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 2009 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 were Archers, Shrimptons, Buffalo, Porters and Terrys creeks. The first round of sampling occurred in September and October and the second in October and November.

A total of 1,970 macroinvertebrates were collected and examined from the edge habitat of these creek systems in Spring 2009. From this total, 41 different taxa were recorded. A total of 75 different taxa have been collected from the edge habitat of these creeks from Spring 2004 to the current period.

Macroinvertebrate results for Spring 2009 indicate that Archers, Shrimptons, Buffalo, Porters and Terrys creeks had impaired macroinvertebrate communities. Similar results have been recorded in Spring 2004 to Autumn 2009. Results of the univariate analyses were consistent with those of previous reports. Archers Creek appeared to have the richest stream health and Shrimptons Creek appeared to have the poorest stream health of the five creeks. The stream health is however similar across the five creeks. EPT taxa were found in very low numbers and only one family (Trichoptera: Hydroptilidae) was collected. They were collected from all creeks except Shrimptons Creek. No AUSRIVAS EPT indicator taxa were collected from the five creeks in Spring 2009.

Multivariate analysis indicated a continuing trend of slight change in macroinvertebrate community composition between sampled seasons for each creek. Shrimptons Creek has provided the most variability in community structure over the 2005 to 2009 period, while Terrys Creek has provided the most stability over this period.

Indicative water quality results of Spring 2009 indicate 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) although concentrations varied between creeks. Similar results were observed at the additional stormwater sites. ANZECC (2000) recommended concentrations were also exceeded for faecal coliforms in Porters Creek in November. These water quality results of Spring 2009 suggest that whilst some similarity exists, influences on water chemistry in each creek are not the same across the City of Ryde LGA. The impaired macroinvertebrate communities recorded in each of the five study streams reflect water quality failures highlighted in the comparison of water quality results to ANZECC (2000) guidelines and probably other unmeasured parameters.

Multivariate analysis of extrinsic water quality parameters for each creek highlighted total nitrogen and pH as an influence on macroinvertebrate community structure. Multivariate analysis of extrinsic water quality parameters for all creeks highlighted the surrogate measure of storm water catchment drainage, Number of Outlets/Catchment Area, as an influence on macroinvertebrate community structure.

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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-19/09. This report for the Spring 2009 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 2009 report completes the sixth year of the program. Macroinvertebrates and water chemistry were each sampled in September and October/November 2009 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 both 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 for 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 the capacity 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, accessed through the Ryde City Depot, after the creek is piped under the 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 2009, refer to Table 8 for these locations.

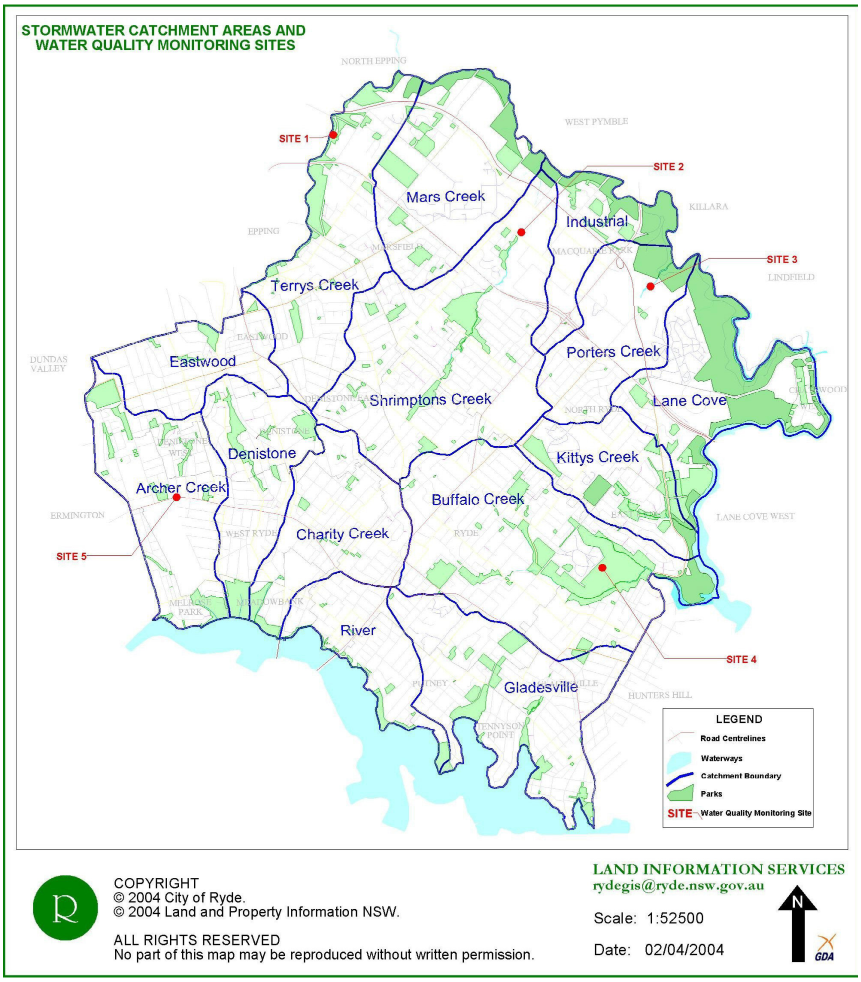


Figure 1 Site locations of the Biological and Chemical Water Quality Monitoring Strategy of the City of Ryde

2.1 Spring 2009 sampling events

Two sampling events were conducted in Spring 2009 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 30th and October 1st 2009
- October 29th, 30th and November 2nd 2009

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 within the season of Spring 2009 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 A.

3.3 Water quality sampling

Water chemistry was sampled once in both October and in November for Spring 2009 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 2009 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 to the sampling 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 were recorded. For the few missing records from station 066156, 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 historic raw data (where comparable) back to 2004 and, where data was available back to 2001. This would allow assessment with the study data collected now and from future sampling seasons, to provide 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 data collected by Sydney Water in Spring 2006, Autumn and Spring 2007, 2008 and 2009 allowed the compilation of data points as summarised in Table 3. Previous 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 when, each variable was sampled, between Spring 2004 and Spring 2009

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	*	*	*	*	*	*	*	*	*	*	*	*	*	*

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 decline in flow over recent years from lack of rainfall.

SIGNAL-SF

The original version of the Stream Invertebrate Grade Number Average Level (SIGNAL) biotic index (Chessman, 1995-Sydney Water data) has been refined by testing that included 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 were present in the samples but with no grade numbers available (relatively few, only 4 with infrequent occurrence) were removed from the calculation of the SIGNAL-SF score for the sample. 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 decisions (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 2009 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 as 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 also 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 is provided in previous Ecowise reports, which sourced this example from Chessman (2003a). In the Spring 2006 report AUSRIVAS OE50-SIGNAL2 values were found to be quite variable and for this reason were not recommended for use in future temporal comparisons. That is, 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 were recommended to 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.

Spring 2009 macroinvertebrate samples were compared in an ordination with 2005, 2006, 2007, 2008 and Autumn 2009 data for all creeks of the monitoring program to look at context of community composition. Please note Spring 2004 data were not included in these comparisons as comparable sites in Buffalo and Porters creeks were not sampled in Spring 2004 and also not sampled in Spring 2004 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 the seasons, Autumn 2005, Spring 2005, Autumn 2006, Spring 2006, Autumn 2007, Spring 2007, Autumn 2008, Spring 2008 and Autumn 2009.

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 mutlivariate 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 & site observations

The field and laboratory results for water quality parameters measured at Archers, Shrimptons, Buffalo, Porters and Terrys creeks in Spring 2009 are presented in Table 7 and Table 8. While sampling was not to the frequency suggested by ANZECC (2000), it did allow for the characterisation of water quality for each study creek against ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary).

Of the five core sites, Porters Creek was the only site to have dissolved oxygen saturation levels within the ANZECC (2000) recommended range of 85-110% for the protection of aquatic ecosystems on both sampling occasions in Spring 2009. The core sites in Shrimptons and Terry creeks had dissolved oxygen saturation levels below 85% on both sampling occasions, and Archers and Buffalo creeks for the September sampling. The dissolved oxygen saturation level for Archers Creek in November was slightly above the 110% level recommended by ANZECC (2000) at 112%.

Dissolved oxygen saturation levels at the three additional sites on Shrimptons Creek were below the 85% level (ranging from 12.3% to 84.8%) with the exception of the Quarry Road site in November (105%). Results for the additional two sites in Buffalo Creek were low in September but increased to be within the guideline range in November. Of the three additional sites on Porters Creek, the Spur Branch and Main Branch at Wicks Road provided results within the 85-110% range on both sampling occasions. The Main Branch Channel (COR staff site) had levels above the range on both occasions.

Rainfall in late October (Figure 3) temporarily increased flow in the creeks and would explain the increase in dissolved oxygen saturation levels experienced at most sites in the November sampling.

Bacteriological results were compared with ANZECC (2000) guidelines for secondary contact (recreation). Since water bodies sampled for City of Ryde were unlikely to be used for primary contact purposes such as swimming, it was considered that application of the secondary contact guidelines were appropriate. However, it must be noted that comparisons with these guidelines do not infer a measure of compliance with the guidelines, as samples have not been collected under an appropriate regime for compliance monitoring (five samples in a 30 day period). The comparisons are indicative only to provide a degree of context to bacteriological results obtained. The core site on Porters Creek was the only site to exceed the 1,000 CFU/100mL ANZECC (2000) recommended guideline level for faecal coliforms with a result of 6,700 CFU/100mL on the 2nd November 2009. This site has a history of elevated faecal coliform concentrations and is the only site to provide an historical average exceeding the ANZECC (2000) guideline.

Turbidity levels for the core and additional site samples taken from Terrys, Shrimptons, Porters, Buffalo and Archers creeks in Spring 2009 were below the ANZECC (2000) guideline level of 50 NTU. The only site to exceed this guideline was Shrimptons Creek at Bridge Street with a result of 447 NTU on 30th September. It was noted that construction was occurring upstream of the sampling site and, although construction was ongoing, the sample collected on 2nd November provided a considerably lower result of 18.2 NTU.

Consistent with previous results, most sites returned total oxidised nitrogen concentrations above the ANZECC (2000) guideline of 40 µg/L. The exceptions to this were the core sites of Archers and Shrimpton creeks results for September (20 µg/L and <10 µg/L, respectively). The additional Shrimptons Creek sites at Kent Road and Quarry Road, and Buffalo Creek site downstream of Burrows Park also had results below the guideline in September. The results for the Archers Creek core site were notably lower than those of Autumn 2009, which were noted as unusually elevated for this site in the previous report. The core Porters Creek site continues to provide the highest oxidised nitrogen concentrations, which were higher than the historical average for the site on both occasions in Spring 2009.

Total phosphorous concentrations were below the ANZECC (2000) guideline of 50 µg/L at all sites in Porters Creek and Archers Creek in Spring 2009. Total phosphorous concentrations in Buffalo Creek ranged between 37 µg/L (at the core site) and 118 µg/L (upstream of Burrows Park). An elevated total phosphorous concentration was recorded at the Terrys Creek site on 30th September (70 µg/L). This concentration had fallen to 31 µg/L by the following sampling on 2nd November.

Total phosphorous concentrations in Shrimptons Creek were elevated at all sites in September, ranging from 144 µg/L at the Kent Road site to 600 µg/L at the Quarry Road site. The total phosphorous concentration for the core site on Shrimptons Creek was the highest recorded from this site at 243 µg/L (compared to an historical average of 63 µg/L). Concentrations had returned to more typical levels by the sampling in November.

Total nitrogen concentrations were typical for most sites, with the exception of Shrimptons Creek. Here, results followed a similar pattern to total phosphorous with high results in September followed by more typical results in November. The result for the core site on Shrimptons Creek in September was amongst the highest recorded for this site at 1,290 µg/L. Results for the Quarry Road and Bridge Street sites were higher still at 2,630 µg/L and 2,390 µg/L respectively.

Ammonium concentrations were variable, with the core sites on Archers, Shrimptons, Buffalo, and Terrys creeks having one result each at or below the ANZECC (2000) guideline level of 20 µg/L and one result above the guideline. Results for the core site on Shrimptons Creek were typical for the site at approximately 40 times above the guideline. Historical averages for the five core sites exceed the recommended guideline.

For the additional sites on Shrimptons Creek the sites on Kent Road and Quarry Road each had one ammonium result below the ANZECC (2000) guideline. Similarly each of the additional sites on Buffalo Creek had one result below the guideline. Ammonium concentrations for three additional sites on Porters Creek all exceeded the guideline with results between 30 and 200 µg/L.

Conductivity levels (as a measure of salinity) were within the ANZECC (2000) guideline range of 125 to 2,200 µS/cm for samples collected from all sites in Spring 2009.

pH levels exceeded the recommended ANZECC (2000) guideline range of 6.8 to 8.0 pH units in the core site of Porters Creek (8.24 pH units) on 30th September 2009. pH levels were also elevated in the three additional Porters Creek sites on this date (8.16 to 8.41 pH units). All other pH results for Spring 2009 were within the guideline range.

Alkalinity results were consistent with those of the previous report and results for the core sites and were reflective of the historical averages for the respective sites.

Concentrations of total dissolved solids were consistent with the previous report and results for the core sites were reflective of the historical averages for the respective sites. The exception was Porters Creek where the historical average remains elevated due to higher total dissolved solids concentrations at this site from 2005 to 2007.

Table 7 ***Water quality results for Spring 2009 in relation to the ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary)***

Parameter Units		Faecal coliform CFU/100mL	NH^{4+} µg/L	Nox µg/L	TP µg/L	TKN µg/L	TN µg/L	Alkalinity mg $CaCO_3$/L	Turb NTU	Cond. µS/cm	TDS mg/L	pH	DO % Sat	Temp. °C
ANZECC (2000)	**Aquatic Ecosystems**	**-**	**20**	**40**	**50**	**N/A**	**500**	**N/A**	**50**	**125-2200**	**N/A**	**6.8-8.0**	**85-110**	**-**
	Secondary Contact	**1000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
ARCHERS CREEK	September	500	100	20	39	380	400	57.2	3.11	280	161	6.9	33.2	13.5
	November	640	40	390	34	340	730	53.6	2.85	327	187	7.5	112	25.0
	Historical*	884	90	261	53	403	663	73	4.32	442	256	7.2	62.6	17.3
SHRIMPTONS CREEK	September	490	<10	<10	243	1290	1290	69.6	8.74	381	219	7.5	36.9	15.2
	November	280	50	280	48	400	680	74.3	4.56	462	275	7.2	61.2	19.6
	Historical*	645	40	156	63	495	640	65	9.20	356	213	7.0	40.3	16.8
BUFFALO CREEK	September	~160	20	60	53	370	430	84.2	4.29	880	486	8.0	81.8	17.3
	November	570	70	290	37	430	720	87.7	4.69	758	424	7.4	86.5	22.2
	Historical*	669	66	301	39	368	642	81	10.06	692	396	7.3	61.1	16.9
PORTERS CREEK	September	280	810	1510	16	1050	2560	73.2	3.67	388	219	8.2	99.8	17.3
	November	6700	810	1200	39	1180	2380	92.2	8.59	442	199	7.8	91.0	19.6
	Historical*	2407	832	1044	26	1286	2468	71	5.21	2274	1392	7.5	89.2	18.1
TERRYS CREEK	September	320	190	200	70	540	740	57.8	40.1	329	187	7.6	61.8	13.0
	November	39	20	170	31	260	430	61.9	4	482	263	7.2	65.6	18.0
	Historical*	334	81	149	40	372	521	58	4.64	384	222	7.1	62.5	15.6

Historical = Average of historical water quality data for samples taken from Spring 2004 – Autumn 2009.*

Table 8 ***Water quality results at additional COR sites for Spring 2009 in relation to the ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River SE Australia) and Recreational Water Quality & Aesthetics (Secondary)***

Parameter Units		**Faecal Coliform CFU/100mL**	**NH4+ µg/L**	**Nox µg/L**	**TP µg/L**	**TKN µg/L**	**TN µg/L**	**Alkalinity mg CaCO3/L**	**Turb NTU**	**Cond. µS/cm**	**TDS mg/L**	**pH**	**DO % Sat**	**Temp. °C**
ANZECC (2000)	**Aquatic Ecosystem**	**-**	**20**	**40**	**50**	**N/A**	**500**	**N/A**	**50**	**125-2200**	**N/A**	**6.8-8.0**	**85-110**	**-**
	Secondary Contact	**1000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Shrimptons Creek	**Historical***	645	40	156	63	495	640	65	9.20	356	213	7.0	40.3	16.8
Shrimptons Creek Kent Road	September	74	10	10	144	980	990	55.2	7.92	300	157	7.07	16.3	13.3
	November	240	60	100	32	420	520	66.5	4.32	647	364	7.06	60.1	20.3
Shrimptons Creek Bridge Street (d/s Santa Rosa Park)	September	240	40	70	365	2320	2390	63.9	447	394	303	6.85	55.5	15.8
	November	500	120	170	69	700	870	76.7	18.2	991	560	7.19	84.8	23.9
Shrimptons Creek Quarry Road (u/s Santa Rosa Park)	September	400	110	10	600	2620	2630	130	12	1687	940	6.8	12.3	12.9
	November	510	20	850	48	330	1180	76.6	3.58	1013	590	7.69	105	24.2
Buffalo Creek	**Historical***	669	66	301	39	368	642	81	10.06	692	396	7.3	61.1	16.9
Buffalo Creek d/s Burrows Park	September	490	<10	30	107	430	460	120	7.93	1679	934	7.73	69.5	16.8
	November	460	100	1030	69	490	1520	109	11.7	1089	626	7.18	91.6	21.7
Buffalo Creek u/s Burrows Park	September	340	40	370	61	380	750	92.5	2.85	1002	530	8.17	84.4	15.5
	November	400	20	1420	118	690	2110	118	32.1	1109	630	8.03	88.7	20.4
Porters Creek	**Historical***	2407	832	1044	26	1286	2468	71	5.21	2274	1392	7.5	89.2	18.1
Porters Creek Spur Branch	September	~13	200	480	13	410	890	124	2.7	693	388	8.21	108	15.2
	November	80	170	400	42	500	900	119	7.18	598	356	7.54	92	20.7
Porters Creek Main Branch Channel (COR staff site)	September	~14	130	550	10	580	1130	392	2.63	965	544	8.16	118	17.8
	November	47	30	160	27	300	460	41.1	3.77	150	84	7.43	120	20.3
Porters Creek Main Branch Wicks Road	September	240	80	370	36	390	760	54.5	8.34	284	165	8.41	105	17.1
	November	45	70	820	23	260	1080	56.9	3.45	341	201	7.7	96.3	19.4

Historical = Average of historical water quality data for Core Site samples taken from Spring 2004 – Autumn 2009*

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 2009 sampling period and preceding five months. In the five months preceding the October 2009 sampling event 314 mm of rainfall occurred within a range of 7 – 109 mm per month. The total annual rainfall recorded for each year of the Water Quality Monitoring Program for the City of Ryde are listed in Table 9. Average rainfall was experienced in 2003, 2007 and 2008 and less than average conditions were recorded in 2004, 2005 and 2006.

Table 9 Total rainfall by year

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

The rainfall in mid to late 2009 was characterised by frequent, light rainfall periods. This pattern changed in October 2009 to include two heavy rainfall periods between frequent, light rainfall.

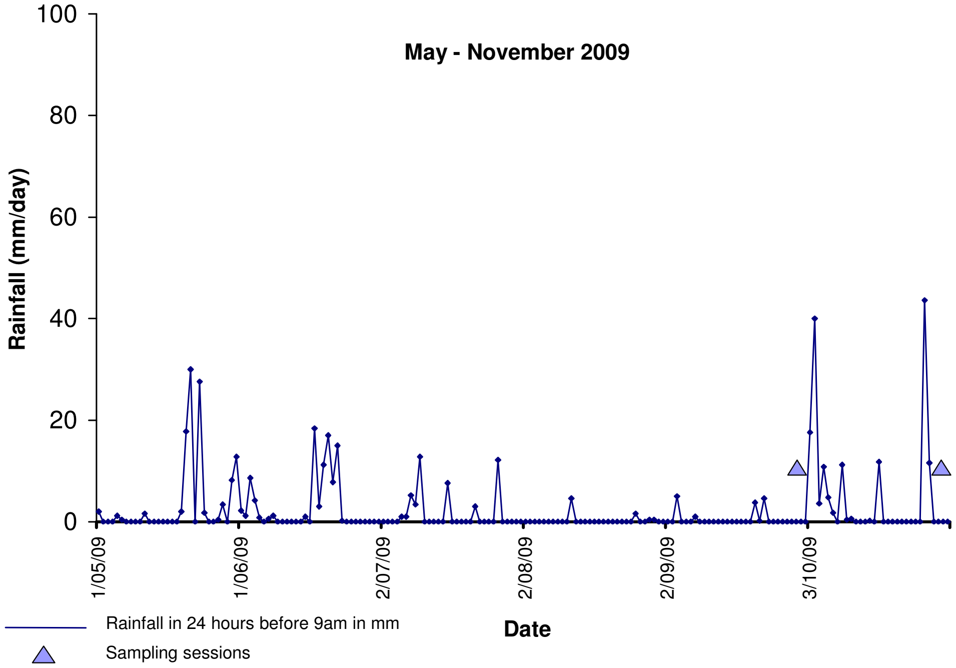


Figure 3 Daily rainfall data 1st May 2009 to 1st November 2009 with sampling occasions indicated

4.3 Macroinvertebrate Results

General Characteristics of Aquatic Macroinvertebrate Assemblages

- A total of 1,970 macroinvertebrates was collected from all five sites in Spring 2009
- From this total, 41 taxa were recorded
- A total of 75 taxa have been collected from the edge habitat of all five creeks from Spring 2004 to Spring 2009
- 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.

Taxa collected in each creek between the sampling period of Spring 2004 to Autumn 2009, is compared to taxa collected between Spring 2004 to Spring 2009. This indicates additional taxa have been collected in Spring 2009 at all five creeks (Table 10). With additional seasonal sampling planned under the strategy, it is likely further additional taxa will be recorded.

Table 10 Number of taxa recorded in each creek in specified sample periods

Sampling Seasons	Archers	Shrimptons	Buffalo	Porters	Terrys
Spring 04 - Autumn 09	52	48	50	51	57
Spring 04 - Spring 09	55	49	51	53	59

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 were observed in Spring 2009 samples and are 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 (Figure 4). The summary indicated that EPT taxa have remained consistent with previous reports and are rarely collected from the five sampled creeks.

No creek showed an average greater than one EPT taxa for Spring 2009. Archers Creek averaged one EPT taxa while Shrimptons Creek had none (Figure 5).

Spring 2009 displayed little impact on the average presence of EPT taxa over the sampling period for all five creeks. Porters Creek showed the highest diversity index, however it still did not average a single EPT taxa per sampling period. Terrys Creek and Shrimptons Creek displayed the lowest occurrence of EPT taxa for both Spring sampling and the combined sampling seasons. Overall, the presence of EPT taxa remained low.

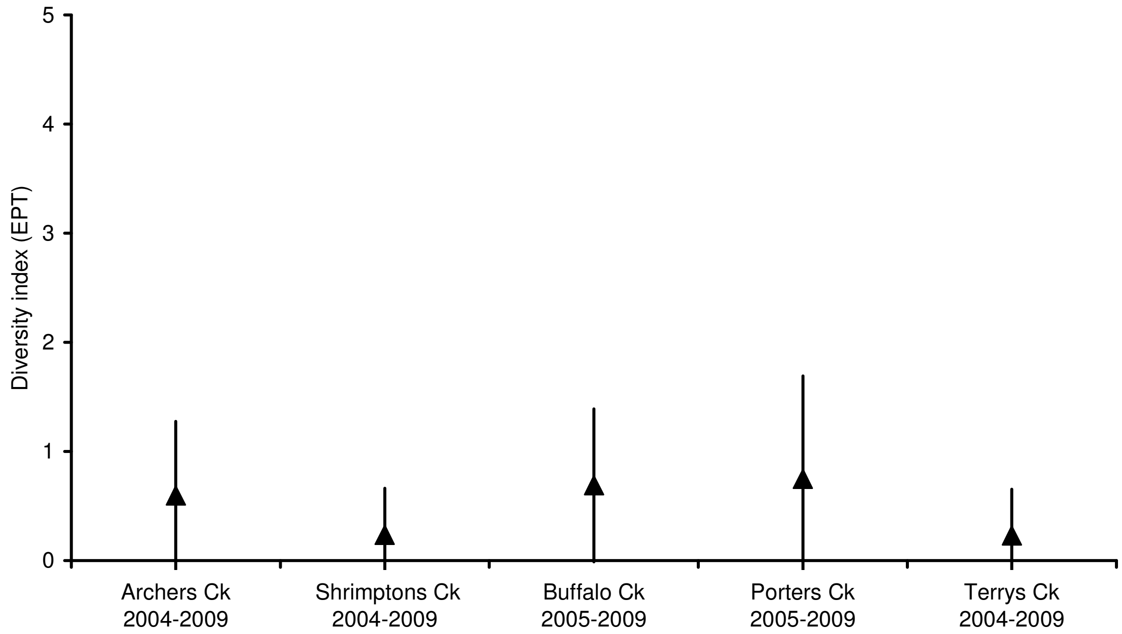


Figure 4 EPT richness of all creeks of monitoring program

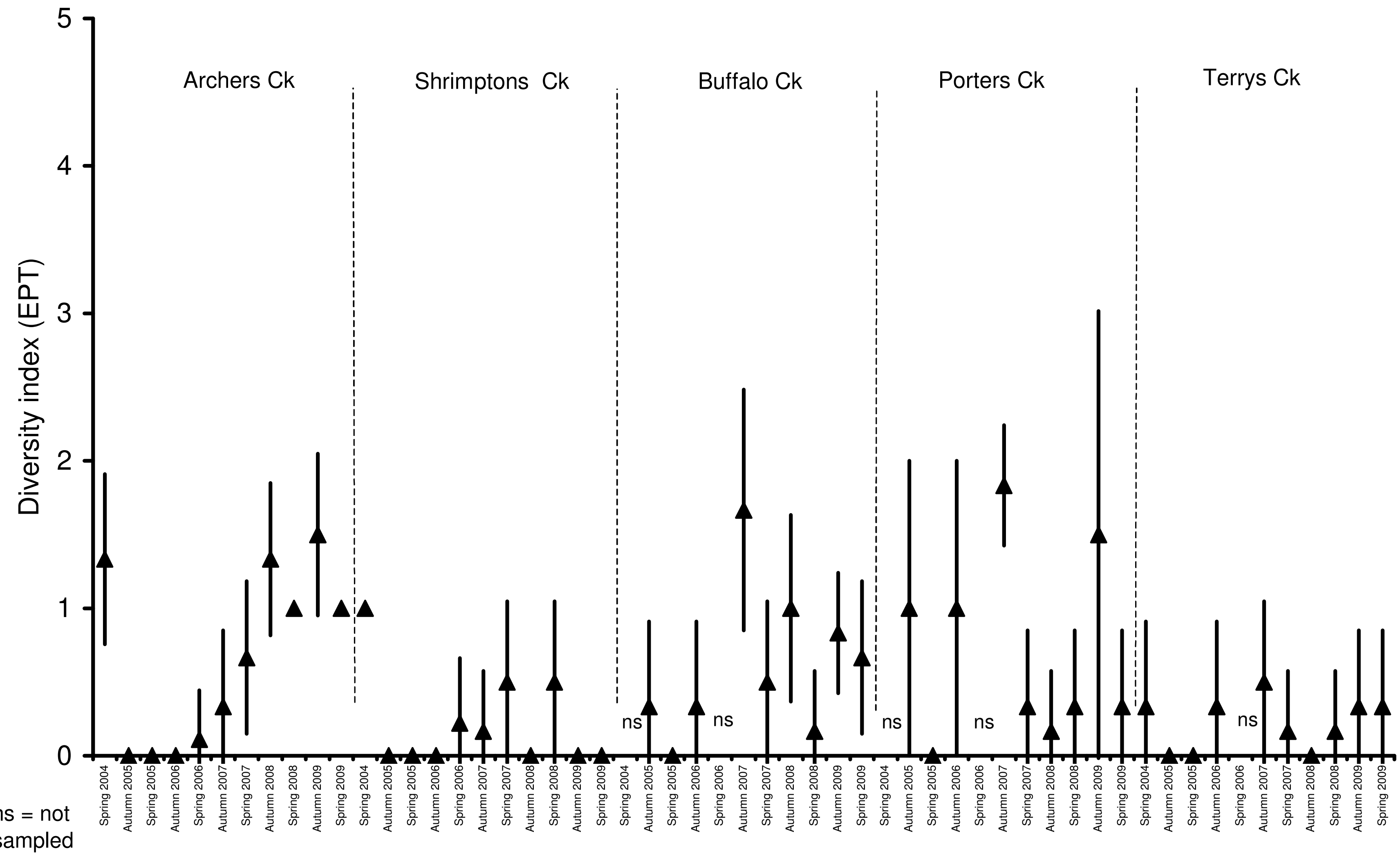


Figure 5 ***EPT richness by season***

SIGNAL-SF

Stream health as described by the SIGNAL-SF biotic index results indicated impaired macroinvertebrate communities for all creeks. Average stream health was indicative of probable moderate and probable severe organic pollution for all creeks (Figure 6, Figure 7 and Table 4).

Spring 2009 average scores for all creeks showed only slight changes compared to the previous Autumn 2009 sampling period. Buffalo Creek's stream health increased slightly in Spring 2009 compared to Autumn 2009, while the remaining creeks experienced slightly decreased stream health (Figure 7).

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 2009 (Figure 6). 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 real observed difference between the creeks (Figure 6). Shrimptons Creek has the largest range in stream health, which reflects the temporal change in average stream health recorded between Spring 2004 and Spring 2009.

Archers Creek has shown very little difference in average stream health in the previous three sampling seasons (Spring 2008 to Spring 2009). There had previously been an indication of slight seasonal changes occurring in Archers Creek, with Autumn having higher average scores compared to Spring (Figure 7).

For Shrimptons Creek the average stream health from the previous four sampling periods has shown very little variation between seasons and is significantly lower than Autumn 2007 average stream health. 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 for Buffalo Creek in Spring 2009 is similar to past results, with little variation through time except in Spring 2008. That period saw a noticeable decline in average stream health. The two sampled seasons since have shown average stream health return to what had been previously recorded (Figure 7).

Porters Creek had slightly higher average stream health in Autumn than in Spring, a potential trend that has been indicated since Autumn 2007. Missing data points from earlier in the sampling program have made it difficult to establish this as a definitive trend (Figure 7).

The range of average stream health for Terrys Creek has been very narrow throughout the sampling program and Spring 2009 falls within that range. There was a very slight decline from Spring 2005 to Spring 2008, however the previous two sampling periods have not continued this trend (Figure 7).

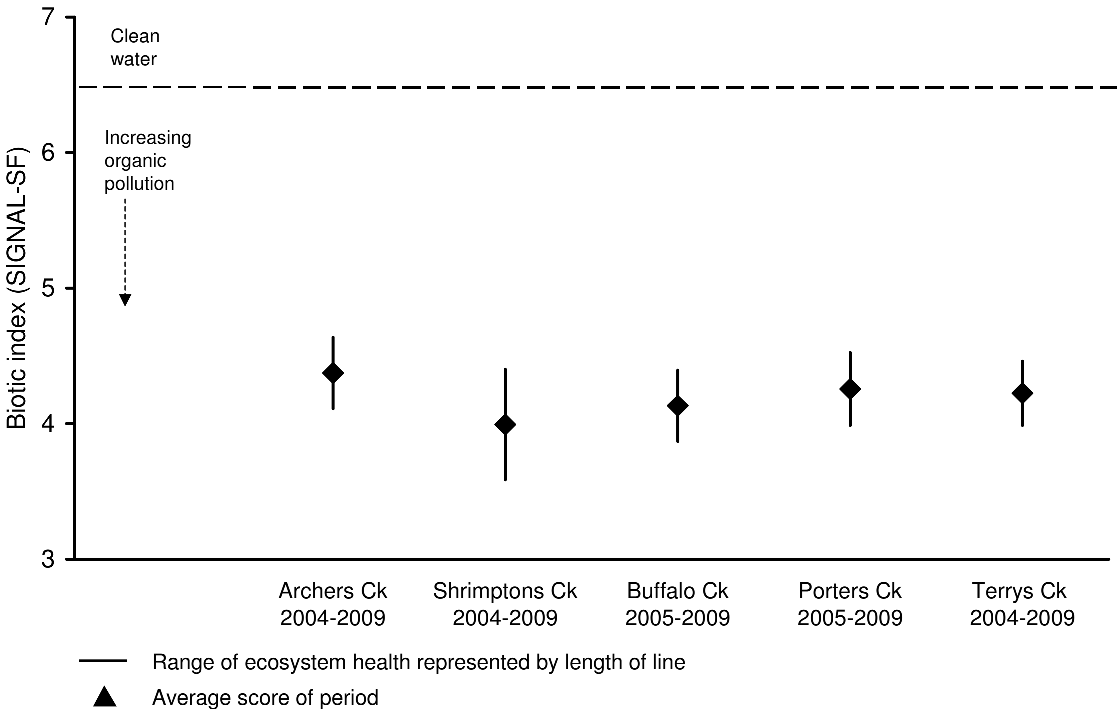
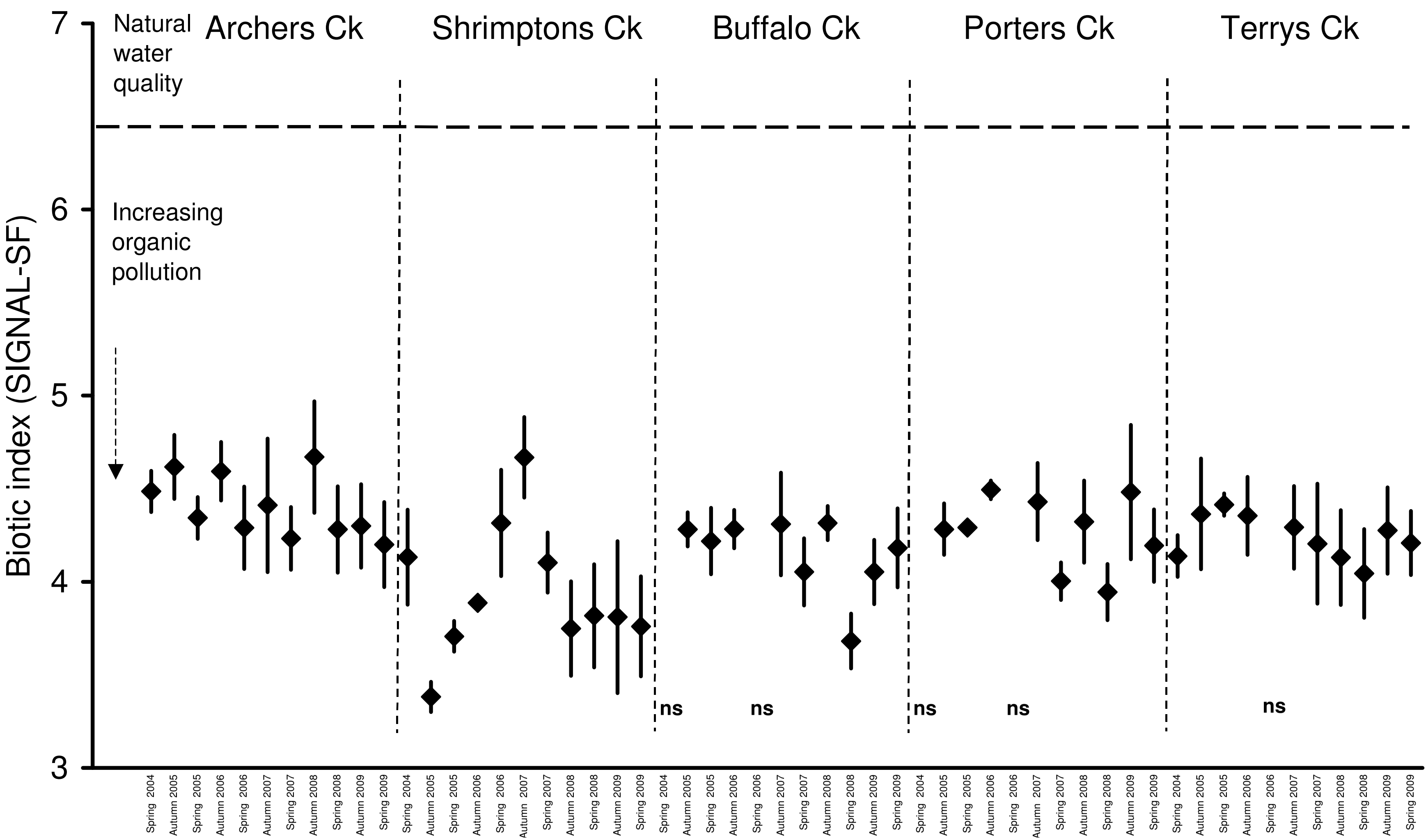


Figure 6 ***SIGNAL-SF of all creeks of monitoring program***



—— Range of ecosystem health represented by length of line

▲ Average score of period

ns Not sampled

Figure 7 ***SIGNAL-SF by season***

AUSRIVAS OE50

The AUSRIVAS OE50 data has been updated for Spring 2009. As the 'Combined Season Edge' data is based on a financial year, it requires the data for Autumn 2010, and so will not be updated until reporting for Autumn 2010.

For four out of the five creeks in the program the Spring 2009 average scores for AUSRIVAS OE50 all fell within the severely impaired band, the fifth Shrimptons Creek, remains in the extremely impaired band.

Archers Creek's average score dropped slightly from Spring 2008 to Spring 2009 (Figure 8), however the change was minimal and remains similar to the previous sampling data points. Historically, Shrimptons Creek's average score has moved between the severely and extremely impaired banding. The Spring 2009 data remains within band D.

An increase in average score was recorded for Buffalo Creek, where the stream health moved from the extremely impaired to severely impaired bands. Statistically, this is a significant change from Spring 2008. The increase, however remains in the lower range of the severely impaired band and lower than the data points of Spring 2005 and 2007 (Figure 8). Porters Creek and Terrys Creek both displayed an increased average score for Spring 2009. The change was not significant and generally remained consistent with previous spring sampling seasons (Figure 8).

The average score for all combined Spring seasons indicated all five creeks fell within the severely impaired band (Figure 11). The variation of each data point suggests a similarity across all creeks, with the only difference indicated is between Archers Creek and Shrimptons Creek. The difference is highlighted when comparing the two creeks during spring sampling for each year (Figure 8). The data points for Archers Creek stay within the mid-range of band C, whereas Shrimptons Creek generally falls just within band C or D (Figure 8).

Archers Creek appears slightly healthier than the other four creeks (Figure 12). Shrimptons and Porters Creeks display the least variation over time, maintaining similar average scores each spring. Terrys Creek shows the greatest variation over time, which is likely to be due to a significant increase of the average score in Spring 2005 (Figure 8 and 11). Then in Spring 2007 (the next Spring season sampled for Terrys Creek) it had a significant drop back to the severely impaired band.

The Spring 2009 average score is predominantly lower than Autumn 2009, it is however, normal to see an increase in average score during autumn compared to spring (Figures 8, 9, 11 and 12). The AUSRIVAS OE50 average scores for both Autumn 2009 and Spring 2009 indicate high variation through time.

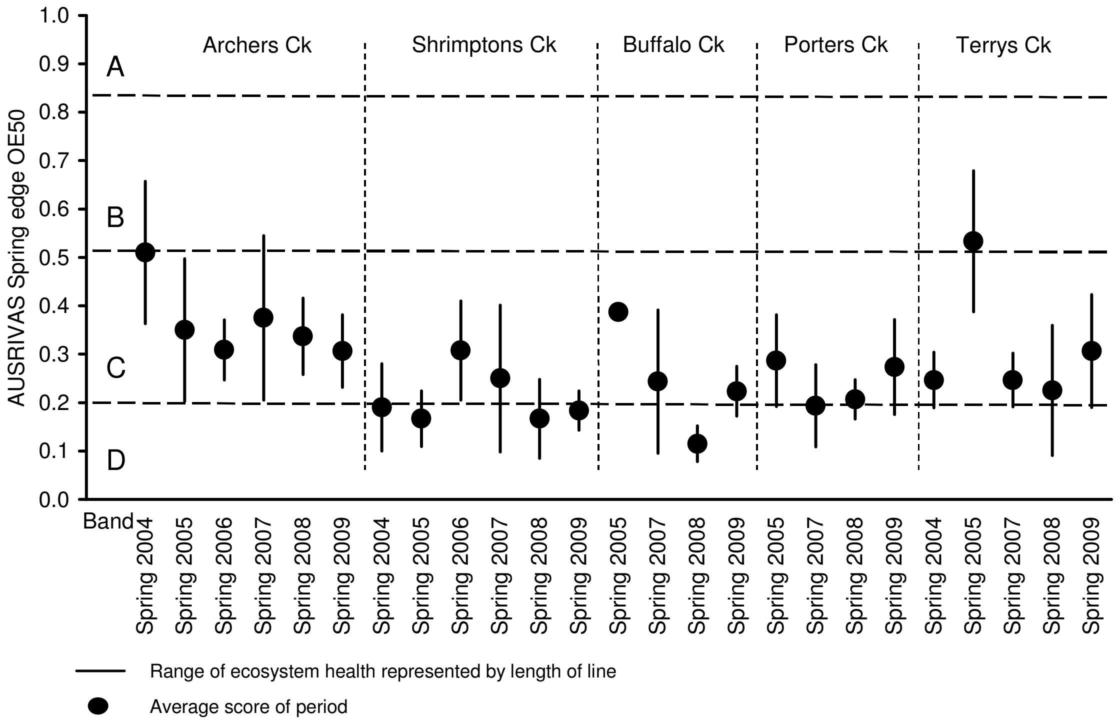


Figure 8 AUSRIVAS OE50 of all creeks from Spring edge model

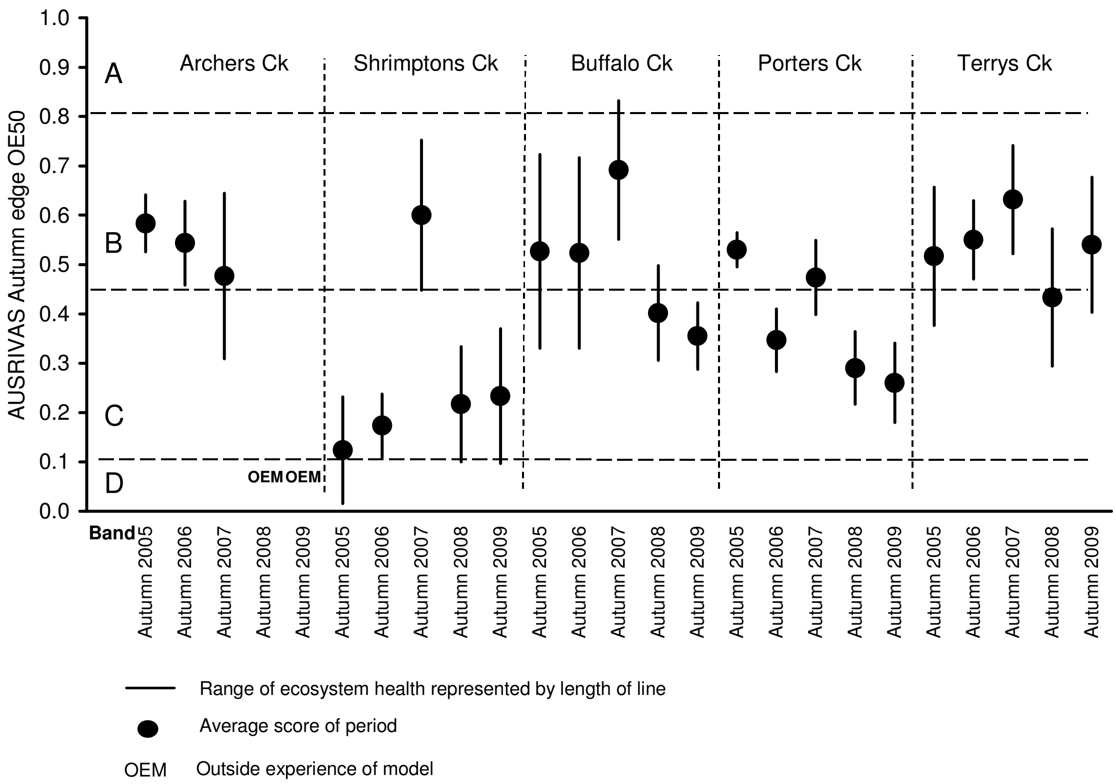


Figure 9 AUSRIVAS OE50 of all creeks from Autumn edge model

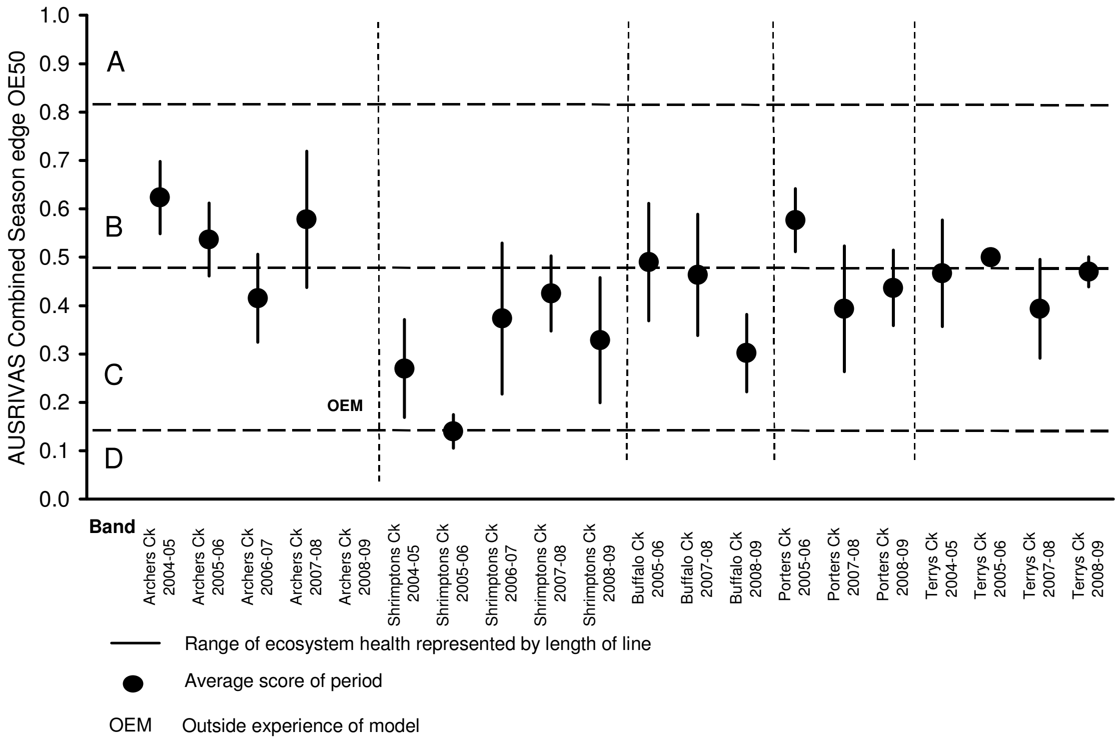


Figure 10 ***AUSRIVAS OE50 of all creeks from combined season edge model (with financial year data combined)***

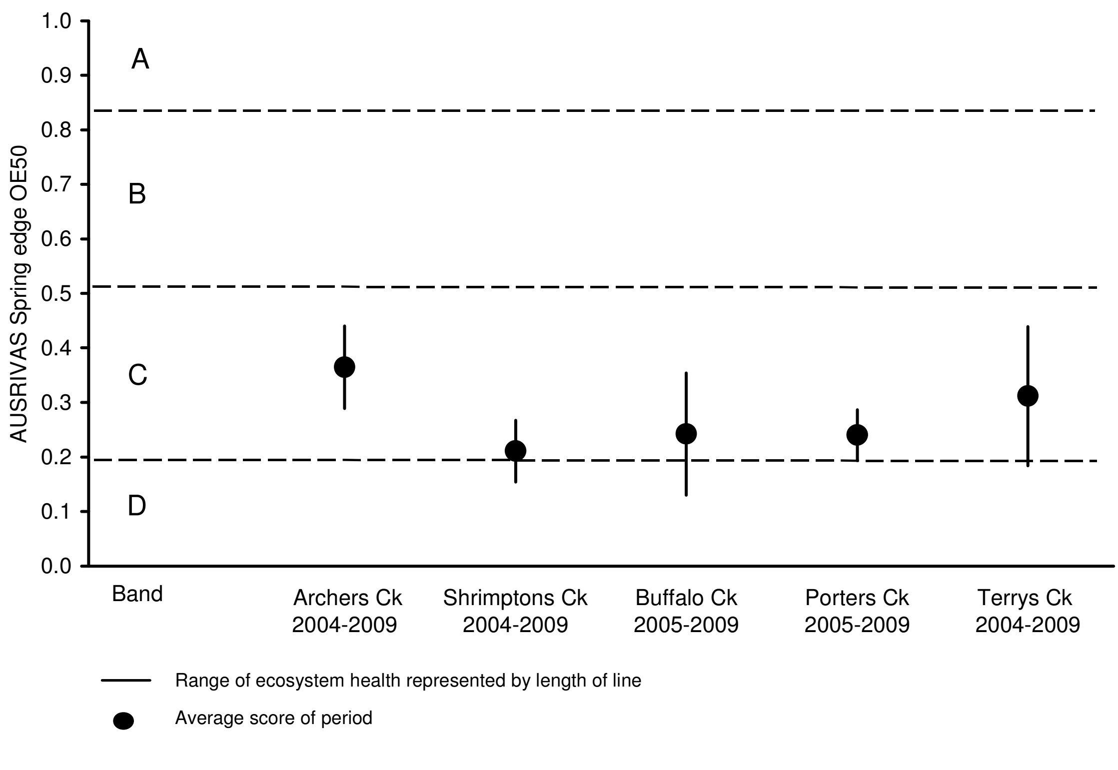


Figure 11 ***AUSRIVAS OE50 summary of all creeks from Spring edge model***

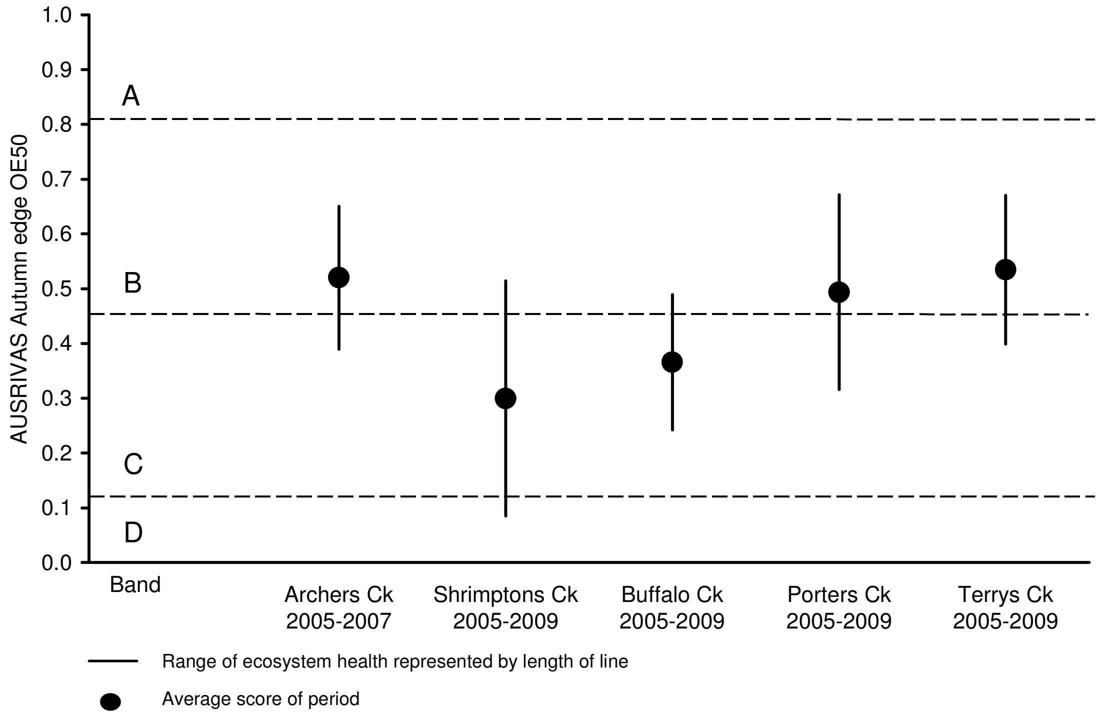


Figure 12 ***AUSRIVAS OE50 summary of all creeks from Autumn edge model***

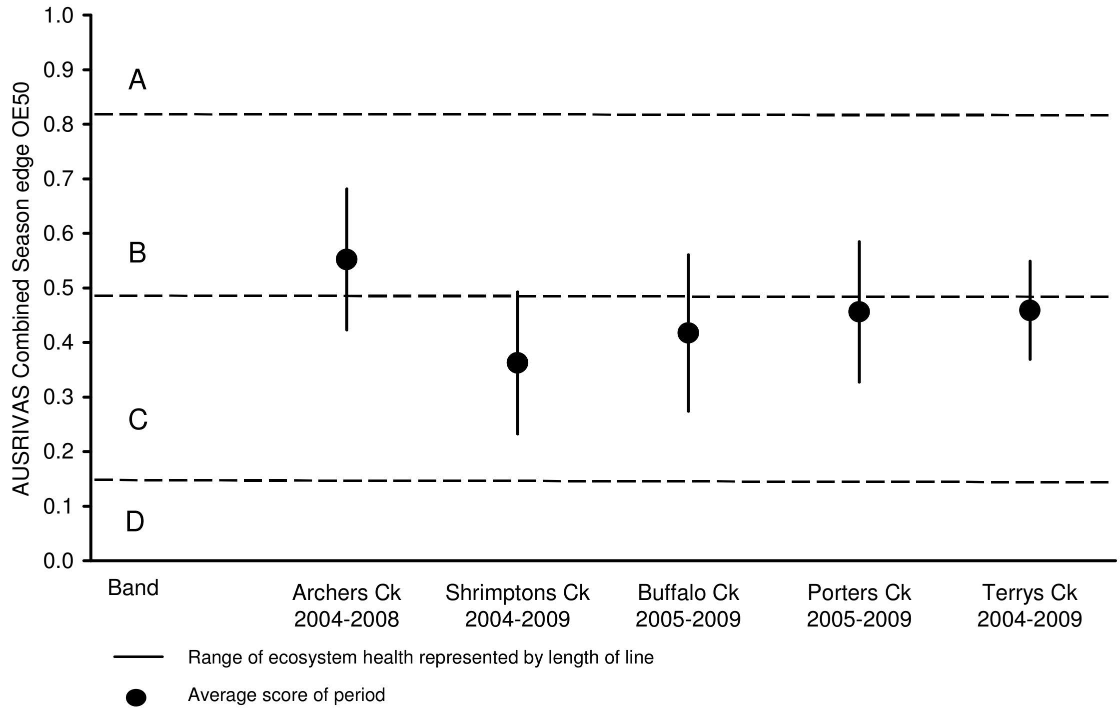


Figure 13 ***AUSRIVAS OE50 summary of all creeks from combined season edge model (with financial year data combined)***

EPT Indicator taxa from AUSRIVAS predictive model output

AUSRIVAS output identifies taxa that were expected to be represented in 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.

To provide consistency 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.

For the five creeks of the monitoring program 15 EPT indicator taxa were identified as missing by the AUSRIVAS Spring edge model. Identified were two mayfly larvae (Ephemeroptera), two stonefly larvae (Plecoptera) and 11 caddisfly larvae (Trichoptera).

There was only one family (Hydroptilidae: Trichoptera) of EPT taxa found during the Spring 2009 sampling period, however it was not an EPT indicator taxa as this taxa has a SIGNAL2 score of 4.

AUSRIVAS OE0 SIGNAL2

The AUSRIVAS OE0 SIGNAL2 data has been updated for Spring 2009. As the ‘Combined Season Edge’ data is based on a financial year, it requires the data for Autumn 2010,and so will not be updated until reporting for Autumn 2010.

The average scores for AUSRIVAS Spring edge OE0 SIGNAL2 are very similar to the previous spring results. All five creeks maintain an average score between 0.6 and 0.8, with few creeks deviating from this range (Figures 14 & 17). Buffalo Creek and Terrys Creek displayed little or no change from Spring 2008. Archers Creek decreased slightly from the previous year and Shrimptons Creek and Porters Creek data showed an increase in Spring 2009 (Figure 14).

The average AUSRIVAS OE0 SIGNAL2 scores for all sampled seasons over the five creeks displayed similar average scores, with the exception of Porters Creek and Terrys Creek (Figure 17). The difference between the two creeks indicated they are the least similar over time. This difference was minimal and both creeks remained within the 0.6 and 0.8 range similar to the other three creeks (Figure 17). Archers Creek and Shrimptons Creek have displayed the greatest variation over time, while the other three creeks have consistently recorded data that is similar to their previous spring samples (Figure 17).

The spring data for each year and for the years combined is very similar in trend and score to the autumn data through time (Figures 14 and 15). The average score for any year remains within the 0.6 and 0.8 range, which is also reflected in the autumn data.

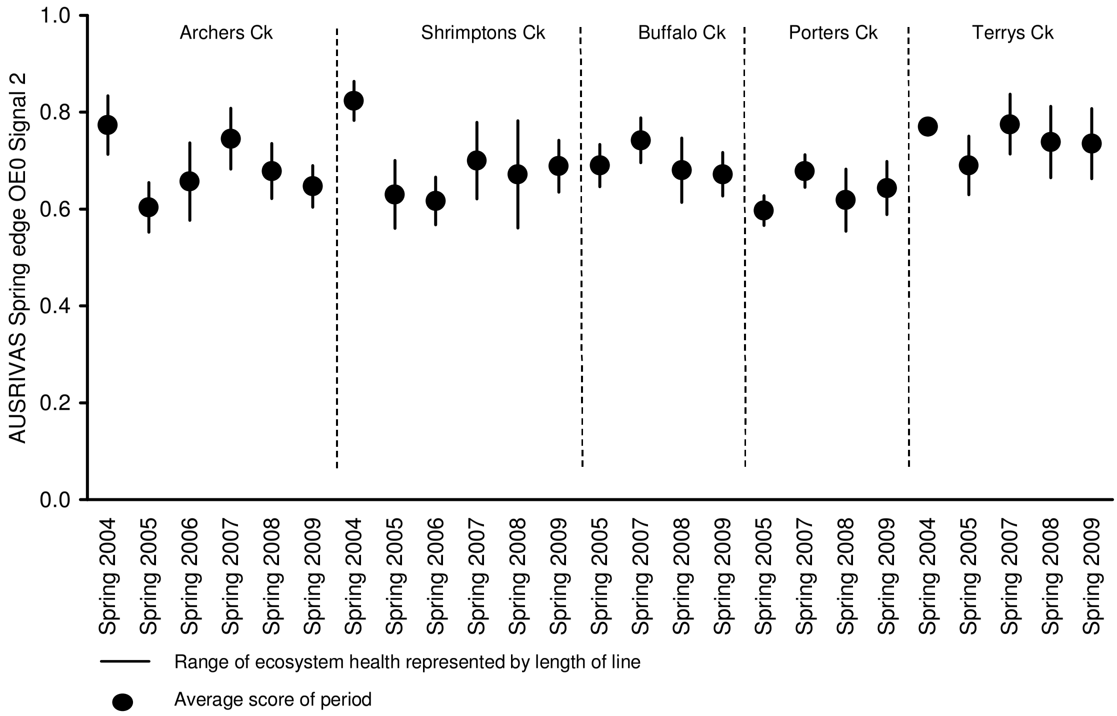


Figure 14 ***AUSRIVAS OE0 SIGNAL2 of all creeks from Spring edge model***

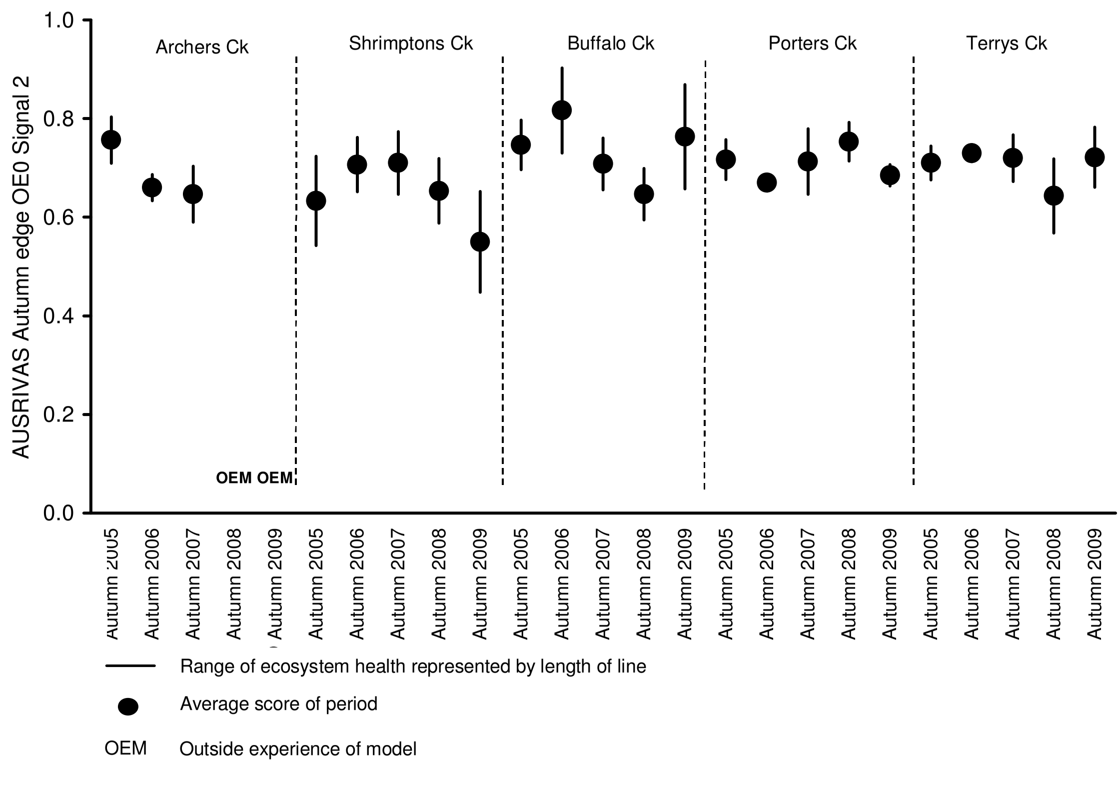


Figure 15 ***AUSRIVAS OE0 SIGNAL2 of all creeks from Autumn edge model***

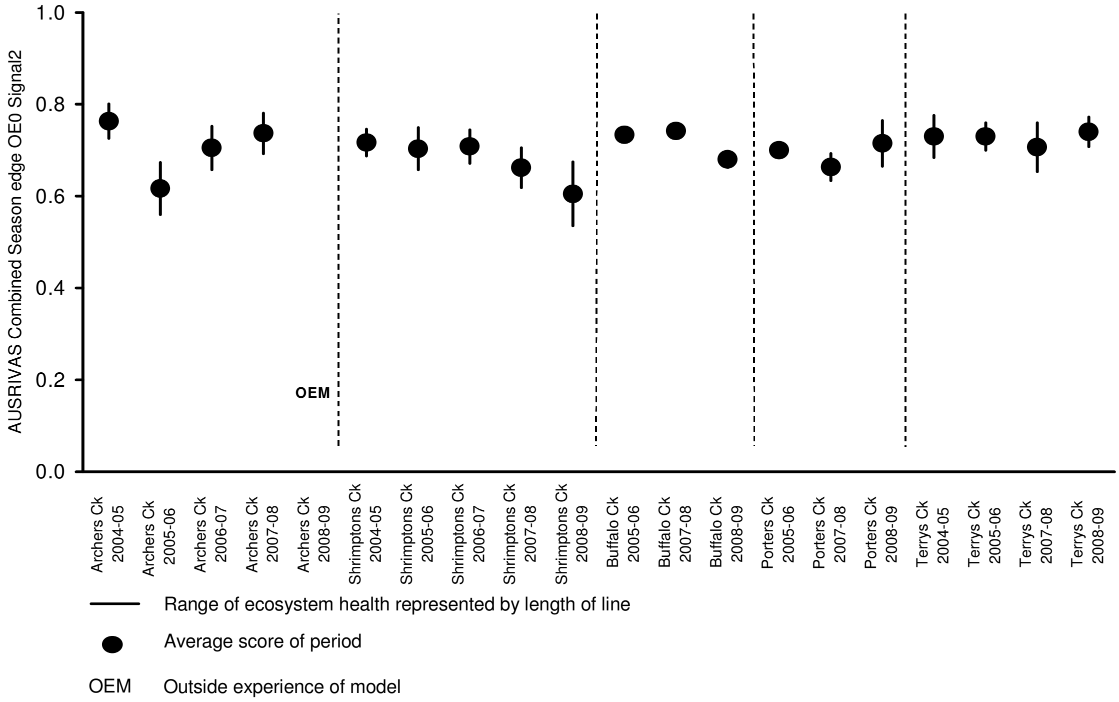


Figure 16 AUSRIVAS OE0 SIGNAL2 of all creeks from combined season edge model (financial year data combined)

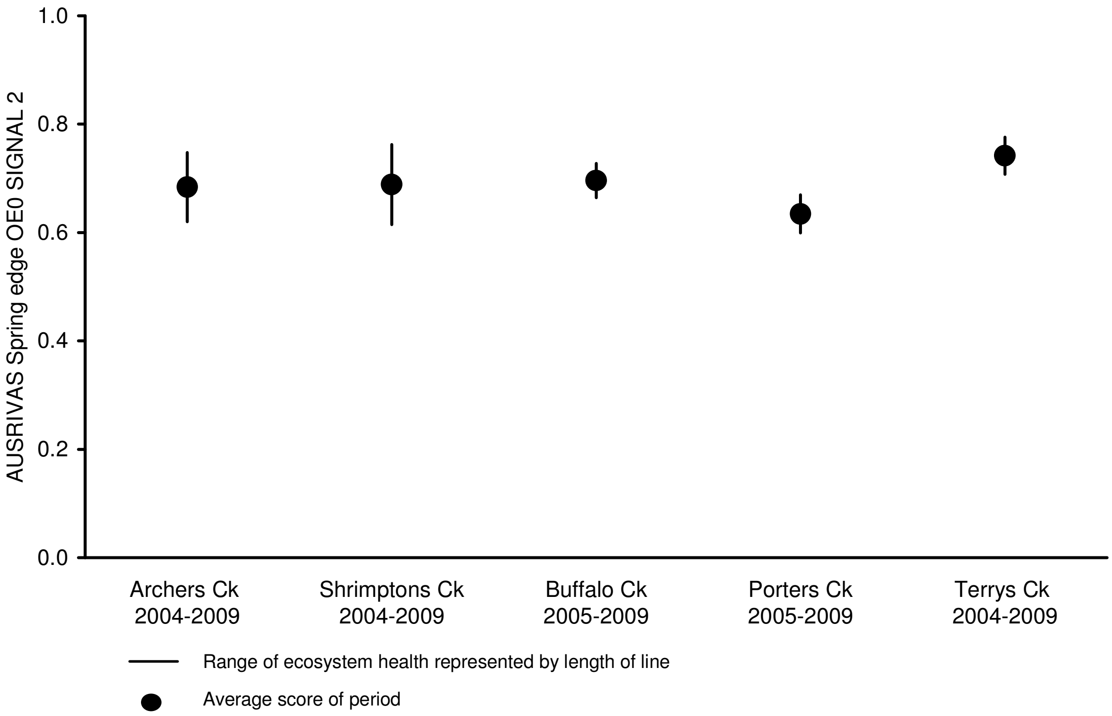
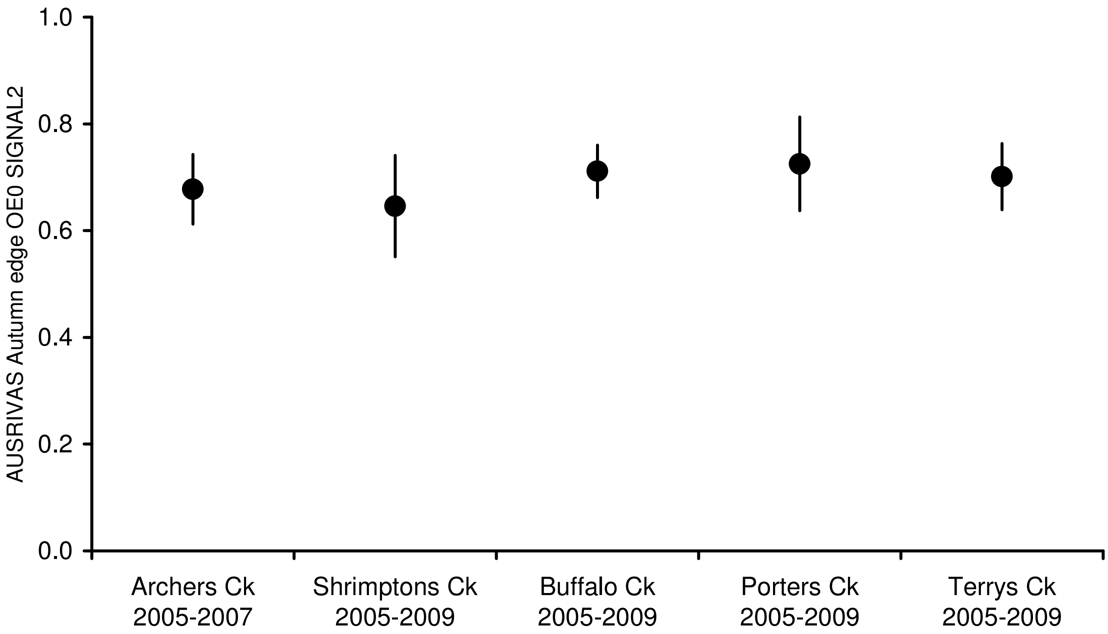


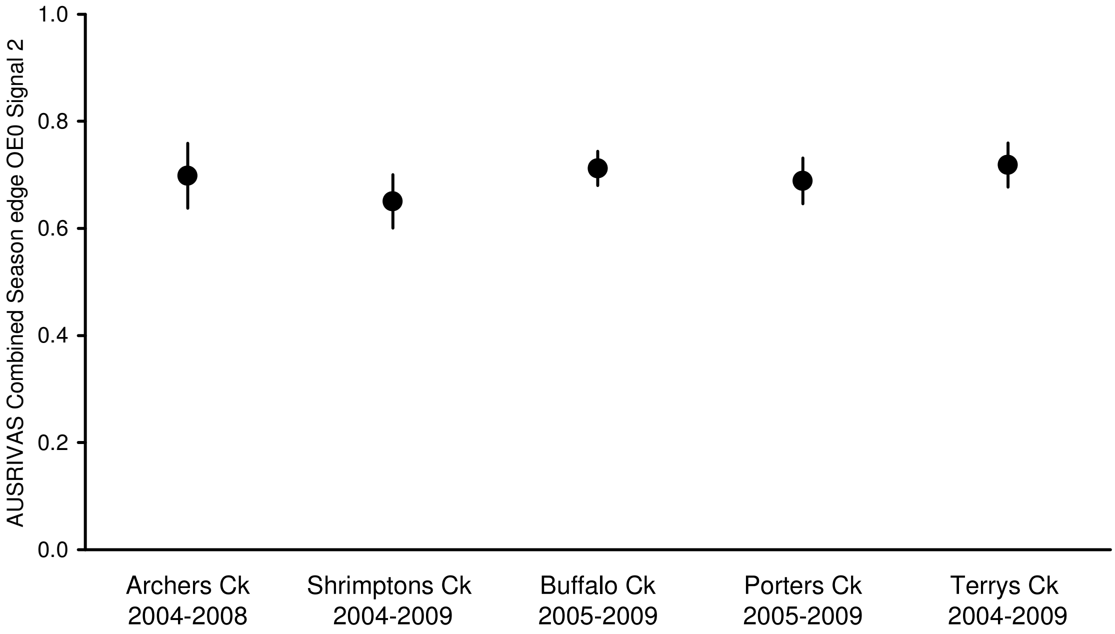
Figure 17 AUSRIVAS OE0 SIGNAL2 summary of all creeks from Spring edge model



Range of ecosystem health represented by length of line

Average score of period

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



Range of ecosystem health represented by length of line

Average score of period

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 analysis of the five creeks together 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 MDS ordination plot for all five creeks is presented in three dimensions, as the stress value is lower in three dimensions than in two. This lower stress value means the differences in community structure between creeks is better represented in the three dimensional plot, despite the three dimensions not being fully shown on paper. A two dimensional presentation of the ordinations would be the preferred reporting format, however ordinations with high stress values (>0.2) are considered inappropriate representations of community structure. This data presentation format has also been used for the Archers, Shrimptons and Terrys Creeks ordination plots, again due to the higher stress values in the two-dimension plots.

The three-dimension ordination plot highlights the between-season variability in community structure of Shrimptons Creek when compared to the other creeks through time. Terrys Creek in particular shows very little variation in community structure between seasons. Archers, Buffalo and Porters Creeks indicate a similar variability through time (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.

The SIMPROF test highlighted seven samples from Shrimptons Creek as the most notable test group to split from all other samples at 50% similarity. The second notable test group separates at 55% similarity and includes all five creeks, with a majority coming from Archers Creek. These samples are all from Autumn 2005 to Autumn 2007. The continuing test groups are made up of a mixture of creeks and seasons, with all of Terrys Creek samples making up the majority of last test groups to be split (Figure 21).

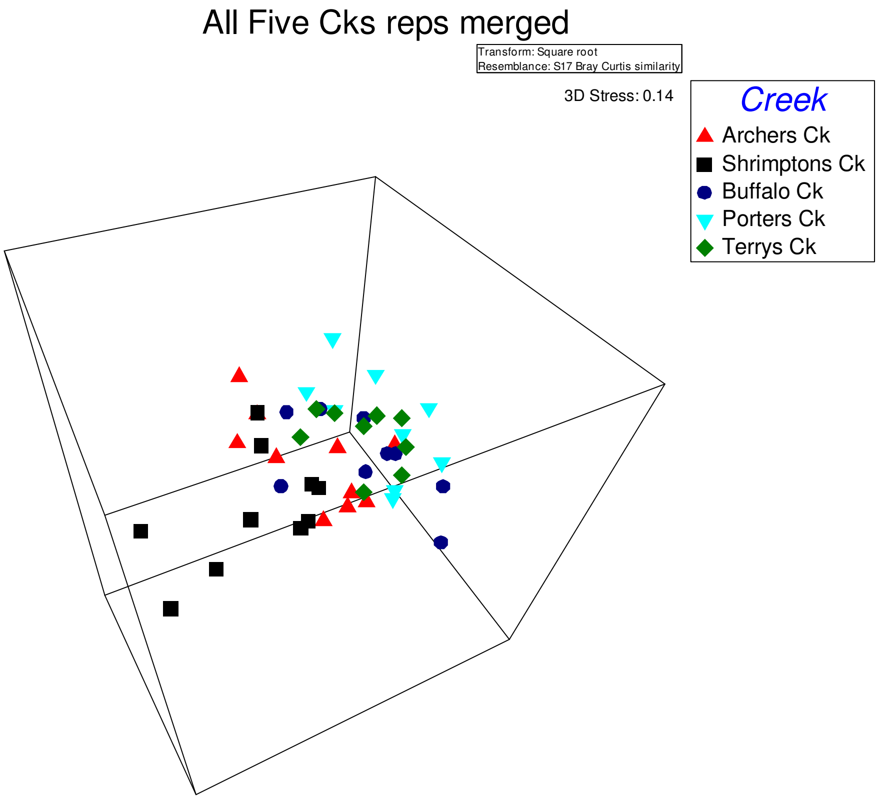


Figure 20 ***Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2009 macroinvertebrate data of all creeks with each point of the same creek representing a different season***

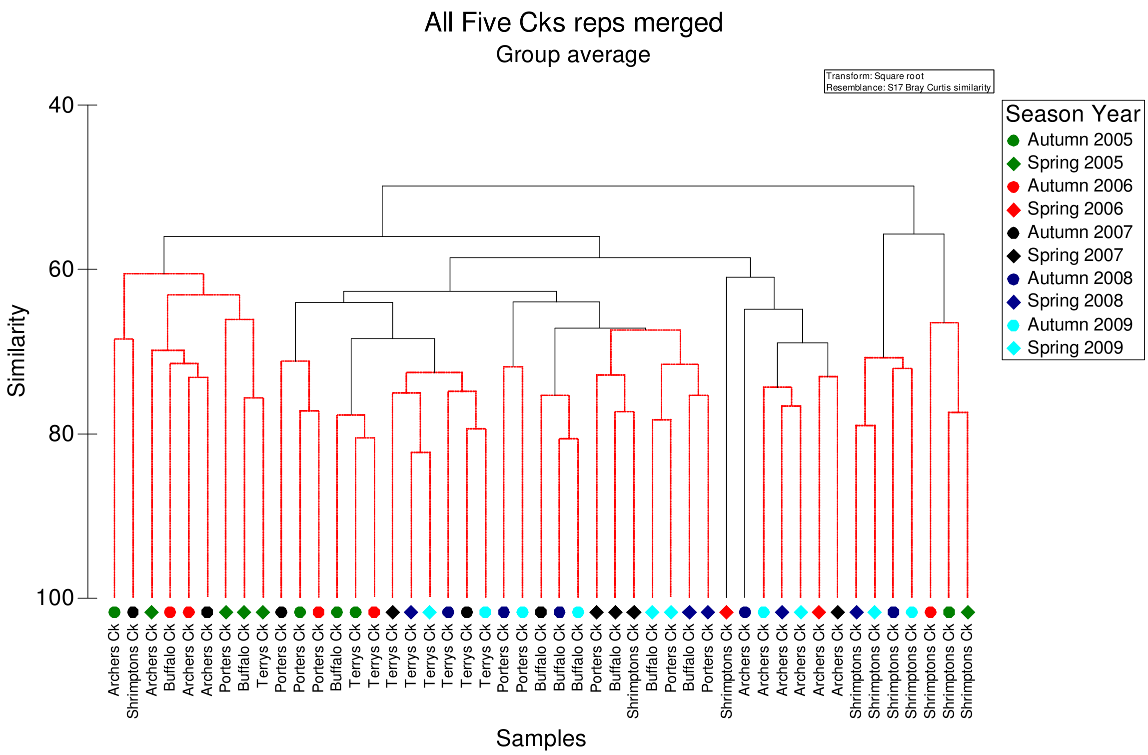


Figure 21 ***Dendrogram of all five creeks with SIMPROF test sample groups***

The Archers Creek ordination plot and SIMPROF test results indicate a general separation of autumn and spring results, with one outlying sample from Autumn 2007 (Figure 22 and Figure 23).

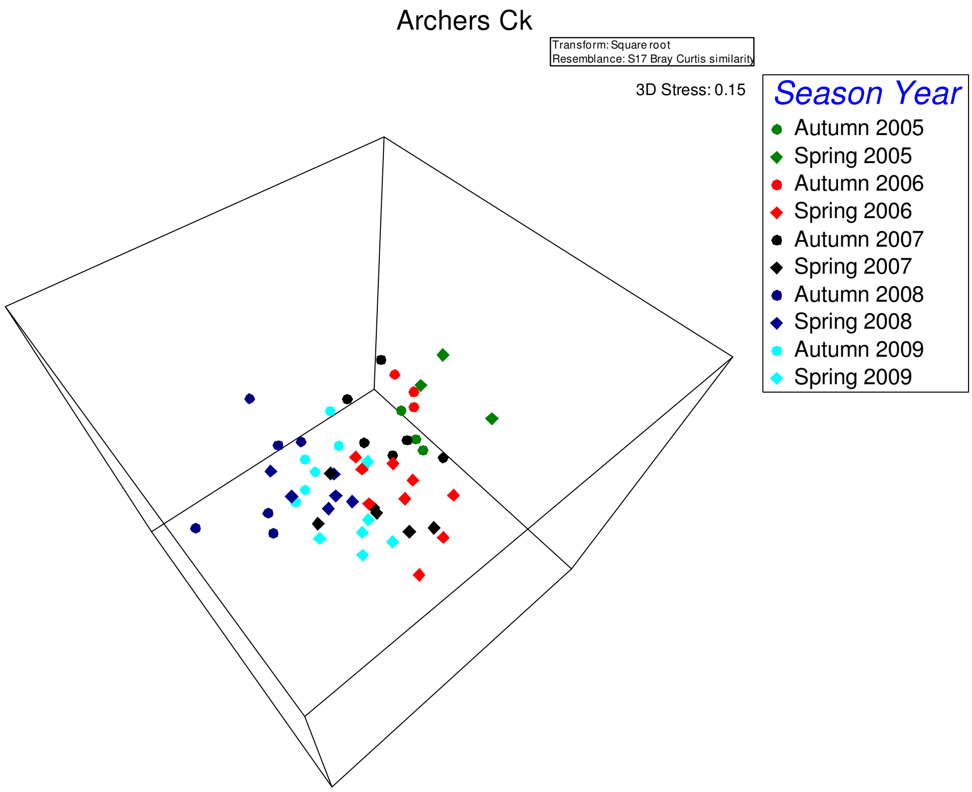


Figure 22 ***Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2009 macroinvertebrate data of Archers Creek***

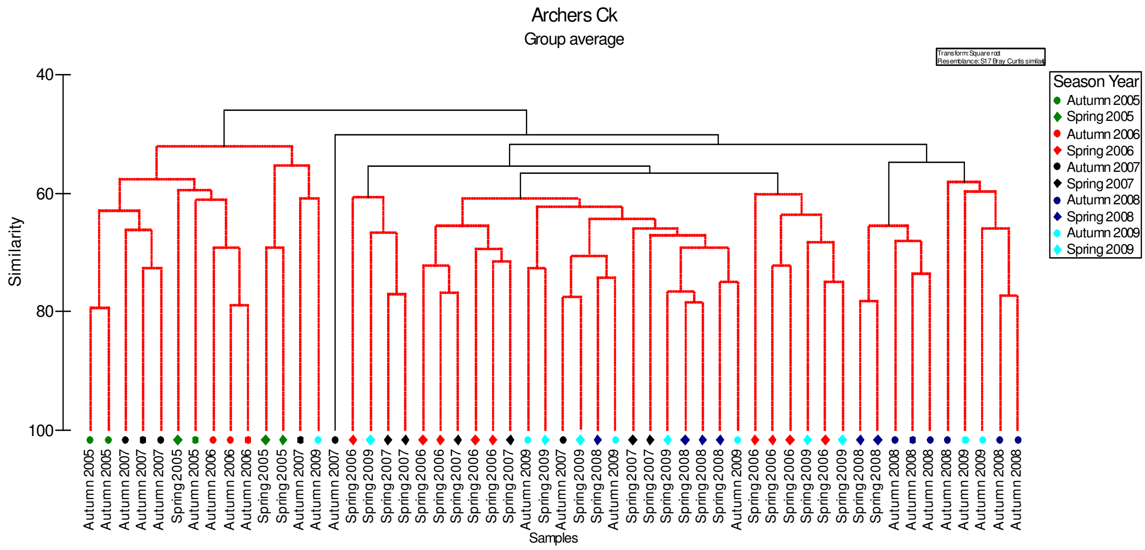


Figure 23 ***Dendrogram of Archers Creek with SIMPROF test sample groups***

The ordination plot of Shrimptons Creek separates samples from Spring 2006, Autumn 2007 and Spring 2007 from other samples (Figure 24). The SIMPROF test results show only one notable test group separation (40% similarity) consisting of one sample from Autumn 2008 and one from Autumn 2009 (Figure 25), a separation that is also indicated in the ordination plot (Figure 24).

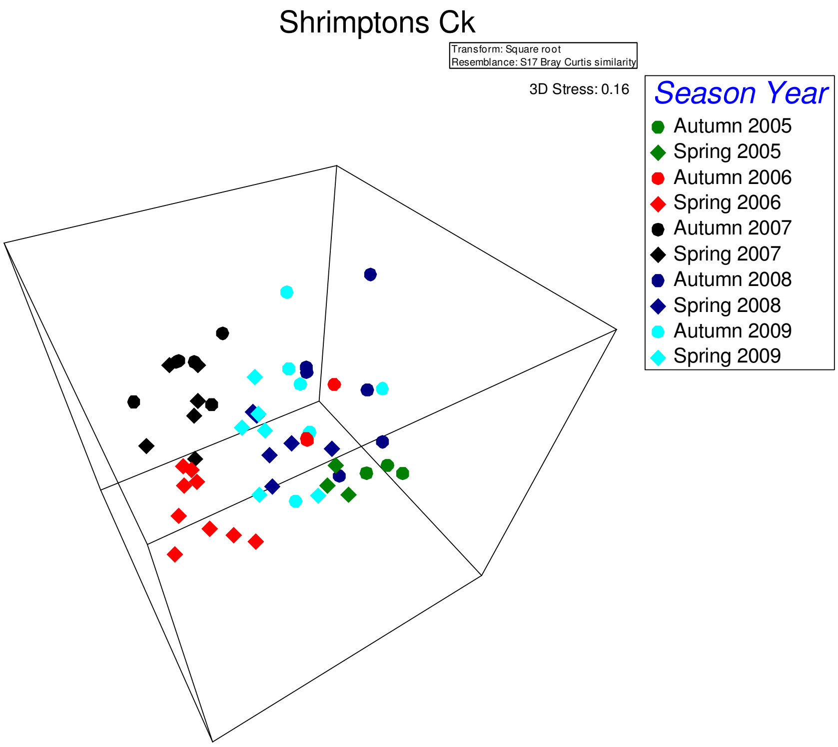


Figure 24 ***Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2009 macroinvertebrate data of Shrimptons Creek***

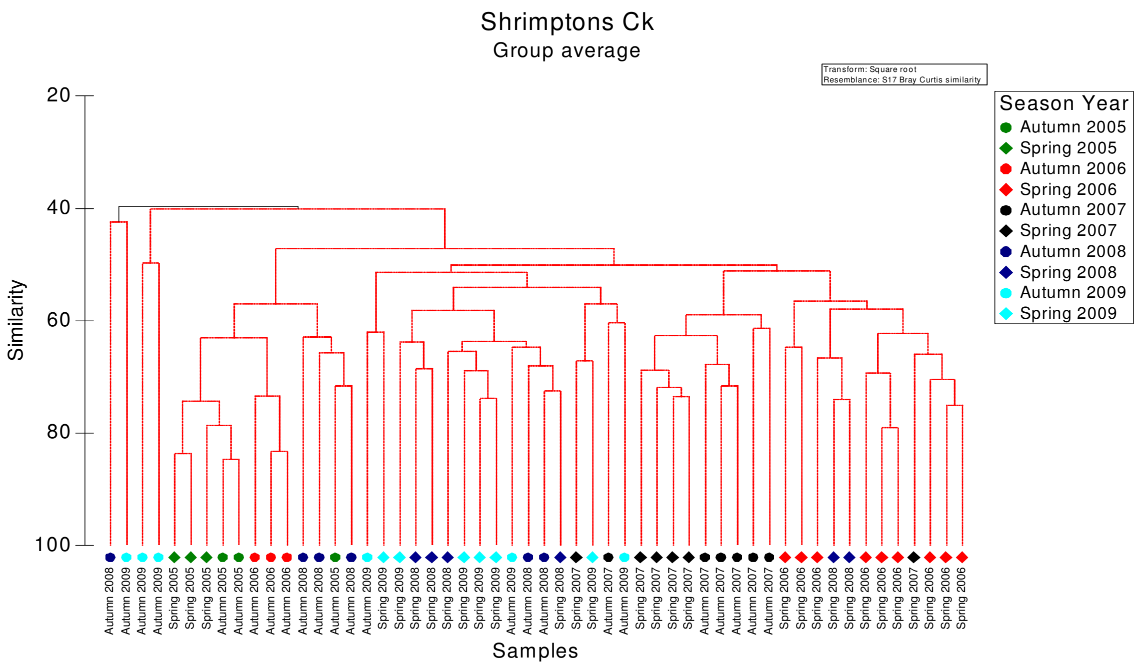


Figure 25 ***Dendrogram of Shrimptons Creek with SIMPROF test sample groups***

The Buffalo Creek ordination plot and the first test group separation from the SIMPROF test results separate Autumn 2005, Spring 2005 and Autumn 2006 from all other samples (Figure 26 and Figure 27). These are the first three seasons sampled in the sampling program.

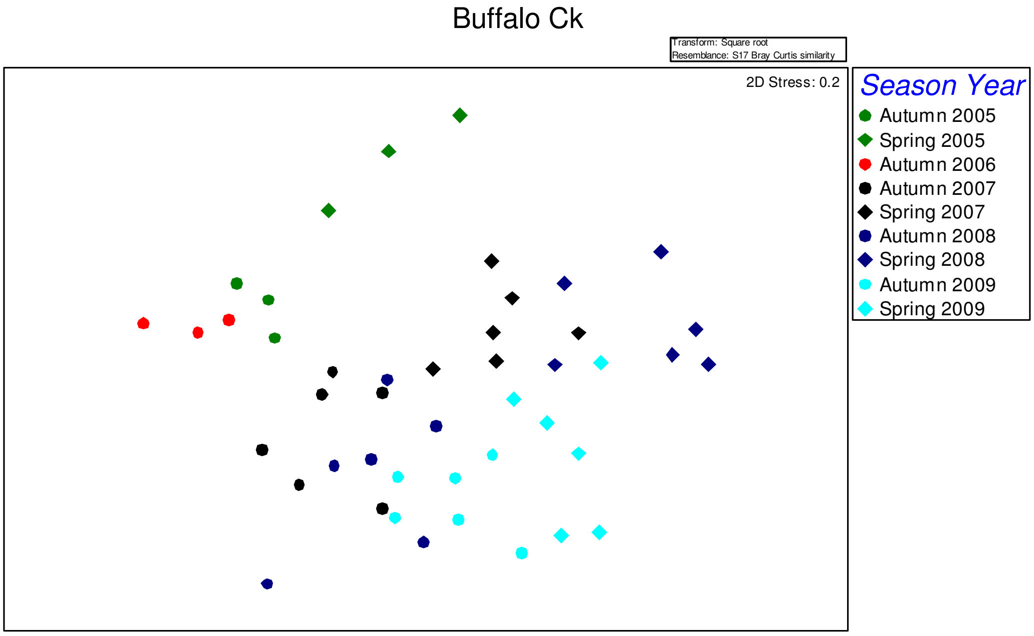


Figure 26 ***Plot of non-metric multidimensional scaling ordination results of dimension 1 and 2 of 3 dimension analysis for 2005 to 2009 macroinvertebrate data of Buffalo Creek***

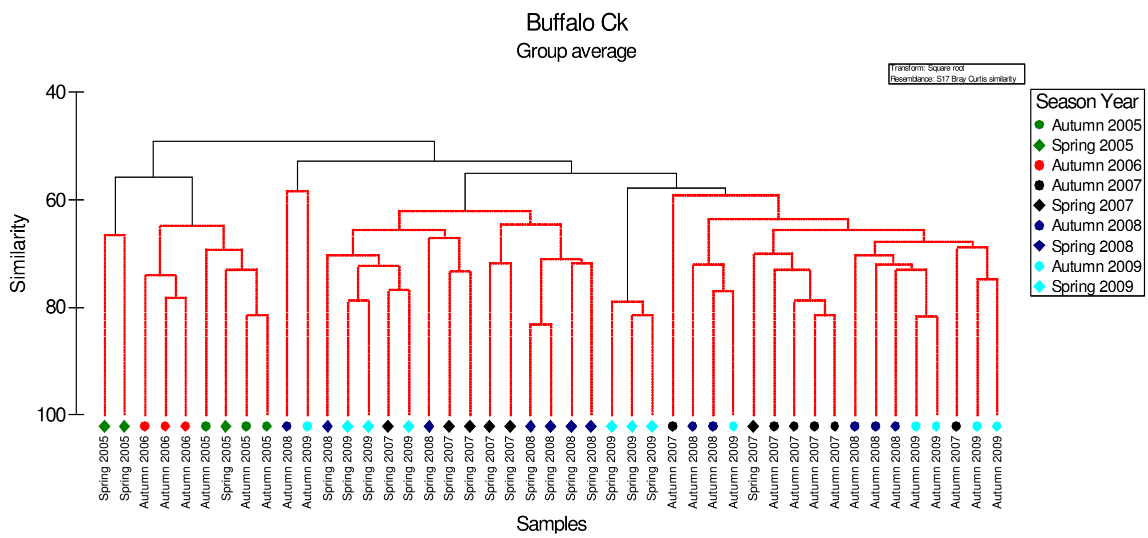


Figure 27 ***Dendrogram of Buffalo Creek with SIMPROF test sample groups***

The Porters Creek ordination plot and SIMPROF test results show one outlying group of samples made up of two samples from Spring 2008. Both multivariate analyses indicate a separation of samples between Autumn 2005 to Autumn 2007 from samples between Spring 2007 to Spring 2009 (Figure 28 and Figure 29).

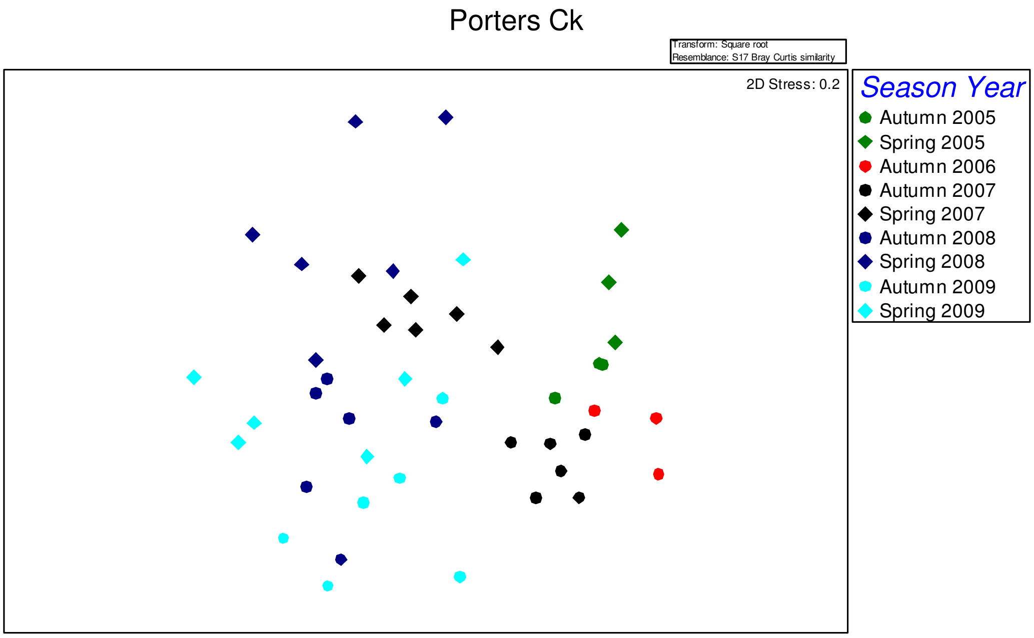


Figure 28 Plot of non-metric multidimensional scaling ordination results of dimension 1 and 2 of 3 dimension analysis for 2005 to 2009 macroinvertebrate data of Porters Creek

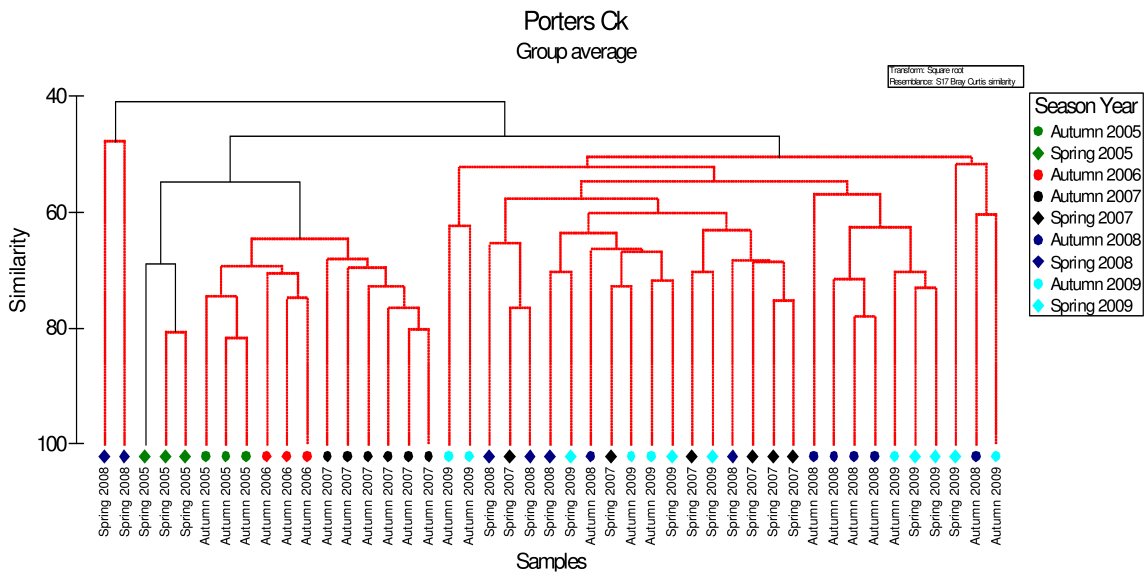


Figure 29 Dendrogram of Porters Creek with SIMPROF test sample groups

There is one outlying sample for Terrys Creek indicated in the ordination plot and SIMPROF test results from Spring 2008. The ordination plot and the SIMPROF test results show the similar macroinvertebrate community structure of Terrys Creek that has occurred during the sampling program (Figure 30 and Figure 31).

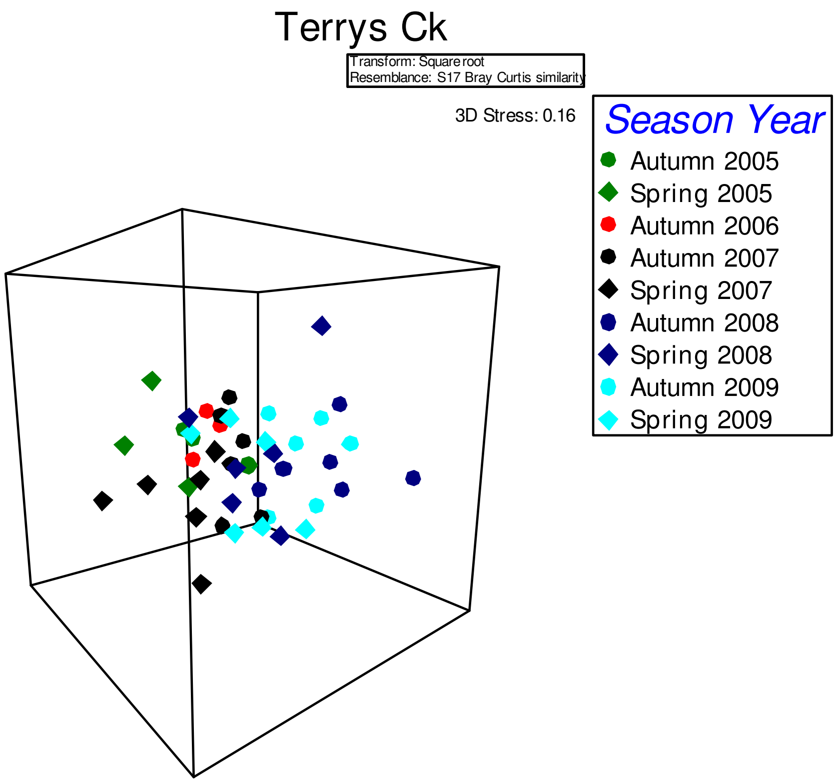


Figure 30 ***Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005 to 2009 macroinvertebrate data of Terrys Creek***

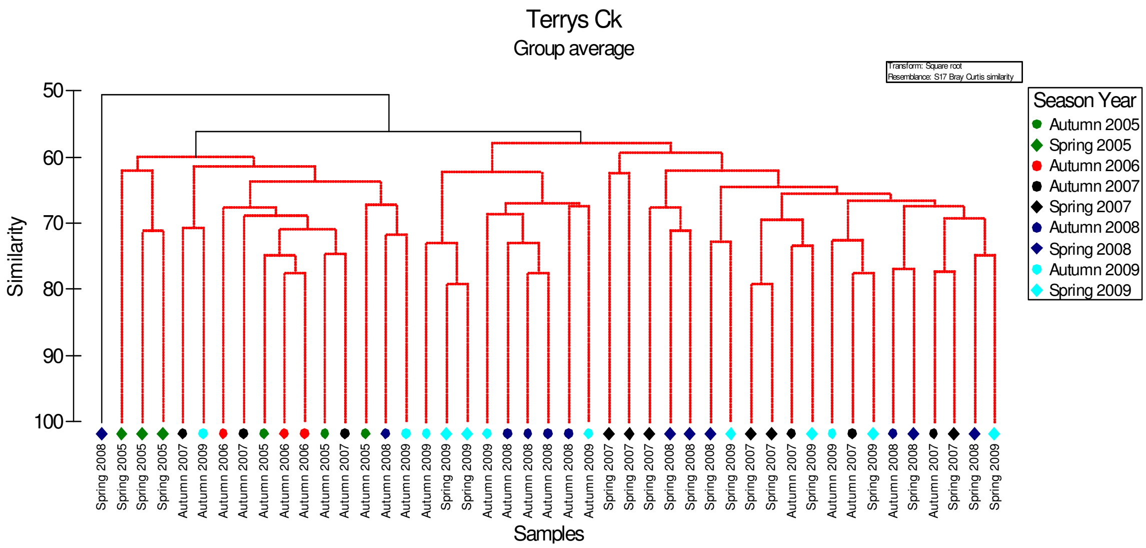


Figure 31 ***Dendrogram of Terrys Creek with SIMPROF test sample groups***

SIMPER

The SIMPER analysis for all five creeks was based on merged replicates from the same season for each creek, as was the combined creek ordination and classification analysis.

SIMPER results from 2005 to 2009 for each creek indicated that Shrimptons Creek had the lowest overall similarity of 58%. Archers, Porters and Buffalo Creeks had slightly higher similarities with 62%, 63% and 64% respectively; Terrys Creek had the highest similarity of 72% (Appendix 5). These similarities reflected the amount of variation (lower the percentage the more variation) in macroinvertebrate community structure over time within each creek.

SIMPER compared samples from each creek with those across all creeks. The results of the SIMPER output are referred to as average dissimilarity. These values are presented in Table 12 and indicated that samples from Buffalo, Porters and Terrys Creeks were most similar to each other. This reflects the closer yet still separate position of those data points in the ordination plot of all five creeks (Figure 20).

Table 11 Average dissimilarity between samples of each creek comparisons

	Archers %	Shrimptons %	Buffalo %	Porters %
Shrimptons %	48			
Buffalo %	43	47		
Porters %	44	50	38	
Terrys %	43	46	37	38

SIMPER was also performed on each creek for samples shown in the MDS plots in the Classification and Ordination section of this report. The range of average similarity of samples within the five creeks was 48% to 77% (Table 11, Appendix 5).

A change in macroinvertebrate community structure is evident for Shrimptons Creek from the SIMPER output. 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 in community structure, with up to 10 dominant taxa and tolerant insects significantly contributing to the community structure. Since Autumn 2008, the community structure has gone back to being dominated by tolerant non-insects with fewer dominant taxa. The change that has occurred in Shrimptons Creek would not appear to be influenced by seasonal variations.

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).

The SIMPER output for Archers, Buffalo, Porters and Terrys Creeks indicated that seasonal variations were influencing 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 stable through time and seasons in Archers Creek. Generally around 4 taxa contribute 50% - 70% to the overall samples.

The community structure in spring for Buffalo, Porters and Terrys Creeks is dominated by few taxa and higher contributions of non-insects occur. For Buffalo Creek in Spring 2008, this was particularly evident with 80% contribution from just three taxa. Autumn has generally seen higher taxa numbers contributing to the overall samples for these three creeks with abundance differences evident through time. In Autumn, contribution from tolerant insects has generally been 60% or greater for these creeks.

The results from the Spring 2009 data in the SIMPER output reflected what has been previously observed as trends for all five creeks of the program.

Table 12 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	67	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

BIOENV

The output of BIOENV routine is presented in Appendix 6. The correlation of extrinsic water quality and physical variables (Table 13) with intrinsic macroinvertebrate sample data of all five creeks for 2005 to 2009 was mild at 0.401.

Investigation into the extrinsic variables identified in the best result correlation included total phosphorus, pH, cobble substrate 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. Total phosphorous was found in nine of the ten best correlations. In contrast to previous reports, rainfall was only found in one of the best ten correlations.

BIOENV analysis of each individual creek for 2005 to 2009 produced weak to moderate correlations of 0.32, 0.29, 0.33, 0.45 and 0.31 for Archers, Shrimptons, Buffalo, Porters and Terrys creeks respectively.

The combination of variables highlighted by BIOENV correlations varied for across all creeks and in contrast to previous reports rainfall was only included in the best correlations for Buffalo and Terrys creeks. Total Kjeldahl nitrogen was included in the best correlations for Archers, Buffalo and Terrys creeks.

The correlations for Spring 2009 BIOENV output were all weaker compared to Autumn 2009 for four of the five creeks; Porters Creek remained the same. The BIOENV output correlations for all five creeks merged in Spring 2009 (0.40) fell slightly compared to Autumn 2009 (0.44).

Table 13 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 & Aesthetics (Secondary).

Results of the Spring 2009 water quality sampling for Shrimptons, Porters, Buffalo, Terrys and Archers creeks support previous sampling results which have indicated 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 also observed in previous sampling events in 2004, 2005, 2006, 2007 and 2008 (Ecowise 2004, 2005a 2005b 2006, Sydney Water 2006, 2007a, 2007b, 2008a, 2008b, 2009a). Pollutant concentrations were spatially highly variable, indicating that they originate in varying locations over a constantly changing time period.

Weather conditions in the five months preceding the collection of the first samples in Spring 2009 were characterised by relatively consistent low to moderate rainfall periods. However, in the month before the collection of the second round of samples, approximately 150mm of rain fell in the general catchment area (Marsfield Bureau of Meteorology Station).

Dissolved oxygen concentrations are the single most important water quality indicator for the survival of aquatic organisms and the control of many important physico-chemical processes. The oxygen balance in waters 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 but the respiratory rate of aquatic organisms increases with temperature (Connell, 1993). With this in mind, the onset of warmer weather between the two sampling events in Spring 2009 increased water temperature from between 2.3^{o}C and 11.5^{o}C. After a long stretch of hot dry weather aquatic organisms may suffer with the lack of oxygen and creeks may experience fish kills.

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 2009 for Terrys, Shrimptons, Buffalo and Archers creeks are an area of concern. These sites are showing continually impacted dissolved oxygen concentrations particularly during periods of extended low flow. Rainfall and the resulting increase in flow between the two sampling events raised dissolved oxygen saturation levels at most sites on the second sampling occasion.

Dissolved oxygen 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 of the five creeks. This is partly related to more efficient run-off transport during both wet and dry periods.

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

Faecal coliform concentrations at the Porters Creek core site in November were elevated above ANZECC (2000) recommended concentrations. This is a common occurrence after periods of moderate rainfall, as experienced in the month prior to sampling, and is likely to be linked to faecal contamination from urban runoff in storm water.

The Shrimpton Creek site at Bridge Street (downstream of Santa Rosa Park) returned a high turbidity result of 447 NTU for the September sampling. It was noted at the time of sampling that construction was occurring upstream of the sampling site. Although construction was ongoing, the sample collected on 2nd November provided a considerably lower result of 18.2 NTU.

Nitrogen and phosphorus are essential elements for life. They are found naturally in the earth's crusts (phosphorus) and atmosphere (nitrogen) but are not directly available to most living organisms. As a result, a lack of these elements is often the factor limiting growth of algae, bacteria and other plants. Increasing the readily available phosphorus and nitrogen loads in streams can lead to algal blooms and excessive plant growth.

Shrimptons Creek experienced elevated concentrations of total phosphorous, total nitrogen and total Kjeldahl nitrogen on 30th September. Elevated nutrient levels may have been the result of decomposing organic matter and low dissolved oxygen levels, which can be a significant factor in increasing the amounts of readily available nutrients from sediments via chemical synthesis. Faecal coliform and ammonia concentrations were not elevated. Therefore, it is unlikely that recent sewage contamination had occurred. The elevated nutrient levels had fallen to more typical concentrations by the 2nd November where rain during the intervening period had increased flow, flushing the creek.

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 temperature occurrences 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 200C. 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 against NH4+ increases exponentially and it is this compound that is detrimental to aquatic life. ANZECC (2000) does not measure this or provide guidelines on this form but it does determine the NH4+ concentrations that are dangerously high and most likely to produce the toxic NH3 compound, and it provides guidelines on this.

Total dissolved solids (TDS) refers to the total amount of organic and inorganic substances, including minerals, salts, metals, cations or anions that are dispersed among a volume of water. By definition the solids must be small enough to be filtered through a 2 mm sieve. Sources for TDS include agricultural and urban runoff, industrial wastewater, sewage and natural sources such as leaves, silt, plankton and rocks. Piping or plumbing may also release metals into the water. The US EPA recommends that the threshold of acceptable criteria for human drinking of TDS concentrations not exceed 500 mg/L (500 ppm). Further testing may be warranted in some cases, as water with a high TDS concentration may indicate elevated levels of ions that pose a health concern such as aluminium, arsenic, copper, lead, nitrate and others.

5.2 Macroinvertebrates

Macroinvertebrate results from the Spring 2009 sampling season indicate that Archers, Shrimptons, Buffalo, Porters and Terrys creeks had impaired macroinverterbrate communities. This result reflects what has been previously observed from Spring 2004 to Autumn 2009.

ANZECC (2000) indicates that adequate baseline data is required to determine an acceptable level of change in an environment. Only then can informed management judgments be made that take account of natural variability in an indicator, in this case macroinvertebrates. ANZECC (2000) also suggests three to five years of data be gathered from control or reference locations.

The City of Ryde Monitoring Strategy uses comparable data from all five creeks, each of which each has its own natural variations 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 (ANZECC, 2000). Presenting data in this way attempts to take account of variation at study sites and provide a basis for management tracking and decision making.

To date, there have been nine seasons of comparable data for all five creeks in the monitoring strategy since sampling began in Spring 2004. The inclusion of data from seasons with above average rainfall would provide a more complete baseline for management decisions. However, the current baseline data should allow for tracking of any significant changes in macroinvertebrate assemblages due to management decisions.

A total of 1,970 macroinvertebrates were collected during the Spring 2009 sampling season. This is slightly higher than the previous sampling period (1,778 in Autumn 2009) but significantly lower than both 2007 seasons (Autumn 2,635 and Spring 2,490). It would be misconceived to try and link this to any water quality or other in-stream factors. The reduced numbers may reflect environmental cues that influence the development of macroinvertebrate taxa; 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 0.25 mm mesh of the net.

Sensitive taxa, as measured by EPT richness, were present in low numbers in Archers, Buffalo, Porters and Terrys creeks in Spring 2009. Archers Creek averaged a single EPT taxa per sample and this was the highest of those four creeks. Shrimptons Creek had no EPT taxa present.

There was only one representative family of EPT taxa sampled in Spring 2009, the Trichopteran, Hydroptilidae. Hydroptilidae, a tolerant EPT taxa, has a SIGNAL2 score of 4 and has been the most historically consistent EPT taxa in all five creeks. Generally, EPT taxa collected in the City of Ryde study creeks are in low abundances and are found sporadically, and are typically tolerant EPT taxa.

Because of these factors, EPT richness as a measure is limited in its ability to suggest any future negative impacts on stream health. In the Spring 2007 report, it was suggested the 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 may return in the future, resulting in higher numbers of EPT taxa. However this may only result in higher numbers and abundances of tolerant EPT taxa

Considering these fluctuations and the relatively low occurrence of EPT taxa, reference to EPT indicator taxa from AUSRIVAS predicted model output status(as per criteria of Section 3.6) should be made in assessing positive changes in this measure, before attributing positive changes to management activities. The EPT indicator taxa are considered sensitive animals and the presence/absence of these taxa 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 all reflected impaired stream health of Archers, Shrimptons, Buffalo, Porters and Terrys 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 being Shrimptons Creek, which showed significant variation through time and when compared to the other four creeks.

The SIGNAL-SF index, AUSRIVAS OE50 Spring, and combined season models indicate that Archers Creek is slightly healthier than the other four creeks, while in the other AUSRIVAS analyses it is usually within the higher range of stream health.

Archers Creek SIGNAL S-F scores had indicated that stream health for the most part was poorer in Spring compared to Autumn. AUSRIVAS OE50 also indicated this same seasonal trend, as it has done for all five creeks in the program. Results from SIMPER indicate a seasonal change in macroinvertebrate assemblages in Archers Creek. In Spring there are low contributions from tolerant insects, while Autumn is higher. The insects and non-insects that contribute significantly to the macroinvertebrate assemblages of Archers Creek are all considered to be tolerant fauna. However, the insects do 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 each season separately.

Archers Creek leading into the Autumn 2008 season had significant rehabilitation work completed both within the creek and the riparian zone. This work was completed within the area that sampling occurs. The SIGNAL S-F score in Autumn 2008 peaked, returning the highest average stream health for any creek of the sampling program. In the three seasons since Autumn 2008 the SIGNAL S-F scores in Archers Creek have been in the lower range of stream health for that creek. A comparison with the AUSRIVAS model output is not completely possible due to there not being a result for the previous two Autumn seasons or the previous combined season (a result explained later in this section). No real change has been observed in the previous AUSRIVAS Spring season model outputs.

No significant shift in community assemblages has been observed by the multivariate analyses for Archers Creek. With this and the univariate results in mind it is not possible to link any currently observed in-stream health shifts to improvement work that has been completed on Archers Creek.

All of the univariate results suggest that Shrimptons Creek has the slightly poorer stream health of the five creeks in the program. The only exception being AUSRIVAS OE0 SIGNAL2 spring model output, in which the average score range overlaps with that of the other four creeks. Incidentally, it also has the highest 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 model scores for any creek in the program. All of the univariate analyses then indicated Shrimptons Creek stream health improved through time, peaking in Autumn 2007. Stream health results indicated by SIGNAL S-F and AUSRIVAS OE50 autumn model in Autumn 2007 were the highest Shrimptons Creek had returned to date in the program. However the following Spring and Autumn seasons the stream health dropped significantly as indicated by SIGNAL S-F and the AUSRIVAS spring and autumn model outputs. Stream health has since stabilised for most of the univariate analyses.

Despite stream health stabilising to an extent through recent sampling seasons, Shrimptons Creek macroinvertebrate results are still the most varied through time of the five creeks of the program. This variation is indicated well by the MDS ordination of all five creeks. It shows clearly Shrimptons Creek samples separating from all other creeks' samples. The SIMPROF ordination separates most Shrimptons Creek samples from all other creeks' samples in what is defined as 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, 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, in turn, the stream health as observed by macroinvertebrates and water quality results. It should be said, however, that dissolved oxygen concentrations are not going to be the only driver limiting stream health and that an improvement in this measure may not be reflected in macroinvertebrate assemblages.

Univariate results for Buffalo Creek are indicative of what has been previously observed at this creek. The SIGNAL S-F average score continues the improvement in stream health observed since its poorest recording in Spring 2008. The AUSRIVAS OE50 spring model also indicates a significant improvement in stream health for Spring 2009, as compared to Spring 2008 when it recorded its poorest result (the only time the average score fell into Band D). The 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. The Autumn and Spring 2009 SIMPER results indicate that the number of taxa contributing to the overall macroinvertebrate assemblages have increased to levels observed in seasons preceding Spring 2008.

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

It was suggested that this change was due to the loss of some taxa resulting 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 became dominant when elevated levels of fine sediment were introduced to streams.

The apparent loss of taxa and drop in stream health in Buffalo Creek would be potentially reversible if the source of sediment could be controlled, or it was only a short-term impact. Wood & Armitage (1997) suggested that short-term increases in fine sediment due to human disturbances like construction developments could precede a rapid recovery. The results of the Autumn and Spring 2009 analyses suggest that a recovery has occurred and that the impact was short term. However, further biological sampling of Buffalo Creek is needed before a recovery can be substantiated.

Porters Creek univariate results for Spring 2009 were indicative of what had been previously observed. The SIGNAL S-F average score for Spring 2009 was lower than the previous Autumn season. Porters Creek has shown a seasonal trend that is similar to what has been observed in Archers Creek; that is, higher scores in Autumn than in Spring. With missing data points, more seasonal sampling would be required before an established trend could be suggested. AUSRIVAS OE50 had higher stream health scores for Autumn and lower scores for Spring but, as previously stated, this trend was true for all five Creeks. Multivariate results for Porters Creek suggest that there is little variation in its macroinvertebrate assemblages through time and that what variation does occur is generally linked to seasonal changes.

The macroinvertebrate results for Terrys Creek in Spring 2009 reflect what has been previously observed in this creek. Univariate and multivariate analyses indicate that Terrys Creek has very little variation in both stream health and macroinvertebrate assemblages through time. This limited variation through time is particularly evident in the MDS ordination of all five creeks.

The univariate and multivariate results indicate that all five creeks have similar stream health both when compared to one another and through time. Little change in stream health has been recorded apart from the aforementioned changes in Shrimptons and Buffalo Creeks. This does mean that as yet no significant impact has been recorded from creek rehabilitation work carried out by Ryde Council. It is suggested however that if an improvement in stream health does occur due to creek rehabilitation it will be evidenced in the data and analyses. This is suggested by the trends that have been indicated by most of the analyses for Shrimptons and Buffalo Creeks.

There are some observations of the univariate analyses that have limitations on reporting. AUSRIVAS OE0 SIGNAL2 is at times contradictory to all other analyses for some of the creeks; the Spring/Autumn seasonal trend in Archers and Porters Creeks is the notable example. The most notable limitation occurs with the AUSRIVAS autumn edge model output for Archers Creek. The output describes the data as being outside the experience of the model, which has resulted in two missing data points for the Autumn model and one combined season output. 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.

In previous reports (SWC 2006, 2007a, 2007b), exploration of stormwater drainage connection was recommended. Due to cost, the calculation of the percentage of effective imperviousness in each of the five catchments was not made. Rather, possible surrogates of this measure were included. Total length of pipe, total number of outlets, catchment area, ratio of total length of pipe to catchment area, and ratio of total number of pipe outlets to catchment area were calculated by the City of Ryde. Calculated values were included in the BIOENV routine for all five creeks.

The results of attempting to link water quality patterns to macroinvertebrate patterns using the multivariate BIOENV routine were weak to moderate for each individual creek and the highlighted variables were varied. The BIOENV result for all five creeks was mild and highlighted Total Phosphorus, pH, Cobble and number of outlets/catchment area in nearly all of its ten best correlations. 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 do not appear to be all of the drivers for the shifts recorded in macroinvertebrate community structure. As such, efforts to improve water quality should not be solely concentrated on variables measured to date.

Strong correlations were not found using the BIOENV routine but, of the best correlations, some of the stormwater surrogates were included. Rainfall was not included in many of the stronger correlations for all five creeks and within creeks. However, as suggested in previous reports, it is suggested that rainfall, impervious surfaces and stormwater connections are some of the main drivers limiting stream health in the Ryde LGA.

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, in press). The primary degrading process to 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 cause 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 research conducted in Melbourne.

Surrogate measures for effective imperviousness were introduced to the BIOENV analysis routine. The surrogate number of outlets/catchment area was highlighted in all of the ten best correlations, this indicates that the impervious connections within the Ryde LGA are impacting on stream health. These surrogates were used to minimise council expenditure on calculating effective imperviousness as defined under the abovementioned Melbourne research. Stronger correlations from the BIOENV routine may have been achieved if effective imperviousness had been calculated and was available for input into the BIOENV analysis. Expenditure on calculation of effective imperviousness is not considered warranted given results obtained from the surrogates. Therefore, the Melbourne work provides a solid basis for council decision-making under the Biological and Chemical Water Quality Monitoring Strategy.

The impaired macroinvertebrate communities described for Archers, Shrimptons, Buffalo, Porters and Terrys creeks appear to be due to stormwater connectivity with regular delivery of pollutants and altered geomorphic conditions due to this connectivity. Further data collection may strengthen the extrinsic variable trend defined by the BIOENV routine and assist in clarifying the broad driver of stream health being investigated in the Biological and Chemical Water Quality Monitoring Strategy.

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. If further historical data becomes available then these will be added into future reports. Analysis of all data in future reports after Spring 2006 has also incorporated 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 will continue in subsequent reports to provide a better understanding of variation between Autumn and Spring seasons and between different climatic conditions, which 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 Spring 2006 report to sample all creeks in each sample session have been implemented and allow capture of 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.

- 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 currently 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 2009 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.

- 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.

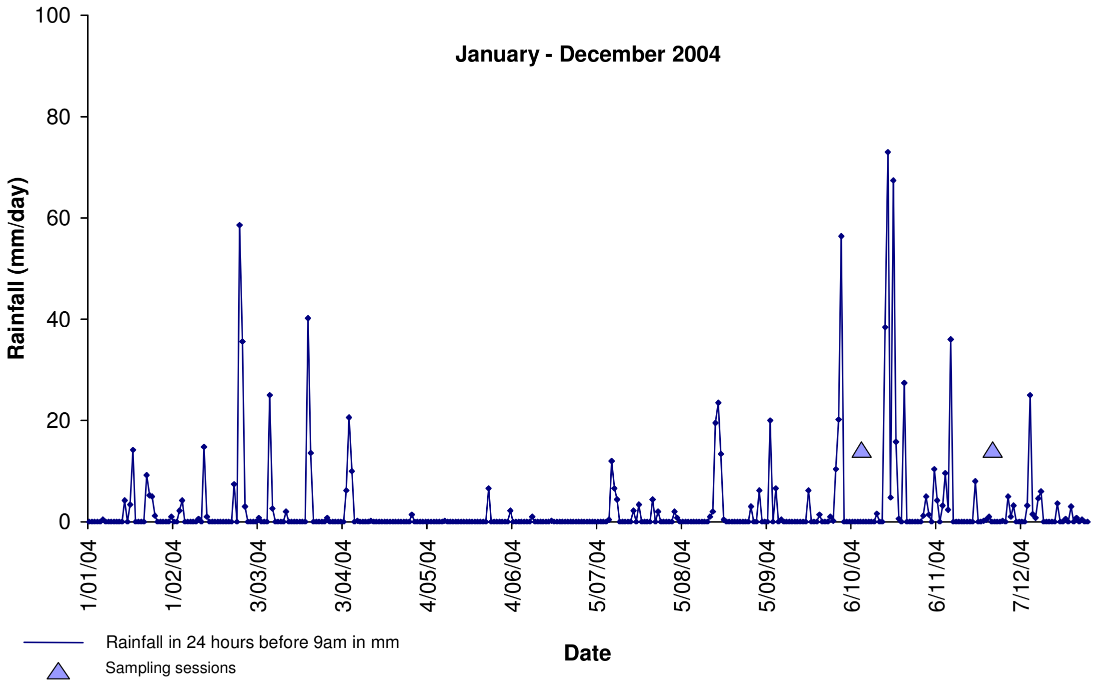
Appendix 2 Water Quality Results

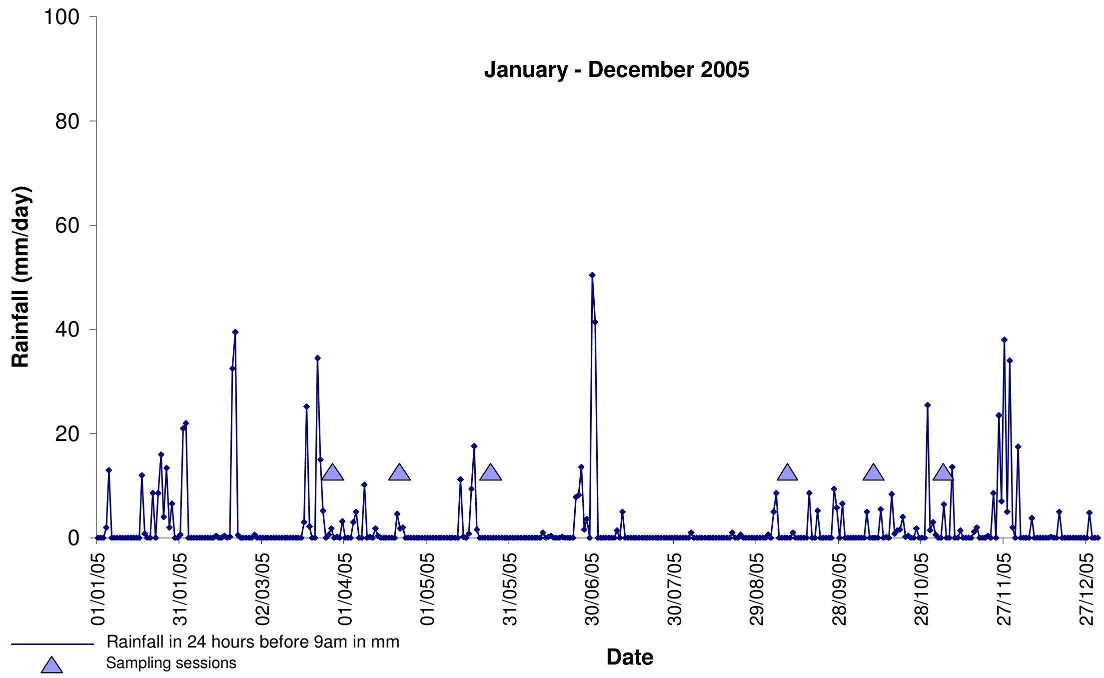
Stream	Site code	Season	Sample date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temperature ^{o}C
Terrys Ck	Site 1	spring 2009	02/11/09	320	190	200	70	540	740	57.8	40.10	329	187	7.6	6.5	13.0
Shrimptons Ck	Site 2	spring 2009	02/11/09	490	<10	<10	243	1290	1290	69.6	8.74	381	219	7.5	3.7	15.2
Porters Ck	Site 3	spring 2009	02/11/09	280	810	1510	16	1050	2560	73.2	3.67	388	219	8.2	9.6	17.3
Buffalo Ck	Site 4	spring 2009	02/11/09	~160	20	60	53	370	430	84.2	4.29	880	486	8.0	7.9	17.3
Archers Ck	Site 5	spring 2009	02/11/09	500	100	20	39	380	400	57.2	3.11	280	161	6.9	3.4	13.5
Terrys Ck	Site 1	spring 2009	30/09/09	39	20	170	31	260	430	61.9	4.00	482	263	7.2	6.2	18.0
Shrimptons Ck	Site 2	spring 2009	30/09/09	280	50	280	48	400	680	74.3	4.56	462	275	7.2	5.6	19.6
Porters Ck	Site 3	spring 2009	30/09/09	6700	810	1200	39	1180	2380	92.2	8.59	442	199	7.8	8.4	19.6
Buffalo Ck	Site 4	spring 2009	30/09/09	570	70	290	37	430	720	87.7	4.69	758	424	7.4	7.5	22.2
Archers Ck	Site 5	spring 2009	30/09/09	640	40	390	34	340	730	53.6	2.85	327	187	7.5	9.3	25.0
Terrys Ck	Site 1	autumn 2009	19/03/09	67	10	260	25	350	610	72.0	2.89	525	282	7.6	7.2	18.0
Shrimptons Ck	Site 2	autumn 2009	19/03/09	1200	<10	90	43	510	600	70.1	2.80	377	220	7.3	0.2	19.4
Porters Ck	Site 3	autumn 2009	19/03/09	3000	820	1290	27	1490	2780	106.0	2.91	487	266	7.8	8.3	20.4
Buffalo Ck	Site 4	autumn 2009	19/03/09	240	20	580	31	520	1100	89.0	7.02	886	490	7.3	4.7	17.8
Archers Ck	Site 5	autumn 2009	19/03/09	4800	1220	1380	171	1760	3140	78.5	2.16	517	278	7.4	5.8	17.8
Terrys Ck	Site 1	autumn 2009	1/5/2009	140	<10	180	20	240	420	64.8	2.10	518	300	7.6	7.9	12.5
Shrimptons Ck	Site 2	autumn 2009	1/5/2009	350	<10	140	34	340	480	81.5	2.06	481	289	7.5	7.4	14.5
Porters Ck	Site 3	autumn 2009	1/5/2009	~190	860	1350	21	1010	2360	86.3	3.97	449	268	7.8	9.4	16.0
Buffalo Ck	Site 4	autumn 2009	1/5/2009	92	<10	330	20	310	640	72.2	4.32	708	408	7.5	7.8	14.0
Archers Ck	Site 5	autumn 2009	1/5/2009	~1700	<10	860	31	270	1130	67.3	2.66	472	269	7.8	8.5	12.8
Terrys Ck	Site 1	spring 2008	16/9/08	~820	10	120	35	370	490	41.5	11.50	254	149	7.2	7.8	14.6
Shrimptons Ck	Site 2	spring 2008	16/9/08	240	20	250	54	440	690	51.0	8.85	278	155	7.1	3.8	16.1
Porters Ck	Site 3	spring 2008	16/9/08	260	4000	1660	24	4520	6180	130.0	5.46	611	336	7.7	9.6	14.7
Buffalo Ck	Site 4	spring 2008	16/9/08	820	10	450	42	400	850	79.5	10.80	524	293	7.3	7.2	14.9
Archers Ck	Site 5	spring 2008	16/9/08	270	10	670	19	350	1020	82.5	2.71	555	311	7.7	10.4	13.7
Terrys Ck	Site 1	spring 2008	13/10/08	~80	20	140	52	440	580	74.0	3.04	509	281	7.1	3.6	14.1
Shrimptons Ck	Site 2	spring 2008	13/10/08	420	120	30	197	900	930	67.0	3.92	301	171	7.1	0.0	16.8
Porters Ck	Site 3	spring 2008	13/10/08	48	980	1870	26	1410	3280	91.5	4.88	456	251	7.4	7.3	16.3
Buffalo Ck	Site 4	spring 2008	13/10/08	~84	130	90	41	540	630	96.5	13.20	1008	573	7.2	0.3	17.1
Archers Ck	Site 5	spring 2008	13/10/08	220	50	380	33	370	750	85.5	2.74	501	279	7.3	3.4	16.5
Terrys Ck	Site 1	autumn 2008	3/5/08	150	10	270	24	310	580	71.5	3.21	474	284	8.0	8.4	21.9
Shrimptons Ck	Site 2	autumn 2008	3/5/08	200	10	10	53	670	680	74.0	3.17	358	214	7.4	5.8	17.3
Porters Ck	Site 3	autumn 2008	3/5/08	530	250	430	38	1100	1530	81.0	15.20	650	444	7.6	6.7	19.3
Buffalo Ck	Site 4	autumn 2008	3/5/08	620	40	450	35	370	820	91.0	37.20	885	552	8.1	6.8	21.0
Archers Ck	Site 5	autumn 2008	3/5/08	170	30	370	20	290	660	77.5	2.18	513	310	7.3	6.5	19.8
Terrys Ck	Site 1	autumn 2008	4/3/08	250	10	120	25	200	320	64.0	3.10	351	160	7.3	8.3	15.7
Shrimptons Ck	Site 2	autumn 2008	4/3/08	700	10	10	92	620	620	73.0	6.17	291	130	7.2	3.8	16.8
Porters Ck	Site 3	autumn 2008	4/3/08	370	750	300	27	1100	4100	100.0	3.96	505	290	7.6	9.3	16.9
Buffalo Ck	Site 4	autumn 2008	4/3/08	120	50	220	33	260	480	77.0	4.69	654	389	7.3	8.0	15.8
Archers Ck	Site 5	autumn 2008	4/3/08	160	40	110	22	230	340	83.0	1.48	470	253	7.3	7.1	16.7

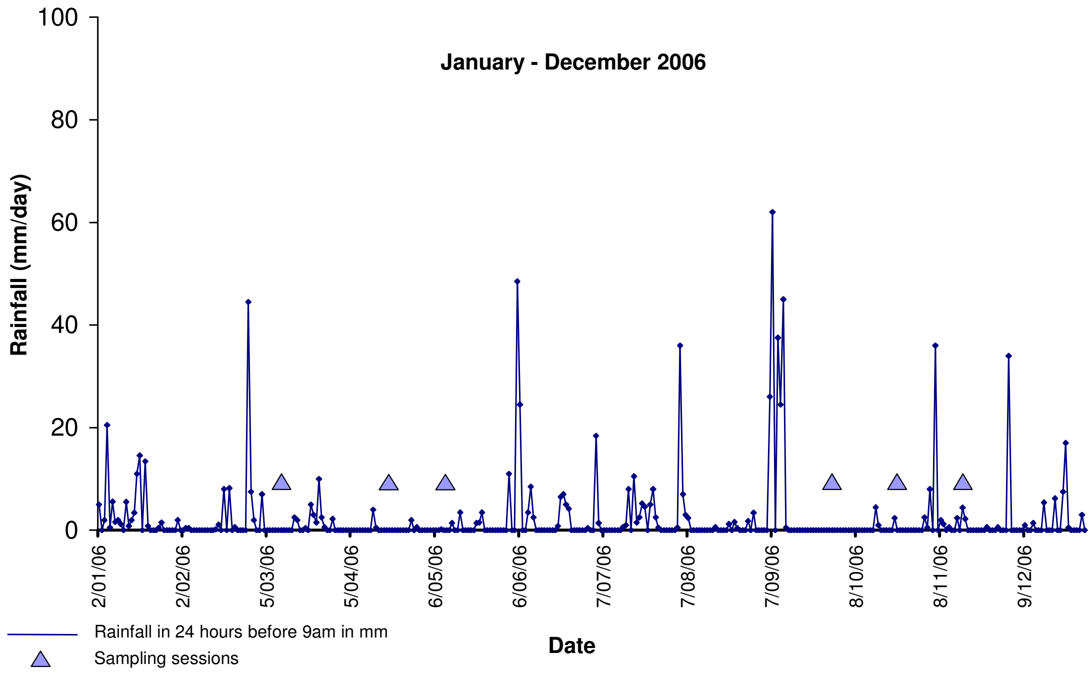
Stream	Site code	Season	Sample date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temperature ^{o}C
Terrys Ck	Site 1	spring 2007	27/09/07	87	20	190	21	290	480	67.0	2.00	503	276	7.3	6.00	14.0
Shrimptons Ck	Site 2	spring 2007	26/09/07	300	160	30	54	650	680	72.0	2.60	403	232	7.1	2.35	16.9
Porters Ck	Site 3	spring 2007	27/09/07	1000	2600	3200	60	3110	6310	122.0	6.70	671	372	7.8	6.50	15.0
Buffalo Ck	Site 4	spring 2007	27/09/07	54	40	170	37	440	610	90.0	7.30	960	484	7.3	5.70	19.0
Archers Ck	Site 5	spring 2007	26/09/07	270	20	480	26	680	1160	59.0	3.20	527	304	7.5	6.30	15.1
Terrys Ck	Site 1	spring 2007	23/10/07	6	40	80	35	730	810	88.0	1.60	712	437	7.0	4.00	15.6
Shrimptons Ck	Site 2	spring 2007	22/10/07	150	<10	<10	111	1000	1000	77.0	11.90	519	350	6.7	2.90	19.8
Porters Ck	Site 3	spring 2007	23/10/07	160	1020	2600	68	1580	4180	90.0	8.20	505	326	7.7	7.30	19.3
Buffalo Ck	Site 4	spring 2007	23/10/07	140	110	60	73	790	850	108.0	7.70	1001	621	7.2	6.95	20.4
Archers Ck	Site 5	spring 2007	22/10/07	90	150	50	57	480	530	74.0	7.10	378	220	6.7	3.90	17.3
Terrys Ck	Site 1	autumn 2007	14-15/03/07	300	<10	370	30	280	650	64.0	1.60	472	358	7.2	5.07	18.1
Shrimptons Ck	Site 2	autumn 2007	14-15/03/07	600	<10	550	58	330	880	64.0	2.87	362	276	7.1	3.2	20.6
Porters Ck	Site 3	autumn 2007	14-15/03/07	600	580	1310	51	1040	2350	97.0	1.27	3030	2010	7.9	8.42	19.3
Buffalo Ck	Site 4	autumn 2007	14-15/03/07	68	90	120	48	440	560	75.0	2.09	646	442	7.3	5.09	19.5
Archers Ck	Site 5	autumn 2007	14-15/03/07	290	<10	170	89	270	440	64.0	0.85	397	300	7.2	4.60	20.8
Terrys Ck	Site 1	autumn 2007	17-18/04/07	900	110	200	53	530	730	57.0	2.74	438	.	7.1	5.30	17.2
Shrimptons Ck	Site 2	autumn 2007	17-18/04/07	550	30	160	45	490	650	81.0	8.41	397	.	6.9	3.75	17.6
Porters Ck	Site 3	autumn 2007	17-18/04/07	10000	710	1590	20	1200	2790	98.0	3.18	3130	.	7.8	7.70	18.0
Buffalo Ck	Site 4	autumn 2007	17-18/04/07	740	130	120	48	540	660	81.0	8.60	912	.	6.7	3.83	17.2
Archers Ck	Site 5	autumn 2007	17-18/04/07	210	30	50	58	520	570	70.0	4.23	322	.	7.2	4.10	18.7
Shrimptons Ck	Site 2	spring 2006	28/09/06	69	130	140	64	580	720	94.0	7.80	717	420	7.1	4.3	17.3
Archers Ck	Site 5	spring 2006	28/09/06	160	<10	<10	104	520	520	83.0	2.03	509	293	7.4	6.5	15.4
Shrimptons Ck	Site 2	spring 2006	18/10/06	560	10	20	136	1180	1200	66.0	6.34	481	311	6.5	2.2	17.2
Archers Ck	Site 5	spring 2006	18/10/06	340	<10	10	90	500	510	70.0	2.32	448	295	6.9	3.9	18.3
Shrimptons Ck	Site 2	spring 2006	10/11/06	880	70	1200	68	800	2000	58.0	96.70	384	265	7.4	4.2	17.5
Archers Ck	Site 5	spring 2006	10/11/06	1700	20	40	50	360	400	84.0	1.78	502	310	7.2	7.2	18.6
Terrys Ck	Site 1	autumn 2006	9-10/03/06	160	<10	60	30	310	370	50	2.30	381	180	6.8	4.99	20.2
Shrimptons Ck	Site 2	autumn 2006	9-10/03/06	330	40	<10	50	380	390	85	4.60	435	230	6.7	2.13	21.1
Porters Ck	Site 3	autumn 2006	9-10/03/06	9800	820	760	20	1500	2300	48	1.90	3712	2200	7.4	7.41	25.2
Buffalo Ck	Site 4	autumn 2006	9-10/03/06	220	130	470	70	500	1000	90	8.00	738	390	7.2	4.36	22.1
Archers Ck	Site 5	autumn 2006	9-10/03/06	140	90	80	100	520	600	95	2.50	1482	830	7.0	4.09	20.6
Terrys Ck	Site 1	autumn 2006	19-20/04/06	560	450	90	100	1100	1200	45	3.20	306	180	7.0	2.40	15.7
Shrimptons Ck	Site 2	autumn 2006	19-20/04/06	860	30	30	80	480	510	40	5.0	281	160	6.7	4.61	16.8
Porters Ck	Site 3	autumn 2006	19-20/04/06	290	350	630	20	700	1300	45	2.3	3792	2100	7.6	8.30	19.8
Buffalo Ck	Site 4	autumn 2006	19-20/04/06	170	90	450	60	470	920	70	5.1	749	400	7.2	4.64	19.2
Archers Ck	Site 5	autumn 2006	19-20/04/06	240	90	470	70	390	860	45	4.1	259	150	7.1	4.38	18.4
Terrys Ck	Site 1	autumn 2006	9-10/05/06	66	70	240	50	380	620	60	2.40	358	220	7.1	3.98	11.9
Shrimptons Ck	Site 2	autumn 2006	9-10/05/06	750	20	40	80	340	380	35	7.70	264	140	6.8	5.04	13.1
Porters Ck	Site 3	autumn 2006	9-10/05/06	40	400	650	10	800	1400	1	1.20	2916	1700	7.3	8.33	15.3
Buffalo Ck	Site 4	autumn 2006	9-10/05/06	110	60	480	60	240	720	90	4.40	667	400	7.3	4.72	11.7
Archers Ck	Site 5	autumn 2006	9-10/05/06	28	50	370	40	300	670	55	5.10	245	120	7.2	6.31	12.4

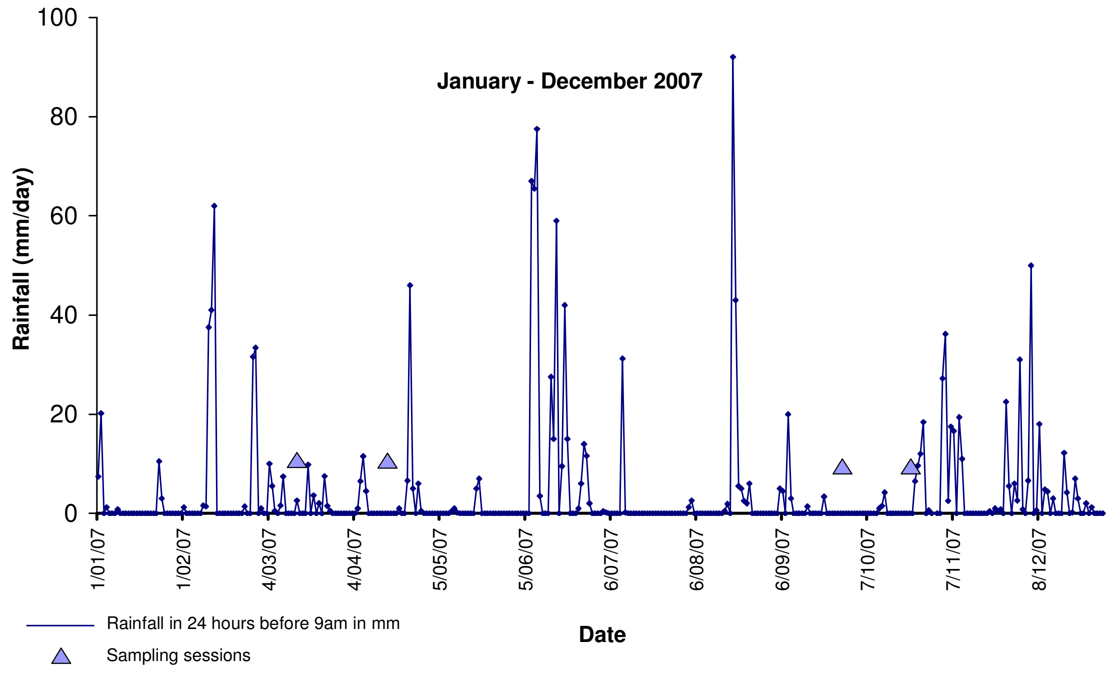
Stream	Site code	Season	Sample date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temperature ^{o}C
Terrys Ck	Site 1	spring 2005	6-7/09/05	300	59	48	10	900	140	43	6.5	187	140	6.7	8.10	11.1
Shrimptons Ck	Site 2	spring 2005	6-7/09/05	90	5	37	40	280	65	42	7	164	140	6.7	4.31	12.9
Porters Ck	Site 3	spring 2005	6-7/09/05	500	110	58	20	2400	300	37	3	6141	4000	7.0	8.72	12.8
Buffalo Ck	Site 4	spring 2005	6-7/09/05	16	10	50	80	270	77	79	5.5	620	380	7.0	6.19	13.2
Archers Ck	Site 5	spring 2005	6-7/09/05	2000	17	26	110	560	82	56	10	245	160	6.8	5.56	14.7
Terrys Ck	Site 1	spring 2005	11-12/10/05	2000	10	33	10	520	85	47	2.2	245	180	7.1	4.49	13.6
Shrimptons Ck	Site 2	spring 2005	11-12/10/05	32000	16	36	100	540	90	43	3.9	246	150	7.2	3.26	15.7
Porters Ck	Site 3	spring 2005	11-12/10/05	16000	54	51	50	1300	180	31	4.5	3965	2600	7.6	8.67	17.9
Buffalo Ck	Site 4	spring 2005	11-12/10/05	6500	26	63	200	700	130	44	29	472	210	7.6	9.16	16.1
Archers Ck	Site 5	spring 2005	11-12/10/05	3800	6	54	100	500	100	30	5.1	206	100	7.3	4.56	20.6
Terrys Ck	Site 1	spring 2005	2/11/05	380	<1	2	40	370	39	37	1	159	110	6.5	5.40	20.8
Shrimptons Ck	Site 2	spring 2005	2/11/05	500	6	19	60	450	64	50	6.1	226	150	6.6	5.24	22.2
Porters Ck	Site 3	spring 2005	2/11/05	260	83	42	<10	2100	250	30	6.4	5633	3500	7.1	7.89	23.4
Buffalo Ck	Site 4	spring 2005	2/11/05	2000	5	28	50	350	63	60	4.1	299	200	7.0	5.65	21.0
Archers Ck	Site 5	spring 2005	2/11/05	640	6	18	40	560	74	79	12.6	350	210	6.9	5.58	25.1
Terrys Ck	Site 1	autumn 2005	30-31/03/05	60000	590	170	100	800	970	40	42	315	130	7.2	8.44	16.9
Shrimptons Ck	Site 2	autumn 2005	30-31/03/05	3400	20	240	40	280	520	52	9	305	170	6.7	4.46	17.1
Porters Ck	Site 3	autumn 2005	30-31/03/05	1000	670	820	40	1100	1900	99	18.9	1719	1100	7.3	7.61	18.3
Buffalo Ck	Site 4	autumn 2005	30-31/03/05	36	130	290	30	370	660	59	17.4	241	140	7.6	8.37	17.8
Archers Ck	Site 5	autumn 2005	30-31/03/05	360	20	50	60	350	400	68	22.2	183	180	7.1	7.49	19.6
Terrys Ck	Site 1	autumn 2005	26-27/04/05	90	70	140	40	300	440	62	1.70	264	180	6.6	6.60	15.8
Shrimptons Ck	Site 2	autumn 2005	26-27/04/05	940	40	100	30	270	370	65	3.21	236	160	6.4	5.73	17.3
Porters Ck	Site 3	autumn 2005	26-27/04/05	220	400	590	20	1100	1700	35	3.64	2520	1800	7.2	8.77	18.3
Buffalo Ck	Site 4	autumn 2005	26-27/04/05	520	80	940	40	.	770	95	7.60	548	390	6.7	5.4	16.6
Archers Ck	Site 5	autumn 2005	26-27/04/05	300	40	20	10	240	260	78	1.40	261	160	6.8	5.80	17.4
Terrys Ck	Site 1	autumn 2005	26-27/05/05	130	40	110	30	260	370	61	1.80	325	180	7.3	8.34	10.8
Shrimptons Ck	Site 2	autumn 2005	26-27/05/05	400	40	290	30	.	560	65	4.94	333	180	7.2	5.65	11.9
Porters Ck	Site 3	autumn 2005	26-27/05/05	59	350	640	20	1100	1700	30	1.53	2305	1500	7.8	10.02	15.6
Buffalo Ck	Site 4	autumn 2005	26-27/05/05	170	90	350	40	300	650	92	7.14	641	360	7.5	7.39	12.6
Archers Ck	Site 5	autumn 2005	26-27/05/05	360	60	70	20	310	380	99	3.32	376	200	7.4	8.14	10.8
Terrys Ck	Site 1	spring 2004	14-15/09/04	80	.	.	110	.	.	50	2.4	.	150	6.8	5.08	10.6
Shrimptons Ck	Site 2	spring 2004	14-15/09/04	880	.	.	90	.	.	58	3.1	.	140	6.8	2.20	11.8
Archers Ck	Site 5	spring 2004	14-15/09/04	650	.	.	150	.	.	70	0.6	.	110	7.0	6.53	13.3
Terrys Ck	Site 1	spring 2004	11-12/10/04	44	.	.	30	.	.	64	0.3	.	310	7.6	5.01	16.1
Shrimptons Ck	Site 2	spring 2004	11-12/10/04	110	.	.	60	.	.	76	0.5	.	260	7.4	5.69	18.5
Archers Ck	Site 5	spring 2004	11-12/10/04	1500	.	.	50	.	.	82	0.8	.	230	7.5	4.27	18.6
Terrys Ck	Site 1	spring 2004	23-24/11/04	150	.	.	40	.	.	56	2.6	.	180	6.7	6.90	15.5
Shrimptons Ck	Site 2	spring 2004	23-24/11/04	1000	.	.	90	.	.	75	11.5	.	190	6.4	2.93	17.0
Archers Ck	Site 5	spring 2004	23-24/11/04	1700	.	.	40	.	.	84	4.7	.	270	6.6	8.02	17.2

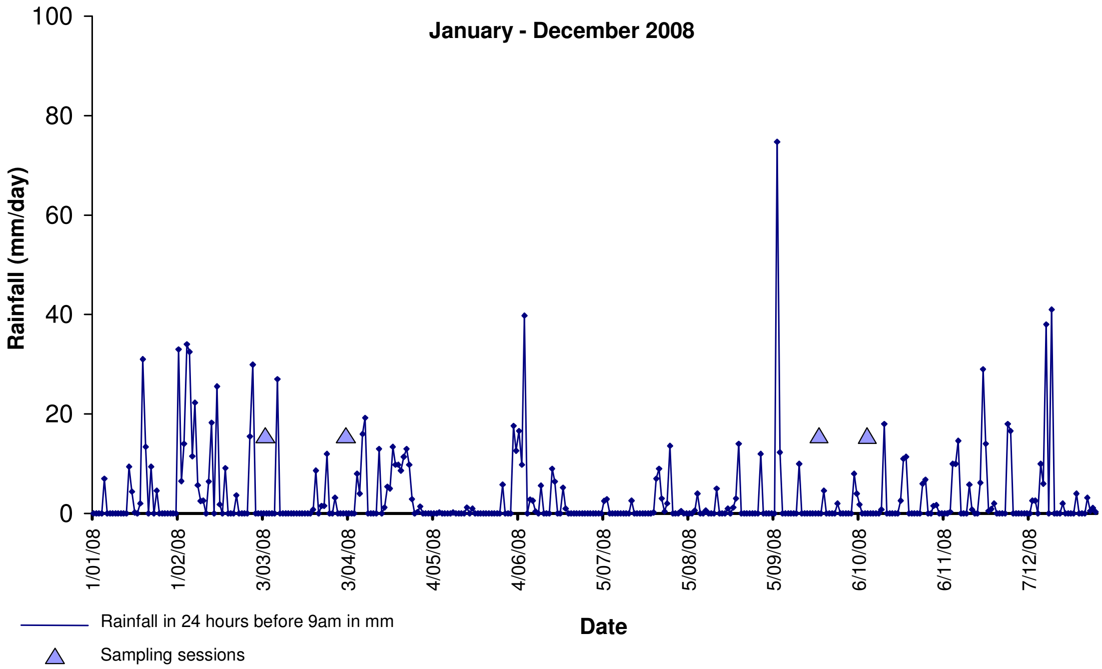
Appendix 3 Rainfall 2004 - 2009

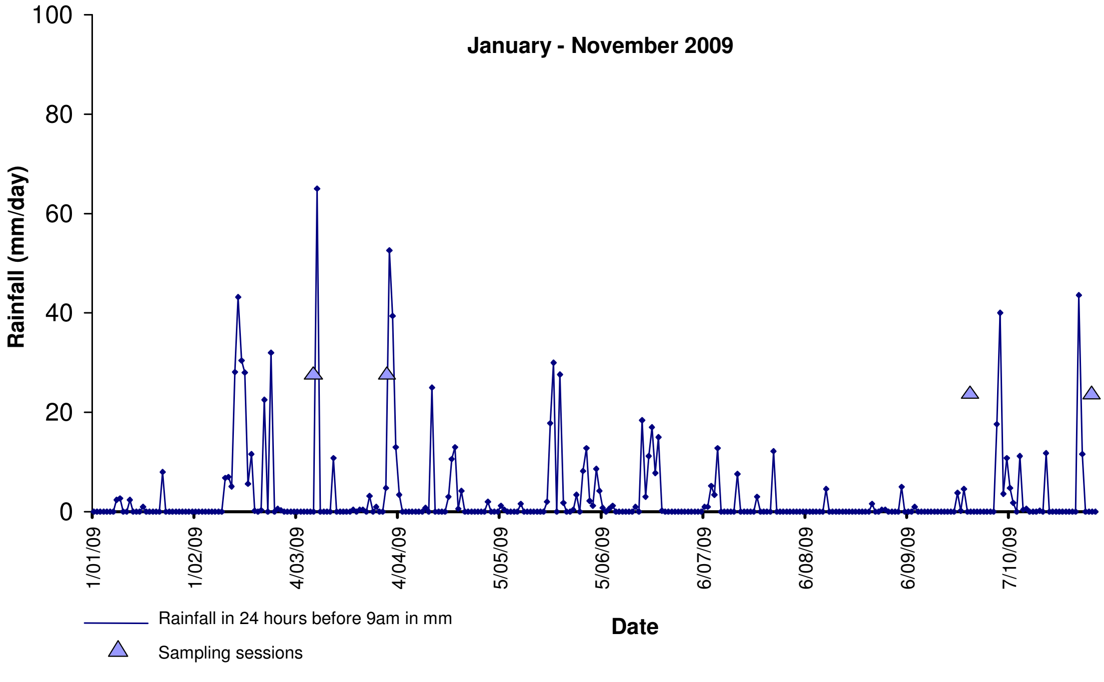





January - December 2006
Rainfall (mm/day)
100
80
60
40
20
0
2/01/06
2/02/06
5/03/06
5/04/06
6/05/06
6/06/06
7/07/06
7/08/06
7/09/06
8/10/06
8/11/06
9/12/06
Date
Rainfall in 24 hours before 9am in mm
Sampling sessions


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 - November 2009
Rainfall (mm/day)
100
80
60
40
20
0
1/01/09
1/02/09
4/03/09
4/04/09
5/05/09
5/06/09
6/07/09
6/08/09
6/09/09
7/10/09
Date
Rainfall in 24 hours before 9am in mm
Sampling sessions

Appendix 4 Macroinvertebrate results

		Spring 2004 Archers Ck S5	Spring 2004 Archers Ck S5	Spring 2004 Archers Ck S5	Autumn 2005 Archers Ck S5	Autumn 2005 Archers Ck S5	Autumn 2005 Archers Ck S5	Spring 2005 Archers Ck S5	Spring 2005 Archers Ck S5	Spring 2005 Archers Ck S5	Autumn 2006 Archers Ck S5	Autumn 2006 Archers Ck S5	Autumn 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Spring 2006 Archers Ck S5	Autumn 2007 Archers Ck S5	Autumn 2007 Archers Ck S5	Autumn 2007 Archers Ck S5	Autumn 2007 Archers Ck S5	Autumn 2007 Archers Ck S5	Autumn 2007 Archers Ck S5	Spring 2007 Archers Ck S5	Spring 2007 Archers Ck S5	Spring 2007 Archers Ck S5	Spring 2007 Archers Ck S5	Spring 2007 Archers Ck S5	Spring 2007 Archers Ck S5	Autumn 2008 Archers Ck S5	Autumn 2008 Archers Ck S5	Autumn 2008 Archers Ck S5	Autumn 2008 Archers Ck S5	Autumn 2008 Archers Ck S5	Autumn 2008 Archers Ck S5	Spring 2008 Archers Ck S5	Spring 2008 Archers Ck S5	Spring 2008 Archers Ck S5	Spring 2008 Archers Ck S5	Spring 2008 Archers Ck S5	Spring 2008 Archers Ck S5	Autumn 2009 Archers Ck S5	Autumn 2009 Archers Ck S5	Autumn 2009 Archers Ck S5	Autumn 2009 Archers Ck S5	Autumn 2009 Archers Ck S5	Autumn 2009 Archers Ck S5	Spring 2009 Archers Ck S5	Spring 2009 Archers Ck S5	Spring 2009 Archers Ck S5	Spring 2009 Archers Ck S5	Spring 2009 Archers Ck S5	Spring 2009 Archers Ck S5
Acarina	Acarina	1	3	1	3	3				1				1	3	1		4			1											3	9		1						1								1				1		2			3
Coleoptera	Dytiscidae		3		1	1		2		1																								1					1																			
Coleoptera	Elmidae																														2																											
Coleoptera	Hydraenidae													1						1																																						
Coleoptera	Hydrophilidae																				1																						1															
Coleoptera	Psephenidae																																																									
Coleoptera	Scirtidae																																		1																							
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
Trichoptera	Leptoceridae		1																																		1																					
Megaloptera	Corydalidae																																															1										
Odonata	Aeshnidae	1	1		2		14	5	5			11	8												3	2	3	1	1									1	2									2										
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		
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			
Odonata	Isostictidae																																																									
Odonata	Lestidae			3											1	1		2			3						3																		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		
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				
Odonata	Synthemistidae															1										1																																
Odonata	Telephlebiidae																																																									
Decapoda	Atyidae		1		6	11	17				5	1													11	1	1					2	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
Porifera	Spongillidae																																																									
Neuroptera	Osmylidae																																																									
Neuroptera	Sisyridae																																																		1							
Arhynchobdellida	Erpobdellidae																																																									
Arhynchobdellida	Hirudinidae																																																									
Rhynchobdellida	Glossiphoniidae		1	4		1					6	6	2							1	1		1	3	1	1	3											2	1	2	3	3	1		1	1							2	1				
Ephemeroptera	Baetidae			1																			3		2								2					6	7	6							3	8		1		3						
Lepidoptera	Pyralidae																													2										1							6	2	30									
Bivalvia	Corbiculidae		1	1			1		3	3																																																
Bivalvia	Sphaeriidae		3																	1									12		1	9	13	1							1														1			
Nemertea	Nemertea																																	1																								
Nematoda	Nematoda		1	1																										2																												
Amphipoda	Ceinidae							2																											1																							
Amphipoda	Talitridae																																																				1			3		
Isopoda	Scyphacidae							7		1	3			1	4			1																			1																1			1	2	

		Archers Ck Spring 2004 S5	Archers Ck Spring 2004 S5	Archers Ck Spring 2004 S5	Archers Ck Autumn 2005 S5	Archers Ck Autumn 2005 S5	Archers Ck Autumn 2005 S5	Archers Ck Spring 2005 S5	Archers Ck Spring 2005 S5	Archers Ck Spring 2005 S5	Archers Ck Autumn 2006 S5	Archers Ck Autumn 2006 S5	Archers Ck Autumn 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Spring 2006 S5	Archers Ck Autumn 2007 S5	Archers Ck Autumn 2007 S5	Archers Ck Autumn 2007 S5	Archers Ck Autumn 2007 S5	Archers Ck Autumn 2007 S5	Archers Ck Autumn 2007 S5	Archers Ck Spring 2007 S5	Archers Ck Spring 2007 S5	Archers Ck Spring 2007 S5	Archers Ck Spring 2007 S5	Archers Ck Spring 2007 S5	Archers Ck Spring 2007 S5	Archers Ck Autumn 2008 S5	Archers Ck Autumn 2008 S5	Archers Ck Autumn 2008 S5	Archers Ck Autumn 2008 S5	Archers Ck Autumn 2008 S5	Archers Ck Autumn 2008 S5	Archers Ck Spring 2008 S5	Archers Ck Spring 2008 S5	Archers Ck Spring 2008 S5	Archers Ck Spring 2008 S5	Archers Ck Spring 2008 S5	Archers Ck Spring 2008 S5	Archers Ck Autumn 2009 S5	Archers Ck Autumn 2009 S5	Archers Ck Autumn 2009 S5	Archers Ck Autumn 2009 S5	Archers Ck Autumn 2009 S5	Archers Ck Autumn 2009 S5	Archers Ck Spring 2009 S5	Archers Ck Spring 2009 S5	Archers Ck Spring 2009 S5	Archers Ck Spring 2009 S5	Archers Ck Spring 2009 S5	Archers Ck Spring 2009 S5
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
Gastropoda	Lymnaeidae							1				1									1		1												1										1			1			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
Gastropoda	Planorbidae																																																				1					
Plecoptera	Eustheniidae																																																									
Hemiptera	Belostomatidae																																																									
Hemiptera	Corixidae					1	10			1																							1	1													3	8	2									1
Hemiptera	Gelastocoridae													1				1																																								
Hemiptera	Gerridae									1	1		1																																													
Hemiptera	Hebridae																																																									
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
Hemiptera	Pleidae																																																									
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	
Diptera	Bibionidae																			2																																						
Diptera	Cecidomyiidae																																																									
Diptera	Ceratopogonidae																																		4		3	2	3			1					2	1	2		1	1			1	4		
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																					
Diptera	Psychodidae																			1											1						1																					
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
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		
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
Diptera	Simuliidae													1										1						2	1					1		3							2		4	2	4	1	4	1				5	8	
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	
Diptera	Syrphidae																				1																																					
Diptera	Tipulidae	1	1										1				2					2									2			2	1	2		1	1		2		2	1		1									2			
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
Decapoda	Parastacidae																																																									
Temnocephala	Temnocephalidae																																																									

		S2 Spring 2004 Shrimptons Ck	S2 Spring 2004 Shrimptons Ck	S2 Spring 2004 Shrimptons Ck	S2 Autumn 2005 Shrimptons Ck	S2 Autumn 2005 Shrimptons Ck	S2 Autumn 2005 Shrimptons Ck	S2 Spring 2005 Shrimptons Ck	S2 Spring 2005 Shrimptons Ck	S2 Spring 2005 Shrimptons Ck	S2 Autumn 2006 Shrimptons Ck	S2 Autumn 2006 Shrimptons Ck	S2 Autumn 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Spring 2006 Shrimptons Ck	S2 Autumn 2007 Shrimptons Ck	S2 Autumn 2007 Shrimptons Ck	S2 Autumn 2007 Shrimptons Ck	S2 Autumn 2007 Shrimptons Ck	S2 Autumn 2007 Shrimptons Ck	S2 Autumn 2007 Shrimptons Ck	S2 Spring 2007 Shrimptons Ck	S2 Spring 2007 Shrimptons Ck	S2 Spring 2007 Shrimptons Ck	S2 Spring 2007 Shrimptons Ck	S2 Spring 2007 Shrimptons Ck	S2 Spring 2007 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Autumn 2008 Shrimptons Ck	S2 Spring 2008 Shrimptons Ck	S2 Spring 2008 Shrimptons Ck	S2 Spring 2008 Shrimptons Ck	S2 Spring 2008 Shrimptons Ck	S2 Spring 2008 Shrimptons Ck	S2 Spring 2008 Shrimptons Ck	S2 Autumn 2009 Shrimptons Ck	S2 Autumn 2009 Shrimptons Ck	S2 Autumn 2009 Shrimptons Ck	S2 Autumn 2009 Shrimptons Ck	S2 Autumn 2009 Shrimptons Ck	S2 Autumn 2009 Shrimptons Ck	S2 Spring 2009 Shrimptons Ck	S2 Spring 2009 Shrimptons Ck	S2 Spring 2009 Shrimptons Ck	S2 Spring 2009 Shrimptons Ck	S2 Spring 2009 Shrimptons Ck	S2 Spring 2009 Shrimptons Ck
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	
Coleoptera	Dytiscidae																				1																																					
Coleoptera	Elmidae																																																							1		
Coleoptera	Hydraenidae																																																									
Coleoptera	Hydrophilidae																																						1					1														
Coleoptera	Psephenidae																																																									
Coleoptera	Scirtidae																																																									
Trichoptera	Antipodoecidae																																																									
Trichoptera	Hydroptilidae	2	3																										2	5	3												2	1	1													
Trichoptera	Leptoceridae			1																																																						
Megaloptera	Corydalidae																																																									
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
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
Odonata	Isostictidae														1								1	3	3	1	5	7	4	1	8	6	4	1								1		1				1	2					1	2		2	
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
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
Odonata	Synthemistidae																																																									
Odonata	Telephlebiidae																								1																																	
Decapoda	Atyidae																																																									
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
Porifera	Spongillidae																																																									
Neuroptera	Osmylidae																														1																											
Neuroptera	Sisyridae																																																		1							
Arhynchobdellida	Erpobdellidae						9																																																			
Arhynchobdellida	Hirudinidae																																																									
Rhynchobdellida	Glossiphoniidae				15	5	9	7	9	12	1	1										1	1												10	2	1			3		6	2	1		1							2	11	7	2	12	
Ephemeroptera	Baetidae																		1			1		1																							4	5	4	3	3							
Lepidoptera	Pyralidae																																																									
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								2	1	2			
Nemertea	Nemertea																																																1									
Nematoda	Nematoda	1																																																								
Amphipoda	Ceinidae																																																									
Amphipoda	Talitridae																																																									
Isopoda	Scyphacidae							2																1							1											1	1															

Order	Family	Spring 2004 Shrimptons Ck S2	Spring 2004 Shrimptons Ck S2	Spring 2004 Shrimptons Ck S2	Autumn 2005 Shrimptons Ck S2	Autumn 2005 Shrimptons Ck S2	Autumn 2005 Shrimptons Ck S2	Spring 2005 Shrimptons Ck S2	Spring 2005 Shrimptons Ck S2	Spring 2005 Shrimptons Ck S2	Autumn 2006 Shrimptons Ck S2	Autumn 2006 Shrimptons Ck S2	Autumn 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2	Spring 2006 Shrimptons Ck S2
Gastropoda	Ancylidae	1	1	1												1	1					
Gastropoda	Hydrobiidae		1							3					1		2					1
Gastropoda	Lymnaeidae							1			1				1						1	
Gastropoda	Physidae	6	7	10	17	17	12	14	20	15	5	11	11	13	16	8	13	10	10	13	9	14
Gastropoda	Planorbidae	2	3	10	11	2	6	4	11	11	2			3	1	6	1	2				
Plecoptera	Eustheniidae																					
Hemiptera	Belostomatidae																					
Hemiptera	Corixidae		3	2				2														
Hemiptera	Gelastocoridae						1	1	2											1		
Hemiptera	Gerridae																					
Hemiptera	Hebridae																					
Hemiptera	Mesoveliidae																					
Hemiptera	Naucoridae																					
Hemiptera	Nepidae																					
Hemiptera	Notonectidae															2	2	1	4	2	1	1
Hemiptera	Pleidae										1											
Hemiptera	Saldidae																					
Hemiptera	Veliidae																		1			
Diptera	Bibionidae																					
Diptera	Cecidomyiidae																					
Diptera	Ceratopogonidae	1												1								
Diptera	Culicidae														2					8		
Diptera	Dixidae																					
Diptera	Dolichopodidae																					
Diptera	Ephydridae																					
Diptera	Muscidae																					
Diptera	Psychodidae																					
Diptera	s-f Chironominae	12	11	10		1		5	10	15		2	3	21	25	21	20	32	18	18	26	12
Diptera	s-f Orthocladiinae					1									1							1
Diptera	s-f Tanypodinae														1		1			2		1
Diptera	Simuliidae																					
Diptera	Stratiomyidae		1		1		4	1							1	1			1			1
Diptera	Syrphidae																					
Diptera	Tipulidae																					
Oligochaeta	Oligochaeta	7	6	12	10	9	17	16	13	17	13	11	17	10	4	8	1	8	10	3	3	
Decapoda	Parastacidae										1			2								1
Temnocephala	Temnocephalidae																					

Order	Family	Autumn 2007 Shrimptons Ck S2	Autumn 2007 Shrimptons Ck S2	Autumn 2007 Shrimptons Ck S2	Autumn 2007 Shrimptons Ck S2	Autumn 2007 Shrimptons Ck S2	Autumn 2007 Shrimptons Ck S2	Spring 2007 Shrimptons Ck S2	Spring 2007 Shrimptons Ck S2	Spring 2007 Shrimptons Ck S2	Spring 2007 Shrimptons Ck S2	Spring 2007 Shrimptons Ck S2	Spring 2007 Shrimptons Ck S2	Autumn 2008 Shrimptons Ck S2	Autumn 2008 Shrimptons Ck S2	Autumn 2008 Shrimptons Ck S2	Autumn 2008 Shrimptons Ck S2	Autumn 2008 Shrimptons Ck S2	Autumn 2008 Shrimptons Ck S2
Gastropoda	Ancylidae		1		1			3	2	2	2	5							
Gastropoda	Hydrobiidae									1		1							
Gastropoda	Lymnaeidae					1			1	1	1		1			1			
Gastropoda	Physidae		1	15	16	8	4	17	17	29	17	9	4	14	8	4	8	6	13
Gastropoda	Planorbidae							2				3			1				
Plecoptera	Eustheniidae																		
Hemiptera	Belostomatidae																		
Hemiptera	Corixidae		1		1	1		1	4		5	2	1		1				
Hemiptera	Gelastocoridae																		
Hemiptera	Gerridae		1	1			1							1					
Hemiptera	Hebridae																		
Hemiptera	Mesoveliidae			1															
Hemiptera	Naucoridae																		
Hemiptera	Nepidae				1					1									
Hemiptera	Notonectidae	2	5	1		2		1			1	1	1	5		3			
Hemiptera	Pleidae																		
Hemiptera	Saldidae																		
Hemiptera	Veliidae		1	11	4							2							
Diptera	Bibionidae																		
Diptera	Cecidomyiidae																		
Diptera	Ceratopogonidae																1		
Diptera	Culicidae											1							
Diptera	Dixidae																		
Diptera	Dolichopodidae																		
Diptera	Ephydridae																		
Diptera	Muscidae											4							
Diptera	Psychodidae																		
Diptera	s-f Chironominae	8	4	5	17	2	26	30	27	50	7	12	11				1		
Diptera	s-f Orthocladiinae												1		1				1
Diptera	s-f Tanypodinae			1		1			1	1	2	5			1				
Diptera	Simuliidae																		
Diptera	Stratiomyidae										1								
Diptera	Syrphidae																		
Diptera	Tipulidae																		
Oligochaeta	Oligochaeta	7	5	4	1		6	12	2	5	5	5	3	3	5	2	4		3
Decapoda	Parastacidae			2	1	3				1					1				
Temnocephala	Temnocephalidae			1															

Order	Family	Spring 2008 Shrimptons Ck S2	Spring 2008 Shrimptons Ck S2	Spring 2008 Shrimptons Ck S2	Spring 2008 Shrimptons Ck S2	Spring 2008 Shrimptons Ck S2	Spring 2008 Shrimptons Ck S2	Autumn 2009 Shrimptons Ck S2	Autumn 2009 Shrimptons Ck S2	Autumn 2009 Shrimptons Ck S2	Autumn 2009 Shrimptons Ck S2	Autumn 2009 Shrimptons Ck S2	Autumn 2009 Shrimptons Ck S2	Spring 2009 Shrimptons Ck S2	Spring 2009 Shrimptons Ck S2	Spring 2009 Shrimptons Ck S2	Spring 2009 Shrimptons Ck S2	Spring 2009 Shrimptons Ck S2	Spring 2009 Shrimptons Ck S2
Gastropoda	Ancylidae																		
Gastropoda	Hydrobiidae		1	4					1						2		12	13	
Gastropoda	Lymnaeidae	1	1	1				1		3	2	1	2	2	2		7	1	3
Gastropoda	Physidae	17	10	8	10	14	14		4	2		8	6	24	6	9	17	20	7
Gastropoda	Planorbidae		1																
Plecoptera	Eustheniidae																		
Hemiptera	Belostomatidae																		
Hemiptera	Corixidae											1		1					1
Hemiptera	Gelastocoridae										1								
Hemiptera	Gerridae								1	1									
Hemiptera	Hebridae																		
Hemiptera	Mesoveliidae																		
Hemiptera	Naucoridae																		
Hemiptera	Nepidae																		
Hemiptera	Notonectidae	4			14	1		1	3	8	1	6			1			18	5
Hemiptera	Pleidae																		
Hemiptera	Saldidae																		
Hemiptera	Veliidae																		
Diptera	Bibionidae																		
Diptera	Cecidomyiidae																		
Diptera	Ceratopogonidae																		
Diptera	Culicidae																		
Diptera	Dixidae																		
Diptera	Dolichopodidae																		
Diptera	Ephydridae																		
Diptera	Muscidae																		
Diptera	Psychodidae																		
Diptera	s-f Chironominae	5	2	6	5	6	12	4		1	2		4	19	7	15	6	11	6
Diptera	s-f Orthocladiinae							1								1			2
Diptera	s-f Tanypodinae						1				2								2
Diptera	Simuliidae																		
Diptera	Stratiomyidae				1								1	1					
Diptera	Syrphidae																		
Diptera	Tipulidae																		
Oligochaeta	Oligochaeta	1	6	2	2	8	9	1			2				4	8	4	1	5
Decapoda	Parastacidae							1	1										
Temnocephala	Temnocephalidae																		

		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
Acarina	Acarina	1					1		1				1		1																					1				1						
Coleoptera	Dytiscidae				1	1	2							2	1								2	1	4																					
Coleoptera	Elmidae																																													
Coleoptera	Hydraenidae																																													
Coleoptera	Hydrophilidae													3											1																	1	1	2		
Coleoptera	Psephenidae							1																																						
Coleoptera	Scirtidae			1										1							1																									
Trichoptera	Antipodoecidae										1														1										2	1	2	2								
Trichoptera	Hydroptilidae										3	3	7	4	5	1			1			1										2	3			1	1	4			3		12			
Trichoptera	Leptoceridae	1		1				1	1			3	4		3	1																					1									
Megaloptera	Corydalidae																																													
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
Odonata	Gomphidae				1																																									
Odonata	Hemicorduliidae	9	8	8	11			5	5	13	10	6	2	9	3	6		2								2		2					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			
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							
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
Odonata	Synthemistidae																																													
Odonata	Telephlebiidae																																													
Decapoda	Atyidae	5				2		5	5	14	10	8	3	1	10	1									1											1										
Turbellaria	Dugesiidae	5	3		2						3	2	2					2			1		5	2	1			5				1	3	3			1		1							2
Porifera	Spongillidae																																													
Neuroptera	Osmylidae																																													
Neuroptera	Sisyridae																																							1						
Arhynchobdellida	Erpobdellidae				2	2	1						2																																	
Arhynchobdellida	Hirudinidae																										1																			
Rhynchobdellida	Glossiphoniidae	2	7	5	3	4	5	8	16	3	2	3		1		2											1	1																		
Ephemeroptera	Baetidae	1																																		1		1					1			
Lepidoptera	Pyralidae																																				1									
Bivalvia	Corbiculidae		4	2																																										
Bivalvia	Sphaeriidae														1													1			3	1														
Nemertea	Nemertea											1																							3						1	3		12		
Nematoda	Nematoda																														2															
Amphipoda	Ceinidae				3	1																																								
Amphipoda	Talitridae									1																	1																			
Isopoda	Scyphacidae				1																4													1												

		Autumn 2005 Porters Ck S3	Autumn 2005 Porters Ck S3	Autumn 2005 Porters Ck S3	Spring 2005 Porters Ck S3	Spring 2005 Porters Ck S3	Spring 2005 Porters Ck S3	Autumn 2006 Porters Ck S3	Autumn 2006 Porters Ck S3	Autumn 2006 Porters Ck S3	Autumn 2007 Porters Ck S3	Autumn 2007 Porters Ck S3	Autumn 2007 Porters Ck S3	Autumn 2007 Porters Ck S3	Autumn 2007 Porters Ck S3	Autumn 2007 Porters Ck S3	Spring 2007 Porters Ck S3	Spring 2007 Porters Ck S3	Spring 2007 Porters Ck S3	Spring 2007 Porters Ck S3	Spring 2007 Porters Ck S3	Spring 2007 Porters Ck S3	Autumn 2008 Porters Ck S3	Autumn 2008 Porters Ck S3	Autumn 2008 Porters Ck S3	Autumn 2008 Porters Ck S3	Autumn 2008 Porters Ck S3	Autumn 2008 Porters Ck S3	Spring 2008 Porters Ck S3	Spring 2008 Porters Ck S3	Spring 2008 Porters Ck S3	Spring 2008 Porters Ck S3	Spring 2008 Porters Ck S3	Spring 2008 Porters Ck S3	Autumn 2009 Porters Ck S3	Autumn 2009 Porters Ck S3	Autumn 2009 Porters Ck S3	Autumn 2009 Porters Ck S3	Autumn 2009 Porters Ck S3	Autumn 2009 Porters Ck S3	Spring 2009 Porters Ck S3	Spring 2009 Porters Ck S3	Spring 2009 Porters Ck S3	Spring 2009 Porters Ck S3	Spring 2009 Porters Ck S3	Spring 2009 Porters Ck S3
Gastropoda	Ancylidae	1										1			1				3	1		7		1			1						3	2		1								3	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
Gastropoda	Lymnaeidae																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
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	
Plecoptera	Eustheniidae							1																																						
Hemiptera	Belostomatidae																																													
Hemiptera	Corixidae				1	2	9																		1	1							1													
Hemiptera	Gelastocoridae																																											1		
Hemiptera	Gerridae								1						1																		1													
Hemiptera	Hebridae																																													
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
Hemiptera	Pleidae																																													
Hemiptera	Saldidae																																													
Hemiptera	Veliidae		3							2																				1																
Diptera	Bibionidae																																													
Diptera	Cecidomyiidae																										1																			
Diptera	Ceratopogonidae																																													
Diptera	Culicidae				1						1			2											1		1																			
Diptera	Dixidae																																													
Diptera	Dolichopodidae																																													
Diptera	Ephydridae																																													
Diptera	Muscidae																																										1			
Diptera	Psychodidae													1										1			1																1			
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
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	
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		
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			
Diptera	Syrphidae																																													
Diptera	Tipulidae																1	1			1		1		1										1								1		1	
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		
Decapoda	Parastacidae																																													
Temnocephala	Temnocephalidae																																													

		Autumn 2005 Buffalo Ck S4	Autumn 2005 Buffalo Ck S4	Autumn 2005 Buffalo Ck S4	Spring 2005 Buffalo Ck S4	Spring 2005 Buffalo Ck S4	Spring 2005 Buffalo Ck S4	Autumn 2006 Buffalo Ck S4	Autumn 2006 Buffalo Ck S4	Autumn 2006 Buffalo Ck S4	Autumn 2007 Buffalo Ck S4	Autumn 2007 Buffalo Ck S4	Autumn 2007 Buffalo Ck S4	Autumn 2007 Buffalo Ck S4	Autumn 2007 Buffalo Ck S4	Autumn 2007 Buffalo Ck S4	Spring 2007 Buffalo Ck S4	Spring 2007 Buffalo Ck S4	Spring 2007 Buffalo Ck S4	Spring 2007 Buffalo Ck S4	Spring 2007 Buffalo Ck S4	Spring 2007 Buffalo Ck S4	Autumn 2008 Buffalo Ck S4	Autumn 2008 Buffalo Ck S4	Autumn 2008 Buffalo Ck S4	Autumn 2008 Buffalo Ck S4	Autumn 2008 Buffalo Ck S4	Autumn 2008 Buffalo Ck S4	Spring 2008 Buffalo Ck S4	Spring 2008 Buffalo Ck S4	Spring 2008 Buffalo Ck S4	Spring 2008 Buffalo Ck S4	Spring 2008 Buffalo Ck S4	Spring 2008 Buffalo Ck S4	Autumn 2009 Buffalo Ck S4	Autumn 2009 Buffalo Ck S4	Autumn 2009 Buffalo Ck S4	Autumn 2009 Buffalo Ck S4	Autumn 2009 Buffalo Ck S4	Autumn 2009 Buffalo Ck S4	Spring 2009 Buffalo Ck S4	Spring 2009 Buffalo Ck S4	Spring 2009 Buffalo Ck S4	Spring 2009 Buffalo Ck S4	Spring 2009 Buffalo Ck S4	Spring 2009 Buffalo Ck S4
Acarina	Acarina	2	2	1	6	1	1											1					1																							
Coleoptera	Dytiscidae					2																																										
Coleoptera	Elmidae																																															
Coleoptera	Hydraenidae																																1															
Coleoptera	Hydrophilidae	1		1					1										1					1																		2						
Coleoptera	Psephenidae																																															
Coleoptera	Scirtidae		1																																													
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			
Trichoptera	Leptoceridae										1																																					
Megaloptera	Corydalidae																																															
Odonata	Aeshnidae	3	1	1			1	3	6	3		2	6	5	4	3							2	3	1	2																						
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				
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							
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				
Odonata	Lestidae																																															
Odonata	Libellulidae		5	2	2	1	13	13	10	4	2		7	3	7		2							2		1		1									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
Odonata	Synthemistidae		1																																													
Odonata	Telephlebiidae											1																																				
Decapoda	Atyidae																																															
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
Porifera	Spongillidae																																															
Neuroptera	Osmylidae																																															
Neuroptera	Sisyridae																																							1							
Arhynchobdellida	Erpobdellidae			1																																												
Arhynchobdellida	Hirudinidae																																											1			
Rhynchobdellida	Glossiphoniidae	2	1	2				4	9		1			2																																		
Ephemeroptera	Baetidae								4		14	8	13												1										1		1			1							
Lepidoptera	Pyralidae																																															
Bivalvia	Corbiculidae	3	8	7	5	1	11	4	6	7																														1							
Bivalvia	Sphaeriidae										1		1		3	9				1		2						1				9	1								5	8	4	1	2	2
Nemertea	Nemertea																																				2		2	3							
Nematoda	Nematoda													1																																		
Amphipoda	Ceinidae		1	2	2	8																																										
Amphipoda	Talitridae								1																																							
Isopoda	Scyphacidae				3	4	2	1																1								1													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
Gastropoda	Ancylidae																					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
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
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
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
Plecoptera	Eustheniidae																																													
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						
Hemiptera	Hebridae																							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
Hemiptera	Pleidae																					1																								
Hemiptera	Saldidae																																													
Hemiptera	Veliidae												1					1			1			2	2	1						1												1		
Diptera	Bibionidae																																													
Diptera	Cecidomyiidae																																													
Diptera	Ceratopogonidae			1						2	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	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
Diptera	s-f Orthocladiinae	2						2	4	2	2			1										4	5	15	4	18							2	2	2	5	3	1						2
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
Diptera	Simuliidae					1																																								
Diptera	Stratiomyidae	2	1	3	1			1	1	5	3		1	2	1	1			1						1	1	2									1			2	1						
Diptera	Syrphidae	1																																												
Diptera	Tipulidae	1																																										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
Decapoda	Parastacidae																																													
Temnocephala	Temnocephalidae																																													

		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
Acarina	Acarina				2		1	1	7	4	2	3	2	1	2		2		1			2		5													2		2	1	1			1					
Coleoptera	Dytiscidae								1																					1																			
Coleoptera	Elmidae	1		3	6	1				3	4	1			4				2			1		1		2		1								1				1			2					1	1
Coleoptera	Hydraenidae																1									1																							
Coleoptera	Hydrophilidae																																	1														1	
Coleoptera	Psephenidae																																																
Coleoptera	Scirtidae	1					1										1		1																														
Trichoptera	Antipodoecidae																																																
Trichoptera	Hydroptilidae		1								1			1										4												1		1				2		1		1			
Trichoptera	Leptoceridae																																																
Megaloptera	Corydalidae										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		
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					
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
Odonata	Lestidae							6																																									
Odonata	Libellulidae								14	13	2	1	4	1		2		2	4					1	1	1		1											1	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
Odonata	Synthemistidae																												1																				
Odonata	Telephlebiidae																												1																				
Decapoda	Atyidae			1																																													
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
Porifera	Spongillidae																																			1													
Neuroptera	Osmylidae																																															1	
Neuroptera	Sisyridae																																								1							1	
Arhynchobdellida	Erpobdellidae																																						1										
Arhynchobdellida	Hirudinidae														1																																		
Rhynchobdellida	Glossiphoniidae				3	2	1		1	1	2	2		1	1			1											1		1	1												1	1				
Ephemeroptera	Baetidae														1	1																						2			1		3						
Lepidoptera	Pyralidae																			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							1	10	2	7		
Nemertea	Nemertea															1																						8		2									
Nematoda	Nematoda																																																
Amphipoda	Ceinidae				3		1	1	3																																								
Amphipoda	Talitridae											1	2		1				1					1					1	1		1					1												
Isopoda	Scyphacidae							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
		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
		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
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
Gastropoda	Lymnaeidae	1						5	3		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
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			
Plecoptera	Eustheniidae																																																
Hemiptera	Belostomatidae	1																																															
Hemiptera	Corixidae									5																																							
Hemiptera	Gelastocoridae						1							1							1															1	1	2	1					1					
Hemiptera	Gerridae		1				2		1	2	3	3	3				4	2										1			1								1	1	2	1		1					
Hemiptera	Hebridae																																																
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
Hemiptera	Pleidae																																																
Hemiptera	Saldidae																																																
Hemiptera	Veliidae						3			1	4	1			1	2				1			5							2	1			1	3			1		7			1	1			1		
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	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
Diptera	s-f Orthocladiinae	2		2	2		1					1		7	5	2			2	1				2		1		1								2		3	3				1				1	1	2
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
Diptera	Simuliidae							1		1					3		3			1		1																		1		2	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			
Diptera	Syrphidae																																																
Diptera	Tipulidae				4																		1	1				1															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
Decapoda	Parastacidae																																																
Temnocephala	Temnocephalidae																																																

Appendix 5 SIMPER output

SIMPER all five creeks reps merged 2005 – 2009

Data worksheet
Name: All five creeks 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: 61.95

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	11.42	10.93	3.61	17.64	17.64
Worms Oligochaeta	6.50	6.70	5.42	10.82	28.46
Snails Physidae	6.07	5.26	3.13	8.49	36.95
Flatworms Dugesiidae	5.64	4.73	2.30	7.63	44.58
Dragonfly larvae Libellulidae	4.00	3.31	2.28	5.34	49.92
True Fly larvae s-f Tanypodinae	3.31	2.95	3.06	4.76	54.68
Dragonfly larvae Hemicorduliidae	3.37	2.70	1.41	4.37	59.04
Dragonfly larvae Coenagrionidae	3.24	2.55	1.71	4.11	63.15
Snails Hydrobiidae	4.22	2.50	0.85	4.04	67.19
Dragonfly larvae Megapodagrionidae	2.86	2.33	2.19	3.76	70.95
True Fly larvae Stratiomyidae	2.37	2.12	3.39	3.42	74.37
True bugs Veliidae	2.70	2.08	2.01	3.36	77.72
True bugs Notonectidae	3.03	2.00	1.09	3.22	80.95
True Fly larvae s-f Orthocladiinae	3.74	1.83	0.93	2.96	83.90
Leeches Glossiphoniidae	2.00	1.31	1.04	2.12	86.03
Caddisfly larvae Hydroptilidae	3.12	1.28	0.58	2.06	88.09
Dragonfly larvae Aeshnidae	1.87	1.08	0.72	1.74	89.83
True Fly larvae Culicidae	2.08	0.95	0.63	1.53	91.36

Group Buffalo Ck
Average similarity: 64.21

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	9.91	10.79	4.98	16.80	16.80
Snails Physidae	7.08	7.25	2.74	11.30	28.10
Snails Hydrobiidae	6.20	6.41	2.16	9.98	38.08
Dragonfly larvae Megapodagrionidae	5.34	5.72	6.22	8.91	46.99
True bugs Notonectidae	4.97	4.34	2.75	6.76	53.75
Worms Oligochaeta	4.19	3.84	2.30	5.98	59.72
Flatworms Dugesiidae	3.48	3.40	4.61	5.29	65.02
Snails Planorbidae	2.95	2.52	1.42	3.93	68.95
True Fly larvae s-f Tanypodinae	2.47	2.06	1.62	3.21	72.16
Dragonfly larvae Coenagrionidae	2.91	1.96	1.03	3.06	75.21
Dragonfly larvae Isostictidae	2.33	1.94	2.94	3.02	78.23
Caddisfly larvae Hydroptilidae	2.98	1.87	0.97	2.91	81.15
Dragonfly larvae Hemicorduliidae	2.91	1.77	1.04	2.76	83.90
Snails Lymnaeidae	1.91	1.41	1.10	2.19	86.09
Dragonfly larvae Libellulidae	2.29	1.31	0.92	2.04	88.13
Mussels Sphaeriidae	1.89	1.05	0.70	1.64	89.78
True Fly larvae Stratiomyidae	1.55	1.03	1.03	1.60	91.37

Group Porters Ck

Average similarity: 63.44

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Snails Hydrobiidae	8.37	9.57	8.68	15.09	15.09
True Fly larvae s-f Chironominae	9.57	9.55	3.16	15.05	30.13
Dragonfly larvae Megapodagrionidae	4.87	4.99	3.36	7.87	38.00
Snails Physidae	4.90	4.77	2.70	7.51	45.51
Worms Oligochaeta	4.49	4.76	4.36	7.50	53.01
Dragonfly larvae Isostictidae	4.19	3.57	2.22	5.63	58.65
Dragonfly larvae Coenagrionidae	3.72	3.25	2.41	5.12	63.77
True bugs Notonectidae	3.59	3.17	1.96	5.00	68.77
Snails Planorbidae	2.53	2.46	3.15	3.89	72.66
True Fly larvae s-f Tanypodinae	3.03	2.42	1.36	3.82	76.47
True Fly larvae s-f Orthocladiinae	2.93	1.87	0.92	2.95	79.42
Flatworms Dugesiidae	1.97	1.69	1.62	2.66	82.08
True Fly larvae Stratiomyidae	1.79	1.53	1.59	2.41	84.49
Dragonfly larvae Hemicorduliidae	2.61	1.49	0.90	2.35	86.84
Dragonfly larvae Libellulidae	2.24	1.40	1.04	2.21	89.05
Leeches Glossiphoniidae	2.12	1.26	0.94	1.99	91.04

Group Shrimptons Ck

Average similarity: 59.37

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Snails Physidae	7.50	10.09	5.33	16.99	16.99
Flatworms Dugesiidae	6.47	9.25	4.16	15.58	32.57
Worms Oligochaeta	5.23	7.03	2.53	11.85	44.42
True Fly larvae s-f Chironominae	6.05	5.05	1.54	8.51	52.93
Dragonfly larvae Coenagrionidae	3.28	3.75	3.13	6.31	59.24
Aquatic mites Acarina	3.08	3.53	2.21	5.95	65.19
Leeches Glossiphoniidae	3.14	3.26	1.07	5.49	70.68
Dragonfly larvae Hemicorduliidae	2.74	2.52	1.39	4.24	74.92
True bugs Notonectidae	2.52	2.02	0.85	3.40	78.32
Snails Lymnaeidae	1.60	1.50	1.59	2.52	80.84
Dragonfly larvae Libellulidae	1.42	1.48	1.11	2.49	83.34
Dragonfly larvae Megapodagrionidae	2.23	1.42	0.80	2.39	85.73
Snails Planorbidae	1.87	1.29	0.70	2.18	87.91
True Fly larvae s-f Tanypodinae	1.15	0.81	0.90	1.37	89.27
True Fly larvae Stratiomyidae	0.92	0.75	0.87	1.26	90.54

Group Terrys Ck

Average similarity: 71.50

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dragonfly larvae Megapodagrionidae	7.79	8.36	5.42	11.69	11.69
Snails Hydrobiidae	8.02	8.20	3.86	11.47	23.17
True Fly larvae s-f Chironominae	7.03	6.10	2.52	8.53	31.69
Snails Physidae	5.63	5.70	6.13	7.97	39.67
Worms Oligochaeta	5.09	5.29	8.03	7.39	47.06
Flatworms Dugesiidae	4.71	4.63	4.66	6.48	53.54
True Fly larvae s-f Tanypodinae	4.35	4.25	4.82	5.94	59.48
Dragonfly larvae Isostictidae	3.66	3.74	5.49	5.23	64.71
Dragonfly larvae Hemicorduliidae	3.63	2.59	1.59	3.63	68.34
True bugs Notonectidae	3.36	2.46	1.24	3.44	71.77
True bugs Veliidae	1.92	1.84	3.79	2.57	74.35
Beetles Elmidae	1.82	1.74	4.51	2.43	76.78
Snails Planorbidae	1.99	1.64	1.66	2.30	79.08
Dragonfly larvae Coenagrionidae	2.12	1.55	1.38	2.16	81.24
True Fly larvae Stratiomyidae	1.65	1.53	3.16	2.13	83.37
Aquatic mites Acarina	1.93	1.48	1.56	2.07	85.44
Mussels Sphaeriidae	2.29	1.42	0.80	1.98	87.42
True Fly larvae s-f Orthocladiinae	1.77	1.34	1.65	1.87	89.30
Leeches Glossiphoniidae	**1.54**	**1.29**	**1.66**	**1.80**	**91.10**

Groups Archers Ck & Buffalo Ck
Average dissimilarity = 42.73

Species	Archers Ck Av.Abund	Buffalo Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Snails Hydrobiidae	4.22	6.20	1.96	1.06	4.60	4.60
True Fly larvae s-f Orthocladiinae	3.74	2.00	1.92	1.14	4.50	9.10
True Fly larvae s-f Chironominae	11.42	9.91	1.91	1.37	4.48	13.57
Caddisfly larvae Hydroptilidae	3.12	2.98	1.84	1.38	4.31	17.88
Snails Planorbidae	0.10	2.95	1.70	1.96	3.98	21.86
Flatworms Dugesiidae	5.64	3.48	1.66	1.67	3.88	25.74
True bugs Notonectidae	3.03	4.97	1.65	1.45	3.85	29.60
Worms Oligochaeta	6.50	4.19	1.62	1.73	3.79	33.38
Dragonfly larvae Megapodagrionidae	2.86	5.34	1.58	2.00	3.70	37.09
Snails Physidae	6.07	7.08	1.55	1.28	3.63	40.72
Dragonfly larvae Libellulidae	4.00	2.29	1.50	1.27	3.52	44.24
Dragonfly larvae Hemicorduliidae	3.37	2.91	1.39	1.38	3.25	47.49
Dragonfly larvae Isostictidae	0.00	2.33	1.35	2.04	3.16	50.65
Dragonfly larvae Coenagrionidae	3.24	2.91	1.29	1.29	3.03	53.68
True bugs Veliidae	2.70	0.74	1.24	1.27	2.90	56.58
Mussels Sphaeriidae	0.90	1.89	1.19	1.19	2.80	59.37
True Fly larvae Culicidae	2.08	1.28	1.17	1.26	2.74	62.11
Dragonfly larvae Aeshnidae	1.87	1.56	1.11	1.22	2.60	64.71
Mayfly larvae Baetidae	1.42	0.99	1.03	0.87	2.42	67.13
Leeches Glossiphoniidae	2.00	1.03	1.02	1.31	2.39	69.52
Mussels Corbiculidae	0.34	1.39	0.90	0.84	2.10	71.61
True Fly larvae s-f Tanypodinae	3.31	2.47	0.88	1.21	2.05	73.67
Snails Lymnaeidae	0.77	1.91	0.87	1.68	2.02	75.69
Fairy shrimps Atyidae	1.36	0.00	0.86	0.68	2.00	77.69
True Fly larvae Simuliidae	1.48	0.11	0.81	1.10	1.89	79.58
Aquatic mites Acarina	1.55	0.78	0.80	1.27	1.88	81.47
True Fly larvae Stratiomyidae	2.37	1.55	0.74	1.21	1.73	83.19
Slatters Oniscidae	1.10	0.89	0.65	1.24	1.52	84.71
True Fly larvae Ceratopogonidae	0.93	0.60	0.62	1.08	1.45	86.16
True Fly larvae Tipulidae	1.11	0.22	0.62	1.19	1.44	87.60
True bugs Corixidae	1.03	0.33	0.61	0.85	1.43	89.03
Snails Ancylidae	0.70	0.33	0.46	0.79	1.07	90.10

Groups Archers Ck & Porters Ck
Average dissimilarity = 44.35

Species	Archers Ck av.Abund	Porters Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Snails Hydrobiidae	4.22	8.37	2.61	1.20	5.89	5.89
True Fly larvae s-f Chironominae	11.42	9.57	2.49	1.41	5.61	11.50
Dragonfly larvae Isostictidae	0.00	4.19	2.45	2.25	5.53	17.03
Flatworms Dugesiidae	5.64	1.97	2.24	1.74	5.04	22.07
True Fly larvae s-f Orthocladiinae	3.74	2.93	1.92	1.23	4.33	26.40
Caddisfly larvae Hydroptilidae	3.12	1.64	1.77	1.30	4.00	30.40
Dragonfly larvae Libellulidae	4.00	2.24	1.49	1.29	3.35	33.75
Snails Physidae	6.07	4.90	1.48	1.44	3.33	37.08
Snails Planorbidae	0.10	2.53	1.48	2.13	3.33	40.40
Dragonfly larvae Megapodagrionidae	2.86	4.87	1.43	1.65	3.23	43.63
Dragonfly larvae Hemicorduliidae	3.37	2.61	1.41	1.38	3.18	46.81
True bugs Veliidae	2.70	0.46	1.39	1.40	3.15	49.96
Worms Oligochaeta	6.50	4.49	1.33	1.69	3.00	52.96
True bugs Notonectidae	3.03	3.59	1.29	1.45	2.91	55.87
Fairy shrimps Atyidae	1.36	1.81	1.25	1.10	2.81	58.68
True Fly larvae Culicidae	2.08	0.46	1.19	1.09	2.69	61.37
Dragonfly larvae Coenagrionidae	3.24	3.72	1.18	1.39	2.67	64.03
Dragonfly larvae Aeshnidae	1.87	1.08	1.08	1.17	2.43	66.46
Leeches Glossiphoniidae	2.00	2.12	1.06	1.33	2.39	68.85
True Fly larvae s-f Tanypodinae	3.31	3.03	1.05	1.47	2.36	71.21
Mussels Sphaeriidae	0.90	1.08	0.85	0.90	1.92	73.13
Mayfly larvae Baetidae	1.42	0.22	0.84	0.75	1.90	75.03
True Fly larvae Simuliidae	1.48	0.11	0.82	1.10	1.84	76.87
Snails Ancylidae	0.70	1.38	0.79	1.23	1.78	78.66
Aquatic mites Acarina	1.55	0.65	0.73	1.22	1.65	80.31
True bugs Corixidae	1.03	0.65	0.73	0.93	1.64	81.94
True Fly larvae Stratiomyidae	2.37	1.79	0.67	1.36	1.52	83.46
Slatters Oniscidae	1.10	0.56	0.63	1.17	1.43	84.89
True Fly larvae Tipulidae	1.11	0.62	0.61	1.29	1.37	86.26
True Fly larvae Ceratopogonidae	0.93	0.00	0.54	0.72	1.21	87.47
Beetles Dytiscidae	0.51	0.71	0.53	1.00	1.19	88.66
Snails Lymnaeidae	0.77	0.47	0.45	1.46	1.01	89.67
Caddisfly larvae Leptoceridae	0.10	0.79	0.45	0.83	1.00	90.68

Groups Buffalo Ck & Porters Ck

Average dissimilarity = 37.73

Species	Buffalo Ck Av.Abund	Porters Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	9.91	9.57	1.96	1.19	5.20	5.20
Snails Physidae	7.08	4.90	1.85	1.37	4.90	10.10
True Fly larvae s-f Orthocladiinae	2.00	2.93	1.63	1.30	4.31	14.41
Caddisfly larvae Hydroptilidae	2.98	1.64	1.54	1.38	4.09	18.49
Dragonfly larvae Hemicorduliidae	2.91	2.61	1.53	1.42	4.05	22.55
True bugs Notonectidae	4.97	3.59	1.52	1.51	4.02	26.57
Dragonfly larvae Isostictidae	2.33	4.19	1.48	1.35	3.93	30.50
Snails Hydrobiidae	6.20	8.37	1.41	1.11	3.75	34.24
Dragonfly larvae Coenagrionidae	2.91	3.72	1.39	1.37	3.68	37.93
Dragonfly larvae Libellulidae	2.29	2.24	1.24	1.36	3.28	41.21
Leeches Glossiphoniidae	1.03	2.12	1.18	1.24	3.11	44.33
True Fly larvae s-f Tanypodinae	2.47	3.03	1.14	1.30	3.03	47.35
Mussels Sphaeriidae	1.89	1.08	1.12	1.24	2.97	50.33
Worms Oligochaeta	4.19	4.49	1.10	1.14	2.92	53.25
Flatworms Dugesiidae	3.48	1.97	1.07	1.48	2.85	56.09
Fairy shrimps Atyidae	0.00	1.81	1.06	0.93	2.82	58.91
Snails Lymnaeidae	1.91	0.47	1.01	1.53	2.67	61.58
Dragonfly larvae Aeshnidae	1.56	1.08	0.99	1.19	2.63	64.20
Snails Planorbidae	2.95	2.53	0.98	1.66	2.60	66.80
Dragonfly larvae Megapodagrionidae	5.34	4.87	0.96	1.32	2.55	69.35
Mussels Corbiculidae	1.39	0.27	0.92	0.77	2.44	71.79
True Fly larvae Culicidae	1.28	0.46	0.77	0.99	2.03	73.82
Snails Ancylidae	0.33	1.38	0.75	1.22	1.99	75.81
True Fly larvae Stratiomyidae	1.55	1.79	0.75	1.23	1.98	77.79
Mayfly larvae Baetidae	0.99	0.22	0.60	0.64	1.59	79.38
Aquatic mites Acarina	0.78	0.65	0.56	1.08	1.50	80.87
Slatters Oniscidae	0.89	0.56	0.53	1.00	1.39	82.26
True bugs Veliidae	0.74	0.46	0.49	1.13	1.29	83.55
True bugs Gerridae	0.76	0.33	0.48	1.11	1.28	84.83
True bugs Corixidae	0.33	0.65	0.48	0.75	1.28	86.11
Beetles Hydrophilidae	0.65	0.53	0.48	1.16	1.26	87.37
Caddisfly larvae Leptoceridae	0.11	0.79	0.46	0.82	1.23	88.60
Beetles Dytiscidae	0.16	0.71	0.46	0.75	1.23	89.82
Sand hoppers Ceinidae	0.54	0.22	0.43	0.60	1.14	90.96

Groups Archers Ck & Shrimptons Ck

Average dissimilarity = 48.00

Species	Archers Ck Av.Abund	Shrimptons Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	11.42	6.05	4.42	1.40	9.20	9.20
Snails Hydrobiidae	4.22	1.36	2.41	1.50	5.02	14.22
True Fly larvae s-f Orthocladiinae	3.74	0.76	2.15	1.06	4.47	18.69
Caddisfly larvae Hydroptilidae	3.12	0.52	1.95	1.06	4.07	22.76
Dragonfly larvae Libellulidae	4.00	1.42	1.78	1.41	3.71	26.47
Snails Physidae	6.07	7.50	1.69	1.34	3.52	29.99
True bugs Veliidae	2.70	0.64	1.64	1.46	3.42	33.41
True Fly larvae s-f Tanypodinae	3.31	1.15	1.52	1.62	3.18	36.58
Leeches Glossiphoniidae	2.00	3.14	1.50	1.43	3.13	39.71
True bugs Notonectidae	3.03	2.52	1.49	1.30	3.10	42.81
Flatworms Dugesiidae	5.64	6.47	1.48	1.21	3.08	45.89
Dragonfly larvae Megapodagrionidae	2.86	2.23	1.42	1.24	2.96	48.85
Dragonfly larvae Hemicorduliidae	3.37	2.74	1.41	1.37	2.93	51.78
True Fly larvae Culicidae	2.08	0.42	1.36	1.06	2.84	54.62
Aquatic mites Acarina	1.55	3.08	1.29	1.43	2.70	57.32
Dragonfly larvae Aeshnidae	1.87	0.50	1.25	1.10	2.61	59.92
Snails Planorbidae	0.10	1.87	1.25	1.00	2.60	62.52
Dragonfly larvae Coenagrionidae	3.24	3.28	1.21	1.31	2.52	65.05
Worms Oligochaeta	6.50	5.23	1.13	1.17	2.35	67.40
Mussels Corbiculidae	0.34	1.36	1.10	0.77	2.29	69.69
True Fly larvae Stratiomyidae	2.37	0.92	1.01	1.58	2.11	71.80
Fairy shrimps Atyidae	1.36	0.00	0.97	0.68	2.01	73.81
Dragonfly larvae Isostictidae	0.00	1.58	0.96	0.93	1.99	75.81
Mayfly larvae Baetidae	1.42	0.24	0.93	0.74	1.93	77.74
True Fly larvae Simuliidae	1.48	0.00	0.93	1.10	1.93	79.67
Mussels Sphaeriidae	0.90	1.01	0.86	0.95	1.79	81.46
True bugs Corixidae	1.03	1.02	0.82	1.09	1.71	83.17
True Fly larvae Tipulidae	1.11	0.00	0.72	1.12	1.49	84.66
Slatters Oniscidae	1.10	0.58	0.69	1.15	1.44	86.10
Snails Lymnaeidae	0.77	1.60	0.68	1.04	1.42	87.52
Snails Ancylidae	0.70	0.66	0.64	0.82	1.34	88.86
True Fly larvae Ceratopogonidae	0.93	0.20	0.63	0.82	1.30	90.16

Groups Buffalo Ck & Shrimptons Ck

Average dissimilarity = 46.65

Species	Buffalo Ck Av.Abund	Shrimptons Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	9.91	6.05	3.77	1.44	8.08	8.08
Snails Hydrobiidae	6.20	1.36	3.60	1.88	7.71	15.79
Dragonfly larvae Megapodagrionidae	5.34	2.23	2.42	1.61	5.18	20.97
Flatworms Dugesiidae	3.48	6.47	2.19	1.65	4.70	25.67
True bugs Notonectidae	4.97	2.52	2.12	1.43	4.55	30.22
Leeches Glossiphoniidae	1.03	3.14	1.93	1.36	4.14	34.35
Caddisfly larvae Hydroptilidae	2.98	0.52	1.92	1.31	4.12	38.47
Aquatic mites Acarina	0.78	3.08	1.71	1.69	3.66	42.13
Dragonfly larvae Hemicorduliidae	2.91	2.74	1.58	1.42	3.39	45.52
Snails Physidae	7.08	7.50	1.56	1.37	3.34	48.86
Worms Oligochaeta	4.19	5.23	1.54	1.44	3.30	52.15
Snails Planorbidae	2.95	1.87	1.50	1.54	3.22	55.37
Dragonfly larvae Coenagrionidae	2.91	3.28	1.40	1.35	3.01	58.38
Mussels Corbiculidae	1.39	1.36	1.40	0.87	2.99	61.38
Dragonfly larvae Isostictidae	2.33	1.58	1.28	1.41	2.73	64.11
True Fly larvae s-f Orthocladiinae	2.00	0.76	1.21	0.99	2.59	66.70
Dragonfly larvae Libellulidae	2.29	1.42	1.20	1.35	2.58	69.28
Mussels Sphaeriidae	1.89	1.01	1.20	1.20	2.57	71.85
True Fly larvae s-f Tanypodinae	2.47	1.15	1.18	1.51	2.52	74.37
Dragonfly larvae Aeshnidae	1.56	0.50	1.02	1.07	2.19	76.56
Snails Lymnaeidae	1.91	1.60	0.96	1.52	2.06	78.62
True Fly larvae Culicidae	1.28	0.42	0.95	1.02	2.03	80.65
True Fly larvae Stratiomyidae	1.55	0.92	0.79	1.35	1.69	82.35
True bugs Veliidae	0.74	0.64	0.68	0.98	1.45	83.80
Mayfly larvae Baetidae	0.99	0.24	0.66	0.64	1.42	85.21
True bugs Corixidae	0.33	1.02	0.63	1.03	1.35	86.56
Yabbies Parastacidae	0.00	0.86	0.58	1.08	1.25	87.82
Slatters Oniscidae	0.89	0.58	0.57	0.97	1.22	89.04
True bugs Gerridae	0.76	0.41	0.55	1.02	1.18	90.22

Groups Porters Ck & Shrimptons Ck

Average dissimilarity = 50.41

Species	Porters Ck Av.Abund	Shrimptons Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Snails Hydrobiidae	8.37	1.36	5.00	3.11	9.91	9.91
True Fly larvae s-f Chironominae	9.57	6.05	3.94	1.30	7.81	17.72
Flatworms Dugesiidae	1.97	6.47	3.25	2.46	6.44	24.17
Dragonfly larvae Megapodagrionidae	4.87	2.23	2.24	1.50	4.44	28.60
Dragonfly larvae Isostictidae	4.19	1.58	2.20	1.50	4.37	32.97
Snails Physidae	4.90	7.50	2.06	1.48	4.09	37.06
True Fly larvae s-f Orthocladiinae	2.93	0.76	1.80	1.27	3.57	40.63
Aquatic mites Acarina	0.65	3.08	1.73	1.69	3.43	44.07
Leeches Glossiphoniidae	2.12	3.14	1.68	1.31	3.33	47.39
True Fly larvae s-f Tanypodinae	3.03	1.15	1.63	1.32	3.24	50.63
True bugs Notonectidae	3.59	2.52	1.59	1.32	3.16	53.79
Dragonfly larvae Hemicorduliidae	2.61	2.74	1.57	1.45	3.11	56.90
Snails Planorbidae	2.53	1.87	1.32	1.56	2.62	59.52
Dragonfly larvae Coenagrionidae	3.72	3.28	1.31	1.46	2.59	62.11
Worms Oligochaeta	4.49	5.23	1.24	1.39	2.46	64.57
Fairy shrimps Atyidae	1.81	0.00	1.19	0.93	2.37	66.93
Caddisfly larvae Hydroptilidae	1.64	0.52	1.16	1.06	2.31	69.24
Mussels Corbiculidae	0.27	1.36	1.15	0.71	2.29	71.53
Dragonfly larvae Libellulidae	2.24	1.42	1.10	1.36	2.19	73.71
Snails Ancylidae	1.38	0.66	0.98	1.25	1.94	75.66
Snails Lymnaeidae	0.47	1.60	0.92	1.33	1.82	77.48
Mussels Sphaeriidae	1.08	1.01	0.87	1.08	1.72	79.20
True Fly larvae Stratiomyidae	1.79	0.92	0.87	1.22	1.72	80.92
Dragonfly larvae Aeshnidae	1.08	0.50	0.80	0.93	1.60	82.52
True bugs Corixidae	0.65	1.02	0.78	1.05	1.55	84.07
Yabbies Parastacidae	0.00	0.86	0.59	1.08	1.17	85.24
True bugs Veliidae	0.46	0.64	0.58	0.79	1.14	86.39
Caddisfly larvae Leptoceridae	0.79	0.00	0.51	0.79	1.01	87.40
Beetles Dytiscidae	0.71	0.10	0.50	0.72	0.99	88.39
Slatters Oniscidae	0.56	0.58	0.49	1.06	0.96	89.36
True Fly larvae Culicidae	0.46	0.42	0.47	0.77	0.92	90.28

Groups Archers Ck & Terrys Ck

Average dissimilarity = 43.10

Species	Archers Ck v.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	11.42	7.03	2.93	1.44	6.79	6.79
Dragonfly larvae Megapodagrionidae	2.86	7.79	2.82	2.94	6.55	13.35
Snails Hydrobiidae	4.22	8.02	2.51	1.26	5.81	19.16
Dragonfly larvae Isostictidae	0.00	3.66	2.11	5.00	4.88	24.05
True Fly larvae s-f Orthocladiinae	3.74	1.77	1.68	1.11	3.90	27.94
Caddisfly larvae Hydroptilidae	3.12	0.91	1.66	1.22	3.85	31.80
Dragonfly larvae Libellulidae	4.00	1.82	1.53	1.39	3.55	35.35
Mussels Sphaeriidae	0.90	2.29	1.34	1.40	3.12	38.47
Flatworms Dugesiidae	5.64	4.71	1.33	1.81	3.09	41.56
True bugs Notonectidae	3.03	3.36	1.30	1.34	3.02	44.57
Dragonfly larvae Hemicorduliidae	3.37	3.63	1.29	1.37	2.98	47.56
Snails Physidae	6.07	5.63	1.18	1.47	2.74	50.29
True Fly larvae Culicidae	2.08	0.70	1.17	1.13	2.71	53.00
Dragonfly larvae Coenagrionidae	3.24	2.12	1.11	1.19	2.58	55.58
Snails Planorbidae	0.10	1.99	1.09	2.09	2.53	58.11
Worms Oligochaeta	6.50	5.09	0.97	1.66	2.26	60.37
Beetles Elmidae	0.14	1.82	0.97	2.68	2.25	62.63
Dragonfly larvae Aeshnidae	1.87	0.86	0.94	1.19	2.18	64.81
True Fly larvae s-f Tanypodinae	3.31	4.35	0.88	1.38	2.05	66.86
Mussels Corbiculidae	0.34	1.35	0.84	0.84	1.95	68.80
Fairy shrimps Atyidae	1.36	0.00	0.83	0.68	1.92	70.72
Mayfly larvae Baetidae	1.42	0.16	0.80	0.72	1.85	72.57
Leeches Glossiphoniidae	2.00	1.54	0.76	1.45	1.77	74.34
True bugs Gerridae	0.24	1.47	0.76	1.47	1.75	76.09
True bugs Veliidae	2.70	1.92	0.75	1.05	1.75	77.84
True Fly larvae Simuliidae	1.48	1.00	0.75	1.23	1.74	79.58
Aquatic mites Acarina	1.55	1.93	0.75	1.41	1.74	81.32
True Fly larvae Ceratopogonidae	0.93	0.67	0.64	1.03	1.49	82.81
True bugs Corixidae	1.03	0.25	0.63	0.86	1.46	84.27
Slatters Oniscidae	1.10	0.33	0.60	1.10	1.40	85.68
True Fly larvae Tipulidae	1.11	0.60	0.59	1.27	1.36	87.04
True Fly larvae Stratiomyidae	2.37	1.65	0.55	1.42	1.27	88.31
Snails Ancylidae	0.70	0.47	0.50	0.83	1.16	89.46
Sand hoppers Talitridae	0.20	0.77	0.47	1.11	1.09	90.56

Groups Buffalo Ck & Terrys Ck

Average dissimilarity = 36.75

Species	Buffalo Ck Av.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	9.91	7.03	2.18	1.32	5.94	5.94
True bugs Notonectidae	4.97	3.36	1.58	1.48	4.30	10.24
Dragonfly larvae Megapodagrionidae	5.34	7.79	1.57	1.73	4.28	14.53
Dragonfly larvae Hemicorduliidae	2.91	3.63	1.55	1.39	4.23	18.75
Snails Hydrobiidae	6.20	8.02	1.48	1.34	4.03	22.79
Caddisfly larvae Hydroptilidae	2.98	0.91	1.46	1.31	3.97	26.76
Snails Physidae	7.08	5.63	1.42	1.50	3.88	30.63
True Fly larvae s-f Tanypodinae	2.47	4.35	1.25	1.30	3.40	34.03
Dragonfly larvae Coenagrionidae	2.91	2.12	1.20	1.51	3.26	37.30
Mussels Sphaeriidae	1.89	2.29	1.19	1.33	3.23	40.53
Dragonfly larvae Libellulidae	2.29	1.82	1.15	1.31	3.12	43.65
Mussels Corbiculidae	1.39	1.35	1.10	0.90	3.00	46.65
Beetles Elmidae	0.00	1.82	1.09	3.69	2.95	49.60
Worms Oligochaeta	4.19	5.09	1.08	1.31	2.95	52.55
True Fly larvae s-f Orthocladiinae	2.00	1.77	1.06	1.19	2.88	55.43
Dragonfly larvae Isostictidae	2.33	3.66	1.03	1.64	2.82	58.25
Snails Planorbidae	2.95	1.99	1.00	1.56	2.72	60.97
Flatworms Dugesiidae	3.48	4.71	0.99	1.37	2.69	63.66
Aquatic mites Acarina	0.78	1.93	0.91	1.54	2.49	66.15
Snails Lymnaeidae	1.91	0.92	0.89	1.56	2.41	68.56
Dragonfly larvae Aeshnidae	1.56	0.86	0.85	1.41	2.30	70.87
True Fly larvae Culicidae	1.28	0.70	0.82	1.07	2.24	73.11
Leeches Glossiphoniidae	1.03	1.54	0.79	1.53	2.16	75.27
True bugs Veliidae	0.74	1.92	0.78	1.61	2.11	77.38
True bugs Gerridae	0.76	1.47	0.72	1.30	1.95	79.33
True Fly larvae Stratiomyidae	1.55	1.65	0.58	1.36	1.59	80.92
True Fly larvae Simuliidae	0.11	1.00	0.58	1.11	1.57	82.49
Mayfly larvae Baetidae	0.99	0.16	0.56	0.60	1.52	84.01
Sand hoppers Ceinidae	0.54	0.44	0.49	0.71	1.32	85.33
Slatters Oniscidae	0.89	0.33	0.48	0.91	1.30	86.63
True Fly larvae Ceratopogonidae	0.60	0.67	0.46	1.01	1.25	87.89
Sand hoppers Talitridae	0.11	0.77	0.46	1.09	1.25	89.13
True bugs Gelastocoridae	0.38	0.79	0.43	1.16	1.18	90.31

Groups Porters Ck & Terrys Ck
Average dissimilarity = 37.56

Species	Porters Ck av.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	9.57	7.03	2.43	1.15	6.46	6.46
Dragonfly larvae Megapodagrionidae	4.87	7.79	1.87	1.78	4.98	11.43
Flatworms Dugesiidae	1.97	4.71	1.68	1.88	4.48	15.91
Dragonfly larvae Hemicorduliidae	2.61	3.63	1.56	1.33	4.14	20.05
True Fly larvae s-f Orthocladiinae	2.93	1.77	1.35	1.42	3.59	23.65
True bugs Notonectidae	3.59	3.36	1.28	1.45	3.42	27.07
Dragonfly larvae Coenagrionidae	3.72	2.12	1.24	1.33	3.31	30.37
Mussels Sphaeriidae	1.08	2.29	1.24	1.40	3.30	33.67
True Fly larvae s-f Tanypodinae	3.03	4.35	1.21	1.37	3.21	36.89
Snails Physidae	4.90	5.63	1.12	1.29	2.98	39.86
Dragonfly larvae Isostictidae	4.19	3.66	1.10	1.62	2.94	42.80
Beetles Elmidae	0.00	1.82	1.10	3.77	2.92	45.72
Dragonfly larvae Libellulidae	2.24	1.82	1.09	1.32	2.89	48.61
Snails Hydrobiidae	8.37	8.02	1.08	1.59	2.87	51.48
Fairy shrimps Atyidae	1.81	0.00	1.03	0.93	2.74	54.22
Leeches Glossiphoniidae	2.12	1.54	0.94	1.34	2.50	56.72
Caddisfly larvae Hydroptilidae	1.64	0.91	0.93	1.30	2.47	59.19
True bugs Veliidae	0.46	1.92	0.91	1.81	2.43	61.62
Aquatic mites Acarina	0.65	1.93	0.87	1.53	2.32	63.95
Mussels Corbiculidae	0.27	1.35	0.86	0.77	2.29	66.23
Worms Oligochaeta	4.49	5.09	0.82	1.38	2.19	68.42
True bugs Gerridae	0.33	1.47	0.77	1.44	2.06	70.48
Snails Ancylidae	1.38	0.47	0.75	1.25	2.00	72.48
Snails Planorbidae	2.53	1.99	0.69	1.15	1.85	74.32
Dragonfly larvae Aeshnidae	1.08	0.86	0.62	1.08	1.66	75.98
True Fly larvae Simuliidae	0.11	1.00	0.58	1.11	1.55	77.54
Snails Lymnaeidae	0.47	0.92	0.53	1.16	1.41	78.95
True Fly larvae Culicidae	0.46	0.70	0.53	0.81	1.40	80.35
True Fly larvae Stratiomyidae	1.79	1.65	0.52	1.12	1.39	81.74
True bugs Corixidae	0.65	0.25	0.48	0.69	1.28	83.03
True Fly larvae Tipulidae	0.62	0.60	0.46	1.11	1.23	84.26
Beetles Dytiscidae	0.71	0.22	0.46	0.84	1.23	85.49
True bugs Gelastocoridae	0.11	0.79	0.46	1.22	1.22	86.72
Sand hoppers Talitridae	0.22	0.77	0.46	1.13	1.21	87.93
Caddisfly larvae Leptoceridae	0.79	0.00	0.44	0.79	1.17	89.10
True Fly larvae Ceratopogonidae	0.00	0.67	0.42	0.75	1.13	90.23

Groups Shrimptons Ck & Terrys Ck
Average dissimilarity = 46.08

Species	Shrimptons Ck Av.Abund	Terrys Ck Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Snails Hydrobiidae	1.36	8.02	4.57	2.58	9.92	9.92
Dragonfly larvae Megapodagrionidae	2.23	7.79	3.88	2.16	8.42	18.34
True Fly larvae s-f Chironominae	6.05	7.03	2.86	1.41	6.20	24.54
True Fly larvae s-f Tanypodinae	1.15	4.35	2.21	2.06	4.81	29.35
Dragonfly larvae Isostictidae	1.58	3.66	1.75	1.76	3.79	33.14
True bugs Notonectidae	2.52	3.36	1.59	1.30	3.45	36.59
Dragonfly larvae Hemicorduliidae	2.74	3.63	1.58	1.32	3.43	40.02
Leeches Glossiphoniidae	3.14	1.54	1.54	1.44	3.33	43.35
Snails Physidae	7.50	5.63	1.52	1.57	3.30	46.65
Flatworms Dugesiidae	6.47	4.71	1.38	1.38	3.00	49.65
Mussels Sphaeriidae	1.01	2.29	1.35	1.38	2.92	52.58
Mussels Corbiculidae	1.36	1.35	1.33	0.88	2.88	55.45
Dragonfly larvae Coenagrionidae	3.28	2.12	1.19	1.44	2.58	58.04
True bugs Veliidae	0.64	1.92	1.18	2.16	2.56	60.59
Snails Planorbidae	1.87	1.99	1.16	1.53	2.52	63.12
Beetles Elmidae	0.10	1.82	1.16	2.88	2.51	65.63
Aquatic mites Acarina	3.08	1.93	1.11	1.35	2.41	68.04
Worms Oligochaeta	5.23	5.09	0.94	1.24	2.04	70.08
Dragonfly larvae Libellulidae	1.42	1.82	0.91	1.18	1.97	72.06
True bugs Gerridae	0.41	1.47	0.85	1.40	1.85	73.90
True Fly larvae s-f Orthocladiinae	0.76	1.77	0.82	1.26	1.78	75.68
Snails Lymnaeidae	1.60	0.92	0.76	1.13	1.66	77.34
Caddisfly larvae Hydroptilidae	0.52	0.91	0.70	1.30	1.52	78.85
True bugs Corixidae	1.02	0.25	0.68	1.08	1.48	80.34
True Fly larvae Simuliidae	0.00	1.00	0.65	1.06	1.42	81.76
True Fly larvae Stratiomyidae	0.92	1.65	0.64	1.29	1.38	83.14
True Fly larvae Culicidae	0.42	0.70	0.60	0.72	1.30	84.44
Dragonfly larvae Aeshnidae	0.50	0.86	0.58	1.31	1.26	85.69
Snails Ancylidae	0.66	0.47	0.56	0.83	1.22	86.92
Yabbies Parastacidae	0.86	0.00	0.56	1.09	1.22	88.14
Sand hoppers Talitridae	0.00	0.77	0.52	1.06	1.14	89.27
True Fly larvae Ceratopogonidae	0.20	0.67	0.48	0.82	1.05	90.32

SIMPER Archers Creek 2005 – 2009

Data worksheet
Name: Archers 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

Group Autumn 2005
Average similarity: 68.02

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dragonfly larvae Megapodagrionidae	3.60	7.56	2.16	11.11	11.11
Fairy shrimps Atyidae	3.30	7.18	8.38	10.56	21.67
Worms Oligochaeta	3.29	6.80	3.09	9.99	31.67
True Fly larvae s-f Chironominae	3.31	6.58	5.68	9.67	41.33
Dragonfly larvae Libellulidae	2.52	5.47	4.54	8.04	49.37
Flatworms Dugesiidae	2.75	5.32	5.50	7.82	57.19
Dragonfly larvae Coenagrionidae	3.19	5.20	4.94	7.65	64.83
True bugs Veliidae	2.14	5.09	3.65	7.49	72.32
Dragonfly larvae Hemicorduliidae	2.66	4.82	8.37	7.08	79.40
Snails Physidae	1.67	3.65	1.80	5.36	84.77
True Fly larvae Stratiomyidae	1.62	2.98	7.13	4.38	89.15
True Fly larvae 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.%
True Fly larvae s-f Chironominae	8.06	19.91	6.33	33.83	33.83
Worms Oligochaeta	4.19	10.61	6.70	18.04	51.87
Snails Physidae	2.95	7.20	6.86	12.24	64.11
Dragonfly larvae Coenagrionidae	3.08	6.42	6.60	10.90	75.01
Dragonfly larvae Libellulidae	2.87	6.04	1.03	10.27	85.28
Dragonfly larvae Aeshnidae	1.49	2.00	0.58	3.40	88.68
Mussels 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.%
True Fly larvae s-f Chironominae	9.12	23.36	19.19	32.29	32.29
Worms Oligochaeta	3.39	8.50	11.35	11.74	44.04
Leeches Glossiphoniidae	2.10	4.91	2.60	6.79	50.82
Dragonfly larvae Megapodagrionidae	2.10	4.62	4.53	6.39	57.21
Dragonfly larvae Libellulidae	2.02	4.46	4.33	6.17	63.38
Dragonfly larvae Coenagrionidae	2.03	4.02	1.99	5.56	68.94
Dragonfly larvae Hemicorduliidae	1.96	3.84	2.25	5.30	74.24
Flatworms Dugesiidae	1.67	3.63	2.69	5.02	79.26
True bugs Veliidae	1.28	3.17	3.92	4.38	83.63
True bugs Notonectidae	1.47	3.16	4.33	4.36	88.00
Dragonfly larvae 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.%
True Fly larvae s-f Chironominae	4.35	14.93	4.12	24.80	24.80
Snails Physidae	2.81	10.04	3.55	16.68	41.47
Flatworms Dugesiidae	2.63	8.66	2.75	14.39	55.86
Worms Oligochaeta	2.43	7.87	2.82	13.07	68.93
Snails Hydrobiidae	1.81	4.51	1.47	7.48	76.41
True Fly larvae s-f Tanypodinae	1.07	3.38	1.76	5.62	82.03
True bugs Veliidae	0.80	1.96	0.79	3.25	85.28
True Fly larvae s-f Orthocladiinae	1.06	1.92	0.79	3.18	88.47
True Fly larvae 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.%
True Fly larvae s-f Chironominae	5.02	17.66	4.21	30.81	30.81
Worms Oligochaeta	2.53	6.59	1.30	11.49	42.30
Snails Physidae	2.35	6.46	3.17	11.27	53.57
Flatworms Dugesiidae	2.20	4.54	1.22	7.93	61.50
True Fly larvae s-f Tanypodinae	1.19	4.00	5.04	6.99	68.48
Dragonfly larvae Libellulidae	1.50	3.89	1.21	6.79	75.27
True bugs Veliidae	1.93	3.06	0.75	5.35	80.62
Leeches Glossiphoniidae	1.08	2.51	1.28	4.38	85.00
Dragonfly larvae Megapodagrionidae	1.01	1.90	0.77	3.31	88.31
Dragonfly larvae Aeshnidae	0.98	1.76	0.78	3.07	91.38

Group Spring 2007

Average similarity: 61.15

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	5.57	14.94	7.60	24.43	24.43
Snails Physidae	3.77	10.20	7.13	16.67	41.10
Snails Hydrobiidae	2.81	6.69	2.42	10.94	52.04
Worms Oligochaeta	2.95	6.47	3.33	10.58	62.62
Flatworms Dugesiidae	2.70	4.97	1.23	8.13	70.76
True Fly larvae s-f Tanypodinae	1.84	3.95	2.50	6.46	77.22
Mussels Sphaeriidae	2.01	3.08	1.02	5.04	82.26
Dragonfly larvae Hemicorduliidae	1.57	2.37	1.15	3.88	86.14
Dragonfly larvae Libellulidae	1.04	2.14	1.29	3.50	89.63
True Fly larvae s-f Orthocladiinae	1.33	1.78	0.73	2.91	92.55

Group Autumn 2008

Average similarity: 61.49

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Orthocladiinae	4.42	13.77	5.31	22.39	22.39
True Fly larvae s-f Chironominae	3.35	10.77	5.75	17.51	39.91
Snails Hydrobiidae	2.52	7.04	2.73	11.45	51.35
Worms Oligochaeta	1.69	5.05	3.62	8.21	59.56
True bugs Veliidae	1.62	4.32	4.25	7.03	66.59
Snails Physidae	2.03	4.28	1.16	6.96	73.55
True bugs Notonectidae	1.69	3.42	1.06	5.56	79.10
Caddisfly larvae Hydroptilidae	1.35	2.21	0.74	3.59	82.69
True Fly larvae Ceratopogonidae	1.15	2.07	0.78	3.36	86.05
Mayfly larvae Baetidae	1.26	1.64	0.48	2.66	88.72
True Fly larvae Stratiomyidae	0.67	1.43	0.79	2.33	91.05

Group Spring 2008

Average similarity: 69.72

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	3.99	12.17	10.20	17.46	17.46
Flatworms Dugesiidae	2.87	8.16	7.17	11.70	29.16
Worms Oligochaeta	2.85	8.05	6.36	11.55	40.71
Caddisfly larvae Hydroptilidae	3.13	7.69	3.78	11.04	51.75
Snails Physidae	2.77	6.64	2.38	9.53	61.28
Snails Hydrobiidae	2.46	6.11	5.80	8.77	70.04
True Fly larvae s-f Orthocladiinae	2.49	4.74	1.09	6.80	76.84
True bugs Notonectidae	1.74	3.20	1.03	4.58	81.43
Snails Ancylidae	1.30	2.59	1.31	3.72	85.15
True Fly larvae s-f Tanypodinae	1.24	2.29	1.29	3.29	88.43
Leeches 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.%
True Fly larvae s-f Chironominae	4.02	10.17	4.55	15.81	15.81
Dragonfly larvae Libellulidae	3.11	6.61	2.09	10.27	26.08
Flatworms Dugesiidae	2.69	6.32	2.12	9.83	35.91
Caddisfly larvae Hydroptilidae	2.52	5.85	2.36	9.10	45.00
Worms Oligochaeta	2.33	5.20	3.07	8.08	53.08
True Fly larvae s-f Orthocladiinae	2.16	4.81	2.62	7.49	60.57
Snails Physidae	2.02	4.29	2.49	6.67	67.24
True Fly larvae Simuliidae	1.57	3.61	3.93	5.61	72.85
Dragonfly larvae Coenagrionidae	1.77	3.55	3.75	5.52	78.37
Snails Hydrobiidae	2.04	3.06	1.17	4.76	83.13
True bugs Notonectidae	1.78	2.08	0.73	3.23	86.36
True Fly larvae Ceratopogonidae	0.97	1.85	1.34	2.87	89.23
Leeches Glossiphoniidae	1.22	1.55	0.77	2.41	91.64

Group Spring 2009

Average similarity: 65.40

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	4.15	11.65	8.63	17.81	17.81
Flatworms Dugesiidae	3.07	9.00	5.71	13.76	31.57
Snails Physidae	3.07	8.90	5.68	13.61	45.18
Snails Hydrobiidae	3.00	8.52	4.30	13.02	58.20
Worms Oligochaeta	2.40	6.42	3.35	9.81	68.01
Caddisfly larvae Hydroptilidae	2.39	5.19	2.24	7.93	75.94
True Fly larvae s-f Tanypodinae	1.98	5.02	3.05	7.68	83.62
True Fly larvae Culicidae	1.44	2.41	1.23	3.69	87.31
True Fly larvae Stratiomyidae	1.02	2.20	1.33	3.37	90.68

SIMPER Shrimptons Creek 2005 – 2009

Data worksheet
Name: Shrimptons 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

Group Autumn 2005
Average similarity: 75.89

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Snails Physidae	3.90	16.31	7.41	21.49	21.49
Flatworms Dugesiidae	3.81	15.30	9.53	20.16	41.65
Worms Oligochaeta	3.43	13.48	44.44	17.77	59.41
Leeches Glossiphoniidae	3.04	10.94	8.30	14.42	73.83
Mussels Corbiculidae	2.63	9.41	3.56	12.40	86.23
Snails 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.%
Snails Physidae	4.03	13.28	19.85	17.35	17.35
Worms Oligochaeta	3.91	13.08	46.28	17.09	34.44
Flatworms Dugesiidae	3.46	11.45	11.43	14.97	49.41
Leeches Glossiphoniidae	3.04	9.70	10.63	12.67	62.08
True Fly larvae s-f Chironominae	3.09	8.94	4.43	11.68	73.76
Snails Planorbidae	2.88	8.57	3.06	11.20	84.96
Mussels 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.%
Worms Oligochaeta	3.68	16.90	13.74	22.03	22.03
Flatworms Dugesiidae	2.82	13.43	9.18	17.51	39.55
Snails Physidae	2.96	13.00	3.19	16.95	56.50
Aquatic mites Acarina	2.08	9.91	14.34	12.92	69.42
Mussels Corbiculidae	2.39	9.70	6.21	12.64	82.06
Dragonfly larvae 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.%
True Fly larvae s-f Chironominae	4.59	20.77	7.14	33.41	33.41
Snails Physidae	3.41	15.57	10.74	25.04	58.46
Worms Oligochaeta	2.05	7.05	1.41	11.35	69.80
Flatworms Dugesiidae	1.31	3.75	1.10	6.03	75.83
True bugs Notonectidae	1.03	3.23	1.14	5.19	81.03
Aquatic mites Acarina	1.12	3.02	1.10	4.86	85.89
Dragonfly larvae 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.%
True Fly larvae s-f Chironominae	2.95	8.39	2.58	13.89	13.89
Dragonfly larvae Megapodagrionidae	2.10	6.97	5.43	11.55	25.44
Flatworms Dugesiidae	2.16	6.71	3.12	11.10	36.54
Aquatic mites Acarina	2.02	5.61	3.42	9.28	45.83
Dragonfly larvae Coenagrionidae	1.80	5.41	2.78	8.96	54.79
Dragonfly larvae Isostictidae	1.72	5.19	3.30	8.59	63.38
Dragonfly larvae Hemicorduliidae	2.14	4.74	1.11	7.85	71.23
Worms Oligochaeta	1.72	4.72	1.08	7.81	79.04
Snails Physidae	2.28	4.63	1.08	7.67	86.71
True bugs 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.%
True Fly larvae s-f Chironominae	4.53	12.18	4.26	19.29	19.29
Snails Physidae	3.79	10.55	5.00	16.72	36.01
Worms Oligochaeta	2.22	6.38	4.93	10.10	46.12
Flatworms Dugesiidae	2.25	5.37	2.58	8.51	54.62
Dragonfly larvae Coenagrionidae	2.01	4.99	3.48	7.90	62.53
Dragonfly larvae Isostictidae	1.88	4.87	3.27	7.71	70.23
Dragonfly larvae Megapodagrionidae	1.95	3.26	0.78	5.17	75.41
Snails Ancylidae	1.37	3.05	1.34	4.83	80.24
True bugs Corixidae	1.28	2.94	1.28	4.65	84.89
Dragonfly larvae Hemicorduliidae	1.25	2.90	1.35	4.59	89.48
True bugs 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.%
Flatworms Dugesiidae	3.55	20.83	4.34	36.15	36.15
Snails Physidae	2.91	16.00	4.67	27.76	63.91
Worms Oligochaeta	1.52	6.57	1.29	11.39	75.30
Dragonfly larvae Megapodagrionidae	1.05	3.47	0.77	6.02	81.32
Leeches Glossiphoniidae	1.22	2.81	0.76	4.87	86.19
Aquatic mites 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.%
Snails Physidae	3.46	15.55	5.33	24.69	24.69
Flatworms Dugesiidae	2.86	12.16	5.11	19.31	44.00
True Fly larvae s-f Chironominae	2.37	9.80	3.96	15.56	59.56
Worms Oligochaeta	2.02	7.51	2.08	11.93	71.48
Dragonfly larvae Coenagrionidae	1.95	6.57	2.85	10.43	81.91
Aquatic mites Acarina	1.41	2.94	0.78	4.66	86.58
Leeches Glossiphoniidae	0.98	2.04	0.77	3.24	89.82
Mussels 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.%
Flatworms Dugesiidae	2.87	15.22	5.70	31.64	31.64
Leeches Glossiphoniidae	1.62	7.41	1.34	15.41	47.05
True bugs Notonectidae	1.50	5.22	1.18	10.86	57.91
Snails Lymnaeidae	1.09	4.86	1.30	10.10	68.01
Snails Physidae	1.45	4.82	0.72	10.02	78.03
Dragonfly larvae Coenagrionidae	1.16	3.69	0.76	7.68	85.71
True Fly larvae 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.%
Snails Physidae	3.60	11.95	3.70	19.30	19.30
Flatworms Dugesiidae	3.09	10.92	5.93	17.63	36.93
True Fly larvae s-f Chironominae	3.18	10.78	6.17	17.41	54.34
Leeches Glossiphoniidae	2.04	4.82	1.22	7.79	62.13
Dragonfly larvae Hemicorduliidae	1.51	4.32	3.66	6.98	69.10
Worms Oligochaeta	1.68	4.26	1.16	6.88	75.98
Snails Lymnaeidae	1.37	3.56	1.25	5.74	81.73
Dragonfly larvae Coenagrionidae	1.47	3.48	1.29	5.63	87.35
Aquatic mites Acarina	1.13	1.91	0.77	3.08	90.43

SIMPER Buffalo Creek 2005 – 2009

Data worksheet
Name: Buffalo 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

Group Autumn 2005
Average similarity: 75.60

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

Group Spring 2005
Average similarity: 66.97

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	6.42	14.61	9.20	21.82	21.82
Worms Oligochaeta	4.67	11.55	20.99	17.24	39.06
Snails Physidae	3.67	8.14	4.59	12.16	51.22
Snails Hydrobiidae	3.19	7.97	6.51	11.90	63.12
Slatters Oniscidae	1.72	4.22	7.11	6.30	69.42
Flatworms Dugesiidae	1.87	4.20	15.55	6.27	75.69
Mussels Corbiculidae	2.18	3.84	2.27	5.74	81.43
True bugs Notonectidae	1.67	3.71	2.25	5.54	86.97
Dragonfly larvae Libellulidae	2.01	3.13	6.71	4.68	91.65

Group Autumn 2006
Average similarity: 75.41

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	7.70	15.95	22.99	21.15	21.15
True bugs Notonectidae	3.55	7.62	12.00	10.11	31.25
Dragonfly larvae Libellulidae	2.92	5.42	3.65	7.19	38.44
Snails Physidae	2.57	5.39	10.50	7.15	45.60
Dragonfly larvae Coenagrionidae	2.72	5.25	12.79	6.96	52.56
Mussels Corbiculidae	2.37	4.90	6.84	6.50	59.06
Worms Oligochaeta	2.57	4.75	3.53	6.30	65.36
Dragonfly larvae Megapodagrionidae	2.41	4.27	2.42	5.66	71.02
Flatworms Dugesiidae	1.82	3.94	40.60	5.22	76.24
Dragonfly larvae Aeshnidae	1.97	3.94	40.60	5.22	81.47
Dragonfly larvae Hemicorduliidae	2.34	3.66	4.91	4.85	86.31
True Fly larvae s-f Orthocladiinae	1.61	3.22	40.60	4.27	90.58

Group Autumn 2007

Average similarity: 69.52

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	4.26	9.71	5.15	13.97	13.97
True bugs Notonectidae	3.23	7.79	6.96	11.21	25.18
Snails Physidae	3.23	6.36	2.24	9.14	34.32
Snails Hydrobiidae	2.51	5.25	2.69	7.55	41.88
Dragonfly larvae Hemicorduliidae	2.47	5.09	2.72	7.33	49.20
Dragonfly larvae Megapodagrionidae	2.06	4.40	6.84	6.33	55.54
Caddisfly larvae Hydroptilidae	1.93	4.09	4.75	5.88	61.42
True Fly larvae s-f Tanypodinae	1.71	3.53	3.54	5.07	66.49
Dragonfly larvae Isostictidae	1.64	3.19	4.05	4.59	71.08
Snails Lymnaeidae	1.60	3.15	4.78	4.53	75.61
Dragonfly larvae Aeshnidae	1.64	2.85	1.35	4.10	79.71
Dragonfly larvae Coenagrionidae	1.57	2.28	1.24	3.28	83.00
Flatworms Dugesiidae	1.43	1.76	0.79	2.53	85.53
Mayfly larvae Baetidae	1.70	1.71	0.48	2.46	87.99
True Fly larvae 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.%
True Fly larvae s-f Chironominae	4.63	14.76	4.83	22.65	22.65
Snails Physidae	3.92	14.38	11.29	22.07	44.72
Snails Hydrobiidae	2.54	8.68	5.00	13.33	58.05
Dragonfly larvae Megapodagrionidae	1.97	5.33	2.53	8.17	66.22
Worms Oligochaeta	1.68	5.09	2.75	7.81	74.03
True bugs Notonectidae	1.43	4.64	4.77	7.12	81.15
Dragonfly larvae Isostictidae	1.51	2.99	0.78	4.58	85.73
Dragonfly larvae Coenagrionidae	1.01	1.86	0.77	2.85	88.58
True Fly larvae 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.%
True Fly larvae s-f Chironominae	3.63	9.91	6.68	15.60	15.60
True bugs Notonectidae	3.12	9.02	3.62	14.19	29.79
Snails Physidae	3.11	6.90	2.31	10.86	40.65
Dragonfly larvae Megapodagrionidae	2.49	6.89	3.97	10.85	51.50
Flatworms Dugesiidae	2.10	6.11	4.67	9.62	61.12
Snails Hydrobiidae	2.61	5.21	1.25	8.20	69.32
Caddisfly larvae Hydroptilidae	2.31	4.66	1.15	7.34	76.66
True Fly larvae s-f Orthocladiinae	2.39	4.48	1.24	7.04	83.70
Snails Planorbidae	1.33	1.85	0.71	2.91	86.61
Dragonfly larvae Aeshnidae	0.93	1.51	0.75	2.38	88.99
Worms Oligochaeta	0.96	1.37	0.77	2.16	91.14

Group Spring 2008

Average similarity: 66.36

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Snails Physidae	3.74	19.33	4.65	29.12	29.12
True Fly larvae s-f Chironominae	3.71	17.61	4.48	26.53	55.65
Snails Hydrobiidae	3.12	15.91	3.89	23.97	79.62
Dragonfly larvae Megapodagrionidae	1.19	4.58	1.30	6.90	86.52
Worms Oligochaeta	1.26	4.10	1.29	6.19	92.71

Group Autumn 2009

Average similarity: 68.72

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Snails Physidae	3.01	9.79	5.02	14.24	14.24
True Fly larvae s-f Chironominae	2.86	8.96	3.23	13.04	27.28
Snails Hydrobiidae	2.97	8.61	3.50	12.53	39.81
True bugs Notonectidae	2.35	7.03	3.56	10.23	50.04
Dragonfly larvae Megapodagrionidae	2.08	6.23	5.89	9.06	59.11
True Fly larvae s-f Orthocladiinae	1.54	4.90	3.79	7.14	66.24
Dragonfly larvae Coenagrionidae	1.63	4.57	4.41	6.65	72.90
Flatworms Dugesiidae	1.67	3.69	1.31	5.36	78.26
Caddisfly larvae Hydroptilidae	1.50	3.25	1.24	4.72	82.98
Snails Planorbidae	1.55	3.02	0.78	4.39	87.38
Dragonfly larvae 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.%
True Fly larvae s-f Chironominae	3.41	11.88	3.46	17.24	17.24
Snails Hydrobiidae	3.23	11.39	6.09	16.53	33.77
Dragonfly larvae Megapodagrionidae	2.52	7.62	2.47	11.05	44.82
Snails Physidae	2.36	7.44	2.02	10.79	55.61
Mussels Sphaeriidae	1.82	5.66	4.05	8.21	63.82
Snails Planorbidae	1.55	5.46	4.11	7.92	71.74
Worms Oligochaeta	1.24	4.24	5.85	6.15	77.89
Snails Lymnaeidae	1.14	4.15	10.80	6.02	83.91
True bugs Notonectidae	1.09	3.07	1.31	4.46	88.37
Caddisfly larvae Hydroptilidae	1.74	2.90	0.75	4.21	92.57

SIMPER Porters Creek 2005 – 2009

Data worksheet
Name: Porters 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

Group Autumn 2005
Average similarity: 76.82

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	6.51	12.89	10.12	16.78	16.78
Snails Hydrobiidae	4.59	8.30	7.22	10.80	27.58
Dragonfly larvae Isostictidae	4.18	8.07	10.67	10.50	38.08
Dragonfly larvae Hemicorduliidae	2.89	5.93	55.42	7.71	45.80
Snails Physidae	3.09	5.90	11.52	7.68	53.47
Dragonfly larvae Megapodagrionidae	3.01	5.40	10.58	7.03	60.50
Dragonfly larvae Coenagrionidae	2.83	4.64	2.61	6.04	66.54
Snails Planorbidae	2.30	4.51	7.69	5.87	72.40
Worms Oligochaeta	2.45	4.13	4.56	5.38	77.79
Leeches Glossiphoniidae	2.10	3.54	3.45	4.61	82.40
True Fly larvae s-f Tanypodinae	2.39	3.38	4.51	4.40	86.79
Dragonfly larvae 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.%
True Fly larvae s-f Chironominae	10.09	23.35	7.12	32.12	32.12
Snails Hydrobiidae	4.74	10.08	8.73	13.86	45.98
Worms Oligochaeta	2.68	5.99	19.38	8.24	54.22
Dragonfly larvae Isostictidae	2.63	5.99	19.38	8.24	62.46
Snails Physidae	2.49	5.65	4.31	7.77	70.24
Leeches Glossiphoniidae	1.99	4.63	6.74	6.37	76.61
Dragonfly larvae Libellulidae	2.22	4.33	2.89	5.95	82.56
True bugs Corixidae	1.80	2.91	3.64	4.00	86.56
Leeches 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.%
Snails Hydrobiidae	4.07	8.77	4.85	12.20	12.20
Dragonfly larvae Coenagrionidae	3.33	7.27	5.23	10.10	22.30
Dragonfly larvae Megapodagrionidae	3.64	7.01	7.28	9.75	32.05
Dragonfly larvae Isostictidae	3.18	6.57	18.65	9.14	41.19
Worms Oligochaeta	2.58	6.08	18.65	8.46	49.65
Dragonfly larvae Hemicorduliidae	2.69	5.55	18.65	7.72	57.37
Fairy shrimps Atyidae	2.74	5.55	18.65	7.72	65.09
Leeches Glossiphoniidae	2.85	5.24	2.96	7.29	72.38
Dragonfly larvae Aeshnidae	2.20	4.69	10.46	6.53	78.91
Snails Physidae	1.93	3.76	15.62	5.23	84.14
Dragonfly larvae Libellulidae	1.66	3.11	2.72	4.32	88.46
True Fly larvae 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.%
Snails Hydrobiidae	4.72	10.58	6.69	14.84	14.84
Snails Physidae	2.61	5.88	5.12	8.24	23.09
True bugs Notonectidae	2.63	5.79	5.28	8.12	31.21
Dragonfly larvae Isostictidae	2.79	5.76	3.27	8.08	39.29
True Fly larvae s-f Chironominae	2.78	5.51	4.23	7.73	47.02
Dragonfly larvae Coenagrionidae	2.63	5.44	3.69	7.64	54.66
Dragonfly larvae Megapodagrionidae	2.45	5.12	4.50	7.18	61.84
Dragonfly larvae Hemicorduliidae	2.37	4.88	3.60	6.85	68.68
Dragonfly larvae Libellulidae	2.15	4.36	3.65	6.11	74.80
Caddisfly larvae Hydroptilidae	1.89	3.85	4.08	5.41	80.20
Fairy shrimps Atyidae	2.15	3.77	2.18	5.29	85.49
True Fly larvae s-f Orthocladiinae	1.72	2.70	1.17	3.79	89.28
True Fly larvae 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.%
True Fly larvae s-f Chironominae	4.72	18.60	7.09	27.50	27.50
Snails Hydrobiidae	3.74	12.08	4.54	17.86	45.36
Snails Physidae	2.81	9.67	4.32	14.29	59.65
Worms Oligochaeta	2.70	8.17	3.30	12.08	71.73
Dragonfly larvae Megapodagrionidae	2.43	7.43	3.03	10.98	82.71
Dragonfly larvae Isostictidae	1.45	3.67	1.28	5.42	88.13
Snails Planorbidae	0.79	1.59	0.78	2.35	90.48

Group Autumn 2008

Average similarity: 60.24

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
True Fly larvae s-f Chironominae	3.77	14.57	6.12	24.18	24.18
Snails Hydrobiidae	3.11	11.74	5.98	19.48	43.67
Dragonfly larvae Megapodagrionidae	2.24	7.00	3.00	11.61	55.28
True Fly larvae s-f Orthocladiinae	2.30	5.76	2.29	9.57	64.85
True bugs Notonectidae	1.87	5.35	3.11	8.87	73.72
True Fly larvae Stratiomyidae	1.45	3.74	1.24	6.21	79.93
Worms Oligochaeta	1.34	2.46	0.78	4.09	84.02
Snails Physidae	1.20	2.10	0.73	3.49	87.51
Flatworms Dugesiidae	1.15	2.00	0.70	3.31	90.82

Group Spring 2008

Average similarity: 52.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Snails Physidae	2.92	12.47	4.82	23.87	23.87
Worms Oligochaeta	2.24	9.31	2.70	17.81	41.68
True Fly larvae s-f Chironominae	2.57	7.72	0.77	14.77	56.44
Snails Hydrobiidae	2.22	6.22	1.09	11.90	68.35
True bugs Notonectidae	1.26	4.09	1.34	7.82	76.17
Dragonfly larvae Megapodagrionidae	1.09	4.04	1.19	7.72	83.89
Snails 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.%
Snails Hydrobiidae	3.36	13.95	5.78	23.95	23.95
True Fly larvae s-f Chironominae	3.22	12.90	5.48	22.15	46.10
True Fly larvae s-f Orthocladiinae	2.18	7.88	2.89	13.53	59.63
Dragonfly larvae Megapodagrionidae	1.59	5.08	1.32	8.72	68.36
Dragonfly larvae Coenagrionidae	1.30	3.40	1.31	5.83	74.19
Worms Oligochaeta	1.07	3.25	1.32	5.58	79.77
True bugs Notonectidae	1.21	2.64	0.79	4.53	84.30
Dragonfly larvae Isostictidae	1.13	2.26	0.77	3.89	88.18
Caddisfly larvae 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.%
True Fly larvae s-f Chironominae	3.68	14.35	2.88	25.69	25.69
Snails Hydrobiidae	3.16	13.14	3.68	23.52	49.22
True bugs Notonectidae	1.77	5.37	0.92	9.61	58.82
Dragonfly larvae Megapodagrionidae	1.38	4.07	1.28	7.30	66.12
Snails Planorbidae	1.60	4.03	1.27	7.22	73.34
Snails Physidae	1.54	3.96	1.26	7.10	80.44
Dragonfly larvae Coenagrionidae	1.09	3.31	1.33	5.92	86.37
True Fly larvae s-f Orthocladiinae	0.90	1.42	0.48	2.54	88.91
True Fly larvae s-f Tanypodinae	0.81	1.25	0.48	2.23	91.14

SIMPER Terrys Creek 2005 – 2009

Data worksheet
Name: Terrys 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

Group Autumn 2005
Average similarity: 69.53

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dragonfly larvae Megapodagrionidae	4.28	8.68	8.63	12.48	12.48
Snails Hydrobiidae	3.36	7.27	14.80	10.45	22.93
True Fly larvae s-f Chironominae	3.72	5.63	2.01	8.10	31.03
Dragonfly larvae Isostictidae	2.58	5.54	13.25	7.97	39.00
Worms Oligochaeta	2.90	5.12	5.83	7.36	46.36
Flatworms Dugesiidae	2.73	4.89	5.00	7.04	53.39
Snails Physidae	2.46	4.70	3.87	6.76	60.16
Mussels Corbiculidae	2.38	4.28	8.30	6.15	66.31
True Fly larvae s-f Tanypodinae	2.77	4.11	14.09	5.91	72.22
True bugs Notonectidae	2.46	4.09	2.80	5.89	78.11
Dragonfly larvae Hemicorduliidae	2.78	3.94	3.39	5.67	83.78
Snails Planorbidae	1.80	3.62	5.83	5.20	88.98
Leeches 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.%
True Fly larvae s-f Chironominae	5.63	13.05	19.49	20.08	20.08
Snails Physidae	3.14	6.76	7.02	10.41	30.49
Worms Oligochaeta	3.17	6.51	11.44	10.02	40.52
Dragonfly larvae Megapodagrionidae	2.93	6.38	16.31	9.82	50.33
Dragonfly larvae Isostictidae	2.57	5.61	6.89	8.63	58.96
Mussels Corbiculidae	2.05	3.57	12.60	5.50	64.46
True Fly larvae s-f Tanypodinae	2.26	3.50	1.77	5.38	69.84
Flatworms Dugesiidae	1.52	3.33	20.76	5.13	74.97
Aquatic mites Acarina	1.88	3.10	2.59	4.78	79.74
True bugs Notonectidae	1.47	2.70	3.90	4.15	83.90
Dragonfly larvae Libellulidae	2.45	2.70	0.58	4.15	88.04
Snails 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.%
Dragonfly larvae Megapodagrionidae	4.95	8.98	18.42	12.34	12.34
Dragonfly larvae Hemicorduliidae	4.41	8.71	18.55	11.98	24.31
Worms Oligochaeta	4.04	8.33	18.95	11.45	35.77
Snails Hydrobiidae	3.58	5.51	2.85	7.58	43.34
True bugs Notonectidae	2.23	4.48	14.83	6.16	49.50
Flatworms Dugesiidae	2.63	4.25	2.15	5.85	55.35
True bugs Gerridae	1.73	3.74	15.97	5.14	60.48
Snails Physidae	2.33	3.70	1.32	5.08	65.57
True Fly larvae s-f Tanypodinae	2.44	3.70	1.32	5.08	70.65
True Fly larvae s-f Chironominae	2.67	3.68	2.86	5.06	75.71
Dragonfly larvae Coenagrionidae	2.10	3.62	3.89	4.98	80.69
Dragonfly larvae Isostictidae	1.80	3.45	5.69	4.75	85.44
Aquatic mites Acarina	1.52	3.05	15.97	4.19	89.63
Dragonfly larvae 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.%
Snails Hydrobiidae	4.10	9.26	5.36	14.08	14.08
Dragonfly larvae Megapodagrionidae	3.47	8.29	5.44	12.60	26.68
True Fly larvae s-f Chironominae	3.19	7.79	4.33	11.84	38.52
Flatworms Dugesiidae	2.60	5.83	2.72	8.85	47.37
Snails Physidae	2.59	5.46	2.48	8.29	55.66
True bugs Notonectidae	2.19	5.03	6.23	7.64	63.30
Worms Oligochaeta	1.93	4.37	3.50	6.64	69.94
True Fly larvae s-f Tanypodinae	2.09	3.92	2.41	5.96	75.90
Dragonfly larvae Hemicorduliidae	1.68	3.07	1.30	4.66	80.56
Dragonfly larvae Isostictidae	1.38	2.07	1.31	3.15	83.71
True Fly larvae s-f Orthocladiinae	1.29	1.75	0.77	2.66	86.36
Dragonfly larvae Libellulidae	0.97	1.40	0.76	2.13	88.50
Dragonfly larvae 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.%
True Fly larvae s-f Chironominae	4.77	14.86	7.37	22.92	22.92
Snails Hydrobiidae	3.55	10.82	3.75	16.68	39.60
Dragonfly larvae Megapodagrionidae	2.98	8.85	4.52	13.66	53.26
Snails Physidae	2.57	7.67	4.19	11.83	65.08
Flatworms Dugesiidae	2.43	6.32	2.15	9.75	74.83
Worms Oligochaeta	1.85	4.55	1.27	7.01	81.85
Dragonfly larvae Hemicorduliidae	1.52	2.87	1.21	4.42	86.27
True Fly larvae s-f Tanypodinae	1.00	2.33	1.35	3.60	89.87
Mussels 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.%
Snails Hydrobiidae	3.50	14.68	4.25	22.02	22.02
Dragonfly larvae Megapodagrionidae	3.03	12.52	7.16	18.78	40.81
True bugs Notonectidae	2.29	9.65	6.24	14.48	55.29
Snails Physidae	2.35	8.98	5.21	13.48	68.77
Flatworms Dugesiidae	1.66	6.76	7.68	10.14	78.90
Worms Oligochaeta	1.37	4.27	1.31	6.40	85.30
True Fly larvae 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.%
Snails Hydrobiidae	3.61	13.31	7.64	21.51	21.51
Snails Physidae	3.19	11.33	6.91	18.30	39.81
Dragonfly larvae Megapodagrionidae	3.06	10.70	4.47	17.29	57.10
True Fly larvae s-f Chironominae	2.90	8.20	1.27	13.25	70.35
Worms Oligochaeta	2.07	6.47	3.13	10.46	80.81
Flatworms Dugesiidae	1.34	3.47	1.32	5.61	86.42
Mussels 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.%
Dragonfly larvae Megapodagrionidae	3.52	12.12	7.99	19.45	19.45
Snails Hydrobiidae	3.60	11.87	5.08	19.05	38.50
True bugs Notonectidae	2.00	5.82	2.87	9.33	47.83
Dragonfly larvae Isostictidae	1.71	5.09	3.92	8.16	55.99
Worms Oligochaeta	1.55	4.70	4.88	7.55	63.53
Snails Physidae	1.80	4.19	1.13	6.72	70.25
Flatworms Dugesiidae	1.60	3.96	1.31	6.35	76.60
True Fly larvae s-f Tanypodinae	1.29	2.94	1.24	4.72	81.32
True bugs Gerridae	0.74	1.54	0.79	2.47	83.79
Dragonfly larvae Coenagrionidae	0.94	1.45	0.78	2.33	86.12
Dragonfly larvae Hemicorduliidae	0.86	1.45	0.77	2.32	88.43
True Fly larvae 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.%
Snails Hydrobiidae	3.58	11.58	4.65	17.30	17.30
Dragonfly larvae Megapodagrionidae	3.49	11.30	5.22	16.89	34.19
True Fly larvae s-f Chironominae	3.03	10.22	5.42	15.27	49.46
True Fly larvae s-f Tanypodinae	2.28	6.67	4.35	9.97	59.43
Flatworms Dugesiidae	1.88	5.70	3.74	8.52	67.95
Snails Physidae	1.73	5.51	3.75	8.23	76.18
Worms Oligochaeta	1.87	5.40	2.58	8.06	84.24
Dragonfly larvae Isostictidae	1.38	4.58	3.88	6.85	91.09

Appendix 6 BIOENV output

BIOENV of all five creeks with replicates merged for 2005 to 2009

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

Resemblance worksheet
Name: All five creeks(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 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall
 13 Altitude
 14 Bedrock
 15 Boulder
 16 Cobble
 17 Total Length Pipe
 18 No. Outlets
 19 Catchment Area
 20 Ratio TLP/CA
 21 Ratio NO/CA

Best results
No.Vars    Corr. Selections
      4    0.401 4,9,16,21
      5    0.394 3,4,9,16,21
      5    0.391 4,9,10,16,21
      5    0.387 4,9,16,20,21
      5    0.385 4,8,9,16,21
      5    0.385 4,9,12,16,21
      4    0.378 8,9,16,21
      3    0.374 4,9,21
      5    0.372 3,4,9,20,21
      5    0.372 4,9,16,17,21
```

BIOENV of Archers Creek 2005 to 2009

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

Resemblance worksheet
Name: Archers(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 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall

Best results
No.Vars    Corr. Selections
      3    0.323 4,5,7
      4    0.309 4,5,7,8
      4    0.305 1,4,5,7
      2    0.298 5,7
      2    0.298 4,7
      5    0.298 3-5,7,8
      1    0.297 7
      3    0.297 4,7,8
      5    0.295 1,4,5,7,8
      4    0.295 3,4,7,8
```

BIOENV of Shrimptons Creek 2005 to 2009

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

Resemblance worksheet
Name: Shrimptons(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 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall

Best results
No.Vars    Corr. Selections
      2    0.286 8,10
      3    0.260 1,8,10
      3    0.260 8,10,12
      3    0.259 8,10,11
      4    0.257 1,8,10,11
      3    0.251 7,8,10
      5    0.250 1,7,8,10,11
      5    0.249 1,7,8,10,12
      4    0.248 7,8,10,12
      4    0.246 1,8,10,12
```

BIOENV of Buffalo Creek 2005 to 2009

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

Resemblance worksheet
Name: Buffalo(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 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall

Best results
No.Vars    Corr. Selections
      5    0.329 2,3,5,10,12
      4    0.326 2,3,5,12
      3    0.322 3,5,12
      5    0.316 2,3,5,7,10
      5    0.315 2,3,5,8,12
      5    0.312 2,3,5,7,12
      4    0.312 3,5,7,12
      5    0.310 2-5,12
      4    0.310 3,5,8,12
      4    0.308 2,3,5,7
```

BIOENV of Porters Creek 2005 to 2009

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

Resemblance worksheet
Name: Porters
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 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall

Best results
No.Vars    Corr. Selections
      2    0.447 1,8
      3    0.444 1,5,8
      3    0.442 1,2,8
      4    0.427 1,5,7,8
      4    0.417 1,3,5,8
      4    0.416 1,2,7,8
      3    0.408 1,7,8
      3    0.408 1,3,8
      4    0.407 1-3,8
      1    0.404 8
```

BIOENV of Terrys Creek 2005 to 2009

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

Resemblance worksheet
Name: Terrys
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 Log 10 Faecal Coliform
  2 Log 10 Ammonia
  3 Log 10 Oxidised Nitrogen
  4 Log 10 Total Phosphorus
  5 Log 10 Total Kjeldahl Nitrogen
  6 Alkalinity (Total)
  7 Log 10 Turbidity
  8 Log 10 Total Dissolved Solids
  9 pH
 10 DO
 11 Temp
 12 Rainfall

Best results
No.Vars    Corr. Selections
      4    0.310 3,5,10,12
      3    0.305 5,10,12
      5    0.303 3,5,10-12
      5    0.298 3-5,10,12
      5    0.298 3,5,9,10,12
      4    0.296 5,9,10,12
      4    0.296 5,10-12
      3    0.291 3,5,10
      3    0.291 3,5,12
      4    0.289 3,4,10,12
```