Biological and Water Quality Monitoring
Prepared for City of Ryde

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Cover Image
Shrimptons Creek by Nathan Harrison

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Executive Summary

This report for the Spring 2010 period forms part of the City of Ryde Council's Biological and Chemical Water Quality Monitoring Strategy. During this period, Sydney Water collected macroinvertebrate and water chemistry samples from five creek systems of the Ryde Local Government Area (LGA). These included Archers, Shrimptons, Buffalo, Porters and Terrys creeks.

Water quality results of Spring 2010 indicated Archers, Shrimptons, Buffalo, Porters and Terrys creeks did not meet, on all or virtually all sampling occasions, ANZECC (2000) guidelines for the protection of aquatic ecosystems for total oxidised nitrogen, total nitrogen, dissolved oxygen and ammonium (NH4). However concentrations varied between creeks. ANZECC (2000) recommended concentrations for faecal coliforms in Buffalo and Porters creeks were also exceeded.

The impaired macroinvertebrate communities recorded in each of the five study streams reflect the poor water quality highlighted in the comparison of results to ANZECC (2000) guidelines and probably other unmeasured parameters. Water quality results of Spring 2010 suggest that while some similarity between the five creeks exists, influences on water chemistry are not the same across the City of Ryde LGA.

A total of 2,153 macroinvertebrates were collected from the edge habitat of these creek systems in Spring 2010. 45 different taxa were recorded from a total of 78 taxa that have been collected from the edge habitat of these creeks from Spring 2004 to the current period.

Macroinvertebrate results from Spring 2010 indicate that Archers, Shrimptons, Buffalo, Porters and Terrys creeks had impaired macroinvertebrate communities. These results are reflective of what has been observed previously during the monitoring program. Of the five creeks in the program, Archers Creek appeared to have the richest stream health and Shrimptons Creek appeared to have the poorest stream health. Stream health is, however, similar across the five creeks. EPT taxa were found in low numbers with only three families collected. All five creeks recorded at least one EPT taxon. One AUSRIVAS EPT indicator taxa was collected during Spring 2010 sampling.

Multivariate analysis indicated a continuing trend of slight changes in macroinvertebrate community composition between sampled seasons for each creek. Shrimptons Creek has provided the most variability in community structure over the 2005 to 2010 period, while Terrys Creek has provided the most stable.

BIOENV results returned only weak to mild correlations. The strongest correlation for all five creeks highlighted total oxidised nitrogen, conductivity, dissolved oxygen, and ratio of number of outlets/catchment area. BIOENV of individual creeks highlighted a variety of parameters that had an influence on macroinvertebrate community structure in each creek.

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1 Introduction

Sydney Water has developed this report in response to engagement under the City of Ryde Council Tender Number COR-RFQ-29/09. This report for the Spring 2010 period forms part of the City of Ryde Council's Biological and Chemical Water Quality Monitoring Strategy.

Under the strategy, Sydney Water carries out macroinvertebrate and water quality sample collection, analysis and reporting for the five creek systems of the Ryde LGA. This strategy is a seven year program in which all five creeks would be monitored for the first two years. For the remaining five years the intention was to target two of the five creeks each year on a rotational basis. In Spring 2006, Ryde Council agreed to continue regular monitoring of all five sites for the remainder of the program after discussions during the Spring 2006 presentation. This would more accurately measure natural variations in stream health during drier and wetter hydrological conditions and set a better baseline for management decisions across all creek catchments.

This Spring 2010 report begins the seventh year of the program. Macroinvertebrates and water chemistry were each sampled in September and October/November 2010 at all five sites. Additional water quality monitoring was conducted at an additional eight sites.

Monitoring macroinvertebrates and water chemistry enables the City of Ryde Council to:

- Evaluate chemical and biological water quality monitoring for short and long term interpretation and temporal evaluation of creek health over the duration of the strategy
- Detail where, when and how often samples should be taken from creeks within the Ryde Local Government Area based on existing site data, catchment position, accessibility and trends identified
- Prescribe how to sample for macroinvertebrates at each site, building on the standard protocols designed by AUSRIVAS
- Provide a series of options for identification of key indicator taxa to family and/or morphospecies
- Identify suitable indices such as SIGNAL SF to assess water quality, including calculation of the Observed/Expected (OE50 and OE0 SIGNAL2) ratios from the respective AUSRIVAS predictive models for autumn, spring, and combined seasons
- Provide the basis for an appraisal of a standard monitoring strategy to be integrated into a community monitoring program such as Streamwatch
- Provide the foundation to augment the Streamwatch capacity within the City of Ryde including options for improved education awareness of water quality issues within schools and community groups.
- Provide information and direction on potential infrastructural works to complement water quality monitoring and improve overall creek health.

2 Study Area

The five designated sites (Figure 1) of the City of Ryde Council's Biological and Chemical Water Quality Monitoring Strategy are:

- Site 1: Terrys Creek near M2 motorway at the end of Somerset Road, North Epping
- Site 2: Shrimptons Creek at Wilga Park
- Site 3: Porters Creek, sampled after the creek exits the Ryde depot
- Site 4: Buffalo Creek, accessed through private property (52 Higginbotham Rd)
- Site 5: Archers Creek at Maze Park

Additional water quality sites for Shrimptons, Porters and Buffalo creeks were sampled for various analytes in Spring 2010. Refer to Table 8 for these locations.

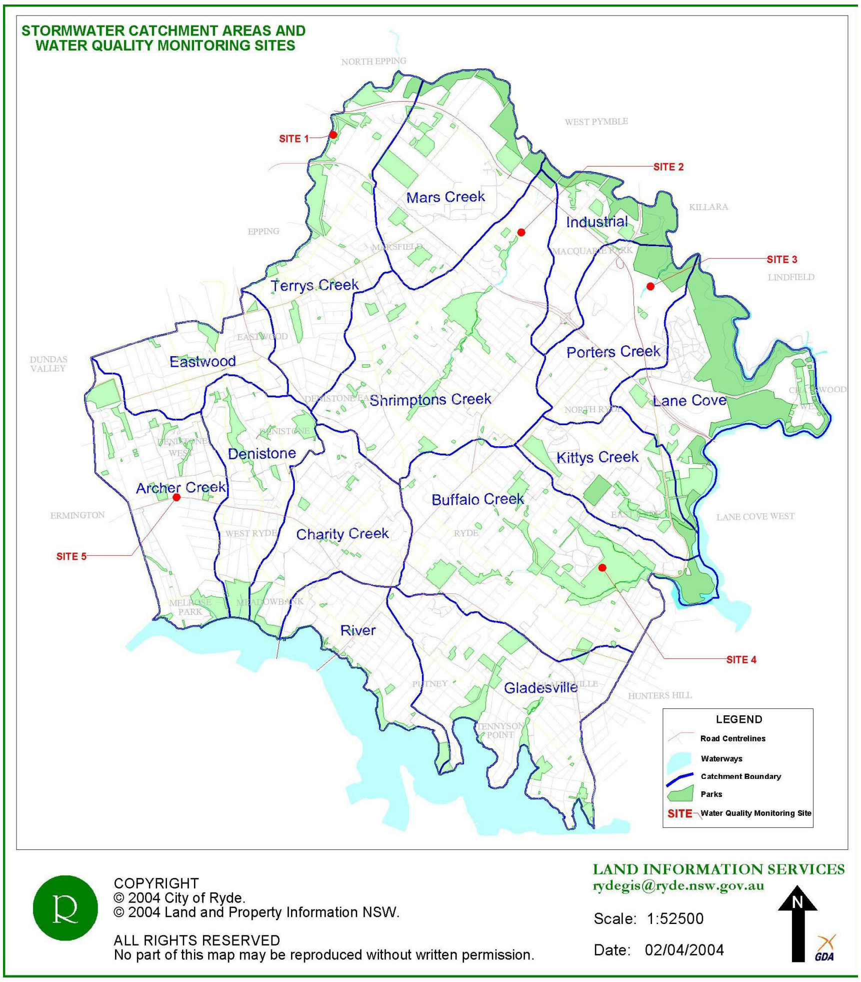

Figure 1 Site locations in the City of Ryde's Biological and Chemical Water Quality Monitoring Strategy

2.1 Spring 2010 sampling events

Two sampling events were conducted in Spring 2010 for the City of Ryde Biological and Chemical Water Quality Monitoring Strategy. Sampling was conducted at all five creeks in each of the following periods:

- September 28th, 29th & 30th 2010
- October 27th & November 4th 2010

Figure 2 Archers Creek in Autumn 2008 showing completed rehabilitation work

3 Methodology

3.1 Macroinvertebrate sampling

Rapid assessment macroinvertebrate sampling was conducted in accordance with AUSRIVAS protocols for NSW (Turak et al., 2004). Sydney Water staff that conducted field sampling have met criteria of the in-house test method for macroinvertebrate identification and enumeration. Use of experienced staff addresses issues identified by Metzeling et al. (2003).

Three edge habitat samples were collected from each site within a pre-selected area in September and October during the Spring 2010 season, as specified in the City of Ryde Biological and Chemical Water Quality Monitoring tender document COR-RFQ-29/09. The 'edge' habitat is defined as areas with little or no current. These areas were sampled with a hand-held dip net with 320 mm by 250 mm opening and 0.25 mm (250 µm) mesh that conformed to ISO 7828-1985 (E). The net was swept from open water towards the shore, working over a bank length of about 10 m moving in an upstream direction. In the process, deposits of silt and detritus on the stream bottom were stirred up so that benthic animals were suspended and then caught in the net.

The net contents were then emptied into a large white sorting tray with a small amount of water to allow live macroinvertebrate specimens to be picked out with fine forceps and pipettes for a period of 40 minutes. If new taxa are collected between 30 and 40 minutes, sorting will continue for a further 10 minutes. If no new taxa are found after 10 minutes the picking ceases. If new taxa are found, the 10-minute processing cycle is continued up to a maximum total sorting time of 1 hour. There is no set minimum number of animals collected using the NSW protocols (Turak et al., 2004).

All specimens collected will be preserved in small glass specimen jars containing 70% ethanol with a clear label indicating site code, creek name, date, habitat and name of Sydney Water staff sampler. Sampling equipment will be washed thoroughly between samples to prevent the cross contamination of animals.

3.2 Macroinvertebrate sample processing

Macroinvertebrates were identified and enumerated to the family taxonomic level, except for: non-biting midges (Chironomids) to sub-family; aquatic worms to Class Oligochaeta; and aquatic mites to Order Acarina. The method used, SSWI433 *In-house test method macroinvertebrate cataloguing, identification and counting*, is in compliance with the requirements of AS ISO/IEC 17025 *General Requirements for the Competence of Testing and Calibration Laboratories* under technical accreditation number 610 issued by National Association of Testing Authorities (NATA) and has been employed since 1997. In particular, macroinvertebrate identification was performed using appropriate published keys listed in Hawking (2000), internal keys to the Sydney Water macroinvertebrate reference collection, unpublished descriptions and voucher specimens.

Quality assurance was conducted as per SSWI434 *In-house test method quality control of macroinvertebrate identification, counting and archiving of collections* in compliance with the requirements of AS ISO/IEC 17025 *General Requirements* *for the Competence of Testing and Calibration Laboratories* under technical accreditation number 610. Quality assurance was conducted on 5% of samples collected for this study. Quality assurance is further described in Appendix 1.

3.3 Water quality sampling

Water chemistry was sampled on one occasion in September and November for Spring 2010 at a similar time to the macroinvertebrate sampling.

Samples were taken by filling the sample bottles directly from the surface of the stream. Temperature, pH and dissolved oxygen were measured on site as per methods summarised in Table 1.

Table 1 Water chemistry parameters, method of analysis in field

ANALYTE	METHOD
pH, Dissolved Oxygen	WTW meter
Temperature	Thermometer

Samples for the analysis of turbidity, conductivity, total dissolved solids (TDS), faecal coliforms, total phosphorus, total nitrogen (as a measure of total oxidised nitrogen and total kjeldahl nitrogen), total alkalinity and ammonia were returned to the laboratory and analysed by the methods summarised in Table 2 within 12 hrs of sampling.

Table 2 Water chemistry parameters, method of analysis in laboratory

ANALYTE	DETECTION LIMIT	METHOD
Turbidity	0.10 NTU	APHA 2130B
Total Dissolved Solids	10 mg/L	APHA 2450 C
Faecal Coliforms	1 cfu/100mL	APHA 9222-D
Total Phosphorus	0.002 mg/L	APHA4500P- H
Alkalinity (CaCO3/L)	0.5 mg/L	APHA 2320 B
Oxidised Nitrogen	0.01 mg/L	APHA 4500-NU43
Total Kjeldahl Nitrogen	0.1 mg/L	Calculation
Ammoniacal Nitrogen	0.01 mg/L	APHA 4500-NU40
Total Nitrogen	0.1 mg/L	APHA 4500-NU57
Conductivity	0.1 mS/m	APHA 2510 B

Additional water quality sample collection and measurements in Spring 2010 on Shrimptons, Buffalo and Porters creeks allowed spatial comparisons of collected variables on each creek in an attempt to investigate potential dry weather point sources.

While not sampled at the frequency suggested by ANZECC (2000), the water quality results did allow characterisation of each study creek against ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary).

3.4 Rainfall Data

Daily rainfall data from the Marsfield Bureau of Meteorology Station number 066156 are presented where records existed. For the few missing records, data was substituted from West Pymble 66189 and/or Turramurra 66158 Bureau of Meteorology Stations. This was done on the recommendation of the Bureau of Meteorology.

3.5 Comparison with historical data

The City of Ryde Council Tender Number COR-EOC-05/07 requested compilation and analysis of all available and comparable historic raw data back to 2001. This allows a temporal evaluation of ecological health of the five creeks under study. Ecowise supplied raw macroinvertebrate and water chemistry data (Spring 2004 to Autumn 2006). This data, together with seasonal data collected by Sydney Water from Spring 2006 to Spring 2010, allowed the compilation of data points as summarised in Table 3. Earlier data were unavailable in a suitable format for this purpose or had comparability issues, such as the location sampled on Porters and Buffalo creeks in Spring 2004.

Table 3 Summary of water quality variables sampled between Spring 2004 and Autumn 2010

Sampling Period	Creek	Macro-invertebrates	Alkalinity (Total)	Ammonia NH3-N	Conductivity	Dissolved Oxygen	Faecal Coliform	Oxidised Nitrogen NOx-N	pH	Temperature	Total Nitrogen	Total Dissolved Solids	Total Kjeldahl Nitrogen	Total Phosphorus	Turbidity
Spring 2004	Terrys	*	*			*	*		*	*		*		*	*
	Shrimptons	*	*			*	*		*	*		*		*	*
	Porters														
	Buffalo														
	Archers	*	*			*	*		*	*		*		*	*
Autumn 2005	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Spring 2005	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Autumn 2006	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Spring 2006	Terrys														
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters														
	Buffalo														
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Autumn 2007	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Spring 2007	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Autumn 2008	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Spring 2008	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Autumn 2009	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Spring 2009	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Autumn 2010	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Spring 2010	Terrys	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Shrimptons	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Porters	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Buffalo	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Archers	*	*	*	*	*	*	*	*	*	*	*	*	*	*

3.6 Data analyses

After identification and enumeration of macroinvertebrates, the data were analysed with univariate and multivariate analysis techniques.

Univariate methods

Data analyses were performed using a number of biological indices and predictive models. These included:

- Diversity index EPT (mayfly, stonefly, caddis fly) richness
- Biotic index SIGNAL-SF
- Output from AUSRIVAS predictive models (Eastern Edge Autumn; Eastern Edge Spring; Combined Edge)
  - AUSRIVAS OE50
  - AUSRIVAS OE0 SIGNAL2

The range of each measure has been plotted in this report with +/-1 standard deviation of the mean for basing ecological decisions (ANZECC, 2000). Presenting data in this way attempts to take account of variation at study sites and provide a basis in future years to enable management tracking and or as a basis for making management decisions.

EPT richness

The biotic index EPT (Ephemeroptera - mayfly, Plecoptera - stonefly and Trichoptera - caddisfly families) richness is based upon the sensitivity of these taxa to respond to changes in water quality condition (Lenat 1988). Generally the number of these taxa found at a site can be used as an indicator of stream biological health, although some EPT taxa are more tolerant.

Some caution must be given when interpreting patterns based on EPT taxa as many of these macroinvertebrates are also sensitive to natural changes in streams, such as altitude. In general, EPT taxa favour higher altitude streams to low altitude streams. However, Sydney Water has observed a diverse range of these taxa at altitudes as low as ten metres in undisturbed waterways in the greater Sydney region and in the Clyde River. The absence of these taxa in streams may be attributable to human disturbances within urban catchments and/or a decline in flow over recent years.

SIGNAL-SF

The original version of the Stream Invertebrate Grade Number Average Level (SIGNAL) biotic index (Chessman, 1995-Sydney Water data) was refined to include the response of SIGNAL to natural and human influenced (anthropogenic) environmental factors (Growns et al. 1995), variations in sampling and sample processing methods (Growns et al. 1997; Metzeling et al. 2003) and setting sensitivity grades of the taxa objectively (Chessman et al. 1997; Chessman et al. 2002). “F” indicates taxonomy is at the family level and “S” indicates Sydney region version. SIGNAL-SF has been derived from macroinvertebrate data of the greater Sydney region (Chessman et al., 2007). Water quality status of clean water has been established in the index using data from near pristine reference sites in the bushland fringes of Sydney by using the 10th percentile of the average score of these reference sites. SIGNAL-SF allows a direct measure of test site condition and incorporates abundance information from the rapid assessment sampling.

The first step in calculating a SIGNAL-SF score is applying predetermined sensitivity grade numbers (from 1, tolerant to 10, highly sensitive) to family counts that occur within a location habitat sample. Then multiply the square root transformed count of each family by the sensitivity grade number for that family, summing the products, and dividing by the total square root transformed number of individuals in all graded families. Families that are present in the samples but with no grade numbers available are removed from the calculation of the SIGNAL-SF score for the sample (very few animals). This procedure was repeated for each sample. Calculation then occurs of a location specific average and a measure of variation (plus and minus one standard deviation of the average score) through time as recommended by Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters (2000) was made to allow stream health comparisons between sampling occasions for each creek and between creeks. Comparisons in this manner allow ranking of stream health as a guide to management decisions.

As aquatic mites (Order Acarina) and aquatic worms (Class Oligochaeta) are left at higher taxonomic levels in the AUSRIVAS protocol, the respective SIGNAL-SF grades of the families of aquatic mites and worms were averaged and used in the calculation of SIGNAL-SF scores for this report.

Arbitrary pollution categories can be assigned (Table 4). Sydney Water has successfully demonstrated the application of this index in stream monitoring of management changes to the sewerage system and subsequent organic pollution responses in creeks from these changes (Besley & Chessman, 2008).

Table 4 Interpretation of SIGNAL-SF scores (Chessman et al., 2007)

SIGNAL-F score	Water quality status
> 6.5	Clean water
5.2-6.5	Possible mild organic pollution
3.8-5.2	Probable moderate organic pollution
< 3.8	Probable severe organic pollution

AUSRIVAS predictive models OE50 output

AUSRIVAS (AUStralian RIVers Assessment System) predictive model is based on the British bioassessment system RIVPACS (River Invertebrate Prediction and Classification System; Wright 1995). The RIVPACS model was modified to suit the environmental conditions present only in Australia (Turak et al. 2004). The AUSRIVAS model is an interactive software package, which uses the macroinvertebrate and environmental data collected from numerous reference river sites across the state of NSW. It is a tool that can quickly assess the ecological health of any river or creek site. Collected macroinvertebrate data are transformed into presence/absence (1 or 0) form, which is also referred to as binary data. The predictor environmental variables required to run for each model vary as outlined in Tables 5 and 6 but generally include altitude, location (latitude and longitude), stream size characteristics, substratum composition, river alkalinity and rainfall (Turak 2001). These environmental variables allow the software to compare test sites, in this case City of Ryde creek samples, to comparable reference site groups with similar environmental characteristics.

AUSRIVAS models can incorporate data taken from pool edge or riffle habitats. The paucity of riffle habitats at the sites under study by the City of Ryde in sampling conducted for the program to date preclude use of the riffle models. Ecowise collected only four riffle samples between Spring 2004 and Autumn 2006. Hence in comparison of Spring 2010 data with historical data the respective edge models have been employed.

The applicable AUSRIVAS models for comparison of the City of Ryde test creek sites are: the eastern edge Autumn model; eastern edge Spring model; and Combined Season eastern edge model. However, Ecowise (Spring 2005) suggested the later model does not allow changes in condition between seasonal sampling events for the City of Ryde strategy. The later model has been included here for completeness. Ransom et al. (2004) describes this model as preferable, as it maximizes the family list for the test site being examined.

The respective model uses the test site information and comparable reference site group information to calculate a score called the “OE50 ratio” (observed/expected number of macroinvertebrate families with greater than 50% probability of occurring at a test site) (Coysh et al., 2000). The OE50 ratio provides a measure of impairment at a test site (Ransom et al., 2004). The OE50 ratio of each test site sample also corresponds to a band that assists in interpretation and aids management decisions (Coysh et al., 2000). That is, the band helps to categorise each test site showing how it compares with reference sites from rivers of the same type. Interpretation of the five possible bands of river condition is detailed in Table 5 (Coysh et al., 2000). Thresholds that correspond to these bands of each respective model are detailed in Table 6.

Table 5 Interpretation of bands associated with AUSRIVAS OE50 model output (Coysh et al., 2000)

Band	Description	O/E taxa	O/E taxa interpretations
X	More biologically diverse than reference	▪ O/E greater than 90th percentile of reference sites used to create the model	▪ More families found than expected ▪ Potential biodiversity 'hot spot' or mild organic enrichment ▪ Continuous irrigation flow in a normally intermittent stream
A	Similar to reference	▪ O/E within range of central 80% of reference sites used to create the model	▪ Expected number of families within the range found at 80% of the reference sites
B	Significantly impaired	▪ O/E below 10th percentile of reference sites used to create the model ▪ Same width as band A	▪ Fewer families than expected ▪ Potential impact either on water and/or habitat quality resulting in a loss of families
C	Severely impaired	▪ O/E below band B ▪ Same width as band A	▪ Many fewer families than expected ▪ Loss of families from substantial impairment of expected biota caused by water and/or habitat quality
D	Extremely impaired	▪ O/E below band C down to zero	▪ Few of the expected families and only the hardy, pollution tolerant families remain ▪ Severe impairment

Table 6 Upper thresholds for bands of impairment (OE50 taxa) for AUSRIVAS models developed for NSW (Turak and Waddell, 2001)

Model	Threshold			
	A	B	C	D
Combined edge (East)	1.17	0.82	0.48	0.14
Autumn edge	1.17	0.81	0.46	0.11
Spring edge	1.16	0.83	0.51	0.19

Indicator taxa from the AUSRIVAS predictive models output

AUSRIVAS output identifies taxa that were expected from the respective reference site group to which a test site is being compared. As part of this output missing taxa are listed with greater than 50% probability of occurrence. To provide consistency in this report the definition used by Ecowise (2004, 2005a, 2005b, 2006) has been used in this report. That is, indicator taxa are defined as taxa within the EPT (Ephemeroptera - mayfly, Plecoptera - stonefly and Trichoptera – caddisfly) orders with SIGNAL2 scores of greater than 6.

AUSRIVAS predictive models OE0 SIGNAL-2 output

Together with OE50 output, each AUSRIVAS model generates AUSRIVAS OE50-SIGNAL2 values and AUSRIVAS OE0-SIGNAL2 values. This output incorporates SIGNAL2 (Chessman 2003a) tolerance grades derived from reference sites across NSW sampled to create the AUSRIVAS models in NSW. Please note SIGNAL2 tolerance grades are different to the greater Sydney region tolerance grades of SIGNAL-SF, as the later has been derived from sites of the Sydney region and not from broadly across NSW.

An example calculation of AUSRIVAS OE50-SIGNAL2 values was provided in the previous Ecowise reports, this example was sourced from Chessman (2003a). In the Spring 2006 report AUSRIVAS OE50-SIGNAL2 values were found to be quite variable and so it was not recommended for use in future temporal comparisons. The large variation recorded in this measure provided little ability to detect future changes in community structure from future management decisions.

In contrast, AUSRIVAS OE0-SIGNAL2 values were found to have less variance and the recommendation was that it be calculated in Autumn 2007 and beyond. The lesser variation of AUSRIVAS OE0-SIGNAL2 is attributed to the inclusion of taxa with 50% probability of occurrence or more used to calculate AUSRIVAS OE50-SIGNAL2 and additional taxa with less than 50% probability of occurrence.

No bands have been developed for SIGNAL2 (Coysh et al. 2000). However, values of around 1 would be similar to reference condition (Chessman pers comm.). Using AUSRIVAS calculated values are recommended by Chessman (2003a) as a way to overcome natural variation, which is an issue for calculation of SIGNAL2 as described in Chessman (2003b).

Multivariate methods

Data analyses were performed using the PRIMER software package (Clark and Warwick 2001). Analysis techniques included:

- Classification and ordination, SIMPROF test
- SIMPER
- BIOENV

These analysis techniques complement univariate analyses by exploring patterns of macroinvertebrate community structure. Macroinvertebrate community structure at a site can also be referred to as the biological signature. Prior to analysis, the data from the field survey was square root transformed and rare taxa observed in only one sample were removed.

Samples from Autumn 2005 to the current Spring 2010 season were compared in an ordination for all creeks of the monitoring program to look at context of community composition. Spring 2004 data were not included in these comparisons as comparable sites in Buffalo and Porters creeks were not sampled in Spring 2004, nor were all water quality variables at Archers, Shrimptons and Terrys creeks (Table 3).

Macroinvertebrate data of each creek were also explored by a comparison of data from each sampled season to look at community composition change through time.

Classification, Ordination and SIMPROF test

The group average classification technique was used to place the sampling sites into groups, each of which had a characteristic macroinvertebrate community based on relative similarity of their attributes. Similarities (distances) between the fauna of each pair of sites were calculated using the Bray-Curtis measure, which is not sensitive to rough approximations in the estimation of taxa abundances (Faith et al. 1987), as is the case with rapid assessment sampling. The group average classification technique initially forms pairs of samples with the most similar taxa and gradually fuses the pairs into larger and larger groups (clusters) with increasing internal variability.

Classification techniques will form groups even if the data set actually forms a continuum. The SIMPROF test provides a way to view community structure differences and similarities between samples and overcome the limitation of classification analysis. SIMPROF results have been overlaid onto classification result output (dendrogram) with red lines indicating no difference between samples and the black line indicating a difference in community structure. SIMPROF test groups can be checked against ordination results. Samples were ordinated using the non-metric multidimensional scaling (MDS) technique. Ordination produces a plot of sites on two or three axes such that sites with similar taxa lie close together and sites with a differing taxon composition lie farther apart. When Ordination and SIMPROF test results produce similar overall patterns the analysis can be considered reliable.

Any ordination procedure inevitably introduces distortion when trying to simultaneously represent the similarities between large numbers of samples in only two or three dimensions. The success of the procedure is measured by a stress value, which indicates the degree of distortion imposed. In the PRIMER software package a stress value of below 0.2 indicates an acceptable representation of the original data, although lower values are desirable.

To achieve suitable multivariate representations of data in 2 or 3 dimensions with greater data collection, an analysis strategy to minimize stress (and achieve a better measure of fit) is to pool up macroinvertebrate data of the same season for each creek to produce one data point per season per creek, as demonstrated in the Spring 2007 report for all five creeks. This analysis strategy has been adopted for the ordination plot of all creeks in this report.

SIMPER

The SIMPER routine was employed to investigate community structure between and within groups of sites as detailed above. This routine employs Bray Curtis similarities to examine the contribution of individual taxa to the average similarity between groups and also within groups.

BIOENV

The extrinsic physical and chemical characteristics of the creeks were compared to the intrinsic macroinvertebrate community structure using the BIOENV routine. The underlying similarity matrix was constructed with the normalised Euclidean Distance association measure option. This option enabled a comparison of water quality variables without undue weight being assigned by differing unit scales. Log10 transformations were applied to faecal coliforms, ammonia, oxidised nitrogen, total phosphorus, total kjeldahl nitrogen, total nitrogen, turbidity, conductivity, and total dissolved solids. All other physical and chemical variables listed in Table 2 were untransformed in the BIOENV analysis.

4 Results

4.1 Water quality and site observations

Water quality results are presented separately for the five creeks with reference to ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality and Aesthetics (Secondary). While not to the sampling frequency suggested by ANZECC (2000), the water quality results did allow characterisation of each creek against these guidelines. Historical average refers to data collected at the core site between Spring 2004 and Autumn 2010.

Archers Creek

Water quality results for Archers Creek in Spring 2010 are presented in Table 7. Overall water quality results for the period were similar to previous report periods. Results for faecal coliforms, total phosphorus, turbidity and conductivity were within guideline limits on both sampling occasions in Spring 2010.

Total nitrogen and oxidised nitrogen concentrations exceeded the respective guidelines (500 µg/L and 40 µg/L) for the site on both the September and November sampling occasions. Ammonium concentrations were above the guideline (20 µg/L) in September at 50 µg/L but not in November (10 µg/L) and were below the historical average of 84 µg/L for the site.

Dissolved oxygen saturation was low on both sampling occasions with results of 55.7 % and 68.5 % falling below the lower guideline of 85 % saturation, which is consistent with the historical average (62.5 %).

Table 7 Water quality results for Archers Creek Spring 2010

	Guideline	Core site Maze Park		Historical average
		September	November	
Faecal Coliforms CFU/100mL	1,000[1]	29	690	820
Ammonia µg/L	20[2]	50	10	84
Oxidised Nitrogen µg/L	40[2]	90	980	249
Total Phosphorus µg/L	50[2]	20	44	50
Total Kjeldahl Nitrogen µg/L	NA	470	490	394
Total Nitrogen µg/L	500[2]	560	1470	643
Alkalinity mg CaCO3/L	NA	81.3	71.8	72
Turbidity NTU	50[2]	1.64	5.42	4.06
Conductivity µS/cm	125-2,200[2]	1562	700	430
Total Dissolved Solids mg/L	NA	1159	418	250
pH units	6.8-8.0[2]	6.86	6.56	7.18
Dissolved Oxygen DO % saturation	85-110[2]	55.7	68.5	62.5
Temperature ^{O}C	NA	12.8	16.1	17.6

[1] ANZECC (2000) guidelines for Recreational Water Quality & Aesthetics (Secondary)

[2] ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia)

Shrimptons Creek

Water quality results for Shrimptons Creek in Spring 2010 are presented in Table 8. Results for faecal coliforms, total phosphorus, turbidity, conductivity and pH were within guideline limits for all Shrimptons Creek sites on both sampling occasions.

Total nitrogen and oxidised nitrogen concentrations exceeded the respective guidelines (500 µg/L and 40 µg/L) at the core and most additional sites for both the September and November sampling occasions. The single exception was oxidised nitrogen (20 µg/L) at Bridge Street in September. Ammonium concentrations were above the guideline (20 µg/L) for both sampling occasions at the core and Bridge Street sites and at Kent Road in November (40 µg/L).

Dissolved oxygen saturation levels were typically low and below the guideline range at all sites on one or both sampling occasions with the exception of Kent Road in November (87.5 % saturation) and Quarry Road in November (94.7 % saturation).

Table 8 ***Water quality results for Shrimptons Creek Spring 2010***

	Guideline	**Core site Wilga Park**		**Kent Road**		**Bridge Street (d/s Santa Rosa Park)**		**Quarry Road (u/s Santa Rosa Park)**		**Historical average**
		Sept	**Nov**	**Sept**	**Nov**	**Sept**	**Nov**	**Sept**	**Nov**	
Faecal Coliforms CFU/100mL	1,000[1]	450	330	25	490	250	230	250	~950	1884
Ammonia µg/L	20[2]	50	50	20	40	30	30	<10	20	36
Oxidised Nitrogen µg/L	40[2]	190	670	90	620	20	490	890	1100	154
Total Phosphorus µg/L	50[2]	41	44	22	32	10	17	31	28	68
Total Kjeldahl Nitrogen µg/L	NA	340	580	500	450	500	330	480	420	515
Total Nitrogen µg/L	500[2]	530	1250	590	1070	520	820	1370	1520	660
Alkalinity mg CaCO3/L	NA	57.8	65.0	74.8	64.7	85.6	75.2	69.3	67.0	65.5
Turbidity NTU	50[2]	3.33	5.89	1.88	5.36	6.09	3.26	1.33	4.42	8.68
Conductivity µS/cm	125-2,200[2]	325	458	746	562	965	650	1276	849	366
Total Dissolved Solids mg/L	NA	189	280	504	322	620	380	848	496	218
pH units	6.8-8.0[2]	7.2	6.88	7.25	6.92	7.22	6.87	7.64	6.95	7.00
Dissolved Oxygen DO % saturation	85-110[2]	48	66.9	66.5	87.5	76.4	76.3	115	94.7	38.1
Temperature °C	NA	17.7	16.9	14.5	16.9	13.4	16.6	13.2	16.9	17.0

[1] ANZECC (2000) guidelines for Recreational Water Quality & Aesthetics (Secondary)

[2] ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia)

Buffalo Creek

Water quality results for Buffalo Creek in Spring 2010 are presented in Table 9. Total phosphorus, turbidity, conductivity and pH results were within the respective guidelines at all Buffalo Creek sites in September and November.

Faecal coliform concentrations in Buffalo Creek were generally below the guideline of 1000 CFU/100mL. The exception to this was Buffalo Ck downstream of Burrows Park in September with a concentration of 5,200 CFU/100mL.

Ammonium concentrations were elevated at the core site in November (30 µg/L), and at the site downstream of Burrows Park in November (30 µg/L). Total nitrogen and oxidised nitrogen concentrations were elevated above the guideline (500 µg/L and 40 µg/L, respectively) in all samples for Spring 2010.

Dissolved oxygen saturation levels were consistently lower than recommended levels (85 – 110% saturation) at all sites in September (79.3 % to 82.9 % saturation). Buffalo Creek samples in November had consistently high levels (92.1 % to 98.7 % saturation) well above the historical average of 63.5 % saturation.

Table 9 Water quality results for Buffalo Creek Spring 2010

	Guideline	**Core site Higginbotham Rd**		**d/s Burrows Park**		**u/s Burrows Park**		**Historical average**
		Sept	**Nov**	**Sept**	**Nov**	**Sept**	**Nov**	
Faecal Coliforms CFU/100mL	1,000[1]	240	270	5200	~980	260	790	664
Ammonia µg/L	20[2]	10	30	<10	30	<10	20	62
Oxidised Nitrogen µg/L	40[2]	250	1090	550	1660	1230	1870	279
Total Phosphorus µg/L	50[2]	28	29	33	35	35	33	39
Total Kjeldahl Nitrogen µg/L	NA	520	470	660	450	450	460	370
Total Nitrogen µg/L	500[2]	770	1560	1210	2110	1680	2330	627
Alkalinity mg CaCO3/L	NA	73.0	69.2	85.1	78.3	84.9	84.3	79.6
Turbidity NTU	50[2]	4.36	6.92	5.88	5.44	4.32	2.94	8.93
Conductivity µS/cm	125-2,200[2]	751	523	1096	799	884	756	691
Total Dissolved Solids mg/L	NA	538	332	786	512	634	486	395
pH units	6.8-8.0[2]	7.30	7.37	7.23	7.13	7.31	7.21	7.32
Dissolved Oxygen % saturation	85-110[2]	79.3	92.1	82.9	98.7	81.4	93.3	63.5
Temperature °C	NA	13.2	16.4	13.8	17.1	13.9	16.3	17.5

[1] ANZECC (2000) guidelines for Recreational Water Quality & Aesthetics (Secondary)

[2] ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia)

Porters Creek

Water quality results for Porters Creek in Spring 2010 are presented in Table 10. Turbidity, pH and dissolved oxygen were well within the respective guidelines at all Porters Creek sites in September and November.

Faecal coliform concentrations in Porters Creek were generally below the guideline of 1000 CFU/100mL. The exception to this was the Main Branch at Wicks Road in September and November with concentrations of 3,800 and 7,200 CFU/100mL.

All total and oxidised nitrogen and ammonia results exceeded the respective guidelines. This is consistent with the relevant historical averages of the core site for Porters Creek. Total phosphorous concentrations exceeded the guideline in September at the Spur Branch site only (55 µg/L).

A low conductivity level was recorded for the Porters Creek Main Branch channel site in November (115 µS/cm) - all other conductivity results for Porters Creek were within the guideline range.

Table 10 ***Water quality results for Porters Creek Spring 2010***

	Guideline	Core Site d/s of Depot		Spur Branch		Main Branch Channel (COR staff site)		Main Branch Wicks Road		Historical average
		Sept	Nov	Sept	Nov	Sept	Nov	Sept	Nov	
Faecal Coliforms CFU/100mL	1,000[1]	40	350	~18	230	120	340	3800	7200	6083
Ammonia µg/L	20[2]	940	400	70	50	160	60	30	50	806
Oxidised Nitrogen µg/L	40[2]	1420	1050	250	260	220	250	1140	1330	1112
Total Phosphorus µg/L	50[2]	30	26	55	30	49	48	26	30	27
Total Kjeldahl Nitrogen µg/L	NA	1350	970	510	340	1110	420	560	320	1245
Total Nitrogen µg/L	500[2]	2770	2020	760	600	1330	670	1700	1650	2470
Alkalinity mg CaCO3/L	NA	85.3	89.0	46.9	57.2	248.0	32.7	117.0	77.7	73.7
Turbidity NTU	50[2]	3.89	3.05	6.46	2.89	13.4	9.71	2.39	3.42	5.15
Conductivity µS/cm	125-2,200[2]	439	451	251	268	757	115	659	495	1952
Total Dissolved Solids mg/L	NA	360	260	195	143	503	50	545	301	1183
pH units	6.8-8.0[2]	7.65	7.34	7.51	7.08	6.89	7.16	7.52	7.20	7.61
Dissolved Oxygen % saturation	85-110[2]	101	93	104	99.9	96	89	91.3	106	85.0
Temperature ^{O}C	NA	13.7	16.4	15.8	16.8	14.9	17.2	14.1	16.8	18.2

[1] ANZECC (2000) guidelines for Recreational Water Quality & Aesthetics (Secondary)
[2] ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia)

Terrys Creek

Water quality results for Terrys Creek in Spring 2010 are presented in Table 11. Overall water quality for the period was similar to previous report periods. Results for faecal coliforms, ammonia, oxidised nitrogen, turbidity, conductivity and pH were within guideline limits on both sampling occasions in Spring 2010.

Total nitrogen concentrations exceeded the guideline (500 µg/L) and historical average (547 µg/L) on both sampling occasions (1350 µg/L and 830 µg/L, respectively). September results were higher than November results for both the nitrogen forms.

The September result for total dissolved solids was also elevated at 461 mg/L, almost twice that of the historical average concentration. The result for November was more usual for this site at 251 mg/L.

Dissolved oxygen saturation was low for the September sampling occasion with a result of 71.1 % saturation. Even though this was outside the guideline range, it was above the historical average for this site at 59.9 % saturation.

Table 11 Water quality results for Terrys Creek Spring 2010

	Guideline	**Core Site Sommerset Park**		**Historical average**
		September	**November**	
Faecal Coliforms CFU/100mL	1,000[1]	280	230	2600
Ammonia µg/L	20[2]	870	30	79
Oxidised Nitrogen µg/L	40[2]	90	480	171
Total Phosphorus µg/L	50[2]	136	35	40
Total Kjeldahl Nitrogen µg/L	NA	1360	350	376
Total Nitrogen µg/L	500[2]	1350	830	547
Alkalinity mg CaCO3/L	NA	69.7	61.9	58.7
Turbidity NTU	50[2]	2.27	5.05	6
Conductivity µS/cm	125-2,200[2]	582	420	397
Total Dissolved Solids mg/L	NA	461	251	230
pH units	6.8-8.0[2]	7.40	7.09	7.15
Dissolved Oxygen % saturation	85-110[2]	71.1	86.4	59.6
Temperature °C	NA	12.4	15.8	15.6

[1] ANZECC (2000) guidelines for Recreational Water Quality & Aesthetics (Secondary)

[2] ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia)

4.2 Rainfall data

Daily rainfall data from the Marsfield Bureau of Meteorology Station number 066156 are presented below in Figure 3 including the Spring 2010 sampling period and preceding five months. In the five months preceding the October 2010 sampling event 455 mm of rainfall occurred within a range of 29 – 126 mm per month. The total annual rainfall recorded for each year of the Water Quality Monitoring Program for the City of Ryde is listed in Table 12. Average rainfall was experienced in 2003, 2007, 2008, 2009 and 2010 and less than average conditions were recorded in 2004, 2005 and 2006 (Bureau of Meteorology).

Table 12 Total rainfall by year

Year	Rainfall (mm)
2003	1262
2004	905
2005	788
2006	730
2007	1430
2008	1203
2009	992
2010	1249

The rainfall in mid to late 2010 was characterised by consistent light to medium rainfall periods. Five of the six months from May to October 2010 received above monthly average rainfall, with increases between 8 – 40 mm. September was the only month where this pattern changed, down by 21 mm on its monthly average (Bureau of Meteorology).

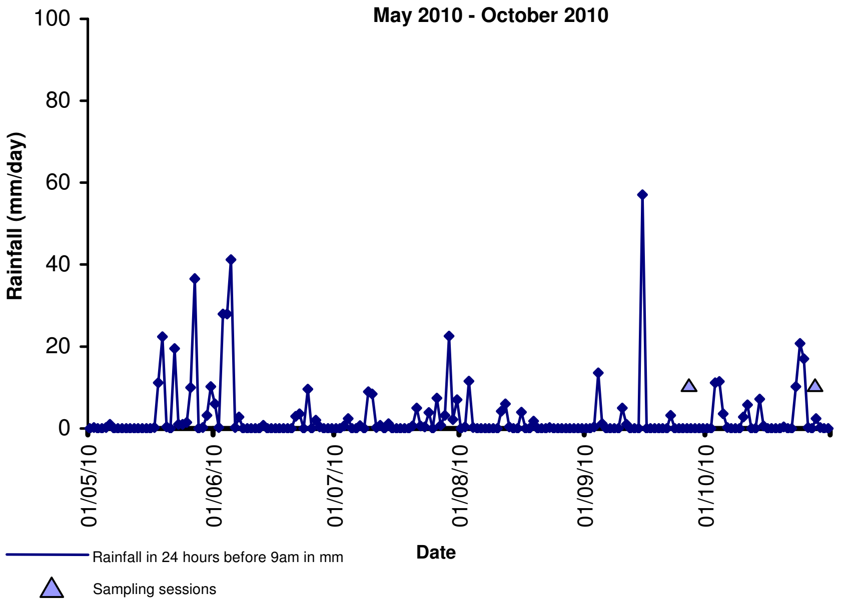

Figure 3 Daily rainfall data 1st May 2010 to 1st November 2010 with sampling occasions indicated

4.3 Macroinvertebrate Results

General Characteristics of Aquatic Macroinvertebrate Assemblages

- 2,153 macroinvertebrates were collected from all five sites in Spring 2010
- From this total, 45 taxa were recorded
- 78 taxa have been collected from the edge habitat of all five creeks from Spring 2004 to Spring 2010
- This compares with 157 taxa of the SIGNAL-SF index of the greater Sydney region, although this total includes taxa from the edge habitat as well as all other stream habitats

Comparisons of taxa collected in each creek between the sampling period of Spring 2004 to Autumn 2010, and Spring 2004 to Spring 2010, indicate additional taxa have been collected in Spring 2010 at four of the five creeks (Table 13).

Table 13 Number of taxa recorded in each creek in specified sample periods

Sampling Seasons	Archers	Shrimptons	Buffalo	Porters	Terrys
Spring 04 - Autumn 10	55	51	52	54	59
Spring 04 - Spring 10	58	52	52	56	60

Macroinvertebrate results for comparable samples (Table 3) are consolidated in Appendix 4.

The larvae of the Sydney Hawk dragonfly, *Austrocordulia leonardi* (listed as endangered under the FM Act 1994), and the Adams Emerald dragonfly, *Archaeophya adamsi* (listed as endangered under the FM Act 1994), are potentially found in the Sydney basin region. Neither of these macroinvertebrates was observed in Spring 2010 samples and is not listed in historical data.

EPT Richness

The average EPT taxa richness has been summarised for each of the five creeks over the monitoring period. Results indicate that EPT taxa are rarely collected from the five sampled creeks. All creeks displayed averages of less than one EPT taxa per sampled season (Figure 4).

EPT taxa richness results for Spring 2010 reflected what had been previously recorded for all creeks (Figure 5). Shrimptons Creek recorded an average of 1 EPT taxa in Spring 2010 (Figure 5), its equal highest recording for a season (equal to the Spring 2004 result). Shrimptons Creek however displayed the lowest occurrence of EPT taxa overall, Porters Creek and Archers Creek showed the highest diversity index, however they still do not average a single EPT taxa (Figure 4).

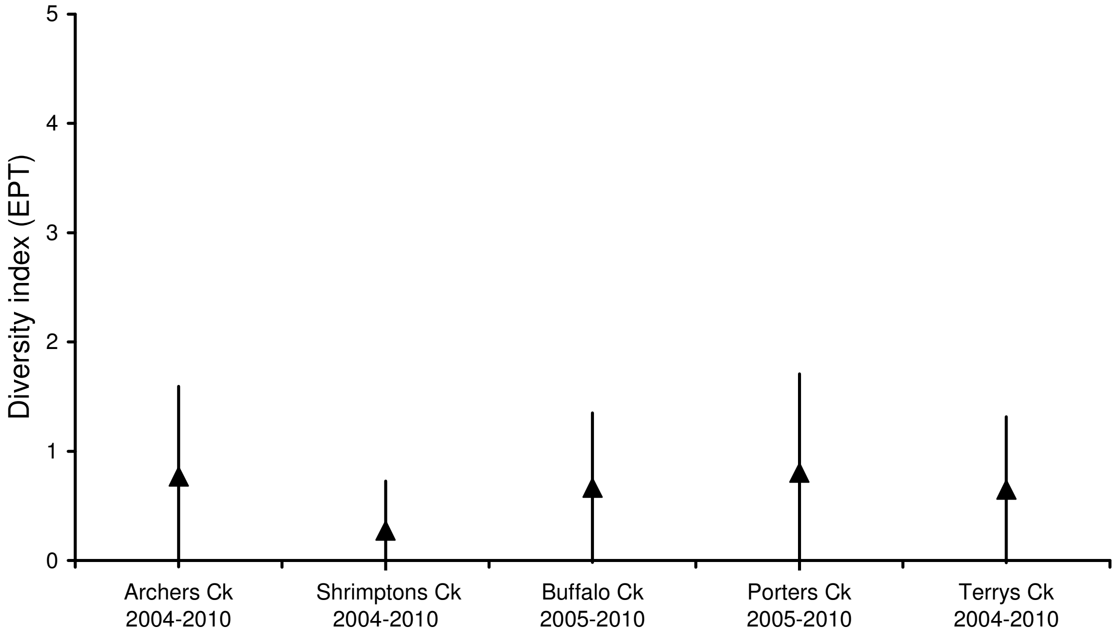

Figure 4 EPT richness of all creeks of monitoring program

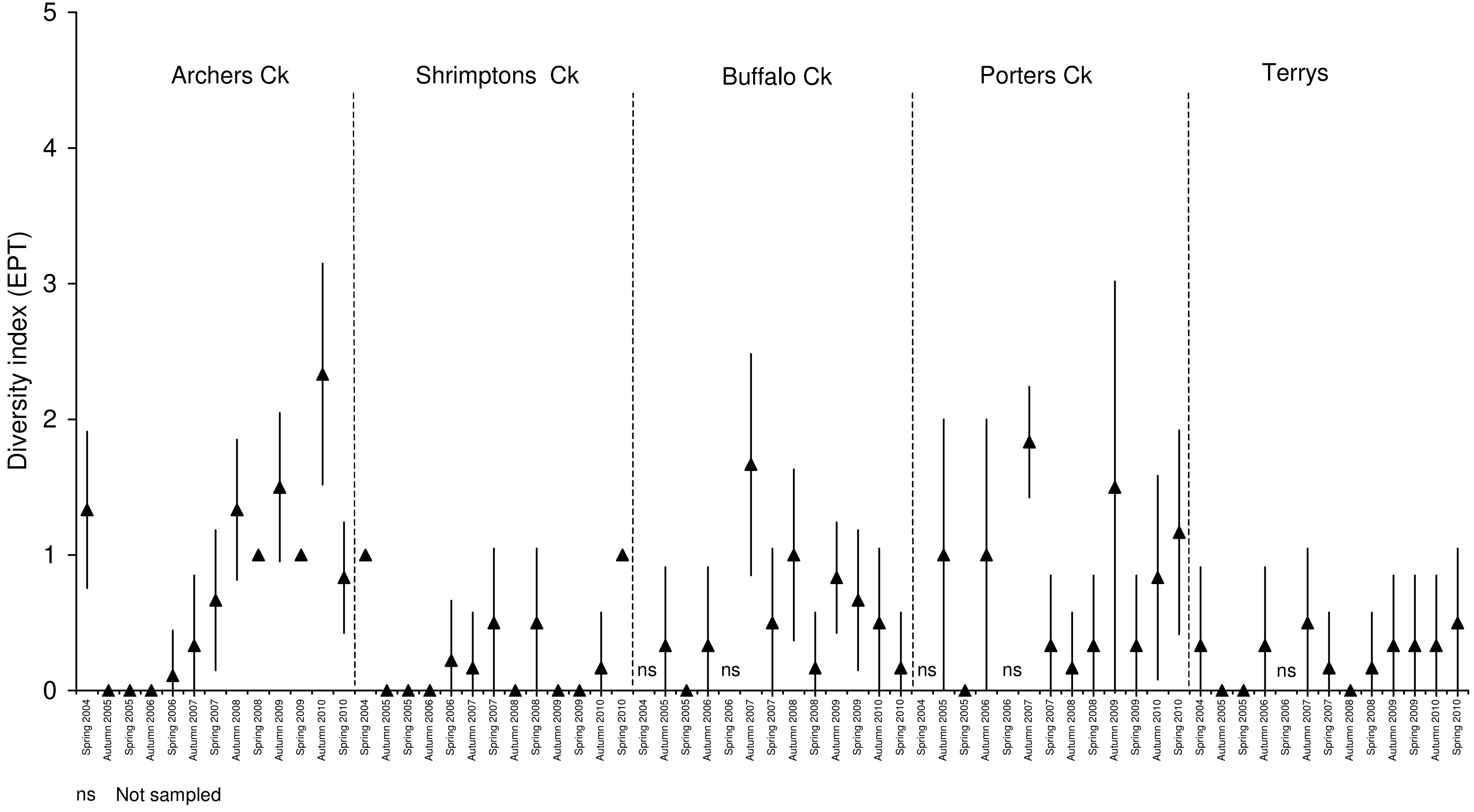

Figure 5 EPT richness by season

SIGNAL-SF

The SIGNAL-SF biotic index indicated impaired macroinvertebrate communities, with average stream health being indicative of probable moderate to severe organic pollution for all creeks.

Archers Creek narrowly had the highest average stream health and Shrimptons Creek narrowly the lowest when assessed with SIGNAL-SF for the sampling periods between Spring 2004 and Spring 2010. When all five creeks are compared in terms of ANZECC (2000) guidelines (+/-1 standard deviation of the average), the overlapping ranges of stream health indicate no significant difference exists between the creeks. Shrimptons Creek has the largest range in stream health, which reflects the change in average stream health recorded between Spring 2004 and Spring 2010 (Figure 6 and Figure 7).

Archers Creek decreased in average stream health in Spring 2010 compared to the previous autumn season. Spring 2010 was reflective of earlier spring seasons, recording a seasonal decrease. Archers Creek has shown a general pattern of having higher scores in autumn compared to spring (Figure 7).

Shrimptons Creek average stream health in the previous five sampling periods showed very little variation between seasons. The result from Spring 2010 however was higher and indicated an increase in stream health compared to these previous seasons. Shrimptons Creek average stream health peaked in Autumn 2007 after steadily increasing from Autumn 2005, when it recorded the lowest stream health from all five creeks for all sampling periods (Figure 7).

The average stream health in Buffalo Creek decreased in Spring 2010 for the first time since Spring 2008, when it was significantly lower than previous recordings. Spring 2010 is reflective of seasonal variations from previous years (Figure 7).

Porters Creek has shown a trend of higher average stream health in autumn than in spring. This trend has continued in Spring 2010 with a slight decrease, this was however the highest spring average recorded during the monitoring program (Figure 7).

The range of average stream health for Terrys Creek has been very narrow throughout the sampling program and Spring 2010 results fall within what has been previously recorded. There had been a steady decline in average stream health from Spring 2005 to Spring 2008, but the four seasons since have indicated slightly higher average stream health (Figure 7).

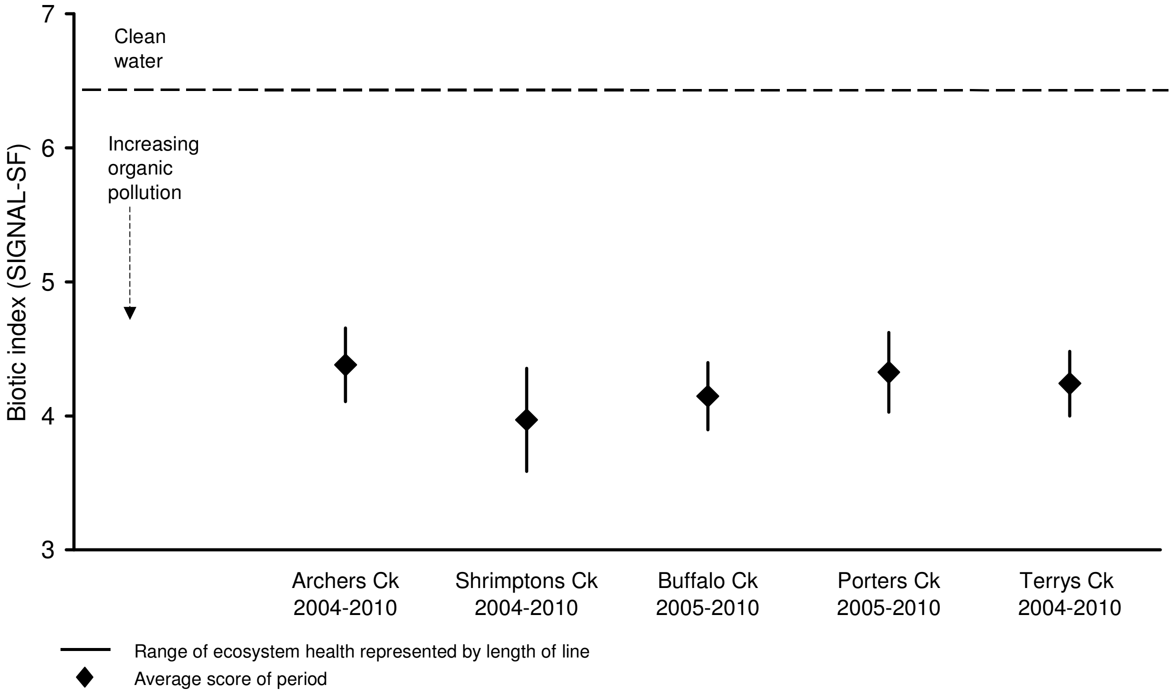

Figure 6 ***SIGNAL-SF of all creeks of monitoring program***

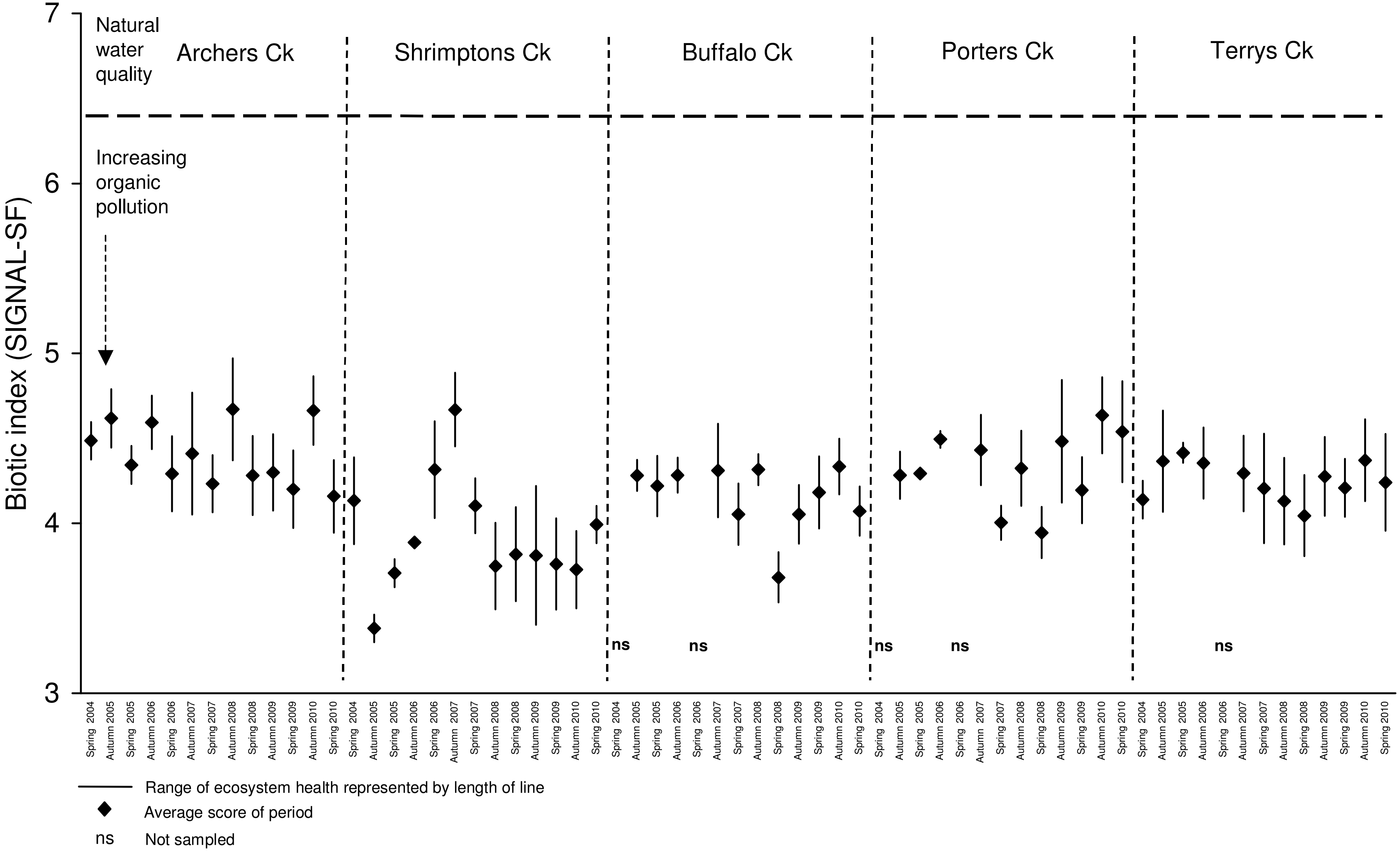

Figure 7 SIGNAL-SF by season

AUSRIVAS OE50

The results for the Spring edge AUSRIVAS OE50 model output for 2010 were reflective of what has been previously observed for all five creeks. The Spring 2010 results were all placed within the severely impaired band (Figure 8).

Archers and Shrimptons creeks average stream health for Spring 2010 slightly increased from the previous spring season. Buffalo Creek had a slight decline in average stream health compared to the previous spring season. Porters and Terrys creeks average stream health was very similar to the previous spring season (Figure 8).

Results of the Spring edge AUSRIVAS OE50 model output for each of the five creeks are similar through time, with most seasons average stream health ranges overlapping. Buffalo Creek average stream health fell from Spring 2005 to Spring 2008, when it fell into the extremely impaired band. It has recently returned to the severely impaired band. Terrys Creek results have been very similar throughout the monitoring program except for Spring 2005 when it increased and was placed in the significantly impaired band (Figure 8).

The Spring edge AUSRIVAS OE50 results indicate that Archers Creek has slightly higher stream health compared to the other creeks of the program. Terrys Creek has the largest range of average stream health with the remaining three creeks having similar average stream health (Figure 9).

The Autumn and Spring edge AUSRIVAS OE50 model output indicates similar trends in stream health across all five creeks. The Autumn model output is generally indicative of higher average stream health when compared to the respective Spring seasons for all creeks (Figure 8, Figure 9, Figure 11 and Figure 12).

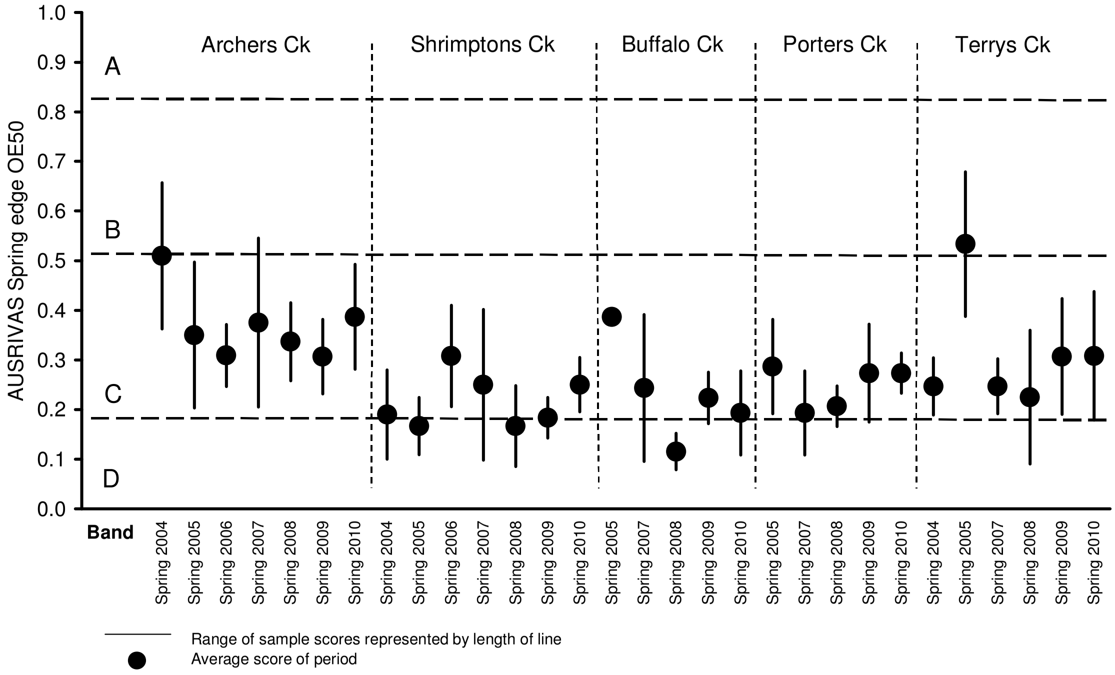

Figure 8 ***AUSRIVAS OE50 of all creeks from Spring edge model***

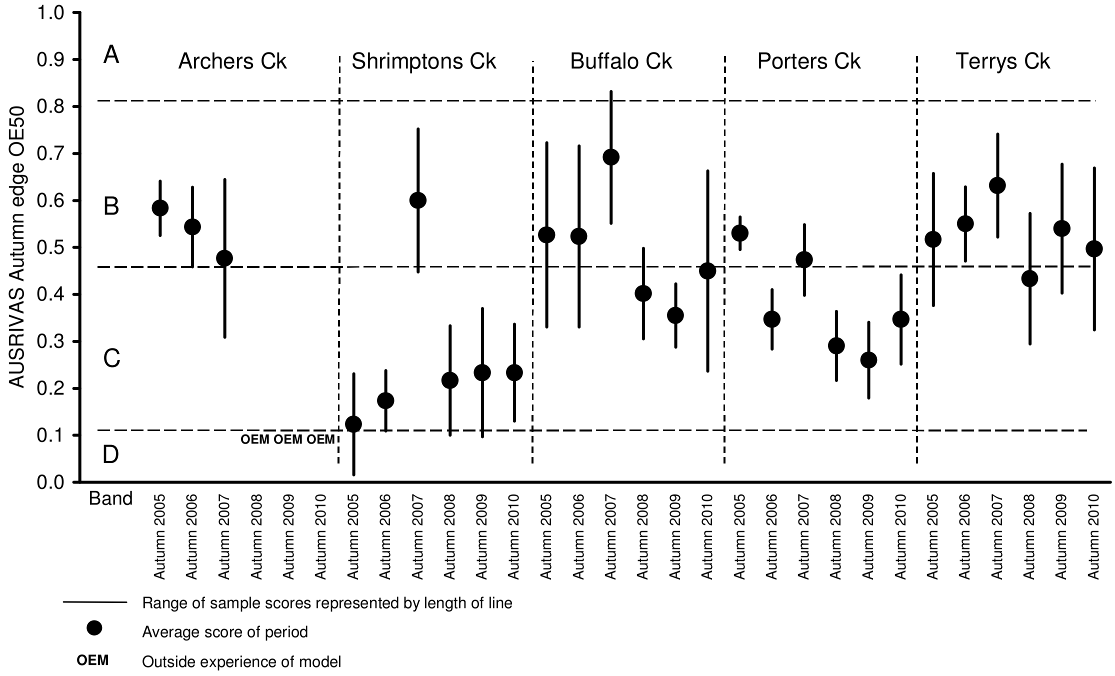

Figure 9 ***AUSRIVAS OE50 of all creeks from Autumn edge model***

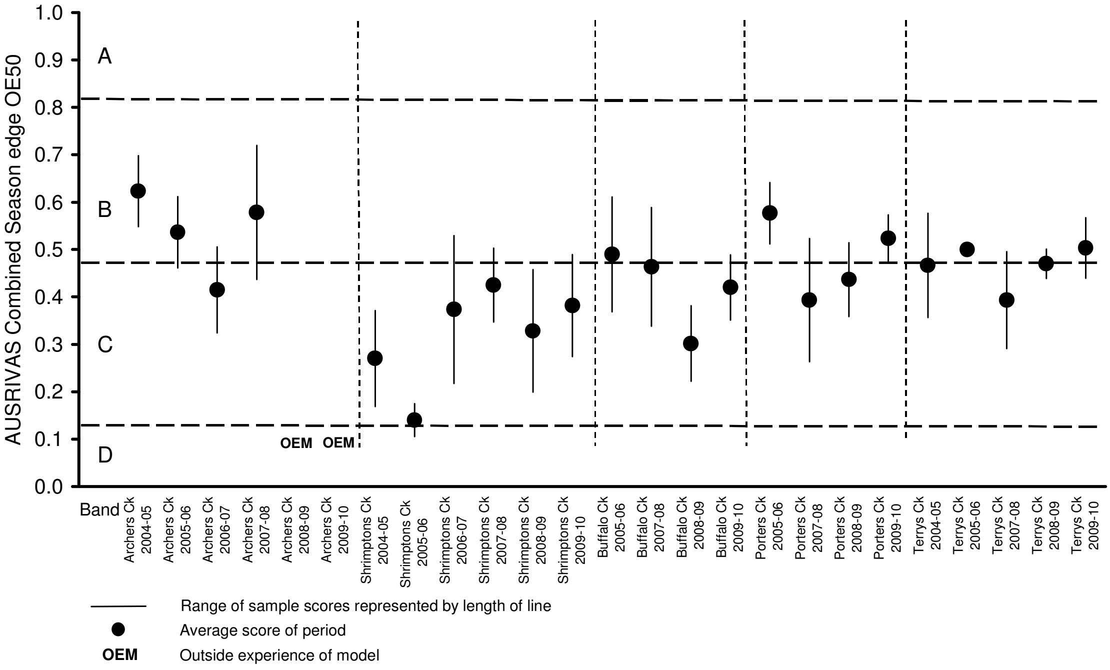

Figure 10 ***AUSRIVAS OE50 of all creeks from combined season edge model (with financial year data combined)***

Figure 11 ***AUSRIVAS OE50 summary of all creeks from Spring edge model***

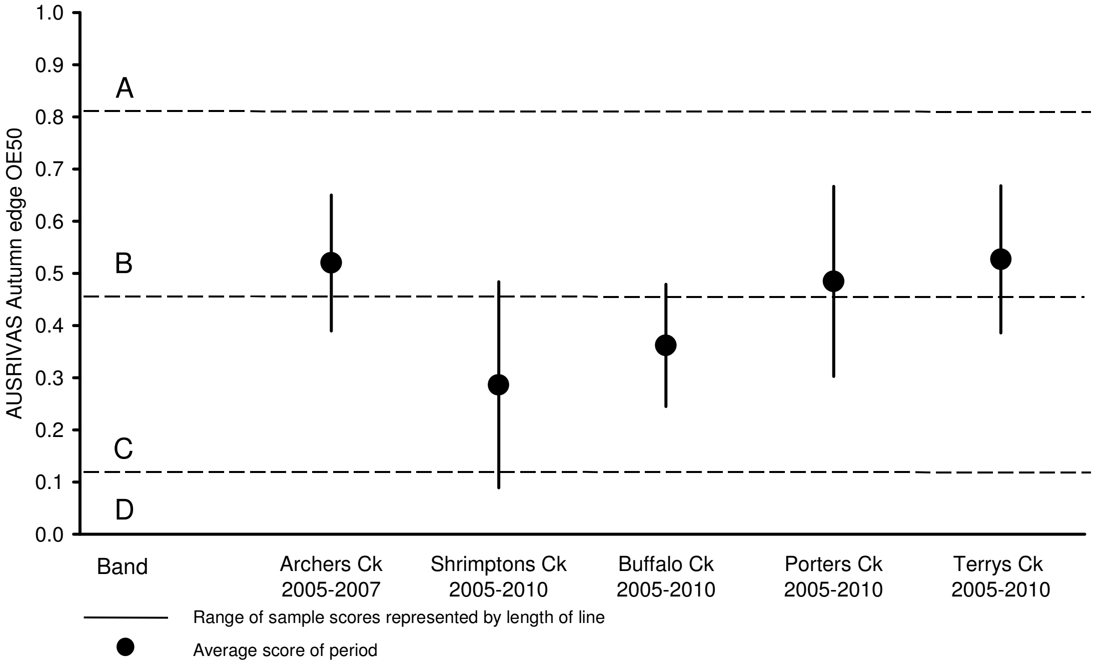

Figure 12 ***AUSRIVAS OE50 summary of all creeks from Autumn edge model***

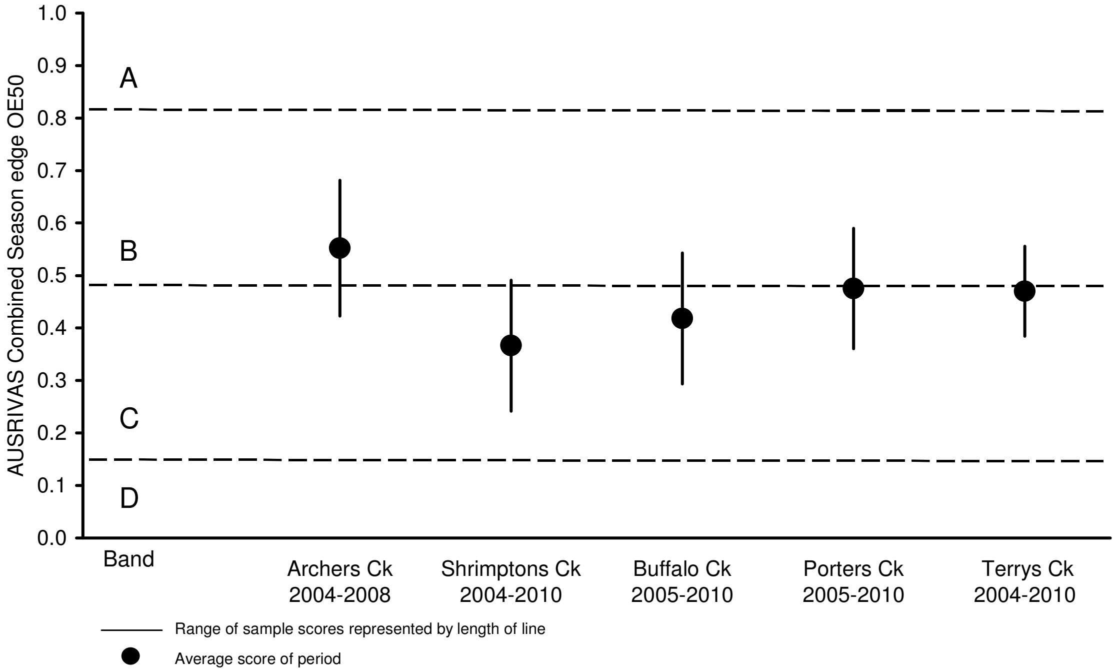

Figure 13 ***AUSRIVAS OE50 summary of all creeks from combined season edge model (with financial year data combined)***

EPT Indicator taxa from AUSRIVAS predictive model output

AUSRIVAS output identifies taxa that were expected to be representative of a sample when compared to the respective reference site group by the AUSRIVAS model. As part of this output, missing taxa are listed with greater than 50% probability of occurrence. Indicator taxa are defined as taxa within the EPT orders (Ephemeroptera - mayfly, Plecoptera - stonefly and Trichoptera – caddisfly) with SIGNAL2 scores of greater than 6 (as per previous reports).

Across the five creeks of the monitoring program, missing EPT indicator taxa identified by AUSRIVAS Spring edge model output listed 16 taxa as missing. The taxa identified included three mayfly larvae (Ephemeroptera), two stonefly larvae (Plecoptera) and 11 caddisfly larvae (Trichoptera).

There were three families of EPT taxa found during the Spring 2010 sampling period, one of which was an indicator taxa the Antipodoeciidae (Trichoptera). It was represented by a small number of specimens in Porters Creek. Antipodoeciidae specimens have been found in Porters Creek sporadically throughout the monitoring program.

AUSRIVAS OE0 SIGNAL2

The results for the Spring edge OE0 SIGNAL2 output for 2010 are reflective of what has been previously observed for all five creeks. The average stream health increased slightly for all five creeks in Spring 2010, but all results were within the range of the previous spring season (Figure 14).

The average stream health in Buffalo, Porters and Terrys creeks were the highest recorded for those creeks during the monitoring program, but only slightly. All of the creeks have had consistently similar results using the Spring edge OE0 SIGNAL2 model. The exceptions being the Spring 2004 results for Archers and Shrimptons creeks that dropped significantly the following spring season (Figure 14)

The Spring edge OE0 SIGNAL2 results indicate that all five creeks have very similar average stream health over the period of the monitoring program. Terrys Creek has the slightly higher average stream health and Porters Creek the lowest, however the average stream health ranges overlap for the five creeks (except when comparing Porters and Terrys creeks) (Figure 17).

The Autumn and Spring edge AUSRIVAS OE0 SIGNAL2 model outputs indicate similar stream health across all five creeks for both models. The Autumn model has slightly larger average stream health range for the monitoring program.

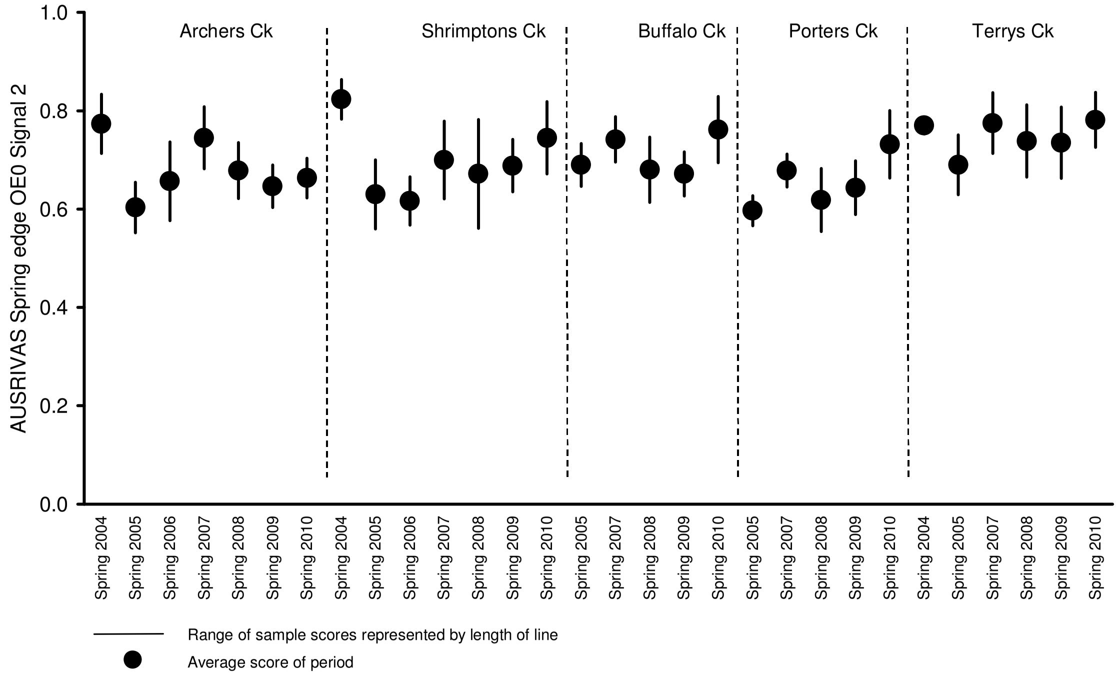

Figure 14 ***AUSRIVAS OE0 SIGNAL2 of all creeks from Spring edge model***

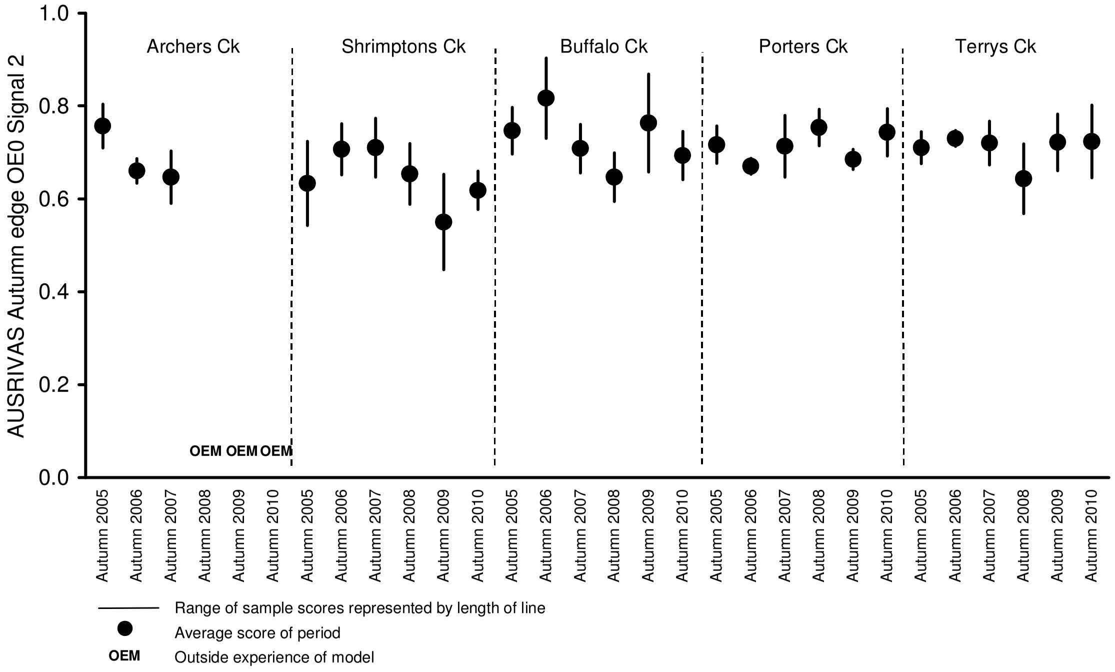

Figure 15 ***AUSRIVAS OE0 SIGNAL2 of all creeks from Autumn edge model***

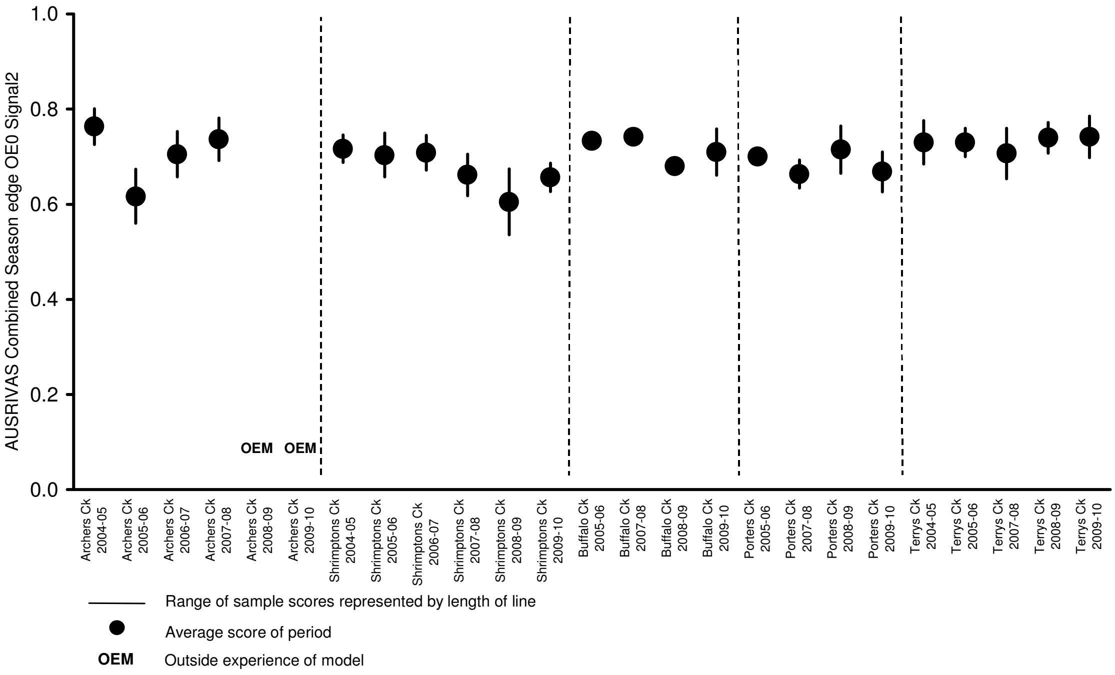

Figure 16 ***AUSRIVAS OE0 SIGNAL2 of all creeks from combined season edge model (financial year data combined)***

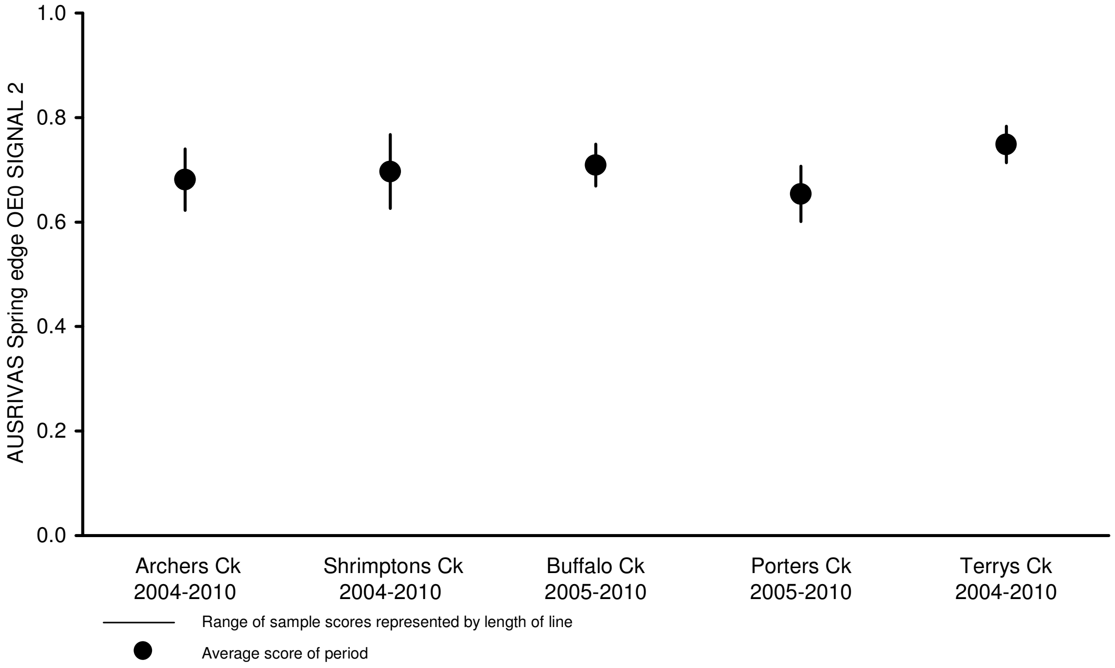

Figure 17 ***AUSRIVAS OE0 SIGNAL2 summary of all creeks from Spring edge model***

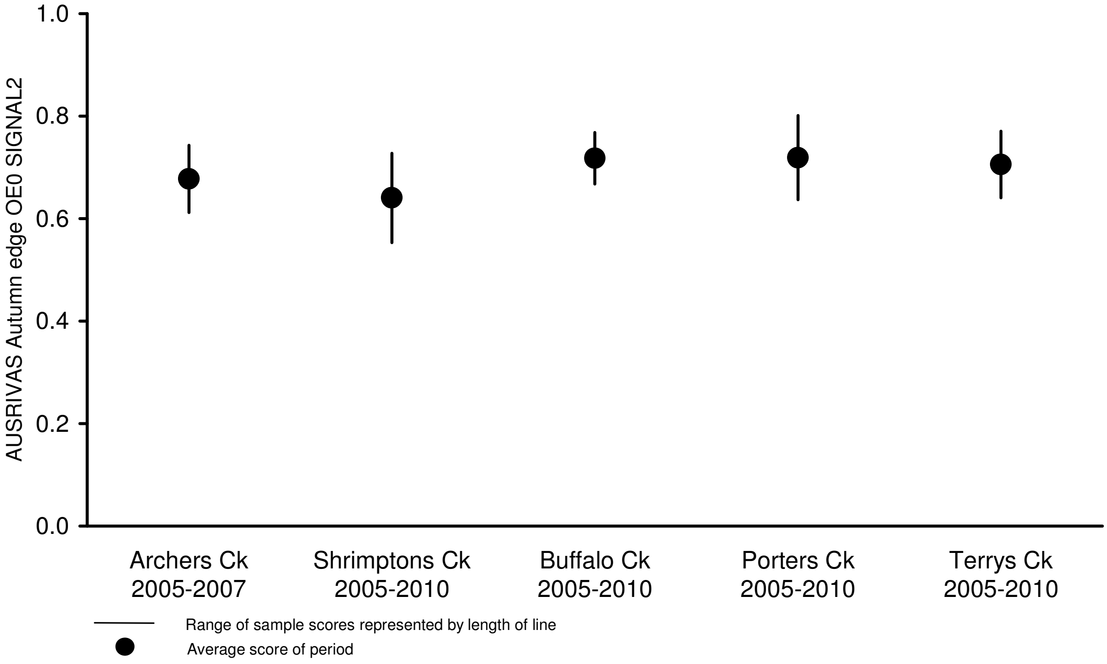

Figure 18 AUSRIVAS OE0 SIGNAL2 summary of all creeks from Autumn edge model

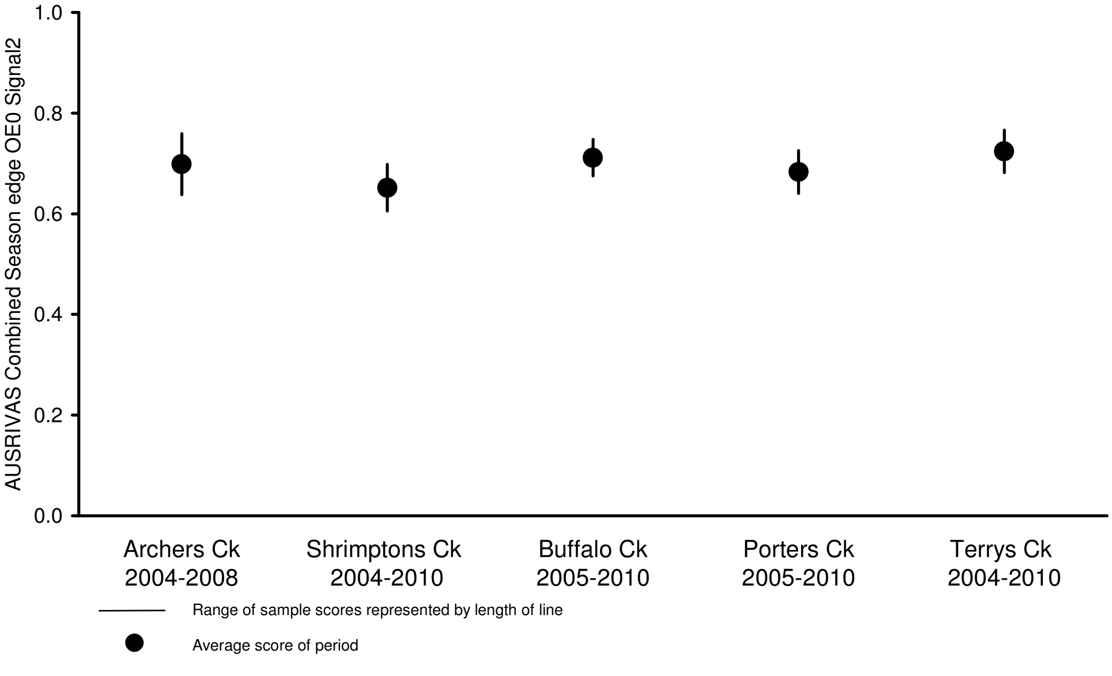

Figure 19 AUSRIVAS OE0 SIGNAL2 summary of all creeks from combined season edge model (with financial year data combined)

Multivariate Analyses

Ordination and SIMPROF test

In order to achieve suitable multivariate representations of data in two or three dimensions, replicates from the same season for each creek were merged. This produces one data point per creek per season, which minimizes the stress and gives a better measure of fit. This strategy has been used for the combined analysis of all five creeks due to the large number of replicates involved. Presenting the data in this way can be seen as reducing the noise of the replicate data from the somewhat patchy occurrence of macroinvertebrates at a stream site.

The three-dimensional MDS ordination plot for all five creeks and individual creeks are presented in the report, as the stress value is lower in three dimensions than in two. This lower stress value means the differences in community structure between creeks and seasons is better represented in the three-dimensional plot, despite the three dimensions being represented in two dimensions. A two-dimensional presentation of the ordinations is the preferred reporting format, however ordinations with high stress values (>0.2) are considered inappropriate representations of community structure.

The three-dimension ordination plot highlights variability in the community structure of Shrimptons Creek, both between its seasons and when compared to the other creeks through time. Terrys Creek has the least variation in community structure of the five creeks of the program. Archers, Buffalo and Porters creeks indicate a similar variability through time, with Archers Creek potentially being slightly more variable (Figure 20).

The SIMPROF test provides another way to view community structure differences and similarities between samples. SIMPROF results are overlaid onto the classification result output (dendrogram), with black lines indicating a real difference in community structure and red lines no real difference.

All Shrimptons Creek samples were separated in the first two test groups highlighted by the SIMPROF test. The first test group consisted of Autumn/Spring 2005 and Autumn 2006 (43% similarity) separating them from all other Shrimtpons Creek samples. The continuing test groups are largely separated based on creek and season. A single season sample from Archers (Autumn 2008) and Porters (Spring 2005) creeks are separated into their own test group. All of the ‘real’ test groups separated by the SIMPROF test apart from the first Shrimptons Creek group split at a relatively high similarity (60% and higher) (Figure 21).

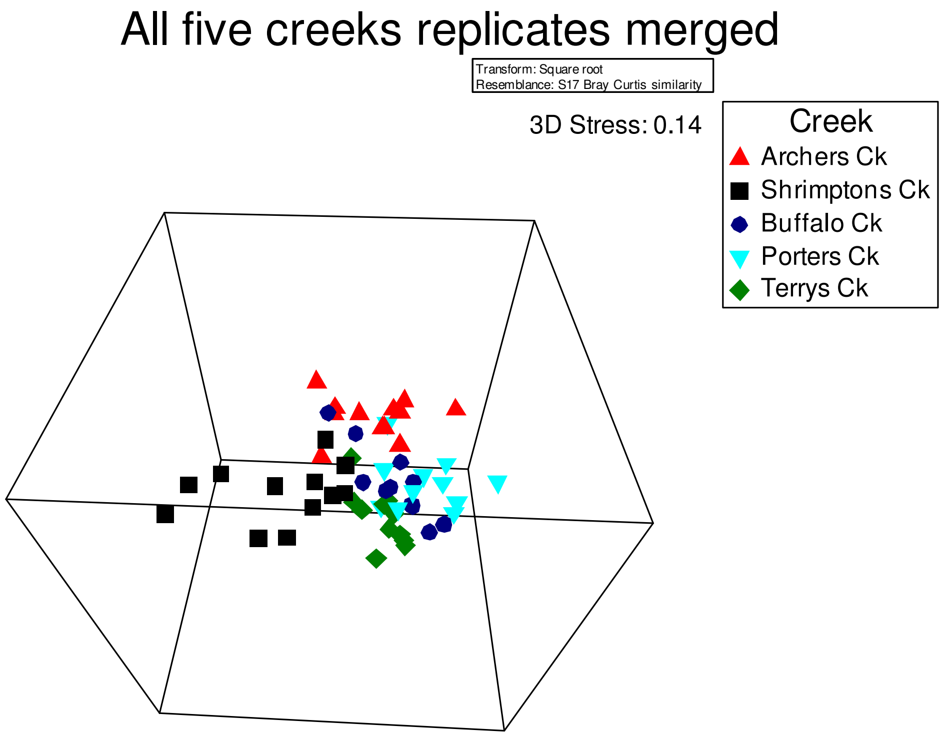

Figure 20 *Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2010 macroinvertebrate data of all creeks, with each point of the same creek representing a different season*

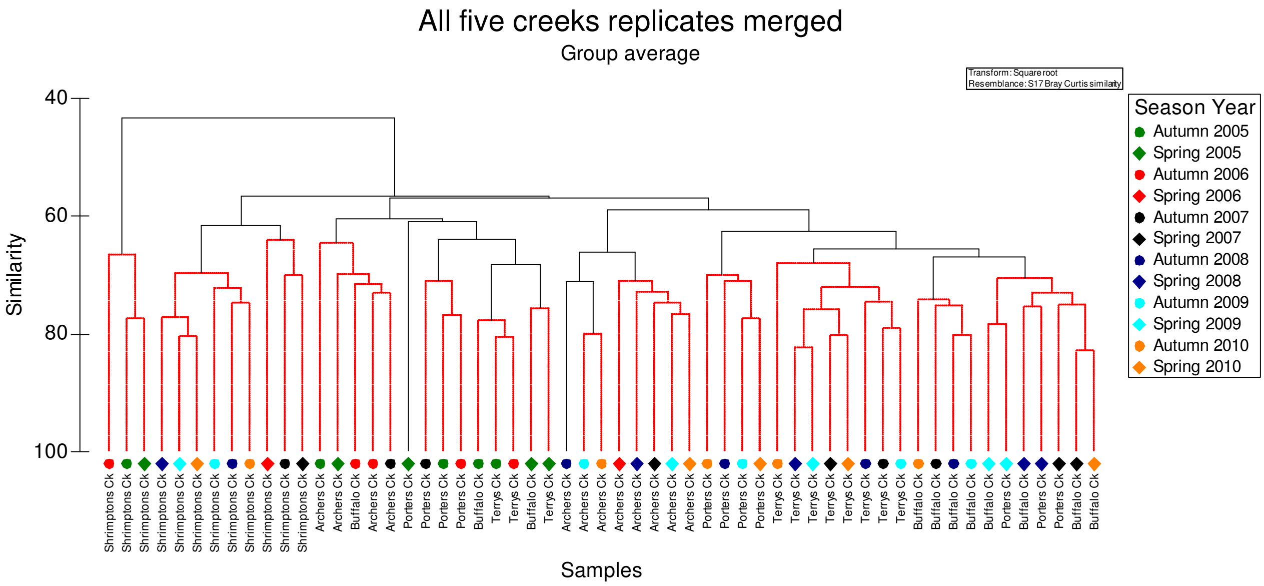

Figure 21 *Dendrogram of all five creeks with SIMPROF test sample groups*

The Archers Creek ordination plot and SIMPROF test results indicate a general separation of autumn and spring results, with two single samples separated from Spring 2006 and 2010 (Figure 22 and Figure 23).

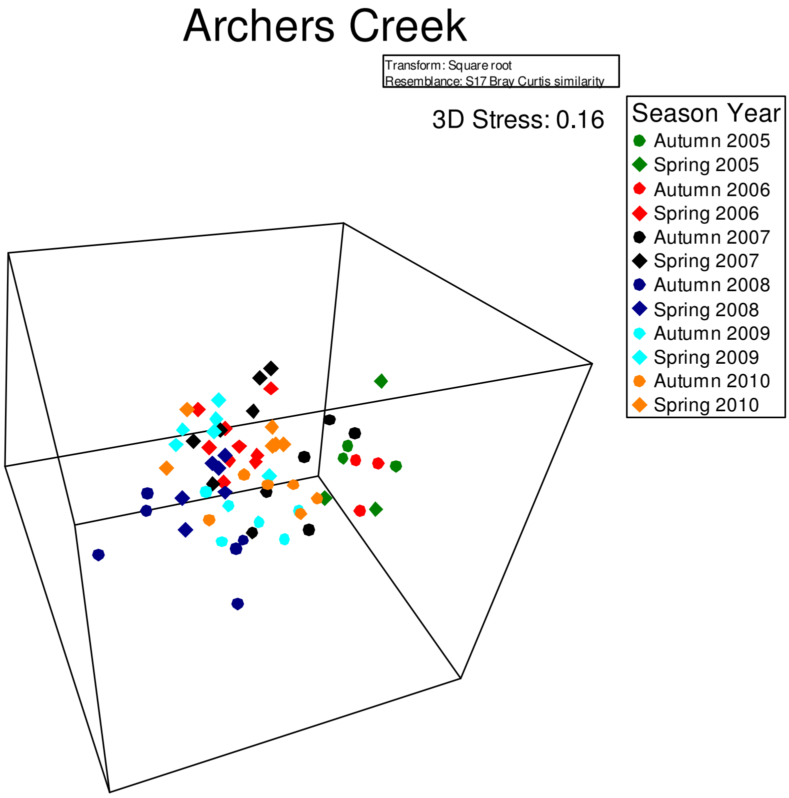

Figure 22 ***Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2010 macroinvertebrate data of Archers Creek***

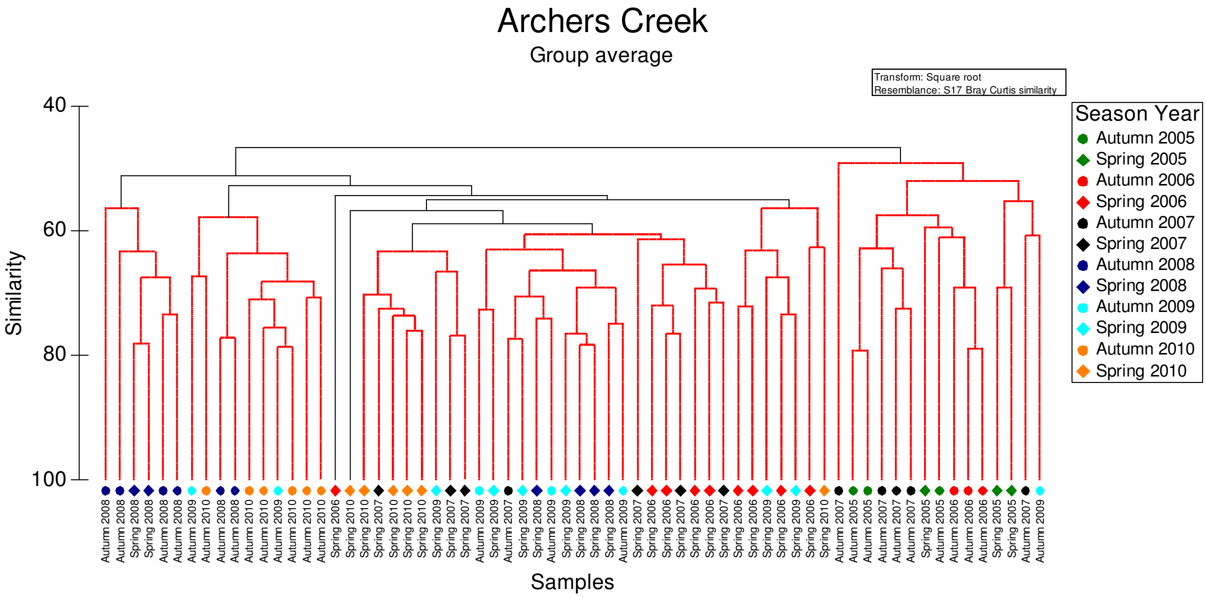

Figure 23 ***Dendrogram of Archers Creek with SIMPROF test sample groups***

The ordination plot of Shrimptons Creek indicates some seasonal separation. The SIMPROF test results show no notable test group separation, despite there being test groups split at 40% similarity (Figure 24 and Figure 25).

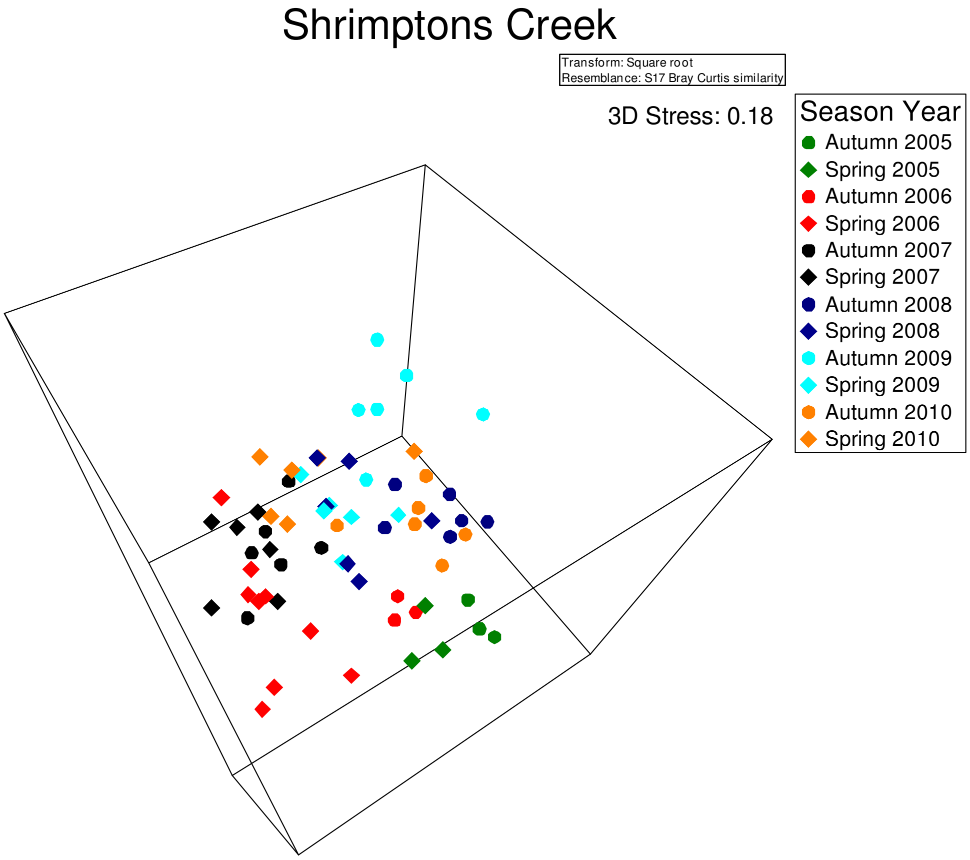

Figure 24 ***Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2010 macroinvertebrate data of Shrimptons Creek***

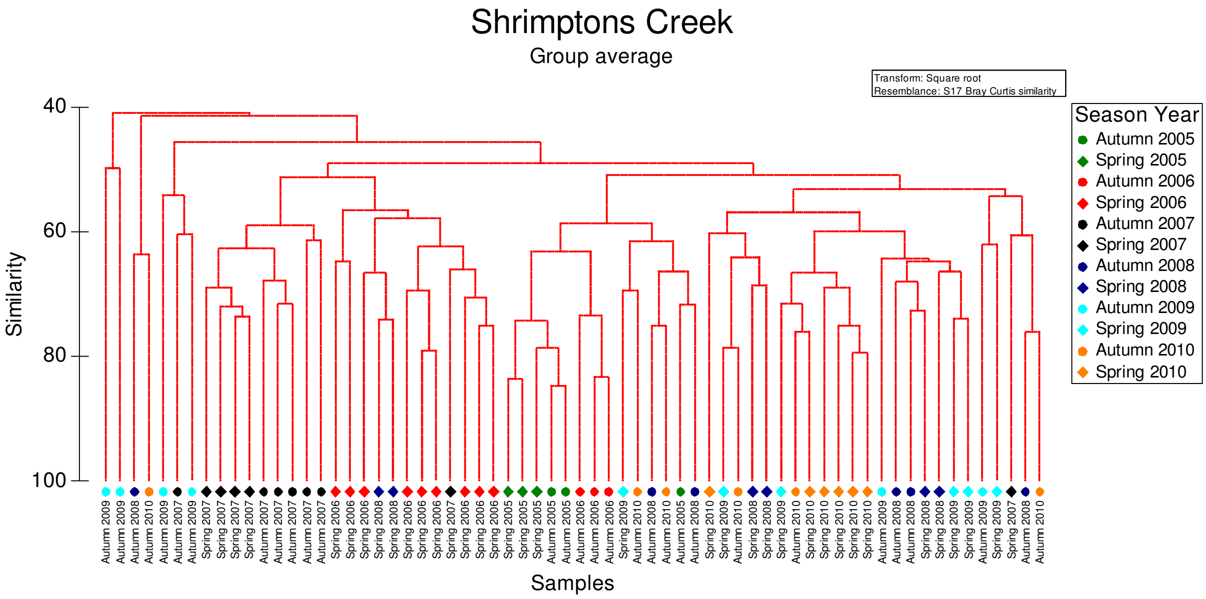

Figure 25 ***Dendrogram of Shrimptons Creek with SIMPROF test sample groups***

The Buffalo Creek ordination plot and SIMPROF test separate Autumn 2005, Spring 2005 and Autumn 2006 from all other samples, these were the first three seasons sampled in the sampling program. For all other samples there is a general separation of spring and autumn samples in the ordination plot. This separation is particularly evident from the SIMPROF test, where all samples are separated into groups based on season except for the first three sampled seasons (Figure 26 and Figure 27).

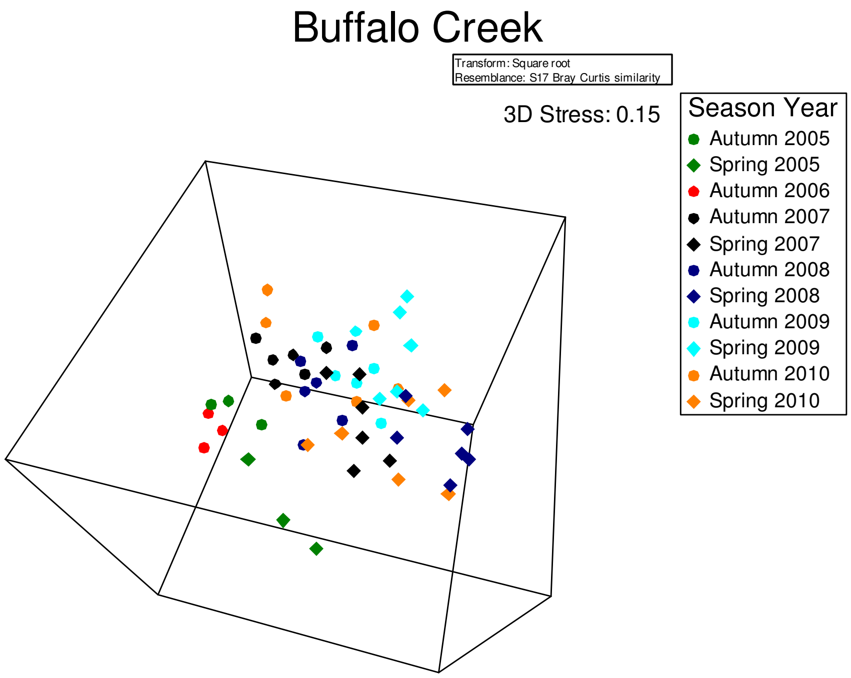

Figure 26 *Plot of non-metric multidimensional scaling ordination results of 3 dimension analysis for 2005 to 2010 macroinvertebrate data of Buffalo Creek*

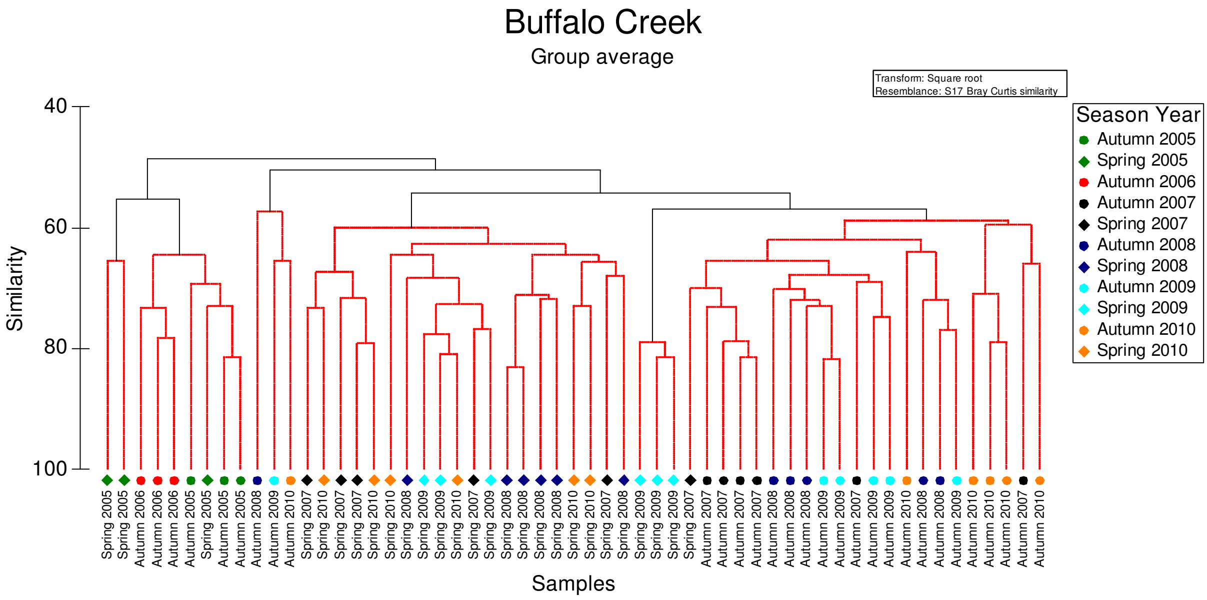

Figure 27 *Dendrogram of Buffalo Creek with SIMPROF test sample groups*

The Porters Creek ordination plot and SIMPROF test results show two outlying groups of samples from Spring 2008. Both multivariate analyses indicate a separation of samples from Autumn 2005 to Autumn 2007 and samples from Spring 2007 to Spring 2010, except one Autumn 2010 sample (Figure 28 and Figure 29).

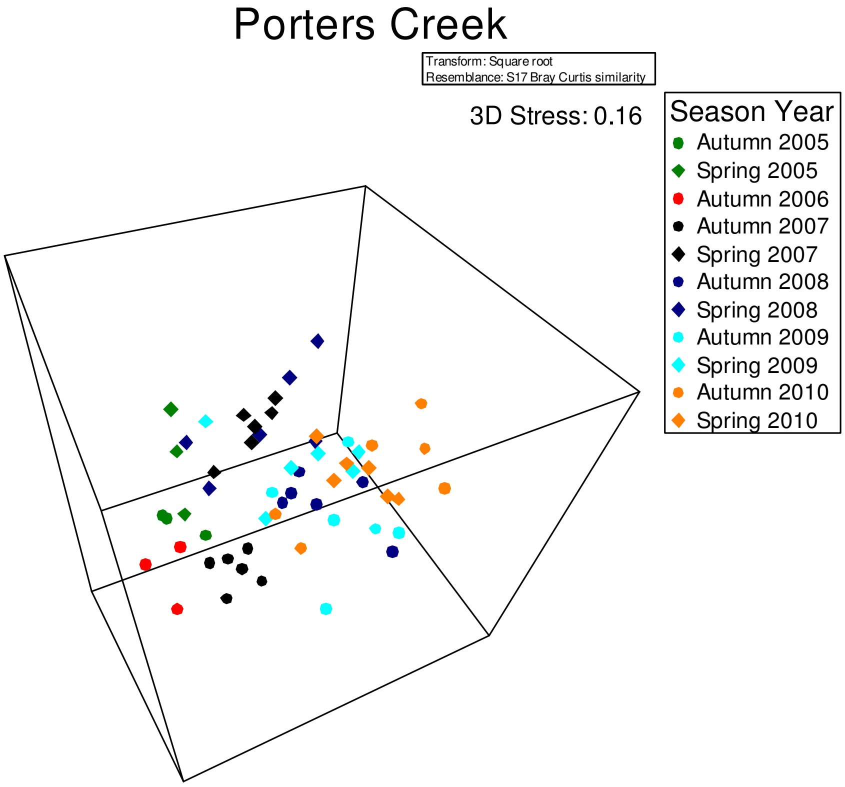

Figure 28 ***Plot of non-metric multidimensional scaling ordination results of 3 dimension analysis for 2005 to 2010 macroinvertebrate data of Porters Creek***

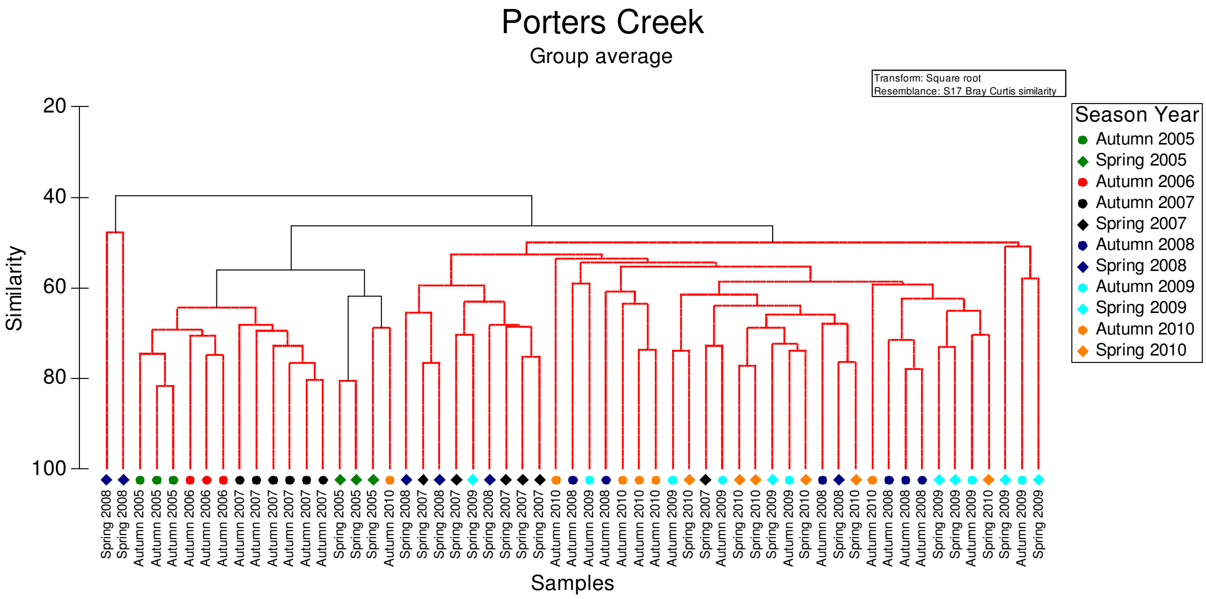

Figure 29 ***Dendrogram of Porters Creek with SIMPROF test sample groups***

The first Terrys Creek test group to be separated by SIMPROF is five of the six Autumn 2010 samples, this separation is evident in the ordination plot. There is one outlying sample from Spring 2008 indicated by the SIMPROF test (Figure 30 and Figure 31).

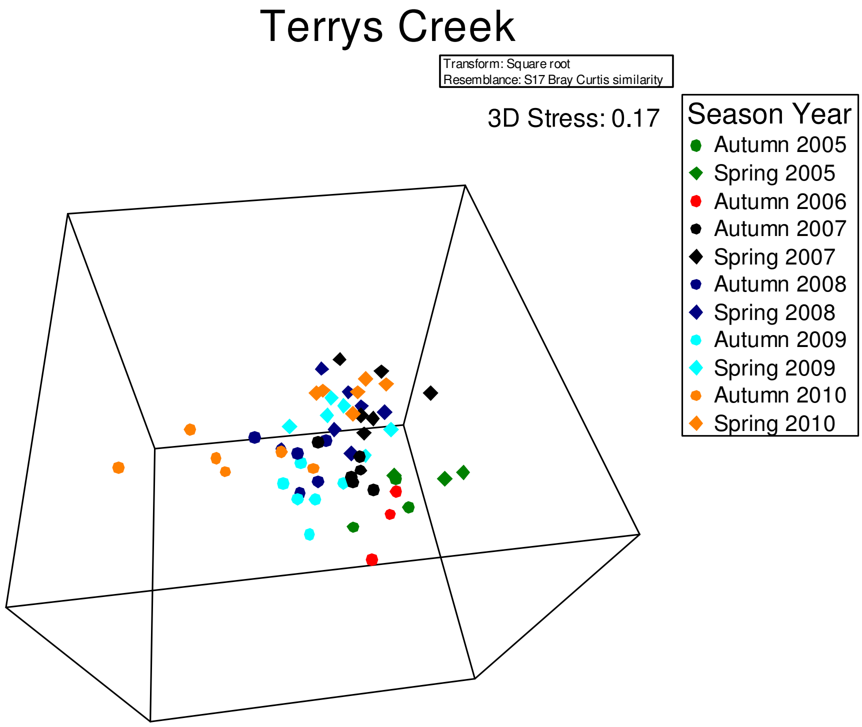

Figure 30 Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2010 macroinvertebrate data of Terrys Creek

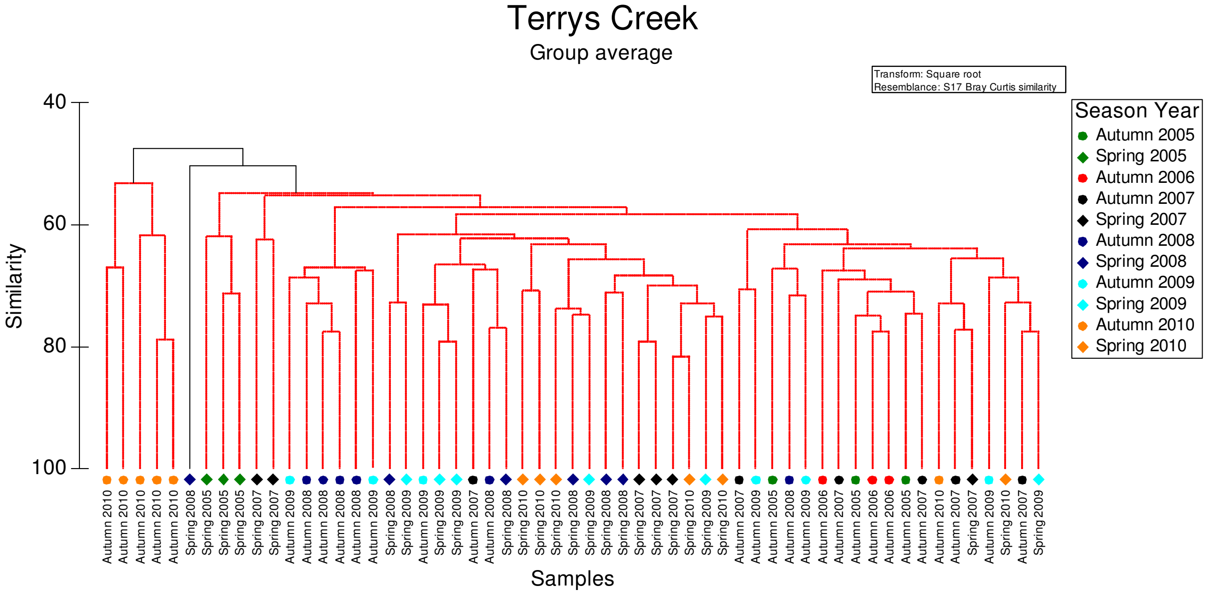

Figure 31 Dendrogram of Terrys Creek with SIMPROF test sample groups

SIMPER

SIMPER results from 2005 to 2010 for each creek indicated that Shrimptons Creek had the lowest overall similarity of 61%. Archers, Porters and Buffalo creeks had slightly higher similarities with 63%, 63% and 65% respectively. Terrys Creek had the highest similarity with 70% (Appendix 5). These similarities reflect the amount of variation (the lower the percentage, the more variation) in macroinvertebrate community structure over time within the individual creeks in the program.

SIMPER compares samples from each creek with those of all other creeks. These results are referred to as average dissimilarity. These values are presented in Table 14 and indicate that samples from Buffalo, Porters and Terrys creeks are most similar. This reflects the closer yet still separate position of those data points in the ordination plot of all five creeks. Shrimptons Creek samples are the most dissimilar to all the other creeks' samples, and this is reflected in the ordination plot of all five creeks (Figure 20).

Table 14 Average dissimilarity between samples of each creek comparisons

	Archers %	Shrimptons %	Buffalo %	Porters %
Shrimptons %	47			
Buffalo %	42	46		
Porters %	44	50	38	
Terrys %	43	45	36	38

SIMPER also looks at the similarity of samples within each of the five creeks of the program, complementing the MDS plots and dendrograms (SIMPROF) in the previous section. The range of average similarity of samples within the five creeks was 48% to 77% (Table 15). The SIMPER output includes individual macroinvertebrate abundances, which are the drivers of the sample similarities.

The largest range in sample similarity (48-77%) is found in Shrimptons Creek, reflective of a significant change in macroinvertebrate community structure. From Autumn 2005 to Autumn 2006, tolerant non-insects dominated community structure, with five to six taxa contributing to 90% of the overall samples. From Spring 2006 to Spring 2007 there was a change, with up to 10 dominant taxa and tolerant insects significantly contributing to the community structure. Since Autumn 2008 to the current Spring 2010 season, the community structure has returned to being dominated by tolerant non-insects with fewer dominant taxa (Appendix 5).

The SIMPER output for Archers, Buffalo, Porters and Terrys creeks indicated that seasonal variations were the main driver influencing changes in macroinvertebrate community structure.

Archers Creek in spring has had a 40% and less contribution from tolerant insects. This contribution in autumn has risen to 50% and more. The number of dominant taxa per season has remained relatively stable through time and seasons in Archers Creek.

The community structure in Buffalo Creek has shown a similar seasonal trend to Archers Creek. In Spring 2008 the low taxa dominance of non-insects was particularly evident with an 80% contribution from just three non-insect taxa. This change however, was linked to a catchment disturbance rather than just seasonal shifts.

The community structure in spring for Porters and Terrys creeks is dominated by few taxa and higher contributions of non-insects occur. In autumn there is a more diverse range of dominant taxa with a higher contribution by insect taxa.

In the five creeks of the Ryde LGA, common non-insect community members included the introduced snail *Physa acuta* (Physidae), flatworms (Dugesiidae) and worms (Oligochaeta). The tolerant insects found were native non-biting midges (Chironominae), dragonflies (Megapodagrionidae, Coenagrionidae, Isostictidae, Hemicorduliidae) and back-swimmers (Notonectidae). For all five creeks of the monitoring program the single most dominant taxa is the dipteran sub-family, Chironominae.

Table 15 Average similarity of the same season samples for each creek

	Archers %	Shrimptons %	Buffalo %	Porters %	Terrys %
Autumn 2005	68	76	76	77	70
Spring 2005	59	77	66	73	65
Autumn 2006	72	77	75	72	73
Spring 2006	60	62	ns	ns	ns
Autumn 2007	57	60	70	71	66
Spring 2007	61	63	65	68	65
Autumn 2008	61	58	64	60	67
Spring 2008	70	63	66	52	62
Autumn 2009	64	48	69	58	62
Spring 2009	65	62	69	56	67
Autumn 2010	66	58	56	55	59
Spring 2010	64	65	61	68	64

BIOENV

The output of BIOENV routine for all five creeks and for each individual creek is presented in Appendix 6. The strongest correlation of the data for all five creeks for 2005 to 2010 was mild at 0.401. The variables identified in the best correlation consisted of total oxidised nitrogen, conductivity, dissolved oxygen, and ratio of number of outlets/catchment area. The ratio of number of outlets/catchment area was the only variable that was found in all of the ten best correlations in the BIOENV output. Cobble (stream rocks, size 6 – 25cm) was found in nine of the ten best correlations.

BIOENV analysis of each individual creek for 2005 to 2010 produced weak to moderate correlations Archers (0.272), Shrimptons (0.262), Buffalo (0.286), Porters (0.446) and Terrys (0.267).

The strongest correlation for Porters Creek was a mild correlation and included conductivity, total dissolved solids and rainfall. These were in most of the strongest correlations for Porters Creek. The remaining creeks returned only weak correlations and included a variety of variables in their strongest correlation. Terrys Creek was the only creek that returned a single variable in its strongest correlation, Rainfall.

Table 16 Catchment storm water delivery characteristics for each creek

Creek	Total Length of Pipe (TLP) (m)	Total Number of pipe Outlets (NO)	Catchment Area (CA)(hectares)	Ratio TLP/CA	Ratio NO/CA
Archers	19,310	65	286	67.5	22.7
Shrimptons	41,797	74	555	75.3	13.3
Buffalo	33,336	62	546	61.1	11.3
Porters	15,797	16	225	70.2	7.1
Terrys	47,952	89	1012	47.4	8.8

5 Discussion

5.1 Water Quality

Water quality results, while not reflecting a sampling frequency suggested by ANZECC (2000), did allow for characterisation of water quality at each study creek against ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality and Aesthetics (Secondary).

Results of the Spring 2010 water quality sampling for Shrimptons, Porters, Buffalo, Terrys and Archers creeks support previous sampling results indicating that urban pollution transport is having an impact on instream water quality. This impact was indicated by low levels of dissolved oxygen and high levels of nutrients, especially nitrogen forms.

This trend was observed in 2004 through to 2010 (Ecowise 2004, 2005a 2005b 2006; Sydney Water 2006, 2007a, 2007b, 2008a, 2008b, 2009a, 2009b, 2010a). Pollutant concentrations have been spatially variable, indicating that they originate from varying locations over a constantly changing time period.

The rainfall in mid to late 2010 was characterised by light to medium rainfall periods. Five of the six months from May to October 2010 received above monthly average rainfall, with increases between 8 – 40 mm. September was the only month where this pattern changed, down 21 mm on its monthly average (Bureau of Meteorology).

Water quality results for the most upstream site in Porters Creek at Wicks Road in Spring 2010 and Buffalo Creek downstream of Burrows Park in September indicated faecal contamination. Results for faecal coliforms, total nitrogen, oxidised nitrogen, and ammonia were also high at these sites indicating that contamination had occurred upstream. The extremely high ammonia result in September at the downstream core Porters Creek site (940 µg/L) may indicate that the peak of the faecal contamination occurred before water quality sampling for September. These results are consistently high for both the September and November samples for all sites at Porters Creek downstream of and including Wicks Road.

The indicator species used for faecal coliforms are naturally occurring, harmless inhabitants of the digestive tract of all warm-blooded animals (Boey, 1993). The occurrence of these bacteria in large numbers signifies the presence of faecal pollution and, therefore, the possible presence of pathogenic organisms that occur in faeces. A variety of factors including urban runoff, presence of waterfowl and other wildlife, waste depots, illegal dumping of waste and sewer overflows can influence faecal contamination of urban streams.

The historical averages for faecal coliforms (calculated from the results of the core site in each creek) were above the recommended guideline of 1,000 CFU/100mL (ANZECC, 2000) for three of the five creeks:

- Terrys (2,600 CFU/100mL with 2 individual exceedences)
- Porters (6,083 CFU/100mL with 6 individual exceedences) and
- Shrimptons (1,884 CFU/100mL with 4 individual exceedences).

This indicates that either or both of the individual exceedence results for Terry Creek were particularly high and contributed to the elevated historical average. A result of 60,000 CFU/100mL was recorded from Terrys Creek in Autumn 2005. If this result is removed the historical average falls to 233 CFU/100mL, indicating that the majority of faecal coliform results for this site were low with rare instances of very high results.

Archers Creek, while having a faecal coliform historical average falling below the guideline at 861 CFU/100mL, has had a higher number of exceedences; 7 individual results greater than 1,000 CFU/100mL. This indicated a more frequent lower level impact for faecal coliforms at this site.

The ammonia concentrations of 940 µg/L and 400 µg/L recorded from the core site on Porters Creek downstream of the depot were similar to the historical average for this site. All other Porters Creek sites experienced ammonia concentrations above the guideline (20 µg/L) but well below the historical core site average (806 µg/L). The ammonia result for Terrys Creek in September was also high at 870 µg/L.

Ammoniacal nitrogen is often present in sewage effluent because of the decomposition of nitrogen containing compounds in the treated waste. The un-dissociated form, ammonia (NH3) is far more toxic to aquatic life than the ionic form, ammonium (NH4+). During low pH and temperatures NH3 dissociates to the less toxic form NH4+. This is then reversed during periods of high pH and temperature.

Laboratory methods for ammonia record the nitrogen content from the ammonium (associated ionic form) ions NH4+. This ion forms compounds with other particles dissolved within the water column. It is harmless to plants and animals within the specified concentration, pH and temperature range. ANZECC (2000) has determined this to be 20 µg/L for the protection of aquatic life in lowland streams with a pH of 8 and temperature of 20^0C.

Ammonia (NH3) is a toxic by-product of NH4+ that exists as a gas, of which the N content is not measured during the routine laboratory analysis. With increasing temperature and pH, the percentage of NH3 increases exponentially and it is this compound that is detrimental to aquatic life.

Dissolved oxygen concentrations are the single most important water quality indicator for the survival of aquatic organisms and control many important physico-chemical processes. The oxygen balance in water is dependant upon physical, chemical and biochemical conditions in the water body. Oxygen input is the result of diffusion from the atmosphere and photosynthesis by algae and other aquatic plants. Dissolved oxygen removal is due to respiration by aquatic organisms, decomposition of organic matter, oxidation of chemically reduced compounds and loss to the atmosphere. The solubility of oxygen in water decreases with increasing temperature, while the respiratory rate of aquatic organisms increases with temperature (Connell, 1993).

Dissolved oxygen concentrations are often subject to large diurnal and seasonal fluctuations as a result of changes in temperature and photosynthetic rates. Therefore, a dissolved oxygen measurement taken at one time of the day may not truly represent the oxygen regime in the water body. Nevertheless, the low dissolved oxygen levels during Spring 2010 for Terrys, Shrimptons, Buffalo and

Archers creeks are an area of concern. These sites are continually showing impacted dissolved oxygen saturation levels, particularly during periods of extended low flow. Shrimptons Creek has the lowest historical average saturation level at 38.1 %. This has fallen a further 2% from the Autumn 2010 historical average of 40.1%.

Dissolved oxygen saturation levels in Porters Creek at both the core site and additional sites appeared to be at acceptable concentrations. Porters Creek has the healthiest historical average for dissolved oxygen saturation (85 % saturation) of the five creeks, having the only historical average falling within the guideline range. This is partly related to more efficient run-off transport during both wet and dry periods.

No sites on Terrys, Shrimptons, Buffalo, Porters or Archers creeks had elevated turbidity levels during Spring 2010. These results are consistent with the historical averages for these sites of which none exceed the recommended guideline of 50 NTU.

Turbidity can be caused by soil erosion, waste discharge, urban runoff, algal growth and other disturbances in the water channel. Particles can smother aquatic insects, clog fish gills, prevent egg and larval development, reduce aquatic flora and fauna growth rates and generally decrease resistance to disease.

5.2 Macroinvertebrates

Results from Spring 2010 indicate that Archers, Shrimptons, Buffalo, Porters and Terrys creeks had impaired macroinverterbrate communities, reflecting what had been observed from Spring 2004 to Autumn 2010.

ANZECC (2000) recommends that to make informed management judgements adequate baseline data is required. Baseline data allows for the determination of an acceptable level of change in an environment accounting for the natural variability of an indicator (in this case, macroinvertebrates). It is suggested by ANZECC (2000) that three to five years of data be gathered from control or reference locations for comparison.

The City of Ryde Monitoring Strategy uses comparable data from all five creeks, each of which experiences natural variations in macroinvertebrate assemblages. To date, there have been eleven seasons of comparable data for all five creeks since sampling began in Spring 2004. The current baseline data should allow for tracking of any significant changes in macroinvertebrate assemblages.

The Sydney specific SIGNAL-SF index and the NSW AUSRIVAS predictive models provide this data by the statistically defined 10th percentile of mean reference condition values. The range of each measure of stream health has been plotted in this report with a +/-1 standard deviation of the mean for basing ecological decisions. Presenting data in this way attempts to take account of variation at study sites and provide a basis for management tracking and ecological decision making (ANZECC, 2000).

A total of 2,153 macroinvertebrates were collected during the Spring 2010 sampling season. The total number of macroinvertebrates collected since Spring 2004 has fluctuated between seasons. The variation in numbers is related to changes in site and replicate sampling each sampled season. The difference in numbers is also reflective of environmental cues that influence the development of macroinvertebrate taxa rather than water quality or other in-stream factors. Taxa may not be present in the water at the time of sampling or the cohort (age class) may be too small to be retained by the 0.25 mm mesh of the net.

The measure of sensitive taxa, EPT richness, indicated very low diversity in Spring 2010. The highest average diversity of EPT taxa was at Porters Creek but was only just above one EPT taxa per sample.

Three families of EPT taxa were present in samples collected in Spring 2010. The samples consisted of three Trichopterans; Hydroptilidae, Leptoceridae, and Antipodoecidae. The Antipodoecidae is the only taxa that is an EPT indicator taxa and has been found sporadically and in low numbers during the monitoring program. It has only been found in Porters Creek.

Since the monitoring program began, only five families of EPT taxa have been sampled from the five creeks. The only consistent EPT taxa present is the Trichopteran Hydroptilidae, which has a SIGNAL2 score of 4. Although it is an EPT taxa it is considered a tolerant macroinvertebrate, as is the next most common EPT taxon the Ephemeroptera, Baetidae.

Due to these factors, EPT richness as a measure of stream health is limited in its ability to suggest any future positive impacts on stream health. The Spring 2007 report suggested that a return to average or above average rainfall conditions might influence the presence of EPT taxa. While nominal average rainfalls have returned, the presence of EPT has remained consistently low. Above average rainfall in the future may result in higher numbers and abundances of tolerant EPT taxa.

Considering the relatively low occurrence and type of EPT taxa, reference to EPT indicator taxa from the AUSRIVAS model (as per criteria of Section 3.6) is recommended. This should be done before assessing positive changes in this measure and attributing them to management activities. EPT indicator taxa are considered sensitive and their presence/absence would be a more appropriate indicator of improved stream health.

Direct measurement of stream health using SIGNAL-SF and measurement via AUSRIVAS predictive model OE50 and OE0 SIGNAL2 outcomes reflected impaired stream health for all five creeks. The multivariate analysis tools complement univariate analyses in exploring patterns of macroinvertebrate communities by looking at the chosen array of samples and all taxa recorded. The univariate analyses indicated that all five creeks had relatively similar stream health. Likewise, the multivariate analyses indicated that all creeks had relatively similar macroinvertebrate community assemblage. The exception to this was Shrimptons Creek, which showed greater variation over time and when compared to the other creeks of the monitoring program.

Archers Creek

The SIGNAL-SF index and AUSRIVAS OE50 Spring and combined season models indicated that Archers Creek was slightly healthier than the other four creeks. The AUSRIVAS OE0 SIGNAL2 Spring and combined season models place Archers Creek within the range of the other four creeks.

The analysis of Archers Creek using AUSRIVAS is greatly restricted by the absence of autumn and combined season data points since Autumn 2007 (explained further in this section). This problem has not affected the running of the spring AUSRIVAS model.

The Archers Creek SIGNAL-SF average score decreased in Spring 2010, recording its lowest average score of the program. The average stream health range is still within the range of previous spring seasons. This result is reflective of the observed trend of slightly higher stream health in autumn than in spring. The previous autumn result was the highest recorded during the monitoring program, and these changes would be related to slight seasonal variation in stream health. AUSRIVAS OE50 also indicated this seasonal trend (where data was available for analysis), as it has done for all five creeks in the program.

Results from SIMPER indicated a seasonal change in macroinvertebrate assemblages in Archers Creek. Archers Creek has higher contributions from tolerant insects in autumn than in spring. The dominant insect and non-insect taxa of Archers Creek are all tolerant. The insects tend to have slightly higher SIGNAL S-F grades than the non-insects and this may explain the trend that appears in the univariate analyses. The Archers Creek MDS ordination plots and SIMPROF dendrogram generally grouped seasons separately.

Despite marginal seasonal variation, no significant shift in community assemblages has been observed during the program by the multivariate or univariate analyses. With this in mind it is not possible to link any currently observed in-stream health shifts to past rehabilitation work on Archers Creek.

Shrimptons Creek

The univariate analyses suggest that Shrimptons Creek has, marginally, the poorest stream health of the five creeks in the program. The exception is the AUSRIVAS OE0 SIGNAL2 spring model output. The average score range overlaps with that of the other four creeks. It does, however, have the largest average score range through time of the five creeks for this model output.

In Autumn 2005, Shrimptons Creek returned the lowest SIGNAL S-F and AUSRIVAS OE50 autumn average stream health for any creek in the program. Shrimptons Creek stream health improved each season since the Autumn 2005 result, peaking in Autumn 2007. The average scores in Autumn 2007 were, generally, the highest for that creek since the program began and fell within the upper range of stream health for the four other creeks. Stream health dropped significantly in Spring 2007 and Autumn 2008 and stabilised through to Autumn 2010. Average stream health has increased slightly in Spring 2010

Despite the recent stability in stream health, Shrimptons Creek has the most varied health through time of the five creeks. This variation was clearly indicated by the MDS ordination of all five creeks. Shrimptons Creek samples are clearly separated from those of other creeks'. The SIMPROF ordination separates Shrimptons Creek samples from all other creeks in what can be considered a 'real' difference in community structure.

Ongoing rehabilitation work in Shrimptons Creek, particularly in its upper catchment, may lead to an improvement in stream health. Dissolved oxygen concentrations in a water body are one of the best indicators for the survival potential of aquatic organisms. It is significant that all of Shrimptons Creek sites have historically had very low dissolved oxygen levels making it the poorest of the five creeks of the program. Improvement in stormwater transportation and in-stream conditions of Shrimptons Creek may improve dissolved oxygen concentrations and stream health, as observed by macroinvertebrates and water quality results. However dissolved oxygen concentrations will not be the only driver limiting stream health and an improvement in this measure may not be reflected in macroinvertebrate assemblages.

Buffalo Creek

Buffalo Creek has shown a continuing improvement in stream health since its poorest recording in Spring 2008. Spring 2010 results have indicated a slight drop in stream health, but are still within the range of previous 'healthier' seasons.

The drop in stream health was indicated clearly by the SIGNAL S-F and AUSRIVAS OE50 models around the Spring 2008 season. These analyses also indicated the improvement in stream health since. The AUSRIVAS OE0

SIGNAL2 model has not indicated this same change and has continued to indicate different trends.

SIMPER results indicated a change in community structure in Spring 2008, with just three taxa contributing to 80% of the overall macroinvertebrate assemblage. These taxa were the Aquatic Snails (Physidae and Hydrobiidae) and the non-biting midge (Chironominae), all tolerant taxa. SIMPER results have since shown that the range of taxa contributing to the overall macroinvertebrate assemblages has increased significantly.

These results indicated that a new impact had limited stream health in Buffalo Creek to levels not previously observed by the program. In Autumn 2008, elevated levels of turbidity were present and observed during a site inspection. A significant build-up of sediment at the core Buffalo Creek site was observed the following Spring 2008 season.

It was suggested in the Spring 2008 report (Sydney Water, 2008b) that the loss of taxa and decline in stream health resulted from a smothering effect by fine sediment that had run-off from development in the upper catchment. This smothering has been linked to the loss of certain taxa in streams that have had an influx of fine sediment within forestry areas (Vuori & Joensuu, 1996; Death et al., 2003), which coincided with the dominance of new taxa. Death et al. (2003) found that dominant sensitive mayfly taxa were lost and that tolerant (including Chironomidae and Hydrobiidae) taxa achieved dominance when elevated levels of fine sediment were introduced to streams.

The loss of taxa and drop in stream health in Buffalo Creek could be reversed if the source of sediment was controlled or was only a short-term impact. Wood & Armitage (1997) suggested that short-term increases in fine sediment due to human disturbances, such as construction developments, could precede a rapid recovery. Results since Spring 2008 suggest that a recovery has occurred and that the impact was short term.

Porters Creek

The highest spring SIGNAL S-F average score was recorded in Spring 2010 and the AUSRIVAS models indicated that Spring 2010 was in the higher range of stream health. The SIGNAL S-F average score was still slightly lower than the previous autumn season, which is a trend that has been observed during the monitoring program.

Porters Creek has shown a seasonal trend of marginally higher stream health in Autumn than in Spring. This trend is evident in both SIGNAL S-F average scores and AUSRIVAS OE50, the latter showing this trend for all five creeks of the program. SIMPER results indicate higher abundances of tolerant insects in Autumn and higher abundances of tolerant non-insects in Spring. As for the trend in Archers Creek, there are slightly higher SIGNAL S-F scores for insects than for non-insects in Porters Creek. Multivariate results for Porters Creek suggest that there is little variation in its macroinvertebrate assemblages through time. The variation that does occur is a general separation of samples from autumn and spring.

Terrys Creek

Macroinvertebrate results for Terrys Creek have shown very little variation through time since first sampled in Spring 2004. The SIGNAL S-F average score decreased slightly in Spring 2010 and the AUSRIVAS OE0 SIGNAL2 spring edge model increased slightly. No noticeable difference was observed in the AUSRIVAS OE50 spring edge output.

The multivariate results in the form of the MDS ordination and SIMPROF dendrogram show little variation in Terrys Creek macroinvertebrate assemblages. In Autumn 2010 samples separated in the SIMPROF dendrogram and in the respective MDS ordination. SIMPER results complemented these observations, indicating that there was a shift in taxa present in Terrys Creek. Spring 2010 samples are similar to those previously sampled during the monitoring program, and this is indicated in the multivariate analyses.

Combined Creeks

The univariate and multivariate results indicate that the five creeks of the monitoring program have similar stream health when compared to one another and amongst seasons. Similarly, not many significant shifts in macroinverterbate community assemblages have occurred. Exceptions have occurred in both Shrimptons and Buffalo creeks, which have been indicated by most of the data analyses. These were not linked to capital works on the creeks. This means that, as yet, no significant impact has been observed from creek rehabilitation work carried out by Ryde Council. However, if an improvement in stream health does occur due to creek rehabilitation it will be evidenced in the data and analyses.

Some observations of the univariate analyses produce limitations on reporting. AUSRIVAS OE0 SIGNAL2 is at times contradictory to the other analyses. The Spring/Autumn seasonal trend in Archers and Porters creeks is an example of this. The most notable limitation occurs with the AUSRIVAS autumn edge model output for Archers Creek. The output describes the data being outside the experience of the model, resulting in three missing data points for the Autumn model and two combined season outputs. This limits the ability to compare and track changes in stream health for that creek. The combination of the physical and biological data was not typical of reference material used by the AUSRIVAS Autumn eastern edge model. Changes to the stream channel of Archers Creek, combined with few AUSRIVAS reference sites situated in the Sydney region, may explain the result.

The attempt to link water quality patterns to macroinvertebrate patterns using the multivariate BIOENV routine produced weak to moderate correlations for each individual creek, and the highlighted variables were varied.

The strongest BIOENV result of the Spring 2010 period was at Porters Creek, returning 0.446. This is only a moderate correlation, the rest of the creeks returned only weak correlations. A stronger correlation would be needed to suggest any direct connection between the water quality variables and the macroinvertebrate community assemblages, as assessed in the program. The BIOENV result for all five creeks was mild (0.401) and highlighted total oxidised nitrogen, conductivity, dissolved oxygen, and ratio of number of outlets/catchment area.

The weak to mild correlations of these extrinsic variables suggest that the respective macroinvertebrate community structures of each creek are not predominantly influenced by these water quality variables as measured. This suggests that physico-chemical analytes measured to date under the strategy are not the only drivers of the shifts recorded in macroinvertebrate community structure. As such, efforts to improve water quality should not solely concentrate on variables measured to date.

Research conducted in the greater Melbourne area that looked at water quality, epilithic diatoms, benthic algae and macroinvertebrate indicators suggested that minimisation of directly piped stormwater drainage connection of impervious surfaces was beneficial in mitigation of urban impacts on receiving streams (Hatt et al., 2004; Walsh, 2004; Taylor et al. 2004; Newall & Walsh, 2005). The primary degrading process in urban steams was suggested to be effective imperviousness (the proportion of a catchment covered by impervious surfaces directly connected to the stream by stormwater pipes) (Walsh et al., 2005a). This is provided that sewer overflows, sewage treatment plant discharges, or long-lived pollutants from earlier land uses are not operable, as these can obscure stormwater impacts (Walsh et al., 2005b). Walsh (2004) determined that community composition was strongly explained by the gradient of urban density, observing that most sensitive taxa were absent from urban sites with greater than 20% connection of impervious surfaces to streams by pipes.

The direct connection of impervious surfaces to a stream allows small rainfall events to produce surface runoff that causes frequent disturbance to the stream through regular delivery of water and pollutants (Walsh et al., 2005). In catchments with existing drainage networks such as those in the City of Ryde, policies that facilitate infiltration, evaporation and transpiration or storage for later in-house use will gradually benefit stream health in the longer term, based on outcomes of the research conducted in Melbourne.

6 Comments on progress of strategy aims

The section places the current knowledge of sampling data consolidated in this report within the context of the aims detailed in the City of Ryde's request for the engagement of consultants No COR-RFQ-29/09.

- Evaluate chemical and biological water quality monitoring both for short and long term interpretation and temporal evaluation over the duration of the strategy;

  Consolidation of available comparable data was conducted in the Spring 2006 report. Analysis of all data in reports after Spring 2006 has also incorporated this available comparable historical data. Continued sampling across all five streams has allowed statistical analysis to identify temporal shifts in community structure across seasons and under varying climatic conditions. Investigation of the data in this way has and will continue in subsequent reports. Providing a better understanding of variation between autumn and spring seasons and between different climatic conditions. This will provide better base line data to assess changes in community structure that may result from future City of Ryde management actions.

- Detail where, when and how often samples should be taken from creeks within the Ryde Local Government Area based on existing site data, catchment position, accessibility and trends identified;

  Recommendations made in the Spring 2006 report to sample all creeks in each sample session have been implemented. Allowing capture of the natural variation through time and under different weather conditions that influence the five study streams. Benefits of sampling all five creeks are detailed above and in the last paragraph of this section. It was also suggested to move from three sampling occasions per season to two, and this was implemented.

  At the conclusion of the current monitoring program, suggestions will be made regarding the design of future monitoring using water quality variables and macroinvertebrates.

- Prescribe how to sample for macroinvertebrates, building on the standard protocols designed by AUSRIVAS;

  Adoption of a standard methodology under the strategy allows for collection of comparable data and in turn statistical analysis of comparable measures, which facilitates interpretation of collected data.

- Provide for a series of options for identification of key indicator taxa to family and or morphospecies;

  This is provided by EPT indicator taxa from AUSRIVAS predicted model output. SIGNAL-SF grades could also be used to assess key indicator taxa. With only two EPT indicator taxa recorded to date, no advantage is afforded by SIGNAL-SF at this stage.

- Identify a standard suite of analyses to determine status and trends in water quality including calculation of the AUSRIVAS index;

  Suitable indices, such as SIGNAL SF to assess water quality status including calculation of the Observed/Expected (OE50 and OE0 SIGNAL2) ratios from the respective AUSRIVAS predictive models for autumn, spring, and combined seasons were evaluated in Spring 2006 with subsequent recommendation made and these have been implemented. Multivariate statistical analysis techniques have also been incorporated into Spring 2006 to the current Spring 2010 reports. A change was made to the routine used to assess water quality and macroinvertebrates linkages in Spring 2006 with the BIOENV routine employed instead of the BVSTEP routine which conducts a less thorough search. This change was made given the relatively small amount of water quality variables and suitable computing power was available to conduct a full search of the data with BIOENV. In the Spring 2008 the SIMPROF test was added, due to recent advances in multivariate statistical software.

Any future advances or alternative methods will be implemented if it is foreseen they could be beneficial to the data analysis methods. Likewise suggestions will be made on how the analyses could be streamlined or redirected for future monitoring programs.

- Provide the basis for an appraisal of the capacity of a standard monitoring strategy to be integrated into a community-monitoring program eg. Streamwatch.

Suggestions were put forward in the Spring 2006 and Autumn 2007 reports for use of SIGNAL2 in a format that could be calculated by community groups without access to the AUSRIVAS predictive models. In the 2007 report, calibration was made for boundary points of water quality status so community groups could use this analysis in the City of Ryde area. Standard collection methods would need to be used and suitable quality control of data would need to be implemented to provide comparability of data through time.

- Provide the foundation to augment the Streamwatch capacity within the City of Ryde including options for improved education awareness of water quality issues within schools and community groups.

As above.

- Provide information and direction on potential infrastructural works to complement water quality monitoring and improve overall creek health.

The consolidation of available comparable data that has occurred and additional sampling will allow capture of variation through time and under different weather conditions in each of the five study streams. Continued average rainfall conditions or better would be advantageous to allow capture of variation in community structure and water quality under wetter conditions. Understanding variation between autumn and spring and under different weather conditions will provide better base line data to assess changes in community structure that may result from future City of Ryde management actions.

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Appendix 1 Quality Assurance

Sydney Water Analytical Services is a quality business organisation, certified to AS/NZS ISO 9001:2008 Quality management systems - requirements certification number 18533-2008-AQ-AUS-JAS-ANZ, issued by Det Norske Veritas (DNV) on 28th December 2007 for the Monitoring Process Management System. All investigations performed for the production of this report, and all business operations of the organisation, have been conducted to the requirements of this standard including project management, macroinvertebrate sampling, water quality sampling and interpretive reporting.

Macroinvertebrates have been identified and enumerated to the genus or species taxonomic level, (as appropriate for the study) by the Aquatic Ecology team. The method used SSWI433 In-house test method macroinvertebrate cataloguing, identification and counting is in compliance with the requirements of AS ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories was added under technical accreditation number 610 issued by National Association of Testing Authorities (NATA) in 1997. In particular macroinvertebrate identification was performed with appropriate published keys listed in Hawking (2000), internal keys to the macroinvertebrate collection, unpublished descriptions and voucher specimens. Where a specimen could not be keyed to a formally described species, a morphospecies number has been assigned as per in-house test method SSWI433. Terrestrial macroinvertebrate morphospecies have been shown to produce similar patterns to those obtained using formally described species (Oliver and Beattie, 1996).

Quality assurance was conducted as per SSWI434 In-house test method quality control of macroinvertebrate identification, counting and archiving of collections in compliance with the requirements of AS ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories was added under technical accreditation number 610 in 1997. Quality assurance was conducted on at least 5% of samples collected for this study, and identification and counting errors on average are less than 10% for the study.

Appendix 2 Water Quality Results

Stream	Site Code	Season	Sample Date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temp. °C
Terrys Ck	Site 1	Spring 2010	04/11/10	230	30	480	35	350	830	61.9	5.05	420	251	7.09	8.6	15.8
Shrimptons Ck	Site 2	Spring 2010	04/11/10	330	50	670	44	580	1250	65	5.89	458	280	6.88	6.6	16.9
Porters Ck	Site 3	Spring 2010	04/11/10	350	400	1050	26	970	2020	89.0	3.05	451	260	7.34	9.1	16.4
Buffalo Ck	Site 4	Spring 2010	04/11/10	270	30	1090	29	470	1560	69.2	6.92	523	332	7.37	9.1	16.4
Archers Ck	Site 5	Spring 2010	04/11/10	690	10	980	44	490	1470	71.8	5.42	700	418	6.56	6.8	16.1
Terrys Ck	Site 1	Spring 2010	30/09/10	280	870	90	136	1360	1350	69.7	2.27	582	461	7.40	7.6	12.4
Shrimptons Ck	Site 2	Spring 2010	30/09/10	450	50	190	41	340	530	57.8	3.33	325	189	7.20	4.6	17.7
Porters Ck	Site 3	Spring 2010	30/09/10	40	940	1420	30	1350	2770	85.3	3.89	439	360	7.65	10.5	13.7
Buffalo Ck	Site 4	Spring 2010	30/09/10	240	10	250	28	520	770	73.0	4.36	751	538	7.30	8.3	13.2
Archers Ck	Site 5	Spring 2010	30/09/10	29	50	90	20	470	560	81.3	1.64	1562	1159	6.86	6.8	12.8
Terrys Ck	Site 1	Autumn 2010	15/04/10	38	10	230	31	310	540	59	1.51	328	208	7.21	6.9	15.2
Shrimptons Ck	Site 2	Autumn 2010	15/04/10	200	40	90	57	310	400	70	3.54	306	177	7.16	4.6	16.2
Porters Ck	Site 3	Autumn 2010	15/04/10	600	560	1950	18	800	2750	91	4.29	478	309	7.75	9.0	17.5
Buffalo Ck	Site 4	Autumn 2010	15/04/10	30	40	170	18	260	430	69	2.24	694	412	7.44	8.0	16.6
Archers Ck	Site 5	Autumn 2010	15/04/10	240	30	30	14	260	290	86	2.42	445	261	7.16	5.9	20.9
Terrys Ck	Site 1	Autumn 2010	15/03/10	430	60	500	21	460	960	67.9	2.03	690	433	7.13	6.5	17.9
Shrimptons Ck	Site 2	Autumn 2010	15/03/10	6200	50	200	46	500	700	71.2	4.91	515	320	7.04	4.3	18.8
Porters Ck	Site 3	Autumn 2010	15/03/10	~88000	550	1070	39	1160	2230	82.2	2.92	377	240	7.75	8.3	21.6
Buffalo Ck	Site 4	Autumn 2010	15/03/10	1800	60	190	48	460	650	52.2	3.17	400	250	7.06	6.7	20.3
Archers Ck	Site 5	Autumn 2010	15/03/10	290	30	310	22	380	690	72	1.3	410	240	7.05	5.2	19.7
Terrys Ck	Site 1	Spring 2009	02/11/09	320	190	200	70	540	740	57.8	40.1	329	187	7.58	6.5	13.0
Shrimptons Ck	Site 2	Spring 2009	02/11/09	490	<10	<10	243	1290	1290	69.6	8.7	381	219	7.54	3.7	15.2
Porters Ck	Site 3	Spring 2009	02/11/09	280	810	1510	16	1050	2560	73.2	3.7	388	219	8.24	9.6	17.3
Buffalo Ck	Site 4	Spring 2009	02/11/09	~160	20	60	53	370	430	84.2	4.3	880	486	8.01	7.9	17.3
Archers Ck	Site 5	Spring 2009	02/11/09	500	100	20	39	380	400	57.2	3.1	280	161	6.94	3.4	13.5
Terrys Ck	Site 1	Spring 2009	30/09/09	39	20	170	31	260	430	61.9	4.0	482	263	7.21	6.2	18.0
Shrimptons Ck	Site 2	Spring 2009	30/09/09	280	50	280	48	400	680	74.3	4.6	462	275	7.18	5.6	19.6
Porters Ck	Site 3	Spring 2009	30/09/09	6700	810	1200	39	1180	2380	92.2	8.6	442	199	7.81	8.4	19.6
Buffalo Ck	Site 4	Spring 2009	30/09/09	570	70	290	37	430	720	87.7	4.7	758	424	7.40	7.5	22.2
Archers Ck	Site 5	Spring 2009	30/09/09	640	40	390	34	340	730	53.6	2.9	327	187	7.51	9.3	25.0
Terrys Ck	Site 1	Autumn 2009	19/03/09	67	10	260	25	350	610	72.0	2.9	525	282	7.60	7.2	18.0
Shrimptons Ck	Site 2	Autumn 2009	19/03/09	1200	<10	90	43	510	600	70.1	2.8	377	220	7.34	0.2	19.4

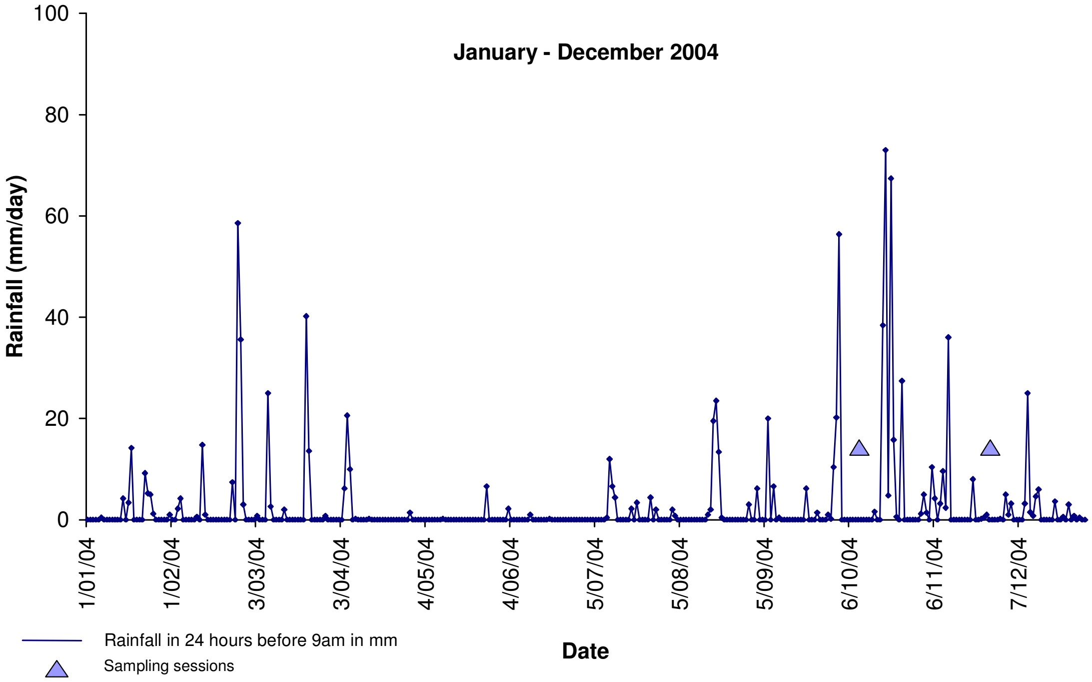
Stream	Site Code	Season	Sample Date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temp. °C
Porters Ck	Site 3	Autumn 2009	19/03/09	3000	820	1290	27	1490	2780	106.0	2.9	487	266	7.75	8.3	20.4
Buffalo Ck	Site 4	Autumn 2009	19/03/09	240	20	580	31	520	1100	89.0	7.0	886	490	7.33	4.7	17.8
Archers Ck	Site 5	Autumn 2009	19/03/09	4800	1220	1380	171	1760	3140	78.5	2.2	517	278	7.42	5.8	17.8
Terrys Ck	Site 1	Autumn 2009	01/05/09	140	<10	180	20	240	420	64.8	2.1	518	300	7.55	7.9	12.5
Shrimptons Ck	Site 2	Autumn 2009	01/05/09	350	<10	140	34	340	480	81.5	2.1	481	289	7.45	7.4	14.5
Porters Ck	Site 3	Autumn 2009	01/05/09	~190	860	1350	21	1010	2360	86.3	4.0	449	268	7.75	9.4	16.0
Buffalo Ck	Site 4	Autumn 2009	01/05/09	92	<10	330	20	310	640	72.2	4.3	708	408	7.53	7.8	14.0
Archers Ck	Site 5	Autumn 2009	01/05/09	~1700	<10	860	31	270	1130	67.3	2.7	472	269	7.84	8.5	12.8
Terrys Ck	Site 1	Spring 2008	16/09/08	~820	10	120	35	370	490	41.5	11.5	254	149	7.20	7.8	14.6
Shrimptons Ck	Site 2	Spring 2008	16/09/08	240	20	250	54	440	690	51.0	8.9	278	155	7.10	3.8	16.1
Porters Ck	Site 3	Spring 2008	16/09/08	260	4000	1660	24	4520	6180	130.0	5.5	611	336	7.70	9.6	14.7
Buffalo Ck	Site 4	Spring 2008	16/09/08	820	10	450	42	400	850	79.5	10.8	524	293	7.34	7.2	14.9
Archers Ck	Site 5	Spring 2008	16/09/08	270	10	670	19	350	1020	82.5	2.7	555	311	7.67	10.4	13.7
Terrys Ck	Site 1	Spring 2008	13/10/08	~80	20	140	52	440	580	74.0	3.0	509	281	7.13	3.6	14.1
Shrimptons Ck	Site 2	Spring 2008	13/10/08	420	120	30	197	900	930	67.0	3.9	301	171	7.14	0.0	16.8
Porters Ck	Site 3	Spring 2008	13/10/08	48	980	1870	26	1410	3280	91.5	4.9	456	251	7.40	7.3	16.3
Buffalo Ck	Site 4	Spring 2008	13/10/08	~84	130	90	41	540	630	96.5	13.2	1008	573	7.16	0.3	17.1
Archers Ck	Site 5	Spring 2008	13/10/08	220	50	380	33	370	750	85.5	2.7	501	279	7.25	3.4	16.5
Terrys Ck	Site 1	Autumn 2008	03/05/08	150	10	270	24	310	580	71.5	3.2	474	284	8.00	8.4	21.9
Shrimptons Ck	Site 2	Autumn 2008	03/05/08	200	10	10	53	670	680	74.0	3.2	358	214	7.40	5.8	17.3
Porters Ck	Site 3	Autumn 2008	03/05/08	530	250	430	38	1100	1530	81.0	15.2	650	444	7.60	6.7	19.3
Buffalo Ck	Site 4	Autumn 2008	03/05/08	620	40	450	35	370	820	91.0	37.2	885	552	8.10	6.8	21.0
Archers Ck	Site 5	Autumn 2008	03/05/08	170	30	370	20	290	660	77.5	2.2	513	310	7.30	6.5	19.8
Terrys Ck	Site 1	Autumn 2008	04/03/08	250	10	120	25	200	320	64.0	3.1	351	160	7.32	8.3	15.7
Shrimptons Ck	Site 2	Autumn 2008	04/03/08	700	10	10	92	620	620	73.0	6.2	291	130	7.16	3.8	16.8
Porters Ck	Site 3	Autumn 2008	04/03/08	370	750	300	27	1100	4100	100.0	4.0	505	290	7.56	9.3	16.9
Buffalo Ck	Site 4	Autumn 2008	04/03/08	120	50	220	33	260	480	77.0	4.7	654	389	7.30	8.0	15.8
Archers Ck	Site 5	Autumn 2008	04/03/08	160	40	110	22	230	340	83.0	1.5	470	253	7.28	7.1	16.7
Terrys Ck	Site 1	Spring 2007	27/09/07	87	20	190	21	290	480	67.0	2.0	503	276	7.30	6.0	14.0
Shrimptons Ck	Site 2	Spring 2007	26/09/07	300	160	30	54	650	680	72.0	2.6	403	232	7.10	2.4	16.9
Porters Ck	Site 3	Spring 2007	27/09/07	1000	2600	3200	60	3110	6310	122.0	6.7	671	372	7.80	6.5	15.0
Buffalo Ck	Site 4	Spring 2007	27/09/07	54	40	170	37	440	610	90.0	7.3	960	484	7.30	5.7	19.0

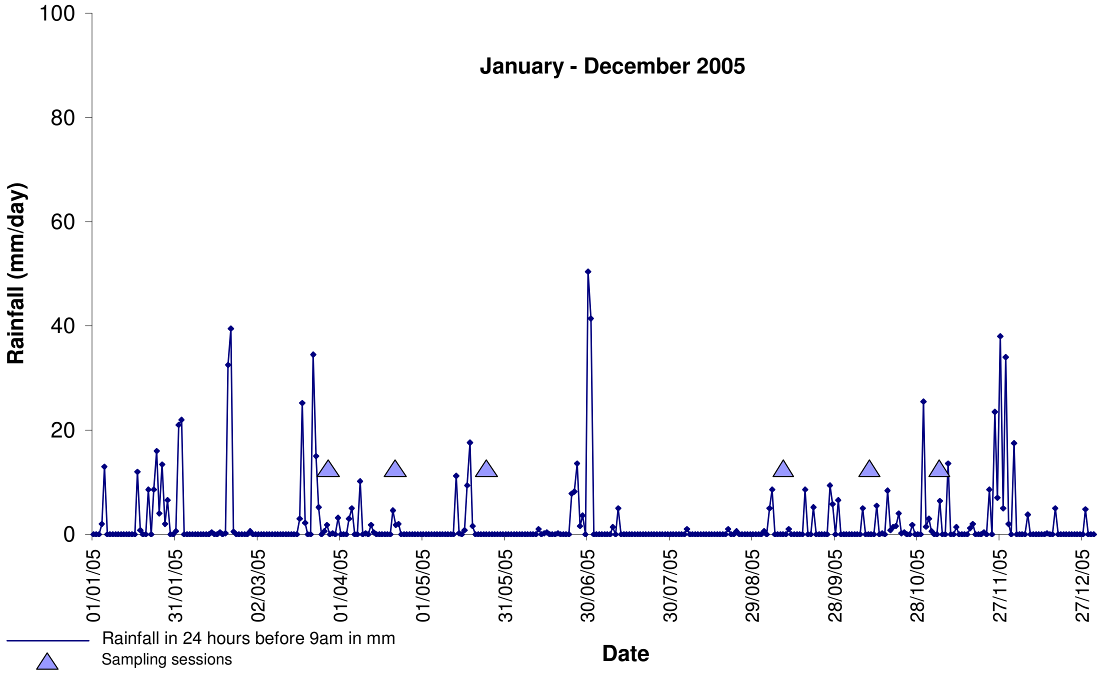
Stream	Site Code	Season	Sample Date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temp. °C
Archers Ck	Site 5	Spring 2007	26/09/07	270	20	480	26	680	1160	59.0	3.2	527	304	7.50	6.3	15.1
Terrys Ck	Site 1	Spring 2007	23/10/07	6	40	80	35	730	810	88.0	1.6	712	437	7.00	4.0	15.6
Shrimptons Ck	Site 2	Spring 2007	22/10/07	150	<10	<10	111	1000	1000	77.0	11.9	519	350	6.70	2.9	19.8
Porters Ck	Site 3	Spring 2007	23/10/07	160	1020	2600	68	1580	4180	90.0	8.2	505	326	7.70	7.3	19.3
Buffalo Ck	Site 4	Spring 2007	23/10/07	140	110	60	73	790	850	108.0	7.7	1001	621	7.20	7.0	20.4
Archers Ck	Site 5	Spring 2007	22/10/07	90	150	50	57	480	530	74.0	7.1	378	220	6.70	3.9	17.3
Terrys Ck	Site 1	Autumn 2007	14-15/03/07	300	<10	370	30	280	650	64.0	1.6	472	358	7.20	5.1	18.1
Shrimptons Ck	Site 2	Autumn 2007	14-15/03/07	600	<10	550	58	330	880	64.0	2.9	362	276	7.10	3.2	20.6
Porters Ck	Site 3	Autumn 2007	14-15/03/07	600	580	1310	51	1040	2350	97.0	1.3	3030	2010	7.90	8.4	19.3
Buffalo Ck	Site 4	Autumn 2007	14-15/03/07	68	90	120	48	440	560	75.0	2.1	646	442	7.30	5.1	19.5
Archers Ck	Site 5	Autumn 2007	14-15/03/07	290	<10	170	89	270	440	64.0	0.9	397	300	7.20	4.6	20.8
Terrys Ck	Site 1	Autumn 2007	17-18/04/07	900	110	200	53	530	730	57.0	2.7	438	.	7.10	5.3	17.2
Shrimptons Ck	Site 2	Autumn 2007	17-18/04/07	550	30	160	45	490	650	81.0	8.4	397	.	6.90	3.8	17.6
Porters Ck	Site 3	Autumn 2007	17-18/04/07	10000	710	1590	20	1200	2790	98.0	3.2	3130	.	7.80	7.7	18.0
Buffalo Ck	Site 4	Autumn 2007	17-18/04/07	740	130	120	48	540	660	81.0	8.6	912	.	6.70	3.8	17.2
Archers Ck	Site 5	Autumn 2007	17-18/04/07	210	30	50	58	520	570	70.0	4.2	322	.	7.20	4.1	18.7
Shrimptons Ck	Site 2	Spring 2006	28/09/06	69	130	140	64	580	720	94.0	7.8	717	420	7.12	4.3	17.3
Archers Ck	Site 5	Spring 2006	28/09/06	160	<10	<10	104	520	520	83.0	2.0	509	293	7.37	6.5	15.4
Shrimptons Ck	Site 2	Spring 2006	18/10/06	560	10	20	136	1180	1200	66.0	6.3	481	311	6.54	2.2	17.2
Archers Ck	Site 5	Spring 2006	18/10/06	340	<10	10	90	500	510	70.0	2.3	448	295	6.93	3.9	18.3
Shrimptons Ck	Site 2	Spring 2006	10/11/06	880	70	1200	68	800	2000	58.0	96.7	384	265	7.41	4.2	17.5
Archers Ck	Site 5	Spring 2006	10/11/06	1700	20	40	50	360	400	84.0	1.8	502	310	7.21	7.2	18.6
Terrys Ck	Site 1	Autumn 2006	9-10/03/06	160	<10	60	30	310	370	50.0	2.3	381	180	6.80	5.0	20.2
Shrimptons Ck	Site 2	Autumn 2006	9-10/03/06	330	40	<10	50	380	390	85.0	4.6	435	230	6.70	2.1	21.1
Porters Ck	Site 3	Autumn 2006	9-10/03/06	9800	820	760	20	1500	2300	48.0	1.9	3712	2200	7.40	7.4	25.2
Buffalo Ck	Site 4	Autumn 2006	9-10/03/06	220	130	470	70	500	1000	90.0	8.0	738	390	7.20	4.4	22.1
Archers Ck	Site 5	Autumn 2006	9-10/03/06	140	90	80	100	520	600	95.0	2.5	1482	830	7.00	4.1	20.6
Terrys Ck	Site 1	Autumn 2006	19-20/04/06	560	450	90	100	1100	1200	45.0	3.2	306	180	7.00	2.4	15.7
Shrimptons Ck	Site 2	Autumn 2006	19-20/04/06	860	30	30	80	480	510	40.0	5.0	281	160	6.70	4.6	16.8
Porters Ck	Site 3	Autumn 2006	19-20/04/06	290	350	630	20	700	1300	45.0	2.3	3792	2100	7.60	8.3	19.8
Buffalo Ck	Site 4	Autumn 2006	19-20/04/06	170	90	450	60	470	920	70.0	5.1	749	400	7.20	4.6	19.2
Archers Ck	Site 5	Autumn 2006	19-20/04/06	240	90	470	70	390	860	45.0	4.1	259	150	7.10	4.4	18.4

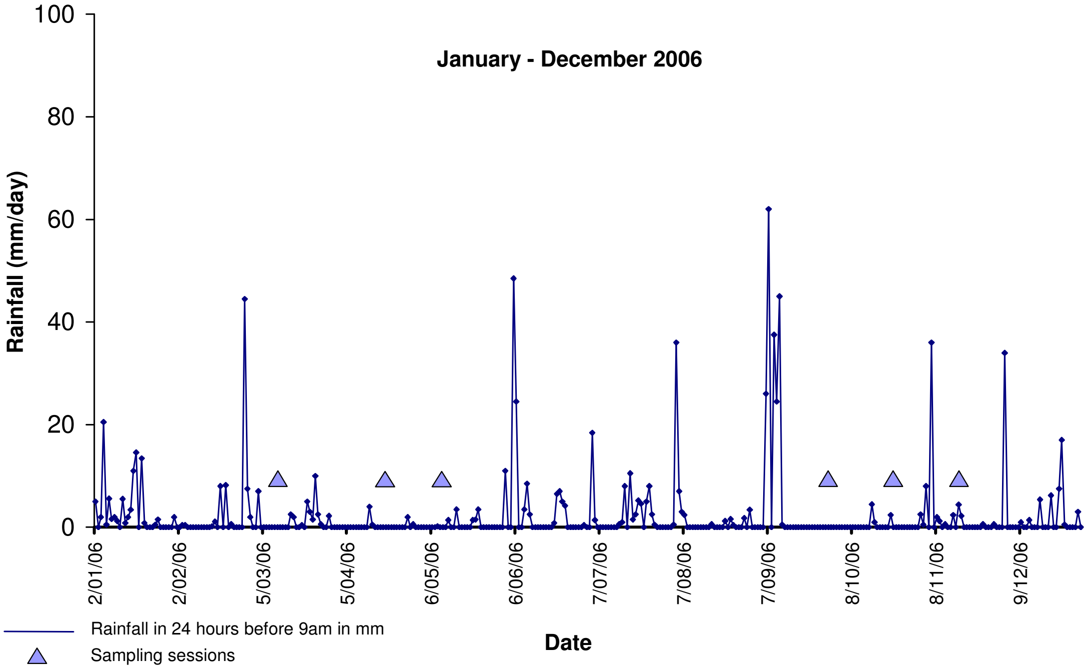
Stream	Site Code	Season	Sample Date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temp. ^{o}C
Terrys Ck	Site 1	Autumn 2006	9-10/05/06	66	70	240	50	380	620	60.0	2.4	358	220	7.10	4.0	11.9
Shrimptons Ck	Site 2	Autumn 2006	9-10/05/06	750	20	40	80	340	380	35.0	7.7	264	140	6.80	5.0	13.1
Porters Ck	Site 3	Autumn 2006	9-10/05/06	40	400	650	10	800	1400	1.0	1.2	2916	1700	7.30	8.3	15.3
Buffalo Ck	Site 4	Autumn 2006	9-10/05/06	110	60	480	60	240	720	90.0	4.4	667	400	7.30	4.7	11.7
Archers Ck	Site 5	Autumn 2006	9-10/05/06	28	50	370	40	300	670	55.0	5.1	245	120	7.20	6.3	12.4
Terrys Ck	Site 1	Spring 2005	6-7/09/05	300	59	48	10	900	140	43.0	6.5	187	140	6.70	8.1	11.1
Shrimptons Ck	Site 2	Spring 2005	6-7/09/05	90	5	37	40	280	65	42.0	7.0	164	140	6.70	4.3	12.9
Porters Ck	Site 3	Spring 2005	6-7/09/05	500	110	58	20	2400	300	37.0	3.0	6141	4000	7.00	8.7	12.8
Buffalo Ck	Site 4	Spring 2005	6-7/09/05	16	10	50	80	270	77	79.0	5.5	620	380	7.00	6.2	13.2
Archers Ck	Site 5	Spring 2005	6-7/09/05	2000	17	26	110	560	82	56.0	10.0	245	160	6.80	5.6	14.7
Terrys Ck	Site 1	Spring 2005	11-12/10/05	2000	10	33	10	520	85	47.0	2.2	245	180	7.10	4.5	13.6
Shrimptons Ck	Site 2	Spring 2005	11-12/10/05	32000	16	36	100	540	90	43.0	3.9	246	150	7.20	3.3	15.7
Porters Ck	Site 3	Spring 2005	11-12/10/05	16000	54	51	50	1300	180	31.0	4.5	3965	2600	7.60	8.7	17.9
Buffalo Ck	Site 4	Spring 2005	11-12/10/05	6500	26	63	200	700	130	44.0	29.0	472	210	7.60	9.2	16.1
Archers Ck	Site 5	Spring 2005	11-12/10/05	3800	6	54	100	500	100	30.0	5.1	206	100	7.30	4.6	20.6
Terrys Ck	Site 1	Spring 2005	02/11/05	380	<1	2	40	370	39	37.0	1.0	159	110	6.50	5.4	20.8
Shrimptons Ck	Site 2	Spring 2005	02/11/05	500	6	19	60	450	64	50.0	6.1	226	150	6.60	5.2	22.2
Porters Ck	Site 3	Spring 2005	02/11/05	260	83	42	<10	2100	250	30.0	6.4	5633	3500	7.10	7.9	23.4
Buffalo Ck	Site 4	Spring 2005	02/11/05	2000	5	28	50	350	63	60.0	4.1	299	200	7.00	5.7	21.0
Archers Ck	Site 5	Spring 2005	02/11/05	640	6	18	40	560	74	79.0	12.6	350	210	6.90	5.6	25.1
Terrys Ck	Site 1	Autumn 2005	30-31/03/05	60000	590	170	100	800	970	40.0	42.0	315	130	7.20	8.4	16.9
Shrimptons Ck	Site 2	Autumn 2005	30-31/03/05	3400	20	240	40	280	520	52.0	9.0	305	170	6.70	4.5	17.1
Porters Ck	Site 3	Autumn 2005	30-31/03/05	1000	670	820	40	1100	1900	99.0	18.9	1719	1100	7.30	7.6	18.3
Buffalo Ck	Site 4	Autumn 2005	30-31/03/05	36	130	290	30	370	660	59.0	17.4	241	140	7.60	8.4	17.8
Archers Ck	Site 5	Autumn 2005	30-31/03/05	360	20	50	60	350	400	68.0	22.2	183	180	7.10	7.5	19.6
Terrys Ck	Site 1	Autumn 2005	26-27/04/05	90	70	140	40	300	440	62.0	1.7	264	180	6.60	6.6	15.8
Shrimptons Ck	Site 2	Autumn 2005	26-27/04/05	940	40	100	30	270	370	65.0	3.2	236	160	6.40	5.7	17.3
Porters Ck	Site 3	Autumn 2005	26-27/04/05	220	400	590	20	1100	1700	35.0	3.6	2520	1800	7.20	8.8	18.3
Buffalo Ck	Site 4	Autumn 2005	26-27/04/05	520	80	940	40	.	770	95.0	7.6	548	390	6.70	5.4	16.6
Archers Ck	Site 5	Autumn 2005	26-27/04/05	300	40	20	10	240	260	78.0	1.4	261	160	6.80	5.8	17.4
Terrys Ck	Site 1	Autumn 2005	26-27/05/05	130	40	110	30	260	370	61.0	1.8	325	180	7.30	8.3	10.8
Shrimptons Ck	Site 2	Autumn 2005	26-27/05/05	400	40	290	30	.	560	65.0	4.9	333	180	7.20	5.7	11.9

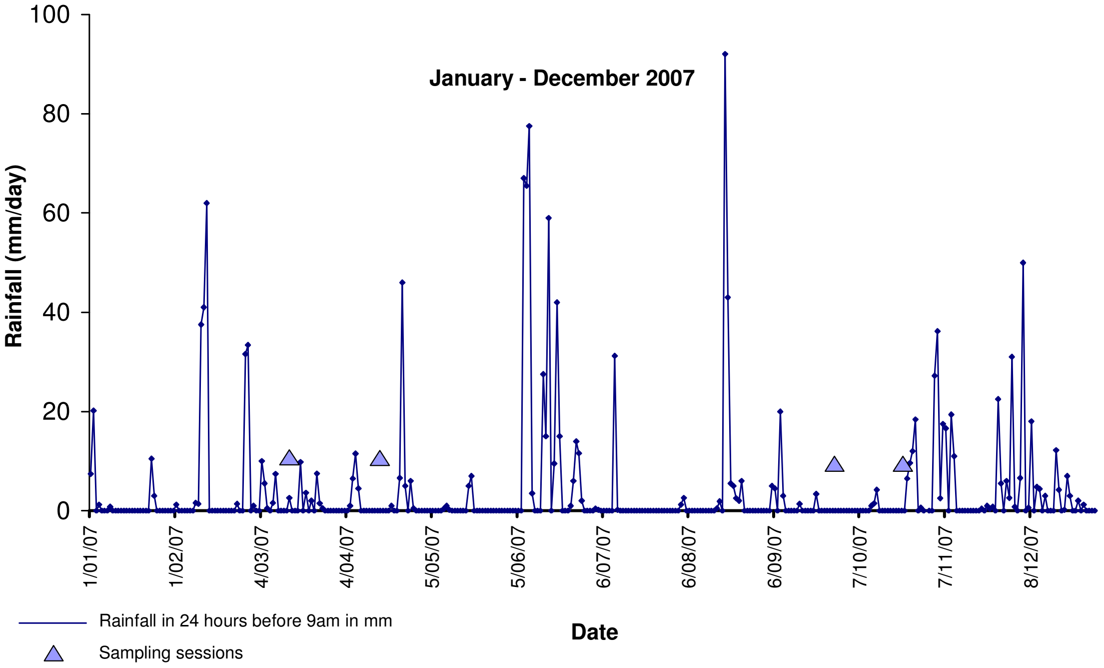
Stream	Site Code	Season	Sample Date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temp. ^{O}C
Porters Ck	Site 3	Autumn 2005	26-27/05/05	59	350	640	20	1100	1700	30.0	1.5	2305	1500	7.80	10.0	15.6
Buffalo Ck	Site 4	Autumn 2005	26-27/05/05	170	90	350	40	300	650	92.0	7.1	641	360	7.50	7.4	12.6
Archers Ck	Site 5	Autumn 2005	26-27/05/05	360	60	70	20	310	380	99.0	3.3	376	200	7.40	8.1	10.8
Terrys Ck	Site 1	Spring 2004	14-15/09/04	80	.	.	110	.	.	50.0	2.4	.	150	6.80	5.1	10.6
Shrimptons Ck	Site 2	Spring 2004	14-15/09/04	880	.	.	90	.	.	58.0	3.1	.	140	6.80	2.2	11.8
Archers Ck	Site 5	Spring 2004	14-15/09/04	650	.	.	150	.	.	70.0	0.6	.	110	7.00	6.5	13.3
Terrys Ck	Site 1	Spring 2004	11-12/10/04	44	.	.	30	.	.	64.0	0.3	.	310	7.60	5.0	16.1
Shrimptons Ck	Site 2	Spring 2004	11-12/10/04	110	.	.	60	.	.	76.0	0.5	.	260	7.40	5.7	18.5
Archers Ck	Site 5	Spring 2004	11-12/10/04	1500	.	.	50	.	.	82.0	0.8	.	230	7.50	4.3	18.6
Terrys Ck	Site 1	Spring 2004	23-24/11/04	150	.	.	40	.	.	56.0	2.6	.	180	6.70	6.9	15.5
Shrimptons Ck	Site 2	Spring 2004	23-24/11/04	1000	.	.	90	.	.	75.0	11.5	.	190	6.40	2.9	17.0
Archers Ck	Site 5	Spring 2004	23-24/11/04	1700	.	.	40	.	.	84.0	4.7	.	270	6.60	8.0	17.2

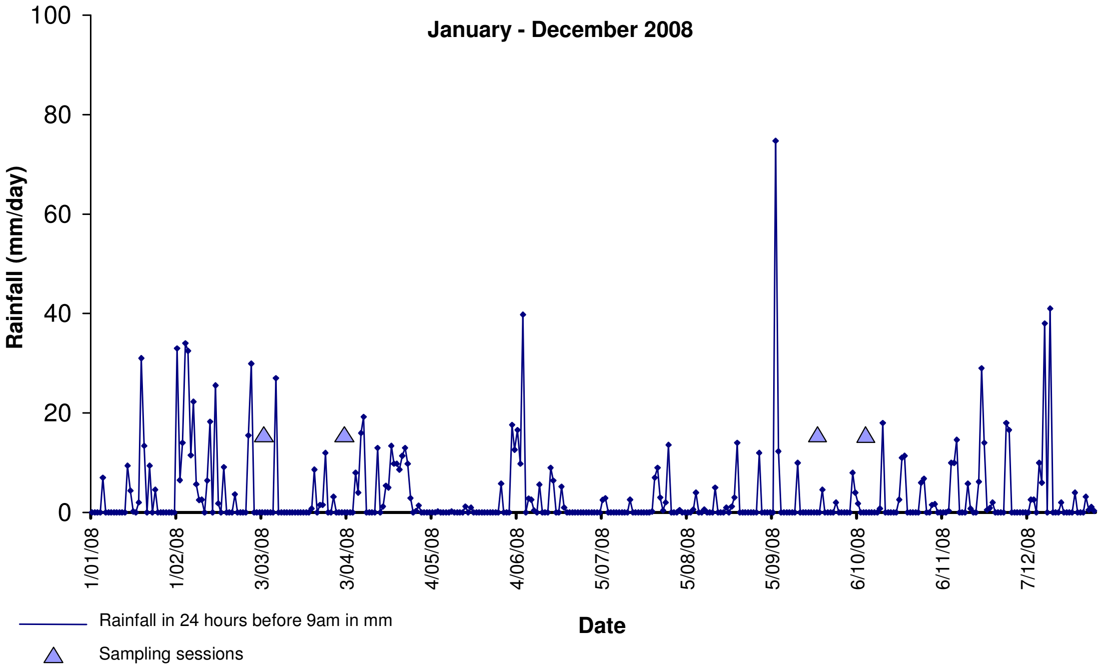
Appendix 3 Rainfall 2004 - 2009

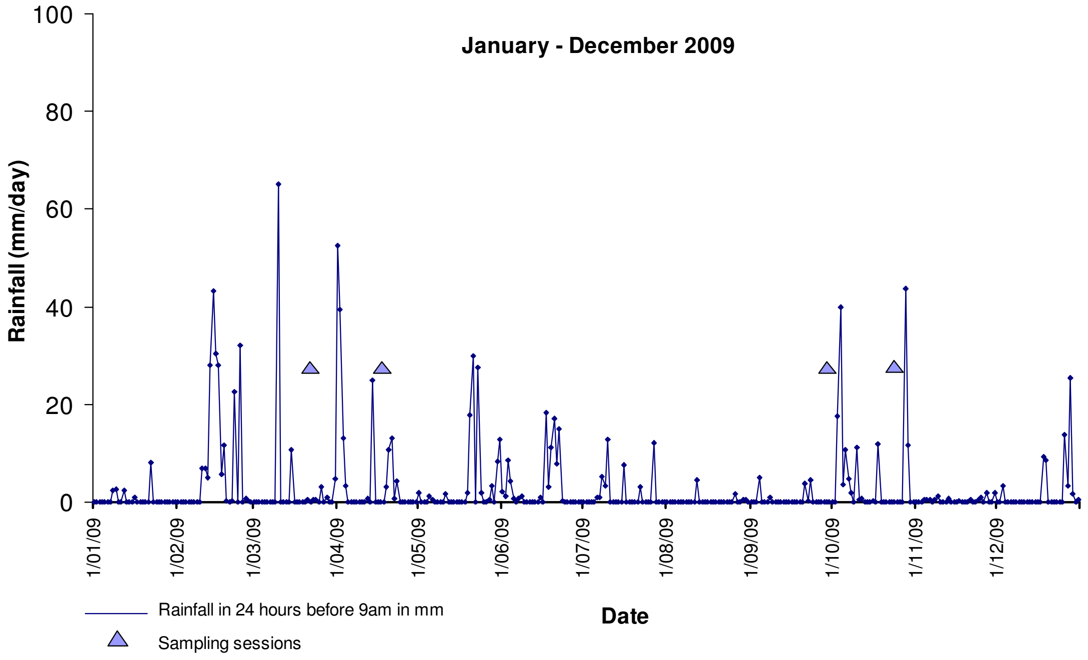


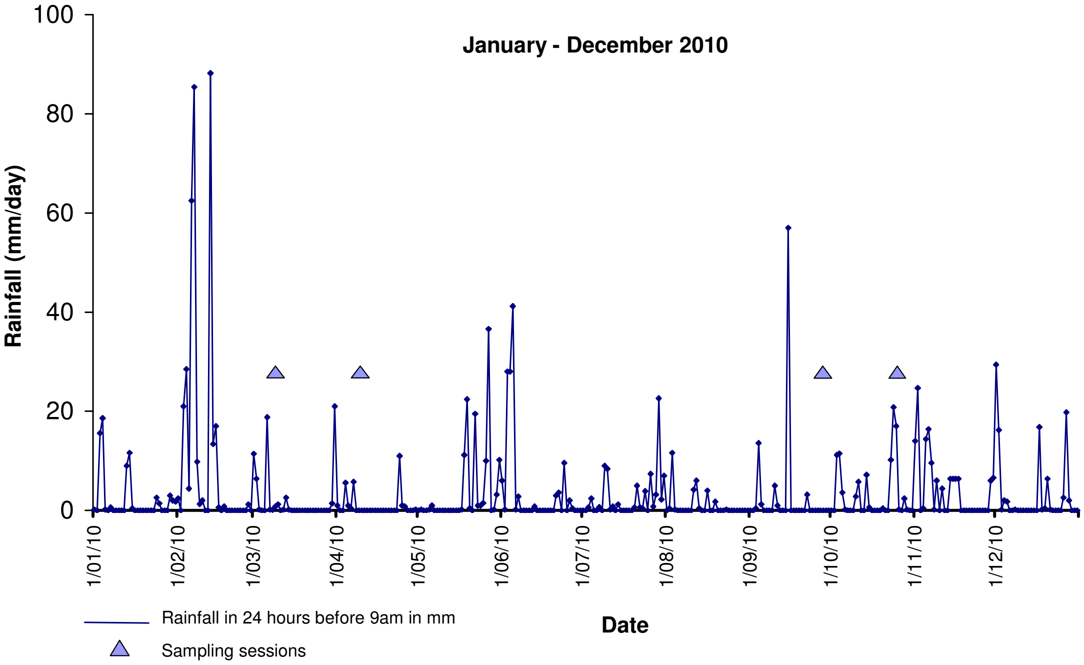



January - December 2006
Rainfall (mm/day)
100
80
60
40
20
0
2/01/06
2/02/06
5/03/06
5/04/06
6/05/06
6/06/06
7/07/06
7/08/06
7/09/06
8/10/06
8/11/06
9/12/06
Date
Rainfall in 24 hours before 9am in mm
△ Sampling sessions


January - December 2007
Rainfall (mm/day)
100
80
60
40
20
0
1/01/07
1/02/07
4/03/07
4/04/07
5/05/07
5/06/07
6/07/07
6/08/07
6/09/07
7/10/07
7/11/07
8/12/07
Date
Rainfall in 24 hours before 9am in mm
△ Sampling sessions


January - December 2008
Rainfall (mm/day)
100
80
60
40
20
0
1/01/08
1/02/08
3/03/08
3/04/08
4/05/08
4/06/08
5/07/08
5/08/08
5/09/08
6/10/08
6/11/08
7/12/08
Date
Rainfall in 24 hours before 9am in mm
Sampling sessions


January - December 2009
Rainfall (mm/day)
100
80
60
40
20
0
1/01/09
1/02/09
1/03/09
1/04/09
1/05/09
1/06/09
1/07/09
1/08/09
1/09/09
1/10/09
1/11/09
1/12/09
Date
Rainfall in 24 hours before 9am in mm
Sampling sessions


January - December 2010
Rainfall (mm/day)
100
80
60
40
20
0
1/01/10
1/02/10
1/03/10
1/04/10
1/05/10
1/06/10
1/07/10
1/08/10
1/09/10
1/10/10
1/11/10
1/12/10
Date
Rainfall in 24 hours before 9am in mm
Sampling sessions

Appendix 4 Macroinvertebrate results

		Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck
		Spring 2004	Spring 2004	Spring 2004	Autumn 2005	Autumn 2005	Autumn 2005	Spring 2005	Spring 2005	Spring 2005	Autumn 2006	Autumn 2006	Autumn 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010
		S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5
Acarina	Acarina	1	3	1	3	3				1				1	3	1		4			1											3	9		1						1								1				1		2			3			1			1				2		3
Amphipoda	Ceinidae							2																											1																																			
Amphipoda	Talitridae																																																				1			3					1									1
Arhynchobdellida	Erpobdellidae																																																																					
Arhynchobdellida	Hirudinidae																																																													1								
Bivalvia	Corbiculidae		1	1			1		3	3																																																												
Bivalvia	Sphaeriidae		3																	1									12		1	9	13	1							1														1										1	2				
Coleoptera	Carabidae																																																																					
Coleoptera	Dytiscidae		3		1	1		2		1																								1					1																				1	1						2		1		
Coleoptera	Elmidae																														2																													1										1
Coleoptera	Hydraenidae													1						1																																										1		5	1		1			1
Coleoptera	Hydrophilidae																				1																						1																											
Coleoptera	Psephenidae																																																																	1				
Coleoptera	Scirtidae																																		1																																			
Decapoda	Atyidae		1		6	11	17				5	1													11	1	1					2	1																											1				2						
Decapoda	Parastacidae																																																																					
Diptera	Bibionidae																			2																																																		
Diptera	Cecidomyiidae																																																																					
Diptera	Ceratopogonidae																																		4		3	2	3			1					2	1	2		1	1			1	4			1	1				5						2
Diptera	Culicidae							17	1		1		1		1			11	6		14						6					4	3																				1		10	6	1	1												
Diptera	Dixidae																																																																					
Diptera	Dolichopodidae																													1																																								
Diptera	Ephydridae																																																						1															
Diptera	Muscidae																			1												1					1																															1		
Diptera	Psychodidae																			1											1						1																																	
Diptera	Sciaridae																																																																					
Diptera	s-f Chironominae	9	10	11	9	5	22	69	94	38	71	72	109	22	15	19	27	6	8	34	32	18	13	34	25	35	25	23	33	18	40	33	42	24	8	16	9	10	9	17	16	12	18	16	19	15	12	20	17	26	17	8	11	18	19	14	11	35	25	28	24	18	22	20	39	41	53	39	15	20
Diptera	s-f Orthocladiinae	1		10	1									7	1		1	2	1	6				3	1	1			3	9	5			1	20	23	22	10	32	14	2		5	16	16	11	14	1	3	4	5	5	1			3			7		6	1		4	2	1		1	1	
Diptera	s-f Tanypodinae	1	6	3	1	1	1	7				3	10	2	1		1	1	1	2	2	2	1	1	2	3	1	1	10	5	1	1	2	5				2			4	1	1		6	1	9		2			2	2	1	8	4	4	7	6	1					3	11	3	5		7
Diptera	Simuliidae													1										1						2	1					1		3							2		4	2	4	1	4	1				5	8			1										
Diptera	Stratiomyidae	3	1		1	2	6	1			1		1		1	4		2	6			1	1				3				5		2	1	1	1	1	1			1		2		4		1	1	1		2		1	3	1	2	1			1		6		5	2					8
Diptera	Syrphidae																				1																																																	
Diptera	Tipulidae	1	1										1				2					2									2			2	1	2		1	1		2		2	1		1									2									1			1			
Ephemeroptera	Baetidae			1																			3		2								2					6	7	6							6	2	30										13	4	14	10	7	4						
Gastropoda	Ancylidae																																1			1					2	2	5	1	3										1	1														
Gastropoda	Hydrobiidae	1	3	2										2	4	1	1	3		7	11	10	5	1					13	12	7	1	11	8	8	13	7	5	8	1	6	2	14	4	10	4	17	4	2		2	11	6	4	11	10	12	13	12	6	2	5	10	8	4	6	5	14	16	22
Gastropoda	Lymnaeidae							1				1									1		1												1										1			1			2											1				1		5		2
Gastropoda	Physidae	3	5	10	4	4	1	9	5	13	1	5		8	4	12	15	3	7	8	7	11	7	2	9	13	6	1	18	10	11	15	12	21	11	5		9	7	1	8	11	16	1	12	4	7	9	1	1	5	5	12	13	13	6	8	6	8	9	2	2	7	10	16	15	17	14	12	11
Gastropoda	Planorbidae																																																				1																1	

		Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck	Archers Ck
		Spring 2004	Spring 2004	Spring 2004	Autumn 2005	Autumn 2005	Autumn 2005	Spring 2005	Spring 2005	Spring 2005	Autumn 2006	Autumn 2006	Autumn 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010
		S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5	S5
Hemiptera	Belostomatidae																																																																					
Hemiptera	Corixidae				1	10			1																							1	1													3	8	2										1	2		3	6	9	1	1			1		
Hemiptera	Gelastocoridae													1				1																																																				
Hemiptera	Gerridae									1	1		1																																															1			2						
Hemiptera	Hebridae																																																																					
Hemiptera	Hydrometridae																																																																1	2				
Hemiptera	Mesoveliidae																																																																					
Hemiptera	Naucoridae																																																																					
Hemiptera	Nepidae																																																																					
Hemiptera	Notonectidae			2			11				2	1	4												2						1	7	12		2	1	9		2	11		2	2	13	1	9	13	3	13			3			2	1		4	3	3	8	3	5	11	7	7	5	11	9	16
Hemiptera	Pleidae																																																																			1		
Hemiptera	Saldidae																																	1																																				
Hemiptera	Veliidae	3	1		6	5	3			3	2	2	1	1		1		2	2	1		2		7	15	3	11			1					3	2	8	1	3	1	2		1	1				4									1		5			6	10	14	1		1			
Isopoda	Scyphacidae								7		1	3			1	4			1																			1															1				1		1			1	2							1						3
Lepidoptera	Pyralidae																													2											1																															
Megaloptera	Corydalidae																																															1																					
Nematoda	Nematoda		1	1																										2																																							
Nemertea	Nemertea																																	1																																			
Neuroptera	Osmylidae																																																																					
Neuroptera	Sisyridae																																																																					
Odonata	Aeshnidae	1	1		2		14	5	5			11	8												3	2	3	1	1										1	2									2													2	1	2	2	5	2		1				
Odonata	Coenagrionidae	7	5	5	6	3	29	21	7	4	1	7	6		1					5			1			2	2	1	1										2	4	3				1	2		2	12	4	3	1	1		1		1				6		3	5	2	3	5	10	1		1
Odonata	Gomphidae																																																																					
Odonata	Hemicorduliidae	2	6	1	4	3	18	25			1	7	5				1			2	10	1			3	4	23		9	1	1	2	9								1		1		1			2	2	1			1	3	1				4	5	2	5	2	3	9	2	5	10		
Odonata	Isostictidae																																																																					
Odonata	Lestidae			3											1	1		2			3						3																				1														1	1											
Odonata	Libellulidae	2	4	5	3	9	8	1	15	14	7	2	4		1		1						6		2	2	3	4	2	1	2	2	1						4	3	1	1	1	1		1		1	17	9	9	26	6	3	16	1	5			2	6		19	9	20	4	11	7	4		1
Odonata	Megapodagrionidae		2		15	22	5	6		1	2	7	5	1			1			1	6		1	2	7			1		2				1				1	1		1	1	2	1				1	3		1	4		1						1								1	1		
Odonata	Synthemistidae															1											1																																												
Odonata	Telephlebiidae																																																																					
Oligochaeta	Oligochaeta	4	6	12	4	16	15	24	19	11	8	13	14	12	9	8	11	3	1	4	8	3	8	11		10	17	3	16	23	6	2	8	5	4	5	2	1	3	3	10	8	7	13	8	4	7	2	11	4	2	10	8	11	7	2	3	6	3	4	2	2	5	7	8	4	1	14	9	3
Plecoptera	Eustheniidae																																																																					
Porifera	Spongillidae																																																																					
Rhynchobdellida	Glossiphoniidae		1	4		1					6	6	2							1	1		1	3	1	1	3											2	1	2	3	3	1		1	1	3	8		1		3		2	1				1	5			2	1	1	1				
Temnocephala	Temnocephalidae																																																																					
Trichoptera	Antipodoecidae																																																																					
Trichoptera	Hydroptilidae	2		3															1										12	3	9				8	2	6		2		18	3	5	14	19	6	8	1	10	4	11	8	9	6	7	18	1	1	6	4	10	2		6	2	7	19	1		16
Trichoptera	Leptoceridae		1																																		1																						1	1				1						
Turbellaria	Dugesiidae	2	3	1	3	15	7		1	2	1	4	4	9	7	3	10	16	11	9	2	2	5		10	8	16	1	17	3		18	12	7	2			3	3		15	7	7	5	10	7	9	10	1	13	10	5	12	6	11	7	14	8	4	5		6	10	8	23	4	7	9	2	2

		Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck
		Spring 2004	Spring 2004	Spring 2004	Autumn 2005	Autumn 2005	Autumn 2005	Spring 2005	Spring 2005	Spring 2005	Autumn 2006	Autumn 2006	Autumn 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010
		S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2
Acarina	Acarina	1		3	1			1		2	4	5	4		1		2	1	1	4	7	1	1	11	2	4	9	2		1		2	1		6		2		1	1	4		3	11	2				3				1	7	2		3							4	4	8	1	1	5	5
Amphipoda	Ceinidae																																																																					
Amphipoda	Talitridae																																																																					
Arhynchobdellida	Erpobdellidae						9																																																															
Arhynchobdellida	Hirudinidae																																																																					
Bivalvia	Corbiculidae		4		9	3	10	6	4	12	9	6	3																																																									
Bivalvia	Sphaeriidae	2	3	10										1																	1		1		3					1		1	1	1	3				1				2	1	2															
Coleoptera	Carabidae																																																																					
Coleoptera	Dytiscidae																				1																																																	
Coleoptera	Elmidae																																																							1														
Coleoptera	Hydraenidae																																																																					
Coleoptera	Hydrophilidae																																						1					1																										
Coleoptera	Psephenidae																																																																					
Coleoptera	Scirtidae																																																																					
Decapoda	Atyidae																																																										1											
Decapoda	Parastacidae										1			2								1			2	1	3				1					1											1	1														1				1				
Diptera	Bibionidae																																																																					
Diptera	Cecidomyiidae																																																																					
Diptera	Ceratopogonidae	1												1																								1																																
Diptera	Culicidae														2					8													1																																					
Diptera	Dixidae																																																																					
Diptera	Dolichopodidae																																																																					
Diptera	Ephydridae																																																																					
Diptera	Muscidae																																4																																					
Diptera	Psychodidae																																																																					
Diptera	Sciaridae																																																										1											
Diptera	s-f Chironominae	12	11	10		1		5	10	15		2	3	21	25	21	20	32	18	18	26	12	8	4	5	17	2	26	30	27	50	7	12	11				1			5	2	6	5	6	12	4		1	2		4	19	7	15	6	11	6	16	1	2		6		12	3	1	21	22	12
Diptera	s-f Orthocladiinae					1									1							1												1		1				1							1								1			2	2						1			1	1	
Diptera	s-f Tanypodinae														1		1			2		1			1		1			1	1	2	5			1										1				2								2										1		1
Diptera	Simuliidae																																																																					
Diptera	Stratiomyidae		1		1		4	1							1	1			1			1										1												1								1	1											1				1	1	1
Diptera	Syrphidae																																																																					
Diptera	Tipulidae																																																																			1		
Ephemeroptera	Baetidae																		1			1		1																																														
Gastropoda	Ancylidae	1	1	1												1	1							1		1			3	2	2	2	5																																					
Gastropoda	Hydrobiidae		1							3					1		2					1									1		1									1	4					1						2		12	13		1				2		6	12		11	1	10
Gastropoda	Lymnaeidae							1			1				1						1						1			1	1	1		1			1				1	1	1				1		3	2	1	2	2	2		7	1	3	1		1					3	1		5	2
Gastropoda	Physidae	6	7	10	17	17	12	14	20	15	5	11	11	13	16	8	13	10	10	13	9	14		1	15	16	8	4	17	17	29	17	9	4	14	8	4	8	6	13	17	10	8	10	14	14		4	2		8	6	24	6	9	17	20	7	11	7	3	11	8	1	16	29	7	11	10	15
Gastropoda	Planorbidae	2	3	10	11	2	6	4	11	11	2			3	1	6	1	2											2				3			1						1																												

		Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck	Shrimptons Ck
		Spring 2004	Spring 2004	Spring 2004	Autumn 2005	Autumn 2005	Autumn 2005	Spring 2005	Spring 2005	Spring 2005	Autumn 2006	Autumn 2006	Autumn 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Spring 2006	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010
		S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2
Hemiptera	Belostomatidae																																																																						
Hemiptera	Corixidae		3	2				2															1		1	1		1	4		5	2	1		1															1		1					1	2			2							1	1
Hemiptera	Gelastocoridae						1	1	2												1																															1												1			2	1				1	
Hemiptera	Gerridae																							1	1			1							1													1	1														1								
Hemiptera	Hebridae																																																																						
Hemiptera	Hydrometridae																																																																						
Hemiptera	Mesoveliidae																								1																																														
Hemiptera	Naucoridae																																																																						
Hemiptera	Nepidae																									1					1																																							1			
Hemiptera	Notonectidae															2	2	1	4	2	1	1	2	5	1		2		1			1	1	1	5		3				4			14	1		1	3	8	1	6			1			18	5	2							1		2	10	2
Hemiptera	Pleidae										1																																																												
Hemiptera	Saldidae																																																																						
Hemiptera	Veliidae																		1					1	11	4								2																																		1		1					
Isopoda	Scyphacidae							2																1							1												1	1								1																			
Lepidoptera	Pyralidae																																																																						
Megaloptera	Corydalidae																																																																						
Nematoda	Nematoda	1																																																																					
Nemertea	Nemertea																																																1																					
Neuroptera	Osmylidae																														1																																								
Neuroptera	Sisyridae																																																		1																				
Odonata	Aeshnidae																								2	4	1	2		1																				1																								
Odonata	Coenagrionidae	3	6		1		2	3			3	1			1		3			1			3	4	1	7	6	1	7	1	13	2	4	2	1	1	1	1			7	1	1	13	3	3	3	4	5			1	1	2	7		3	4	4		2	1		2	6	9		7	3	5
Odonata	Gomphidae	1																																																																					
Odonata	Hemicorduliidae	1	4	2		1					7	4	1		5	2	2	4		1	4			7	1	9	6	14	2		5	2	2	1	2		2	1			1			1						2			1	5	8	1	1	1	2	4	2	2	1		1	1				
Odonata	Isostictidae														1							1	3	3	1	5	7	4	1	8	6	4	1								1		1				1	2				1	2		2										1			
Odonata	Lestidae			1												1			8		2	3																																																	
Odonata	Libellulidae		3						2	4	1		1											1	1	2			2					1				4				1							3	1	1			1			1	2	1				4	1			1	2	
Odonata	Megapodagrionidae		2																			1	1	3	2	8	7	4	4	6	13	8	8			3	2	2		3		1		1						1	6					1		1	4		2				3	2	9	1	1	1	1
Odonata	Synthemistidae																																																																						
Odonata	Telephlebiidae																								1																																														
Oligochaeta	Oligochaeta	7	6	12	10	9	17	16	13	17	13	11	17	10	4	8	1	8	10	3	3		7	5	4	1		6	12	2	5	5	5	3	3	5	2	4		3	1	6	2	2	8	9	1			2				4	8	4	1	5	6	11	3	6	2	2	2	2	1	4	1	
Plecoptera	Eustheniidae																																																																						
Porifera	Spongillidae																																																																						
Rhynchobdellida	Glossiphoniidae				15	5	9	7	9	12	1	1										1	1													10	2	1			3		6	2	1		1	4	5	4	3	3		2	11	7	2	12		2	13		4	2	1		4	1		1	
Temnocephala	Temnocephalidae																								1																																														
Trichoptera	Antipodoecidae																																																																						
Trichoptera	Hydroptilidae	2	3																										2	5	3												2	1	1																1							2	3	1	2	1	2
Trichoptera	Leptoceridae			1																																																																			
Turbellaria	Dugesiidae	2	4	9	14	19	11	14	12	10	7	8	9	4	1		2		8	3	2	2	4	4	4	7	11	1	7	9	13	5	1	1	8	13	17	13	9	17	10	11	4	12	9	5	8	4	14	7	16	4	6	7	10	14	7	15	11	14	10	14	13	11	8	16	10	9	9	20

		Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck	Porters Ck
		Autumn 2005	Autumn 2005	Autumn 2005	Spring 2005	Spring 2005	Spring 2005	Autumn 2006	Autumn 2006	Autumn 2006	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010
		S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3
Acarina	Acarina	1					1		1				1		1																					1				1							2	2		4		1	2					
Amphipoda	Ceinidae				3	1																																																				
Amphipoda	Talitridae									1																	1																						1									
Arhynchobdellida	Erpobdellidae				2	2	1						2																																			1										
Arhynchobdellida	Hirudinidae																										1																													1		
Bivalvia	Corbiculidae		4	2																																																						
Bivalvia	Sphaeriidae														1													1			3	1			3						1	3		12					1	4					1			
Coleoptera	Carabidae																																																								1	
Coleoptera	Dytiscidae				1	1	2							2	1								2	1	4																									1		1						1
Coleoptera	Elmidae																																																									
Coleoptera	Hydraenidae																																																1									
Coleoptera	Hydrophilidae													3											1																	1	1	2							1							
Coleoptera	Psephenidae							1																																																		
Coleoptera	Scirtidae			1										1							1																																					
Decapoda	Atyidae	5				2		5	5	14	10	8	3	1	10	1									1											1															1	1						
Decapoda	Parastacidae																																																									
Diptera	Bibionidae																																																									
Diptera	Cecidomyiidae																										1																															
Diptera	Ceratopogonidae																																																				3					
Diptera	Culicidae				1						1			2											1		1																					1										
Diptera	Dixidae																																																									
Diptera	Dolichopodidae																																																									
Diptera	Ephydridae																																																									
Diptera	Muscidae																																										1															
Diptera	Psychodidae													1										1			1																1															1
Diptera	Sciaridae																																																									
Diptera	s-f Chironominae	34	48	46	77	132	100		10	7	3	14	6	4	17	7	22	22	18	27	20	25	10	13	14	15	16	18	17	10	15		18		6	19	14	12	8	6	18	3	24	16	14	12	19	41	21	15	19	15	6	16	10	17	22	17
Diptera	s-f Orthocladiinae	7	1					1			6	7	5	1	4								6	19	13	1	2	1		1	2	3			12	4	7	3	1	5	5	2			3		2	3	6		1	2	8	3	2	9		3
Diptera	s-f Tanypodinae	4	2	14					18	11	3	4	5		4		1			1		2			1			1				15		12	2	1				1		3	3	2				1										
Diptera	Simuliidae																						1																																			
Diptera	Stratiomyidae		2		1							1		1	1	1	1	3				1	1	4	3		5	3			3		1					2		1		2	1							1					2	1		
Diptera	Syrphidae																																																									
Diptera	Tipulidae																1	1			1		1		1										1								1		1											1		
Ephemeroptera	Baetidae	1																																			1												1									
Gastropoda	Ancylidae	1										1			1				3	1		7		1			1						3	2		1								3	1										1	1		1
Gastropoda	Hydrobiidae	30	22	13	23	13	34	23	10	18	15	33	15	26	18	30	9	18	21	4	28	11	10	8	8	12	7	14	2	1	10		15	15	12	5	12	11	19	11	12	18	5	8	9	10	17	18	2	10	12	13	18	10	15	14	11	9
Gastropoda	Lymnaeidae																1				1								1			1									1		1					1										
Gastropoda	Physidae	12	10	7	4	8	7	2	7	3	10	8	6	5	4	9	3	10	14	11	6	6	3	5	5			1	8	6	5	15	17	4					2	1	5	4	9		1	1	1	1	1	1	2				1		3	1
Gastropoda	Planorbidae	4	6	6		2	2		2	2				2				1		1	1	3		1	1	1			1		1	1	1	4				2	1		7	3	8	2	1													

		Porters Ck Autumn 2005 S3	Porters Ck Autumn 2005 S3	Porters Ck Autumn 2005 S3	Porters Ck Spring 2005 S3	Porters Ck Spring 2005 S3	Porters Ck Spring 2005 S3	Porters Ck Autumn 2006 S3	Porters Ck Autumn 2006 S3	Porters Ck Autumn 2006 S3	Porters Ck Autumn 2007 S3	Porters Ck Autumn 2007 S3	Porters Ck Autumn 2007 S3	Porters Ck Autumn 2007 S3	Porters Ck Autumn 2007 S3	Porters Ck Autumn 2007 S3	Porters Ck Spring 2007 S3	Porters Ck Spring 2007 S3	Porters Ck Spring 2007 S3	Porters Ck Spring 2007 S3	Porters Ck Spring 2007 S3	Porters Ck Spring 2007 S3	Porters Ck Autumn 2008 S3	Porters Ck Autumn 2008 S3	Porters Ck Autumn 2008 S3	Porters Ck Autumn 2008 S3	Porters Ck Autumn 2008 S3	Porters Ck Autumn 2008 S3	Porters Ck Spring 2008 S3	Porters Ck Spring 2008 S3	Porters Ck Spring 2008 S3	Porters Ck Spring 2008 S3	Porters Ck Spring 2008 S3	Porters Ck Spring 2008 S3	Porters Ck Autumn 2009 S3	Porters Ck Autumn 2009 S3	Porters Ck Autumn 2009 S3	Porters Ck Autumn 2009 S3	Porters Ck Autumn 2009 S3	Porters Ck Autumn 2009 S3	Porters Ck Spring 2009 S3	Porters Ck Spring 2009 S3	Porters Ck Spring 2009 S3	Porters Ck Spring 2009 S3	Porters Ck Spring 2009 S3	Porters Ck Spring 2009 S3	Porters Ck Autumn 2010 S3	Porters Ck Autumn 2010 S3	Porters Ck Autumn 2010 S3	Porters Ck Autumn 2010 S3	Porters Ck Autumn 2010 S3	Porters Ck Autumn 2010 S3	Porters Ck Spring 2010 S3	Porters Ck Spring 2010 S3	Porters Ck Spring 2010 S3	Porters Ck Spring 2010 S3	Porters Ck Spring 2010 S3	Porters Ck Spring 2010 S3
Hemiptera	Belostomatidae																																																									
Hemiptera	Corixidae				1	2	9																		1	1							1														2	1										
Hemiptera	Gelastocoridae																																											1														
Hemiptera	Gerridae								1						1																		1																									
Hemiptera	Hebridae																																																	1								
Hemiptera	Hydrometridae																																																									
Hemiptera	Mesoveliidae																																																									
Hemiptera	Naucoridae																																																									
Hemiptera	Nepidae				1																																																					
Hemiptera	Notonectidae	2		2	1			4	8		7	8	4	4	9	11				1	2		4	7	10	2	1	1	1		2	4	3	2		2	9	2	2		1	1		7	8	10		6	4	11	4	1	2	1	2	9	6	8
Hemiptera	Pleidae																																																1									
Hemiptera	Saldidae																																																									
Hemiptera	Veliidae		3							2																				1																				1	1	1		1		1		
Isopoda	Scyphacidae				1																4													1						1													1					
Lepidoptera	Pyralidae																																																									
Megaloptera	Corydalidae																																																									
Nematoda	Nematoda																														2																											
Nemertea	Nemertea											1																																														
Neuroptera	Osmylidae																																																									
Neuroptera	Sisyridae																																																									
Odonata	Aeshnidae	2	2	2	1			3	5	7		2																							1																							
Odonata	Coenagrionidae	3	10	13	9		2	15	7	12	8	12	2	10	5	7	1	3	1		1		1				2	2				1			2	2	1	1	9		2	2	3	1		1		5		6				1				
Odonata	Gomphidae				1																																																					
Odonata	Hemicorduliidae	9	8	8	11			5	5	13	10	6	2	9	3	6		2								2		2					1															4		1		1						
Odonata	Isostictidae	21	19	13	9	5	7	18	7	7	8	6	2	13	13	8	1	8	3	3	2						2	2						2	7			2	3	1	2		2					10	2				3	1	4		1	2
Odonata	Lestidae																																																									
Odonata	Libellulidae	1	3	4	2	5	9	5	1	3	5	9	4	6	5	1		1				1	1			1									2			1	1											2					1			
Odonata	Megapodagrionidae	6	14	8	4		2	10	7	26	8	7	2	5	11	5	4	13	10	1	4	8	2	5	3	12	2	10	2	2	1	3	1		5		2	3	3	6	5	5	2		2	1		1		3	2		1	1	1		1	1
Odonata	Synthemistidae																																																									
Odonata	Telephlebiidae																																																									
Oligochaeta	Oligochaeta	3	6	10	10	5	7	6	6	8		3	7	7			8	17	15	2	3	5	2	4	7			4	4	7	4	6	11	1	1	1		1	4	2	3		3	2				7		2			2	2	2	2	4	4
Plecoptera	Eustheniidae							1																																																		
Porifera	Spongillidae																																																									
Rhynchobdellida	Glossiphoniidae	2	7	5	3	4	5	8	16	3	2	3		1		2											1	1								1		1					1														1	
Temnocephala	Temnocephalidae																																																									
Trichoptera	Antipodoecidae										1														1										2	1	2	2																		2		
Trichoptera	Hydroptilidae										3	3	7	4	5	1			1			1										2	3			1	1	4			3		12					1	2		2	3	1	2		1	2	3
Trichoptera	Leptoceridae	1		1				1	1			3	4		3	1																					1																				1	
Turbellaria	Dugesiidae	5	3		2						3	2	2					2			1		5	2	1			5				1	3	3			1		1							2		1		3								

		Buffalo Ck Autumn 2005 S4	Buffalo Ck Autumn 2005 S4	Buffalo Ck Autumn 2005 S4	Buffalo Ck Spring 2005 S4	Buffalo Ck Spring 2005 S4	Buffalo Ck Spring 2005 S4	Buffalo Ck Autumn 2006 S4	Buffalo Ck Autumn 2006 S4	Buffalo Ck Autumn 2006 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4
Acarina	Acarina	2	2	1	6	1	1											1					1																																1	3		
Amphipoda	Ceinidae		1	2	2	8																																																				
Amphipoda	Talitridae								1																																													1				
Arhynchobdellida	Erpobdellidae			1																																																						
Arhynchobdellida	Hirudinidae																																											1														
Bivalvia	Corbiculidae	3	8	7	5	1	11	4	6	7																																																
Bivalvia	Sphaeriidae										1		1		3	9				1		2						1				9	1				2		2	3	5	8	4	1	2	2		8			7	5	1	3	1			
Coleoptera	Carabidae																																																									
Coleoptera	Dytiscidae					2																																																				
Coleoptera	Elmidae																																																									
Coleoptera	Hydraenidae																															1																		3	3	1	1					
Coleoptera	Hydrophilidae	1		1					1										1					1																	2																	
Coleoptera	Psephenidae																																																									
Coleoptera	Scirtidae		1																																																							
Decapoda	Atyidae																																															1	1									
Decapoda	Parastacidae																																																									
Diptera	Bibionidae																																																									
Diptera	Cecidomyiidae																																																									
Diptera	Ceratopogonidae			1						2	1								1																1																			1		1		
Diptera	Culicidae		1			5			1	2								2																		1					8	4	5															
Diptera	Dixidae																																																									
Diptera	Dolichopodidae																																																									
Diptera	Ephydridae																																																									
Diptera	Muscidae																																																									
Diptera	Psychodidae																																																									
Diptera	Sciaridae																																																									
Diptera	s-f Chironominae	9	13	36	26	31	74	78	46	56	14	29	16	20	10	23	51	28	19	9	19	13	8	10	18	17	7	23	6	5	25	18	11	25	7	12	3	13	12	5	9	15	4	11	17	17	6	9	9	10	8	8	20	13	27	41	23	24
Diptera	s-f Orthocladiinae	2						2	4	2	2			1										4	5	15	4	18							2	2	2	5	3	1						2	1		3				1		1			
Diptera	s-f Tanypodinae	2	2	7	2					4	1	6	3	5	2	2		1	4		2	2				3	3									5	2			1				2	4	2		3		3	7	1		4	2	1		2
Diptera	Simuliidae					1																																													1							
Diptera	Stratiomyidae	2	1	3	1			1	1	5	3		1	2	1	1			1						1	1	2									1			2	1												1	1					
Diptera	Syrphidae	1																																																								
Diptera	Tipulidae	1																																										1														
Ephemeroptera	Baetidae								4		14	8	13												1																																	
Gastropoda	Ancylidae																					1									1													1								1	1					
Gastropoda	Hydrobiidae	6	4	18	11	13	7	2			9	12	4	4	2	10	7	10	6	3	5	9		7	10	14	17	4	5	14	6	12	6	19	3	10	11	3	17	14	17	13	7	6	14	8	15	11	1	10	15	10	6	6	10	4	6	6
Gastropoda	Lymnaeidae							1		1	1	1	4	3	6	2			4	2				1	3	1					1	2				1	1	1	1	2	2	1	2	1	1	1			1			5	2			3		
Gastropoda	Physidae	4	1	6	7	12	24	8	7	5	14	1	7	15	18	15	12	12	18	14	18	19	7	18	26	2	2	15	5	12	25	16	16	14	7	4	9	12	13	11	1	10	2	9	10	6	5	2		5	2	2	5	5	22	22	2	2
Gastropoda	Planorbidae	2	2	3			1				3			4	8	2	1	1	6		2		5	9	3			1	1			5	1	1	3			6	7	6	1	3	2	4	3	2	4	1	1	3	3	4	1	4				1

		Buffalo Ck Autumn 2005 S4	Buffalo Ck Autumn 2005 S4	Buffalo Ck Autumn 2005 S4	Buffalo Ck Spring 2005 S4	Buffalo Ck Spring 2005 S4	Buffalo Ck Spring 2005 S4	Buffalo Ck Autumn 2006 S4	Buffalo Ck Autumn 2006 S4	Buffalo Ck Autumn 2006 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Autumn 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Spring 2007 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Autumn 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Spring 2008 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Autumn 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Spring 2009 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Autumn 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4	Buffalo Ck Spring 2010 S4
Hemiptera	Belostomatidae																																																									
Hemiptera	Corixidae	1				1								1																																												
Hemiptera	Gelastocoridae												1							1	1			1																																		
Hemiptera	Gerridae							1	1		1			1		1							1		3										1	1				1									1	2								
Hemiptera	Hebridae																							1																																		
Hemiptera	Hydrometridae																																																	1								
Hemiptera	Mesoveliidae								1				1																																													
Hemiptera	Naucoridae																																																									
Hemiptera	Nepidae																																																									
Hemiptera	Notonectidae	11	10	10	4	4	1	14	10	14	10	10	11	7	13	12	4	1	2	1	3	2	13	5	14	9	12	7	1	1	1				6	13	3	7	2	5	1		2	3	1	2	9	7	7	8	4	9		2		4	2	2
Hemiptera	Pleidae																					1																																				
Hemiptera	Saldidae																																																									
Hemiptera	Veliidae												1					1			1			2	2	1						1												1			1			7	3	12						
Isopoda	Scyphacidae				3	4	2	1																1								1								1					1													
Lepidoptera	Pyralidae																																							1																		
Megaloptera	Corydalidae																																																									
Nematoda	Nematoda													1																																												
Nemertea	Nemertea																																																									
Neuroptera	Osmylidae																																																									
Neuroptera	Sisyridae																																																									
Odonata	Aeshnidae	3	1	1			1	3	6	3		2	6	5	4	3							2	3	1	2																						1		3	3	16						
Odonata	Coenagrionidae	5	8	15				5	6	12	1		4	9	2	4	2	2	5	1				3			1	2							1	4	3	2	1	7	1	1	1						1	6	16	16	1		1	1		
Odonata	Gomphidae																																																									
Odonata	Hemicorduliidae	1	16	19	7			13	4	2	1	5	10	6	8	10			2	1	1	4	1	1	1			1												4									1	3	8	1			2	1		
Odonata	Isostictidae		1	2	1			2		2	1	1	2	3	6	5	3		8	5		5		2	1		2				1				1		2	1	1	1	1	1	1					2		1	7	1			1	1		
Odonata	Lestidae																																																									
Odonata	Libellulidae		5	2	2	1	13	13	10	4	2		7	3	7		2							2		1		1									1											1		1	1	5				3		1
Odonata	Megapodagrionidae	9	21	19	20		3	9	2	8	2	3	5	5	9	3	1	1	9	10	2	5	8	9	7	9	3	3	1	1	2	3	4		2	4	2	5	5	10	12	9	6	3	1	12		3	4	4	10		3	3	5	8	1	
Odonata	Synthemistidae		1																																																							
Odonata	Telephlebiidae											1																																														
Oligochaeta	Oligochaeta	11	11	9	32	17	18	8	3	10		2		2	9	3	4	1	1	4	2	7		3		4	1	1	1	1	1	10		2	1						3	1	1	1	1	3	1	1		2	4	2	1	3	8	3		1
Plecoptera	Eustheniidae																																																									
Porifera	Spongillidae																																																									
Rhynchobdellida	Glossiphoniidae	2	1	2				4	9		1			2																					1		1			1																		
Temnocephala	Temnocephalidae																																																									
Trichoptera	Antipodoecidae																																																									
Trichoptera	Hydroptilidae			3							8	3	6	2	3	2		2	2		1			2	7	12	9	11			3					2	3	7	1	5	7	5	17	2			4	1				1						1
Trichoptera	Leptoceridae										1																																															
Turbellaria	Dugesiidae	4	6	5	3	2	6	3	4	3			3	8	4	4				2	4		5	5	4	6	2	5			2	3				2	6	3	2	9			2	1		1	9			5	4	2		1	1	1		1

		Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck	Terrys Ck
		Spring 2004	Spring 2004	Spring 2004	Autumn 2005	Autumn 2005	Autumn 2005	Spring 2005	Spring 2005	Spring 2005	Autumn 2006	Autumn 2006	Autumn 2006	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Autumn 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Spring 2007	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Autumn 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Spring 2008	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Autumn 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Spring 2009	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Autumn 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010	Spring 2010
		S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Acarina	Acarina				2		1	1	7	4	2	3	2	1	2		2		1			2		5													2		2	1	1			1										2		2	4	2	8			1
Amphipoda	Ceinidae				3		1	1	3																																																				
Amphipoda	Talitridae											1	2		1				1					1					1	1		1					1																								
Arhynchobdellida	Erpobdellidae																																						1																								
Arhynchobdellida	Hirudinidae														1																																														
Bivalvia	Corbiculidae		5	1	3	5	10	2	9	3	9		8																																																
Bivalvia	Sphaeriidae	4	1	3											4		2	4				4	1	3	4	4						3		1	1	2	12	8		2				1	10	2	7			1					2	4			3	1	
Coleoptera	Carabidae																																																												
Coleoptera	Dytiscidae								1																					1																															
Coleoptera	Elmidae	1		3	6	1				3	4	1			4				2			1		1		2		1								1				1			2					1	1	2	1	3			1						1
Coleoptera	Hydraenidae																1									1																																			
Coleoptera	Hydrophilidae																																	1														1													
Coleoptera	Psephenidae																																																									1		1	
Coleoptera	Scirtidae	1					1										1		1																																										
Decapoda	Atyidae			1																																														12	12	11	4	6	2			1		4	
Decapoda	Parastacidae																																																												
Diptera	Bibionidae																																																												
Diptera	Cecidomyiidae																																																												
Diptera	Ceratopogonidae						1		2																						1	1			6																										
Diptera	Culicidae								3			1											9	4																																					
Diptera	Dixidae																							1																																					
Diptera	Dolichopodidae																																																												
Diptera	Ephydridae																							1																																					
Diptera	Muscidae																																																												
Diptera	Psychodidae																																																1												
Diptera	Sciaridae																																																												
Diptera	s-f Chironominae	8	11	11	3	17	28	33	32	30	2	19	5	8	15	13	9	13	5	41	16	33	17	18	17	5		2	1	3	3	14	19	15		9	6	2		2		2		9	10	8	14	4	12	1	1		2		6	17	30	14	12	26	10
Diptera	s-f Orthocladiinae	2		2	2		1					1		7	5	2			2	1				2		1		1								2		3	3				1				1	1	2		2										4
Diptera	s-f Tanypodinae		2	1	3	4	21	11	6	1	1	9	11	14	1	5	8	1	3	1	4	1		1	1	5		2	1			4		1	11	2		4	3	1		1	4	7	6	2	2	4	14			1	1			1	1	3		3	10
Diptera	Simuliidae							1		1					3		3			1		1																		1		2	1				1	1	1							1				1	
Diptera	Stratiomyidae	1			1	2			1		5				1		3	1	1			1					1	2		1		1		1				2	1			1				1											1				
Diptera	Syrphidae																																																												
Diptera	Tipulidae				4																		1	1				1															1							1		1								1	
Ephemeroptera	Baetidae														1	1																																													
Gastropoda	Ancylidae			1																				1								3	1		1														1												
Gastropoda	Hydrobiidae	4	7	6	11	10	13		14	11	25	4	14	26	8	10	18	34	12	15	21	17	7	6	13	9	11	8	13	17	17	22	14	13	9	10	12	13	11	7	22	13	14	15	6	6	18	21	15	27	25	24	19	13	21	14	10	8	18	16	14
Gastropoda	Lymnaeidae	1						5	3		1					1																		1						1						1	1						1				1		1		
Gastropoda	Physidae	4	4	6	3	8	8	12	11	7	1	9	9	6	1	4	13	10	11	8	6	2	12	7	7	7	4	8	2	9	5	14	4	14	10	10	11	7	1		9	6	3	5	1	5	3	2	3	4	1	1	1		5	7	4	8	5	10	8
Gastropoda	Planorbidae		1	5	2	4	4	1		4	2			1			1	1	5		1		1	3	2	1		1								1	2							1	4	1								1							2

		Terrys Ck Spring 2004 S1	Terrys Ck Spring 2004 S1	Terrys Ck Spring 2004 S1	Terrys Ck Autumn 2005 S1	Terrys Ck Autumn 2005 S1	Terrys Ck Autumn 2005 S1	Terrys Ck Spring 2005 S1	Terrys Ck Spring 2005 S1	Terrys Ck Spring 2005 S1	Terrys Ck Autumn 2006 S1	Terrys Ck Autumn 2006 S1	Terrys Ck Autumn 2006 S1	Terrys Ck Autumn 2007 S1	Terrys Ck Autumn 2007 S1	Terrys Ck Autumn 2007 S1	Terrys Ck Autumn 2007 S1	Terrys Ck Autumn 2007 S1	Terrys Ck Autumn 2007 S1	Terrys Ck Spring 2007 S1	Terrys Ck Spring 2007 S1	Terrys Ck Spring 2007 S1	Terrys Ck Spring 2007 S1	Terrys Ck Spring 2007 S1	Terrys Ck Spring 2007 S1	Terrys Ck Autumn 2008 S1	Terrys Ck Autumn 2008 S1	Terrys Ck Autumn 2008 S1	Terrys Ck Autumn 2008 S1	Terrys Ck Autumn 2008 S1	Terrys Ck Autumn 2008 S1	Terrys Ck Spring 2008 S1	Terrys Ck Spring 2008 S1	Terrys Ck Spring 2008 S1	Terrys Ck Spring 2008 S1	Terrys Ck Spring 2008 S1	Terrys Ck Spring 2008 S1	Terrys Ck Autumn 2009 S1	Terrys Ck Autumn 2009 S1	Terrys Ck Autumn 2009 S1	Terrys Ck Autumn 2009 S1	Terrys Ck Autumn 2009 S1	Terrys Ck Autumn 2009 S1	Terrys Ck Spring 2009 S1	Terrys Ck Spring 2009 S1	Terrys Ck Spring 2009 S1	Terrys Ck Spring 2009 S1	Terrys Ck Spring 2009 S1	Terrys Ck Spring 2009 S1	Terrys Ck Autumn 2010 S1	Terrys Ck Autumn 2010 S1	Terrys Ck Autumn 2010 S1	Terrys Ck Autumn 2010 S1	Terrys Ck Autumn 2010 S1	Terrys Ck Autumn 2010 S1	Terrys Ck Spring 2010 S1	Terrys Ck Spring 2010 S1	Terrys Ck Spring 2010 S1	Terrys Ck Spring 2010 S1	Terrys Ck Spring 2010 S1	Terrys Ck Spring 2010 S1
Hemiptera	Belostomatidae	1																																																											
Hemiptera	Corixidae									5																																																			
Hemiptera	Gelastocoridae						1							1							1															1	1	2	1					1									2						1		
Hemiptera	Gerridae		1				2		1	2	3	3	3				4	2										1			1								1	1	2	1		1						1					1						
Hemiptera	Hebridae																																																												
Hemiptera	Hydrometridae																																																												
Hemiptera	Mesoveliidae																																																												
Hemiptera	Naucoridae			1		1																																																							
Hemiptera	Nepidae																1																																												
Hemiptera	Notonectidae			3	11	2	7	4	1	2	5	6	4	3	4	7	11	3	3							4	4	7	6	7	4			2				1	8	9	3	3	3					1	1	8	8	3	1	1	6			1		2	
Hemiptera	Pleidae																																																												
Hemiptera	Saldidae																																																												
Hemiptera	Veliidae						3			1	4	1			1	2				1			5							2	1			1	3			1		7			1	1			1			2		1									
Isopoda	Scyphacidae							1																												1					1																				
Lepidoptera	Pyralidae																			1																																									
Megaloptera	Corydalidae										1																																																		
Nematoda	Nematoda																																																												
Nemertea	Nemertea															1																																													
Neuroptera	Osmylidae																																															1													
Neuroptera	Sisyridae																																						1									1													
Odonata	Aeshnidae				1					1	1				1			2																	1			1									1														
Odonata	Coenagrionidae	1	1	3		3	4			7	7	5	2	5	1		3		2	1	1	1						1										2	5	1	1						1				2		1	1		1			1		2
Odonata	Gomphidae	1																																																											
Odonata	Hemicorduliidae	2	4	7	2	6	20	21			17	16	26	3	2		5	5	6	3	1		1	10	5						2			1				1	3	2			1	1								1	2		5	1			1	1	
Odonata	Isostictidae			2	6	8	6	8	5	7	4	2	4	3	2	1	10		1					2	5			6	1	1	5			2	2		3	6	4	2	2	4	1	2	2	3	1	3	1				3	1	1		4	1	3		1
Odonata	Lestidae							6																																																					
Odonata	Libellulidae								14	13	2	1	4	1		2		2	4					1	1	1		1											1	1	1			1						2		2			1					1	1
Odonata	Megapodagrionidae	6	10	12	16	26	14	11	8	7	42	17	18	18	11	6	8	16	16	16	9	3	8	8	12	12	7	10	8	13	6	8	11	6	19	10	5	17	9	13	11	12	13	22	16	7	6	16	10	3		5	7	2	14	11	10	9	4	10	3
Odonata	Synthemistidae																												1																																
Odonata	Telephlebiidae																												1																																
Oligochaeta	Oligochaeta	7	10	7	4	15	8	9	15	7	18	14	17	4	8	4	4	1	3	8	8	4	4		2	4	1	3	3	3		7	4	1	3	3	11	2	1	7	2	2	2	1	8	1	5	3	6	5		4	2	2	3	2		11	2	2	3
Plecoptera	Eustheniidae																																																												
Porifera	Spongillidae																																			1																									
Rhynchobdellida	Glossiphoniidae				3	2	1		1	1	2	2		1	1			1											1		1	1						2			1		3	1	1																
Temnocephala	Temnocephalidae																																																												
Trichoptera	Antipodoecidae																																																												
Trichoptera	Hydroptilidae		1								1			1										4												1		1				2		1		1					1	1						1		1	4
Trichoptera	Leptoceridae																																																												
Turbellaria	Dugesiidae	1	3	3	6	14	4	2	2	3	10	2	11	3	2	10	9	8	12	10	14	1	8	2	6	5	2	3	2	3	2	2	1	4		2	5	6	4	2	4		3	7	5	2	5	1	3	4		1	11	6	13	1	3		1	1	2

Appendix 5 SIMPER output

SIMPER all five creeks reps merged 2005 – 2010

Data worksheet
Name: All five Cks sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	Creek
S5	Archers Ck
S4	Buffalo Ck
S3	Porters Ck
S2	Shrimptons Ck
S1	Terrys Ck

Group Archers Ck
Average similarity: 63.28

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	11.69	10.81	3.78	17.08	17.08
Oligochaeta	6.34	6.22	4.66	9.83	26.92
Physidae	6.34	5.32	3.24	8.41	35.33
Dugesiidae	5.75	4.77	2.50	7.53	42.86
Libellulidae	4.39	3.46	2.35	5.46	48.32
Hydrobiidae	4.74	2.97	1.00	4.70	53.01
s-f Tanypodinae	3.43	2.89	3.07	4.57	57.58
Hemicorduliidae	3.62	2.88	1.57	4.56	62.14
Coenagrionidae	3.41	2.65	1.86	4.19	66.32
Notonectidae	3.63	2.32	1.22	3.67	69.99
Stratiomyidae	2.53	2.17	3.44	3.42	73.42
Veliidae	2.86	2.04	1.85	3.22	76.64
Megapodagrionidae	2.58	1.95	1.87	3.09	79.72
s-f Orthocladiinae	3.66	1.89	1.06	2.99	82.71
Hydroptilidae	3.60	1.73	0.72	2.74	85.45
Glossiphoniidae	2.03	1.35	1.15	2.13	87.58
Aeshnidae	1.95	1.13	0.79	1.78	89.36
Acarina	1.60	0.97	1.15	1.53	90.89

Group Buffalo Ck
Average similarity: 65.45

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	9.86	10.75	4.20	16.43	16.43
Physidae	6.85	7.04	2.62	10.76	27.19
Hydrobiidae	6.35	6.75	2.41	10.31	37.50
Megapodagrionidae	5.19	5.64	6.95	8.62	46.12
Notonectidae	4.96	4.44	2.92	6.78	52.91
Oligochaeta	4.08	3.91	2.51	5.97	58.88
Dugesiidae	3.43	3.35	4.28	5.12	63.99
Planorbidae	3.00	2.69	1.63	4.12	68.11
s-f Tanypodinae	2.63	2.35	1.79	3.59	71.70
Coenagrionidae	3.10	2.14	1.15	3.28	74.98
Isostictidae	2.34	1.98	3.02	3.03	78.01
Hemicorduliidae	2.86	1.90	1.21	2.90	80.91
Hydroptilidae	2.75	1.74	1.05	2.67	83.58
Lymnaeidae	1.99	1.65	1.29	2.51	86.09
Libellulidae	2.31	1.51	1.11	2.31	88.41
Sphaeriidae	2.15	1.40	0.85	2.13	90.54

Group Porters Ck
Average similarity: 63.22

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	9.72	10.30	3.26	16.29	16.29
Hydrobiidae	8.41	10.00	7.76	15.82	32.11
Oligochaeta	4.31	4.69	4.62	7.43	39.53
Megapodagrionidae	4.41	4.36	2.95	6.90	46.44
Physidae	4.44	4.19	2.55	6.62	53.05
Notonectidae	3.88	3.73	1.93	5.90	58.95
Isostictidae	4.05	3.68	2.58	5.83	64.78
Coenagrionidae	3.43	2.98	2.17	4.71	69.48
s-f Orthocladiinae	3.19	2.42	1.07	3.83	73.31
s-f Tanypodinae	2.57	1.77	1.03	2.80	76.11
Planorbidae	2.07	1.61	1.20	2.55	78.66
Stratiomyidae	1.71	1.55	1.72	2.45	81.11
Dugesiidae	1.79	1.43	1.26	2.27	83.38
Libellulidae	2.05	1.35	1.17	2.13	85.51
Hemicorduliidae	2.36	1.30	0.83	2.06	87.57
Hydroptilidae	1.87	1.16	0.73	1.83	89.40
Glossiphoniidae	1.82	1.00	0.83	1.58	90.98

Group Shrimptons Ck
Average similarity: 61.09

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	7.56	10.08	5.66	16.51	16.51
Dugesiidae	6.81	9.49	4.12	15.53	32.04
Oligochaeta	5.08	6.71	2.47	10.99	43.02
s-f Chironominae	6.16	5.50	1.70	9.00	52.02
Coenagrionidae	3.44	3.91	3.13	6.39	58.42
Acarina	3.14	3.55	2.32	5.81	64.23
Glossiphoniidae	3.22	3.43	1.18	5.61	69.84
Hemicorduliidae	2.68	2.56	1.45	4.18	74.02
Notonectidae	2.54	2.11	0.95	3.46	77.48
Megapodagrionidae	2.37	1.73	0.95	2.82	80.30
Libellulidae	1.57	1.69	1.25	2.77	83.07
Lymnaeidae	1.73	1.64	1.67	2.69	85.76
Hydrobiidae	1.80	1.01	0.75	1.65	87.42
Planorbidae	1.56	0.88	0.54	1.44	88.86
Stratiomyidae	1.00	0.88	1.02	1.44	90.31

Group Terrys Ck
Average similarity: 70.45

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	8.41	8.82	3.86	12.52	12.52
Megapodagrionidae	7.50	8.08	5.77	11.47	23.99
s-f Chironominae	6.99	6.07	2.30	8.62	32.61
Physidae	5.51	5.62	5.04	7.98	40.59
Oligochaeta	4.93	5.25	9.23	7.44	48.04
Dugesiidae	4.65	4.61	4.03	6.54	54.57
s-f Tanypodinae	4.08	3.87	3.08	5.50	60.07
Isostictidae	3.47	3.55	5.42	5.04	65.11
Notonectidae	3.38	2.62	1.30	3.71	68.83
Hemicorduliidae	3.38	2.50	1.78	3.55	72.38
Elmidae	1.82	1.73	3.49	2.46	74.84
Acarina	2.11	1.71	1.70	2.43	77.27
Coenagrionidae	2.10	1.67	1.62	2.37	79.64
Sphaeriidae	2.29	1.57	0.95	2.23	81.87
Veliidae	1.73	1.54	1.82	2.18	84.05
Planorbidae	1.85	1.54	1.77	2.18	86.23
s-f Orthocladiinae	1.76	1.46	1.87	2.07	88.30
Stratiomyidae	1.44	1.20	1.72	1.70	90.00

Groups Archers Ck & Buffalo Ck

Average dissimilarity = 42.22

	Archers Ck	Buffalo Ck				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	rib%	Cum.%
s-f Chironominae	11.69	9.86	1.91	1.41	4.53	4.53
Hydroptilidae	3.60	2.75	1.81	1.43	4.28	8.82
Hydrobiidae	4.74	6.35	1.77	0.99	4.19	13.01
s-f Orthocladiinae	3.66	1.95	1.75	1.11	4.15	17.15
Planorbidae	0.17	3.00	1.66	2.09	3.92	21.07
Dugesiidae	5.75	3.43	1.65	1.70	3.92	24.99
Megapodagrionidae	2.58	5.19	1.60	2.16	3.79	28.78
Notonectidae	3.63	4.96	1.56	1.41	3.69	32.46
Libellulidae	4.39	2.31	1.54	1.32	3.66	36.12
Oligochaeta	6.34	4.08	1.54	1.75	3.64	39.76
Physidae	6.34	6.85	1.46	1.29	3.45	43.21
Veliidae	2.86	1.04	1.33	1.34	3.16	46.36
Isostictidae	0.00	2.34	1.32	2.13	3.13	49.50
Hemicorduliidae	3.62	2.86	1.32	1.39	3.13	52.63
Coenagrionidae	3.41	3.10	1.26	1.29	2.98	55.61
Sphaeriidae	0.89	2.15	1.24	1.30	2.93	58.54
Aeshnidae	1.95	1.71	1.15	1.27	2.71	61.25
Baetidae	1.78	0.81	1.13	0.85	2.67	63.93
Culicidae	1.73	1.05	1.08	1.11	2.55	66.47
Glossiphoniidae	2.03	0.85	1.03	1.36	2.44	68.91
s-f Tanypodinae	3.43	2.63	0.84	1.19	1.99	70.90
Lymnaeidae	0.96	1.99	0.83	1.73	1.98	72.88
Stratiomyidae	2.53	1.45	0.79	1.35	1.87	74.75
Atyidae	1.28	0.00	0.79	0.67	1.86	76.61
Acarina	1.60	0.82	0.78	1.35	1.85	78.46
Corbiculidae	0.29	1.14	0.74	0.73	1.76	80.22
Corixidae	1.36	0.27	0.74	0.92	1.75	81.97
Simuliidae	1.31	0.18	0.71	1.00	1.67	83.64
Ceratopogonidae	1.12	0.62	0.64	1.17	1.52	85.16
Scyphacidae	1.15	0.73	0.62	1.19	1.48	86.64
Tipulidae	1.09	0.18	0.59	1.19	1.39	88.03
Gerridae	0.35	0.78	0.46	1.02	1.09	89.12
Ancylidae	0.58	0.45	0.43	0.83	1.03	90.15

Groups Archers Ck & Porters Ck

Average dissimilarity = 44.39

	Archers Ck	Porters Ck				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Dugesiidae	5.75	1.79	2.36	1.88	5.32	5.32
Hydrobiidae	4.74	8.41	2.34	1.09	5.28	10.60
Isostictidae	0.00	4.05	2.34	2.40	5.28	15.88
s-f Chironominae	11.69	9.72	2.33	1.42	5.24	21.12
Hydroptilidae	3.60	1.87	1.85	1.52	4.17	25.29
s-f Orthocladiinae	3.66	3.19	1.77	1.22	3.98	29.27
Libellulidae	4.39	2.05	1.66	1.42	3.75	33.01
Physidae	6.34	4.44	1.66	1.48	3.74	36.75
Hemicorduliidae	3.62	2.36	1.46	1.41	3.28	40.04
Megapodagrionidae	2.58	4.41	1.36	1.53	3.06	43.10
Notonectidae	3.63	3.88	1.35	1.40	3.04	46.13
Veliidae	2.86	0.66	1.34	1.31	3.03	49.16
Oligochaeta	6.34	4.31	1.33	1.68	3.00	52.16
s-f Tanypodinae	3.43	2.57	1.18	1.50	2.66	54.82
Planorbidae	0.17	2.07	1.17	1.43	2.63	57.44
Coenagrionidae	3.41	3.43	1.14	1.36	2.57	60.01
Atyidae	1.28	1.61	1.13	1.04	2.54	62.55
Aeshnidae	1.95	0.89	1.09	1.18	2.46	65.02
Culicidae	1.73	0.47	1.04	0.98	2.34	67.36
Baetidae	1.78	0.27	1.02	0.79	2.30	69.66
Glossiphoniidae	2.03	1.82	1.02	1.34	2.30	71.96
Sphaeriidae	0.89	1.18	0.83	0.96	1.87	73.84
Corixidae	1.36	0.69	0.83	1.03	1.86	75.70
Ancylidae	0.58	1.28	0.75	1.21	1.70	77.40
Simuliidae	1.31	0.09	0.73	1.01	1.65	79.05
Acarina	1.60	0.93	0.72	1.28	1.63	80.68
Stratiomyidae	2.53	1.71	0.71	1.51	1.60	82.29
Ceratopogonidae	1.12	0.16	0.64	0.92	1.45	83.74
Scyphacidae	1.15	0.55	0.61	1.19	1.37	85.11
Tipulidae	1.09	0.60	0.57	1.27	1.28	86.39
Dytiscidae	0.69	0.80	0.53	1.13	1.20	87.59
Lymnaeidae	0.96	0.48	0.50	1.30	1.12	88.71
Leptoceridae	0.23	0.74	0.44	0.89	0.99	89.70
Lestidae	0.61	0.00	0.36	0.72	0.80	90.50

Groups Buffalo Ck & Porters Ck

Average dissimilarity = 38.00

	Buffalo Ck	Porters Ck				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Physidae	6.85	4.44	2.01	1.37	5.29	5.29
s-f Chironominae	9.86	9.72	1.88	1.20	4.96	10.24
s-f Orthocladiinae	1.95	3.19	1.65	1.39	4.34	14.59
Hemicorduliidae	2.86	2.36	1.47	1.41	3.87	18.46
Notonectidae	4.96	3.88	1.45	1.54	3.83	22.29
Coenagrionidae	3.10	3.43	1.41	1.43	3.71	26.00
Hydroptilidae	2.75	1.87	1.41	1.41	3.70	29.70
Isostictidae	2.34	4.05	1.39	1.35	3.65	33.35
Hydrobiidae	6.35	8.41	1.37	1.13	3.61	36.96
s-f Tanypodinae	2.63	2.57	1.18	1.44	3.11	40.07
Sphaeriidae	2.15	1.18	1.17	1.35	3.08	43.14
Dugesiidae	3.43	1.79	1.17	1.46	3.07	46.21
Libellulidae	2.31	2.05	1.15	1.35	3.03	49.24
Planorbidae	3.00	2.07	1.13	1.47	2.98	52.22
Megapodagrionidae	5.19	4.41	1.11	1.44	2.93	55.15
Glossiphoniidae	0.85	1.82	1.10	1.17	2.89	58.04
Aeshnidae	1.71	0.89	1.07	1.13	2.82	60.86
Lymnaeidae	1.99	0.48	1.05	1.68	2.76	63.62
Oligochaeta	4.08	4.31	1.01	1.09	2.66	66.28
Atyidae	0.00	1.61	0.95	0.88	2.51	68.79
Corbiculidae	1.14	0.22	0.78	0.68	2.05	70.84
Stratiomyidae	1.45	1.71	0.70	1.24	1.84	72.68
Ancylidae	0.45	1.28	0.69	1.21	1.82	74.50
Veliidae	1.04	0.66	0.69	0.96	1.81	76.31
Culicidae	1.05	0.47	0.68	0.91	1.78	78.10
Acarina	0.82	0.93	0.67	1.17	1.77	79.87
Baetidae	0.81	0.27	0.54	0.62	1.41	81.28
Dytiscidae	0.13	0.80	0.51	0.88	1.34	82.62
Scyphacidae	0.73	0.55	0.49	0.95	1.29	83.92
Gerridae	0.78	0.27	0.49	1.07	1.29	85.21
Corixidae	0.27	0.69	0.49	0.77	1.29	86.49
Leptoceridae	0.09	0.74	0.44	0.83	1.16	87.65
Hydrophilidae	0.53	0.52	0.44	1.04	1.15	88.80
Ceratopogonidae	0.62	0.16	0.42	1.06	1.11	89.91
Tipulidae	0.18	0.60	0.40	0.95	1.06	90.97

Groups Archers Ck & Shrimptons Ck

Average dissimilarity = 46.96

	Archers Ck	Shrimptons CK				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
s-f Chironominae	11.69	6.16	4.20	1.43	8.95	8.95
Hydrobiidae	4.74	1.80	2.47	1.56	5.26	14.22
Hydroptilidae	3.60	0.79	2.10	1.25	4.48	18.69
s-f Orthocladiinae	3.66	0.89	1.96	1.07	4.18	22.87
Libellulidae	4.39	1.57	1.85	1.50	3.93	26.80
Notonectidae	3.63	2.54	1.60	1.37	3.40	30.20
Veliidae	2.86	0.70	1.59	1.38	3.38	33.58
Physidae	6.34	7.56	1.58	1.30	3.36	36.94
s-f Tanypodinae	3.43	1.07	1.57	1.67	3.35	40.29
Dugesiidae	5.75	6.81	1.41	1.13	3.01	43.30
Glossiphoniidae	2.03	3.22	1.40	1.41	2.99	46.29
Hemicorduliidae	3.62	2.68	1.37	1.43	2.91	49.20
Megapodagrionidae	2.58	2.37	1.26	1.20	2.69	51.88
Aeshnidae	1.95	0.42	1.24	1.14	2.64	54.53
Acarina	1.60	3.14	1.24	1.41	2.64	57.16
Culicidae	1.73	0.35	1.16	0.92	2.47	59.63
Coenagrionidae	3.41	3.44	1.15	1.33	2.44	62.07
Oligochaeta	6.34	5.08	1.10	1.21	2.34	64.41
Baetidae	1.78	0.20	1.09	0.76	2.33	66.74
Stratiomyidae	2.53	1.00	1.02	1.66	2.16	68.91
Planorbidae	0.17	1.56	1.01	0.86	2.16	71.06
Corbiculidae	0.29	1.14	0.91	0.68	1.95	73.01
Corixidae	1.36	1.13	0.89	1.18	1.90	74.91
Atyidae	1.28	0.08	0.89	0.69	1.89	76.80
Isostictidae	0.00	1.40	0.83	0.87	1.76	78.55
Simuliidae	1.31	0.00	0.81	1.00	1.73	80.28
Sphaeriidae	0.89	0.84	0.76	0.87	1.62	81.90
Lymnaeidae	0.96	1.73	0.72	1.13	1.53	83.43
Ceratopogonidae	1.12	0.17	0.69	0.93	1.46	84.89
Tipulidae	1.09	0.08	0.67	1.18	1.43	86.32
Scyphacidae	1.15	0.49	0.67	1.14	1.43	87.75
Parastacidae	0.00	0.88	0.55	1.21	1.18	88.93
Ancylidae	0.58	0.55	0.55	0.73	1.18	90.10

Groups Buffalo Ck & Shrimptons Ck
Average dissimilarity = 45.87

Species	Buffalo Ck Av.Abund	Shrimptons Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
s-f Chironominae	9.86	6.16	3.56	1.37	7.76	7.76
Hydrobiidae	6.35	1.80	3.41	1.79	7.44	15.20
Dugesiidae	3.43	6.81	2.44	1.75	5.32	20.52
Megapodagrionidae	5.19	2.37	2.20	1.56	4.80	25.32
Notonectidae	4.96	2.54	2.05	1.43	4.47	29.79
Glossiphoniidae	0.85	3.22	2.00	1.42	4.36	34.15
Hydroptilidae	2.75	0.79	1.70	1.29	3.71	37.86
Acarina	0.82	3.14	1.69	1.69	3.68	41.54
Planorbidae	3.00	1.56	1.58	1.66	3.44	44.98
Physidae	6.85	7.56	1.56	1.42	3.40	48.38
Hemicorduliidae	2.86	2.68	1.45	1.39	3.17	51.55
Oligochaeta	4.08	5.08	1.45	1.44	3.16	54.71
Coenagrionidae	3.10	3.44	1.44	1.35	3.14	57.85
Sphaeriidae	2.15	0.84	1.31	1.26	2.86	60.70
s-f Tanypodinae	2.63	1.07	1.28	1.59	2.79	63.49
Isostictidae	2.34	1.40	1.27	1.45	2.76	66.25
Corbiculidae	1.14	1.14	1.24	0.79	2.71	68.96
Aeshnidae	1.71	0.42	1.11	1.03	2.43	71.39
Libellulidae	2.31	1.57	1.09	1.31	2.38	73.77
s-f Orthocladiinae	1.95	0.89	1.08	0.97	2.34	76.11
Lymnaeidae	1.99	1.73	0.92	1.56	2.02	78.13
Veliidae	1.04	0.70	0.81	0.88	1.76	79.89
Culicidae	1.05	0.35	0.81	0.88	1.76	81.64
Corixidae	0.27	1.13	0.70	1.14	1.52	83.16
Stratiomyidae	1.45	1.00	0.69	1.25	1.51	84.67
Parastacidae	0.00	0.88	0.60	1.21	1.31	85.98
Gerridae	0.78	0.43	0.56	1.08	1.21	87.19
Baetidae	0.81	0.20	0.55	0.57	1.20	88.40
Scyphacidae	0.73	0.49	0.53	0.93	1.16	89.56
Ancylidae	0.45	0.55	0.52	0.92	1.14	90.70

Groups Porters Ck & Shrimptons Ck
Average dissimilarity = 50.34

Species	Porters Ck Av.Abund	Shrimptons Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	8.41	1.80	4.78	2.58	9.49	9.49
s-f Chironominae	9.72	6.16	3.76	1.29	7.48	16.96
Dugesiidae	1.79	6.81	3.63	2.55	7.22	24.18
Physidae	4.44	7.56	2.40	1.60	4.76	28.94
Isostictidae	4.05	1.40	2.18	1.60	4.33	33.27
Megapodagrionidae	4.41	2.37	1.92	1.37	3.82	37.10
s-f Orthocladiinae	3.19	0.89	1.92	1.43	3.81	40.90
Glossiphoniidae	1.82	3.22	1.74	1.33	3.47	44.37
Acarina	0.93	3.14	1.64	1.63	3.26	47.62
Notonectidae	3.88	2.54	1.64	1.28	3.25	50.88
Hemicorduliidae	2.36	2.68	1.53	1.46	3.04	53.91
s-f Tanypodinae	2.57	1.07	1.46	1.23	2.90	56.82
Planorbidae	2.07	1.56	1.36	1.38	2.70	59.51
Coenagrionidae	3.43	3.44	1.31	1.48	2.59	62.11
Hydroptilidae	1.87	0.79	1.27	1.24	2.53	64.64
Oligochaeta	4.31	5.08	1.25	1.44	2.48	67.11
Atyidae	1.61	0.08	1.05	0.89	2.08	69.19
Libellulidae	2.05	1.57	0.99	1.32	1.97	71.17
Corbiculidae	0.22	1.14	0.99	0.63	1.96	73.13
Lymnaeidae	0.48	1.73	0.97	1.34	1.93	75.06
Ancylidae	1.28	0.55	0.94	1.22	1.87	76.92
Sphaeriidae	1.18	0.84	0.85	1.08	1.70	78.62
Corixidae	0.69	1.13	0.81	1.17	1.61	80.23
Stratiomyidae	1.71	1.00	0.77	1.15	1.52	81.75
Aeshnidae	0.89	0.42	0.70	0.83	1.38	83.13
Veliidae	0.66	0.70	0.65	0.97	1.28	84.42
Parastacidae	0.00	0.88	0.61	1.22	1.22	85.64
Dytiscidae	0.80	0.08	0.56	0.86	1.11	86.75
Leptoceridae	0.74	0.00	0.49	0.80	0.96	87.71
Gelastocoridae	0.09	0.66	0.48	0.95	0.95	88.66
Scyphacidae	0.55	0.49	0.47	1.02	0.92	89.58
Tipulidae	0.60	0.08	0.45	0.90	0.89	90.47

Groups Archers Ck & Terrys Ck

Average dissimilarity = 43.29

Species	Archers Ck Av.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
s-f Chironominae	11.69	6.99	3.02	1.47	6.97	6.97
Megapodagrionidae	2.58	7.50	2.76	2.96	6.38	13.36
Hydrobiidae	4.74	8.41	2.44	1.18	5.64	19.00
Isostictidae	0.00	3.47	1.97	4.50	4.54	23.54
Hydroptilidae	3.60	1.09	1.81	1.46	4.18	27.72
Libellulidae	4.39	1.82	1.63	1.48	3.77	31.49
s-f Orthocladiinae	3.66	1.76	1.55	1.07	3.57	35.06
Notonectidae	3.63	3.38	1.36	1.37	3.13	38.20
Dugesiidae	5.75	4.65	1.29	1.66	2.98	41.17
Sphaeriidae	0.89	2.29	1.27	1.45	2.94	44.11
Physidae	6.34	5.51	1.23	1.47	2.83	46.94
Hemicorduliidae	3.62	3.38	1.22	1.38	2.82	49.76
Coenagrionidae	3.41	2.10	1.09	1.24	2.53	52.29
Culicidae	1.73	0.58	1.03	0.98	2.39	54.68
Atyidae	1.28	0.83	1.02	0.78	2.37	57.05
Aeshnidae	1.95	0.70	0.97	1.16	2.24	59.28
Oligochaeta	6.34	4.93	0.97	1.59	2.23	61.52
Planorbidae	0.17	1.85	0.97	1.91	2.23	63.75
Baetidae	1.78	0.13	0.96	0.74	2.23	65.97
Veliidae	2.86	1.73	0.90	1.08	2.08	68.05
Elmidae	0.28	1.82	0.89	2.00	2.06	70.11
s-f Tanypodinae	3.43	4.08	0.88	1.41	2.03	72.14
Glossiphoniidae	2.03	1.26	0.81	1.33	1.87	74.01
Corixidae	1.36	0.20	0.76	0.94	1.76	75.77
Acarina	1.60	2.11	0.75	1.34	1.74	77.51
Stratiomyidae	2.53	1.44	0.70	1.48	1.62	79.13
Simuliidae	1.31	0.95	0.70	1.18	1.62	80.75
Corbiculidae	0.29	1.10	0.70	0.73	1.61	82.36
Gerridae	0.35	1.33	0.67	1.34	1.55	83.91
Ceratopogonidae	1.12	0.55	0.65	1.05	1.51	85.42
Scyphacidae	1.15	0.27	0.61	1.13	1.40	86.82
Tipulidae	1.09	0.58	0.55	1.24	1.26	88.09
Gelastocoridae	0.12	0.87	0.48	1.41	1.12	89.21
Ancylidae	0.58	0.39	0.44	0.74	1.01	90.21

Groups Buffalo Ck & Terrys Ck

Average dissimilarity = 36.49

Species	Buffalo Ck Av.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
s-f Chironominae	9.86	6.99	2.32	1.32	6.35	6.35
Hydrobiidae	6.35	8.41	1.61	1.35	4.41	10.76
Notonectidae	4.96	3.38	1.57	1.51	4.31	15.06
Megapodagrionidae	5.19	7.50	1.51	1.67	4.13	19.20
Physidae	6.85	5.51	1.43	1.44	3.93	23.13
Hemicorduliidae	2.86	3.38	1.42	1.35	3.89	27.02
Hydroptilidae	2.75	1.09	1.28	1.24	3.51	30.53
Coenagrionidae	3.10	2.10	1.25	1.51	3.43	33.96
Sphaeriidae	2.15	2.29	1.14	1.37	3.12	37.08
s-f Tanypodinae	2.63	4.08	1.13	1.29	3.11	40.19
Elmidae	0.00	1.82	1.11	3.05	3.03	43.22
Libellulidae	2.31	1.82	1.06	1.31	2.91	46.13
Dugesiidae	3.43	4.65	1.04	1.36	2.86	48.99
Planorbidae	3.00	1.85	1.03	1.60	2.82	51.81
Oligochaeta	4.08	4.93	1.00	1.26	2.75	54.56
Corbiculidae	1.14	1.10	0.99	0.81	2.71	57.27
Acarina	0.82	2.11	0.99	1.49	2.71	59.97
Aeshnidae	1.71	0.70	0.96	1.22	2.63	62.60
Isostictidae	2.34	3.47	0.96	1.56	2.62	65.22
s-f Orthocladiinae	1.95	1.76	0.94	1.10	2.56	67.79
Lymnaeidae	1.99	0.97	0.87	1.69	2.39	70.18
Veliidae	1.04	1.73	0.87	1.54	2.39	72.57
Glossiphoniidae	0.85	1.26	0.77	1.34	2.10	74.66
Culicidae	1.05	0.58	0.74	0.94	2.03	76.69
Gerridae	0.78	1.33	0.68	1.26	1.87	78.56
Stratiomyidae	1.45	1.44	0.58	1.30	1.58	80.14
Simuliidae	0.18	0.95	0.55	1.12	1.51	81.65
Atyidae	0.00	0.83	0.54	0.40	1.48	83.13
Gelastocoridae	0.31	0.87	0.47	1.27	1.30	84.43
Baetidae	0.81	0.13	0.47	0.54	1.28	85.72
Ceratopogonidae	0.62	0.55	0.46	1.03	1.26	86.97
Scyphacidae	0.73	0.27	0.44	0.85	1.20	88.17
Ceinidae	0.44	0.36	0.42	0.63	1.14	89.32
Talitridae	0.18	0.63	0.39	0.97	1.08	90.40

Groups Porters Ck & Terrys Ck

Average dissimilarity = 38.28

Species	Porters Ck Av.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
s-f Chironominae	9.72	6.99	2.54	1.21	6.62	6.62
Megapodagrionidae	4.41	7.50	2.03	1.69	5.29	11.92
Dugesiidae	1.79	4.65	1.81	1.78	4.72	16.64
Hemicorduliidae	2.36	3.38	1.53	1.36	3.99	20.63
s-f Orthocladiinae	3.19	1.76	1.43	1.54	3.74	24.37
s-f Tanypodinae	2.57	4.08	1.41	1.44	3.69	28.05
Physidae	4.44	5.51	1.31	1.38	3.42	31.48
Notonectidae	3.88	3.38	1.28	1.37	3.36	34.83
Atyidae	1.61	0.83	1.18	0.91	3.09	37.93
Sphaeriidae	1.18	2.29	1.18	1.47	3.07	41.00
Coenagrionidae	3.43	2.10	1.16	1.33	3.04	44.04
Elmidae	0.00	1.82	1.13	3.10	2.95	46.99
Hydrobiidae	8.41	8.41	1.09	1.42	2.86	49.84
Isostictidae	4.05	3.47	1.01	1.42	2.65	52.49
Libellulidae	2.05	1.82	0.99	1.26	2.58	55.07
Hydroptilidae	1.87	1.09	0.98	1.47	2.57	57.64
Glossiphoniidae	1.82	1.26	0.95	1.25	2.48	60.12
Acarina	0.93	2.11	0.94	1.46	2.45	62.57
Oligochaeta	4.31	4.93	0.81	1.35	2.12	64.70
Planorbidae	2.07	1.85	0.81	1.28	2.12	66.82
Veliidae	0.66	1.73	0.76	1.45	2.00	68.81
Ancylidae	1.28	0.39	0.75	1.22	1.96	70.77
Gerridae	0.27	1.33	0.74	1.36	1.94	72.71
Corbiculidae	0.22	1.10	0.73	0.68	1.90	74.61
Aeshnidae	0.89	0.70	0.60	1.01	1.56	76.17
Simuliidae	0.09	0.95	0.57	1.09	1.48	77.65
Stratiomyidae	1.71	1.44	0.56	1.11	1.46	79.11
Lymnaeidae	0.48	0.97	0.53	1.19	1.38	80.49
Gelastocoridae	0.09	0.87	0.52	1.38	1.35	81.84
Dytiscidae	0.80	0.18	0.50	0.93	1.30	83.14
Corixidae	0.69	0.20	0.49	0.72	1.29	84.43
Culicidae	0.47	0.58	0.49	0.80	1.27	85.70
Tipulidae	0.60	0.58	0.45	1.11	1.18	86.87
Leptoceridae	0.74	0.00	0.43	0.80	1.11	87.99
Talitridae	0.27	0.63	0.41	1.03	1.06	89.05
Ceratopogonidae	0.16	0.55	0.40	0.73	1.04	90.10

Groups Shrimptons Ck & Terrys Ck

Average dissimilarity = 45.47

Species	Shrimptons Ck Av.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	1.80	8.41	4.62	2.23	10.15	10.15
Megapodagrionidae	2.37	7.50	3.59	2.08	7.90	18.06
s-f Chironominae	6.16	6.99	2.77	1.37	6.09	24.15
s-f Tanypodinae	1.07	4.08	2.09	1.90	4.61	28.76
Isostictidae	1.40	3.47	1.73	1.88	3.80	32.56
Glossiphoniidae	3.22	1.26	1.67	1.40	3.67	36.23
Dugesiidae	6.81	4.65	1.63	1.47	3.58	39.82
Physidae	7.56	5.51	1.61	1.53	3.55	43.36
Notonectidae	2.54	3.38	1.56	1.31	3.43	46.79
Hemicorduliidae	2.68	3.38	1.45	1.32	3.20	49.99
Sphaeriidae	0.84	2.29	1.33	1.38	2.93	52.92
Coenagrionidae	3.44	2.10	1.19	1.37	2.63	55.54
Corbiculidae	1.14	1.10	1.19	0.79	2.62	58.16
Elmidae	0.08	1.82	1.18	2.58	2.60	60.76
Planorbidae	1.56	1.85	1.15	1.51	2.54	63.29
Acarina	3.14	2.11	1.10	1.35	2.41	65.71
Veliidae	0.70	1.73	1.02	1.71	2.25	67.95
Oligochaeta	5.08	4.93	0.95	1.32	2.10	70.05
Libellulidae	1.57	1.82	0.84	1.16	1.85	71.89
Hydroptilidae	0.79	1.09	0.82	1.40	1.80	73.69
Gerridae	0.43	1.33	0.78	1.33	1.71	75.41
Lymnaeidae	1.73	0.97	0.77	1.15	1.69	77.10
Corixidae	1.13	0.20	0.75	1.20	1.65	78.74
s-f Orthocladiinae	0.89	1.76	0.74	1.20	1.62	80.36
Atyidae	0.08	0.83	0.64	0.44	1.41	81.78
Simuliidae	0.00	0.95	0.62	1.05	1.37	83.14
Parastacidae	0.88	0.00	0.58	1.22	1.29	84.43
Stratiomyidae	1.00	1.44	0.58	1.21	1.28	85.71
Aeshnidae	0.42	0.70	0.52	1.11	1.14	86.85
Culicidae	0.35	0.58	0.51	0.64	1.12	87.97
Gelastocoridae	0.66	0.87	0.50	1.24	1.10	89.07
Ancylidae	0.55	0.39	0.49	0.74	1.08	90.14

SIMPER Archers Creek 2005 – 2010

Data worksheet
Name: Archers Ck sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	Season Year
S5	Autumn 2005
S5	Spring 2005
S5	Autumn 2006
S5	Spring 2006
S5	Autumn 2007
S5	Spring 2007
S5	Autumn 2008
S5	Spring 2008
S5	Autumn 2009
S5	Spring 2009
S5	Autumn 2010
S5	Spring 2010

Group Autumn 2005
Average similarity: 68.02

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Megapodagrionidae	3.60	7.56	2.16	11.11	11.11
Atyidae	3.30	7.18	8.38	10.56	21.67
Oligochaeta	3.29	6.80	3.09	9.99	31.67
s-f Chironominae	3.31	6.58	5.68	9.67	41.33
Libellulidae	2.52	5.47	4.54	8.04	49.37
Dugesiidae	2.75	5.32	5.50	7.82	57.19
Coenagrionidae	3.19	5.20	4.94	7.65	64.83
Veliidae	2.14	5.09	3.65	7.49	72.32
Hemicorduliidae	2.66	4.82	8.37	7.08	79.40
Physidae	1.67	3.65	1.80	5.36	84.77
Stratiomyidae	1.62	2.98	7.13	4.38	89.15
s-f Tanypodinae	1.00	2.65	8.58	3.90	93.04

Group Spring 2005
Average similarity: 58.85

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	8.06	19.91	6.33	33.83	33.83
Oligochaeta	4.19	10.61	6.70	18.04	51.87
Physidae	2.95	7.20	6.86	12.24	64.11
Coenagrionidae	3.08	6.42	6.60	10.90	75.01
Libellulidae	2.87	6.04	1.03	10.27	85.28
Aeshnidae	1.49	2.00	0.58	3.40	88.68
Corbiculidae	1.15	1.97	0.58	3.36	92.04

Group Autumn 2006
Average similarity: 72.35

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	9.12	23.36	19.19	32.29	32.29
Oligochaeta	3.39	8.50	11.35	11.74	44.04
Glossiphoniidae	2.10	4.91	2.60	6.79	50.82
Megapodagrionidae	2.10	4.62	4.53	6.39	57.21
Libellulidae	2.02	4.46	4.33	6.17	63.38
Coenagrionidae	2.03	4.02	1.99	5.56	68.94
Hemicorduliidae	1.96	3.84	2.25	5.30	74.24
Dugesiidae	1.67	3.63	2.69	5.02	79.26
Veliidae	1.28	3.17	3.92	4.38	83.63
Notonectidae	1.47	3.16	4.33	4.36	88.00
Aeshnidae	2.05	2.45	0.58	3.38	91.38

Group Spring 2006

Average similarity: 60.22

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.35	14.93	4.12	24.80	24.80
Physidae	2.81	10.04	3.55	16.68	41.47
Dugesiidae	2.63	8.66	2.75	14.39	55.86
Oligochaeta	2.43	7.87	2.82	13.07	68.93
Hydrobiidae	1.81	4.51	1.47	7.48	76.41
s-f Tanypodinae	1.07	3.38	1.76	5.62	82.03
Veliidae	0.80	1.96	0.79	3.25	85.28
s-f Orthocladiinae	1.06	1.92	0.79	3.18	88.47
Stratiomyidae	0.87	1.55	0.57	2.58	91.05

Group Autumn 2007

Average similarity: 57.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	5.02	17.66	4.21	30.81	30.81
Oligochaeta	2.53	6.59	1.30	11.49	42.30
Physidae	2.35	6.46	3.17	11.27	53.57
Dugesiidae	2.20	4.54	1.22	7.93	61.50
s-f Tanypodinae	1.19	4.00	5.04	6.99	68.48
Libellulidae	1.50	3.89	1.21	6.79	75.27
Veliidae	1.93	3.06	0.75	5.35	80.62
Glossiphoniidae	1.08	2.51	1.28	4.38	85.00
Megapodagrionidae	1.01	1.90	0.77	3.31	88.31
Aeshnidae	0.98	1.76	0.78	3.07	91.38

Group Spring 2007

Average similarity: 60.72

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	5.57	14.82	7.94	24.41	24.41
Physidae	3.77	10.12	7.07	16.67	41.08
Hydrobiidae	2.81	6.64	2.42	10.94	52.02
Oligochaeta	2.95	6.42	3.32	10.58	62.60
Dugesiidae	2.70	4.97	1.23	8.19	70.79
s-f Tanypodinae	1.84	3.93	2.47	6.47	77.26
Sphaeriidae	2.01	3.07	1.01	5.05	82.31
Hemicorduliidae	1.57	2.35	1.15	3.88	86.19
Libellulidae	1.04	2.12	1.29	3.49	89.68
s-f Orthocladiinae	1.33	1.76	0.73	2.90	92.58

Group Autumn 2008

Average similarity: 61.14

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Orthocladiinae	4.42	13.68	5.42	22.37	22.37
s-f Chironominae	3.35	10.70	5.74	17.51	39.88
Hydrobiidae	2.52	6.99	2.75	11.43	51.31
Oligochaeta	1.69	5.02	3.59	8.21	59.52
Veliidae	1.62	4.29	4.33	7.02	66.54
Physidae	2.03	4.28	1.16	7.00	73.54
Notonectidae	1.69	3.38	1.06	5.54	79.07
Hydroptilidae	1.35	2.18	0.74	3.57	82.65
Ceratopogonidae	1.15	2.05	0.78	3.35	86.00
Baetidae	1.26	1.64	0.48	2.68	88.68
Stratiomyidae	0.67	1.42	0.79	2.32	91.00

Group Spring 2008

Average similarity: 69.72

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	3.99	12.17	10.20	17.46	17.46
Dugesiidae	2.87	8.16	7.17	11.70	29.16
Oligochaeta	2.85	8.05	6.36	11.55	40.71
Hydroptilidae	3.13	7.69	3.78	11.04	51.75
Physidae	2.77	6.64	2.38	9.53	61.28
Hydrobiidae	2.46	6.11	5.80	8.77	70.04
s-f Orthocladiinae	2.49	4.74	1.09	6.80	76.84
Notonectidae	1.74	3.20	1.03	4.58	81.43
Ancylidae	1.30	2.59	1.31	3.72	85.15
s-f Tanypodinae	1.24	2.29	1.29	3.29	88.43
Glossiphoniidae	1.08	2.28	1.24	3.27	91.70

Group Autumn 2009

Average similarity: 64.32

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.02	10.17	4.55	15.81	15.81
Libellulidae	3.11	6.61	2.09	10.27	26.08
Dugesiidae	2.69	6.32	2.12	9.83	35.91
Hydroptilidae	2.52	5.85	2.36	9.10	45.00
Oligochaeta	2.33	5.20	3.07	8.08	53.08
s-f Orthocladiinae	2.16	4.81	2.62	7.49	60.57
Physidae	2.02	4.29	2.49	6.67	67.24
Simuliidae	1.57	3.61	3.93	5.61	72.85
Coenagrionidae	1.77	3.55	3.75	5.52	78.37
Hydrobiidae	2.04	3.06	1.17	4.76	83.13
Notonectidae	1.78	2.08	0.73	3.23	86.36
Ceratopogonidae	0.97	1.85	1.34	2.87	89.23
Glossiphoniidae	1.22	1.55	0.77	2.41	91.64

Group Spring 2009

Average similarity: 65.01

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.15	11.59	8.44	17.82	17.82
Dugesiidae	3.07	8.94	5.85	13.76	31.58
Physidae	3.07	8.84	5.79	13.60	45.18
Hydrobiidae	3.00	8.47	4.25	13.03	58.22
Oligochaeta	2.40	6.38	3.39	9.81	68.02
Hydroptilidae	2.39	5.15	2.26	7.93	75.95
s-f Tanypodinae	1.98	5.00	3.02	7.68	83.63
Culicidae	1.44	2.40	1.23	3.69	87.33
Stratiomyidae	1.02	2.19	1.33	3.37	90.69

Group Autumn 2010

Average similarity: 65.73

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.77	11.51	6.78	17.51	17.51
Baetidae	2.86	6.16	3.08	9.37	26.88
Hydrobiidae	2.59	5.31	4.67	8.08	34.96
Physidae	2.41	4.83	3.53	7.35	42.31
Notonectidae	2.26	4.75	4.82	7.22	49.54
Hemicorduliidae	1.84	4.05	6.00	6.17	55.71
Oligochaeta	1.91	4.04	7.75	6.14	61.85
Libellulidae	2.62	3.67	1.15	5.59	67.43
Dugesiidae	2.11	3.54	1.34	5.39	72.82
Aeshnidae	1.48	3.24	4.79	4.93	77.75
Hydroptilidae	1.91	3.19	1.25	4.85	82.60
Corixidae	1.60	2.47	1.14	3.75	86.36
Veliidae	1.93	2.31	0.78	3.52	89.87
s-f Orthocladiinae	1.35	1.60	0.69	2.44	92.31

Group Spring 2010

Average similarity: 63.78

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	5.75	13.41	6.83	21.03	21.03
Physidae	3.75	9.75	7.66	15.28	36.31
Notonectidae	2.97	7.16	4.95	11.22	47.53
Hydrobiidae	3.19	7.00	2.73	10.98	58.51
Oligochaeta	2.38	4.92	2.16	7.71	66.22
Dugesiidae	2.55	4.84	4.06	7.59	73.81
s-f Tanypodinae	1.94	3.18	1.32	4.98	78.80
Hydroptilidae	2.24	2.92	0.97	4.58	83.38
Libellulidae	1.83	2.76	1.17	4.32	87.70
Coenagrionidae	1.52	2.11	1.16	3.30	91.01

SIMPER Shrimptons Creek 2005 – 2010

Data worksheet
Name: Shrimptons Ck sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	Season Year
S2	Autumn 2005
S2	Spring 2005
S2	Autumn 2006
S2	Spring 2006
S2	Autumn 2007
S2	Spring 2007
S2	Autumn 2008
S2	Spring 2008
S2	Autumn 2009
S2	Spring 2009
S2	Autumn 2010
S2	Spring 2010

Group Autumn 2005
Average similarity: 75.89

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	3.90	16.31	7.41	21.49	21.49
Dugesiidae	3.81	15.30	9.53	20.16	41.65
Oligochaeta	3.43	13.48	44.44	17.77	59.41
Glossiphoniidae	3.04	10.94	8.30	14.42	73.83
Corbiculidae	2.63	9.41	3.56	12.40	86.23
Planorbidae	2.39	7.68	3.56	10.12	96.35

Group Spring 2005
Average similarity: 76.54

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	4.03	13.28	19.85	17.35	17.35
Oligochaeta	3.91	13.08	46.28	17.09	34.44
Dugesiidae	3.46	11.45	11.43	14.97	49.41
Glossiphoniidae	3.04	9.70	10.63	12.67	62.08
s-f Chironominae	3.09	8.94	4.43	11.68	73.76
Planorbidae	2.88	8.57	3.06	11.20	84.96
Corbiculidae	2.64	7.51	12.72	9.82	94.78

Group Autumn 2006
Average similarity: 76.70

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Oligochaeta	3.68	16.90	13.74	22.03	22.03
Dugesiidae	2.82	13.43	9.18	17.51	39.55
Physidae	2.96	13.00	3.19	16.95	56.50
Acarina	2.08	9.91	14.34	12.92	69.42
Corbiculidae	2.39	9.70	6.21	12.64	82.06
Hemicorduliidae	1.88	6.51	2.65	8.49	90.55

Group Spring 2006
Average similarity: 62.17

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.59	20.77	7.14	33.41	33.41
Physidae	3.41	15.57	10.74	25.04	58.46
Oligochaeta	2.05	7.05	1.41	11.35	69.80
Dugesiidae	1.31	3.75	1.10	6.03	75.83
Notonectidae	1.03	3.23	1.14	5.19	81.03
Acarina	1.12	3.02	1.10	4.86	85.89
Hemicorduliidae	1.12	2.85	0.79	4.58	90.47

Group Autumn 2007

Average similarity: 60.39

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	2.95	8.39	2.58	13.89	13.89
Megapodagrionidae	2.10	6.97	5.43	11.55	25.44
Dugesiidae	2.16	6.71	3.12	11.10	36.54
Acarina	2.02	5.61	3.42	9.28	45.83
Coenagrionidae	1.80	5.41	2.78	8.96	54.79
Isostictidae	1.72	5.19	3.30	8.59	63.38
Hemicorduliidae	2.14	4.74	1.11	7.85	71.23
Oligochaeta	1.72	4.72	1.08	7.81	79.04
Physidae	2.28	4.63	1.08	7.67	86.71
Notonectidae	1.01	2.01	0.75	3.33	90.04

Group Spring 2007

Average similarity: 63.13

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.53	12.18	4.26	19.29	19.29
Physidae	3.79	10.55	5.00	16.72	36.01
Oligochaeta	2.22	6.38	4.93	10.10	46.12
Dugesiidae	2.25	5.37	2.58	8.51	54.62
Coenagrionidae	2.01	4.99	3.48	7.90	62.53
Isostictidae	1.88	4.87	3.27	7.71	70.23
Megapodagrionidae	1.95	3.26	0.78	5.17	75.41
Ancylidae	1.37	3.05	1.34	4.83	80.24
Corixidae	1.28	2.94	1.28	4.65	84.89
Hemicorduliidae	1.25	2.90	1.35	4.59	89.48
Notonectidae	0.67	1.56	0.78	2.48	91.96

Group Autumn 2008

Average similarity: 57.63

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dugesiidae	3.55	20.83	4.34	36.15	36.15
Physidae	2.91	16.00	4.67	27.76	63.91
Oligochaeta	1.52	6.57	1.29	11.39	75.30
Megapodagrionidae	1.05	3.47	0.77	6.02	81.32
Glossiphoniidae	1.22	2.81	0.76	4.87	86.19
Acarina	0.98	2.63	0.78	4.57	90.76

Group Spring 2008

Average similarity: 62.97

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	3.46	15.55	5.33	24.69	24.69
Dugesiidae	2.86	12.16	5.11	19.31	44.00
s-f Chironominae	2.37	9.80	3.96	15.56	59.56
Oligochaeta	2.02	7.51	2.08	11.93	71.48
Coenagrionidae	1.95	6.57	2.85	10.43	81.91
Acarina	1.41	2.94	0.78	4.66	86.58
Glossiphoniidae	0.98	2.04	0.77	3.24	89.82
Sphaeriidae	0.79	1.84	0.78	2.92	92.73

Group Autumn 2009

Average similarity: 48.10

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dugesiidae	2.87	15.22	5.70	31.64	31.64
Glossiphoniidae	1.62	7.41	1.34	15.41	47.05
Notonectidae	1.50	5.22	1.18	10.86	57.91
Lymnaeidae	1.09	4.86	1.30	10.10	68.01
Physidae	1.45	4.82	0.72	10.02	78.03
Coenagrionidae	1.16	3.69	0.76	7.68	85.71
s-f Chironominae	1.07	3.50	0.69	7.29	92.99

Group Spring 2009

Average similarity: 61.92

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	3.60	11.95	3.70	19.30	19.30
Dugesiidae	3.09	10.92	5.93	17.63	36.93
s-f Chironominae	3.18	10.78	6.17	17.41	54.34
Glossiphoniidae	2.04	4.82	1.22	7.79	62.13
Hemicorduliidae	1.51	4.32	3.66	6.98	69.10
Oligochaeta	1.68	4.26	1.16	6.88	75.98
Lymnaeidae	1.37	3.56	1.25	5.74	81.73
Coenagrionidae	1.47	3.48	1.29	5.63	87.35
Acarina	1.13	1.91	0.77	3.08	90.43

Group Autumn 2010

Average similarity: 57.66

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dugesiidae	3.48	19.10	6.71	33.12	33.12
Physidae	2.47	10.75	2.60	18.64	51.77
Oligochaeta	2.13	9.50	5.06	16.48	68.25
Glossiphoniidae	1.57	4.69	1.25	8.13	76.38
Hemicorduliidae	1.21	4.67	1.30	8.10	84.48
s-f Chironominae	1.48	3.05	0.73	5.28	89.76
Coenagrionidae	0.97	2.71	0.76	4.69	94.45

Group Spring 2010

Average similarity: 65.17

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	3.73	11.90	10.18	18.27	18.27
Dugesiidae	3.41	11.54	6.05	17.71	35.98
s-f Chironominae	3.16	8.22	1.99	12.61	48.58
Acarina	1.88	5.33	3.24	8.18	56.76
Coenagrionidae	2.01	4.86	1.31	7.46	64.22
Hydrobiidae	2.23	4.83	1.07	7.41	71.64
Hydroptilidae	1.33	4.39	6.28	6.74	78.38
Megapodagrionidae	1.40	3.91	6.32	6.00	84.37
Oligochaeta	1.14	2.85	1.32	4.38	88.75
Lymnaeidae	1.06	1.88	0.78	2.88	91.63

SIMPER Buffalo Creek 2005 – 2010

Data worksheet
Name: Buffalo Ck sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	Season Year
S4	Autumn 2005
S4	Spring 2005
S4	Autumn 2006
S4	Autumn 2007
S4	Spring 2007
S4	Autumn 2008
S4	Spring 2008
S4	Autumn 2009
S4	Spring 2009
S4	Autumn 2010
S4	Spring 2010

Group Autumn 2005
Average similarity: 75.60

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Megapodagrionidae	3.98	7.74	6.17	10.23	10.23
s-f Chironominae	4.20	7.21	13.30	9.54	19.77
Notonectidae	3.21	7.16	10.08	9.47	29.24
Oligochaeta	3.21	7.06	6.27	9.34	38.58
Coenagrionidae	2.98	5.47	10.81	7.24	45.82
Hydrobiidae	2.90	4.86	7.76	6.42	52.24
Dugesiidae	2.23	4.69	14.61	6.21	58.45
Corbiculidae	2.40	4.56	5.24	6.03	64.48
Hemicorduliidae	3.12	4.35	1.26	5.75	70.22
Planorbidae	1.52	3.20	10.08	4.24	74.46
s-f Tanypodinae	1.82	3.20	10.08	4.24	78.69
Physidae	1.82	3.00	2.44	3.96	82.66
Acarina	1.28	2.61	3.18	3.45	86.11
Stratiomyidae	1.38	2.57	5.00	3.40	89.51
Glossiphoniidae	1.28	2.57	5.00	3.40	92.90

Group Spring 2005
Average similarity: 66.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	6.42	14.47	9.77	21.81	21.81
Oligochaeta	4.67	11.44	24.58	17.24	39.05
Physidae	3.67	8.06	4.71	12.15	51.20
Hydrobiidae	3.19	7.89	6.77	11.89	63.10
Scyphacidae	1.72	4.18	7.44	6.30	69.40
Dugesiidae	1.87	4.16	13.86	6.27	75.67
Corbiculidae	2.18	3.82	2.22	5.75	81.42
Notonectidae	1.67	3.67	2.28	5.53	86.95
Libellulidae	2.01	3.11	6.34	4.68	91.64

Group Autumn 2006

Average similarity: 74.85

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	7.70	15.83	20.12	21.15	21.15
Notonectidae	3.55	7.57	11.10	10.11	31.26
Libellulidae	2.92	5.38	3.70	7.19	38.44
Physidae	2.57	5.35	10.99	7.15	45.59
Coenagrionidae	2.72	5.21	13.45	6.96	52.55
Corbiculidae	2.37	4.86	7.03	6.49	59.04
Oligochaeta	2.57	4.72	3.44	6.31	65.36
Megapodagrionidae	2.41	4.24	2.37	5.67	71.02
Dugesiidae	1.82	3.91	49.03	5.22	76.25
Aeshnidae	1.97	3.91	49.03	5.22	81.47
Hemicorduliidae	2.34	3.63	5.00	4.85	86.31
s-f Orthocladiinae	1.61	3.19	49.03	4.26	90.58

Group Autumn 2007

Average similarity: 69.52

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.26	9.71	5.15	13.97	13.97
Notonectidae	3.23	7.79	6.96	11.21	25.18
Physidae	3.23	6.36	2.24	9.14	34.32
Hydrobiidae	2.51	5.25	2.69	7.55	41.88
Hemicorduliidae	2.47	5.09	2.72	7.33	49.20
Megapodagrionidae	2.06	4.40	6.84	6.33	55.54
Hydroptilidae	1.93	4.09	4.75	5.88	61.42
s-f Tanypodinae	1.71	3.53	3.54	5.07	66.49
Isostictidae	1.64	3.19	4.05	4.59	71.08
Lymnaeidae	1.60	3.15	4.78	4.53	75.61
Aeshnidae	1.64	2.85	1.35	4.10	79.71
Coenagrionidae	1.57	2.28	1.24	3.28	83.00
Dugesiidae	1.43	1.76	0.79	2.53	85.53
Baetidae	1.70	1.71	0.48	2.46	87.99
Stratiomyidae	1.02	1.68	1.33	2.42	90.41

Group Spring 2007

Average similarity: 65.17

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.63	14.76	4.83	22.65	22.65
Physidae	3.92	14.38	11.29	22.07	44.72
Hydrobiidae	2.54	8.68	5.00	13.33	58.05
Megapodagrionidae	1.97	5.33	2.53	8.17	66.22
Oligochaeta	1.68	5.09	2.75	7.81	74.03
Notonectidae	1.43	4.64	4.77	7.12	81.15
Isostictidae	1.51	2.99	0.78	4.58	85.73
Coenagrionidae	1.01	1.86	0.77	2.85	88.58
s-f Tanypodinae	0.97	1.81	0.77	2.78	91.36

Group Autumn 2008

Average similarity: 63.54

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	3.63	9.91	6.68	15.60	15.60
Notonectidae	3.12	9.02	3.62	14.19	29.79
Physidae	3.11	6.90	2.31	10.86	40.65
Megapodagrionidae	2.49	6.89	3.97	10.85	51.50
Dugesiidae	2.10	6.11	4.67	9.62	61.12
Hydrobiidae	2.61	5.21	1.25	8.20	69.32
Hydroptilidae	2.31	4.66	1.15	7.34	76.66
s-f Orthocladiinae	2.39	4.48	1.24	7.04	83.70
Planorbidae	1.33	1.85	0.71	2.91	86.61
Aeshnidae	0.93	1.51	0.75	2.38	88.99
Oligochaeta	0.96	1.37	0.77	2.16	91.14

Group Spring 2008
Average similarity: 65.89

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	3.74	19.20	4.53	29.13	29.13
s-f Chironominae	3.71	17.49	4.38	26.54	55.67
Hydrobiidae	3.12	15.80	3.82	23.98	79.65
Megapodagrionidae	1.19	4.54	1.29	6.89	86.54
Oligochaeta	1.26	4.07	1.28	6.18	92.72

Group Autumn 2009
Average similarity: 68.72

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	3.01	9.79	5.02	14.24	14.24
s-f Chironominae	2.86	8.96	3.23	13.04	27.28
Hydrobiidae	2.97	8.61	3.50	12.53	39.81
Notonectidae	2.35	7.03	3.56	10.23	50.04
Megapodagrionidae	2.08	6.23	5.89	9.06	59.11
s-f Orthocladiinae	1.54	4.90	3.79	7.14	66.24
Coenagrionidae	1.63	4.57	4.41	6.65	72.90
Dugesiidae	1.67	3.69	1.31	5.36	78.26
Hydroptilidae	1.50	3.25	1.24	4.72	82.98
Planorbidae	1.55	3.02	0.78	4.39	87.38
Isostictidae	0.90	2.48	1.34	3.61	90.98

Group Spring 2009
Average similarity: 68.93

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	3.41	11.88	3.46	17.24	17.24
Hydrobiidae	3.23	11.39	6.09	16.53	33.77
Megapodagrionidae	2.52	7.62	2.47	11.05	44.82
Physidae	2.36	7.44	2.02	10.79	55.61
Sphaeriidae	1.82	5.66	4.05	8.21	63.82
Planorbidae	1.55	5.46	4.11	7.92	71.74
Oligochaeta	1.24	4.24	5.85	6.15	77.89
Lymnaeidae	1.14	4.15	10.80	6.02	83.91
Notonectidae	1.09	3.07	1.31	4.46	88.37
Hydroptilidae	1.74	2.90	0.75	4.21	92.57

Group Autumn 2010
Average similarity: 56.43

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	2.88	9.63	4.34	17.07	17.07
Notonectidae	2.69	8.86	3.26	15.69	32.76
Hydrobiidae	3.06	8.34	2.42	14.79	47.55
Planorbidae	1.58	4.46	4.16	7.90	55.45
Physidae	1.45	3.19	1.24	5.66	61.11
Megapodagrionidae	1.48	2.67	0.77	4.73	65.84
Oligochaeta	1.14	2.34	1.34	4.14	69.98
Coenagrionidae	1.91	2.26	0.70	4.00	73.98
Dugesiidae	1.44	2.10	0.74	3.73	77.71
Veliidae	1.47	1.73	0.73	3.07	80.78
s-f Tanypodinae	1.18	1.61	0.72	2.85	83.62
Aeshnidae	1.41	1.54	0.77	2.73	86.36
Hemicorduliidae	1.09	1.38	0.76	2.45	88.80
Sphaeriidae	1.29	1.37	0.48	2.43	91.23

Group Spring 2010
Average similarity: 60.60

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.90	21.28	3.90	35.12	35.12
Hydrobiidae	2.49	11.38	3.60	18.77	53.89
Physidae	2.78	8.81	3.59	14.54	68.43
Megapodagrionidae	1.59	4.41	1.32	7.28	75.71
Oligochaeta	1.38	3.46	1.29	5.72	81.42
Notonectidae	1.04	2.95	0.76	4.86	86.29
s-f Tanypodinae	0.97	2.07	0.74	3.42	89.71
Dugesiidae	0.67	1.69	0.78	2.79	92.50

SIMPER Porters Creek 2005 – 2010

Data worksheet
Name: Porters Ck sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	Season Year
S3	Autumn 2005
S3	Spring 2005
S3	Autumn 2006
S3	Autumn 2007
S3	Spring 2007
S3	Autumn 2008
S3	Spring 2008
S3	Autumn 2009
S3	Spring 2009
S3	Autumn 2010
S3	Spring 2010

Group Autumn 2005
Average similarity: 76.82

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	6.51	12.89	10.12	16.78	16.78
Hydrobiidae	4.59	8.30	7.22	10.80	27.58
Isostictidae	4.18	8.07	10.67	10.50	38.08
Hemicorduliidae	2.89	5.93	55.42	7.71	45.80
Physidae	3.09	5.90	11.52	7.68	53.47
Megapodagrionidae	3.01	5.40	10.58	7.03	60.50
Coenagrionidae	2.83	4.64	2.61	6.04	66.54
Planorbidae	2.30	4.51	7.69	5.87	72.40
Oligochaeta	2.45	4.13	4.56	5.38	77.79
Glossiphoniidae	2.10	3.54	3.45	4.61	82.40
s-f Tanypodinae	2.39	3.38	4.51	4.40	86.79
Aeshnidae	1.41	2.96	55.42	3.86	90.65

Group Spring 2005
Average similarity: 72.69

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	10.09	23.35	7.12	32.12	32.12
Hydrobiidae	4.74	10.08	8.73	13.86	45.98
Oligochaeta	2.68	5.99	19.38	8.24	54.22
Isostictidae	2.63	5.99	19.38	8.24	62.46
Physidae	2.49	5.65	4.31	7.77	70.24
Glossiphoniidae	1.99	4.63	6.74	6.37	76.61
Libellulidae	2.22	4.33	2.89	5.95	82.56
Corixidae	1.80	2.91	3.64	4.00	86.56
Erpobdellidae	1.28	2.88	4.62	3.97	90.53

Group Autumn 2006
Average similarity: 71.92

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	4.07	8.77	4.85	12.20	12.20
Coenagrionidae	3.33	7.27	5.23	10.10	22.30
Megapodagrionidae	3.64	7.01	7.28	9.75	32.05
Isostictidae	3.18	6.57	18.65	9.14	41.19
Oligochaeta	2.58	6.08	18.65	8.46	49.65
Hemicorduliidae	2.69	5.55	18.65	7.72	57.37
Atyidae	2.74	5.55	18.65	7.72	65.09
Glossiphoniidae	2.85	5.24	2.96	7.29	72.38
Aeshnidae	2.20	4.69	10.46	6.53	78.91
Physidae	1.93	3.76	15.62	5.23	84.14
Libellulidae	1.66	3.11	2.72	4.32	88.46
s-f Tanypodinae	2.52	2.58	0.58	3.58	92.04

Group Autumn 2007

Average similarity: 71.28

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	4.72	10.58	6.69	14.84	14.84
Physidae	2.61	5.88	5.12	8.24	23.09
Notonectidae	2.63	5.79	5.28	8.12	31.21
Isostictidae	2.79	5.76	3.27	8.08	39.29
s-f Chironominae	2.78	5.51	4.23	7.73	47.02
Coenagrionidae	2.63	5.44	3.69	7.64	54.66
Megapodagrionidae	2.45	5.12	4.50	7.18	61.84
Hemicorduliidae	2.37	4.88	3.60	6.85	68.68
Libellulidae	2.15	4.36	3.65	6.11	74.80
Hydroptilidae	1.89	3.85	4.08	5.41	80.20
Atyidae	2.15	3.77	2.18	5.29	85.49
s-f Orthocladiinae	1.72	2.70	1.17	3.79	89.28
s-f Tanypodinae	1.33	1.79	0.78	2.51	91.80

Group Spring 2007

Average similarity: 67.64

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.72	18.60	7.09	27.50	27.50
Hydrobiidae	3.74	12.08	4.54	17.86	45.36
Physidae	2.81	9.67	4.32	14.29	59.65
Oligochaeta	2.70	8.17	3.30	12.08	71.73
Megapodagrionidae	2.43	7.43	3.03	10.98	82.71
Isostictidae	1.45	3.67	1.28	5.42	88.13
Planorbidae	0.79	1.59	0.78	2.35	90.48

Group Autumn 2008

Average similarity: 59.84

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	3.77	14.45	6.36	24.15	24.15
Hydrobiidae	3.11	11.65	5.95	19.47	43.62
Megapodagrionidae	2.24	6.95	2.96	11.62	55.23
s-f Orthocladiinae	2.30	5.72	2.27	9.57	64.80
Notonectidae	1.87	5.31	3.06	8.88	73.68
Stratiomyidae	1.45	3.70	1.25	6.19	79.87
Oligochaeta	1.34	2.46	0.78	4.12	83.99
Physidae	1.20	2.10	0.73	3.51	87.50
Dugesiidae	1.15	2.00	0.70	3.33	90.84

Group Spring 2008

Average similarity: 52.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Physidae	2.92	12.47	4.82	23.87	23.87
Oligochaeta	2.24	9.31	2.70	17.81	41.68
s-f Chironominae	2.57	7.72	0.77	14.77	56.44
Hydrobiidae	2.22	6.22	1.09	11.90	68.35
Notonectidae	1.26	4.09	1.34	7.82	76.17
Megapodagrionidae	1.09	4.04	1.19	7.72	83.89
Planorbidae	1.00	3.25	1.33	6.23	90.12

Group Autumn 2009

Average similarity: 58.24

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	3.36	13.95	5.78	23.95	23.95
s-f Chironominae	3.22	12.90	5.48	22.15	46.10
s-f Orthocladiinae	2.18	7.88	2.89	13.53	59.63
Megapodagrionidae	1.59	5.08	1.32	8.72	68.36
Coenagrionidae	1.30	3.40	1.31	5.83	74.19
Oligochaeta	1.07	3.25	1.32	5.58	79.77
Notonectidae	1.21	2.64	0.79	4.53	84.30
Isostictidae	1.13	2.26	0.77	3.89	88.18
Antipodoecidae	0.87	2.18	0.78	3.75	91.93

Group Spring 2009

Average similarity: 55.84

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	3.68	14.35	2.88	25.69	25.69
Hydrobiidae	3.16	13.14	3.68	23.52	49.22
Notonectidae	1.77	5.37	0.92	9.61	58.82
Megapodagrionidae	1.38	4.07	1.28	7.30	66.12
Planorbidae	1.60	4.03	1.27	7.22	73.34
Physidae	1.54	3.96	1.26	7.10	80.44
Coenagrionidae	1.09	3.31	1.33	5.92	86.37
s-f Orthocladiinae	0.90	1.42	0.48	2.54	88.91
s-f Tanypodinae	0.81	1.25	0.48	2.23	91.14

Group Autumn 2010

Average similarity: 55.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.57	19.95	4.13	36.12	36.12
Hydrobiidae	3.34	13.28	2.38	24.05	60.17
Notonectidae	1.79	4.78	1.22	8.64	68.81
s-f Orthocladiinae	1.33	4.40	1.25	7.97	76.78
Physidae	0.90	3.11	1.27	5.64	82.42
Hydroptilidae	0.93	2.39	0.71	4.33	86.75
Acarina	0.97	2.13	0.76	3.85	90.60

Group Spring 2010

Average similarity: 67.50

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	3.76	16.55	4.80	24.52	24.52
Hydrobiidae	3.56	16.51	9.22	24.47	48.98
Notonectidae	2.02	7.50	3.01	11.11	60.09
Oligochaeta	1.61	7.35	9.30	10.88	70.97
s-f Orthocladiinae	1.78	5.76	1.27	8.53	79.50
Isostictidae	1.19	4.00	1.29	5.92	85.42
Hydroptilidae	1.09	3.80	1.29	5.63	91.05

SIMPER Terrys Creek 2005 – 2010

Data worksheet
Name: Terrys Ck sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	Season Year
S1	Autumn 2005
S1	Spring 2005
S1	Autumn 2006
S1	Autumn 2007
S1	Spring 2007
S1	Autumn 2008
S1	Spring 2008
S1	Autumn 2009
S1	Spring 2009
S1	Autumn 2010
S1	Spring 2010

Group Autumn 2005
Average similarity: 69.53

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Megapodagrionidae	4.28	8.68	8.63	12.48	12.48
Hydrobiidae	3.36	7.27	14.80	10.45	22.93
s-f Chironominae	3.72	5.63	2.01	8.10	31.03
Isostictidae	2.58	5.54	13.25	7.97	39.00
Oligochaeta	2.90	5.12	5.83	7.36	46.36
Dugesiidae	2.73	4.89	5.00	7.04	53.39
Physidae	2.46	4.70	3.87	6.76	60.16
Corbiculidae	2.38	4.28	8.30	6.15	66.31
s-f Tanypodinae	2.77	4.11	14.09	5.91	72.22
Notonectidae	2.46	4.09	2.80	5.89	78.11
Hemicorduliidae	2.78	3.94	3.39	5.67	83.78
Planorbidae	1.80	3.62	5.83	5.20	88.98
Glossiphoniidae	1.38	2.60	3.43	3.74	92.72

Group Spring 2005
Average similarity: 64.98

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	5.63	13.05	19.49	20.08	20.08
Physidae	3.14	6.76	7.02	10.41	30.49
Oligochaeta	3.17	6.51	11.44	10.02	40.52
Megapodagrionidae	2.93	6.38	16.31	9.82	50.33
Isostictidae	2.57	5.61	6.89	8.63	58.96
Corbiculidae	2.05	3.57	12.60	5.50	64.46
s-f Tanypodinae	2.26	3.50	1.77	5.38	69.84
Dugesiidae	1.52	3.33	20.76	5.13	74.97
Acarina	1.88	3.10	2.59	4.78	79.74
Notonectidae	1.47	2.70	3.90	4.15	83.90
Libellulidae	2.45	2.70	0.58	4.15	88.04
Hydrobiidae	2.35	2.48	0.58	3.82	91.86

Group Autumn 2006

Average similarity: 72.76

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Megapodagrionidae	4.95	8.98	18.42	12.34	12.34
Hemicorduliidae	4.41	8.71	18.55	11.98	24.31
Oligochaeta	4.04	8.33	18.95	11.45	35.77
Hydrobiidae	3.58	5.51	2.85	7.58	43.34
Notonectidae	2.23	4.48	14.83	6.16	49.50
Dugesiidae	2.63	4.25	2.15	5.85	55.35
Gerridae	1.73	3.74	15.97	5.14	60.48
Physidae	2.33	3.70	1.32	5.08	65.57
s-f Tanypodinae	2.44	3.70	1.32	5.08	70.65
s-f Chironominae	2.67	3.68	2.86	5.06	75.71
Coenagrionidae	2.10	3.62	3.89	4.98	80.69
Isostictidae	1.80	3.45	5.69	4.75	85.44
Acarina	1.52	3.05	15.97	4.19	89.63
Libellulidae	1.47	2.44	5.69	3.36	92.99

Group Autumn 2007

Average similarity: 65.81

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	4.10	9.26	5.36	14.08	14.08
Megapodagrionidae	3.47	8.29	5.44	12.60	26.68
s-f Chironominae	3.19	7.79	4.33	11.84	38.52
Dugesiidae	2.60	5.83	2.72	8.85	47.37
Physidae	2.59	5.46	2.48	8.29	55.66
Notonectidae	2.19	5.03	6.23	7.64	63.30
Oligochaeta	1.93	4.37	3.50	6.64	69.94
s-f Tanypodinae	2.09	3.92	2.41	5.96	75.90
Hemicorduliidae	1.68	3.07	1.30	4.66	80.56
Isostictidae	1.38	2.07	1.31	3.15	83.71
s-f Orthocladiinae	1.29	1.75	0.77	2.66	86.36
Libellulidae	0.97	1.40	0.76	2.13	88.50
Coenagrionidae	1.06	1.28	0.76	1.95	90.45

Group Spring 2007

Average similarity: 64.85

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.77	14.86	7.37	22.92	22.92
Hydrobiidae	3.55	10.82	3.75	16.68	39.60
Megapodagrionidae	2.98	8.85	4.52	13.66	53.26
Physidae	2.57	7.67	4.19	11.83	65.08
Dugesiidae	2.43	6.32	2.15	9.75	74.83
Oligochaeta	1.85	4.55	1.27	7.01	81.85
Hemicorduliidae	1.52	2.87	1.21	4.42	86.27
s-f Tanypodinae	1.00	2.33	1.35	3.60	89.87
Sphaeriidae	1.12	1.98	0.73	3.06	92.93

Group Autumn 2008

Average similarity: 66.65

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	3.50	14.68	4.25	22.02	22.02
Megapodagrionidae	3.03	12.52	7.16	18.78	40.81
Notonectidae	2.29	9.65	6.24	14.48	55.29
Physidae	2.35	8.98	5.21	13.48	68.77
Dugesiidae	1.66	6.76	7.68	10.14	78.90
Oligochaeta	1.37	4.27	1.31	6.40	85.30
s-f Chironominae	1.35	3.72	1.29	5.59	90.89

Group Spring 2008

Average similarity: 61.90

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	3.61	13.31	7.64	21.51	21.51
Physidae	3.19	11.33	6.91	18.30	39.81
Megapodagrionidae	3.06	10.70	4.47	17.29	57.10
s-f Chironominae	2.90	8.20	1.27	13.25	70.35
Oligochaeta	2.07	6.47	3.13	10.46	80.81
Dugesiidae	1.34	3.47	1.32	5.61	86.42
Sphaeriidae	1.44	2.93	1.29	4.74	91.15

Group Autumn 2009

Average similarity: 62.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Megapodagrionidae	3.52	12.12	7.99	19.45	19.45
Hydrobiidae	3.60	11.87	5.08	19.05	38.50
Notonectidae	2.00	5.82	2.87	9.33	47.83
Isostictidae	1.71	5.09	3.92	8.16	55.99
Oligochaeta	1.55	4.70	4.88	7.55	63.53
Physidae	1.80	4.19	1.13	6.72	70.25
Dugesiidae	1.60	3.96	1.31	6.35	76.60
s-f Tanypodinae	1.29	2.94	1.24	4.72	81.32
Gerridae	0.74	1.54	0.79	2.47	83.79
Coenagrionidae	0.94	1.45	0.78	2.33	86.12
Hemicorduliidae	0.86	1.45	0.77	2.32	88.43
s-f Chironominae	0.71	0.99	0.48	1.58	90.02

Group Spring 2009

Average similarity: 66.93

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	3.58	11.58	4.65	17.30	17.30
Megapodagrionidae	3.49	11.30	5.22	16.89	34.19
s-f Chironominae	3.03	10.22	5.42	15.27	49.46
s-f Tanypodinae	2.28	6.67	4.35	9.97	59.43
Dugesiidae	1.88	5.70	3.74	8.52	67.95
Physidae	1.73	5.51	3.75	8.23	76.18
Oligochaeta	1.87	5.40	2.58	8.06	84.24
Isostictidae	1.38	4.58	3.88	6.85	91.09

Group Autumn 2010

Average similarity: 59.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	4.61	18.14	7.36	30.61	30.61
Atyidae	2.68	9.50	2.43	16.04	46.64
Notonectidae	1.97	6.14	2.41	10.36	57.00
Dugesiidae	2.06	4.92	1.11	8.31	65.31
Megapodagrionidae	1.96	4.78	1.32	8.07	73.38
Oligochaeta	1.47	4.14	1.33	7.00	80.37
Physidae	1.21	2.87	1.28	4.84	85.21
Elmidae	0.86	1.70	0.77	2.87	88.09
s-f Chironominae	0.98	1.66	0.78	2.81	90.90

Group Spring 2010

Average similarity: 64.47

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
s-f Chironominae	4.18	14.38	6.02	22.31	22.31
Hydrobiidae	3.62	13.08	7.40	20.29	42.60
Megapodagrionidae	2.73	9.32	3.53	14.46	57.06
Physidae	2.62	9.30	10.25	14.42	71.48
Oligochaeta	1.55	3.72	1.35	5.78	77.26
s-f Tanypodinae	1.44	3.10	1.27	4.81	82.07
Dugesiidae	1.02	2.76	1.33	4.28	86.35
Acarina	1.21	2.11	0.73	3.27	89.62
Isostictidae	0.96	1.87	0.73	2.90	92.52

Appendix 6 BIOENV output

ALL FIVE CREEKS Spring 2010

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

Resemblance worksheet
Name: All five Cks(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables

```
 1 Log10 Faecal Coliforms
 2 Log10 Ammonia
 3 Log10 Oxidised Nitrogen
 4 Log10 Total Phosphorus
 5 Log10 Total Kjeldahl Nitrogen
 6 Alkalinity mg
 7 Log10 Turbidity
 8 Log10 Conductivity
 9 Log10 Total Dissolved Solids
10 pH
11 Dissolved Oxygen DO mg/L
12 Temperature OC
13 Rainfall
14 Altitude
15 Bedrock
16 Boulder
17 Cobble
18 Total Length Pipe
19 No. Outlets
20 Catchment Area
21 Ratio TLP/CA
22 Ratio NO/CA
```

Best results

```
No.Vars    Corr. Selections
      5    0.401 3,8,11,17,22
      5    0.397 3,10,11,17,22
      5    0.395 3,9,11,17,22
      5    0.395 3,8,10,17,22
      5    0.394 8,10,11,17,22
      5    0.393 3,11,17,21,22
      5    0.393 3,8,11,21,22
      4    0.393 3,11,17,22
      5    0.389 9-11,17,22
      5    0.389 3,9,10,17,22
```

ARCHERS CK Spring 2010

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

Resemblance worksheet
Name: Archers Ck(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
```
 1 Log10 Faecal Coliforms
 2 Log10 Ammonia
 3 Log10 Oxidised Nitrogen
 4 Log10 Total Phosphorus
 5 Log10 Total Kjeldahl Nitrogen
 6 Log10 Alkalinity
 7 Log10 Turbidity
 8 Log10 Conductivity
 9 Log10 Total Dissolved Solids
10 pH
11 Dissolved Oxygen
12 Temperature
13 Rainfall
```

Best results
```
No.Vars    Corr. Selections
      4    0.272 3,4,6,7
      5    0.270 3,4,6-8
      2    0.267 4,7
      3    0.263 4,6,7
      5    0.262 3,4,6,7,13
      4    0.261 4-7
      5    0.259 3,4,6,7,9
      3    0.258 4,7,8
      3    0.256 4,5,7
      5    0.253 1,4-7
```

BUFFALO CK Spring 2010

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

Resemblance worksheet
Name: Buffalo Ck(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
1 Log10 Faecal Coliforms
2 Log10 Ammonia
3 Log10 Oxidised Nitrogen
4 Log10 Total Phosphorus
5 Log10 Total Kjeldahl Nitrogen
6 Alkalinity
7 Log10 Turbidity
8 Log10 Conductivity
9 Log10 Total Dissolved Solids
10 pH
11 Dissolved Oxygen
12 Temperature
13 Rainfall

Best results

No.Vars	Corr.	Selections
5	0.286	3,4,9,11,13
4	0.282	4,9,11,13
5	0.280	3-5,9,13
5	0.278	3,4,7,9,13
4	0.277	3,4,9,13
5	0.277	4,5,9,11,13
5	0.274	4,7,9,11,13
3	0.273	9,11,13
5	0.272	4,5,8,11,13
5	0.272	3-5,8,13

PORTERS CK Spring 2010

Data worksheet

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

Resemblance worksheet

Name: Porters Ck(2)
Data type: Similarity
Selection: All

Parameters

Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables

```
 1 Log10 Faecal Coliforms
 2 Log10 Ammonia
 3 Log10 Oxidised Nitrogen
 4 Log10 Total Phosphorus
 5 Log10 Total Kjeldahl Nitrogen
 6 Alkalinity
 7 Log10 Turbidity
 8 Log10 Conductivity
 9 Log10 Total Dissolved Solids
10 pH
11 Dissolved Oxygen
12 Temperature
13 Rainfall
```

Best results

```
No.Vars   Corr. Selections
      3   0.446 8,9,13
      5   0.438 1,6,8,9,13
      5   0.437 1,2,8,9,13
      4   0.435 1,8,9,13
      4   0.433 2,8,9,13
      5   0.432 1,5,8,9,13
      4   0.431 6,8,9,13
      3   0.430 1,8,9
      4   0.429 1,2,8,9
      4   0.426 1,6,8,9
```

SHRIMPTONS CK Spring 2010

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

Resemblance worksheet
Name: Shrimptons Ck
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
1 Log10 Faecal Coliforms
2 Log10 Ammonia
3 Log10 Oxidised Nitrogen
4 Log10 Total Phosphorus
5 Log10 Total Kjeldahl Nitrogen
6 Alkalinity
7 Log10 Turbidity
8 Log10 Conductivity
9 Log10 Total Dissolved Solids
10 pH
11 Dissolved Oxygen
12 Temperature
13 Rainfall

Best results

```
No.Vars   Corr. Selections
     4    0.262 1,9,11,12
     5    0.261 1,7,9,11,12
     3    0.255 1,9,11
     5    0.251 1,2,9,11,12
     4    0.247 1,7,9,11
     5    0.245 1,8,9,11,12
     5    0.243 1,9-12
     4    0.237 1,7,9,12
     3    0.235 1,9,12
     2    0.235 9,11
```

TERRYS CK Spring 2010

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

Resemblance worksheet
Name: Terrys Ck(2)
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
1 Log10 Faecal Coliforms
2 Log10 Ammonia
3 Log10 Oxidised Nitrogen
4 Log10 Total Phosphorus
5 Log10 Total Kjeldahl Nitrogen
6 Alkalinity
7 Log10 Turbidity
8 Log10 Conductivity
9 Log10 Total Dissolved Solids
10 pH
11 Dissolved Oxygen
12 Temperature
13 Rainfall

Best results

```
No.Vars    Corr. Selections
      1    0.267 13
      2    0.247 8,13
      3    0.241 8,11,13
      2    0.233 3,13
      4    0.233 3,8,11,13
      3    0.233 3,8,13
      5    0.233 1,8,10,11,13
      4    0.232 1,8,11,13
      3    0.231 6,8,13
      4    0.228 6,8,11,13
```