGOCHAETA		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■
Plecoptera	sp.										■	■												
	Gripopterygidae	■	■	■		■	■	■	■	■		■	■	■	■			■						
Trichoptera	Calamoceratidae		■	■	■																			
	Conoesucidae	■	■	■	■	■	■																	
	Ecnomidae			■	■	■	■		■			■	■		■		■	■		■		■		■
	Hydrobiosidae		■				■					■	■		■									
	Hydropsychidae					■	■	■	■	■		■	■		■		■	■	■		■		■	■
	Hydroptilidae	■	■	■	■	■	■		■	■	■	■	■	■	■						■			
	Leptoceridae	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■
Turbellaria	Dugesiidae	■			■		■																	

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