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MURRUMBIDGEE ECOLOGICAL MONITORING PROGRAM

PART 2: BURRA CREEK

AUTUMN 2011

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Abbreviations

ACT – Australian Capital Territory

AFDM – Ash Free Dry Mass (periphyton)

ALS – Australian Laboratory Services

ANZECC –Australian and New Zealand Environment and Conservation Council

ANOVA – Analysis of Variance (statistics)

APHA – American Public Health Association

ARMCANZ – Agriculture and Resource management Council of Australia and New Zealand

ARI – Average Recurrence Interval

AUSRIVAS – Australian River Assessment System

BACI – Before After Control Impact

CI – Confidence Interval

CMA – Catchment Management Authority

EC – Electrical Conductivity

EIS – Environmental Impact Statement

EPA – Environmental Protection Authority

GL/a – Gigalitres per annum

GPS – Global positioning system

IBT- Inter-Basin Water Transfer

M2G – Murrumbidgee to Googong

MEMP – Murrumbidgee Ecological Monitoring Program

ML/d – Megalitres per day

NATA – National Association of Testing Authorities

NMDS – Non-metric Multidimensional Scaling (statistics)

NSW – New South Wales

NTU – Nephlelometric Turbidity Units

QA – Quality Assurance

QC – Quality Control

SD – Standard Deviation

TN – Total Nitrogen

TP – Total Phosphorus

Executive Summary

ACTEW is committed to improving the security of the ACT water supply through the construction of an additional pumping structure and pipeline that will abstract Murrumbidgee River water. The pumping system will transfer water through an underground pipeline into Burra Creek, and then transfer the water by 'run of river' flows into the Googong Reservoir. The system is being developed to enable pumping of up to 100 ML/d, and is expected to be operational by mid-2012. Abstraction from the Murrumbidgee River and its subsequent transfer and release into Burra Creek will be primarily dictated by the level of demand for the water, and the availability of water and whether the Murrumbidgee River water quality complies with the EPA water quality guidelines. The proposal is referred to as Murrumbidgee to Googong transfer project (M2G).

The hydrological change will increase the base flow of Burra Creek noticeably and, therefore requires an assessment of the response of the river and its ecology to flow variability in order to help predict potential impacts associated with such changes.

This ecological monitoring program aims to establish the baseline river condition prior to water discharges into Burra Creek over a three year period and then to continue monitoring after the commencement of the operation phase of the M2G Project to determine what changes (if any) are attributable to water discharges from the Murrumbidgee River into Burra Creek.

The key aims of the sampling program were to:

- Establish the current status of the macroinvertebrate community at key sites on Burra Creek and the nearby Queanbeyan River;
- Provide ActewAGL with river health assessments based on AUSRIVAS protocols at these key sites to determine how river health may be affected during and after the pipeline development and the subsequent discharges into Burra Creek;
- Establish baseline periphyton data that will be used to characterise seasonal and temporal changes under baseline conditions
- Report on water quality from continuous and grab sample monitoring in order to characterise baseline water quality conditions and provide data that could be used to predict impacts associated with the M2G project.

This report presents the findings from biological sampling of Burra Creek and the Queanbeyan River conducted in autumn 2011. Sampling was conducted on the 2nd and 3rd May 2011 and was based on ACT AUSRIVAS sampling protocols; but was extended to include multiple replicates from each site where specimens were identified to genus level, instead of family level.

The purpose of this protocol was to:

1. Collect biological signatures of condition at each site prior to the commencement of pumping;
2. Enable subtle changes to be detected if there are impacts associated with reduced flows; and
3. Provide within-site replication that will potentially allow hypothesis testing statistical analyses to be performed on the data as part of any impact assessment.

The key results from the autumn 2011 sampling of Burra Creek are as follows:

- Continuous water quality measurements from the monitoring stations indicate that apart from the expected gradual decrease in water temperature. Changes in water quality coincided with the autumn high flow events. Turbidity quickly receded as flow levels receded following those events. EC levels took slightly longer to recover, but interestingly, high flow events later in the season had less relative influence on EC compared to events early in the season, regardless of the fact that those flows were sometimes higher compared to events earlier in the season. .
- EC levels in Burra Creek continue to exceed ANZECC and ARMCANZ (2000) guideline levels, but probably reflect natural local conditions to which aquatic fauna may be adapted to.
- Burra Creek had prolonged periods over which DO saturation maxima were below the recommended range. This again might be a natural phenomenon, but the factors contributing to this require further investigation if changes in water quality associated with discharge from the Murrumbidgee River are to be appropriately managed. Notwithstanding any potential eutrophication effects, release from the Murrumbidgee River, will probably increase the oxygenation of water in Burra Creek downstream of the release point.
- Nutrient levels were generally within the guideline ranges, with the exception of the downstream site BUR3. This was attributed to the effects of water from Googong Dam inundating that site.
- In autumn 2011 there were no significant differences in chlorophyll-a concentration or AFDM between sites. This may reflect the generally low nutrient concentrations across the sites monitored, though the snap shot nature of sampling for this study prevents more conclusive evidence with regards to phytoplankton-nutrient availability relationships.
- Consistent with spring 2010, most sites were rated as Band B (significantly impaired). The exception to this was site BUR3, which was rated Band A (similar to reference condition) and BUR2b, however this site has not been previously sampled in the riffle habitat and cannot be compared to previous sampling runs.
- Results for edge habitat showed that O/E50 scores were significantly higher downstream of the discharge point, indicating that this reach had more of the taxa that were predicted to occur there based on habitat conditions and site locations.
- The factors contributing to the significantly impaired status of most of the sites monitored are unknown at this stage. High EC and low DO saturation in Burra Creek may have contributed, but results from this study suggest that the macroinvertebrate community was probably in the advanced stages of recovery from high flow events that occurred in March 2011. The M2G project will not prevent further effects of natural high flow events from impacting the macroinvertebrate community in Burra Creek, but may increase the frequency of high flow disturbance through the intermittent switching on and off of discharges.

Recommendations

In line with the adaptive management approach advocated for the MEMP program; we recommend a number of site selection changes. These include:

- Removing site QBYN2 from the program as it is within the full supply level of Googong Dam;
- Moving site BUR3 or having a 'floating site' to accommodate circumstances such as those that occurred in autumn 2011 where water backed up from Googong Dam inundated this site (though not to the same degree as QBYN2 where water was too deep to sample safely);
- Removing site CAS1 from the program as it is now choked with *Typha*, difficult to sample and no longer a valid upstream control site;
- Identify additional upstream an additional downstream site for the operation phase monitoring, with emphasis should be given to choosing sites with representative riffle habitat as this habitat is most vulnerable to hydrological changes associated with the M2G transfer.

In order to fill current knowledge gaps and to provide a more comprehensive and meaningful assessment as part of the operation phase monitoring, we recommend that:

Local water quality objectives are developed for Burra Creek that take into account its natural tendency for elevated EC and low turbidity as a result of groundwater influence;

Hyporheic fauna to be monitored as part of the operations phase, as the M2G transfer has the potential to change the substratum, surface water quality and potentially the groundwater quality within the system which could in turn impact upon the hyporheic fauna, but no specific monitoring of such impacts has been carried out to date;

Carry out seasonal monitoring outside of the standard autumn/spring AUSRIVAS sampling as well as in spring and autumn to assess patterns in community turnover over a full range of hydraulic conditions and, therefore, provide data to better predict and assess the impacts associated with the M2G transfer;

Undertake an extensive temporal assessment of all baseline data collected biannually since autumn 2009, as so far assessments have focussed on individual sampling events, which hasn't allowed any detailed understanding of inter-annual trends. The monitoring of such trends will be critical to assessing the potential impacts associated with the M2G transfer, albeit that some allowance may need to be made for conducting long term data analysis separately for autumn and spring data if clear seasonal differences in macroinvertebrate community structure are established.

1 Introduction

The Murrumbidgee Ecological Monitoring Program (MEMP) was set up by ACTEW Corporation to evaluate the potential impacts of water abstraction from the Murrumbidgee River. It is being undertaken as part of the ACT water supply security infrastructure upgrade. The scope of this study is to undertake sampling in spring and autumn over a three year period commencing in autumn 2009.

There are four components / geographic areas considered as part of the MEMP study:

Part 1: Angle Crossing

Part 2: Burra Creek

Part 3: Murrumbidgee Pump Station

Part 4: Tantangara to Burrinjuck

This report focuses on Part 2: Burra Creek.

ActewAGL is constructing an additional pumping structure and pipeline to abstract water from the Murrumbidgee River from a location near Angle Crossing (southern border of the ACT). The pumping system will transfer water from the Murrumbidgee River, through an underground pipeline into Burra Creek, and then transfer the water by 'run of river' flows into the Googong Reservoir. The system is being designed to enable pumping of up to 100 ML/d, and is expected to be in operation in late 2011. Abstraction at from the Murrumbidgee River and the subsequent discharges to Burra Creek will be dictated by the level of demand for the water, and by the availability of water in the Murrumbidgee River. This development is referred to as the Murrumbidgee to Googong project (M2G).

From the commencement of recording at the Burra Creek stream flow gauge in 1985 through to 2011 (as of 1st June), the mean daily flow was 9.78 ML/d. However, over the last five years flows have reduced substantially to 4.78 ML/d. Since flow records began in 1985 a mean monthly flow of 100 ML/d has only been exceeded 8 times, while flows in excess of 100 ML/d have occurred less than 2 % of the time on a daily basis.

In light of the current low flow conditions in Burra Creek, it is expected that the increased flow through the discharge from the Murrumbidgee River will have several impacts on water quality, channel and bank geomorphology and the ecology of the system (Table 1-1). Some favourable ecological effects could be expected in the reaches of Burra Creek between the discharge point and downstream of the confluence of the Queanbeyan River. These include:

- The main channel being more frequently used by fish species;
- Increased biodiversity in macroinvertebrate communities; and
- A reduction in the extent of macrophyte encroachment in the Burra Creek main channel.

The transfer of Murrumbidgee River water into Burra Creek has the potential to adversely impact the natural biodiversity within Burra Creek due to the different physico-chemical characteristics of water in each system (particularly with regards to EC). Further, the inter-basin water transfer also poses a risk of spreading exotic plant and fish species which could displace native biota directly through competition or indirectly through the spread of disease. Other potential impacts are highlighted in Table 1-1.

These potential impacts have been assessed by the relevant Government authorities through submission of Environmental Impact Statements (EIS) or similar assessments. One of the components of the EIS is to undertake an ecological monitoring program, for which this program is based.

Table 1- 1: Potential impacts to Burra Creek following Murrumbidgee River discharges.

Property	Possible impact	Source
Water Quality	Increased turbidity from Murrumbidgee water which could decrease light penetration, resulting in lower macrophyte and algal growth.	Biosis, 2009
	The inter-basin transfers (IBT) of soft Murrumbidgee water into the harder water of Burra Creek may change the natural biodiversity within Burra Creek.	Fraser, 2009
	Changes in water temperature could be expected from the IBT and increased turbidity. This may affect plant growth, nutrient uptake and dissolved oxygen levels.	Biosis, 2009.
Ecology	Changes in macroinvertebrate communities and diversity through habitat loss from sedimentation, riparian vegetation and scouring of macrophytes. Changes in macroinvertebrates are also expected with an increase of flow (e.g. increased abundances of flow dependant taxa).	Bunn and Arthington, 2002.
	Potential risk of exotic species recruitment from IBT, this could displace native species in the catchment and pose a risk of the spread of disease.	Biosis, 2009; Davies et al. 1992
	Infilling from fine sediment transport could threaten the quality of the hyporheic zone, which provides important habitat for macroinvertebrates in temporary streams.	Williams and Hynes, 1974; Brunke and Gonser, 1997.
	Increased flow with improved longitudinal connectivity which potentially will provide fish with more breeding opportunities and range expansion, although this will be dependent on the flow regime	Biosis, 2009.
Bank	Bank failure from the initial construction phase and first releases. This could result in increased sedimentation, loss of riparian vegetation	Skinner,

Property	Possible impact	Source
Geomorphology	and increase erosion rates from bank instability	2009.
Channel Geomorphology	Scouring of the river bed may result in a loss of emergent and submerged macrophyte species. This would result in a reduction of river bed stability and a change in macroinvertebrate diversity and dynamics.	Harrod, 1964 (Riis and Biggs, 2003)

1.1 Project Objectives

The objectives of the Murrumbidgee Ecological Monitoring Program (MEMP) are to provide ActewAGL with seasonal assessments of river health prior to (baseline) and during the construction and operational phases of the new pipeline and discharge into Burra Creek.

Specifically, the aims of the project are to:

(a) Provide seasonal "river health" reports in accordance with ActewAGL water abstraction licence requirements;

(b) Collect baseline macroinvertebrate, water quality and periphyton data in order to ascertain whether the future discharges into Burra Creek from the Murrumbidgee River are likely to impact the ecology and ecological "health" of Burra Creek;

(c) Collect baseline periphyton data that will be used as a guide to monitor seasonal and temporal changes; and

(d) Report on water quality upstream and downstream of the discharge point in Burra Creek.

1.2 Project Scope

The current ecological health of the sites monitored as part of the Burra Creek component of the Murrumbidgee Ecological Monitoring Program (MEMP) program has been estimated using ACT AUSRIVAS protocols for macroinvertebrate community data, combined with a suite of commonly used biological metrics and descriptors of community composition.

Specifically, as outlined in the MEMP proposal to ACTEW Corporation (Ecowise, 2009a), this work includes:

- Biannual sampling which commenced in autumn 2009;
- Macroinvertebrate sampling from riffle and edge habitats (where available) as per the ACT AUSRIVAS protocols;
- Macroinvertebrates counted and identified to the taxonomic level of genus;
- Riffle and edge samples assessed through the appropriate AUSRIVAS models;
- Selected water quality measurements to be measured in-situ, and collected for analysis at Australian Laboratory Services (ALS's) NATA accredited laboratory.

The scope of this report is to convey the results from the autumn 2011 sampling run.

Six months prior to the commencement of this program, ALS sought advice from independent industry experts on the sampling regime and study design required for a robust interpretation of the biological data collected. The program was adjusted from its original design before it was finalised due to difficulties in finding appropriate control sites.

1.3 Rationale for using biological indicators

Macroinvertebrates and periphyton are two of the most commonly used biological indicators in river health assessment. Macroinvertebrates are commonly used to characterise ecosystem health because they represent a continuous record of preceding environmental, chemical and physical conditions at a given site. Macroinvertebrates are also very useful indicators in determining specific stressors on freshwater ecosystems because many taxa have known tolerances to heavy metal contamination, sedimentation, and other physical or chemical changes (Chessman, 2003). Macroinvertebrate community assemblage, and two indices of community condition; the AUSRIVAS index and the proportions of three common taxa (the Ephemeroptera, Plecoptera, and Trichoptera, or EPT index), were used during this study to assess river health.

Periphyton is the matted floral and microbial community that resides on the river bed. The composition of these communities is dominated by algae but the term "periphyton" also includes fungal and bacterial matter (Biggs and Kilroy, 2000). Periphyton is important to maintaining healthy freshwater ecosystems as it absorbs nutrients from the water, adds oxygen to the ecosystem via photosynthesis, and provides a food and shelter for higher order animals. Periphyton communities respond rapidly to changes in water quality, light penetration of the water column and other disturbances, such as floods or low flow, and this makes them a valuable indicator of river health.

2 Materials and Methodology

Prior to sampling, comprehensive site assessments were carried out, including assessments of safety, suitability and access permission from landowners. There are no suitable reference sites in the proximity for this assessment, so a Before – After / Control – Impact (BACI) design (Downes *et al.*, 2002) was adopted based on sites upstream of the abstraction point serving as 'Control' sites and sites downstream of the abstraction / construction point serving as 'Impacted' sites. Baseline monitoring carried out as part of this study will serve as the 'Before' period for this assessment.

2.1 Study sites

Macroinvertebrate community composition, periphyton assemblages and water quality were monitored in Burra Creek, Cassidy's Creek and the Queanbeyan River to obtain baseline ecological information prior to the construction and implementation of the M2G pipeline. Seven sites were monitored in total, including three control sites and four impact sites. This design previously had BUR2a listed as an impact site, because the exact location of the discharge was unknown. It is now understood that the discharge point will be located just upstream of Williamsdale Bridge. Accordingly, site BUR2a is now included as a control site on Burra Creek (Table 2-1; Figure 2-1). Site photographs can be seen in APPENDIX A.

To monitor for potential impacts to the ecological condition of Burra Creek, aquatic macroinvertebrates were sampled from two habitats (riffle and pool edges) and organisms identified to genus level (where practical), to characterise each site. Periphyton was sampled in the riffle zones at each site and analysed for chlorophyll-a and Ash Free Dry Mass (AFDM) to provide estimates of the algal (autotrophic) biomass and total organic mass respectively based on the methods of Biggs and Kilroy (2000).

Both the riffle and edge habitats were sampled (where available) to provide a comprehensive assessment of each site and allow for flow related impacts to be distinguished from other disturbances. The reason behind this is that each habitat is likely to be effected in different ways. Riffle zones, for example, are often dry in Burra Creek because of its intermittent flow regime, and are likely to become more permanent habitats downstream of the release point due to the additional flow being provided. Further, due to the high number of no-flow days and the chain-of–ponds nature of Burra Creek, sampling the pool/edges allows data collection when surface flow has ceased. In any case, edge habitat would be affected by the M2G project in that edge habitat would be increasingly (and artificially) maintained in terms of water level downstream of the release point, so the potential effects on edge habitat are certainly worth monitoring in their own right.

Table 2- 1: Sampling site locations and details

Site Code	Location	Purpose	Latitude	Longitude
CAS1	Cassidy's Creek, upstream Burra Creek confluence	Control site	-35˚ 35.918	149˚ 13.641
BUR1	Burra Creek, upstream Cassidy Creek confluence	Control site	-35˚ 35.855	149˚ 13.666
BUR2a	Burra Creek, downstream of Williamsdale Road Bridge	Control site	-35˚ 33.326	149˚ 13.400
BUR2b	Burra Creek, downstream of Burra Road bridge	Impact site	-35˚ 35.571	149˚ 13.649
BUR3	Burra Creek, downstream of London Bridge	Impact site	-35˚ 30.620	149˚ 15.861
QBYN1	Queanbeyan River at Flynn's Crossing	Control site	-35˚ 31.459	149˚ 18.198
QBYN2	Queanbeyan River, downstream of Burra Creek confluence	Impact site	-35˚ 29.937	149˚ 15.942

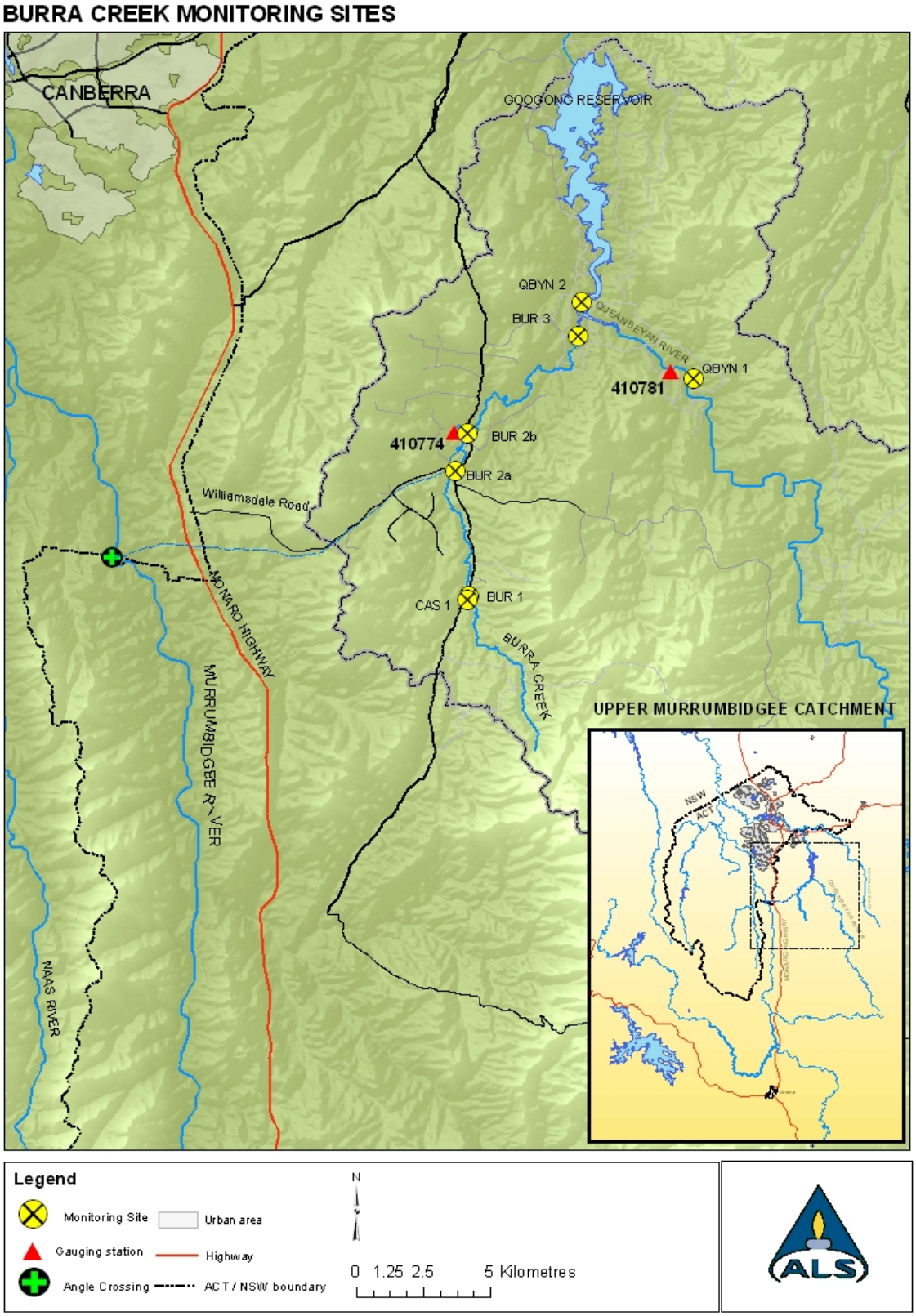


Figure 2- 1: Location of the monitoring sites and gauging stations for the Burra Creek monitoring program

2.2 Hydrology and rainfall

River flows and rainfall were recorded at ALS gauging stations at Burra Road (410774, downstream of the Burra Road Bridge) and the Queanbeyan River (410781, upstream of Googong reservoir). Site locations and codes are given in Table 2-2.

Table 2- 2: Stream flow and water quality monitoring site locations.

Site code	Location	Parameters*	Latitude	Longitude
410774	Burra Creek	WL, Q, pH, EC, DO, Temp, Turb.	-35.5425	149.2279
410781	Queanbeyan River US of Googong Reservoir	WL, Q, pH, EC, DO, Temp, Turb.	-35.5222	149.3005

**Notes: WL = Water Level; Q = Rated Discharge; EC = Electrical Conductivity; DO = Dissolved Oxygen; Temp = Temperature; Turb = Turbidity*

2.3 Water quality

Baseline in-situ physico-chemical parameters including temperature, pH, electrical conductivity, turbidity, and dissolved oxygen were recorded at each sampling site using a multiprobe Hydrolab® Minisonde 5a Surveyor. The Surveyor was calibrated in accordance with ALS QA procedures and the manufacturer's requirements prior to sampling.

Additionally, grab samples were taken from each site in accordance with ACT AUSRIVAS protocols for Hydrolab® verification and nutrient analysis.

Nutrient analysis included nitrogen oxides (total NOx), total nitrogen (TN) and total phosphorus (TP) in accordance with the protocols outlined in APHA (2005). This information will assist in the interpretation of biological data and provide a basis to gauge changes that can potentially be linked to increased flow and potential changes in the Burra Creek system due to inter-basin water transfers from the donor (Murrumbidgee) system.

All water samples were appropriately labelled and placed on ice in the field. The samples were delivered 'same day' to the ALS laboratory for analysis.

2.4 Periphyton

Estimates of algal biomass were made using complementary data from both chlorophyll-a (which measures autotrophic biomass) and ash free dry mass (AFDM, which estimates the total organic matter in periphyton samples and includes the biomass of bacteria, fungi, small fauna and detritus in samples) measurements (Biggs, 2000).

A total of four sites were initially selected for this project for periphyton assessment in conjunction with the macroinvertebrate sampling program, including sites BUR1, BUR3, QBYN1 and QBYN2. Unfortunately, site QBYN2 and BUR3 are located within the full supply zone of Googong Dam, and were inundated at the time of sampling. Consequently, two additional sites were selected and sampled during autumn 2011, BUR2a and BUR2b, due to the newly improved habitat conditions at each of these sites post- floods.

All periphyton (i.e. adnate and loose forms of periphyton, as well as organic/inorganic detritus in the periphyton matrix) samples were collected using the in-situ syringe method similar to Loeb (1981), as described in Biggs and Kilroy (2000). A one metre wide transect was established across riffles at each site. Along each transect, twelve samples were collected at regular intervals, using a sampling device consisting of two 60 ml syringes and a scrubbing surface of stiff nylon bristles, covering an area of ~637 mm2.

The samples were divided randomly into two groups of six samples to be analysed for Ash Free Dry Mass (AFDM) and chlorophyll-a. Samples for Ash Free Dry Mass and chlorophyll-a analysis were filtered onto glass filters and frozen. Sample processing followed the methods outlined in APHA (2005).

2.5 Macroinvertebrates

Riffle and edge habitats were sampled for macroinvertebrates using the ACT AUSRIVAS (Australian River Assessment System) protocols (Coysh *et al.*, 2000). The nets and all other associated equipment were washed thoroughly between habitats, sites and sampling events to remove any macroinvertebrates retained on them.

The field program occurred on 2nd and 3rd May 2011. Two replicate samples were collected from each of two habitats (edge and riffle - where available) at most sites in autumn (Table 2-3). With the exception of sampling problems caused by the inundation of downstream sites by Googong dam, there were some new riffle habitat at sites BUR2a and 2b in Burra Creek. Autumn 2011 is the first sampling event where riffle samples have been collected at BUR2a.

Table 2- 3: Macroinvertebrate samples collected for the Burra Creek component of MEMP, autumn 2011.

Sites	Edge	Riffle
CAS1	2	N/A
BUR1	2	1
BUR2a	2	2
BUR2b	2	2
BUR3	2	N/S
QBYN1	2	2
QBYN2	N/S	N/S

Notes:

1. *N/A – habitat not available.*
2. *N/S – not sampled, inundated by Googong Dam.*

Sampling of the riffle habitat (flowing broken water over gravel, pebble, cobble or boulder, with a depth greater than 10 cm; (Coysh, *et al.*, 2000) involved using a framed net with 250 µm mesh size. Sampling began at the downstream end of each riffle, with the net held perpendicular to the substrate and the opening facing upstream. The stream bed directly upstream of the net opening was agitated by vigorous kicking, allowing dislodged invertebrates to be carried into the net by the current. The process continued, working upstream over ten metres of riffle habitat.

The edge habitat sample was collected by sweeping the collection net along the edge of the creek line at the sampling site, with the operator working systematically over a ten metre section covering all microhabitats such as overhanging vegetation, submerged snags, macrophyte beds, overhanging banks and areas with trailing vegetation.

The bulk samples were placed in separate 1L white containers, preserved with 70% ethanol, and clearly labelled inside and out with project information, site code, date, habitat, and sampler details.

Processing of the aquatic macroinvertebrate bulk samples followed the ACT AUSRIVAS protocols. In the laboratory, each preserved macroinvertebrate sample was 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, and the contents of randomly selected cells were removed and examined under a dissecting microscope until a minimum of 200 animals were counted. All animals within the selected cells were identified.

In order to provide additional replication within the experimental design, laboratory processing of each sample was repeated 3 times to total up to 6 samples per habitat per site (2 field replicates x 3 laboratory processed replicates). This method was possible for most samples, as outlined in Table 2-4.

Table 2- 4: Percentage sorted for each laboratory replicate within each bulk sample, autumn 2011.

Site Code	Habitat	Field Replicate	Laboratory Replicates		
			1	2	3
QBYN1	Riffle	1	25	25	33
QBYN1	Riffle	2	34	40	26
QBYN1	Edge	1	75	25	--
QBYN1	Edge	2	75	25	--
CAS1	Edge	1	35	45	20
CAS1	Edge	2	75	25	--
BUR1	Riffle	1	15	30	20
BUR1	Edge	1	20	20	20
BUR1	Edge	2	30	30	30
BUR2A	Riffle	1	5	8	5
BUR2A	Edge	1	85	15	--
BUR2A	Edge	2	100	--	--
BUR2B	Riffle	1	20	25	20
BUR2B	Edge	1	15	27	17
BUR2B	Edge	2	20	23	22
BUR3	Edge	1	20	21	20
BUR3	Edge	2	40	40	20

Macroinvertebrates were identified to genus level (where possible) using taxonomic keys outlined in Hawking (2000) and later publications. Specimens that could not be identified to the specified taxonomic level (i.e. immature or damaged taxa) were removed from the data set prior to analysis.

2.6 Data analysis

2.6.1 Hydrology and rainfall

Data from the two water quality stations was extracted from the database management system Hydstra©.

2.6.2 Water quality

Water quality parameters were examined for compliance with ANZECC & ARMCANZ (2000) water guidelines for aquatic ecosystems in upland streams of south-east Australia. Trend analyses of water quality parameters will be conducted at the end of the baseline collection period.

2.6.3 Periphyton

The raw chlorophyll-a and AFDM data were converted to estimates of concentrations and biomass per square metre following the methodology outlined in Biggs and Kilroy (2000).

Previous assessments on this data included tests for differences between upstream-control locations versus downstream-impact locations; however, site QBYN2 was found to be inundated by the impounded water of Googong Dam during the autumn 2011 event, as was site BUR3, and hence were not sampled. This type of assessment was only conducted on the Burra Creek sites (BUR1 and BUR2a versus BUR2b), and a summary only was provided for the QBYN1 site results. BUR1, BUR2a and BUR2b chlorophyll-a and AFDM data was log-transformed and compared using a one-way analysis of variance (ANOVA). The ANOVA was run using the statistics software package Statistica version 9.0.

2.6.4 Macroinvertebrate communities

The macroinvertebrate data were examined separately for riffle and edge habitats. Replicates were examined individually (i.e. not averaged) at all sites because the aim is to examine within-site variation as much as it is to describe patterns among sites at this stage.

2.6.4.1 Univariate analysis

The univariate techniques performed on the macroinvertebrate data, include:

- Taxa Richness and EPT Taxa Index
- SIGNAL-2 Biotic Index (Chessman, 2003)
- ACT AUSRIVAS O/E scores and bandings

Taxa Richness refers to the number of different taxa contained in a sample. **EPT Taxa Index** refers to the proportional representation of key macroinvertebrate taxa belonging to the Ephemeroptera, Plecoptera and Trichoptera groups.

Stream Invertebrate Grade Number – Average Level (SIGNAL) is a biotic index based on pollution sensitivity values (grade numbers) assigned to aquatic macroinvertebrate families that have been derived from published and unpublished information on their tolerance to pollutants, such as sewage and nitrification (Chessman, 1995). Each family in a sample is assigned a grade between 1 (most tolerant) and 10 (most sensitive). The SIGNAL index is then calculated as the average grade number for all families present in the sample. The resulting index score can then be interpreted by comparison with reference and/or control sites. Recently these grades have been improved and standard errors applied under the SIGNAL2 model approach developed by Chessman (2003). These changes were introduced to improve the reliability of the SIGNAL index.

The **AUStralian RIVer Assessment System (AUSRIVAS)** is a prediction system that uses macroinvertebrates to assess the biological health of rivers and streams. Specifically, the model uses site-specific information to predict the macroinvertebrate fauna Expected (E) to be present in the absence of environmental stressors. The expected fauna from sites with similar sets of predictor variables (physical and chemical characteristics influenced by non-human characters, 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 ratio derived from this analysis is compiled into bandwidths (i.e. X, A-D; Table 2-5) which are used to gauge the overall health of a particular 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) and the previously mentioned rating bands (Table 2-5).

Table 2- 5: AUSRIVAS band- widths and interpretations for the ACT autumn riffle and edge models.

BAND	O/E Band width	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	0.82-1.13	Similar to reference. Water quality and / or habitat in good condition.
B	0.64-0.87	0.49-0.81	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	0-0.39	0-0.14	Extremely impaired. Highly degraded. Water and /or habitat quality is very low and very few of the expected taxa remain.

Macroinvertebrate results were simplified to family level to allow for an AUSRIVAS assessment, except for Chironomidae (identified to sub-family), Oligochaeta (class) and Acarina (order) groups, as is the required approach for input to the ACT AUSRIVAS models.

Site assessments are based on the results from both the riffle and edge samples. The overall site assessment was based on the furthest band from reference in a particular habitat at a particular site. For example, a site that had a Band A assessment in the edge and a Band B in the riffle would be given an overall site assessment of Band B (Coysh, *et al.*, 2000). In cases where the bands deviate significantly between habitat (e.g. D – A) an overall assessment is avoided due to the unreliability of the results.

The use of the O/E 50 scores is standard in AUSRIVAS. However, it should be noted that this restricts the inclusion of rare taxa and influences the sensitivity of the model. Taxa that are not predicted to occur more than 50% of the time are not included in the O/E scores produced by the model. This could potentially limit the inclusion of rare and sensitive taxa and might also reduce the ability of the model to detect any changes in macroinvertebrate community composition over time (Cao *et al.*, 2001). However, it should also be noted that the presence or absence of rare taxa does vary over time and in some circumstances the inclusion of these taxa in the model might indicate false changes in the site classification because the presence or absence of these taxa might be a function of sampling effort rather than truly reflecting ecological change.

One caveat to note in this study is that while AUSRIVAS predictions based on physical information can result in similar taxa expected to occur within different stream types (i.e.

intermittent and perennial), disparities in macroinvertebrate communities are related to system-specific differences such as water chemistry and the disturbance and flows regimes, resulting in adaptations to cope with these differences (Wallace, 1990). The AUSRIVAS model does not take the degree of flow permanence into account which could result in erroneous predictions by the model and lead to misleading outputs. It is therefore advised that caution should be given to the AUSRIVAS outputs for the Burra Creek sites.

The variation in the above univariate indices between location ('upstream' versus 'downstream' site groups) and also individual sites was assessed using analysis of variance (ANOVA) methods.

2.6.4.2 Multivariate analysis

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

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 by describing trends in the joint occurrence of taxa and aids with interpretation. The initial step in this process was to log(y+1) transform the data and calculate a similarity matrix for all pairs of samples based on the Bray-Curtis similarity coefficient (Clarke and Warwick, 2001). For the macroinvertebrate data collected during this survey, the final number of dimensions is reduced to two. How well the patterns in the 2-dimensional NMDS plot represent the multivariate data is indicated by the stress value of each plot. The stress level is a measure of the distortion produced by compressing multidimensional data into a reduced set of dimensions and will increase as the number of dimensions is reduced. Stress can be considered a measure of "goodness of fit" to the original data matrix (Kruskal, 1964), and when near zero suggests that NMDS patterns are highly representative of the multidimensional data. Stress values greater than 0.2 indicates a poor representation (Clarke and Warwick 2001).

An **ANalysis Of SIMilarities (ANOSIM)** test is a non-parametric permutation procedure, applied to the similarity matrix underlying the NMDS. This test was performed on the data to determine whether macroinvertebrate communities were statistically different upstream and downstream of the discharge point, and also between individual sites. Outputs are expressed as R-values (multivariate equivalent of an F-test result) and p-values. Significance was defined as being at the 5% probability level ($p<0.05$).

The **SIMilarity PERcentages (SIMPER)** routine was carried out on the datasets to examine which taxa were responsible for, and explained the most, variation among statistically significant groupings. This procedure was also used to describe groups (i.e. which taxa characterised each group of sites) (Clarke and Warwick, 2001).

2.7 Macroinvertebrate quality control procedures

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

- Organisms that were heavily damaged were not selected during sorting. To overcome losses associated with damage to intact organisms during vial transfer, attempts were made to obtain significantly more than 200 organisms;
- Identification was performed by qualified and experienced aquatic biologists with more than 100 hours of identification experience;

- When required, taxonomic experts confirmed identification. Reference collections were also used when possible;
- ACT AUSRIVAS QA/QC protocols were followed;
- An additional 10% of samples will be re-identified by another senior taxonomist and these QAQC results will be made available as part of the final report; and
- Very small, immature, or damaged animals or pupae that could not be positively identified were not included in the dataset.

All procedures were performed by AUSRIVAS accredited staff.

2.8 Licenses and permits

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

ALS field staff maintain current AUSRIVAS accreditation.

3 Results

3.1 Sampling conditions

Autumn sampling was completed on the 2nd and 3rd of May 2011. In this round of sampling, flow conditions were stable for much of autumn due to low rainfall leading up to sampling. Mean monthly rainfall in April was 11.6mm compared to the long term (period of record: 1985-2011) mean of 44.5mm. This period of low flows resulted in a reduction of available habitat at BUR1 (Figure 3-1) which meant only 1 riffle sample was possible at that site.

Figure 3- 1: Heavy erosion and limited available riffle habitat at site BUR1, autumn 2011.

A high density of *Typha sp*. at CAS1 restricted the sampling to only edge habitats during autumn 2011 (Figure 3-2).

Figure 3- 2: ***Typha*** **sp. growth at site CAS1 (facing downstream) and sampling the edge habitat within the small isolated pools, autumn 2011.**

Googong reservoir reached capacity in early December resulting in the reservoir delta backing up beyond the BUR3 reach limits inundating this site. While there is influence from Googong Dam at this site, due to its location below the discharge point, the edge habitat was still sampled for macroinvertebrates during this round of sampling.

QBYN2 remained deeply inundated by Googong Dam and safety concerns restricted this site from being sampled during the autumn 2011 program.

Surface water was clear from the Cassidy Creek bridge downstream, while upstream at BUR1, tannin stains coloured the water. BUR1 has a large volume of woody debris from recent flood events. Evidence of flood damage downstream of Williamsdale Bridge was apparent, as indicated by flattened grasses on the flood plains and scattered organic debris. The water quality, based on the in-situ readings, appeared normal and there was a notable removal of silt from the riffle zones.

Air temperatures of the sampling period ranged between 9˚C and 14˚C and weather conditions were fine.

3.2 Hydrology and rainfall

Mean daily flow recorded at the time of sampling at Burra Creek weir (Station #410774) was 1.1 ML/d and 1.3ML for the whole autumn period (Table 3-1). In the Queanbeyan River at Station #410781, mean daily flow at the time of sampling was 74 ML/d and over the autumn season was 103.5ML/d (Table 3-1).

Table 3- 1: Monthly flow and rainfall statistics for Burra Creek at Burra Road (410774) and Queanbeyan River upstream of Googong Reservoir (410781) autumn 2011.

	Burra Creek		Queanbeyan River	
Station	Rainfall Total (mm)	Mean Flow (ML/d)	Rainfall Total (mm)	Mean Flow (ML/d)
March	59	1.8 (15.1)	48	151.7 (649.6)
April	11.6	0.9 (1.3)	7.6	94.7 (142.2)
May	25.2	1.1 (3.6)	20	64.2 (127.4)
Autumn	**95.8**	**1.3 (15.1)**	**75.6**	**103.5 (649.6)**

Notes:

1. Monthly maximums are shown in parentheses

Three peak flow events occurred along Burra Creek, two in March and one in May, coinciding with rainfall events. The largest of these occurred in early March and equated to 15.1ML/d (Figure 3-3.). The Queanbeyan River system recorded a peak flow in late March of 649.6ML/d. Peak flows in response to this rainfall event occurred with a 5 day lag, showing that the location of the rainfall event within the catchment and the delay of the contributing tributaries reaching the main water channel should be considered when interpreting this hydrograph (Figure 3-3).

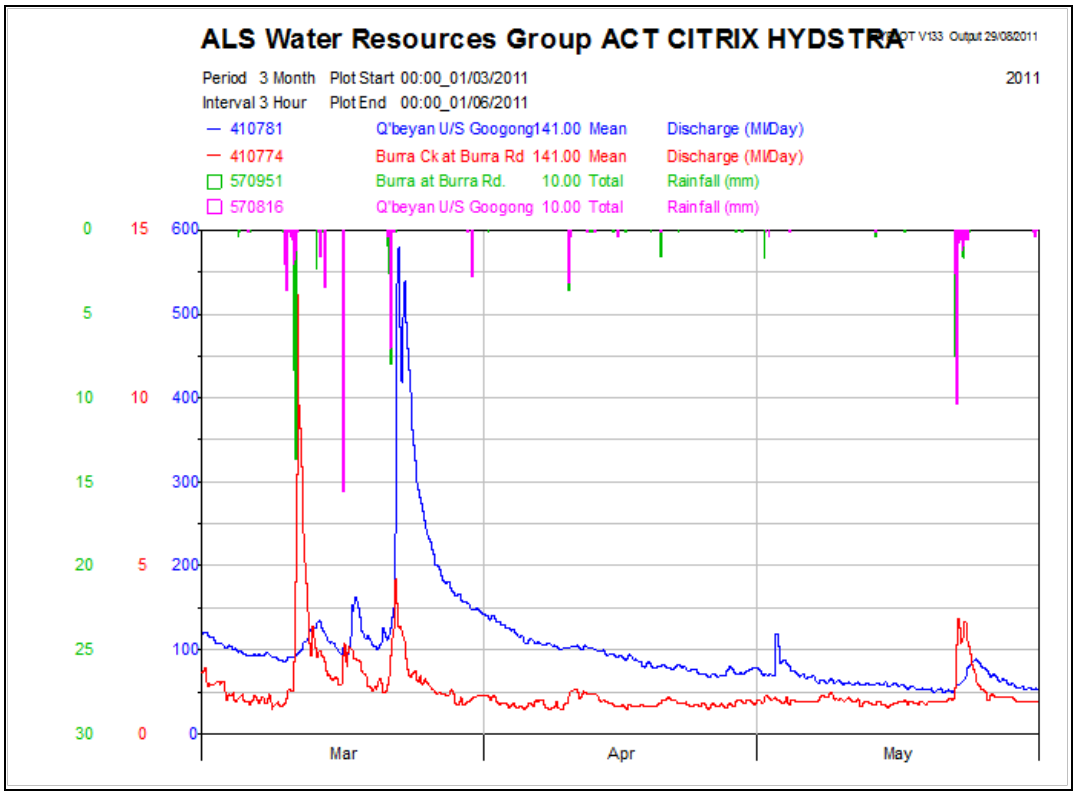


Figure 3- 3: : Autumn hydrograph from the Burra Creek and Queanbeyan River gauging stations.

3.3 Water quality

Continuous water quality records were collected from Burra Creek (Station #410774) (Figure 3-4) and the Queanbeyan River (Station #410781) (Figure 3-5). The major flow events that occurred in March and May coincided with the rapid changes in water quality of Burra Creek. Turbidity was immediately influenced during each flow event, with turbidity levels quickly peaking then reducing as flows receded (Figure 3-4). Conversely, EC gradually reduced following the first March flow event, then steadily increased over the remaining autumn period. The subsequent peak flows in March and May had little impact on EC levels (Figure 3-4). The two peak flow events in March led to a slight reduction in pH and reduced DO concentration maxima. As with EC, the May peak flow event had little impact on pH, but that event did lead to a reduction in both the range and average DO saturation levels for the week or so following that event.

The Queanbeyan River water quality results show that water quality was also influenced by the major flow events (Figure 3-5) and that the nature of those influences was broadly similar to that observed in Burra Creek. The March peak flow event in the Queanbeyan River resulted in slightly higher peaks in turbidity levels compared to Burra Creek, but reductions in EC were only around half of that recorded in Burra Creek. Also, EC levels at the end of the monitoring period were within the range recorded at the start of autumn in the Queanbeyan River, whereas EC levels in Burra Creek at the end of autumn were actually greater than at the start of autumn.

Grab sample results collected at the time of the biological sample collection are compared against ANZECC and ARMCANZ (2000) guideline levels in Table 3-2. EC concentrations were above the ANZECC and ARMCANZ (2000) guidelines in the Burra Creek system downstream of the confluence with Cassidy Creek, but the control site on Cassidy Creek in

the upper reaches of the catchment also had elevated EC.. In addition, nitrogen (and its ionic forms) was found to exceed the guidelines in Burra Creek downstream (BUR3), although this site was influenced by the impoundment of water from Googong Dam so nutrient results for this site are not necessarily directly comparable to (or representative of) stream sampling sites.

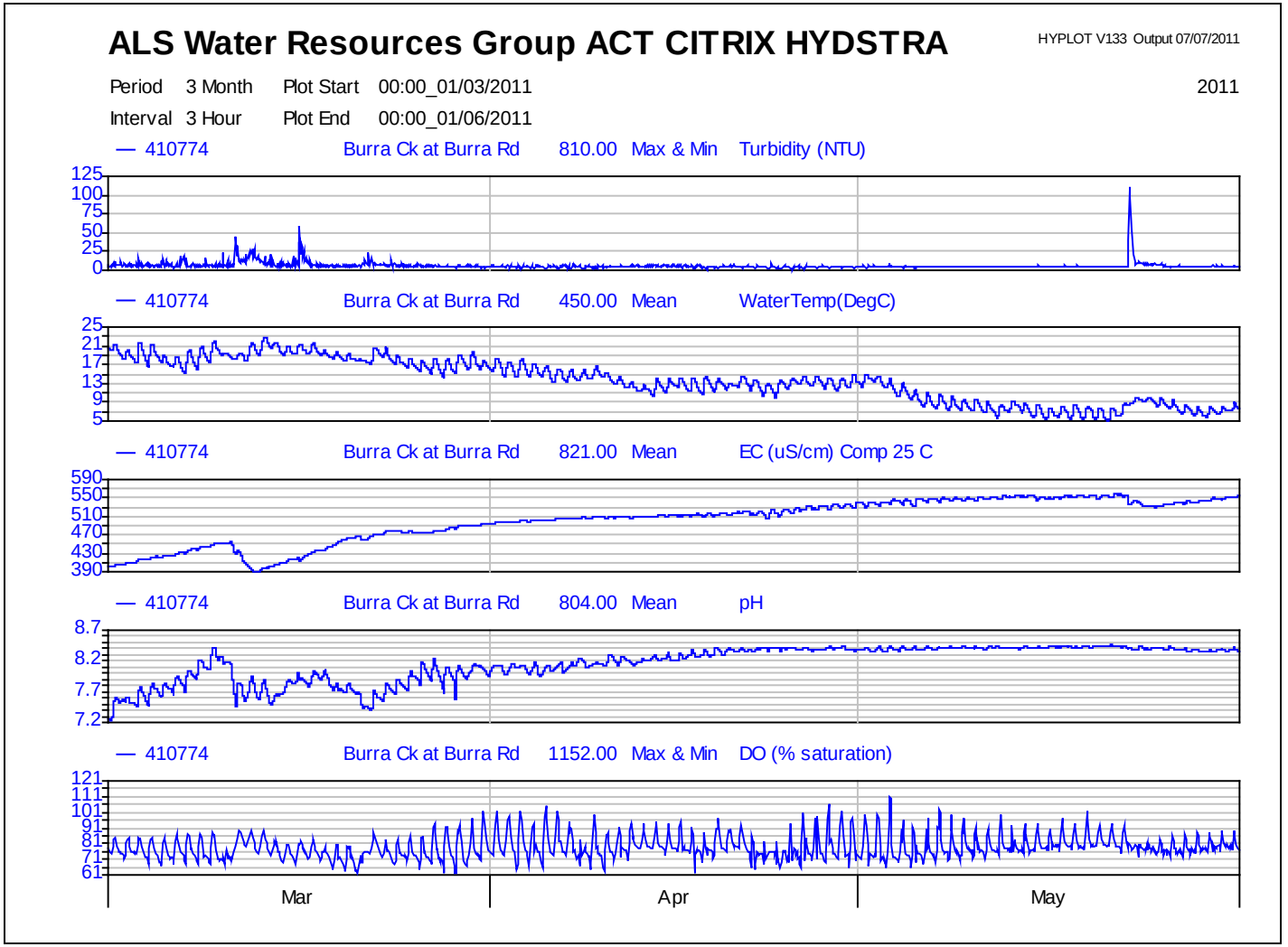


Figure 3- 4: Water quality records from Burra Creek (410774) during autumn 2011.

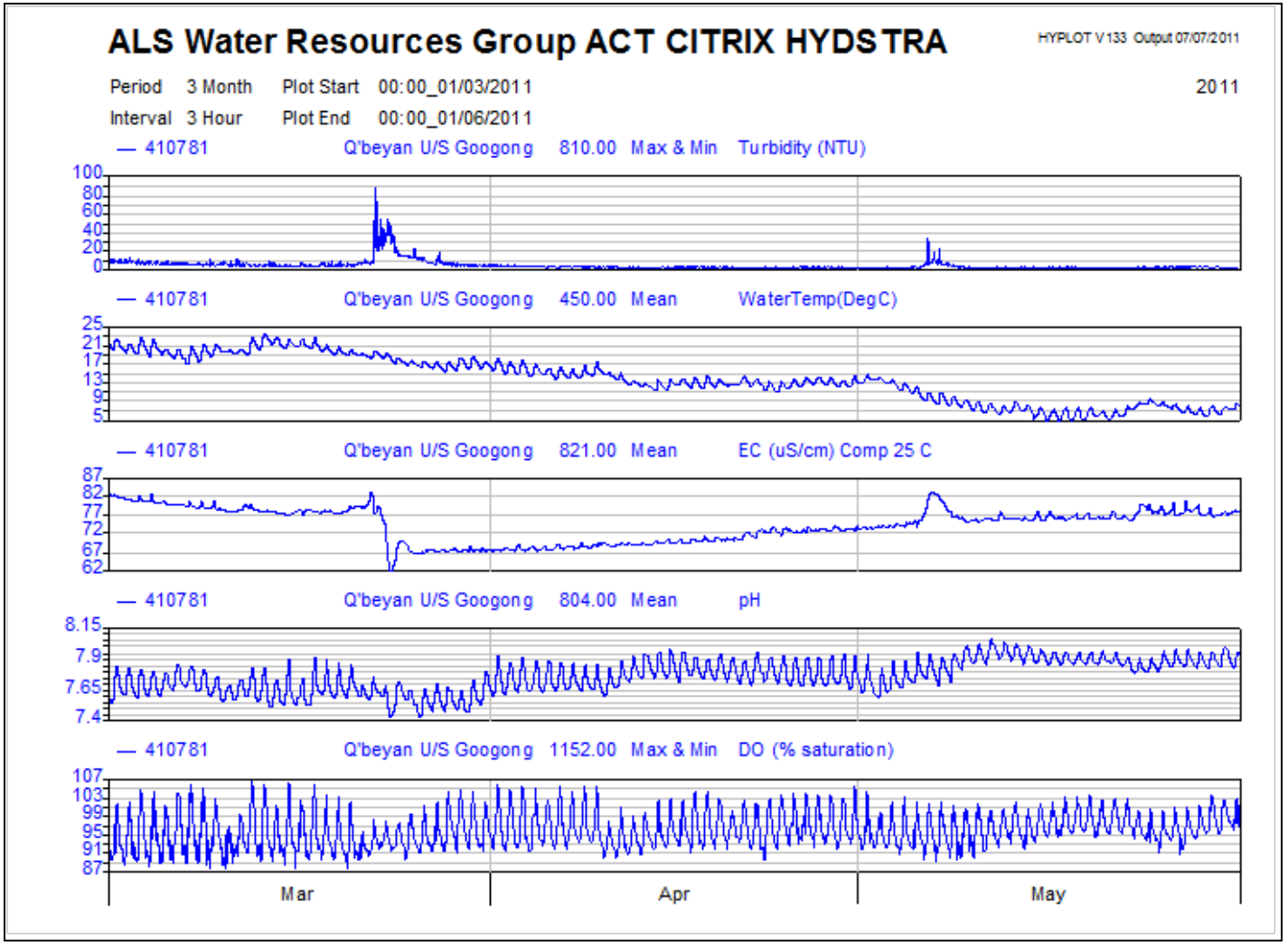


Figure 3- 5: Water quality records from Queanbeyan Creek (410781) during autumn 2011.

Table 3- 2: In- situ water quality results, autumn 2011.

Notes:

1 *ANZECC & ARMCANZ (2000) guideline values are indicated in the headings in parentheses*
2. ***Bold** cells indicate values recorded outside guidelines.*
3. *N/S – not sampled, site within Googong Dam inundation area.*

Location	Site	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 (mg/L)	NOx (mg/L) (0.015)	Nitrate (mg/L)	Nitrite (mg/L)	TP (mg/L) (0.02)	TN (mg/L) (0.25)
Control sites	CAS 1	4/5/2011 12.00	12.0	**415.1**	3.5	4	7.9	**82.9**	7.62	188	<0.01	<0.01	<0.01	0.01	0.23
	BUR 1	4/5/2011 11.00	13.6	149.4	7	13	7.3	91.6	8.56	45	<0.01	<0.01	<0.01	0.01	**0.31**
	QBYN 1	3/5/2011 14.00	14.1	67.3	3	2	7.8	98.5	10.3	32	<0.01	<0.01	<0.01	0.01	0.16
	BUR 2a	4/5/2011 15.00	14	**444.5**	11	13	**8.2**	92.8	9.70	173	<0.01	<0.01	<0.01	0.01	0.23
Test sites	BUR 2b	4/5/2011 13.50	14.7	**543.6**	4.4	11	**8.3**	101.1	10.40	229	<0.01	<0.01	<0.01	0.01	0.20
	BUR 3	3/5/2011 09.15	**14.8**	296.2	14	44	**8.2**	**87.6**	8.96	141	**0.05**	0.05	<0.01	**0.03**	**0.56**
	QBYN 2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Monthly water quality summary statistics recorded at the water quality stations are also presented in Table 3-3. As would be expected, water temperature reduced across the autumn months from around 19ºC in March to an average low of 8ºC by May 2011. EC values were recorded consistently higher within Burra Creek catchment (mean = 501µS/cm) in comparison to the Queanbeyan River system (mean =74µS/cm). The pH level remained relatively stable within both river systems, while turbidity was generally low and only spiked during high flow periods.

Table 3- 3: Monthly average water quality statistics recorded from Burra Creek (410774) and the Queanbeyan River (410781) water quality stations, autumn 2011.

Station	Burra Creek				Queanbeyan River			
Analyte	**Temp.**	**EC**	**pH**	**Turbidity**	**Temp.**	**EC**	**pH**	**Turbidity**
March	18.5	444.2	7.8	7.5 (59)	19.3	75.8	7.65	8.6 (88)
April	13.6	512.9	8.2	4.7 (8.5)	13.7	70.2	7.78	2.8 (6)
May	8.5	546.1	8.4	58 (110)	8.3	76.8	7.87	2.9 (34)
Autumn	13.5	**501.1**	**8.1**	**23.4 (110)**	**13.8**	**74.3**	**7.8**	**4.7 (88)**

Notes

1. *All values are means.*
2. *Monthly maximum turbidity values are in parentheses*

3.4 Periphyton assessment

Chlorophyll-*a* concentrations varied markedly between samples at the three upstream Burra Creek sites, particularly at BUR1 where concentrations ranged between 272 mg/m^3 and 16164 mg/m^3 (Figure 3-6). By comparison, site QBYN1 recorded relatively low intra-site variability. The two sites immediately upstream and downstream of the discharge location had relatively similar chlorophyll-a concentrations during the autumn 2011 program (Figure 3-6). One-way ANOVA results presented in Table 3-4 show that there was no significant difference in chlorophyll-a concentration between sites in autumn 2011 and, by extension, no difference between upstream and downstream of the discharge point (albeit that there was only one downstream site sampled).

Raw periphyton data are presented in APPENDIX B.

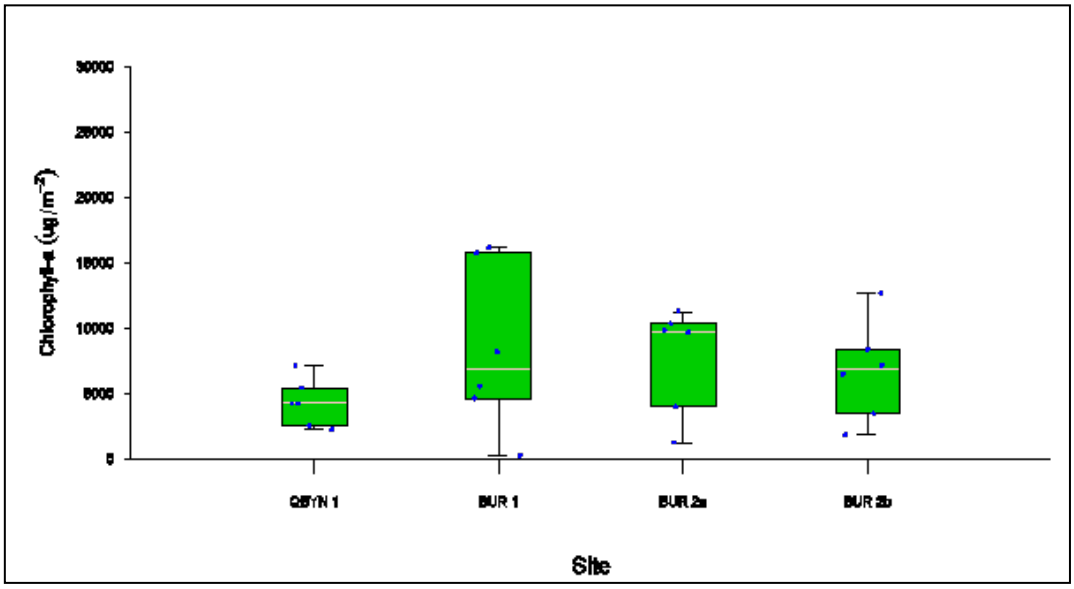


Figure 3- 6: Periphyton chlorophyll- a concentrations from upstream (QBYN1, BUR1, and BUR2a) and downstream (BUR2b) locations, autumn 2011.

The trends for chlorophyll-a results was also apparent for AFDM (Figure 3-7) and there were also no differences in AFDM between sites (Table 3-4).

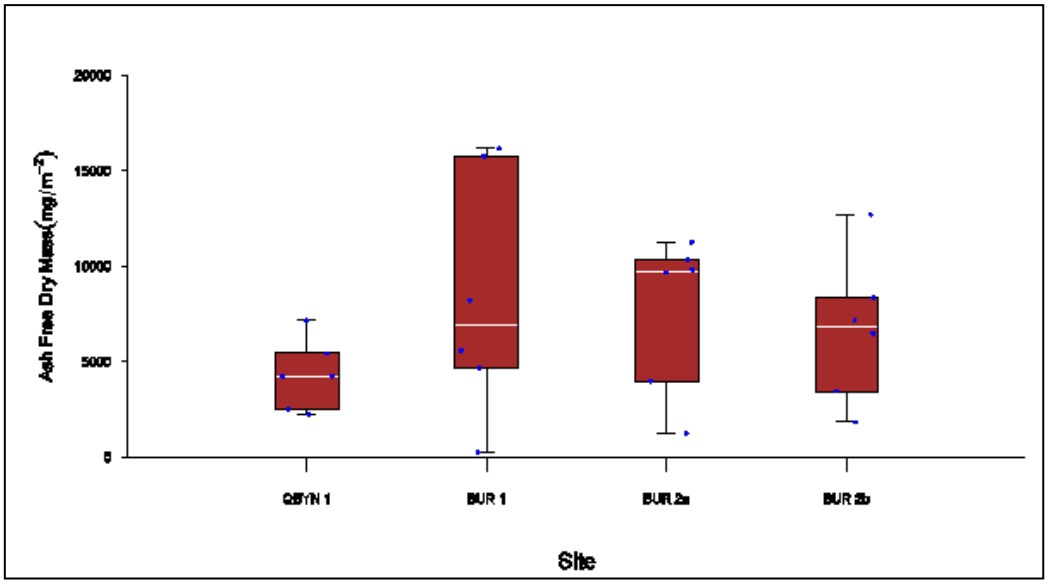


Figure 3- 7: Periphyton Ash Free Dry Mass from upstream (QBYN1, BUR1 and BUR2a) and downstream (BUR2b) locations, autumn 2011.

Table 3- 4: One- way ANOVA results for Chlorophyll- a and AFDM between sites in autumn 2011.

Parameter	SS	DF	MS	F	p- value
Chlorophyll- a (log)					
SITE	0.121	3	0.0470	0.231	0.874
error	3.508	20	0.175		
AFDM (log)					
SITE	0.671	3	0.224	1.112	0.367
error	4.022	20	0.201		

3.5 Macroinvertebrate communities

3.5.1 Univariate analysis

The results of all univariate indices across all sites and samples are presented in Table 3-5. Raw macroinvertebrate data are presented in APPENDIX C.

One-way ANOVAs were used to test for differences in these univariate parameters between upstream and downstream site groups (Locations). These tests were performed on both genus-level and family level taxonomic resolution data with respect to taxa richness and EPT richness. Separate results are shown for riffle habitat (Table 3-6) and edge habitat (Table 3-7).

Results shown in Table 3-6 indicate that, in terms of riffle habitat, there were no significant differences between upstream and downstream reaches for any of the measured parameters, regardless of taxonomic resolution.

Results for edge habitat show that were no significant differences between upstream and downstream reaches in terms of taxa richness or EPT richness, irrespective of taxonomic resolution. However, there was a significant difference in mean O/E50 score between the upstream and downstream site groups and results for SIGNAL 2 bordered on being significant (Table 3-7). Mean SIGNAL 2 score for edge habitat from downstream sites was slightly lower than that for upstream sites, suggesting that upstream sites contained a greater ratio of pollution-sensitive to pollution tolerant taxa. At the same time, upstream sites had a lower mean O/E50 score than downstream sites, suggesting that upstream sites had fewer taxa present than predicted by the ACT AUSRIVAS autumn edge habitat model when compared to downstream sites. This is discussed in more detail in Section 3.5.3.

Table 3- 5: Univariate results for autumn 2011.

Site	Field Rep.	Lab Rep.	Taxa richness: families		EPT richness: families		SIGNAL- 2 index		AUSRIVAS O/E50 score		AUSRIVAS Band		Overall habitat assessment		Overall site assessment
			Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	
CAS1	1	1		23		4		4.53		0.73		B			
		2		23		6		4.19		0.73		B		B	B
		3		18		4		4.27		0.73		B			
	2	1		24		7		4.14		0.73		B			
		2		17		4		3.71		0.59		B		B	B
		3													
BUR1	1	1	19	24	9	9	4.50	5.30	0.7	0.7	B	B			
		2	23	20	8	8	4.72	5.68	0.64	0.78	B	B	B	B	B
		3	24	21	8	8	4.74	5.66	0.7	0.86	B	A			

Site	Field Rep.	Lab Rep.	Taxa richness: families		EPT richness: families		SIGNAL- 2 index		AUSRIVAS O/E50 score		AUSRIVAS Band		Overall habitat assessment		Overall site assessment
			Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	
	2	1		14		7		5.90		0.54		B			
		2		17		6		6.08		0.54		B		B	B
		3		12		5		6.18		0.62		B			
BUR2A	1	1	14	16	7	6	3.65	3.44	0.6	0.85	C	A			
		2	12	13	6	3	3.68	3.61	0.6	0.62	C	B	C	B	C
		3	14		6		3.80		0.67		B				
	2	1		19		6		3.74		0.85		A			
		2												A	A
		3													

Site	Field Rep.	Lab Rep.	Taxa richness: families		EPT richness: families		SIGNAL- 2 index		AUSRIVAS O/E50 score		AUSRIVAS Band		Overall habitat assessment		Overall site assessment
			Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	
BUR2B	1	1	18	16	9	6	5.38	5.04	0.83	0.77	B	B	B	B	B
		2	18	18	9	7	5.28	4.83	0.76	0.87	B	A			
		3	16	13	8	6	5.67	4.71	0.76	0.68	B	B			
	2	1		23		9		4.04		1.06		A		A	A
		2		25		8		4.11		0.87		A			
		3		18		7		4.05		0.87		A			
BUR3	1	1		18		7		4.00		0.82		A		A	A
		2		20		7		3.59		0.82		A			
		3		19		6		3.50		0.82		A			

Site	Field Rep.	Lab Rep.	Taxa richness: families		EPT richness: families		SIGNAL- 2 index		AUSRIVAS O/E50 score		AUSRIVAS Band		Overall habitat assessment		Overall site assessment
			Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	
	2	1		18		8		4.01		0.82		A			
		2		17		7		4.15		0.82		A		B	B
		3		16		7		3.95		0.63		B			
QBYN1	1	1	20	22	11	9	6.37	4.31	0.77	0.85	B	A			
		2	17	13	10	5	6.48	4.90	0.83	0.78	B	B	B	B	B
		3	18		9		6.69		0.83		B				
	2	1	16	22	10	9	6.48	4.84	0.77	0.78	B	B			
		2	17	14	11	7	6.35	4.79	0.84	0.7	B	B	B	B	B
		3	16		10		6.30		0.77		B				

Table 3- 6: Results of One- way ANOVA based on riffle habitat data comparing taxa richness, EPT richness, SIGNAL 2 and O/E50 between sites upstream and downstream of the discharge point. Results for both Genus- level and Family- level resolution are shown.

Parameter	SS	DF	MS	F	p- value
Taxa Richness –Genus (log)					
Location	0.000028	1	0.000028	0.004	0.949
error	0.087600	13	0.006738		
Taxa Richness- Family (log)					
Location	0.001063	1	0.001063	0.148	0.706
error	0.09310	13	0.007162		
EPT Richness –Genus (log)					
Location	0.000037	1	0.000037	0.005	0.945
error	0.097080	13	0.007468		
EPT Richness- Family (log)					
Location	0.003101	1	0.003101	0.568	0.465
error	0.071010	13	0.005462		
SIGNAL 2					
Location	0.04056	1	0.04056	0.031	0.863
error	16.931	13	1.302		
O/E50					
Location	0.007707	1	0.007707	1.147	0.304
error	0.087330	13	0.006718		

Table 3- 7: Results of One- way ANOVA based on edge habitat data comparing taxa richness, EPT richness, SIGNAL 2 and O/E50 between sites upstream and downstream of the discharge point. Results for both Genus- level and Family- level resolution are shown. Values in red represent significant differences at the p<0.05 level.

Parameter	SS	DF	MS	F	p- value
Taxa Richness –Genus (log)					
Location	0.001402	1	0.001402	0.017	0.898
error	0.235	28	0.008385		
Taxa Richness- Family (log)					
Location	0.000151	1	0.000151	0.014	0.908
error	0.237	28	0.008453		
EPT Richness –Genus (log)					
Location	0.03473	1	0.03473	2.658	0.114
error	0.366	28	0.01347		
EPT Richness- Family (log)					
Location	0.008081	1	0.008081	0.772	0.387
error	0.293	28	0.01047		
SIGNAL 2					
Location	2.358	1	2.358	4.166	0.051
error	15.844	28	0.566		
O/E50					
Location	0.07160	1	0.07160	6.525	0.016
error	0.307	28	0.01097		

3.5.2 Dominance Structure

A review of the distribution of taxa recorded within the samples is presented as cumulative dominance graphs below for the riffle (Figure 3-8) and edge (Figure 3-9) habitats. Site QBYN1 samples recorded one taxon making up between 50-60% of the total abundance recorded at that site (Figure 3-8). There was also evidence of unevenness in taxa distribution within the edge samples, with QBYN1 samples recording over 40% of the abundance from a single genus (Figure 3-9).

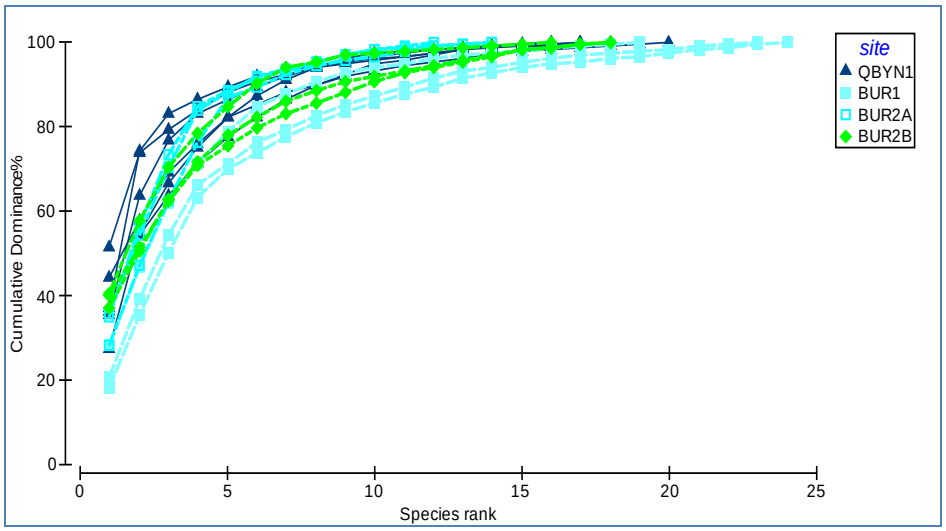


Figure 3- 8: Cumulative dominance of taxa (generic level) within the riffle samples, autumn 2011.

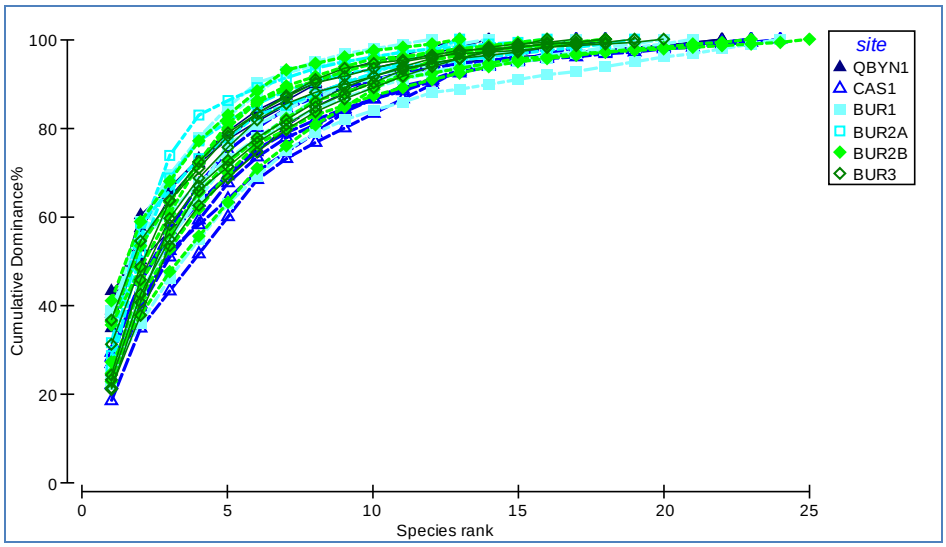


Figure 3- 9: Cumulative dominance of taxa (generic level) within the edge samples, autumn 2011.

Further investigation into the taxa dominating the riffle habitat samples revealed that the dominance structure differed among sites (Figure 3-10), with no single taxa dominating all sites. The Chironomidae sub-family *Orthocladiinae* (non-biting midge) was the most common taxa found in the top five most abundant taxa within three of the four riffle sites (see Table 3-8 for a key to abbreviated taxa names given in Figure 3-10) . Many of the other abundant taxa present within riffle habitat samples belonged to the Trichoptera and Ephemeroptera orders, part of the sensitive EPT taxa group These included Hydropsychidae *Cheumatopsychidae*, Philopotamidae *Chimarra*, Ecnomidae *Ecnomus*, Caenidae *Tasmanocoenis* and Leptophlebiidae sp. and Baetidae: *Baetidae Genus 2*.

Figure 3-10 also highlights the difference in overall taxa abundance across the four sites. For example, site BUR2a recorded very high abundance (>1500 individuals) of four taxa whereas at the downstream site BUR2b, abundances for four taxa were<500 individuals.

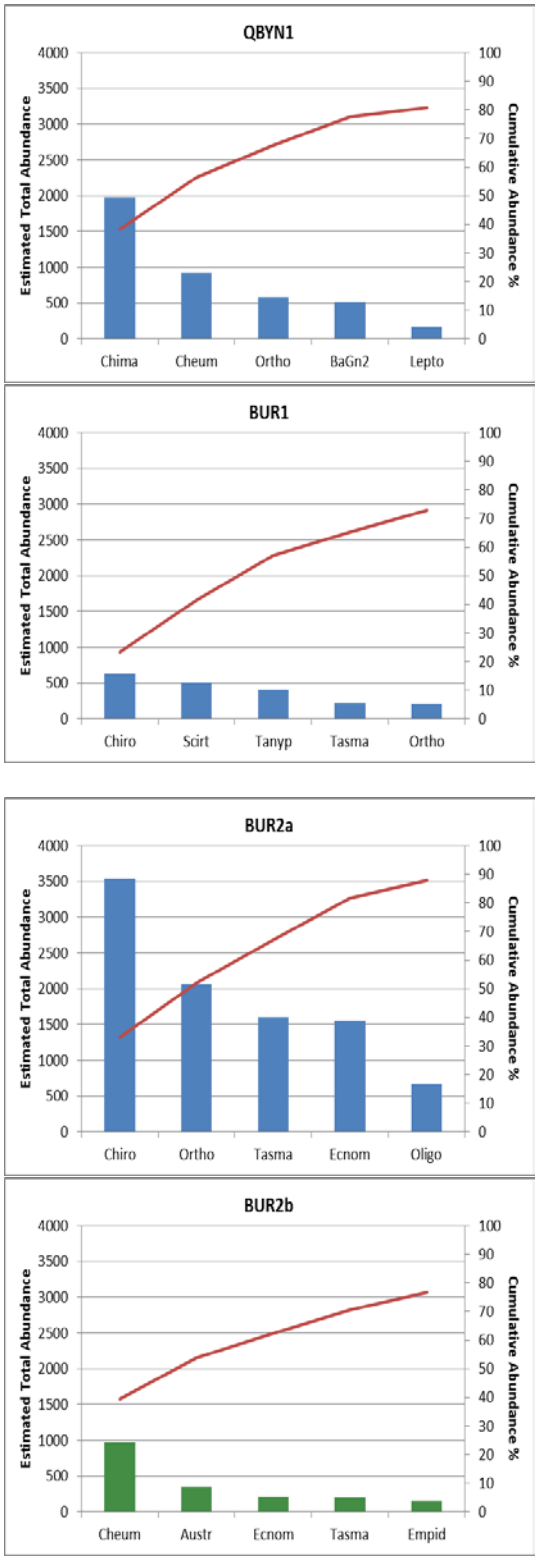
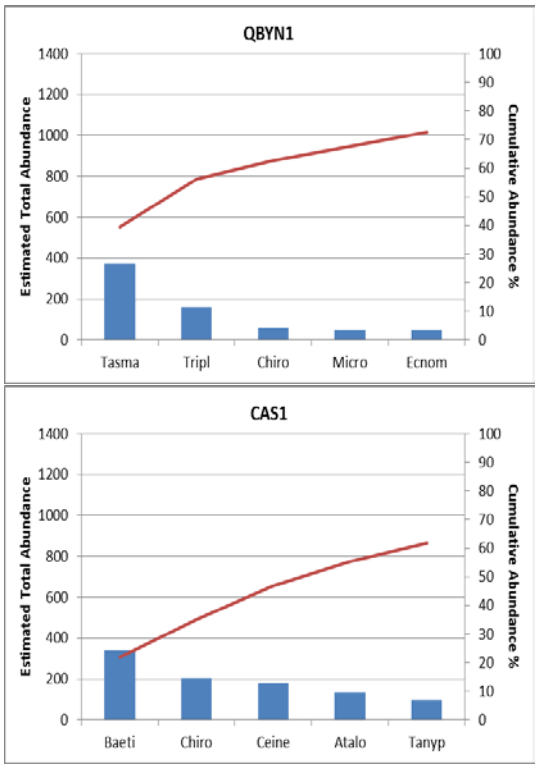


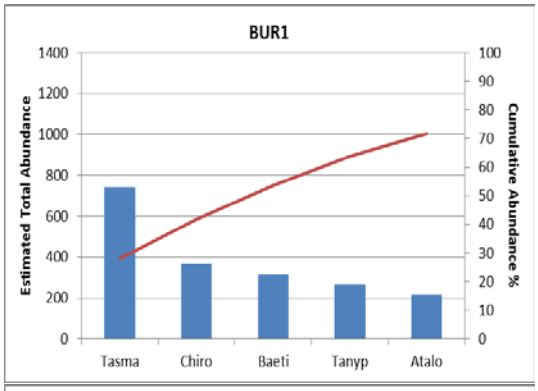
Figure 3- 10: **The estimated total abundance per sample and cumulative percentage of the five most abundant taxa within riffle samples from each site. Blue columns are sites upstream and green columns are sites downstream of discharge location. See Table 3- 8 for taxa abbreviation explanation.**

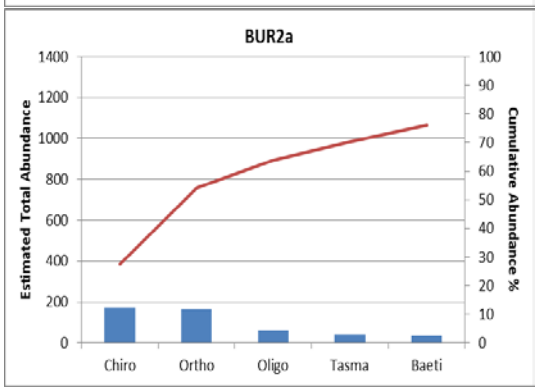
The most common animal in the edge samples included Chironomidae sub-family *Chironominae* (non-biting midges) present in five of the six sites most dominant taxa list (Figure 3-11) (see Table 3-8 for a key to abbreviated taxa names given in Figure 3-11) . .

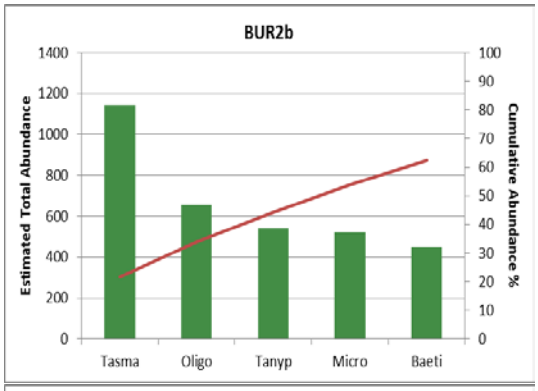
All taxa collected from the edge samples represented less than 30% of the total abundance at each site, with no one taxa dominating within the habitat. Similar to the riffle habitat, there were a number of EPT taxa present within the edge samples at all sites, including the highly sensitive Leptophlebiidae *Atalophlebia* sp., which was among the dominant edge habitat taxa at two sites (CAS1 and BUR1).

The overall relative abundance of macroinvertebrates from edge habitats was much higher at the sites below the discharge location than at other sites upstream and along the Queanbeyan River.









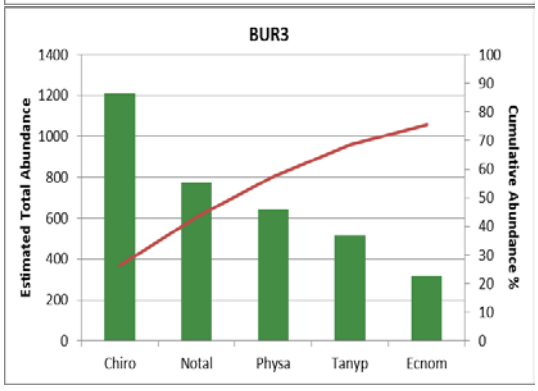


Figure 3- 11: The total abundance and cumulative percentage of the five most abundant taxa within edge samples from each site. Blue columns are sites upstream and green columns are sites located downstream of discharge location. See Table 3- 8 for taxa abbreviation explanation.

Table 3- 8: Key to abbreviated taxa names in Figure 3- 10 and Figure 3- 11. Taxa from the EPT group are highlighted within the thicker border.

Abbreviation	Order [CLASS]	Family (*sub- family*)	*Genus*	SIGNAL- 2 score
Scirt	Coleoptera	Scirtidae	*sp.*	6
Chiro	Diptera	*Chironominae*	*sp.*	3
Ortho	Diptera	*Orthocladiinae*	*sp.*	4
Tanyp	Diptera	*Tanypodinae*	*sp.*	4
Empid	Diptera	Empididae	*sp.*	5
Austr	Diptera	Simulidae	*Austrosimulium*	5
Micro	Hemiptera	Corixidae	*Micronecta*	2
Baeti	Ephemeroptera	Baetidae	*sp.*	5
BaGn2	Ephemeroptera	Baetidae	*Baetidae Genus 2*	5
Tasma	Ephemeroptera	Caenidae	*Tasmanocoenis*	4
Atalo	Ephemeroptera	Leptophlebiidae	*Atalophlebia*	8
Notal	Trichoptera	Leptoceridae	*Notalina*	6
Tripl	Trichoptera	Leptoceridae	*Triplectides*	6
Ecnom	Trichoptera	Ecnomidae	*Ecnomus*	4
Chima	Trichoptera	Philopotamidae	*Chimarra*	8
Cheum	Trichoptera	Hydropsychidae	*Cheumatopsychidae*	6
Physa	GASTROPODA	Physidae	*Physa*	1
Oligo	OLIGOCHAETA	--	--	2
Ceini	Amphipoda	Ceinidae	*sp.*	2

3.5.3 AUSRIVAS Bandings

Most of the samples were within AUSRIVAS Band B (87% riffle, 57% edge), suggesting the sites were 'significantly impaired'. However, the remaining samples were within Band A, with the exception of two replicate riffle samples from site BUR2a that recorded a 'C' banding. However, the autumn 2011 event was the first sampling round to sample a riffle habitat at site BUR2a, suggesting that the C-banding attributed to riffle habitat this site may have been related to habitat permanence rather than any particular pollution or habitat disturbance-related factor.

The AUSRIVAS output for the riffle samples indicated several taxa with a greater than 50% likelihood of being present, but which were not collected during autumn (Table 3-9). The greatest number of taxa absent from samples was from site BUR1, with 13 of the 19 taxa absent across all samples collected in autumn 2011 were absent from that site. Included in the absent taxa were families from the sensitive EPT groups, such as Leptophlebiidae (Ephemeroptera), Gripopterygidae (Plecoptera), and five Trichoptera taxa among which was the highly sensitive Glossosomatidae (SIGNAL-2 score of 9) (Table 3-9).

A total of 6 taxa were considered to be >90% predicted within a mix of samples from sites.

Table 3- 9: Taxa predicted with at least a 50% chance to be present within each sample, but which were not collected, riffle habitat autumn 2011. Figures in table represent likelihood of occurrence.

Taxon Name	Oligochaeta	Hydrophilidae	Elmidae	Psephenidae	Simuliidae	Podonominae	Tanypodinae	Chironominae	Leptophlebiidae	Corydalidae	Gomphidae	Gripopterygidae	Hydrobiosidae	Glossosomatidae	Hydroptilidae	Philopotamidae	Hydropsychidae	Ecnomidae	Conoesucidae	TOTAL
Signal Score	2	2	7	6	5	6	4	3	8	7	5	8	8	9	4	8	6	4	7	
QBYN1_R1_1		0.5		0.86		0.59	0.5	1		0.58	0.63			0.63					0.86	9
QBYN1_R1_2		0.5		0.86		0.59	0.5			0.58	0.63			0.63					0.86	8
QBYN1_R1_3		0.5		0.86		0.59				0.58	0.63			0.63				0.5	0.86	8
QBYN1_R2_1	0.96			0.81		0.59	0.52			0.52	0.62			0.58					0.8	8
QBYN1_R2_2	0.96					0.59	0.52			0.52	0.62			0.58					0.8	7

Taxon Name	Oligochaeta	Hydrophilidae	Elmidae	Psephenidae	Simuliidae	Podonominae	Tanypodinae	Chironominae	Leptophlebiidae	Corydalidae	Gomphidae	Gripopterygidae	Hydrobiosidae	Glossosomatidae	Hydroptilidae	Philopotamidae	Hydropsychidae	Ecnomidae	Conoesucidae	TOTAL
Signal Score	2	2	7	6	5	6	4	3	8	7	5	8	8	9	4	8	6	4	7	
QBYN1_R2_3	0.96			0.81		0.59	0.52			0.52	0.62			0.58					0.8	8
BUR1_R1_1			0.96	0.83	0.91	0.59			0.91	0.54	0.63			0.6					0.82	9
BUR1_R1_2			0.96	0.83	0.91	0.59				0.54	0.63			0.6		0.63	0.95		0.82	10
BUR1_R1_3			0.96	0.83	0.91	0.59				0.54		0.83		0.6	0.6				0.82	9
BUR2A_R1_1			0.96	0.78	0.91	0.59					0.61	0.78	0.6	0.55		0.57			0.76	10
BUR2A_R1_2			0.96	0.78	0.91	0.59			0.9		0.61	0.78		0.55		0.57			0.76	10

Taxon Name	Oligochaeta	Hydrophilidae	Elmidae	Psephenidae	Simuliidae	Podonominae	Tanypodinae	Chironominae	Leptophlebiidae	Corydalidae	Gomphidae	Gripopterygidae	Hydrobiosidae	Glossosomatidae	Hydroptilidae	Philopotamidae	Hydropsychidae	Ecnomidae	Conoesucidae	TOTAL
Signal Score	2	2	7	6	5	6	4	3	8	7	5	8	8	9	4	8	6	4	7	
BUR2A_R1_3			0.96	0.78		0.59					0.61	0.78		0.55		0.57	0.94		0.76	9
BUR2B_R1_1						0.57					0.5									2
BUR2B_R1_2						0.57	0.7				0.5									3
BUR2B_R1_3						0.57		1	0.87		0.5									4

A total of 24 taxa with a greater than 50% predicted likelihood of occurrence were recorded from edge habitat in autumn 2011Nine of these were representatives of the EPT taxa group(Table 3-10). Notably, the two downstream sites (BUR2b and BUR3) did not record any of the Trichoptera taxa with a greater than 50% likelihood of being present based on habitat conditions at these sites and their locality.

The most common taxa predicted by the AUSRIVAS model to be present, but were not collected from edge habitat were from the Coleoptera order, Elmidae (SIGNAL sensitivity rating =7) (Table 3-10). All sites had at least one taxa with a greater than 50% likelihood of occurring in edge habitat that was, in fact, not recorded.

Table 3- 10: Taxa with at least a 50 % predicted chance of occurring in each sample, but which were not collected, edge habitat autumn 2011. Figures in table represent likelihood of occurrence.

Taxon Name	Planorbidae	Sphaeriidae	Oligochaeta	Acarina	Hydrophilidae	Elmidae	Ceratopogonidae	Simuliidae	Podonominae	Orthocladiinae	Chironominae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Coenagrionidae	Synlestidae	Gomphidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Calamoceratidae	Leptoceridae	TOTAL
Signal Score	2	5	2	6	2	7	4	5	6	4	3	5	8	4	2	2	7	5	8	4	4	7	7	6	
QBYN1_E1_1	0.55					0.62													0.69	0.93		0.59			5
QBYN1_E1_2	0.55										0.97						0.65		0.69	0.93		0.59			6
QBYN1_E2_1	0.55		0.97			0.62											0.65			0.93		0.59			6
QBYN1_E2_2	0.55		0.97												0.62		0.65		0.69	0.93		0.59			7

Taxon Name	Planorbidae	Sphaeriidae	Oligochaeta	Acarina	Hydrophilidae	Elmidae	Ceratopogonidae	Simuliidae	Podonominae	Orthocladiinae	Chironominae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Coenagrionidae	Synlestidae	Gomphidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Calamoceratidae	Leptoceridae	TOTAL
Signal Score	2	5	2	6	2	7	4	5	6	4	3	5	8	4	2	2	7	5	8	4	4	7	7	6	
CAS1_E1_1		0.5		0.75		0.76	0.61	0.53	0.52									0.5					0.5		8
CAS1_E1_2					0.9	0.76	0.61	0.53	0.52						0.68			0.5					0.5		8
CAS1_E1_3						0.76	0.61	0.53	0.52	1					0.68			0.5					0.5		8
CAS1_E2_1			1		0.9	0.76		0.53	0.52						0.68			0.5					0.5		8
CAS1_E2_2				0.75	0.9	0.76	0.61	0.53	0.52						0.68	0.52		0.5					0.5		10

Taxon Name	Planorbidae	Sphaeriidae	Oligochaeta	Acarina	Hydrophilidae	Elmidae	Ceratopogonidae	Simuliidae	Podonominae	Orthocladiinae	Chironominae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Coenagrionidae	Synlestidae	Gomphidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Calamoceratidae	Leptoceridae	TOTAL
Signal Score	2	5	2	6	2	7	4	5	6	4	3	5	8	4	2	2	7	5	8	4	4	7	7	6	
BUR1_E1_1	0.55		0.97			0.62											0.65		0.69		0.58	0.59			7
BUR1_E1_2	0.55					0.62				1							0.65		0.69			0.59			6
BUR1_E1_3	0.55																0.65		0.69	0.93		0.59			5
BUR1_E2_1	0.55		0.97			0.62				1					0.62		0.65		0.69	0.93		0.59			9
BUR1_E2_2	0.55		0.97			0.62				1							0.65		0.69	0.93	0.58	0.59			9

Taxon Name	Planorbidae	Sphaeriidae	Oligochaeta	Acarina	Hydrophilidae	Elmidae	Ceratopogonidae	Simuliidae	Podonominae	Orthocladiinae	Chironominae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Coenagrionidae	Synlestidae	Gomphidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Calamoceratidae	Leptoceridae	TOTAL
Signal Score	2	5	2	6	2	7	4	5	6	4	3	5	8	4	2	2	7	5	8	4	4	7	7	6	
BUR1_E2_3	0.55		0.97							1							0.65		0.69	0.93	0.58	0.59			8
BUR2A_E1_1	0.55					0.62											0.65		0.69			0.59			5
BUR2A_E1_2	0.55					0.62								1			0.65		0.69		0.58	0.59		0.96	8
BUR2A_E2_1	0.55																0.65		0.69			0.59		0.96	5
BUR2B_E1_1			0.99	0.52	0.71	0.72																			4

Taxon Name	Planorbidae	Sphaeriidae	Oligochaeta	Acarina	Hydrophilidae	Elmidae	Ceratopogonidae	Simuliidae	Podonominae	Orthocladiinae	Chironominae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Coenagrionidae	Synlestidae	Gomphidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Calamoceratidae	Leptoceridae	TOTAL
Signal Score	2	5	2	6	2	7	4	5	6	4	3	5	8	4	2	2	7	5	8	4	4	7	7	6	
BUR2B_E1_2			0.99	0.52		0.72																			3
BUR2B_E1_3			0.99	0.52	0.71	0.72				1															5
BUR2B_E2_1				0.52																					1
BUR2B_E2_2				0.52	0.71	0.72																			3
BUR2B_E2_3				0.52	0.71	0.72																			3

Taxon Name	Planorbidae	Sphaeriidae	Oligochaeta	Acarina	Hydrophilidae	Elmidae	Ceratopogonidae	Simuliidae	Podonominae	Orthocladiinae	Chironominae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Coenagrionidae	Synlestidae	Gomphidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Calamoceratidae	Leptoceridae	TOTAL
Signal Score	2	5	2	6	2	7	4	5	6	4	3	5	8	4	2	2	7	5	8	4	4	7	7	6	
BUR3_E1_1					0.77	0.73						0.93	0.95												4
BUR3_E1_2						0.73				1		0.93	0.95												4
BUR3_E1_3					0.77	0.73						0.93	0.95												4
BUR3_E2_1					0.77	0.73				1			0.95												4
BUR3_E2_2					0.77	0.73						0.93	0.95												4

Taxon Name	Planorbidae	Sphaeriidae	Oligochaeta	Acarina	Hydrophilidae	Elmidae	Ceratopogonidae	Simuliidae	Podonominae	Orthocladiinae	Chironominae	Baetidae	Leptophlebiidae	Caenidae	Corixidae	Coenagrionidae	Synlestidae	Gomphidae	Gripopterygidae	Hydroptilidae	Ecnomidae	Conoesucidae	Calamoceratidae	Leptoceridae	TOTAL
Signal Score	2	5	2	6	2	7	4	5	6	4	3	5	8	4	2	2	7	5	8	4	4	7	7	6	
BUR3_E2_3				0.59	0.77	0.73				1		0.93	0.95												6

3.5.4 Multivariate analysis

3.5.4.1 Riffle habitat

The cluster dendogram in Figure 3-12 and the NMDS plot Figure 3-13 for the riffle samples show that there was separation between sites based on macroinvertebrate taxonomic composition, with upstream Burra Creek sites separating from the downstream site and QBYN1 at around the 40% similarity level. An ANOSIM test revealed that there were significant differences in macroinvertebrate taxonomic composition between sites (Global R statistic = 0.975, p = 0.001). However, pairwise tests shown in Table 3-11show that the taxonomic composition of riffle habitat at QBYN1 was significantly different from that of riffle habitats sampled in Burra Creek in autumn 2011. SIMPER analysis showed that the main contributors to such differences were the absence of Philopotamidae: *Chimarra* sp. from Burra Creek sites, the absence of Scirtidae sp. From QBYN1 and differences in the relative abundances of Tanypodinae sp., Chironominae sp., Baetidae: Genus 2 and Elmidae: *Austrolimnius* sp. between QBYN1 and Burra Creek sites.

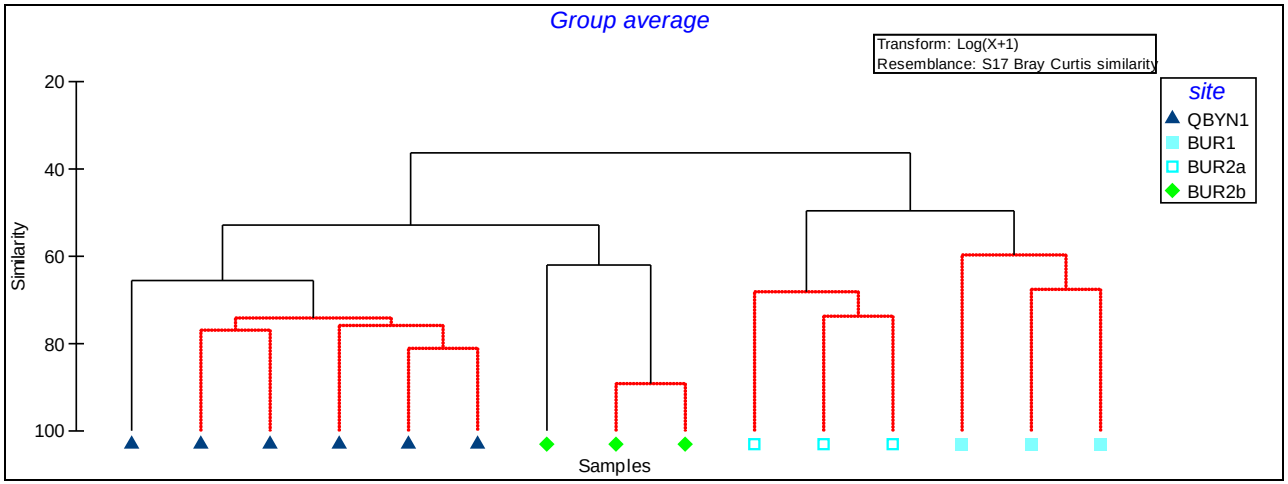


Figure 3- 12: Cluster analysis based on genus level data for autumn riffle samples. *Green symbols - downstream; blue symbols - upstream.*

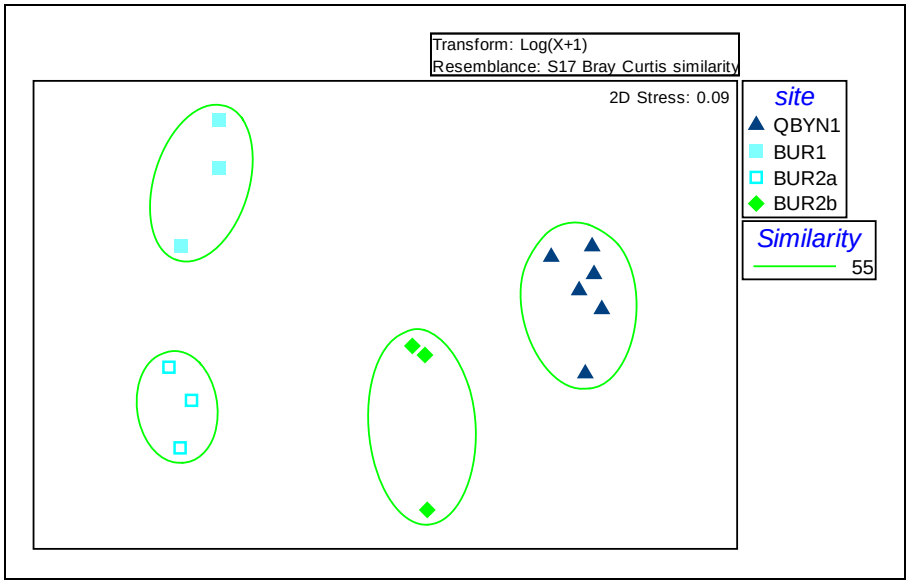


Figure 3- 13: **Non- metric multidimensional scaling (NMDS) of genus data for autumn riffle samples. *Green symbols - downstream; blue symbols - upstream.***

Table 3- 11: **Pair- wise ANOSIM test results comparing riffle- associated macroinvertebrate taxonomic composition between sites. Values in red represent significant differences at the 5% (p=0.05 level).**

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number ≥ Observed
QBYN1, BUR1	1	1.2	84	84	1
QBYN1, BUR2a	1	1.2	84	84	1
QBYN1, BUR2b	0.951	1.2	84	84	1
BUR1, BUR2a	0.926	10	10	10	1
BUR1, BUR2b	1	10	10	10	1
BUR2a, BUR2b	1	10	10	10	1

3.5.4.2 Edge habitat

The cluster dendogram shown in Figure 3-14 and the NMDS plot in Figure 3-13 for edge habitat samples show that there was some grouping according to site based on macroinvertebrate taxonomic composition. Three control sites formed separate clusters from the other sites, these being QBYM1, BUR1 and CAS1. There was a degree of similarity between the remaining three sites at around the 50% similarity level, but samples from the control site BUR2a and the impact site BUR2b were more similar to each other than to those from other sites. An ANOSIM test confirmed that there were significant differences between sites in autumn 2011 based on edge habitat macroinvertebrate taxonomic composition (Global R statistic = 0.942,p = 0.001). Results of pairwise ANOSIM tests presented in Table 3-12 show that the taxonomic composition of edge habitat samples varied significantly between all sites.

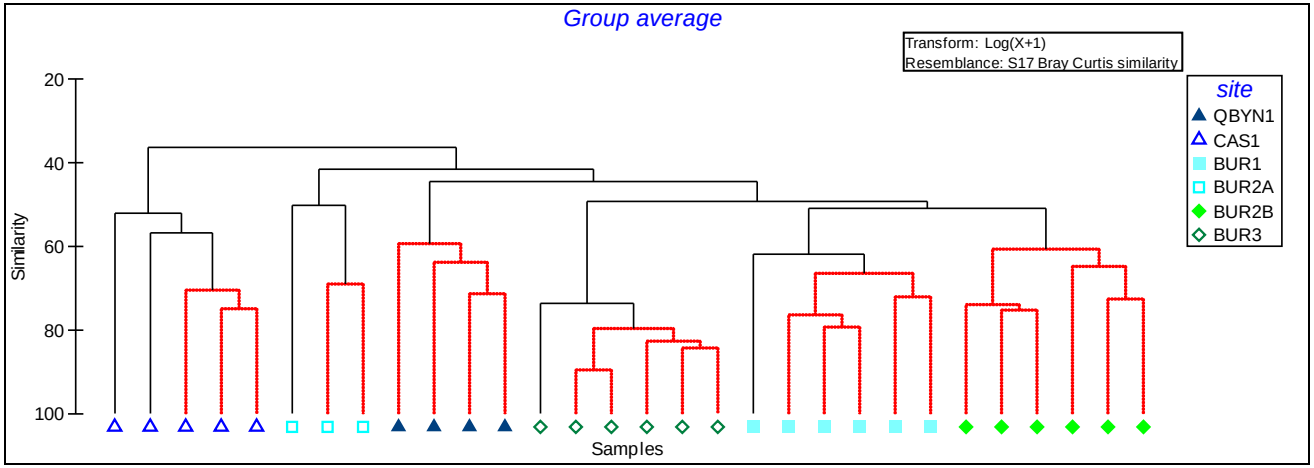


Figure 3- 14: Cluster analysis based on genus level data for autumn edge samples. Green *symbols - downstream; blue symbols* - upstream.

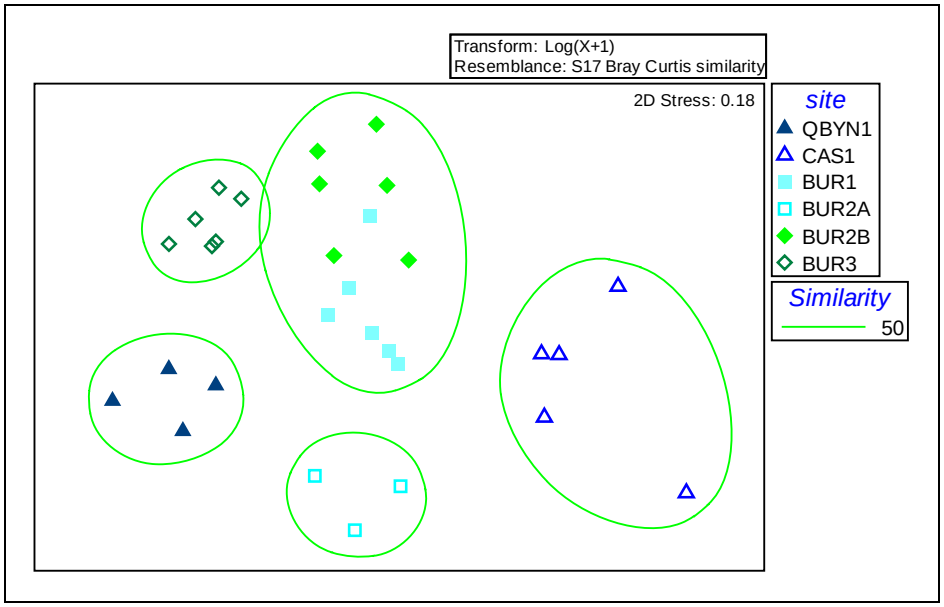


Figure 3- 15: **Non- metric multidimensional scaling (NMDS) of genus data from autumn edge samples. Green *symbols* – downstream; blue symbols - upstream.**

Table 3- 12: **Pair- wise ANOSIM test results comparing edge- associated macroinvertebrate taxonomic composition between sites. Values in red represent significant differences at the 5% (p=0.05 level).**

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number ≥ Observed
QBYN1, CAS1	1	0.8	126	126	1
QBYN1, BUR1	1	0.5	210	210	1
QBYN1, BUR2A	0.926	2.9	35	35	1
QBYN1, BUR2B	1	0.5	210	210	1
QBYN1, BUR3	0.996	0.5	210	210	1
CAS1, BUR1	0.931	0.2	462	462	1
CAS1, BUR2A	0.877	1.8	56	56	1
CAS1, BUR2B	0.963	0.2	462	462	1
CAS1, BUR3	0.989	0.2	462	462	1
BUR1, BUR2A	0.994	1.2	84	84	1
BUR1, BUR2B	0.913	0.2	462	462	1
BUR1, BUR3	0.981	0.2	462	462	1
BUR2A, BUR2B	0.92	1.2	84	84	1
BUR2A, BUR3	0.994	1.2	84	84	1
BUR2B, BUR3	0.961	0.2	462	462	1

4 Discussion

4.1 Sampling conditions

The high intensity flooding flows, which occurred prior to Spring 2010, have left obvious erosion and deposition within the catchment. Physical changes have occurred to the Burra Creek system allowing for the collection of riffle samples for the first time during this program at site BUR2a and BUR2b

Of worthy note is the location of site QBYN2 within the full supply level of Googong Dam (Figure 4-1). If Googong Dam remains inundated above the 80 % supply level, this site will no longer service this project as a downstream site. It is recommended this site be removed from the program and another site established upstream of the full supply level influence if possible.

Figure 4- 1: Site QBYN2 inundated by impounded water from Googong Dam at time of sampling for the autumn 2011 event.

BUR3 was also inundated in autumn 2011 for the same reasons, so a replacement or alternative 'floating' site, located approximately 500m upstream of BUR3, is recommended. This site had appropriate habitat for sampling and is upstream of the inundation zone.

Figure 4- 2: Site BUR3 inundated by Googong Dam, autumn 2011.

4.2 Water quality and periphyton

Continuous measurements indicate that apart from a steady seasonal decrease in water temperature, the most notable changes in water quality coincided with the autumn flow events. Turbidity changed the most markedly during such events, but quickly returned to background levels. Turbidity can influence aquatic ecosystems by reducing light penetration, and as a consequence, affect primary production (Kirk, 1985) and interfere with the feeding mechanisms of taxa i.e. clogging of gills or feeding appendages (Hellawell, 1986), though responses to turbidity are not necessarily direct dose-related as many aquatic organisms are adapted to short term elevated levels associated with flow events. Similarly, it is unlikely that aquatic organisms will have been adversely affected by the type of short term decreases in pH and daily DO saturation maxima observed in association with flow events during autumn 2011. The tendency for EC levels in Burra Creek to be well above the recommended guideline range and the fact that DO maxima in Burra Creek were often at or below the minimum recommended range in autumn 2011 would potentially have had greater influence on macroinvertebrate fauna in that system, notwithstanding that elevated EC is not uncommon for waterways in the study region and local aquatic fauna may be adapted to such conditions.

One of the chief concerns regarding the potential for nutrient enrichment in the Burra Creek system due to the M2G transfers is the potential for increased filamentous green algae and cyanobacteria (blue-green algae) growth, the rate at which is determined partly by the level of nutrients in the water. Proliferations can cause problems to water storages, alter water quality in lentic and lotic systems, lower the aesthetic value, cause operational difficulties (i.e. clogging intake valves) (Biggs and Kilroy, 2000), and have been linked to reduced numbers of sensitive macroinvertebrate taxa (Suren and Jowett, 2006). In autumn 2011, the downstream site BUR3 recorded total nitrogen, NOx and total phosphorus levels higher than the recommended ANZECC and ARMCANZ (2000) Guideline levels, but other than that, most sites had nutrient levels within the recommended ranges. Furthermore, exceedances at BUR3 were relatively minor and the fact that this site was subject to the influence of the impoundment at the time means that those results were not indicative of natural flowing stream conditions. Impoundments have an entirely different chemistry and limnology to stream habitats. As no periphyton samples were collected at BUR3 in this round, no correlation between these elevated nutrient levels and periphyton growth could be made. There were, however, no significant differences in either chlorophyll-a concentration or AFDM between sampling sites in 2011, which corresponds with the general low nutrient levels across the sites they were sampled.

It should be noted that the grab sampling carried out as part of this study do not provide a definitive assessment of the nutrient status of these systems or allow accurate predictions of algal response to nutrient enhancement in these systems. While nutrients are often limiting to algal growth (Biggs, 1989; Bowes et al., 2007), other environmental factors such as flows, algal grazing and local microhabitat conditions are likely to be influential to algal growth rates and standing stock. Further, as described in Ecowise (2009a), periphyton growth is a cumulative response to water quality conditions over a much greater period of time than a single day. Hence, greater replication of paired nutrient and periphyton sampling would be required if relationships between algal growth and nutrients in these systems are to be better understood. Some initial into such relationships might be gleaned from the temporal data assessment following this study.

4.3 River health and patterns in macroinvertebrate communities

Taxa richness was variable across sites and habitats during autumn 2011, but there were no significant differences in taxa richness between sites located upstream to those downstream of the pipeline discharge location irrespective of genus or family-level taxonomic resolution or on habitat type. This also held for EPT richness. The only measurable difference between sites upstream and downstream of the discharge point was in relation to O/E50 scores from edge habitat samples. The autumn 2011 edge habitat data showed that O/E50 scores were higher downstream of the discharge point than upstream of it. Such difference did not however translate into marked differences in AUSRIVAS bandings as, with the exception of BUR2a, which had an anomalous result due to a highly temporary riffle being sampled for the first time, most sites were rated as Band B (significantly impaired). The two downstream sites included a Band B and a Band A rating (the latter pertaining to site BUR3), which demonstrates there was no consistently higher AUSRIVAS bandings in downstream reaches compared to upstream reaches.

On the whole there has been little change in AUSRIVAS bandings since spring 2010, where all sites were characterised as Band B (significantly impaired) (ALS, 2011). This broadly consistent pattern (both spatially and temporally) suggests that there may be broad-scale factors affecting the study area that have led to the depletion of the range of taxa expected to occur there. Such factors could include runoff from surrounding agricultural land, riparian vegetation clearing, naturally elevated EC levels and at times supressed DO saturation within Burra Creek, hydraulic disturbance associated with high flow events, the ephemeral nature of flows in Burra Creek, or a combination of these. Once again, it must be pointed out that the AUSRIVAS model was not developed with ephemeral stream flow conditions in mind, so some caution should be placed on the direct interpretation of AUSRIVAS bandings given in this study when assessing the health of the macroinvertebrate community.

Missing taxa from both edge and riffle habitat included members of the EPT group among which were relatively pollution-sensitive taxa based on SIGNAL sensitivity ratings. Thus degraded water quality in Burra Creek may have contributed to the significantly impaired AUSRIVAS bandings observed in autumn 2011. Based on our results, high EC and low DO saturation appear to be the most likely contributors to this, though nutrient enrichment cannot be ruled out altogether as our grab sampling results only represent a snap shot of conditions at the time of sampling and not the historic water quality conditions the macroinvertebrate community will have responded to over time. Discharges into Burra Creek will involve water from a different catchment being transferred, which will result in changes to the water quality in downstream reaches. Some of those changes may be detrimental to pollution-sensitive taxa, however, artificial flows may also lead to an increase in DO levels in this reach, which would provide a beneficial effect to aquatic fauna in general. The impacts of altered water quality on macroinvertebrates in the lower reaches of Burra Creek will need to be carefully monitored during the operation phase.

With respect to the hydraulic disturbance, sampling for the autumn 2011 round was taken around a month after a high flow event that occurred in late March. This was followed by a period of relative low and stable flows, so it is quite possible that the AUSRIVAS

assessment results reflect a stage of late recovery. The spring 2010 sampling round was also preceded by a high flow event a few weeks before sampling took place (ALS, 2011). High flow events can scour-remove macroinvertebrates and benthic habitats. Some taxa and habitats are more vulnerable than others to this (Cobb et al 1992; Robinson et al 2004) and recovery may be influenced by the degree of disturbance in connection with the timing from a previous disturbance, the composition of the community in response to previous floods and the propensity of certain taxa to recolonise through drift (Hynes, 1970a; Irvine and Henriques, 1984; Niemi et al. 1990; Peterson et al. 1994; Miller and Gollady, 1996; Imbert and Perry, 2000; Collier and Quinn, 2003; Fritz and Dodds, 2004). As with spring 2010, dominant taxa in the autumn samples included several Diptera families such as Chironominae and Simuliidae taxa, and Ephemeroptera families such as Baetidae taxa. These taxa are disturbance tolerant with fast recovery times following floods (Robinson et al 2004). At the same time, EPT taxa, which are perhaps more vulnerable to scour removal because they tend to live mainly in flowing habitats in the main channel, were among the dominant taxa at some sites. This corroborates the above hypothesis that the AUSRIVAS assessment results for autumn 2011 reflect a stage of late recovery from hydraulic disturbance. Another result supporting this theory is that the Band A rating for BUR3 edge habitat corresponded with BUR3 being subject to inundation by Googong Dam. The backwater conditions created will have reduced surface flows, thus reducing the potential for scour removal of macroinvertebrate taxa. Also, the Band A rating was achieved despite the fact this site had a number of water quality parameters outside the recommended ranges (Table 3-2)

Abrupt flow increases associated with rainfall-driven high flow events will continue to occur in Burra Creek during the operation phase of the M2G over and above the increase in flows due to the discharges into Burra Creek. Hence, the periodic hydraulic disturbance of macroinvertebrates and stream habitat will continue to influence the status of the macroinvertebrate community upstream and downstream of the discharge point will continue to partially reflect historic flow conditions. However, sudden increases associated with the switching on and off of the discharge may increase the frequency of hydraulic disturbance relative to upstream, which could lead to a depletion of the downstream assemblages relative to the upstream assemblages at the same time. The result of that is that the discharges into Burra Creek may lead to some improvements in those downstream assemblages relative to upstream assemblages at times where natural base flows are low or absent and where those additional artificial flows are maintained at relatively stable levels for prolonged periods.

There were no distinct differences in macroinvertebrate taxonomic composition between upstream and downstream reaches based on edge habitat samples as all sites differed significantly from each other. This suggests that local microhabitat conditions dictated the taxonomic composition of edge habitat at the various sites in autumn 2011. There were, however, distinctions between Burra Creek sites and QBYN1 riffle assemblages based on taxonomic composition. This may have been due to between catchment differences or to individual site related factors. For instance, the absence of Philopotamidae: *Chimarra* sp. from Burra Creek sites may have been due to the fat that this species prefers fast flowing water and flow velocities were lower in Burra Creek compared to the Queanbeyan River in autumn 2011 (see Figure 3-3 and Appendix A). However, the exact reasons for such differences cannot be ascertained at this stage.

5 Conclusions

The Burra Creek ecological monitoring program aims to establish the baseline river condition prior to water discharges into Burra Creek over a three year period, of which this report presents the findings of the autumn 2011 sampling event (7th baseline sampling). The main outcomes concluded from this sampling event are as follows:

- Continuous water quality measurements from the monitoring stations indicate that apart from the expected gradual decrease in water temperature. Changes in water quality coincided with the autumn high flow events. Turbidity quickly receded as flow levels receded following those events. EC levels took slightly longer to recover, but interestingly, high flow events later in the season had less relative influence on EC compared to events early in the season, regardless of the fact that those flows were sometimes higher compared to events earlier in the season.
- Burra Creek had prolonged periods over which DO saturation maxima were below the recommended range. This again might be a natural phenomenon, but the factors contributing to this require further investigation if changes in water quality associated with the abstraction and subsequent discharge into Burra Creek are to be appropriately managed. Notwithstanding any potential eutrophication effects, water transfers from the Murrumbidgee River, will probably increase the oxygenation of water in Burra Creek downstream of the release point.
- Nutrient levels were more or less within guideline ranges, apart from the downstream site BUR3. This was, however, probably attributed to the effects of water from Googong Dam inundating that site.
- In autumn 2011 there were no significant differences in chlorophyll-a concentration or AFDM between sites. This may reflect the generally low nutrient concentrations across the sites monitored, though the snap shot nature of sampling for this study prevents more conclusive evidence with regards to phytoplankton-nutrient availability relationships.
- Consistent with spring 2010, most sites were rated as Band B (significantly impaired). Exceptions were sites BUR2b (which was rated C due to the fact that a highly temporary riffle habitat had been sampled for the first time) and the downstream site BUR3, which was rated Band A (similar to reference conditions). ANOVA results for edge habitat support this in that O/E50 scores were highest downstream, indicating that this reach had more of the taxa that were predicted to occur there based on habitat conditions and site locations.
- The factors contributing to the significantly impaired status of most of the sites monitored are unknown at this stage. High EC and low DO saturation in Burra Creek may have contributed to this, but results from this study suggest that the macroinvertebrate community was probably in the advanced stages of recovery from high flow events that occurred in March 2011. The M2G project will not prevent further effects of natural high flow events from impacting the macroinvertebrate community in Burra Creek, but may increase the frequency of high flow disturbance through the intermittent switching on and off of discharges.

6 Recommendations

A condition stated in the Burra Creek monitoring proposal (section 1) is that the program is to agree to an adaptive management approach; so that the methodology, site selection and analyses are periodically reviewed so that the objectives of the program are being met to ActewAGLS's requirements.

With regards to site evaluation:

- Site QBYN2 was located within the full supply level of Googong Dam, and will no longer service this project as a downstream site along that system should Googong Dam remain inundated above the 80% supply level. This could potentially be for the duration of the operations phase monitoring period if sufficient rainfall occurs;
- BUR 3 needs to be moved, or at least include a roaming site as a backup for when the dam level is above 80% full supply level. Pumping for the M2G transfer will not commence unless Googong Dam is below 80% capacity;
- Site CAS1 should be removed from the program as it is now choked with *Typha*, difficult to sample and no longer a valid upstream control site;
- Additional upstream and additional downstream sites have been identified as alternatives to CAS1 and BUR3. The upstream site is located approximately 4km downstream of the BUR1 and the downstream site is located approximately 500m upstream of BUR3, outside of the inundation zone. In choosing these sites, emphasis was placed on choosing sites with representative riffle habitat sites as such habitats usually support a more diverse taxa community than edge habitat and are most vulnerable to hydrological changes associated with the M2G transfer.

The results from this study suggest that there are similar knowledge gaps that were outlined in previous studies as part of this baseline program (Ecowise, 2009b). Based on this, the same suite of recommendations is put forward here, which are as follows:

1) If compliance monitoring is to take place following the collection of baseline data, it is recommended that current trigger levels be revised for Burra Creek (i.e. a set of local water quality objectives should be developed for Burra Creek based on procedures outlined in the ANZECC & ARMCANZ (2000) Guidelines). Groundwater fed creeks such as Burra Creek have naturally elevated levels of salts and lower turbidity because the water is filtered through porous limestone. Both these parameters are often outside the bounds of the current guidelines, which would give the impression of guideline breeches when the values are likely to be within the natural boundaries of the system. Procedures for determining local water quality objectives are outlined in the ANZECC and ARMCANZ (2000) guidelines.

2) The importance of the hyporheic zone (HZ) as a refuge for over-summering taxa, and during periods of flood and drought is highlighted by several authors (Hynes, 1970b; Williams and Hynes, 1977; Boulton, 1989) and its importance within the Burra Creek system is poorly understood. The M2G transfer has the potential to change the substratum, surface water quality and potentially the groundwater quality within the system which could in turn impact upon the hyporheic fauna. ALS conducted a pilot study trialling various hyporheic fauna sampling methods and that study included sampling in Burra Creek (ALS, 2010). However, those data would not be sufficient to properly characterise the hyporheic fauna of Burra Creek or to predict the potential impacts associated with the M2G water transfers to Burra Creek. We recommend a more detailed study involving the survey hyporheic community at each surface water aquatic ecology site using the optimum sampling method identified in ALS (2010). Adding the HZ to the existing program as a third habitat (i.e. riffle, pool/edge, and hyporheic zone) would also mean that even in periods when there is no surface flow, there would be the opportunity to collect representative ecological data.

3) A total of 3 years of baseline data are now available for Burra Creek. Although this information will provide seasonal assessments on a site-specific basis, it lacks the ability to make inferences relating to the dynamics of the macroinvertebrate communities in Burra Creek, especially in relation to:

- Seasonal patterns in community turnover (outside of the standard autumn/spring AUSRIVAS sampling);
- Responses to various flow regimes, including large spates and increasing number of flow days since re-wetting (this would involve pre-event and event based sampling in refugial pools on top of any additional sampling that may or may not be deemed necessary).

A comprehensive understanding of this system in relation to changing flow would involve a more intensive sampling regime, but would provide ACTEW with a more detailed assessment which would fill a large knowledge gap existing in this system at present.

In addition to the recommendations above, another recommendation is highlighted as an outcome from the more recent sampling events (spring 2010 and autumn 2011), including:

4) Undertake an extensive temporal assessment of all baseline data collected biannually since spring 2008, as so far assessments have focussed on individual sampling events, which hasn't allowed any detailed understanding of inter-annual trends. The monitoring of such trends will be critical to assessing the potential impacts associated with the M2G transfer, albeit that some allowance may need to be made for conducting long term data analysis separately for autumn and spring data if clear seasonal differences in macroinvertebrate community structure are established.

7 References

ALS (2010). Hyporheic Research and Development Project: 'Pilot Study Report'. Report produced September 2010 for ActewAGL and Xstrata.

ALS (2011). Murrumbidgee Ecological Monitoring Program: Part II – Burra Creek. May 2011. Report for Actew Corporation.

ANZECC & ARMCANZ (2000) National water quality management strategy: Paper No. 4. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1. The Guidelines. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

A.P.H.A. (2005) Standard methods for the examination of water and waste water.21st Edition. American Public Health Association. Washington.

BIOSIS Research Pty. Ltd. (2009) Draft Murrumbidgee to Googong Water Transfer Project: Aquatic Impact Assessment. Queanbeyan, NSW.

Biggs, B.J.F. (1989) Biomonitoring of organic pollution using periphyton, South Branch, Canterbury, New Zealand. New Zealand Journal of Marine and Freshwater Research, 23, 263-274.

Biggs, B.J.F. (2000) New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams. Ministry for the Environment, Wellington.

Biggs, B.J.F. & Kilroy, C. (2000) Stream Periphyton Monitoring Manual. NIWA, Christchurch. NIWA. Christchurch.

Boulton, A.J. (1989) Over-summering refuges of aquatic macroinvertebrates in two intermittent streams in central Victoria. Transactions of the Royal Society of South Australia 113, 23-34.

Boulton, A.J. & Lake, P.S. (1992) The ecology of two intermittent streams in Victoria, Australia. II. Comparisons of faunal composition between habitats, rivers and years. Freshwater Biology, 27, 99-121.

Bowes, M.J., Smith, J.T., Hilton, J., Sturt, M.M. & Armitage, P.D. (2007) Periphyton biomass response to changing phosphorus concentrations in a nutrient-impacted river: methodology for phosphorus target setting. Canadian Journal of Fisheries and Aquatic Sciences, 64, 227-238.

Cao, T., Larsen, D.P. & St-J. Thorne, R. (2001) Rare species in multivariate analysis for bioassessment: some considerations. Journal of the North American Benthological Society, 20, 144-153.

Chessman, B. C. (1995). Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat specific sampling, family level identification and a biotic index. *Australian Journal of Ecology*, **14**, 122-9.

Chessman, B.C. (2003) New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research*, **54**, 95-103.

Clarke, K.R. & Gorley, R.N. (2006) PRIMER v6: User Manual/Tutorial. PRIMER-E: Plymouth.

Clarke, K.R. & Warwick, R.M. (2001) Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER-E: Plymouth.

Cobb D.G, Galloway T.D., Flannagan J.F. (1992). Effects of discharge and substrate stability on density and species composition of stream insects. Canadian Journal of Fisheries and Aquatic Sciences 49: 1788–1795.

Collier, K.J. & Quinn, J.M. (2003) Land-use influences macroinvertebrate community response following a pulse disturbance. Freshwater Biology, 48, 1462-1481.

Coysh, J.L., Nichols, S.J., Simpson, J.C., Norris, R.H., Barmuta, L.A., Chessman, B.C. & Blackman, P. (2000) Australian River Assessment System (AUSRIVAS) National River Health Program Predictive Model Manual. Co-operative Research Centre for Freshwater Ecology, Canberra.

Downes, B.J., Barmuta, L.A., Fairweather, P.G., Faith, D.P., Keough, M.J., Lake, P.S., Mapstone, B.D. & Quinn, G.P. (2002) Monitoring Environmental Impacts - Concepts and Practice in Flowing Waters., Cambridge, U.K.

Ecowise Environmental. (2009a) Murrumbidgee Ecological Monitoring Program. Spring 2009. Part 1: Angle Crossing. Report to ACTEW Corporation.

Ecowise Environmental. (2009b) Murrumbidgee Ecological Monitoring Program. Spring 2009. Part 2: Burra Creek. Report to ACTEW Corporation.

Fritz, K.M. & Dodds, W.K. (2004) Resistance and resilience of macroinvertebrate assemblages to drying and flood in a tallgrass prairie stream system. Hydrobiologia, 527, 99-112.

Harrod, J.J. (1964) The distribution of invertebrates on submerged aquatic plants in a chalk stream. Journal of Animal Ecology, 33, 335-348.

Hawking, J.H. (2000) Key to Keys. A guide to keys and zoological information to identify invertebrates from Australian inland waters. Identification Guide No.2 Cooperative Research Centre for Freshwater Ecology.

Hellawell, J.M. (1986). Biological indicators of freshwater pollution and environmental management. London: Elsevier Applied Science.

Hynes, H.B.N. (1970a) The Ecology of Running Waters, Liverpool University Press, Liverpool.

Hynes, H.B.N. (1970b) The ecology of stream insects. Annual Review of Entomology, 15, 25-42.

Imbert J.B., Perry J.A. (2000). Drift and benthic invertebrate responses to stepwise and abrupt increases in non-scouring flow. Hydrobiologia 436:191–208.

Irvine JR, Henriques PR. (1984). A preliminary investigation on effects of fluctuating flows on invertebrates of the Hawea River, a large regulated river in New Zealand. New Zealand Journal of Marine and Freshwater Research 18: 283–290.

Kirk, J. T. O. (1985). Effects of suspensiods (turbidity) on penetration of solar radiation in aquatic systems. *Hydrobiology,* **125**, pp. 195 - 208.

Kruskal, J.B. (1964) Multidimensional scaling by optimizing goodness of fit to a non-parametric hypothesis. Psychometrika, 20, 1-27.

Lawrence LJ, Ward JV. (1982). Effects of sediment releases from a reservoir on stream macroinvertebrates. Hydrobiologia 96: 177–184.

Loeb, S. (1981) An in-situ method for measuring the primary productivity and standing crop of the epilithic periphyton community in lentic systems. Limnology and Oceanography, 394-399.

Marchant, R. (1989) A subsampler for samples of benthic invertebrates. Bulletin of the Australian Society of Limnology, 12, 49-52.

Miller, A.M. & Gollady, S.W. (1996) Effects of spates and drying on macroinvertebrate assemblages of an intermittent and perennial prairie stream. Journal of the North American Benthological Society, 15, 670-689.

Nichols, S., Sloane, P., Coysh, J., Williams, C., & Norris, R. (2000). ACT Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual. CRC for Freshwater Ecology, Uni of Canberra, ACT.

Niemi, G.J., Devore, P., Detenbeck, N., Taylor, D., Lima, A., Pastor, J., Yount, D.J. & Naiman, R.J. (1990) Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management, 14, 571-587.

Peterson CG, Weibel AC, Grimm NB, Fisher SG. (1994). Mechanisms of benthic algal recovery following spates: comparison of simulated and natural events. Oecologia 98: 280–290.

Robinson, C.T., Uehlinger, U., & Monaghan, M.T. (2004) Stream ecosystem response to multiple experimental floods from a reservoir. River Res. Applic. 20: 359–377.

Suren, A.M. & Jowett, I.G. (2006) Effects of floods versus low flows on invertebrates in a New Zealand gravel-bed river. Freshwater Biology, 51, 2207-2227.

Thorp, J.H., & Covich, A.P. (2001). Ecology and classification of North American freshwater invertebrates. 2nd Ed. Academic Press, California, USA.

Turak, E,. Waddell, N., & Johnstone, G. (2004). NSW Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual. Department of Environment and Conservation, NSW.

Wallace, J.B. (1990) Recovery of lotic macroinvertebrate communities from disturbance. Environmental Management, 14, 605-620.

Williams, D.D. & Hynes, H.B.N. (1977) The Ecology of Temporary Streams .II. General Remarks on Temporary Streams. Internationale Revue Der Gesamten Hydrobiologie, 62, 53-61.

Appendix A -
Site photos for Autumn 2011

Cassidy Creek – CAS1

Facing upstream.

Facing downstream

Burra Creek– BUR2A

Facing downstream

Facing downstream

Burra Creek- BUR1







Burra Creek- BUR2B

Downstream

Upstream

Downstream of weir

Burra Creek- BUR3

Upstream

Substrate.

Periphyton growth

Downstream

Queanbeyan River – QBYN1

Upstream

Downstream

Substrate

Queanbeyan River – QBYN2

Appendix B - Periphyton results, Autumn 2011

Site	Location	Season	Year	afdm mg/m	Logafdm	Chla ug/m	Log Chla	Raw Chla	Raw AFDM
QBYN1	u	autumn	2011	7154.52015	3.8545805	12586.66	4.09991	190	5.4
QBYN1	u	autumn	2011	2252.34893	3.3526357	7949.467	3.900338	120	1.7
QBYN1	u	autumn	2011	4239.71564	3.6273367	3643.506	3.561519	55	3.2
QBYN1	u	autumn	2011	2517.33116	3.4009404	3378.523	3.528727	51	1.9
QBYN1	u	autumn	2011	4239.71564	3.6273367	28485.59	4.454625	430	3.2
QBYN1	u	autumn	2011	5432.13567	3.7349706	12586.66	4.09991	190	4.1
QBYN2	d	autumn	2011	ns	ns	ns	ns	ns	ns
QBYN2	d	autumn	2011	ns	ns	ns	ns	ns	ns
QBYN2	d	autumn	2011	ns	ns	ns	ns	ns	ns
QBYN2	d	autumn	2011	ns	ns	ns	ns	ns	ns
QBYN2	d	autumn	2011	ns	ns	ns	ns	ns	ns
QBYN2	d	autumn	2011	ns	ns	ns	ns	ns	ns
BUR2a	u	autumn	2011	1244.34658	3.0949414	21198.58	4.326307	320	12.2
BUR2a	u	autumn	2011	9804.34242	3.9914185	19211.21	4.283555	290	7.4
BUR2a	u	autumn	2011	11261.7447	4.0516057	9936.834	3.997248	150	8.5
BUR2a	u	autumn	2011	10334.3069	4.0142814	8611.922	3.9351	130	7.8
BUR2a	u	autumn	2011	3974.73341	3.599308	3113.541	3.493255	47	3
BUR2a	u	autumn	2011	9671.85131	3.9855096	4703.435	3.672415	71	7.3
BUR1	u	autumn	2011	272.73115	2.4357347	861.1922	2.9351	13	4.3
BUR1	u	autumn	2011	15766.4425	4.1977337	457.0943	2.660006	6.9	4.2
BUR1	u	autumn	2011	16163.9159	4.2085466	19873.67	4.298278	300	6.2
BUR1	u	autumn	2011	5564.62678	3.745436	3974.733	3.599308	60	3.5
BUR1	u	autumn	2011	8214.44906	3.9145784	27823.13	4.444406	420	6.3
BUR1	u	autumn	2011	4637.18898	3.6662548	11261.74	4.051606	170	3.9
BUR2b	d	autumn	2011	1833.00703	3.2631641	6624.556	3.821157	100	11.9
BUR2b	d	autumn	2011	6492.06458	3.8123828	5233.399	3.718784	79	4.9
BUR2b	d	autumn	2011	8346.94017	3.9215273	2782.313	3.444406	42	6.3
BUR2b	d	autumn	2011	3444.76896	3.5371601	3709.751	3.569345	56	2.6
BUR2b	d	autumn	2011	7154.52015	3.8545805	3246.032	3.511353	49	5.4
BUR2b	d	autumn	2011	12719.1469	4.104458	2318.594	3.365225	35	9.6
BUR3	d	autumn	2011	ns	ns	ns	ns	ns	ns
BUR3	d	autumn	2011	ns	ns	ns	ns	ns	ns
BUR3	d	autumn	2011	ns	ns	ns	ns	ns	ns
BUR3	d	autumn	2011	ns	ns	ns	ns	ns	ns
BUR3	d	autumn	2011	ns	ns	ns	ns	ns	ns
BUR3	d	autumn	2011	ns	ns	ns	ns	ns	ns

Appendix C - Macroinvertebrate results, Autumn 2011

	QBYN1_K1_L1	QBYN1_K1_L2	QBYN1_K1_L3	QBYN1_K2_L1	QBYN1_K2_L2	QBYN1_K2_L3	BUR1 _K1_L1	BUR1 _K1_L2	BUR1 _K1_L3	BUR1_K2_L1	BUR1_K2_L2	BUR1_K2_L3	BUR3_K1_L1	BUR3_K1_L2	BUR3_K1_L3	BUR3_K2_L1	BUR3_K2_L2
Acarinasp.	20	40	60	25	50	40	0	13	11	10	0	0	0	43	29	2	2
AtyidaeParatya	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0
BaetidaeBaetidae Genus 2	0	20	0	25	100	0	0	0	0	0	0	0	80	29	29	2	4
BaetidaeCloeon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
CaenidaeTasmanocoenis	40	60	0	50	125	40	0	0	0	0	0	0	0	0	0	4	0
CeratopogonidaeCeratopoginae	0	0	20	0	0	0	38	13	0	30	30	30	280	271	114	34	18
ColeopteraDytiscidae	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0
ColeopteraGyrinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
ColeopteraScirtidae	0	0	0	0	0	0	0	0	0	10	0	10	20	0	0	0	2
Copepodasp.	0	0	0	0	0	0	0	0	0	10	0	10	0	0	0	0	0
DipteraChironominae	680	660	720	1300	1400	820	113	175	122	120	40	130	240	371	314	100	86
DipteraDolichopodidae	40	20	20	0	0	20	0	0	0	0	10	0	0	0	0	0	0
DipteraEmpididae	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0
DipteraOrthocladiinae	1360	1520	1520	1550	1225	1160	525	625	511	600	570	690	1320	886	1014	120	106
DipteraPsychodidae	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0
DipteraSimuliidae	380	380	620	350	725	440	163	163	167	40	90	90	900	757	857	4	2
DipteraTabanidae	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0
DipteraTanypodinae	80	120	160	150	225	120	138	163	111	110	120	50	0	43	29	30	28
DipteraTipulidae	0	0	0	0	0	0	0	0	0	0	30	0	0	0	14	0	0
DytiscidaeNecterosoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
DytiscidaePlatynectes	20	0	0	0	0	0	0	13	0	10	30	10	0	0	0	2	0
EcnomidaeEcnomus	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ElmidaeAustrolimnius	20	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0
EphemeropteraBaetidae	60	60	40	75	25	40	25	88	44	30	50	40	0	14	0	0	0
EphemeropteraCaenidae	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EphemeropteraLeptophlebiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
GastropodaLymnaeidae	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
GripopterygidaeDinotoperla	40	40	20	50	50	80	0	0	0	0	0	0	0	0	0	0	0

	QBYN1_K1_L1	QBYN1_K1_L2	QBYN1_K1_L3	QBYN1_K2_L1	QBYN1_K2_L2	QBYN1_K2_L3	BUR1 _K1_L1	BUR1 _K1_L2	BUR1 _K1_L3	BUR1_K2_L1	BUR1_K2_L2	BUR1_K2_L3	BUR3_K1_L1	BUR3_K1_L2	BUR3_K1_L3	BUR3_K2_L1	BUR3_K2_L2
GripopterygidaeIlliesoperla	0	0	20	125	75	0	0	0	0	0	0	0	20	0	0	2	2
HydraenidaeHydraena	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
HydrobiosidaeAustrochorema	0	0	0	100	25	0	0	0	0	0	0	0	0	0	0	0	0
HydrobiosidaePsyllobetina	0	0	0	0	0	40	0	13	0	30	0	0	0	0	0	0	0
HydrobiosidaeTaschorema	0	0	20	0	25	0	0	0	11	0	10	20	0	0	0	6	0
HydrobiosidaeUlmerochorema	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0
HydroptilidaeHellyethira	20	0	0	0	0	0	0	0	0	0	0	0	0	43	0	4	4
HydroptilidaeOxyethira	80	180	60	150	100	260	25	25	22	0	30	20	400	200	257	60	70
LeptophlebiidaeAtalophlebia	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
LymnaeidaePseudosuccinea	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
Oligochaetasp.	100	80	140	175	150	40	63	88	89	250	260	160	160	129	86	38	22
PhysidaePhysa	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0
PlanorbidaePygmanisus	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PlecopteraGripopterygidae	0	0	60	0	0	20	0	0	0	0	0	0	0	0	0	0	0
Plecopterasp.	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SimuliidaeAustrosimulium	1220	1580	1160	1450	1575	1380	1725	1588	1300	1560	1610	1420	580	386	300	0	2
SimuliidaeSimulium	160	60	0	25	100	100	63	88	44	50	70	40	140	71	29	2	0
TrichopteraHydrobiosidae	60	0	60	0	25	40	13	13	11	40	30	10	40	29	14	0	0
TrichopteraHydroptilidae	0	0	0	0	0	0	25	13	11	0	0	0	0	0	0	0	0
abundance	4460	4900	4700	5625	6075	4640	2913	3088	2478	2900	3000	2740	4180	3271	3143	416	348

Taxa	QBYN1_E1_L1	QBYN1_E1_L2	QBYN1_E1_L3	QBYN1_E2_L1	QBYN1_E2_L2	QBYN1_E2_L3	BUR1_E1_L1	BUR1_E1_L2	BUR1_E1_L3	BUR1_E2_L1	BUR1_E2_L2	BUR1_E2_L3	BUR2A_E1_L1	BUR2A_E1_L2	BUR2A_E1_L3	BUR2A_E2_L1	BUR2A_E2_L2	BUR2A_E2_L3	BUR2B_E1_L1	BUR2B_E1_L2	BUR2B_E1_L3	BUR2B_E2_L1	BUR2B_E2_L2	BUR2B_E2_L3	BUR3_E1_L1	BUR3_E1_L2	BUR3_E1_L3	BUR3_E2_L1	BUR3_E2_L2	BUR3_E2_L3	CAS1_E1_L1	CAS1_E1_L2	CAS1_E1_L3
Acarinasp.	0	33	29	8	0	3	4	3	0	0	0	0	5	0	6	0	12	7	20	27	8	5	0	13	3	3	3	5	0	0	0	6	7
AeschnidaeBrevyistyla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	3	0	0	0	0	0	0
AeshnidaeAnox Papuensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	5	4	0	0	0	0	0	0	0	0	0
AmphipodaCeinidae	0	0	14	24	20	20	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	4	7	3	7	25	0	9	463	650	520
AncylidaeFerrissia	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
AtyidaeParatya	67	0	29	32	20	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BaetidaeCloeon	0	0	0	8	7	3	4	0	3	0	0	0	74	213	150	147	82	107	40	55	17	55	40	25	7	20	20	5	10	9	16	25	27
CaenidaeTasmanocoenis	0	0	0	8	13	7	0	0	0	0	0	0	0	7	6	7	0	7	0	9	0	5	25	4	3	0	3	10	30	5	0	6	0
CalamatoceridaeAnisocentropus	0	0	0	0	10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CeratopogonidaeCeratopoginae	0	0	0	20	0	7	18	10	3	17	6	20	0	0	0	0	6	7	10	0	8	0	10	4	10	10	17	0	15	9	0	0	0
CoenagrionidaeIschnura	0	0	0	4	10	13	0	0	0	0	0	0	5	13	17	27	0	13	30	0	50	0	15	8	13	10	10	15	15	0	0	0	0
ColeopteraCurculionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
ColeopteraDytiscidae	0	0	0	0	0	0	11	7	3	0	0	0	5	0	0	27	0	0	0	36	17	5	10	13	30	10	13	20	0	0	0	0	7
ColeopteraElmidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
ColeopteraHydrophilidae	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ColeopteraScirtidae	0	0	0	0	0	0	14	3	13	11	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Collembolasp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Copepodasp.	0	0	0	0	0	0	0	0	0	0	0	0	11	20	6	7	0	0	30	27	0	5	5	4	0	0	0	0	5	0	0	0	7
CorixidaeMicronecta	0	0	0	0	0	0	0	0	0	0	0	0	0	7	11	0	0	13	0	0	0	0	0	4	13	13	7	0	0	0	5	0	0
DipteraChironomidae	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	8	0	0	0	0	0	0	0	0	0	0	0	0
DipteraChironominae	2567	2517	2343	464	403	393	132	127	147	100	169	140	295	333	272	393	476	540	260	336	242	115	190	167	190	197	200	200	250	195	142	319	453
DipteraCulicidae	0	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DipteraCulicidae	0	0	0	28	7	7	11	27	10	6	6	7	0	0	0	0	0	0	60	9	17	5	0	4	7	0	0	5	20	41	5	0	0
DipteraDixidae	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	10	14	11	6	40
DipteraOrthocladiinae	350	383	357	56	33	37	232	197	237	206	338	260	358	360	350	307	329	480	920	891	808	390	390	367	230	253	183	365	370	291	274	281	300
DipteraPsychodidae	0	0	0	0	0	0	0	3	10	0	6	0	0	0	0	0	0	0	10	0	8	0	0	0	0	0	0	5	20	14	0	0	0
DipteraSciomyzidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	0	0	0	0	0	0
DipteraSimuliidae	0	17	57	0	7	0	0	0	3	72	25	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	10	0	0	0	0
DipteraTanypodinae	50	33	57	56	73	50	229	193	227	217	225	173	111	140	83	127	135	67	50	18	100	100	130	125	30	40	40	100	120	77	158	206	233
DipteraTipulidae	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DytiscidaeAntiporus	0	0	0	0	0	0	4	3	7	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	5	0	0	5	6	0
DytiscidaeHydrovatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
DytiscidaeNecterosoma	0	0	0	0	0	0	21	17	7	6	6	0	21	20	6	20	0	7	60	27	42	25	20	13	3	27	0	10	20	32	0	6	0
DytiscidaePlatynectes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	5	0	0	0
DytiscidaeRhantus	0	0	0	0	0	0	0	3	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
EphemeropteraBaetidae	33	33	14	20	10	10	4	3	7	50	81	33	174	273	178	67	59	167	70	100	100	25	40	29	7	0	13	10	5	0	26	31	33
EphemeropteraCaenidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EphemeropteraLeptophlebiidae	0	0	0	4	0	0	4	3	3	6	0	0	0	0	0	0	6	20	0	0	0	5	5	4	3	3	0	5	0	0	5	13	13
GastropodaLymnaeidae	33	0	14	4	0	3	11	7	0	11	0	0	0	7	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	5	0	0	7
GastropodaPlanorbidae	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropodasp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
GripopterygidaeDinotoperla	67	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HemipteraCorixidae	0	0	0	0	0	0	7	17	0	0	0	0	0	7	0	13	12	0	0	9	0	0	0	4	0	0	0	0	0	0	0	31	7

Taxa	QBYN1_E1_L1	QBYN1_E1_L2	QBYN1_E1_L3	QBYN1_E2_L1	QBYN1_E2_L2	QBYN1_E2_L3	BUR1_E1_L1	BUR1_E1_L2	BUR1_E1_L3	BUR1_E2_L1	BUR1_E2_L2	BUR1_E2_L3	BUR2A_E1_L1	BUR2A_E1_L2	BUR2A_E1_L3	BUR2A_E2_L1	BUR2A_E2_L2	BUR2A_E2_L3	BUR2B_E1_L1	BUR2B_E1_L2	BUR2B_E1_L3	BUR2B_E2_L1	BUR2B_E2_L2	BUR2B_E2_L3	BUR3_E1_L1	BUR3_E1_L2	BUR3_E1_L3	BUR3_E2_L1	BUR3_E2_L2	BUR3_E2_L3	CAS1_E1_L1	CAS1_E1_L2	CAS1_E1_L3
HemipteraNotonectidae	0	0	0	0	0	0	11	10	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	20	33	5	10	14	0	25	0
HydraenidaeHydraena	0	17	43	0	0	0	4	10	7	22	19	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
HydrochidaeHydrochus	0	0	0	0	0	0	0	0	3	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrophilidaeBerosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
HydroptilidaeHellyethira	0	0	0	0	3	0	7	10	17	0	6	0	5	60	28	40	29	67	30	64	50	15	5	17	77	53	63	120	95	73	0	6	7
HydroptilidaeOxyethira	383	467	371	20	17	10	7	0	0	100	125	87	0	0	0	0	6	13	0	0	0	0	0	4	10	3	7	0	0	9	0	0	0
LeptoceridaeNotalina	100	100	57	36	30	47	0	0	0	0	0	0	0	7	6	7	0	13	0	0	8	0	0	13	13	27	10	15	0	5	0	0	0
LeptoceridaeOecetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
LeptoceridaeTriaenodes	0	0	0	0	0	0	7	3	17	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
LeptoceridaeTriplectides	50	17	29	4	7	7	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LeptophlebiidaeAtalophlebia	0	0	0	4	0	7	0	0	0	0	0	0	0	7	6	0	0	27	0	0	0	0	0	4	3	0	3	10	5	0	0	0	13
LeptophlebiidaeJappa	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LymnaeidaePseudosuccinea	0	50	0	0	0	3	0	0	0	0	0	0	0	0	0	0	6	7	0	0	8	0	0	8	0	10	10	5	10	0	5	6	0
NotonectidaeEnithares	0	0	0	4	0	0	0	0	3	0	0	0	0	0	6	0	6	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
NotonectidaeParanisops	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	7	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OdonataEpiproctophora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
OdonataGomphidae	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OdonataLibellulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	5	0	0	0	0
OdonataZygoptera	0	0	0	4	10	3	0	0	0	0	0	0	37	13	11	0	6	7	0	9	0	35	10	29	0	0	0	0	0	5	11	6	13
Oligochaetasp.	17	0	0	0	13	0	4	10	3	33	25	13	47	53	22	387	194	53	450	427	383	235	260	154	40	10	20	15	10	32	68	144	60
ParastacidaeCherax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
PhysidaePhysa	17	17	0	36	13	20	4	7	7	0	0	0	63	53	50	40	35	53	100	36	92	0	15	42	50	20	40	80	40	95	0	0	0
Planorbidae/physidaesp.	0	0	14	0	0	3	0	0	0	0	19	7	11	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PlanorbidaeGlyptophysa	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PlanorbidaePygmanisus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
PlecopteraGripopterygidae	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecopterasp.	0	0	0	0	0	0	4	0	0	11	6	13	0	7	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
SialidaeStenosialis	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SimuliidaeAustrosimulium	17	83	129	12	3	10	36	47	40	556	688	660	11	13	6	7	6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SimuliidaeSimulium	0	0	0	0	0	0	4	0	3	6	0	0	0	0	6	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
StratiomyidaeOdontomyia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
SynlestidaeSynlestes	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TrichopteraHydrobiosidae	0	0	0	0	0	0	0	0	0	0	6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TrichopteraHydroptilidae	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
TrichopteraLeptoceridae	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichopterasp.	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TurbellariaDugesiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veliidaeimmature/damaged	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	0	0	0	0	7
abundance	3783	3783	3586	868	713	687	796	723	817	1444	1769	1507	1247	1640	1222	1640	1424	1687	2190	2100	1983	1045	1195	1071	800	747	723	1050	1075	955	1200	1775	1753