Institute of Freshwater Ecology

Biological Assessment of Buckfastleigh Sewage Treatment Works, River Dart

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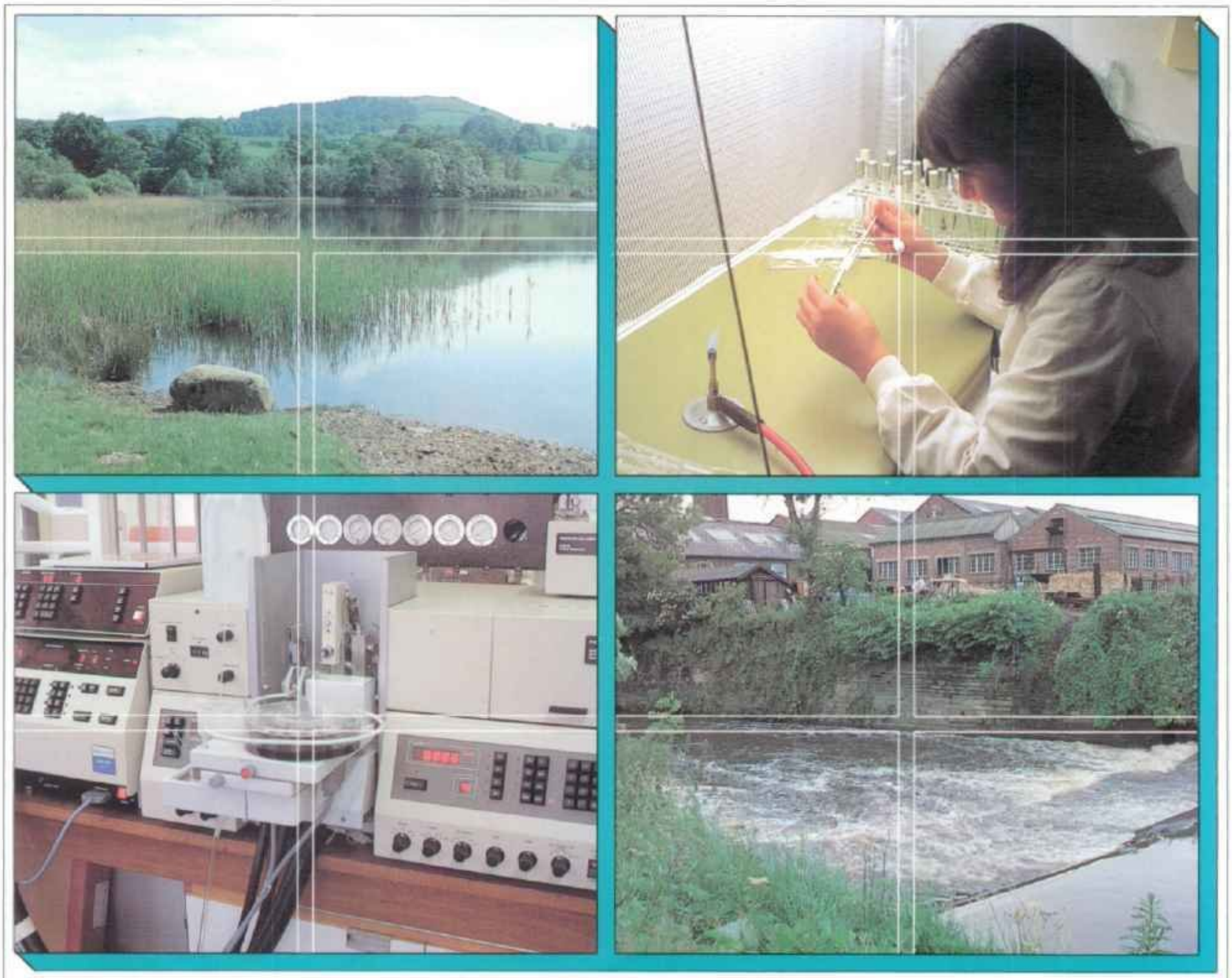

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EXECUTIVE SUMMARY

Buckfastleigh Sewage Treatment Works (STW) discharges organic effluent and consented levels of the organophosphorus pesticides Diazinon, Sulcofuron, Propetamphos and Chlorfenvinphos into the River Dart.

Previous biological surveys and routine monitoring of the River Dart, between Dart Bridge and Staverton, have indicated slight organic enrichment caused by the discharge from the STW but have provided no firm evidence of pesticide impact on the benthic macroinvertebrate communities.

The surveys as a whole have been difficult to evaluate because they involved different sampling sites and sampling methods. The ordering and standardising of data from these reports provides a means of exploiting their potential to elucidate, at a future date, the processes in the River Dart leading to changes in ecological quality.

In July 1997 the Institute of Freshwater Ecology conducted a sampling programme at seven sites on the River Dart near Buckfastleigh, from Dart Bridge to Staverton Bridge. Three quantitative Surber samples and a single qualitative three minute RIVPACS standard kick sample were taken at each site. Environmental data were recorded both on site and from maps.

The information from the Surber samples does not show a definite impact of an organic or chemical nature caused by the effluent from the STW because intra-site variations between most of the replicate samples can be as great as inter-site variations. However, an overall decrease in water quality from upstream to downstream is apparent with the samples from Dart Bridge at the most upstream point, and Staverton Bridge at the most downstream point, being quite distinct both from each other and from the rest of the samples. A comparison with the 1994 Surber survey showed a deterioration in 1997 at the two most downstream sites.

The information from the RIVPACS samples shows some evidence for organic enrichment with a slight indication of low level pesticide effect. However, the site 30m downstream of the effluent discharge is of better ecological quality than either the site 400m upstream, or the site 300m downstream, of the discharge. Comparison with the 1995 survey demonstrates an improvement in ecological quality immediately downstream of the STW discharge in 1997 but a deterioration in the two most downstream sites.

It is concluded, on the basis of the analysis of the biological evidence to date, that there is an overall upstream to downstream decline in ecological quality of the River Dart in the study reach but this decline cannot be directly linked to the effluent from the Buckfastleigh STW, nor can the STW be eliminated as a contributory factor.

BIOLOGICAL ASSESSMENT OF BUCKFASTLEIGH SEWAGE TREATMENT WORKS, RIVER DART

INTRODUCTION

The Buckfastleigh (Kilbury) Sewage Treatment Works discharges into the River Dart about 34km from the source of the river. The biological quality of the watercourse below the plant has for some time been a cause for concern to the Environment Agency. In addition to organic effluent, organophosphate pesticides are also released with industrial detergents at a consented level from local manufacturing processes. Routine biological monitoring has been carried out by the Environment Agency, and three reports have also been commissioned to assess the impact, if any, of these discharges on the river during the period 1990 - 1996. These surveys have indicated a decline in water quality below the discharge point with signs of slight localised organic pollution but have not been able to detect firm evidence of problems related to pesticides, although it has not been possible to eliminate this as a contributory cause in the decline of water quality.

The aim of the current project is to provide information on the River Dart near to the Buckfastleigh STW showing the likely impact that the Treatment Works might have on the biological quality of the river. The work is presented in three parts. A data and literature review is followed by a survey of benthic macro-invertebrates first by quantitative surber sampling and secondly using qualitative RIVPACS samples with subsequent identification of the fauna to species level.

PART 1

DATA REVIEW

a) NRA/Environment Agency data sources

It was considered that the most important body of information available was that already in the hands of the Environment Agency (EA). This had been gathered by their own biologists or commissioned from independent bodies over the last seven years and was exactly the type of information, from appropriate locations, required to make a biological assessment of any impact on the River Dart that might be caused by the Buckfastleigh Sewage Treatment Works. The potential of this data has not been fully realised to date because it comprises many samples collected at different sites and using a variety of sampling methods.

The sources of information are the routine biological assessments based on standard RIVPACS style kick samples and carried out by the Environment Agency (formerly the National Rivers Authority), a quantitative Surber survey carried out by P. Green in 1994 for the Environment Agency, a non-standard kick sample survey completed by Acer Environmental for South West Water in 1995, a RIVPACS kick sample survey by the Institute of Freshwater Ecology (IFE) in 1995, and the current IFE Surber and RIVPACS survey in 1997.

b) Other reference sources

The search for data from the Biological Records Centre, English Nature, Local Environmental Records Centres and Naturalists Trusts provided no useful data for the assessment of the impact of the Buckfastleigh STW because of the type of information available from these sources and the way in which it is recorded. The majority of the plant and animal types which are particular indicators of stress in aquatic environments are not recorded in a way which enables an impact assessment, or comparisons with existing data recorded by aquatic ecologists, to be made.

i) Summary presentation of data

In order to provide an historical perspective to the area of impact assessment, and to provide a basis for comparison between surveys, the invertebrate data for summer season only has been collated and tabulated in a uniform format that allows an overview of all sites and surveys of this reach of the River Dart for the years 1990 - 1997. This has required the reduction of the information to a 'common denominator' format. Any obvious mathematical errors or procedural mistakes in previously produced reports were corrected before data were used in the spreadsheet. Therefore the figures used may differ slightly from those given in the original reports.

A sketch map showing the location of all summer survey sites near Buckfastleigh on the River Dart, 1990 - 1997 is given in Figure 1. Table 1 lists all summer survey site location details in upstream to downstream order on the River Dart between Dart Bridge and Staverton Bridge, giving the nearest equivalent sites, from 1990 - 1997.

A summary presentation of macroinvertebrate data is shown in Table 2. This shows information held in common for all summer survey sites 1990 - 1997 on the River Dart between Dart Bridge and Staverton Bridge. For each sample, at each site, the following information is presented: survey name or surveyor, grid reference, site description, site number, sampling method, date (year), number of scoring families, total number of families, Biological Monitoring Working Party (BMWP) score, ASPT, total abundance, number of insects, % insects, number of non-insects, % non-insects, number of chironomids, % chironomids. This allows the information to be accessed in a variety of ways, for example, by site order from upstream to downstream, by date, by surveyor, and by sampling method. Both spatial and temporal variations can now be examined in detail at a future date if required. It is also possible to relate a sampling site to its neighbouring sites. Although it was not part of the remit of this present contract, data from this summary has been used to make comparisons between results from two surveys, undertaken in 1994 and 1995, and results obtained in the summer of 1997.

ii) An assessment of impacts of the sewage outflow on river ecology
Phil Green's 1994 survey concluded that some impact on the fauna downstream of the Buckfastleigh (Kilbury) STW was evident but localised. Data from the survey indicated that the impact was mostly from organic pollution. It was difficult to discern any pesticide impact as this may have been masked by the organic influence.

In 1995 the General Quality Assessment (GQA) showed some decline below the Kilbury works. In the same year the Institute of Freshwater Ecology (IFE) survey concluded that some changes in the invertebrate fauna were apparent immediately downstream of the STW but that these changes were considered insignificant. Also in 1995 Acer Environmental, for South West Water, came to similar conclusions as the IFE but added that current levels of outputs would not have any detrimental affects on the biological quality of the River Dart.

On the basis of these findings the Environment Agency assessed the impact from the STW on invertebrate fauna as localised but was unable to reach a decision as to whether the impact was only organic in origin and therefore pesticide influence could be discounted. It was recognised that any pesticide influence would be difficult to isolate from that caused by organic pollutants, flow regime and substrate type. Factors such as sampling difficulties and low flows would provide further complications in interpreting the data..

Overall the surveys from 1990 to 1996 illustrated that the Buckfastleigh (Kilbury) STW had a recognised but minor and localised impact on the river which was mainly considered to be organic in origin with only the slightest indication or suspicion of pesticide influence.

LITERATURE REVIEW

The search of literature on aquatic macroinvertebrates, plants and algae in the River Dart was not very productive. The fourteen papers from the Freshwater Biological Association (FBA) Library catalogue, referring to the invertebrates and plants of the River Dart, generally made no contribution to an understanding of whether the River Dart is being affected by discharges from Buckfastleigh STW. Those papers from the FBA library which were reviewed are denoted by an asterisk in the references listed at the end of this report. Reports which were consulted for the effects of pesticides on aquatic macroinvertebrates are also listed in the references. A search of the literature for information on macroinvertebrates in the River Dart using the computer-based Bath Information and Data Services (BIDS) produced no further references.

PART 2

BENTHIC MACROINVERTEBRATE SURVEYS (SUMMER)

A. SURBER SURVEY

A.1 SITE LOCATIONS

Seven sites were sampled. These included an upstream control site near Dart Bridge and one other site above both the sewage treatment plant discharge point and the emergency storm overflow from the treatment plant. Five sites were chosen downstream of the discharge point. Table 3 gives the site details and National Grid References and Figure 2 is a sketch map to show the location of the sites sampled by the Institute of Freshwater Ecology (IFE) in July 1997.

A.2. METHODS

Quantitative samples were taken to facilitate a direct comparison between sites, to provide replicates, and to eliminate 'noise' by concentrating sampling effort in as near as possible the same mesohabitat type (ie midchannel gravel/cobble) each time. Three replicate samples were taken at each of seven sites on the River Dart in July 1997 using a Surber sampler (Standing Committee of Analysts Reports 1982). The coarse nature of the substratum made the use of box or cylinder samplers unsuitable because they need to be embedded in the substratum. The Surber sampler sits on the surface of the substrate to demarcate the sampling area. The conditions were probably at the limit for the use of a Surber sampler because the substratum included large boulders and bedrock in many places.

The samples were placed in polythene bags and preserved in 8% formaldehyde solution in the laboratory. The samples were sorted and identified to species level where possible, with the exception of Oligochaeta, Chironomidae, Sphaeriidae and non-BMWP families of Diptera and Hydracarina. In most instances, all the animals were removed from the sample and preserved in vials of 70% industrial methylated spirit containing glycerol. Where there were exceptionally large numbers of animals, then a only a fraction of the sample or of a particular group of animals was picked. Numbers were then multiplied up to get the total abundance. In all cases the entire sample was checked to ensure that all taxa present would feature in the species list.

A.3. RESULTS

A.3.1 Species identification and frequency

Table 4 presents the species identified in each of the Surber sample replicates together with the actual numbers of animals found and their percentage relative abundance in the sample. The sites are numbered 1 to 7 in Figure 2. Each replicate within a sample was labelled with the site number and a letter A, B, or C. The types and proportions of the different species vary between replicates at a single site and between sites (Table 4). The total numbers of animals vary a great deal from sample to sample - from as few as 55 to as many as 1261.

A.3.2 Biotic indices

In order to understand the significance of the differences in species composition and abundance observed in Table 4, various biotic indices were calculated for each individual replicate sample and for a combination of the three replicate samples at each site. Mean values of the three replicates at each site were also calculated (Table 5).

A.3.2.1 Number of taxa

The number of scoring taxa ranges from 7 to 22 in individual replicates but rises to as many as 25 in the combined replicates (Table 5). Non-BMWP scoring taxa account for no more than three extra taxa in any sample. The lowest average number of scoring taxa is recorded at Site 2, above the STW discharge. The highest average number of scoring taxa was recorded at Site 3, immediately below the STW discharge.

A.3.2.2 BMWP score

Biological Monitoring Working Party (BMWP) scores fluctuate from 26 to 144 for individual samples (Table 5). The highest score is achieved for combined replicates from Site 3, d/s STW, and the lowest at Site 7. BMWP scores for combined replicates are plotted as a bar chart in Figure 3, which shows the degree of variation between sites although general upstream to downstream decrease in score is discernible.

A.3.2.3 ASPT

Average score per taxon (ASPT) gives a more accurate measure of the quality of the sites than does BMWP score (Armitage et al 1983). The ASPT values are shown in Table 5 and have been plotted for the combined replicates in Figure 4. ASPT value falls from 6.62 at the control (Site 1) to 5.69 and 5.84 at Sites 2 and 3 respectively. Values rise again at Sites 4 and 5 before decreasing at the sites furthest downstream (Sites 6 and 7). Site 1 has the highest value and Site 2 the lowest.

A.3.3 Relative proportions of major groups

In order to understand the reasons underlying the difference in biotic scores for the Surber samples, and in particular to ascertain whether they reflected environmental quality changes that might be attributed to an impact caused by the discharge of organic or chemical effluent from the STW, the relative abundances of different groups of organisms were examined. Counts were made of animals belonging to the major groups: flatworms, molluscs, oligochaetes, leeches, crustaceans, mayflies, stoneflies, dragonflies, beetles, caddis flies and true flies were counted. The total numbers of individuals in each of these orders (or groups) in individual replicate, combined and averaged Surber samples can be found in Table 6. The differences in proportions of major groups in individual samples is illustrated in Figure 5, and for combined samples in Figure 6.

Examination of the proportions in combined replicates (Figure 6) indicates a pronounced trend for an increase in the proportion of molluscs downstream but a decrease in the proportion of oligochaetes, mayflies, stoneflies, caddis and true flies. The sites immediately above and below the STW discharge point show deviations from this trend, Site 2 having a high proportion of oligochaetes and Site 3 having an unusually high proportion of molluscs.

A.3.4 Insects and non-insects

BMWP scores and ASPT reflect the quality of a site since the scores allocated to taxa are based on the extent to which they will tolerate organic pollution. However these biotic indices may not always reflect impacts from other sources, such as physical environmental changes or toxic pollution, especially at low levels of impact. Insects and crustaceans are especially vulnerable to chemical pollutants, such as pesticides. Another approach is to examine differences in the proportions of the various animal groups by looking at the relative frequency of insects to non-insects and therefore to determine whether they reflect chemically-imposed stress. Crustacea occur naturally in very low numbers in the River Dart and are not suitable for study in this respect.

Insect species numbers and relative proportions are listed in Table 7. Non-insect species data are listed in Table 8. A summary showing the total numbers and percentages of insect and non-insect taxa is shown in Table 9. The proportions of insects to non-insects in the combined replicate surber samples for each site are shown as a bar chart in Figure 7. This demonstrates an inverse relationship between insects and non-insects with a general increase in non-insects from upstream to downstream. Site 4 is anomalous with almost equal proportions of insects to non-insects. Site 3, immediately downstream of the STW discharge, has slightly higher numbers of non-insects than would be expected from a gradual natural upstream to downstream transition, and the numbers of insects at Site 2 are lower than might be expected for a site above the discharge point and relatively close to the control site.

A.3.5 Proportion of Chironomids

High numbers of insects, such as chironomids and psychodids, can occur at organically polluted sites. Chironomids in particular are often associated with these conditions. Figure 8 shows the proportion of chironomids as a percentage of the insects present in each combined replicate sample. Chironomids represented between 45% and 55% for most sites but at Site 2 chironomids accounted for only 26% of all insects while at the most downstream site, Site 7, they reached a level of 74%.

A.3.6 Families sensitive to pesticides

Both organic and pesticide pollutants affect the types of animals and their frequency within a benthic community. BMWP score and ASPT more accurately reflect the extent of any impact from organic pollutants because the scoring system is based on susceptibility to these. Insects in general are more vulnerable than non-insects to organophosphate toxins (Ashby-Crane et al 1994). Ephemeroptera (mayflies), Trichoptera (caddis flies) and Plecoptera (stone flies) are especially susceptible in even low concentrations although all insects and some non-insects will be affected at higher concentrations (House et al 1992; National Rivers Authority 1995).

The numbers and relative abundance of mayfly, caddis and stonefly families in combined replicate Surber samples is given in Table 10. Many families are represented by only a few individuals at some of the sites; these include Ephemeridae, Nemouridae, Chloroperlidae, Hydroptilidae and Goeridae. It is difficult to detect any pattern with these families. Other families occur in higher numbers. Some of these tend to show a peak at particular sites such as the Baetidae and Rhyacophilidae at Site 2; Leuctridae, Limnephilidae, Leptoceridae, Lepidostomatidae, Brachycentridae and Sericostomatidae at Site 3; with Heptageniidae and Hydropsychidae at a maximum in Site 4.

Charts showing the actual numbers of three of the more commonly occurring families in combined replicate Surber samples at each site (Baetidae, Ephemerellidae and Leuctridae) are shown in Figure 9 and the percentage frequencies in Figure 10. The distribution patterns illustrated are complex and difficult to interpret. The distribution of these families might just as easily reflect natural randomness associated with habitat differences as provide evidence for or against pollution impact.

A.3.7 Correspondence analysis (CANOCO)

Quantitative Surber samples cannot be analysed with RIVPACS because that program requires that samples are collected using the standardized three minute kick sampling method (Environment Agency 1997). One statistical tool which can be used to determine the relationships between the Surber samples is canonical correspondence analysis. This can be carried out with the CANOCO programme (Ter Braak, 1988). The numbers of individuals in each of the major groups for each individual replicate Surber sample were used in a correspondence analysis to see how closely replicates at one site were related to each other and how distinct were the samples from each site in comparison with other sites. An annotated version of the computer printout of this analysis is found in Figure 11. This shows that the individual samples from the control Site 1 are quite different from each other but as a group are well separated from other sites. At the other end of the spectrum the samples from site 7 are very similar and closely aligned as well as forming a distinct site grouping. As for the other samples, there is a remarkable degree of overlap in their characteristics with a tendency for as much variation within a site as between sites. In other words there appears to be a great deal of natural variation and noise within the replicates despite the fact as near as possible the samples were taken in the same mesohabitats every time. Site 3, however, is more closely related to Site 6 and Site 7 than it is to other sites.

A.4. DISCUSSION

The quantitative Surber samples of benthic macroinvertebrates from sites upstream and downstream of Buckfastleigh (Kilbury) Sewage Treatment Works were examined as individual replicates, as the three replicates combined for each site, and as the mean of the three replicates for each site. The species present in the samples, their numbers and relative frequency, their biotic scores, the relative proportions of the major groups, the ratio of insects to non-insects, the proportional representation of chironomids, the frequency of animals belonging to families particularly sensitive to pesticides were all studied to see if they provided evidence for any impact in terms of organic or organophosphate pesticide output from the sewage treatment plant into the River Dart. Finally the data relating to the representation of the different orders of macroinvertebrates was subjected to a canonical correspondence analysis.

It is immediately obvious that both the types and number of macroinvertebrates in the Surber samples exhibit great variability. Biotic scores were calculated to determine the significance of the variations. Perhaps contrary to expectations, the lowest average number of scoring taxa was related to the replicates from Site 2, at 150m upstream of Austin's Bridge and upstream of both the STW discharge point and storm overflow. On the other hand, the highest average number of scoring taxa was recorded at Site 3, 30m below the STW outfall.

The BMWP scores have a wide range between individual samples with the highest score achieved at Site 3 below the STW. Within the wide variation of score a general upstream to downstream decrease in scores can be detected.

ASPT values at both Site 2 Austin's Bridge and Site 3 below the STW fall slightly from the highest level at the control Site 1, 15m upstream of Dart Bridge. There is a partial recovery at the next two downstream sites, 4, 100m above the railway tunnel, and Site 5, 200m below the railway tunnel. The ASPT values decrease again at the lowermost study sites, Site 6 which is upstream of Riverford Bridge and Site 7 located 15m upstream of Staverton Bridge. It is interesting to note that low values are found not only at the site immediately below the STW discharge point but also well above it, closer to the control site. The lowest value of ASPT is recorded for the most downstream site, Site 7 near Staverton Bridge.

From the relative proportions of the major groups it is possible to see an overall upstream to downstream change in community composition, particularly with regard to molluscs, which increase in proportion in a downstream direction, and mayflies, stoneflies, caddis, true flies and oligochaetes, which increase in an upstream direction. However, the sites immediately upstream and downstream of the STW do not conform to this general trend.

The ratios of insects to non-insects show a relative loss of insects progressively from Sites 1 to 7. Site 3 and Site 4, the first two sites below the STW discharge, do not conform to the otherwise gradual downstream transition between the two groups. The relatively low percentage of insects at Site 3 results from the presence of high proportions of molluscs (*Ancylus fluviatilis* and *Potamopyrgus jenkinsi*) and oligochaetes. Insects and non-insects are almost equal at Site 4, where the relatively high proportion of insects cannot be explained by a large presence of chironomids that might be associated with sewage effluent. The proportion of chironomids is about the same as in the majority of sites where they account for between 45% and 55% of all insects.

An examination of the frequency of occurrence of animals belonging to families which are particularly vulnerable to organophosphate chemicals, in terms of behavioural change or mortality, shows that the sites immediately below the STW discharge point, where a problem might be expected to manifest itself, are characterised by the highest abundances of these sensitive taxa.

Canonical correspondence analysis confirms that the variation between replicates from a single site can be as great as that between replicates from different sites with the exception of the uppermost Site 1 at Dart Bridge, and the lowest of the reach, Site 7 at Staverton Bridge. These two sites seem to represent the two ends of a spectrum which is typified by a decline in river quality (as assessed by macroinvertebrates) from upstream to downstream.

The evidence from the quantitative Surber samples suggests an impact of an organic nature at Site 3 for three reasons. At Site 3 the BMWP score increases while the ASPT value decreases, the numbers of molluscs increase, and the correspondence analysis indicates that Site 3 is more closely related in faunal composition to downstream Site 6 and Site 7. This does not, however, provide definitive evidence that the impact is caused by the Buckfastleigh (Kilbury) STW because at Site 2 the ASPT value has also fallen and the numbers of oligochaetes rise. Many of the variations in species and their abundances could be natural. There is no sign of pesticide effect on insects, including the particularly sensitive families which are found in their highest numbers at the four upstream sites.

The findings of this I.F.E. 1997 Surber survey differ from the only other Surber survey of this reach of the River Dart carried out by P. Green for the National Rivers Authority in 1994 (Green, 1994). The sampling sites in the two surveys are not always identical but it is possible to relate their results. In 1994 a decline was recorded in river quality in an upstream to downstream direction. At that time it was particularly noticeable immediately downstream of the effluent discharge and there was a recovery at the lowermost sites. In 1997 this is not the case. Although the downstream site nearest the discharge has a low ASPT, so has the site immediately upstream. There appears to be a slight recovery between sites 3 and 5 followed by an even bigger decline in ASPT values at the two sites which are most downstream.

In 1994 the top two sites, above both the STW discharge and the storm overflow, showed good invertebrate diversity with the majority of the community being insects. In 1997 this only holds true for Site 1. In the 1997 Site 2, further upstream than the 1994 Site 2 but both in the stretch of river between the control site and the STW storm overflow, there is a high level of non-insects, particularly oligochaetes and molluscs - groups which in 1994 did not start to increase in level until below the storm overflow. The 1997 Site 2 is closer to the confluence with the Mardle Tributary. It is possible that the input from this stream is having some localised effect on a site which was considered difficult to sample. The combination of these two factors may affect the faunal results from this location.

The dominance of insect species just below the STW discharge in 1994 was caused by the presence of 'red blood worm' chironomids, Chironomini. No such high numbers of insects were recorded in 1997 at this location. Although Chironomini were recorded here in 1997 and were the dominant group of chironomid, they are also present at all the other sites and were dominant in at least the two most downstream sites with which Site 3 also shows other similarities

Low water quality at Riverford Bridge in 1994 was thought to result from the sewage works but the Surber results in 1997 suggest that the quality of water decreases overall downstream. On the basis of the comparison between the results of the two Surber surveys it is possible to say that the water quality immediately below the STW discharge pipe is better in 1997 than in 1994 with fewer signs of organic enrichment or pesticide influence. Water quality further downstream at Riverford Bridge and Staverton Bridge is now demonstrated as lower than that indicated by the 1994 survey. It is suggested that this could be a delayed impact from the sewage discharge or other source, possibly associated with the effect of weirs and the impact of different adjacent topography. Sediment particles, to which pesticides may be bound (House et al 1991; Kawamoto and Urano 1989), could accumulate at these sites when the sediment load of the water column is deposited as fast flowing water is slowed down by the weirs.

The results of the 1997 Surber survey and the interpretations suggested for the intra-site and inter-site variations should be treated as tentative. Verification would require a much more detailed survey and analysis programme. The availability of RIVPACS kick samples taken at these sites at the same time enables the problems of variability in this stretch of the River Dart to be examined on a firmer statistical basis. The results of the RIVPACS sample analysis are presented in the next section of the report.

BENTHIC MACROINVERTEBRATE SURVEY (SUMMER)

B. RIVPACS SURVEY

B.1. SITE LOCATIONS

The seven sites at which RIVPACS three minute kick samples were taken on the River Dart were the same ones at which replicate Surber samples were collected. These include an upstream control site near Dart Bridge and one other site above the sewage treatment plant discharge point and also above the storm overflow from the plant. Five sites were chosen at increasing distances downstream of the discharge point. The reach studied was just over 6 Km in length. The location of these sites is shown in Figure 2. Table 3 presents the site details and National Grid References.

B.2. METHODS

The samples were collected according to the protocol in the RIVPACS manual (Environment Agency 1997). The samples were placed in labelled polythene bags and preserved in 8% formalin at the laboratory. The samples were sorted and identified to species level where possible with the exception of Oligochaeta, Chironomidae, and non-BMWP families of Diptera and Hydracarina. All the animals were removed from four of the samples but in the remaining three samples, animals from one quarter of the sample were picked and the numbers multiplied up to find the numbers for the whole sample. In every instance the whole sample was checked for single representatives of a taxon. Animals removed from the samples were preserved in 70% industrial methylated spirit with glycerol in glass vials.

Environmental data were also recorded at each site, and from maps, for use with the species data in the RIVPACS III+ programme.

B.3. RESULTS

B.3.1 Species identification and frequency

The species of macroinvertebrates recorded in each sample, the numbers found and their relative abundances are presented in Table 11. This shows the variation that exists in the composition of the benthic community at the different sites.

B.3.2 Biotic indices

To determine the significance of the observed differences in community structure, various biotic scores were calculated. A summary of biological data calculated from the RIVPACS samples can be found in Table 12.

B.3.2.1 Number of taxa

The highest number of BMWP scoring taxa (26) was found at Site 3, 30m downstream of the STW discharge. The lowest number of scoring taxa (18) was found at Site 6, upstream of the Riverford Bridge. Only two or three non-scoring taxa were identified from most of the sites; the exception was five non-scoring taxa at Site 6.

B.3.2.2 BMWP

The range of BMWP scores is illustrated in Figure 12. Scores drop from 145 at Site 1, which is the control at Dart Bridge, to 111 at Site 2 by Austin's Bridge. The STW discharge is below Site 2. The fall in score above the discharge point is unexpected. The highest BMWP score of 162 is achieved for Site 3 just 30m below the STW discharge. This is also unexpected. Scores continue to fall steadily at Sites 4 (123), 5 (118) and 6 (99) before showing a partial recovery at the most downstream Site 7 (138). There appears to be a tendency overall for a reduction in scores in a downstream direction.

B.3.2.3 ASPT

The range of ASPT values in the RIVPACS samples is shown in Figure 13. Site 1 has the highest ASPT of 6.59 as would be expected for the upstream control site. Site 2 shows a marked decrease with an ASPT of 5.84. Sites 3, 4, and 5 as a group have similar ASPTs of 6.23, 6.15 and 6.21 respectively. Sites 6 and 7 show the lowest ASPTs of 5.5 and 5.52. These values echo the trend shown by the BMWP scores, showing a general reduction in values and therefore water quality from upstream to downstream with a lower than expected value for Site 2. In contrast to the impression given by the BMWP scores, Site 7 shows little sign of recovery. The high BMWP scores for this site resulted from high numbers of low scoring taxa.

B.3.3 RIVPACS III+

B.3.3.1 RIVPACS III+ Predictions

The biological data and environmental data were analysed using the RIVPACS III+ program to assess the significance of differences in biotic scores between the RIVPACS samples at each site in terms of ecological quality. Details of the program are given in the RIVPACS III+ User Manual (Clarke et al 1997). This version of the program applies more stringent criteria to the data than previous versions, taking into consideration various sources of error from both sampling, recording and identification procedures. There are six ecological quality bands instead of the former four. In addition to predictions of membership of different quality bands it is now possible to make statistical comparisons between samples.

B.3.3.2 Quality bands

Species data and environmental data were analysed using the RIVPACS III+ program to assess the ecological quality band appropriate to each site. This procedure assigns an overall quality band based on observed over expected (O/E) number of taxa, ASPT and overall band based upon these values (GQA). The results of the predictions are shown in Table 13. The results show that the sites on the River Dart can be allocated to the three uppermost quality bands. Site 1 is band A, Sites 2 to 5 are band B, and Sites 6 and 7 are band C, demonstrating a decrease in water quality from upstream to downstream with the transition from band A to band B above the STW outflow.

B.3.3.3 Probability of group membership

Quality bands are based on the characteristics of a large number of sites in Great Britain. These unpolluted sites are divided on the basis of their biological characters into groups of similar sites which are allocated group numbers. RIVPACS predictions assess the probability of a new sample belonging to one or more of these defined groups on the basis of the sites' environmental characteristics. The seven sites on the Dart are most likely to belong to Group 15 but the probability with which they may belong to this and other groups varies from site to site. The faunal assemblages and environmental data therefore indicate that the characteristics of the river itself change slightly along the length of the studied reach. Figure 14 shows the probabilities of group membership at each site.

Based on the environmental data, the programme also predicts the fauna which should be captured at the site and lists specific probabilities of capture of each taxon. List are generated of the BMWP families or species not found but with a probability of capture greater than 50%, and the BMWP families or species actually found but with a probability of capture less than 50%. [Many of the species listed as not recorded in the samples were oligochaetes and chironomids which had not been identified to species level for this project]. These details for each site are summarised in Table 12. Site 3, below the discharge point, had the lowest number of expected but absent BMWP families and species (4 and 5) while Site 6 had the most expected but absent BMWP families (11). Site 4 had the lowest number of BMWP families with a low probability of capture (3) while Site 7 had the highest (8).

B.3.4 RIVPACS III+ comparisons

B.3.4.1 Test for statistically significant difference between samples

RIVPACS III+ was used again to make comparisons between the samples to find out if they were significantly different in statistical terms. The comparisons are based on the between-sample differences in observed over expected number of taxa and ASPT. Each sample is compared with every other sample. Matrices of the results of the comparisons are presented in Table 14 with a minus sign (-) representing no significance difference and a plus sign (+) representing a significant difference. There was very little significant difference, even between samples belonging to different ecological quality bands. In comparisons of O/E taxa Site 3 differs from Sites 5 and 6. In comparisons of O/E ASPT Sites 6 and 7 differ from Site 1, and Site 3 again differs from Site 6.

B.3.4.2 Probability of compared samples being different quality bands

The programme also calculates the percentage probability of each sample being the same, one or two better, or one or two worse quality bands than another sample. It is possible from this to see the extent of the differences on which the overall quality bands were based for the seven sites on the River Dart. A simplified version of the probability of difference in quality band based on O/E for number of taxa and ASPT and on the difference in overall GQA band for each site compared with every other site is presented in Table 15. In these tables the probabilities for one and two bands better have been added together to give the overall probability of the band being of better quality. The same has been done with the probabilities for one or two bands worse quality. The results from Table 15 are presented graphically in Figures 15, 16 and 17.

These probability figures shows the extent of the differences between the samples which were allocated to the different quality bands. Of particular interest are the samples at the boundaries of the quality bands; for example, between Site 1 (band A) and Site 2 (band B), and between Site 5 (band B) and Site 6 (band C). Reference to Table 15 reveals that there is a 66.4%, 82.6% and 71.2% probability that Site 2 is worse than Site 1 on the basis of difference in O/E number of taxa, ASPT and the overall band respectively. There is a 45% probability that Site 6 is the same as Site 5 on the basis of O/E number of taxa but 81.8% and 65.8% probability of Site 6 being worse than Site 5 using differences in O/E ASPT and the overall band. A comparison of Site 1 (band A) and Site 6 (band C) gives probabilities of 71%, 94.6% and 93% for Site 6 being worse than Site 1 for taxa, ASPT and overall values respectively. The actual breakdown of these probability figures gives probabilities of 49%, 31% and 48% that Site 6 is one band worse than Site 1; and 22%, 63.6% and 45% probabilities that it is two bands worse than Site 1. The probability figures demonstrate that in most cases the differences in values responsible for the allocation of quality bands are substantial.

B.3.5 Relative proportions of major groups

The faunal composition of the samples was further examined to find out if there might be subtle underlying changes in the structure of the benthic communities that might be related to an impact by pesticides which was not revealed by other means. The relative proportions of the major orders are found in Table 16 and illustrated in Figure 18. Most noticeable is the increase in molluscs and the decrease in true flies and mayflies from Site 1 to Site 7. Site 2 has, however, an exceptionally high proportion of true flies and Site 4 a high proportion of oligochaetes. The relationship between insect and non-insect families is examined further.

B.3.6 Insects and non-insects

Tables 17 and 18 present lists of the families and species of insects and non-insects respectively. The actual numbers and relative abundance of each species in each sample are also given. The overall numbers and relative abundance of insects and non-insects in each sample are shown in Table 19 while Figure 19 illustrates the relative abundances of the two groups in each sample. The highest proportions of insects are found in samples from Site 2 (81.9%) and Site 1 (73.1%) and the lowest at Site 7 (13%) and Site 6 (35.6%). Conversely, the highest proportions of non-insects are recorded for Sites 7 (87%) and 6 (64.4%) and the lowest at Sites 2 (18.1%) and 1 (27%). There is a general trend downstream toward a greater proportion of non-insect groups. However, the transition from upstream dominance of insects to downstream dominance of non-insects is not smooth, with Site 2 having more insects than the control site; and Site 4 has fewer insects than its neighbouring upstream and downstream sites.

B.3.7 Proportion of Chironomids

Looking at the composition of the insect part of the samples reveals that chironomids occur in large numbers (932) at Site 2 and account for 74.4% of the sample (Figure 20); this accounts for the overall high proportion of insects at this site. Chironomids also dominate at Sites 4 (59.2%) and Site 7 (66.2%) but do not occur in such large numbers (77 and 292 respectively). Although not recorded on the species lists given here, a note was made of the numbers of specimens in each chironomid group and from this it is possible to say that at Sites 1, 2 ,3 and 6 Orthocladiinae predominate whilst at Sites 4, 5 and 7 the Chironomini are the most common group.

B.3.8 Families sensitive to pesticides

The sensitivity of aquatic macroinvertebrates to water contaminated by pesticides varies according to family (Ashby-Crane et al 1994; House et al 1992; Pinder et al 1993; Yasuno et al 1985). The vulnerability will depend on the family of organism, type of chemical, the initial concentration, and any residual effect. The families most likely to show behavioural changes or mortality are the higher BMWP scoring ones. These include Ephemeroptera, Plecoptera and Trichoptera. Absence or decline in these orders may indicate pesticide-induced stress. Table 20 gives the numbers and relative abundances with which families belonging to these orders are found in the RIVPACS samples from the River Dart. [Crustacea are also vulnerable to pesticides but do not occur naturally to any large extent in this river and so are not a good indicator in this particular case.]

From Table 20 it can be seen that upstream sites are generally richer in terms of these sensitive families than the downstream ones. Sites 1, 2 and 3 all contain at least one of the families at its greatest abundance. Site 1 has two families , Site 2 has three and Site 3 has seven of these sensitive families at their highest level of occurrence for the whole 6Km stretch. The numbers of three of the families - Baetidae, Ephemerellidae and Leuctridae - are shown in bar charts of frequency. The actual numbers are used in Figure 21 and the relative abundances in Figure 22. For Baetidae and Ephemerellidae, actual numbers rise from Site 1 (27 & 124) to Site 3 (82 & 248) but show a subsequent dramatic fall at Site 4 (4 & 12); a slight and gradually recovery can be detected in Sites 5 to 7. The picture from the percentage frequencies is less clear. Numbers and percentage frequency of Leuctridae are much higher at Site 1 (20 & 6.3%) than elsewhere although Site 4 has proportionally more leuctrids (4.6%) than the remaining five sites.

B.3.9 Comparison of IFE 1995 and IFE 1997 data

In summer 1995 J H Blackburn for IFE conducted a survey on the River Dart near the Buckfastleigh STW using three replicate RIVPACS style kick samples at each site. The sites were designated by the letters A, B and C and the replicates were identified by the site letter and a number, eg A1, A2, A3. Although the position of the sites differs in the two surveys, their positions in relation to each other is known so that the downstream sequence of sites is 1 ('97), 2 ('97), A ('95), STW discharge, 3 ('97), B ('95), 4 ('97), C ('95), 5 ('97), 6 ('97) and 7 ('97).

In 1995 the quality bands of the sites were predicted using RIVPACS II and were band A, band B and band B for Sites A, B and C respectively. RIVPACS II gives an option of four quality bands. The 1995 data has been re-tested using RIVPACS III+ which is statistically more stringent and allocates sites to one of six quality bands from band A to band F. The new quality band allocation for the 1995 RIVPACS sample sites is band B, band C and band C for Sites A, B and C respectively.

Since the 1995 Site A is equivalent to the 1997 Site 2, upstream of the STW discharge, the bands for these two sites show that the quality has remained the same at band B. The probability that the two sites are the same quality band , based on number of taxa is 41.4%, 45.6% and 45% for replicates A1, A2 and A3; for ASPT 54.8%, 49.4% and 56.8%; and for overall GQA band 51.8%, 56% and 55.8% respectively (Table 21 and Figure 23) .

In 1995 Site B was located downstream of the STW discharge between 1997 Sites 3 and 4. This area shows an improvement from band C in 1995 to band B in 1997. The levels of probability for a change in quality band are very high (Table 21, Figure 23), with many values above the 90% level.

Site C in 1995 was located between 1997 Sites 4 and 5 both of which are now band B showing an improvement from band C in 1995. The percentage probabilities for this change are again high (Table 21, Figure 23) but with a wider range of values from 50.2% to 92.2%.

B.4. DISCUSSION

The results for the RIVPACS survey are now discussed, with particular attention being paid to their relevance in deciding whether the River Dart in this reach near Buckfastleigh is affected by discharge from the Kilbury STW. Certain characteristics have emerged for the reach of river as a whole from the series of analyses carried out on the seven sites. Within the general picture inter-site variations can be detected and these can now be examined to determine possible causes.

The main trend emerging from the data is an upstream to downstream decline in water quality. The reasons for this decline are not easily identified. The features of the samples from each site can be considered in turn and explanations for the sample characteristics attempted. The control Site 1, 15m upstream of Dart Bridge, is approximately 1.3km upstream of the Buckfastleigh (Kilbury) STW discharge point. This site has the highest ASPT due to the proportion of high scoring taxa. The water quality is good, the best of all the sites in the reach studied. It is the only site that belongs to quality band A. The probability of Site 1 being better than the other sites is high, especially for O/E ASPT and overall GQA band. The sample has the lowest proportion of molluscs and moderate abundance of oligochaetes as opposed to the highest proportion of mayflies, stoneflies, beetles and caddis which overall combine to give the highest ratio of insects to non-insects for all sites. Only 26% of the insects were chironomids and of these the Orthocladiinae, associated with mosses, dominated. Eleven families of the types most sensitive to pesticides were represented but only the numbers or relative abundances of Leuctridae, Lepidostomatidae and Sericostomatidae were the highest recorded of all sites.

At Site 2 above Austin's Bridge and still 300m upstream of the STW discharge there is a marked and unexpected change from Site 1. The BMWP score and ASPT drop noticeably and there is a transition to a lower quality band B. The probabilities of Site 2 being a lower quality band are high although there is no statistically significant difference in O/E number of taxa or O/E ASPT between this site and the others. The sample comprises high and almost equal numbers of molluscs and mayflies. True flies however occur in the highest numbers and relative abundance of all the sites, giving the highest insect to non-insect ratio. An examination of the component taxa within the Diptera shows that chironomids account for nearly 75% but these are mostly first instar Orthocladiinae living in association with mosses and not the Chironomini, or red blood worms, often found with organic enrichment and sewage in particular. Nine families sensitive to pesticides are recorded at Site 2, and Baetidae, Ephemerellidae, Rhyacophilidae, Hydropsychidae, Limnephilidae and Brachycentridae occur in higher numbers than at the control site. Therefore the low ASPT cannot be explained adequately in terms of either organic or chemical pollution. It is possible that the physical characteristics of the site, the consequent difficulty in taking kick samples and maybe some influence from the Mardle Tributary just upstream, have combined to result in low O/E index values.

Site 3, at only 30m downstream of the effluent discharge pipe, provided a sample with a very different faunal composition to Site 2. The BMWP score is the highest of all sites. ASPT is greater than Site 2 but on a par with Sites 4 and 5 further downstream - all four sites belonging to quality band B. Site 3 is not significantly different from any other site (O/E taxa or ASPT). There are high probabilities that Site 2 is a worse quality band than Site 3 although overall it has been allocated to the same band. The numbers of both molluscs and oligochaetes are high at Site 3 but so are mayflies, caddis, true flies and beetles. The relatively high numbers of insects are not due to a dominance of chironomids but Chironomini are present and these are known to thrive in rivers affected by sewage. Twelve families of Ephemeroptera, Plecoptera and Trichoptera are recorded from this site, often in peak abundances. It may be concluded that there is little evidence for organic enrichment or pesticide pollution at this site.

Site 4, 100m upstream of the railway tunnel and 300m downstream of the STW discharge, is assigned to quality band B but has a slightly lower number of taxa, BMWP score, and ASPT than Site 3 although it is similar in these respects to the other sites in the same band. It is not significantly different from any of the other sites (O/E number of taxa and O/E ASPT). The sample has fewer molluscs than Site 3 but has the highest proportion of oligochaetes for all sites and these are responsible for the relatively high level of non-insects. Chironomids, including Chironomini, dominate the insects. The proportions of mayflies and true flies are lower than Site 3 but stoneflies are higher and caddis much the same. The real difference between Site 3 and Site 4 lies in the actual numbers of the two mayfly families, Baetidae and Ephemerellidae, which decrease from 82 to 4 and 248 to 12 respectively, between these two sites. Other less well represented families in this reach also decline or disappear. This site therefore supplies some minimal signs that might suggest stress from both organic and pesticide pollution: the organic reflected in the preponderance of non-insects, such as oligochaetes and the high proportion of certain insects such as chironomids with dominant Chironomini; the pesticides possibly through the abrupt decline in numbers of some Ephemeroptera and other sensitive families. However, this interpretation of the decreasing numbers of mayflies must be tentative because information relating to, for example, habitat availability at this point has not been assessed.

Site 5, 0.5km below the STW discharge and 200m downstream of the railway tunnel, has slightly fewer taxa and lower BMWP score than Site 4. The ASPT is a bit higher but it shares the same quality band B as Site 4. It is significantly different statistically from Site 3 on the basis of the number of taxa but not from the other sites. Non-insects are dominant at Site 5, which has double the proportion of molluscs found at Site 4 but few oligochaetes. Most of the insects are not chironomids although Chironomini are present. There is a higher proportion of mayflies and true flies here than at Site 4 as well as greater numbers of Ephemerellidae and Baetidae, signalling a slight recovery in conditions. Hydroptilidae appear for the first time in the reach but Leuctridae, Lepidostomatidae, Brachycentridae and Sericostomatidae show a further decline.

Between Site 5 and Site 6 there is another major change in the character of the samples and therefore of water quality. Site 6 has the lowest number of taxa, BMWP score, and ASPT, which contribute to its assignment to the lower quality Band C. It is significantly different from both Site 1 and Site 3. Molluscs, oligochaetes and leeches increase in numbers and proportion of the sample in comparison with Site 5 but there are even fewer mayflies, caddis and Diptera and no stoneflies. The non-insects rise to the level recorded at Site 4. Chironomids comprise less than half the insects but blood worms are present. Baetidae continue to increase slightly but other sensitive families decline or disappear.

Site 7 has a high number of taxa and BMWP score but the second lowest ASPT indicating many low scoring taxa.. It belongs to band C along with Site 6. There are huge numbers of molluscs (2582 and 75.9% of sample), mostly *Potamopyrgus jenkinsi*. This site consequently has the highest proportion of non-insects. Beetles occur in their highest numbers but mayflies, caddis and true flies are at their lowest. Chironomids are the most common insect and Chironomini the most abundant of these.

To sum up, there is a decline in water quality in the River Dart from upstream at Dart Bridge to Staverton Bridge, over 6km downstream. Changes in quality occur at Site 2, upstream of Austin's Bridge from band A to band B, and at Site 5, 200m downstream of the railway tunnel, from band B to band C. The abrupt change in quality at Site 2 cannot be definitely attributed to any known source of organic or chemical pollution, although some influence from the Mardle Tributary cannot be ruled out. The physical peculiarities of the site and difficulties encountered in sampling, may also have influenced the BMWP index values and the O/E ratios derived from them.

At Site 6 the second major downward change in water quality from band B to band C may partly be due to impacts from effluent but could also be related to changing physical and natural characteristics of the site associated, for example, with the presence of weirs and islands leading to water backing up with subsequent deposition of sediment load, and to geomorphological changes in the river channel and the surrounding countryside.

The site thought most likely show an impact from pollution, Site 3, demonstrates in this survey very little evidence for pollution although a slight enrichment may contribute to the high numbers of animals. Attempts to interpret the influence of the effluent discharged are complicated by the uncertainties associated with the cause of relatively low index values at Site 2 and the extent to which the effects may persist at Site 3. Site 4, further downstream, seems to provide the only hint of pollution with its pronounced decrease in numbers of Baetidae and Ephemerellidae. These and other sensitive groups are, however, still present at the site. High percentages of non-insects together with high numbers of chiromonids, dominated by Chironomini, point to organic enrichment. It is surprising that any impact is first noticed here and not nearer the outfall. This may be caused by the hydrological characteristics of the river which rapidly carries discharge away from the pipe along the right hand part of the channel, possibly delaying the mixing of pollutants until further downstream.

The results of the 1997 RIVPACS survey together with the 1997 Surber survey indicate an overall decrease in water quality from upstream to downstream. For the greater part of the 6km reach surveyed, an improvement in quality in 1997 compared with results from 1994 and 1995 has been demonstrated. However, the two sites in the lowermost part of the stretch have deteriorated. Although it is not possible to say from the Surber samples that variations are definitely due to pollutants of any kind (because the high degree of intra-site variations between replicate samples can be as great as the inter-site variations), the BMWP scores, ASPT and ordination, together with an increase in abundance of molluscs, suggest it. In particular, no overlap in ordination space between Sites 6 and 7, and either of these and the other five sites. There are signs of enrichment at Site 3 in Surber surveys of 1994 and 1997, including in 1997 a lower ASPT than control Site 1, a faunal assemblage dominated by molluscs, and a relatively close association with Sites 6 and 7 on the ordination plot. Basically the site is not grossly stressed, having a diverse and abundant fauna.

The RIVPACS survey provides a firmer statistical basis than the Surber survey for concluding that although there are definite and marked changes in water quality progressively downstream these cannot be categorically linked with output from the Sewage Treatment Works. Results for the site immediately downstream of the discharge (Site 3) confirm that it is of good quality with signs of slight organic enrichment.

At Site 4 the sample shows a decline in quality especially with regard to the decrease in relative abundance of Baetidae and Ephemerellidae, which is not mirrored in the Surber samples from the same site. The RIVPACS samples supply the only indication of a possible effect from organophosphates in the water although it must be emphasised that there could be other explanations for the findings. One possible explanation for this phenomenon is that the Surber samples were collected in a main channel mesohabitat whereas the RIVPACS sample was collected in the broadest range of habitat types at the site including the main channel and the slack water areas in the siltier margins of the river channel. These marginal areas might act as reservoirs of sub-lethal concentrations of pesticide residues that have an insidious and longterm effect on some of the more vulnerable families of macroinvertebrate. In Kreutzweiser (1991) a beaver pond situated on the stream allowed Permethrin residues to remain at or near peak levels for four hours while drift density declined. The pond apparently acted as a reservoir for contaminated water both diluting and prolonging insecticide concentrations downstream. The effective concentration to initiate drift in the benthic community was apparently below 0.1 µg/L. A parallel might be drawn with the slackwater margins and undercut banks at this location on the Dart.

Experiments with Diazinon (Arthur et al 1983) showed that mayflies, caddisflies and damselflies were among the least tolerant insects to this toxin even at low doses. Figures from Walker (1964) show that the organophosphate Simazine, for example, at 0.5 - 2mg dm^{-3} concentration gives 88% mortality in Ephemeroptera after 1 week and depressed numbers for 14 months. Another organophosphate, Permethrin, at concentrations as low as 0.03µg dm^{-3} will induce 55% mortality in *Brachycentrus* after 28 days (Anderson 1982).

Kreutzweiser (1991), discussing experiments on the effect of Permethrin on macroinvertebrates in headwater streams, noticed that peak drift density was recorded not at the first drift-net station nearest the impact zone but further downstream. Immediate catastrophic drift occurred immediately after the Permethrin treatment, followed by a rapid decline in drift density. Although the peak concentration of toxin at the second site was only 1/16 that of the first site, the peak drift density was nearly 1 1/2 times higher than the first site. This was thought to result from either higher initial benthos density at the second site or immigrant insect larvae drifting downstream from the impact point. This may partially explain why in the River Dart the main impact of any pesticide may be felt lower down stream than expected. In addition it has already been noted that water flows rapidly away from the discharge point along a narrow and deep channel so that it may not have the opportunity to be thoroughly mixed across the full width of the channel and achieve full impact until further downstream at Site 4.

CONCLUDING STATEMENT

Evidence for slight organic enrichment of the water immediately downstream of the sewage plant has been demonstrated by earlier reports. This is confirmed by both the Surber and RIVPACS sampling surveys in 1997. There is no evidence for pesticide effect at the site immediately (30m) below the discharge point but 300m downstream of the discharge point a decrease in numbers of Empheroptera suggests some possible low level pesticide effect.

The ecological quality of the whole reach, from Dart Bridge to Staverton, shows a progression from band A at the top site to band C at the lowest site. The transition from band A to band B occurs near Austin's Bridge which is 400m upstream of the sewage works but downstream of the Mardle tributary. The transition from band B to band C occurs upstream of Riverford Bridge which is 3.3km downstream of the treatment works. Although physical and environmental characteristics change along the length of the river, differences in quality band cannot be attributed to them. The quality bands show a definite overall downstream decline in water quality.

Comparisons of 1997 survey results with surveys in 1994 and 1995 demonstrate that, while the river upstream of the sewage works has remained the same quality, there has been an improvement in ecological quality in the area immediately below the sewage works, and a deterioration in the lowest two sites at Riverford and Staverton.

The overall decline in quality cannot be attributed to the sewage treatment works alone since the decline begins upstream of both the outfall and the storm overflow. It is recommended that the Mardle tributary be monitored on a more regular basis to determine whether it may be a contributory factor in the decrease in water quality.

Since the river closest to the sewage outfall is of relatively good quality, and the quality in this area has improved over the last three years, organic pollution or pesticides from the Buckfastleigh (Kilbury) sewage works can neither be linked, on the present biological evidence, with the deterioration observed in the river 3.3km further downstream, nor eliminated, as a cause. Other causes or sources of pollution cannot be ruled out.

To determine the significance of the observed differences over the years at the various sites, and to help distinguish causes and effects of any decline, it is recommended that all existing data relating to RIVPACS style kick samples from all sources should be analyzed using RIVPACS III+ to verify this decline and establish the extent to which changes may be due to natural or other causes. From the data summary for all surveys in Table 2 it is possible to see how river quality, based on ASPT values, for example, changes both up and down even at the control site Dart Bridge from year to year which indicates the level of natural fluctuations to which the river is liable. Additionally, a more intensive sampling programme, in at least the three seasons, would be required to fully understand the problems in this reach of the Dart.

It is also recommended that bioaccumulation studies of toxins should be carried out on fish, such as bullheads or minnows, because the only other analysis for the chemical Sulcofuran in mosses were inconclusive.

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TABLES

Table 1: SITE DETAILS FOR ALL SURVEYS ON R. DART NEAR BUCKFASTLEIGH IN SUMMERS 1990 - 1997

	Site Number	Grid Reference	Northing	Site Description	Other site same or near
IFE Surber Survey 1997	Site 1A	SX 7440 6675	6675	15m u/s Dart Bridge	Near. NR06.0708
IFE Surber Survey 1997	Site 1B	SX 7440 6675	6675	15m u/s Dart Bridge	Near. NR06.0708
IFE Surber Survey 1997	Site1C	SX 7440 6675	6675	15m u/s Dart Bridge	Near. NR06.0708
IFE Rivpacs Kick Sample Survey 1997	Site 1	SX 7440 6675	6675	15m u/s Dart Bridge	Near. NR06.0708
Acer Environmental Kick Sample 1995 Survey	Site 1	SX 7449 6670	6670	U/s STW - Control	Near. NR06.0708
P. Green 1994 Surber Survey	Site 1	SX 7449 6678	6678	10m d/s Dart Br., u/s STP	NR06.0708
NRA/EA Routine Sampling Sites	NR06.0708	SX 7445 6668	6668	10m d/s Dart Br., u/s STP	P. Green 1994 Site 1, Acer Environ. 1995 Site 1, IFE 1997 Site 1
NRA/EA Routine Sampling Sites	NR06.0712	SX 7462 6613	6613	40m u/s Rail Bridge, R. Mardle, u/s STP	Near IFE 1995 Site A, near IFE 1997 Site 2
Acer Environmental Kick Sample 1995 Survey	Site 2	SX 7470 6610	6610	R. Mardle u/s STW	Near NR06.0712
IFE Surber Survey 1997	Site2A	SX 7491 6605	6605	c.150m u/s Austins Bridge	Near NR06.0712
IFE Surber Survey 1997	Site 2B	SX 7491 6605	6605	c.150m u/s Austins Bridge	Near NR06.0712
IFE Surber Survey 1997	Site 2C	SX 7491 6605	6605	c.150m u/s Austins Bridge	Near NR06.0712
IFE Rivpacs Kick Sample Survey 1997	Site 2	SX 7491 6605	6605	c.150m u/s Austins Bridge	Near NR06.0712
Acer Environmental Kick Sample 1995 Survey	Site 3	SX 7492 6604	6604	U/s STW - control	
IFE Kick/Sweep Survey 1995	Site A1	SX 7500 6598	6598	U/s Austins Bridge, c.300m u/s STP discharge	Nearest NR06.0712
IFE Kick/Sweep Survey 1995	Site A2	SX 7500 6598	6598	U/s Austins Bridge, c.300m u/s STP discharge	Nearest NR06.0712
IFE Kick/Sweep Survey 1995	Site A3	SX 7500 6598	6598	U/s Austins Bridge, c.300m u/s STP discharge	Nearest NR06.0712
P. Green 1994 Surber Survey	Site 2	SX 7512 6588	6588	5m u/s Storm Overflow	
P. Green 1994 Surber Survey	Site 3	SX 7512 6587	6587	25m d/s Storm Overflow	
Acer Environmental Kick Sample 1995 Survey	Site 4	SX 7512 6587	6587	25m d/s Storm Overflow	Same as P.Green Site 3
P. Green 1994 Surber Survey	Site 4	SX 7513 6568	6568	15m d/s Discharge	Near IFE 1997 Site 3
IFE Surber Survey 1997	Site 3A	SX 7518 6560	6560	c.30m d/s STW discharge	Near P. Green 1994 Site 4
IFE Surber Survey 1997	Site 3B	SX 7518 6560	6560	c.30m d/s STW discharge	Near P. Green 1994 Site 4
IFE Surber Survey 1997	Site 3C	SX 7518 6560	6560	c.30m d/s STW discharge	Near P. Green 1994 Site 4
IFE Rivpacs Kick Sample Survey 1997	Site 3	SX 7518 6560	6560	c.30m d/s STW discharge	Near P. Green 1994 Site 4
Acer Environmental Kick Sample 1995 Survey	Site 5	SX 7520 6554	6554	D/s STW Discharge in1Km	
NRA/EA Routine Sampling Sites	NR06.0736	SX 7525 6550	6550	92m u/s railway tunnel, d/s Buckfastleigh STP	Near IFE 1995 Site B, near IFE 1997 Site 4
IFE Kick/Sweep Survey 1995	Site B1	SX 7531 6544	6544	250m d/s STW discharge, right half channel	Near IFE 1997 Site 4, near NR06.0736
IFE Kick/Sweep Survey 1995	Site B2	SX 7531 6544	6544	250m d/s STW discharge, right half channel	Near IFE 1997 Site 4, near NR06.0736
IFE Kick/Sweep Survey 1995	Site B3	SX 7531 6544	6544	250m d/s STW discharge, right half channel	Near IFE 1997 Site 4, near NR06.0736
IFE Surber Survey 1997	Site 4A	SX 7534 6540	6540	c.100m u/s railway tunnel	U/s of IFE 1995 Site C, near NR06.0736
IFE Surber Survey 1997	Site 4B	SX 7534 6540	6540	c.100m u/s railway tunnel	U/s of IFE 1995 Site C, near NR06.0736
IFE Surber Survey 1997	Site 4C	SX 7534 6540	6540	c.100m u/s railway tunnel	U/s of IFE 1995 Site C, near NR06.0736
IFE Rivpacs Kick Sample Survey 1997	Site 4	SX 7534 6540	6540	c.100m u/s railway tunnel	U/s of IFE 1995 Site C, near NR06.0736
Acer Environmental Kick Sample 1995 Survey	Site 6	SX 7536 6531	6531	D/s STW Discharge in 1Km	
IFE Kick/Sweep Survey 1995	Site C1	SX 7537 6530	6530	450m d/s STW discharge, full width of channel	
IFE Kick/Sweep Survey 1995	Site C2	SX 7537 6530	6530	450m d/s STW discharge, full width of channel	Between IFE 1997 Sites 4 & 5
IFE Kick/Sweep Survey 1995	Site C3	SX 7537 6530	6530	450m d/s STW discharge, full width of channel	
IFE Surber Survey 1997	Site 5A	SX 7534 6510	6510	c.200m d/s railway tunnel	D/s of IFE 1995 Site C
IFE Surber Survey 1997	Site 5B	SX 7534 6510	6510	c.200m d/s railway tunnel	D/s of IFE 1995 Site C
IFE Surber Survey 1997	Site 5C	SX 7534 6510	6510	c.200m d/s railway tunnel	D/s of IFE 1995 Site C
IFE Rivpacs Kick Sample Survey 1997	Site 5	SX 7534 6510	6510	c.200m d/s railway tunnel	D/s of IFE 1995 Site C
Acer Environmental Kick Sample 1995 Survey	Site 7	SX7527 6471	6471	D/s STW Discharge in 1Km	
NRA/EA Routine Sampling Sites	NR06.0709	SX 7682 6398	6398	500m u/s Riverford Bridge	P. Green Site 5, Acer Environ. Site 8, near IFE 1997 Site 6
P. Green 1994 Surber Survey	Site 5	SX 7682 6398	6398	500m u/s Riverford Bridge	NR06.0709

Table 1 continued: SITE DETAILS FOR ALL SURVEYS ON R. DART NEAR BUCKFASTLEIGH IN SUMMERS 1990 - 1997

	Site Number	Grid Reference	Northing	Site Description	Other site same or near
Acer Environmental Kick Sample 1995 Survey	Site 8	SX 7682 6398	6398	More than 3Km d/s Discharge	Same as P. Green Site 5, near NR06.0709
IFE Surber Survey 1997	Site 6A	SX 7686 6390	6390	U/s Riverford Bridge	Near NR06.0709
IFE Surber Survey 1997	Site 6B	SX 7686 6390	6390	U/s Riverford Bridge	Near NR06.0709
IFE Surber Survey 1997	Site 6C	SX 7686 6390	6390	U/s Riverford Bridge	Near NR06.0709
IFE Rivpacs Kick Sample Survey 1997	Site 6	SX 7686 6390	6390	U/s Riverford Bridge	Near NR06.0709
P. Green 1994 Surber Survey	Site 6	SX 7840 6365	6365	100m u/s Staverton Bridge	
IFE Surber Survey 1997	Site 7A	SX 7840 6365	6365	15m u/s Staverton Bridge	Nearest NR06.0739 (150m u/s)
IFE Surber Survey 1997	Site 7B	SX 7840 6365	6365	15m u/s Staverton Bridge	Nearest NR06.0739 (150m u/s)
IFE Surber Survey 1997	Site 7C	SX 7840 6365	6365	15m u/s Staverton Bridge	Nearest NR06.0739 (150m u/s)
IFE Rivpacs Kick Sample Survey 1997	Site 7	SX 7840 6365	6365	15m u/s Staverton Bridge	Nearest NR06.0739 (150m u/s)
NRA/EA Routine Sampling Sites	NR06.0739	SX 7961 6360	6360	Opp.Staverton Ford Plant., Dartington Hall	P. Green 1994 Site 7, near IFE 1997 Site 7
P. Green 1994 Surber Survey	Site 7	SX 7961 6360	6360	Opp.Staverton Ford Plant., Dartington Hall	NR06.0739
NRA/EA Routine Sampling Sites	NR06.0710	SX 8000 6133	6133	25m U/s Totnes Weir	

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Table 2: SUMMARY OF DATA FOR SURVEYS ON R. DART NEAR BUCKFASTLEIGH IN SUMMERS 1990 -1997

Survey	Site Number	Kick or Surber	Date	No. Scoring Taxa	Total Number of Taxi	BMWP Score	ASPT	Total Abundance	No. Insects	% Insects	No. Non-Insects	% Non-Insects	No. Chironomids	% Chironomids
IFE Surber Survey 1997	Site 1A	S	1997	17	19	116	6.82	174	142	81.61	32	18.39	48	33.8
IFE Surber Survey 1997	Site 1B	S	1997	7	9	43	6.14	116	53	45.69	63	54.31	28	52.83
IFE Surber Survey 1997	Site1C	S	1997	15	17	86	5.73	175	86	49.14	89	50.86	51	59.3
IFE Surber Survey 1997	Site 1 combined replicate surbers	S	1997	21	23	139	6.62	465	281	60.43	184	39.57	127	45.2
IFE Surber Survey 1997	Site 1 average of replicate surbers	S	1997	13	15	81.67	6.23	155	93.67	60.43	61.33	39.57	42.33	45.2
IFE Rivpacs Kick Sample Survey 1997	Site 1	K	1997	22	25	145	6.59	434	317	73.07	117	26.96	82	25.87
Acer Environmental Kick Sample 1995 Survey	Site 1 combined samples	K	1995	24	27	146	6.08	2700	2362	87.48	338	12.52	297	11
Acer Environmental Kick Sample 1995 Survey	Site 1 Margins samples	K	1995	21	24	123	5.86	952	788	82.77	164	17.23	17	1.79
Acer Environmental Kick Sample 1995 Survey	Site 1 Mid channel riffle samples	K	1995	18	21	104	5.78	1748	1574	90.05	174	9.95	280	16.02
P. Green 1994 Surber Survey	Site 1	S	1994	24	27	156	6.5	840	667	79.4	173	20.6	143	17.02
NRA/EA Routine Sampling Sites	NR06.0708	K	1990	16	18	84	5.25	1322	1094	82.75	228	17.25	56	4.24
NRA/EA Routine Sampling Sites	NR06.0708	K	1991	20	20	128	6.4	343	283	82.51	60	17.49	11	3.21
NRA/EA Routine Sampling Sites	NR06.0708	K	1992	17	18	101	5.94	764	663	86.78	101	13.22	18	2.36
NRA/EA Routine Sampling Sites	NR06.0708	K	1993	18	20	111	6.16	602	531	88.21	71	11.79	57	9.47
NRA/EA Routine Sampling Sites	NR06.0708	K	1994	20	24	121	6.05	727	608	83.63	119	16.37	63	8.67
NRA/EA Routine Sampling Sites	NR06.0708	K	1996	18	21	101	5.61	273	176	64.47	97	35.53	94	34.43
NRA/EA Routine Sampling Sites	NR06.0712	K	1990	14	16	72	5.14	188	86	45.74	102	54.26	26	13.83
NRA/EA Routine Sampling Sites	NR06.0712	K	1993	18	19	104	5.78	671	531	79.14	140	20.86	153	22.8
Acer Environmental Kick Sample 1995 Survey	Site 2 combined samples	K	1995	21	24	122	5.81	1286	942	73.25	344	26.75	388	30.17
Acer Environmental Kick Sample 1995 Survey	Site 2 Margins samples	K	1995	20	21	112	5.6	648	392	60.49	256	39.51	287	44.29
Acer Environmental Kick Sample 1995 Survey	Site 2 Mid channel riffle samples	K	1995	14	17	75	5.36	638	550	86.21	88	13.79	101	15.83
IFE Surber Survey 1997	Site2A	S	1997	7	8	26	3.71	77	27	35.06	50	64.94	8	29.63
IFE Surber Survey 1997	Site 2B	S	1997	13	15	77	5.92	69	45	65.22	24	34.78	13	28.29
IFE Surber Survey 1997	Site 2C	S	1997	9	10	40	4.44	120	35	29.17	85	70.83	7	20
IFE Surber Survey 1997	Site 2 combined replicate surbers	S	1997	16	18	91	5.69	266	107	40.23	159	59.77	28	26.17
IFE Surber Survey 1997	Site 2 average of replicate surbers	S	1997	9.67	11	47.67	4.44	88.67	35.67	40.23	53	59.77	9.33	26.17
IFE Rivpacs Kick Sample Survey 1997	Site 2	K	1997	19	22	111	5.84	1529	1252	81.81	277	18.12	932	74.44
Acer Environmental Kick Sample 1995 Survey	Site 3 combined samples	K	1995	29	31	182	6.28	2209	1888	85.47	321	14.53	515	23.31
Acer Environmental Kick Sample 1995 Survey	Site 3 Margins samples	K	1995	23	25	141	6.13	736	529	71.88	207	28.13	259	35.19
Acer Environmental Kick Sample 1995 Survey	Site 3 Mid channel riffle samples	K	1995	18	20	104	5.78	1473	1359	92.26	114	7.74	256	17.38
IFE Kick/Sweep Survey 1995	Site A1	K	1995	20	28	114	5.7	1331	1194	89.71	137	10.29	418	31.4
IFE Kick/Sweep Survey 1995	Site A2	K	1995	18	25	108	6	896	782	87.28	114	12.72	200	22.32
IFE Kick/Sweep Survey 1995	Site A3	K	1995	19	27	112	5.895	1982	1624	81.94	358	18.06	572	28.86
P. Green 1994 Surber Survey	Site 2	S	1994	21	23	130	6.19	1036	784	75.68	251	24.23	135	13.03
P. Green 1994 Surber Survey	Site 3	S	1994	25	26	146	5.84	1231	504	40.94	727	59.06	76	0.06
Acer Environmental Kick Sample 1995 Survey	Site 4 combined samples	K	1995	23	25	139	6.04	2401	1855	77.26	546	22.74	331	13.79
Acer Environmental Kick Sample 1995 Survey	Site 4 Margins samples	K	1995	22	23	134	6.09	1371	880	64.19	491	35.81	89	6.49
Acer Environmental Kick Sample 1995 Survey	Site 4 Mid channel riffle samples	K	1995	16	18	81	5.06	1030	975	94.66	55	5.64	242	24.82
P. Green 1994 Surber Survey	Site 4	S	1994	18	19	97	5.39	1476	1095	74.19	381	25.81	1016	68.83
IFE Surber Survey 1997	Site 3A	S	1997	17	19	104	6.12	449	119	26.5	330	73.5	64	53.78
IFE Surber Survey 1997	Site 3B	S	1997	22	25	134	6.09	958	247	25.78	711	74.22	88	35.63
IFE Surber Survey 1997	Site 3C	S	1997	16	17	106	6.63	373	129	34.58	244	65.42	73	56.59
IFE Surber Survey 1997	Site 3 combined replicate surbers	S	1997	25	28	146	5.84	1780	495	27.81	1285	72.19	225	45.45
IFE Surber Survey 1997	Site 3 average of replicate surbers	S	1997	18.33	20.33	114.67	6.28	593.33	165	27.81	428.33	72.19	75	45.45
IFE Rivpacs Kick Sample Survey 1997	Site 3	K	1997	26	29	162	6.23	1298	777	59.86	521	40.14	332	72.73
Acer Environmental Kick Sample 1995 Survey	Site 5 combined samples	K	1995	27	31	167	6.19	3577	2262	63.24	1315	36.76	450	12.58
Acer Environmental Kick Sample 1995 Survey	Site 5 Margins samples	K	1995	24	27	147	6.13	843	554	65.72	289	34.28	135	16.01
Acer Environmental Kick Sample 1995 Survey	Site 5 Mid channel riffle samples	K	1995	20	23	113	5.65	2734	1708	62.47	1026	37.53	315	11.52
IFE Kick/Sweep Survey 1995	Site B1	K	1995	19	25	103	5.421	507	261	51.48	246	48.52	52	10.26
IFE Kick/Sweep Survey 1995	Site B2	K	1995	20	24	105	5.25	772	534	69.17	238	30.83	68	8.81
IFE Kick/Sweep Survey 1995	Site B3	K	1995	17	24	87	5.118	1065	775	72.77	290	27.23	44	4.13
IFE Surber Survey 1997	Site 4A	S	1997	12	13	66	5.5	137	80	58.39	57	41.61	40	50
IFE Surber Survey 1997	Site 4B	S	1997	9	10	46	5.1	55	23	41.82	32	58.18	7	30.43
IFE Surber Survey 1997	Site 4C	S	1997	16	18	101	6.31	188	90	47.87	98	52.13	39	43.33
IFE Surber Survey 1997	Site 4 combined replicate surbers	S	1997	18	20	116	6.44	380	193	50.79	187	49.21	86	44.56
IFE Surber Survey 1997	Site 4 average of replicate surbers	S	1997	12.33	13.67	71	5.64	126.67	64.33	50.79	62.33	49.21	28.67	44.61
IFE Rivpacs Kick Sample Survey 1997	Site 4	K	1997	20	22	123	6.15	359	130	36.21	229	63.79	77	59.23
Acer Environmental Kick Sample 1995 Survey	Site 6 combined samples	K	1995	24	26	142	5.92	2231	1612	72.25	619	27.75	250	11.21
Acer Environmental Kick Sample 1995 Survey	Site 6 Margins samples	K	1995	20	22	117	5.85	730	413	56.58	317	76.76	83	11.37
Acer Environmental Kick Sample 1995 Survey	Site 6 Mid channel riffle samples	K	1995	18	20	104	5.78	1501	1199	79.88	302	20.12	167	11.13
IFE Kick/Sweep Survey 1995	Site C1	K	1995	20	26	114	5.7	929	509	54.79	420	45.21	184	19.81
IFE Kick/Sweep Survey 1995	Site C2	K	1995	15	21	73	4.867	738	611	82.79	127	17.21	92	12.47
IFE Kick/Sweep Survey 1995	Site C3	K	1995	19	29	99	5.211	1627	1222	75.11	405	24.89	684	42.04
IFE Surber Survey 1997	Site 5A	S	1997	12	15	63	5.25	214	93	43.46	121	56.54	36	38.71
IFE Surber Survey 1997	Site 5B	S	1997	11	13	66	6	271	74	27.31	197	72.69	29	39.19
IFE Surber Survey 1997	Site 5C	S	1997	22	24	144	6.55	1073	231	21.53	842	78.47	124	53.68
IFE Surber Survey 1997	Site 5 combined replicate surbers	S	1997	22	25	144	6.55	1558	398	25.55	1160	74.45	189	47.49
IFE Surber Survey 1997	Site 5 average of replicate surbers	S	1997	15	17.33	91	5.93	519.33	132.67	25.55	386.67	74.46	63	47.49
IFE Rivpacs Kick Sample Survey 1997	Site 5	K	1997	19	21	118	6.21	441	269	61	172	39	101	37.55
Acer Environmental Kick Sample 1995 Survey	Site 7 combined samples	K	1995	31	35	190	6.13	3041	1735	57.05	1306	42.95	574	18.88
Acer Environmental Kick Sample 1995 Survey	Site 7 Margins samples	K	1995	24	28	145	6.04	1470	634	43.13	836	56.87	102	6.94
Acer Environmental Kick Sample 1995 Survey	Site 7 Mid channel riffle samples	K	1995	23	26	124	5.39	1571	1101	70.08	470	29.92	472	30.04
NRA/EA Routine Sampling Sites	NR06.0709	K	1990	15	17	66	4.4	1206	455	37.73	751	62.27	59	4.89
NRA/EA Routine Sampling Sites	NR06.0709	K	1993	15	17	74	4.93	566	416	73.5	150	26.5	57	10.07
P. Green 1994 Surber Survey	Site 5	S	1994	16	19	79	4.94	1318	558	42.34	760	57.66	214	16.24
Acer Environmental Kick Sample 1995 Survey	Site 8 combined samples	K	1995	25	29	150	6	2239	1190	53.15	1049	46.85	217	9.69
Acer Environmental Kick Sample 1995 Survey	Site 8 Margins samples	K	1995	20	23	125	6.25	958	287	29.96	671	70.04	113	11.8
Acer Environmental Kick Sample 1995 Survey	Site 8 Mid channel riffle samples	K	1995	17	20	91	5.24	1281	903	70.49	378	29.51	104	8.12
IFE Surber Survey 1997	Site 6A	S	1997	11	12	54	4.91	282	63	22.34	219	77.66	47	74.6
IFE Surber Survey 1997	Site 6B	S	1997	9	10	41	4.56	102	33	32.35	69	67.55	8	24.24
IFE Surber Survey 1997	Site 6C	S	1997	14	16	83	5.93	403	59	14.64	344	85.36	29	49.15

Table 2 continued: SUMMARY OF DATA FOR SURVEYS ON R. DART NEAR BUCKFASTLEIGH IN SUMMERS 1990 -1997

Survey	Site Number	Kick or Surber	Date	No. Scoring Taxa	Total Number of Taxa	BMWP Score	ASPT	Total Abundance	No. Insects	% Insects	No. Non-Insects	% Non-Insects	No. Chironomids	% Chironomids
IFE Surber Survey 1997	Site 6 combined replicate surbers	S	1997	18	20	105	5.83	787	155	19.7	632	80.3	84	54.19
IFE Surber Survey 1997	Site 6 average of replicate surbers	S	1997	11.33	12.67	59.33	5.13	262.33	51.67	19.7	210.67	80.3	28	54.19
IFE Rivpacs Kick Sample Survey 1997	Site 6	K	1997	18	23	99	5.5	606	216	35.64	390	64.36	92	42.59
P. Green 1994 Surber Survey	Site 6	S	1994	20	23	112	5.6	925	340	36.76	585	63.24	69	7.46
IFE Surber Survey 1997	Site 7A	S	1997	12	13	51	4.25	275	42	15.27	233	84.73	28	66.67
IFE Surber Survey 1997	Site 7B	S	1997	13	15	58	4.46	1261	132	10.47	1129	89.53	116	87.88
IFE Surber Survey 1997	Site 7C	S	1997	11	12	54	4.91	672	63	9.38	609	90.63	32	50.79
IFE Surber Survey 1997	Site 7 combined replicate surbers	S	1997	15	17	73	4.87	2208	237	10.73	1971	89.27	176	74.26
IFE Surber Survey 1997	Site 7 average of replicate surbers	S	1997	12	13.33	54.33	4.54	736	79	10.73	657	89.27	58.67	74.27
IFE Rivpacs Kick Sample Survey 1997	Site 7	K	1997	25	28	138	5.52	3403	441	12.96	2962	87.04	292	66.21
P. Green 1994 Surber Survey	Site 7	S	1994	16	18	91	5.69	846	233	27.54	613	72.46	50	5.91
NRA/EA Routine Sampling Sites	NR06.0710	K	1990	19	19	82	4.32	1464	518	35.38	946	64.62	260	17.76
NRA/EA Routine Sampling Sites	NR06.0710	K	1993	21	22	104	4.95	684	358	52.34	326	47.66	283	41.37

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Table 3 : SITE LOCATION DETAILS

Site No.	Site Details	Grid reference
1	15m u/s Dart Bridge	SX 7440 6675
2	c. 150m u/s Austin's Bridge	SX 7491 6605
3	c. 30m d/s STP discharge	SX 7518 6560
4	c.100m u/s railway tunnel	SX 7534 6540
5	c. 200m d/s railway tunnel	SX 7534 6510
6	U/s Riverford Bridge	SX 7686 6390
7	15m u/s Staverton Bridge	SX 7840 6365

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Table 4 : SURBER SAMPLE SPECIES LIST
Actual numbers and (% relative abundance)

	1A	1B	1C	2A	2B	2C	3A	3B	3C
HEPTAGENIIDAE									
Ecdyonurus sp.					1 [1.45]			1 [0.10]	1 [0.27]
EPHEMERELLIDAE									
Ephemerella ignita	11 [7.48]	3 [2.59]	3 [1.71]		4 [5.80]	1 [0.83]	16 [3.56]	12 [1.25]	2 [0.54]
EPHEMERIDAE									
Ephemera danica									
LEUCTRIDAE									
Leuctra fusca	6 [3.45]	2 [1.72]	5 [2.86]				1 [0.22]	8 [0.84]	2 [0.54]
Leuctra geniculata	7 [4.02]	1 [0.86]	6 [3.43]		1 [1.45]		1 [0.22]	20 [2.09]	7 [1.88]
CHLOROPERLIDAE									
Chloroperla torrentium			1 [0.57]						
LEPTOCERIDAE									
Athripsodes albifrons		1 [0.86]						24 [2.51]	3 [0.80]
Athripsodes cinereus	1 [0.57]	1 [0.86]					4 [0.89]	3 [0.31]	2 [0.54]
Athripsodes sp.							2 [0.45]		
Ceraclea dissimilis									
Ceraclea sp									1 [0.27]
Mystacides azurea									
Oecetis (?testacea)									
GOERIDAE									
Goera pilosa									
Silo pallipes	6 [3.45]								
LEPIDOSTOMATIDAE									
Lasiocephala basalis	1 [0.57]								
Lepidostoma hirtum	6 [3.45]				1 [1.45]		3 [0.67]	12 [1.25]	4 [1.07]
Indet juv prob Lasiocephala								1 [0.10]	
BRACHYCENTRIDAE									
Brachycentrus subnubilus	1 [0.57]						9 [2.00]	28 [2.92]	13 [3.49]
SERICOSTOMATIDAE									
Sericostoma personatum	12 [6.90]		3 [1.71]				7 [1.56]	16 [1.67]	8 [2.14]
CALOPTERYGIDAE									
Calopteryx virgo									
CORDULEGASTERIDAE									
Cordulegaster boltonii									
NEMOURIDAE									
Nemurella picteti									
RHYACOPHILIDAE									
Rhyacophila dorsalis	2 [1.15]				5 [7.25]	2 [1.67]		1 [0.10]	1 [0.27]
Rhyacophila munda									
Agapetus sp.	3 [1.72]								
Glossosoma sp.								1 [0.10]	1 [0.27]
POLYCENTROPODIDAE									
Plectrocnemia conspersa									
LIMNEPHILIDAE									
Drusus annulatus	1 [0.57]		1 [0.57]						
Halesus radiatus								4 [0.42]	
Halesus sp							1 [0.22]		
Potamophylax cingulatus									
Potamophylax latipennis	1 [1.57]							1 [0.10]	
ANCYLIDAE									
Ancylus fluviatilis			1 [0.57]				137 [30.58]	316 [32.99]	93 [24.93]
HYDROPTILIDAE									
Hydroptila sp.									
GAMMARIDAE									
Gammarus pulex	1 [0.57]			1 [1.30]					
DYTISCIDAE									
Oreodytes sanmarkii									
Potamonectes depressus gp.									
GYRINIDAE									
Gyrinus sp.									
HYDROPHILIDAE									
Hydreana gracilis	1 [0.57]		1 [0.57]		1 [1.45]			1 [0.10]	
ELMIDAE									
Elmis aenea	3 [1.72]	1 [0.86]						4 [0.42]	
Esolus parallelepipedus	2 [1.15]	9 [7.76]	3 [1.71]	1 [1.30]			4 [0.89]	8 [0.84]	2 [0.54]
Limnius volkmari	16 [9.20]	1 [0.86]	1 [0.57]	1 [1.30]			1 [0.22]	4 [0.42]	7 [1.88]
Oulimnius sp.									
HYDROPSYCHIDAE									
Hydropsyche pellucidula			1 [0.57]						
Hydropsyche siltalai	1 [0.57]		1 [0.57]		1 [1.45]	2 [1.67]	1 [0.22]	4 [0.42]	
Hydropsyche sp.									

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Table 4 continued: SURBER SAMPLE SPECIES LIST
Actual numbers and (% relative abundance)

	1A	1B	1C	2A	2B	2C	3A	3B	3C
TIPULIDAE									
Antocha vitripennis	3 [1.72]	3 [2.59]	3 [1.71]		1 [1.45]		1 [0.22]		
Dicranota sp.									1 [0.27]
SIMULIIDAE									
Simulium argyreatum gp.									
Simulium aureum gp.									
Simulium reptans				11 [14.29]	10[14.49]	8 [6.67]		1 [0.10]	
Indet.									
PLANARIIDAE									
Dugesia tigrina									
Phagocata vitta									
Polycelis felina								1 [0.10]	
Polycelis nigra gp.									
BAETIDAE									
Baetis rhodani				2 [2.60]	4 [5.80]	8 [6.67]	2 [0.45]	1 [0.10]	
Baetis scambus gp.			1 [0.57]		1 [1.45]	2 [1.67]		1 [0.10]	
Centroptilum luteolum									
Centroptilum pennulatum									
PISCICOLIDAE									
Piscicola geometra									1 [0.27]
HYDROBIIDAE									
Potamopyrgus jenkinsi	5 [2.87]		1 [0.57]	4 [5.19]	5 [7.25]	14 [11.67]	107 [23.88]	212 [22.13]	29 [7.77]
LYMNAEIDAE									
Lymnaea peregra								1 [0.10]	
PLANORBIDAE									
Armiger crista									
SPHAERIIDAE									
Pisidium sp.								1 [0.10]	
GLOSSIPHONIIDAE									
Glossiphonia complanata							8 [1.79]		7 [1.88]
Helobdella stagnalis									1 [0.27]
Indet glossiphoniid juv.									
ERPOBDELLIDAE									
Erpobdella octoculata			1 [0.57]			3 [2.50]		8 [0.84]	
Trocheta subviridis							1 [0.22]		
Indet. juv.							2 [0.45]		
CHIRONOMIDAE	48 [27.59]	28 [24.14]	51 [29.14]	8 [10.39]	13 [18.84]	7 [5.83]	64 [14.29]	88 [9.19]	73 [19.57]
OLIGOCHAETA	26 [14.94]	63 [54.31]	86 [49.14]	45 [58.44]	18 [26.09]	68 [56.67]	75 [16.74]	160 [16.70]	113 [30.29]
EMPIDIDAE	*2 [1.15]*	*1 [0.86]*	*2 [1.14]*				*1 [0.22]*		
RHAGIONIDAE	*8 [4.60]*	*2 [1.72]*	*2 [1.14]*	*4 [5.19]*	*2 [2.90]*	*5 [4.17]*	*1 [0.22]*	*2 [0.21]*	1 [0.27]
HYDRACARINA								*12 [1.25]*	
NEMATODA					1 [1.45]				
PSYCHODIDAE								1 [0.10]	
CERATOPOGONIDAE			*1 [0.57]*						
Total number of animals	**174**	**116**	**175**	**77**	**69**	**120**	**449**	**958**	**373**

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Table 4 continued: SURBER SAMPLE SPECIES LIST
Actual numbers and (% relative abundance)

	4A	4B	4C	5A	5B	5C	6A	6B	6C
HEPTAGENIIDAE									
Ecdyonurus sp.	3 [2.19]					1 [0.09]			
EPHEMERELLIDAE									
Ephemerella ignita	11 [8.03]		9 [4.79]	19 [8.88]	11 [4.06]	8 [0.75]	3 [1.06]	2 [1.96]	2 [0.50]
EPHEMERIDAE									
Ephemera danica						1 [0.09]			
LEUCTRIDAE									
Leuctra fusca		1 [1.82]	1 [0.53]			1 [0.09]			
Leuctra geniculata	1 [0.73]	1 [1.82]			7 [2.58]	5 [0.47]	1 [0.35]		
CHLOROPERLIDAE									
Chloroperla torrentium									
LEPTOCERIDAE									
Athripsodes albifrons									
Athripsodes cinereus			3 [1.60]	1 [0.47]		2 [0.19]			1 [0.25]
Athripsodes sp.									
Ceraclea dissimilis									
Ceraclea sp									
Mystacides azurea									
Oecetis (?testacea)									
GOERIDAE									
Goera pilosa						1 [0.09]			
Silo pallipes									
LEPIDOSTOMATIDAE									
Lasiocephala basalis									
Lepidostoma hirtum			3 [1.60]		1 [0.37]	5 [0.47]			3 [0.74]
Indet juv prob Lasiocephala						3 [0.28]			
BRACHYCENTRIDAE									
Brachycentrus subnubilus		5 [9.09]	18 [9.57]		1 [0.37]	11 [1.03]			2 [0.50]
SERICOSTOMATIDAE									
Sericostoma personatum			3 [1.60]			9 [0.84]			1 [0.25]
CALOPTERYGIDAE									
Calopteryx virgo									
CORDULEGASTERIDAE									
Cordulegaster boltonii									
NEMOURIDAE									
Nemurella picteti									
RHYACOPHILIDAE									
Rhyacophila dorsalis									
Rhyacophila munda									
Agapetus sp.									
Glossosoma sp.									
POLYCENTROPODIDAE									
Plectrocnemia conspersa									
LIMNEPHILIDAE									
Drusus annulatus			1 [0.53]						
Halesus radiatus									
Halesus sp									
Potamophylax cingulatus						1 [0.09]			
Potamophylax latipennis				2 [0.93]					
ANCYLIDAE									
Ancylus fluviatilis	4 [2.92]	2 [3.64]	12 [6.38]	3 [1.40]	57 [21.03]	456 [42.50]	109 [38.65]	30 [29.41]	164 [40.69]
HYDROPTILIDAE									
Hydroptila sp.									
GAMMARIDAE									
Gammarus pulex									
DYTISCIDAE									
Oreodytes sanmarkii									
Potamonectes depressus gp.									
GYRINIDAE									
Gyrinus sp.									
HYDROPHILIDAE									
Hydreana gracilis									
ELMIDAE									
Elmis aenea									
Esolus parallelepipedus	1 [0.73]			1 [0.47]					1 [0.25]
Limnius volkmari	1 [0.73]		1 [0.53]		4 [1.48]	6 [0.56]	1 [0.35]	1 [0.98]	12 [2.98]
Oulimnius sp.									
HYDROPSYCHIDAE									
Hydropsyche pellucidula									
Hydropsyche siltalai	2[1.46]	3 [5.45]	5 [2.66]	7 [3.27]		1 [0.09]	6 [2.13]	1 [0.98]	
Hydropsyche sp.	1 [0.73]								

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Table 4 continued: SURBER SAMPLE SPECIES LIST
Actual numbers and (% relative abundance)

	4A	4B	4C	5A	5B	5C	6A	6B	6C
TIPULIDAE									
Antocha vitripennis	3 [2.19]			1 [0.47]	6 [2.21]	40 [3.73]			4 [0.99]
Dicranota sp.									
SIMULIIDAE									
Simulium argyreatum gp.		1 [1.82]							
Simulium aureum gp.									
Simulium reptans	6 [4.38]		2 [1.06]	6 [2.80]		2 [0.19]		12 [11.76]	2 [0.50]
Indet.							1 [0.35]		
PLANARIIDAE									
Dugesia tigrina									
Phagocata vitta									
Polycelis felina						2 [0.19]			
Polycelis nigra gp.									
BAETIDAE									
Baetis rhodani	8 [5.84]	1 [1.82]	1 [0.53]	8 [3.74]				7 [6.86]	
Baetis scambus gp.	1 [0.73]			2 [0.94]	3 [1.11]	1 [0.09]	1 [0.35]		
Centroptilum luteolum									
Centroptilum pennulatum									
PISCICOLIDAE									
Piscicola geometra									
HYDROBIIDAE									
Potamopyrgus jenkinsi	15 [10.95]	8 [14.55]	4 [2.13]	1 [0.47]	50 [18.45]	264 [24.60]	20 [7.09]	7 [6.86]	145 [35.98]
LYMNAEIDAE									
Lymnaea peregra						1 [0.09]			
PLANORBIDAE									
Armiger crista									
SPHAERIIDAE									
Pisidium sp.									1 [0.25]
GLOSSIPHONIIDAE									
Glossiphonia complanata						3 [0.28]			1 [0.25]
Helobdella stagnalis									
Indet glossiphoniid juv.			1 [0.53]						
ERPOBDELLIDAE									
Erpobdella octoculata							8 [2.84]		
Trocheta subviridis									
Indet. juv.									
CHIRONOMIDAE	40 [29.20]	7 [12.73]	39 [20.74]	36 [16.82]	29 [10.70]	124 [11.56]	47 [16.67]	8 [7.84]	29 [7.20]
OLIGOCHAETA	38 [27.74]	22 [40.00]	81 [43.09]	117 [54.67]	90 [33.21]	116 [10.81]	82 [29.08]	32 [31.37]	33 [8.19]
EMPIDIDAE				*2 [0.93]*				*2 [1.96]*	*1 [0.25]*
RHAGIONIDAE	*2 [1.46]*	*4 [7.27]*	*3 [1.60]*	*7 [3.27]*	*11 [4.06]*	*8 [0.75]*	*3 [1.06]*		*1 [0.25]*
HYDRACARINA									
NEMATODA									
PSYCHODIDAE									
CERATOPOGONIDAE			*1 [0.53]*	*1 [0.47]*	*1 [0.37]*	1 [0.09]			
Total number of animals	**137**	**55**	**188**	**214**	**271**	**1072**	**282**	**102**	**403**

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Table 4 continued: SURBER SAMPLE SPECIES LIST
Actual numbers and (% relative abundance)

	7A	7B	7C
HEPTAGENIIDAE			
Ecdyonurus sp.			
EPHEMERELLIDAE			
Ephemerella ignita	2 [0.73]	1 [0.08]	3 [0.45]
EPHEMERIDAE			
Ephemera danica			
LEUCTRIDAE			
Leuctra fusca			
Leuctra geniculata			
CHLOROPERLIDAE			
Chloroperla torrentium			
LEPTOCERIDAE			
Athripsodes albifrons			
Athripsodes cinereus			
Athripsodes sp.			1 [0.15]
Ceraclea dissimilis			
Ceraclea sp			
Mystacides azurea			
Oecetis (?testacea)			
GOERIDAE			
Goera pilosa			
Silo pallipes			
LEPIDOSTOMATIDAE			
Lasiocephala basalis			
Lepidostoma hirtum			
Indet juv prob Lasiocephala			
BRACHYCENTRIDAE			
Brachycentrus subnubilus			
SERICOSTOMATIDAE			
Sericostoma personatum			
CALOPTERYGIDAE			
Calopteryx virgo			
CORDULEGASTERIDAE			
Cordulegaster boltonii			
NEMOURIDAE			
Nemurella picteti		1 [0.08]	
RHYACOPHILIDAE			
Rhyacophila dorsalis			
Rhyacophila munda			
Agapetus sp.			
Glossosoma sp.			
POLYCENTROPODIDAE			
Plectrocnemia conspersa			
LIMNEPHILIDAE			
Drusus annulatus			
Halesus radiatus			
Halesus sp			
Potamophylax cingulatus			
Potamophylax latipennis			
ANCYLIDAE			
Ancylus fluviatilis	45 [16.63]	208 [16.49]	100 [14.88]
HYDROPTILIDAE			
Hydroptila sp.	1 [0.36]	1 [0.08]	1 [0.15]
GAMMARIDAE			
Gammarus pulex			
DYTISCIDAE			
Oreodytes sanmarkii			
Potamonectes depressus gp.			
GYRINIDAE			
Gyrinus sp.			
HYDROPHILIDAE			
Hydreana gracilis			
ELMIDAE			
Elmis aenea			
Esolus parallelepipedus		1 [0.08]	2 [0.30]
Limnius volkmari	5 [1.082]	5 [0.40]	12 [1.79]
Oulimnius sp.	2 [0.73]	1 [0.08]	
HYDROPSYCHIDAE			
Hydropsyche pellucidula			
Hydropsyche siltalai			4 [0.60]
Hydropsyche sp.			7 [1.04]

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Table 4 continued: SURBER SAMPLE SPECIES LIST
Actual numbers and (% relative abundance)

	7A	7B	7C
TIPULIDAE			
Antocha vitripennis	2 [0.73]	1 [0.08]	
Dicranota sp.			
SIMULIIDAE			
Simulium argyreatum gp.			
Simulium aureum gp.			
Simulium reptans			
Indet.			
PLANARIIDAE			
Dugesia tigrina			
Phagocata vitta			
Polycelis felina			
Polycelis nigra gp.			
BAETIDAE			
Baetis rhodani		1 [0.08]	
Baetis scambus gp.	1 [0.36]		
Centroptilum luteolum			
Centroptilum pennulatum			
PISCICOLIDAE			
Piscicola geometra			
HYDROBIIDAE			
Potamopyrgus jenkinsi	130 [47.27]	552 [43.77]	416 [61.90]
LYMNAEIDAE			
Lymnaea peregra	1 [0.36]	1 [0.08]	
PLANORBIDAE			
Armiger crista			
SPHAERIIDAE			
Pisidium sp.			
GLOSSIPHONIIDAE			
Glossiphonia complanata	1 [0.36]	7 [0.56]	6 [0.89]
Helobdella stagnalis			
Indet glossiphoniid juv.			
ERPOBDELLIDAE			
Erpobdella octoculata	1 [0.36]		1 [0.15]
Trocheta subviridis	1 [0.36]		
Indet. juv.		1[0.08]	
CHIRONOMIDAE	28 [10.18]	116 [9.20]	32 [4.76]
OLIGOCHAETA	54 [19.64]	360 [28.55]	86 [12.80]
EMPIDIDAE			
RHAGIONIDAE	*1 [0.36]*	*3 [0.24]*	*1 [0.15]*
HYDRACARINA			
NEMATODA			
PSYCHODIDAE			
CERATOPOGONIDAE		*1 [0.08]*	
Total number of animals	**275**	**1261**	**672**

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Table 5 : SUMMARY OF DATA FOR SURBER SAMPLES

Site Number	Total Abundance	Scoring Taxa	Total Taxa	BMWP Score	ASPT	No. Insects	% Insects	No. Non-Insects	% Non-Insects	No. Chironomids	Chironomids as % insects
Site 1A	174	17	19	116	6.82	142	81.61	32	18.39	48	33.80
Site 1B	116	7	9	43	6.14	53	45.69	63	54.31	28	52.83
Site1C	175	15	17	86	5.73	86	49.14	89	50.86	51	59.30
Site 1 combined replicate Surbers	465	21	23	139	6.62	281	60.43	184	39.57	127	45.20
Site 1 average of replicate Surbers	155.00	13.00	15.00	81.67	6.23	93.67	60.43	61.33	39.57	42.33	45.20
Site2A	77	7	8	26	3.71	27	35.06	50	64.94	8	29.63
Site 2B	69	13	15	77	5.92	45	65.22	24	34.78	13	28.29
Site 2C	120	9	10	40	4.44	35	29.17	85	70.83	7	20.00
Site 2 combined replicate Surbers	266	16	18	91	5.69	107	40.23	159	59.77	28	26.17
Site 2 average of replicate Surbers	88.67	9.67	11.00	47.67	4.44	35.67	40.23	53.00	59.77	9.33	26.16
Site 3A	449	17	19	104	6.12	119	26.50	330	73.50	64	53.78
Site 3B	958	22	25	134	6.09	247	25.78	711	74.22	88	35.63
Site 3C	373	16	17	106	6.63	129	34.58	244	65.42	73	56.59
Site 3 combined replicate Surbers	1780	25	28	146	5.84	495	27.81	1285	72.19	225	45.45
Site 3 average of replicate Surbers	593.33	18.33	20.33	114.67	6.28	165.00	27.81	428.33	72.19	75.00	45.45
Site 4A	137	12	13	66	5.50	80	58.39	57	41.61	40	50.00
Site 4B	55	9	10	46	5.10	23	41.82	32	58.18	7	30.43
Site 4C	188	16	18	101	6.31	90	47.87	98	52.13	39	43.33
Site 4 combined replicate Surbers	380	18	20	116	6.44	193	50.79	187	49.21	86	44.56
Site 4 average of replicate Surbers	126.67	12.33	13.67	71.00	5.64	64.33	50.79	62.33	49.21	28.67	44.61
Site 5A	214	12	15	63	5.25	93	43.46	121	56.54	36	38.71
Site 5B	271	11	13	66	6.00	74	27.31	197	72.69	29	39.19
Site 5C	1073	22	24	144	6.55	231	21.53	842	78.47	124	53.68
Site 5 combined replicate Surbers	1558	22	25	144	6.55	398	25.55	1160	74.45	189	47.49
Site 5 average of replicate Surbers	519.33	15.00	17.33	91.00	5.93	132.67	25.55	386.67	74.46	63.00	47.49
Site 6A	282	11	12	54	4.91	63	22.34	219	77.66	47	74.60
Site 6B	102	9	10	41	4.56	33	32.35	69	67.65	8	24.24
Site 6C	403	14	16	83	5.93	59	14.64	344	85.36	29	49.15
Site 6 combined replicate Surbers	787	18	20	105	5.83	155	19.70	632	80.30	84	54.19
Site 6 average of replicate Surbers	262.33	11.33	12.67	59.33	5.13	51.67	19.70	210.67	80.30	28.00	54.19
Site 7A	275	12	13	51	4.25	42	15.27	233	84.73	28	66.67
Site 7B	1261	13	15	58	4.46	132	10.47	1129	89.53	116	87.88
Site 7C	672	11	12	54	4.91	63	9.38	609	90.63	32	50.79
Site 7 combined replicate Surbers	2208	15	17	73	4.87	237	10.73	1971	89.27	176	74.26
Site 7 average of replicate Surbers	736.00	12.00	13.33	54.33	4.54	79.00	10.73	657.00	89.27	58.67	74.27

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Table 6: RELATIVE PROPORTIONS OF DIFFERENT ORDERS

Surber A replicates - actual numbers

	1	2	3	4	5	6	7
Flatworms	0	0	0	0	0	0	0
Molluscs	5	4	244	19	4	129	176
Oligochaetes	26	45	75	38	117	82	54
Leeches	0	0	11	0	0	8	3
Crustacea	1	1	0	0	0	0	0
Mayflies	11	2	18	23	29	4	3
Stoneflies	13	0	2	1	0	1	0
Odonata	0	0	0	0	0	0	0
Beetles	22	2	1	2	1	1	7
Caddis flies	35	0	25	2	10	6	1
True flies	58	23	67	51	53	51	31

Surber B replicates - actual numbers

	1	2	3	4	5	6	7
Flatworms	0	0	1	0	0	0	0
Molluscs	0	5	530	10	107	37	761
Oligochaetes	63	18	160	22	90	32	360
Leeches	0	0	8	0	0	0	8
Crustacea	0	0	0	0	0	0	0
Mayflies	3	10	15	1	14	9	2
Stoneflies	3	1	28	2	7	0	1
Odonata	0	0	0	0	0	0	0
Beetles	11	1	17	0	4	1	7
Caddis flies	2	7	95	8	2	1	1
True flies	34	26	92	12	47	22	121

Surber C replicates - actual numbers

	1	2	3	4	5	6	7
Flatworms	0	0	0	0	2	0	0
Molluscs	2	14	122	16	721	310	516
Oligochaetes	86	68	113	81	116	33	86
Leeches	1	3	9	1	3	1	7
Crustacea	0	0	0	0	0	0	0
Mayflies	4	11	3	10	11	2	3
Stoneflies	12	0	9	1	6	0	0
Odonata	0	0	0	0	0	0	0
Beetles	5	0	9	1	6	13	14
Caddis flies	8	4	33	33	33	7	13
True flies	58	20	75	45	175	37	33

Combined replicates

	1	2	3	4	5	6	7
Flatworms	0	0	1	0	2	0	0
Molluscs	7	23	896	45	832	476	1453
Oligochaetes	175	131	348	141	323	147	500
Leeches	1	3	28	1	3	9	18
Crustacea	1	1	0	0	0	0	0
Mayflies	18	23	36	34	54	15	8
Stoneflies	28	1	39	4	13	1	1
Odonata	0	0	0	0	0	0	0
Beetles	38	3	27	3	11	15	28
Caddis flies	45	11	153	43	45	14	15
True flies	150	69	234	108	275	110	185

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Table 7: INSECTS IN SURBER SAMPLES
Numbers and relative abundance

	1A	**1B**	**1C**	**2A**	**2B**	**2C**	**3A**	**3B**	**3C**
HEPTAGENIIDAE									
Ecdyonurus sp.					1 [2.22]			1 [0.40]	1 [0.78]
EPHEMERELLIDAE									
Ephemerella ignita	11 [7.75]	3 [5.66]	3 [3.49]		4 [8.89]	1 [2.86]	16 [13.45]	12 [4.86]	2 [1.55]
EPHEMERIDAE									
Ephemera danica									
LEUCTRIDAE									
Leuctra fusca	6 [4.23]	2 [3.77]	5 [5.81]				1 [0.84]	8 [3.24]	2 [1.55]
Leuctra geniculata	7 [4.93]	1 [1.89]	6 [6.98]		1 [2.22]		1 [0.84]	20 [8.10]	7 [5.43]
CHLOROPERLIDAE									
Chloroperla torrentium			1 [1.16]						
LEPTOCERIDAE									
Athripsodes albifrons		1 [1.89]						24 [9.72]	3 [2.33]
Athripsodes cinereus	1 [0.70]	1 [1.89]					4 [3.36]	3 [1.21]	2 [1.55]
Athripsodes sp.							2 [1.68]		
Ceraclea dissimilis									
Ceraclea sp									1 [0.78]
Mystacides azurea									
Oecetis (?testacea)									
GOERIDAE									
Goera pilosa									
Silo pallipes	6 [4.23]								
LEPIDOSTOMATIDAE									
Lasiocephala basalis	1 [0.70]								
Lepidostoma hirtum	6 [4.23]				1 [2.22]		3 [2.52]	12 [4.86]	4 [3.10]
Indet juv prob Lasiocephala								1 [0.40]	
BRACHYCENTRIDAE									
Brachycentrus subnubilus	1 [0.70]						9 [7.56]	28 [11.34]	13 [10.08]
SERICOSTOMATIDAE									
Sericostoma personatum	12 [8.45]		3 [3.49]				7 [5.88]	16 [6.48]	8 [6.20]
CALOPTERYGIDAE									
Calopteryx virgo									
CORDULEGASTERIDAE									
Cordulegaster boltonii									
NEMOURIDAE									
Nemurella picteti									
RHYACOPHILIDAE									
Rhyacophila dorsalis	2 [1.41]				5 [11.11]	2 [5.71]		1 [0.40]	1 [0.78]
Rhyacophila munda									
Agapetus sp.	3 [2.11]								
Glossosoma sp.								1 [0.40]	1 [0.78]
POLYCENTROPODIDAE									
Plectrocnemia conspersa									
LIMNEPHILIDAE									
Drusus annulatus	1 [0.70]		1 [1.16]						
Halesus radiatus								4 [1.62]	
Halesus sp							1 [0.84]		
Potamophylax cingulatus									
Potamophylax latipennis	1 [0.70]							1 [0.40]	
HYDROPTILIDAE									
Hydroptila sp.									
DYTISCIDAE									
Oreodytes sanmarkii									
Potamonectes depressus gp.									
GYRINIDAE									
Gyrinus sp.									
HYDROPHILIDAE									
Hydreana gracilis	1 [0.70]		1 [1.16]		1 [2.22]			1 [0.40]	
ELMIDAE									
Elmis aenea	3 [2.11]	1 [1.89]						4 [1.62]	
Esolus parallelepipedus	2 [1.41]	9 [16.98]	3 [3.49]	1 [3.70]			4 [3.36]	8 [3.24]	2 [1.55]
Limnius volkmari	16 [11.27]	1 [1.89]	1 [1.16]	1 [3.70]			1 [0.84]	4 [1.62]	7 [5.43]
Oulimnius sp.									
HYDROPSYCHIDAE									
Hydropsyche pellucidula			1 [1.16]						
Hydropsyche siltalai	1 [0.70]		1 [1.16]		1 [2.22]	2 [5.71]	1 [0.84]	4 [1.62]	
Hydropsyche sp.									
TIPULIDAE									
Antocha vitripennis	3 [2.11]	3 [5.66]	3 [3.49]		1 [2.22]		1 [0.84]		
Dicranota sp.									1 [0.78]
SIMULIIDAE									
Simulium argyreatum gp.									
Simulium aureum gp.									
Simulium reptans				11 [40.74]	10 [22.22]	8 [22.86]		1 [0.40]	
Indet.									
BAETIDAE									
Baetis rhodani				2 [7.41]	4 [8.89]	8 [22.86]	2 [1.68]	1 [0.40]	
Baetis scambus gp.			1 [1.16]		1 [2.22]	2 [5.71]		1 [0.40]	
Centroptilum luteolum									
Centroptilum pennulatum									
CHIRONOMIDAE	48 [33.80]	28 [52.83]	51 [59.30]	8 [29.63]	13 [28.89]	7 [20.00]	64 [53.78]	88 [35.63]	73 [56.59]
EMPIDIDAE	2 [1.41]	*1 [1.89]*	*2 [2.33]*				1 [0.84]		
RHAGIONIDAE	*8 [5.63]*	*2 [3.77]*	*2 [2.33]*	*4 [14.81]*	*2 [4.44]*	*5 [14.29]*	1 [0.84]	*2 [0.81]*	1 [0.78]
PSYCHODIDAE								1 [0.40]	
CERATOPOGONIDAE			*1 [1.16]*						
Total number	**142**	**53**	**86**	**27**	**45**	**35**	**119**	**247**	**129**

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Table 7: INSECTS IN SURBER SAMPLES
Numbers and relative abundance

	4A	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**6C**
HEPTAGENIIDAE									
Ecdyonurus sp.	3 [3.75]					1 [0.43]			
EPHEMERELLIDAE									
Ephemerella ignita	11 [13.75]		9 [10.00]	19 [20.43]	11 [14.86]	8 [3.46]	3 [4.76]	2 [6.06]	2 [3.39]
EPHEMERIDAE									
Ephemera danica						1 [0.43]			
LEUCTRIDAE									
Leuctra fusca		1 [4.35]	1 [1.11]			1 [0.43]			
Leuctra geniculata	1 [1.25]	1 [4.35]			7 [9.46]	5 [2.16]	1 [1.59]		
CHLOROPERLIDAE									
Chloroperla torrentium									
LEPTOCERIDAE									
Athripsodes albifrons									
Athripsodes cinereus			3 [3.33]	1 [1.08]		2 [0.87]			1 [1.69]
Athripsodes sp.									
Ceraclea dissimilis									
Ceraclea sp									
Mystacides azurea									
Oecetis (?testacea)									
GOERIDAE									
Goera pilosa						1 [0.43]			
Silo pallipes									
LEPIDOSTOMATIDAE									
Lasiocephala basalis									
Lepidostoma hirtum			3 [3.33]		1 [1.35]	5 [2.16]			3 [5.08]
Indet juv prob Lasiocephala						3 [1.30]			
BRACHYCENTRIDAE									
Brachycentrus subnubilus		5 [21.74]	18 [20.00]		1 [1.35]	11 [4.76]			2 [3.39]
SERICOSTOMATIDAE									
Sericostoma personatum			3 [3.33]			9 [3.90]			1 [1.69]
CALOPTERYGIDAE									
Calopteryx virgo									
CORDULEGASTERIDAE									
Cordulegaster boltonii									
NEMOURIDAE									
Nemurella picteti									
RHYACOPHILIDAE									
Rhyacophila dorsalis									
Rhyacophila munda									
Agapetus sp.									
Glossosoma sp.									
POLYCENTROPODIDAE									
Plectrocnemia conspersa									
LIMNEPHILIDAE									
Drusus annulatus			1 [1.11]						
Halesus radiatus									
Halesus sp									
Potamophylax cingulatus						1 [0.43]			
Potamophylax latipennis				2 [2.15]					
HYDROPTILIDAE									
Hydroptila sp.									
DYTISCIDAE									
Oreodytes sanmarkii									
Potamonectes depressus gp.									
GYRINIDAE									
Gyrinus sp.									
HYDROPHILIDAE									
Hydreana gracilis									
ELMIDAE									
Elmis aenea									
Esolus parallelepipedus	1 [1.25]			1 [1.08]					1 [1.69]
Limnius volkmari	1 [1.25]		1 [1.11]		4 [5.41]	6 [2.60]	1 [1.59]	1 [3.03]	12 [20.34]
Oulimnius sp.									
HYDROPSYCHIDAE									
Hydropsyche pellucidula									
Hydropsyche siltalai	2 [2.50]	3 [13.04]	5 [5.56]	7 [7.53]		1 [0.43]	6 [9.52]	1 [3.03]	
Hydropsyche sp.	1 [1.25]								
TIPULIDAE									
Antocha vitripennis	3 [3.75]			1 [1.08]	6 [8.11]	40 [17.32]			4 [6.78]
Dicranota sp.									
SIMULIIDAE									
Simulium argyreatum gp.		1 [4.35]							
Simulium aureum gp.									
Simulium reptans	6 [6.75]		2 [2.22]	6 [6.45]		2 [0.87]		12 [36.36]	2 [3.39]
Indet.							1 [1.59]		
BAETIDAE									
Baetis rhodani	8 [10.00]	1 [4.35]	1 [1.11]	8 [8.60]				7 [21.21]	
Baetis scambus gp.	1 [1.25]			2 [2.15]	3 [4.05]	1 [0.43]	1 [1.59]		
Centroptilum luteolum									
Centroptilum pennulatum									
CHIRONOMIDAE	40 [50.00]	7 [30.43]	39 [43.33]	36 [38.71]	29 [39.19]	124 [53.68]	47 [74.60]	8 [24.24]	29 [49.15]
EMPIDIDAE				2 [2.15]				*2 [6.06]*	*1 [1.69]*
RHAGIONIDAE	*2 [2.50]*	*4 [17.39]*	*3 [3.33]*	*7 [7.53]*	*11 [14.86]*	*8 [3.46]*	*3 [4.76]*		*1 [1.69]*
PSYCHODIDAE									
CERATOPOGONIDAE			*1 [1.11]*	1 [1.08]	*1 [1.35]*	*1 [0.43]*			
Total number	**80**	**23**	**90**	**93**	**74**	**231**	**63**	**33**	**59**

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Table 7: INSECTS IN SURBER SAMPLES
Numbers and relative abundance

	7A	7B	7C
HEPTAGENIIDAE			
Ecdyonurus sp.			
EPHEMERELLIDAE			
Ephemerella ignita	2 [4.76]	1 [0.76]	3 [4.76]
EPHEMERIDAE			
Ephemera danica			
LEUCTRIDAE			
Leuctra fusca			
Leuctra geniculata			
CHLOROPERLIDAE			
Chloroperla torrentium			
LEPTOCERIDAE			
Athripsodes albifrons			
Athripsodes cinereus			
Athripsodes sp.			1 [1.59]
Ceraclea dissimilis			
Ceraclea sp			
Mystacides azurea			
Oecetis (?testacea)			
GOERIDAE			
Goera pilosa			
Silo pallipes			
LEPIDOSTOMATIDAE			
Lasiocephala basalis			
Lepidostoma hirtum			
Indet juv prob Lasiocephala			
BRACHYCENTRIDAE			
Brachycentrus subnubilus			
SERICOSTOMATIDAE			
Sericostoma personatum			
CALOPTERYGIDAE			
Calopteryx virgo			
CORDULEGASTERIDAE			
Cordulegaster boltonii			
NEMOURIDAE			
Nemurella picteti		1 [0.76]	
RHYACOPHILIDAE			
Rhyacophila dorsalis			
Rhyacophila munda			
Agapetus sp.			
Glossosoma sp.			
POLYCENTROPODIDAE			
Plectrocnemia conspersa			
LIMNEPHILIDAE			
Drusus annulatus			
Halesus radiatus			
Halesus sp			
Potamophylax cingulatus			
Potamophylax latipennis			
HYDROPTILIDAE			
Hydroptila sp.	1 [2.38]	1 [0.76]	1 [1.59]
DYTISCIDAE			
Oreodytes sanmarkii			
Potamonectes depressus gp.			
GYRINIDAE			
Gyrinus sp.			
HYDROPHILIDAE			
Hydreana gracilis			
ELMIDAE			
Elmis aenea			
Esolus parallelepipedus		1 [0.76]	2 [3.17]
Limnius volkmari	5 [11.90]	5 [3.79]	12 [19.05]
Oulimnius sp.	2 [4.76]	1 [0.76]	
HYDROPSYCHIDAE			
Hydropsyche pellucidula			
Hydropsyche siltalai			4 [6.35]
Hydropsyche sp.			7 [11.11]
TIPULIDAE			
Antocha vitripennis	2 [4.76]	1 [0.76]	
Dicranota sp.			
SIMULIIDAE			
Simulium argyreatum gp.			
Simulium aureum gp.			
Simulium reptans			
Indet.			
BAETIDAE			
Baetis rhodani		1 [0.76]	
Baetis scambus gp.	1 [2.38]		
Centroptilum luteolum			
Centroptilum pennulatum			
CHIRONOMIDAE	28 [66.67]	116 [87.88]	32 [50.79]
EMPIDIDAE			
RHAGIONIDAE	*1 [2.38]*	*3 [2.27]*	*1 [1.59]*
PSYCHODIDAE			
CERATOPOGONIDAE		*1 [0.76]*	
Total number	**42**	**132**	**63**

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Table 8: NON-INSECTS IN SURBER SAMPLES
Numbers and relative abundance

	1A	1B	1C	2A	2B	2C	3A	3B	3C
ANCYLIDAE									
Ancylus fluviatilis			1 [1.12]				137 [41.52]	316 [44.44]	93 [38.11]
GAMMARIDAE									
Gammarus pulex	1 [3.13]			1 [2.00]					
PLANARIIDAE									
Dugesia tigrina									
Phagocata vitta									
Polycelis felina								1 [0.14]	
Polycelis nigra gp.									
PISCICOLIDAE									
Piscicola geometra									1 [0.41]
HYDROBIIDAE									
Potamopyrgus jenkinsi	5 [15.63]		1 [1.12]	4 [8.00]	5 [20.83]	14 [16.47]	107 [32.42]	212 [29.82]	29 [11.89]
LYMNAEIDAE									
Lymnaea peregra								1 [0.14]	
PLANORBIDAE									
Armiger crista									
SPHAERIIDAE									
Pisidium sp.								1 [0.14]	
GLOSSIPHONIIDAE									
Glossiphonia complanata							8 [2.42]		7 [2.87]
Helobdella stagnalis									1 [0.41]
Hemiclepsis marginata									
Indet. juv. glossiphoniid									
ERPOBDELLIDAE									
Erpobdella octoculata			1 [1.12]			3 [3.53]		8 [1.13]	
Trocheta subviridis							1 [0.30]		
Indet. juv.							2 [0.61]		
OLIGOCHAETA	26 [81.25]	63 {100.00	86 [96.63]	45 [90.00]	18 [75.00]	68 [80.00]	75 [22.73]	160 [22.50]	113 [46.31]
HYDRACARINA								*12 [1.69]*	
NEMATODA					*1 [4.17]*				
Total number	**32**	**63**	**89**	**50**	**24**	**85**	**330**	**711**	**244**

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Table 8 continued: NON-INSECTS IN SURBER SAMPLES
Numbers and relative abundance

	4A	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**6C**
ANCYLIDAE									
Ancylus fluviatilis	4 [7.02]	2 [6.25]	12 [12.24]	3 [2.48]	57 [28.93]	456 [54.16]	109 [49.77]	30 [43.48]	164 [47.67]
GAMMARIDAE									
Gammarus pulex									
PLANARIIDAE									
Dugesia tigrina									
Phagocata vitta									
Polycelis felina						2 [0.24]			
Polycelis nigra gp.									
PISCICOLIDAE									
Piscicola geometra									
HYDROBIIDAE									
Potamopyrgus jenkinsi	15 [26.32]	8 [25.00]	4 [4.08]	1 [0.83]	50 [25.38]	264 [31.35]	20 [9.13]	7 [10.14]	145 [42.15]
LYMNAEIDAE									
Lymnaea peregra						1 [0.12]			
PLANORBIDAE									
Armiger crista									
SPHAERIIDAE									
Pisidium sp.									1 [0.29]
GLOSSIPHONIIDAE									
Glossiphonia complanata						3 [0.36]			1 [0.29]
Helobdella stagnalis									
Hemiclepsis marginata									
Indet. juv. glossiphoniid			1 [1.02]						
ERPOBDELLIDAE									
Erpobdella octoculata							8 [3.65]		
Trocheta subviridis									
Indet. juv.									
OLIGOCHAETA	38 [66.67]	22 [68.75]	81 [82.65]	117 [96.69]	90 [45.69]	116 [13.78]	82 [37.44]	32 [46.38]	33 [9.59]
HYDRACARINA									
NEMATODA									
Total number	**57**	**32**	**98**	**121**	**197**	**842**	**219**	**69**	**344**

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Table 8 continued: NON-INSECTS IN SURBER SAMPLES
Numbers and relative abundance

	7A	7B	7C
ANCYLIDAE			
Ancylus fluviatilis	45 [19.31]	208 [18.42]	100 [16.42]
GAMMARIDAE			
Gammarus pulex			
PLANARIIDAE			
Dugesia tigrina			
Phagocata vitta			
Polycelis felina			
Polycelis nigra gp.			
PISCICOLIDAE			
Piscicola geometra			
HYDROBIIDAE			
Potamopyrgus jenkinsi	130 [55.79]	552 [48.89]	416 [68.31]
LYMNAEIDAE			
Lymnaea peregra	1 [0.43]	1 [0.09]	
PLANORBIDAE			
Armiger crista			
SPHAERIIDAE			
Pisidium sp.			
GLOSSIPHONIIDAE			
Glossiphonia complanata	1 [0.43]	7 [0.62]	6 [0.99]
Helobdella stagnalis			
Hemiclepsis marginata			
Indet. juv. glossiphoniid			
ERPOBDELLIDAE			
Erpobdella octoculata	1 [0.43]		1 [0.16]
Trocheta subviridis	1 [0.43]		
Indet. juv.		1 [0.09]	
OLIGOCHAETA	54 [23.18]	360 [31.89]	86 [14.12]
HYDRACARINA			
NEMATODA			
Total number	**233**	**1129**	**609**

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Table 9: INSECT AND NON-INSECT TAXA IN SURBER SAMPLES

	Total abundanc	No. Insects	No. Non-insects	% Insects	% Non-insects
1A	174	142	32	81.61	18.39
1B	116	53	63	45.69	54.31
1C	175	86	89	49.14	50.86
1 combined Surber	465	281	184	60.43	39.57
1 mean Surber	155.00	93.67	61.33	60.43	39.57
2A	77	27	50	35.06	64.94
2B	69	45	24	65.22	34.78
2C	120	35	85	29.17	70.83
2 combined Surber	266	107	159	40.23	59.77
2 mean Surber	88.67	35.67	53.00	40.23	59.77
3A	449	119	330	26.50	73.50
3B	958	247	711	25.78	74.22
3C	373	129	244	34.58	65.42
3 combined Surber	1780	495	1285	27.81	72.19
3 mean Surber	593.33	165	428.33	27.81	72.19
4A	137	80	57	58.39	41.61
4B	55	23	32	41.82	58.18
4C	188	90	98	47.87	52.13
4 combined Surber	380	193	187	50.79	49.21
4 mean Surber	126.67	64.33	62.33	50.79	49.21
5A	214	93	121	43.46	56.54
5B	271	74	197	27.31	72.69
5C	1073	231	842	21.53	78.47
5 combined Surber	1558	398	1160	25.55	74.45
5 mean Surber	519.33	132.67	386.67	25.55	74.46
6A	282	63	219	22.34	77.66
6B	102	33	69	32.35	67.65
6C	403	59	344	14.64	85.36
6 combined Surber	787	155	632	19.70	80.30
6 mean Surber	262.33	51.67	210.67	19.70	80.30
7A	275	42	233	15.27	84.73
7B	1261	132	1129	10.47	89.53
7C	672	63	609	9.38	90.63
7 combined Surber	2208	237	1971	10.73	89.27
7 mean Surber	736.00	79	657	10.73	89.27

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Table 10: ABUNDANCE OF FAMILIES SENSITIVE TO PESTICIDES (combined replicate Surber samples)

SITE	Baetidae		Heptageniidae		Ephemerellidae		Ephemeridae		Nemouridae		Leuctridae		Chloroperlidae		Rhyacophilidae		Hydropsychidae		Hydroptilidae		Limnephilidae		Leptoceridae		Goeridae		Lepidostomatida		Brachycentridae		Sericostomatidae	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	1	0.36	0	0.00	17	6.05	0	0.00	0	0.00	27	9.61	1	0.36	5	1.78	3	1.07	0	0.00	3	1.07	3	1.07	6	2.14	7	2.49	1	0.36	15	5.34
2	17	15.89	1	0.93	5	4.67	0	0.00	0	0.00	1	0.93	0	0.00	7	6.54	3	2.80	0	0.00	0	0.00	0	0.00	0	0.00	1	0.93	0	0.00	0	0.00
3	4	0.81	2	0.40	30	6.06	0	0.00	0	0.00	39	7.88	0	0.00	4	0.81	5	1.01	0	0.00	6	1.21	39	7.88	0	0.00	20	4.04	50	10.10	31	6.26
4	11	5.70	3	1.55	20	10.36	0	0.00	0	0.00	4	2.07	0	0.00	0	0.00	10	5.18	0	0.00	1	0.52	3	1.55	0	0.00	3	1.55	23	11.92	3	1.55
5	14	3.52	1	0.25	38	9.55	1	0.25	0	0.00	13	3.27	0	0.00	0	0.00	8	2.01	0	0.00	3	0.75	3	0.75	1	0.25	9	2.26	12	3.02	9	2.26
6	8	5.16	0	0.00	7	4.52	0	0.00	0	0.00	1	0.65	0	0.00	0	0.00	7	4.52	0	0.00	0	0.00	1	0.65	0	0.00	3	1.94	2	1.29	1	0.65
7	2	0.84	0	0.00	6	2.53	0	0.00	1	0.42	0	0.00	0	0.00	0	0.00	11	4.64	3	1.27	0	0.00	1	0.42	0	0.00	0	0.00	0	0.00	0	0.00

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Table 11: SPECIES LIST FOR RIVPACS SAMPLES
Actual numbers and (% relative abundance)

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
HEPTAGENIIDAE							
Ecdyonurus sp.	1 [0.23]	1 [0.07]	5 [0.39]	1 [0.28]			
EPHEMERELLIDAE							
Ephemerella ignita	124 [28.57]	215 [14.06]	248 [19.11]	12 [3.34]	79 [17.91]	48 [7.92]	56 [1.65]
EPHEMERIDAE							
Ephemera danica							
LEUCTRIDAE							
Leuctra fusca	10 [2.30]	2 [0.13]	1 [0.08]	2 [0.56]	2 [0.45]		2 [0.06]
Leuctra geniculata	10 [2.30]	3 [0.20]	5 [0.39]	4 [1.11]	1 [0.23]		2 [0.06]
CHLOROPERLIDAE							
Chloroperla torrentium							
LEPTOCERIDAE							
Athripsodes albifrons	1 [0.23]			1 [0.28]	2 [0.45]	1 [0.17]	
Athripsodes cinereus			1 [0.08]				
Athripsodes sp.							
Ceraclea dissimilis			2 [0.15]			1 [0.17]	
Ceraclea sp							
Mystacides azurea			9 [0.69]			1 [0.17]	2 [0.06]
Oecetis (?testacea)			1 [0.08]				
GOERIDAE							
Goera pilosa			1 [0.08]				1 [0.03]
Silo pallipes	1 [0.23]						
LEPIDOSTOMATIDAE							
Lasiocephala basalis							
Lepidostoma hirtum	7 [1.61]	3 [0.20]	8 [0.62]	2 [0.56]	1 [0.23]		
Indet juv prob Lasiocephala	1 [0.23]						5 [0.15]
BRACHYCENTRIDAE							
Brachycentrus subnubilus	5 [1.15]	19 [1.24]	6 [0.46]	10 [2.79]	4 [0.91]	4 [0.66]	1 [0.03]
SERICOSTOMATIDAE							
Sericostoma personatum	12 [2.76]		8 [0.62]	3 [0.84]	1 [0.23]	1 [0.17]	
CALOPTERYGIDAE							
Calopteryx virgo	1 [0.23]	1 [0.07]					
CORDULEGASTERIDAE							
Cordulegaster boltonii			1 [0.08]				
NEMOURIDAE							
Nemurella picteti							
RHYACOPHILIDAE							
Rhyacophila dorsalis	2 [0.46]	5 [0.33]	9 [0.69]		1 [0.23]		
Rhyacophila munda		1 [0.07]					
Agapetus sp.	3 [0.69]		4 [0.31]				
Glossosoma sp.							1 [0.03]
POLYCENTROPODIDAE							
Plectrocnemia conspersa						1 [0.17]	
LIMNEPHILIDAE							
Drusus annulatus			1 [0.08]				
Halesus radiatus			1 [0.08]				
Halesus sp.	1 [0.23]						
Potamophylax cingulatus							
Potamophylax latipennis						1 [0.17]	
ANCYLIDAE							
Ancylus fluviatilis	1 [0.23]		16 [1.23]	3 [0.84]	81 [18.37]	128 [21.12]	152 [4.47]
HYDROPTILIDAE							
Hydroptila sp.					1 [0.23]		6 [0.18]
GAMMARIDAE							
Gammarus pulex	1 [0.23]			1 [0.28]	1 [0.23]		
DYTISCIDAE							
Oreodytes sanmarkii			4 [0.31]				
Potamonectes depressus gp.							5 [0.15]
GYRINIDAE							
Gyrinus sp.			1 [0.08]				
HYDROPHILIDAE							
Hydreana gracilis		1 [0.07]					
ELMIDAE							
Elmis aenea	2 [0.46]	3 [0.20]	5 [0.39]				2 [0.06]
Esolus parallelepipedus	2 [0.46]		1 [0.08]				1 [0.03]
Limnius volkmari	6 [1.38]	2 [0.13]	6 [0.46]	3 [0.84]	2 [0.45]	5 [0.83]	22 [0.65]
Oulimnius sp.					1 [0.23]		1 [0.03]

Table 11 continued: SPECIES LIST FOR RIVPACS SAMPLES

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**
HYDROPSYCHIDAE							
Hydropsyche pellucidula							
Hydropsyche siltalai		5 [0.33]	6 [0.46]	2 [0.56]		1 [0.17]	
Hydropsyche sp.		1 [0.07]			4 [0.91]		1 [0.03]
TIPULIDAE							
Antocha vitripennis		3 [0.20]	2 [0.15]	1 [0.28]	3 [0.68]		4 [0.12]
Dicranota sp.		1 [0.07]					
SIMULIIDAE							
Simulium argyreatum gp.			1 [0.08]		5 [1.13]	32 [5.28]	1 [0.03]
Simulium aureum gp.				1 [0.28]			
Simulium reptans	6 [1.38]	6 [0.39]	16 [1.23]		45 [10.20]	2 [0.33]	
Indet.	1 [0.23]						
PLANARIIDAE							
Dugesia tigrina						1 [0.17]	3 [0.09]
Phagocata vitta		3 [0.20]	4 [0.31]	2 [0.56]		2 [0.33]	
Polycelis felina	4 [0.92]	2 [0.13]	1 [0.08]				
Polycelis nigra gp.			2 [0.15]			1 [0.17]	3 [0.09]
BAETIDAE							
Baetis rhodani	10 [2.30]	39 [2.55]	76 [5.86]	4 [1.11]	5 [1.13]	12 [1.98]	1 [0.03]
Baetis scambus gp.	17 [3.92]	4 [0.26]	4 [0.31]		2 [0.45]	4 [0.66]	20 [0.59]
Centroptilum luteolum							1 [0.03]
Centroptilum pennulatum			2 [0.15]				
PISCICOLIDAE							
Piscicola geometra							1 [0.03]
HYDROBIIDAE							
Potamopyrgus jenkinsi	38 [8.76]	248 [16.22]	240 [18.49]	50 [13.93]	55 [12.47]	128 [21.12]	2396 [70.41]
LYMNAEIDAE							
Lymnaea peregra			4 [0.31]			1 [0.17]	3 [0.09]
PLANORBIDAE							
Armiger crista							2 [0.06]
SPHAERIIDAE							
Pisidium sp.				1 [0.28]			29 [0.85]
GLOSSIPHIIDAE							
Glossiphonia complanata	1 [0.23]	2 [0.13]	16 [1.23]	2 [0.56]		1 [0.17]	7 [0.21]
Helobdella stagnalis							1 [0.03]
Hemiclepsis marginata					2 [0.45]		
Indet. glossiphoniid sp.							
ERPOBDELLIDAE							
Erpobdella octoculata		1 [0.07]	2 [0.15]				1 [0.03]
Trocheta subviridis							1 [0.03]
Indet. juv.	1 [0.23]					4 [0.66]	2 [0.06]
CHIRONOMIDAE	82 [18.89]	932 [60.95]	332 [25.58]	77 [21.45]	101 [22.90]	92 [15.18]	292 [8.58]
OLIGOCHAETA	70 [16.13]	20 [1.31]	208 [16.02]	170 [47.35]	33 [7.48]	120 [19.80]	360 [10.58]
EMPIDIDAE	1 [0.23]	1 [0.07]	2 [0.15]	1 [0.28]	*4 [0.91]*	1 [0.17]	
RHAGIONIDAE	*11 [2.53]*	*4 [0.26]*	*8 [0.62]*	*6 [1.67]*	*5 [1.13]*	*8 [1.32]*	*13 [0.38]*
HYDRACARINA	1 [0.23]	1 [0.07]	*28 [2.16]*			4 [0.66]	1 [0.03]
NEMATODA							
PSYCHODIDAE							
CERATOPOGONIDAE						1 [0.17]	1 [0.03]
Total number of animals	**434**	**1529**	**1298**	**359**	**441**	**606**	**3403**

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Table 12 : SUMMARY OF DATA CALCULATED FOR RIVPACS SAMPLES

	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7
BIOLOGICAL DATA							
Total number animals	434	1529	1298	359	441	606	3403
Number scoring taxa	22	19	26	20	19	18	25
Number non-scoring taxa	3	3	3	2	3	5	3
Total taxa	25	22	29	22	21	23	28
BMWP score	145	111	162	123	118	99	138
ASPT	6.59	5.84	6.23	6.15	6.21	5.50	5.52
Number of insects	317	1252	777	130	269	216	441
% insects	73.07	81.81	59.86	36.21	61	35.64	12.96
Number of non-insects	117	277	521	229	172	390	2962
% non-insects	26.96	18.12	40.14	63.79	39	64.36	87.04
Number chironomids	82	932	332	77	101	92	292
% chironomids	25.87	74.44	72.73	59.23	37.55	42.59	66.21
Number BMWP families recorded	22	19	26	20	19	18	25
No. BMWP families expected at 50% level but not found	8	9	4	6	10	11	6
No. BMWP families found with less than 50% probability of capture	6	4	7	3	5	4	8
No. of species recorded	28	25	37	20	20	22	31
No. species expected at 50% level but not found	6	8	5	11	12	12	11
No. species found with less than 50% probability of capture (excluding oligochaetes and chironomids)	12	11	19	9	8	12	17
Overall ecological quality band	A	B	B	B	B	C	C

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Table 13: QUALITY BAND PREDICTIONS FROM RIVPACS III +
RIVPACS samples

	SITES/SAMPLES						
Predictions based on:	**1**	**2**	**3**	**4**	**5**	**6**	**7**
TAXA	A	B	A	B	B	B	A
ASPT	A	B	B	B	B	C	C
EA GQA	A	B	B	B	B	C	C
OVERALL QUALITY BAND	A	B	B	B	B	C	C

N.B. STW discharge occurs between sites 2 and 3

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Table 14: STATISTICAL SIGNIFICANCE OF DIFFERENCE IN O/E VALUES

STATISTICAL SIGNIFICANCE OF DIFFERENCE IN O/E NUMBER OF TAXA

SITE	1	2	3	4	5	6	7
1		-	-	-	-	-	-
2			-	-	-	-	-
3				-	+	+	-
4					-	-	-
5						-	-
6							-
7							

STATISTICAL SIGNIFICANCE OF DIFFERENCE IN O/E ASPT

SITE	1	2	3	4	5	6	7
1		-	-	-	-	+	+
2			-	-	-	-	-
3				-	-	+	-
4					-	-	-
5						-	-
6							-
7							

- represents no significant difference

+ represents significant difference

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Table 15: PROBABILITY OF DIFFERENCE IN QUALITY BAND

Based on O/E no. taxa

Sites	Better	Same	Worse
1 cf 2	8.6	34.8	66.4
1 cf 3	32.4	66.4	1.2
1 cf 4	10.6	38.8	50.6
1 cf 5	7.6	33.6	58.8
1 cf 6	3.6	25.4	71.0
1 cf 7	29.0	63.2	7.8
2 cf 1	60.0	33.4	6.6
2 cf 3	80.4	19.4	0.2
2 cf 4	36.0	44.2	19.8
2 cf 5	27.8	47.6	24.6
2 cf 6	19.0	45.4	35.6
2 cf 7	75.6	21.4	3.0
3 cf 1	0.6	70.2	29.2
3 cf 2	0.4	19.4	80.2
3 cf 4	0.8	30.2	69.0
3 cf 5	0.2	21.6	78.2
3 cf 6	0.2	11.2	88.6
3 cf 7	1.4	87.0	11.6
4 cf 1	53.8	39.2	7.0
4 cf 2	22.2	43.6	34.2
4 cf 3	68.8	30.2	1.0
4 cf 5	23.4	44.6	32.0
4 cf 6	15.4	42.0	42.6
4 cf 7	66.2	30.0	3.8
5 cf 1	63.4	31.0	5.6
5 cf 2	33.4	42.6	24.0
5 cf 3	82.0	17.2	0.8
5 cf 4	42.0	40.0	18.0
5 cf 6	20.6	45.0	34.4
5 cf 7	77.2	20.4	2.4
6 cf 1	72.4	24.0	3.6
6 cf 2	41.2	43.2	15.6
6 cf 3	93.2	6.6	0.2
6 cf 4	44.4	42.8	12.8
6 cf 5	35.2	47.4	17.4
6 cf 7	88.8	9.2	2.0
7 cf 1	8.6	65.8	25.6
7 cf 2	2.4	27.8	69.8
7 cf 3	11.6	87.0	1.4
7 cf 4	3.6	33.6	62.8
7 cf 5	2.2	25.6	72.2
7 cf 6	1.4	16.6	82.0

Based on O/E ASPT

Sites	Better	Same	Worse
1 cf 2	0.6	16.8	82.6
1 cf 3	10.2	42.6	47.2
1 cf 4	6.8	33.6	59.6
1 cf 5	5.4	31.0	63.6
1 cf 6	0.2	5.2	94.6
1 cf 7	0.2	10.0	89.8
2 cf 1	84.2	15.0	0.8
2 cf 3	56.0	40.6	3.4
2 cf 4	45.0	50.0	5.0
2 cf 5	41.6	52.4	6.0
2 cf 6	6.8	34.8	58.4
2 cf 7	13.2	42.6	44.2
3 cf 1	43.0	46.2	10.8
3 cf 2	3.2	36.4	60.4
3 cf 4	16.2	51.0	32.8
3 cf 5	13.4	50.6	36.0
3 cf 6	0.2	12.6	87.2
3 cf 7	0.6	24.8	74.6
4 cf 1	55.2	39.2	5.6
4 cf 2	5.0	47.4	47.6
4 cf 3	30.8	49.4	19.8
4 cf 5	17.0	56.6	26.4
4 cf 6	0.6	15.6	83.8
4 cf 7	1.0	30.2	68.8
5 cf 1	61.6	32.4	6.0
5 cf 2	6.0	51.0	43.0
5 cf 3	34.0	52.6	13.4
5 cf 4	23.0	59.2	17.8
5 cf 6	0.6	17.6	81.8
5 cf 7	1.0	33.2	65.8
6 cf 1	95.0	5.0	0.0
6 cf 2	57.2	36.2	6.6
6 cf 3	87.4	12.2	0.4
6 cf 4	81.4	17.8	0.8
6 cf 5	80.0	18.8	1.2
6 cf 7	32.8	54.8	12.4
7 cf 1	91.0	9.0	0.0
7 cf 2	41.2	46.4	12.4
7 cf 3	77.4	22.4	0.2
7 cf 4	69.2	29.8	1.0
7 cf 5	66.2	32.8	1.0
7 cf 6	10.6	59.6	29.8

Based on O/E overall quality band

Sites	Better	Same	Worse
1 cf 2	1.0	27.8	71.2
1 cf 3	19.0	50.6	30.4
1 cf 4	4.6	40.2	55.2
1 cf 5	3.0	37.4	59.6
1 cf 6	0.2	6.8	93.0
1 cf 7	0.6	18.4	81.0
2 cf 1	71.2	27.8	1.0
2 cf 3	66.2	32.0	1.8
2 cf 4	40.2	50.8	9.0
2 cf 5	35.8	50.6	13.6
2 cf 6	5.4	45.2	49.4
2 cf 7	6.8	49.8	33.4
3 cf 1	30.4	50.6	19.0
3 cf 2	1.8	32.0	66.2
3 cf 4	5.8	47.0	47.2
3 cf 5	4.0	43.2	52.8
3 cf 6	0.2	9.6	90.2
3 cf 7	0.6	25.2	74.2
4 cf 1	55.2	40.2	4.6
4 cf 2	9.0	50.8	40.2
4 cf 3	47.2	47.0	5.8
4 cf 5	16.0	59.0	25.0
4 cf 6	0.8	24.8	74.4
4 cf 7	4.6	42.4	53.0
5 cf 1	59.6	37.4	3.0
5 cf 2	13.6	50.6	35.8
5 cf 3	52.8	43.2	4.0
5 cf 4	25.0	59.0	16.0
5 cf 6	1.6	32.6	65.8
5 cf 7	7.0	47.6	45.4
6 cf 1	93.0	6.8	0.2
6 cf 2	49.4	45.2	5.4
6 cf 3	90.2	9.6	0.2
6 cf 4	74.4	24.8	0.8
6 cf 5	65.8	32.6	1.6
6 cf 7	36.4	57.2	6.4
7 cf 1	81.0	18.4	0.6
7 cf 2	33.4	49.8	16.8
7 cf 3	74.2	25.2	0.6
7 cf 4	53.0	42.4	4.6
7 cf 5	45.4	47.6	7.0
7 cf 6	6.4	57.2	36.4

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Table 16: RELATIVE PROPORTIONS OF DIFFERENT ORDERS IN RIVPACS SAMPLES

	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Flatworms	4	0.92	5	0.33	7	0.55	2	0.56	0	0.00	4	0.66	6	0.18
Molluscs	39	8.99	248	16.23	260	20.47	54	15.04	136	30.77	257	42.69	2582	75.90
Oligochaetes	70	16.13	20	1.31	208	16.38	170	47.35	33	7.47	120	27.15	360	10.58
Leeches	2	0.46	3	0.20	18	1.42	2	0.56	2	0.45	5	0.83	13	0.38
Crustacea	1	0.23	0	0.00	0	0.00	1	0.28	1	0.23	0	0.00	0	0.00
Mayflies	152	35.02	259	16.95	335	26.38	17	4.74	86	19.46	64	10.63	78	2.29
Stoneflies	20	4.61	5	0.33	6	0.47	6	1.67	3	0.68	0	0.00	4	0.12
Odonata	1	0.23	1	0.07	1	0.08	0	0.00	0	0.00	0	0.00	0	0.00
Beetles	10	2.30	6	0.39	17	1.34	3	0.84	3	0.68	5	0.83	31	0.91
Caddis	33	7.60	34	2.23	57	4.49	18	5.01	15	3.39	11	1.83	17	0.50
True flies	102	23.50	947	61.98	361	28.43	86	23.96	163	36.88	136	22.59	311	9.14

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Table 17 : INSECTS IN RIVPACS SAMPLES
Numbers and (relative abundance)

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**
HEPTAGENIIDAE							
Ecdyonurus sp.	1 [0.32]	1 [0.08]	5 [0.64]	1 [0.77]			
EPHEMERELLIDAE							
Ephemerella ignita	124 [39.12]	215 [17.17]	248 [31.92]	12 [9.23]	79 [29.37]	48 [22.22]	56 [12.70]
EPHEMERIDAE							
Ephemera danica							
LEUCTRIDAE							
Leuctra fusca	10 [3.15]	2 [0.16]	1 [0.13]	2 [1.54]	2 [0.74]		2 [0.45]
Leuctra geniculata	10 [3.15]	3 [0.24]	5 [0.64]	4 [3.08]	1 [0.37]		2 [0.45]
CHLOROPERLIDAE							
Chloroperla torrentium							
LEPTOCERIDAE							
Athripsodes albifrons	1 [0.32]			1 [0.77]	2 [0.74]	1 [0.46]	
Athripsodes cinereus			1 [0.13]				
Athripsodes sp.							
Ceraclea dissimilis			2 [0.26]			1 [0.46]	
Ceraclea sp							
Mystacides azurea			9 [1.16]			1 [0.46]	2 [0.45]
Oecetis (?testacea)			1 [0.13]				
GOERIDAE							
Goera pilosa			1 [0.13]				1 [0.23]
Silo pallipes	1 [0.32]						
LEPIDOSTOMATIDAE							
Lasiocephala basalis							
Lepidostoma hirtum	7 [2.21]	3 [0.24]	8 [1.03]	2 [1.54]	1 [0.37]		
Indet juv prob Lasiocephala	1 [0.32]						5 [1.13]
BRACHYCENTRIDAE							
Brachycentrus subnubilus	5 [1.58]	19 [1.52]	6 [0.77]	10 [7.69]	4 [1.49]	4 [1.85]	1 [0.23]
SERICOSTOMATIDAE							
Sericostoma personatum	12 [3.79]		8 [1.08]	3 [2.31]	1 [0.37]	1 [0.46]	
CALOPTERYGIDAE							
Calopteryx virgo	1 [0.32]	1 [0.08]					
CORDULEGASTERIDAE							
Cordulegaster boltonii			1 [0.13]				
NEMOURIDAE							
Nemurella picteti							
RHYACOPHILIDAE							
Rhyacophila dorsalis	2 [0.63]	5 [0.40]	9 [1.16]		1 [0.37]		
Rhyacophila munda		1 [0.08]					
Agapetus sp.	3 0.95]		4 [0.52]				
Glossosoma sp.							1 [0.23]
POLYCENTROPODIDAE							
Plectrocnemia conspersa						1 [0.46]	
LIMNEPHILIDAE							
Drusus annulatus			1 [0.13]				
Halesus radiatus			1				
Halesus sp	1 [0.32]						
Potamophylax cingulatus							
Potamophylax latipennis						1 [0.46]	
HYDROPTILIDAE							
Hydroptila sp.					1 [0.37]		6 [1.36]
DYTISCIDAE							
Oreodytes sanmarkii			4 [0.52]				
Potamonectes depressus gp.							5 [1.13]
GYRINIDAE							
Gyrinus sp.			1 [0.13]				
HYDROPHILIDAE							
Hydreana gracilis		1 [0.08]					
ELMIDAE							
Elmis aenea	2 [0.63]	3 [0.24]	5 [0.64]				2 [0.45]
Esolus parallelepipedus	2 [0.63]		1 [0.13]				1 [0.23]
Limnius volkmari	6 [1.89]	2 [0.16]	6 [0.77]	3 [2.31]	2 [0.74]	5 [2.31]	22 [4.99]
Oulimnius sp.					1 [0.37]		1 [0.23]
HYDROPSYCHIDAE							
Hydropsyche pellucidula							
Hydropsyche siltalai		5 [0.40]	6 [0.77]	2 [1.54]		1 [0.46]	
Hydropsyche sp.		1 [0.08]			4 [1.49]		1 [0.23]
TIPULIDAE							
Antocha vitripennis		3 [0.24]	2 [0.26]	1 [0.77]	3 [1.12]		4 [0.91]
Dicranota sp.		1 [0.08]					
SIMULIIDAE							
Simulium argyreatum gp.			1 [0.13]		5 [1.86]	32 [14.81]	1 [0.23]
Simulium aureum gp.				1 [0.77]			
Simulium reptans	6 [1.89]	6 [0.48]	16 [2.06]		45 [16.73]	2 [0.93]	
Indet.	1 [0.32]						
BAETIDAE							
Baetis rhodani	10 [3.15]	39 [3.12]	76 [9.78]	4 [3.08]	5 [1.86]	12 [5.56]	1 [0.23]
Baetis scambus gp.	17 [5.36]	4 [0.32]	4 [0.52]		2 [0.74]	4 [1.85]	20 [4.54]
Centroptilum luteolum							1 [0.23]
Centroptilum pennulatum			2 [0.26]				
CHIRONOMIDAE	82 [25.87]	932 [74.44]	332 [42.73]	77 [59.23]	101 [37.55]	92 [42.59]	292 [66.21]
EMPIDIDAE	*1 [0.32]*	*1 [0.08]*	*2 [0.26]*	*1 [0.77]*	*4 [1.49]*	1 [0.46]	
RHAGIONIDAE	*11 [3.47]*	*4 [0.32]*	*8 [1.03]*	*6 [4.62]*	*5 [1.86]*	*8 [3.70]*	*13 [2.95]*
PSYCHODIDAE							
CERATOPOGONIDAE						1 [0.46]	*1 [0.23]*
Total number	**317**	**1252**	**777**	**130**	**269**	**216**	**441**

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Table 18: NON-INSECTS IN RIVPACS SAMPLES
Numbers and (relative abundance)

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
ANCYLIDAE							
Ancylus fluviatilis	1 [0.85]		16 [3.07]	3 [1.31]	81 [47.09]	128 [32.82]	152 [5.13]
GAMMARIDAE							
Gammarus pulex	1 [0.85]			1 [0.44]	1 [0.58]		
PLANARIIDAE							
Dugesia tigrina						1 [0.26]	3 [0.10]
Phagocata vitta		3 [1.08]	4 [0.77]	2 [0.87]		2 [0.51]	
Polycelis felina	4 [3.42]	2 [0.72]	1 [0.19]				
Polycelis nigra gp.			2 [0.38]			1 [0.26]	3 [0.10]
PISCICOLIDAE							
Piscicola geometra							1 [0.03]
HYDROBIIDAE							
Potamopyrgus jenkinsi	38 [32.48]	248 [89.53]	240 [46.07]	50 [21.83]	55 [31.98]	128 [32.82]	2396 [80.89]
LYMNAEIDAE							
Lymnaea peregra			4 [0.77]			1 [0.26]	3 [0.10]
PLANORBIDAE							
Armiger crista							2 [0.07]
SPHAERIIDAE							
Pisidium sp.				1 [0.44]			29 [0.98]
GLOSSIPHONIIDAE							
Glossiphonia complanata	1 [0.85]	2 [0.72]	16 [3.07]	2 [0.87]		1 [0.26]	7 [0.24]
Helobdella stagnalis							1 [0.03]
Hemiclepsis marginata					2 [1.16]		
Indet. juv. glossiphoniid							
ERPOBDELLIDAE							
Erpobdella octoculata		1 [0.36]	2 [0.38]				1 [0.03]
Trocheta subviridis							1 [0.03]
Indet. juv.	1 [0.85]					4 [1.03]	2 [0.07]
OLIGOCHAETA	70 [59.83]	20 [7.22]	208 [39.92]	170 [74.24]	33 [19.19]	120	360 [12.15]
HYDRACARINA	1 [0.85]	1 [0.36]	*28 [5.37]*			*4 [1.03]*	*1 [0.03]*
NEMATODA							
Total number	**117**	**277**	**521**	**229**	**172**	**390**	**2962**

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Table 19: INSECT AND NON-INSECT TAXA IN RIVPACS SAMPLES

	Total abundance	No. insects	No. non-insects	% Insects	% Non-insects
SITE 1	434	317	117	73.07	26.96
SITE 2	1529	1252	277	81.88	18.12
SITE 3	1298	777	521	59.86	40.14
SITE 4	359	130	229	36.21	63.79
SITE 5	441	269	172	61.00	39.00
SITE 6	606	216	390	35.64	64.36
SITE 7	3403	441	2962	12.96	87.04

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Table 20: ABUNDANCE OF FAMILIES SENSITIVE TO PESTICIDES (RIVPACS samples)

SITE		1	2	3	4	5	6	7
Baetidae	No.	27	43	82	4	7	16	22
	%	8.52	3.43	10.55	3.08	2.60	7.41	4.99
Heptageniidae	No.	1	1	5	1	0	0	0
	%	0.32	0.08	0.64	0.77	0.00	0.00	0.00
Ephemerellidae	No.	124	215	248	12	79	48	56
	%	39.12	17.17	31.92	9.23	29.37	22.22	12.70
Leuctridae	No.	20	5	6	6	3	0	4
	%	6.31	0.40	0.77	4.62	1.12	0.00	0.91
Rhyacophilidae	No.	5	6	13	0	1	0	1
	%	1.58	0.48	1.67	0.00	0.37	0.00	0.23
Polycentropodidae	No.	0	0	0	0	0	1	0
	%	0.00	0.00	0.00	0.00	0.00	0.46	0.00
Hydropsychidae	No.	0	6	6	2	4	1	1
	%	0.00	0.48	0.77	1.54	1.49	0.46	0.23
Hydroptilidae	No.	0	0	0	0	2	0	6
	%	0.00	0.00	0.00	0.00	0.74	0.00	1.36
Limnephilidae	No.	1	2	2	0	0	1	0
	%	0.32	0.16	0.26	0.00	0.00	0.46	0.00
Leptoceridae	No.	1	0	13	1	2	3	2
	%	0.32	0.00	1.67	0.77	0.74	1.39	0.45
Goeridae	No.	1	0	1	0	0	0	1
	%	0.32	0.00	0.13	0.00	0.00	0.00	0.23
Lepidostomatidae	No.	8	3	8	2	1	0	5
	%	2.52	0.24	1.03	1.54	0.37	0.00	1.13
Brachycentridae	No.	5	19	6	10	4	4	1
	%	1.58	1.52	0.77	7.69	1.49	1.85	0.23
Sericostomatidae	No.	12	0	8	3	1	1	0
	%	3.79	0.00	1.03	2.31	0.37	0.46	0.00

Buckfastleigh STW Biological Assessment IFE 1995 cf IFE 1997
Table 21: % PROBABILITY OF DIFFERENCE IN QUALITY BAND

Based on O/E number of taxa

	Better	Same	Worse
A1 cf 1	46.8	40.6	12.6
A1 cf 2	17.0	41.4	39.6
A1 cf 3	63.2	35.6	1.2
A1 cf 4	24.6	41.2	34.2
A1 cf 5	15.2	45.8	39.0
A1 cf 6	8.4	36.6	55.0
A1 cf 7	59.0	37.4	3.6
A2 cf 1	73.0	23.8	3.2
A2 cf 2	38.2	45.6	16.2
A2 cf 3	88.8	11.0	0.2
A2 cf 4	47.2	40.4	12.4
A2 cf 5	39.8	43.2	17.0
A2 cf 6	28.0	44.8	27.2
A2 cf 7	82.8	16.4	0.8
A3 cf 1	59.2	33.4	7.4
A3 cf 2	26.8	45.0	28.2
A3 cf 3	17.8	59.6	22.6
A3 cf 4	33.0	43.2	23.8
A3 cf 5	24.2	45.6	30.2
A3 cf 6	17.4	44.4	38.2
A3 cf 7	73.8	24.8	1.4
B1 cf 1	51.8	37.2	11.0
B1 cf 2	19.0	48.8	32.2
B1 cf 3	66.4	33.0	0.6
B1 cf 4	25.2	45.4	29.4
B1 cf 5	20.0	42.0	38.0
B1 cf 6	11.8	35.8	52.4
B1 cf 7	62.4	34.6	3.0
B2 cf 1	95.6	4.2	0.2
B2 cf 2	79.6	18.0	2.4
B2 cf 3	100.0	0.0	0.0
B2 cf 4	84.4	13.8	1.8
B2 cf 5	78.2	19.2	2.6
B2 cf 6	63.8	30.4	5.8
B2 cf 7	98.8	1.2	0.0
B3 cf 1	61.2	34.2	4.6
B3 cf 2	27.4	44.4	28.2
B3 cf 3	80.6	19.2	0.2
B3 cf 4	33.0	46.4	20.6
B3 cf 5	29.4	44.2	26.4
B3 cf 6	18.2	43.2	38.6
B3 cf 7	75.0	22.4	2.6
C1 cf 1	63.2	30.8	6.0
C1 cf 2	31.2	43.4	25.4
C1 cf 3	78.6	21.4	0.0
C1 cf 4	36.0	42.0	22.0
C1 cf 5	28.6	43.2	28.2
C1 cf 6	17.8	41.2	41.0
C1 cf 7	71.2	25.8	3.0
C2 cf 1	50.0	39.6	10.4
C2 cf 2	19.0	44.8	36.2
C2 cf 3	64.8	34.6	0.6
C2 cf 4	24.4	44.0	31.6
C2 cf 5	17.6	44.4	38.0
C2 cf 6	9.0	42.4	48.6
C2 cf 7	60.2	36.8	3.0
C3 cf 1	82.6	16.6	0.8
C3 cf 2	55.6	35.8	8.6
C3 cf 3	96.4	3.6	0.0
C3 cf 4	59.0	34.6	6.4
C3 cf 5	50.2	39.8	10.0
C3 cf 6	37.8	45.2	17.0
C3 cf 7	92.4	7.2	0.4

Based on O/E ASPT

	Better	Same	Worse
A1 cf 1	81.4	18.2	0.4
A1 cf 2	21.8	54.8	23.4
A1 cf 3	54.2	43.6	2.2
A1 cf 4	45.8	50.4	3.8
A1 cf 5	40.2	53.4	6.4
A1 cf 6	5.6	33.6	60.8
A1 cf 7	9.6	46.4	44.0
A2 cf 1	58.0	35.6	6.4
A2 cf 2	4.8	49.4	45.8
A2 cf 3	33.2	46.4	20.4
A2 cf 4	22.4	52.4	25.2
A2 cf 5	19.0	55.0	26.0
A2 cf 6	1.4	16.6	82.0
A2 cf 7	1.8	30.6	67.6
A3 cf 1	71.8	26.2	2.0
A3 cf 2	9.2	56.8	34.0
A3 cf 3	41.6	50.2	8.2
A3 cf 4	30.4	59.0	10.6
A3 cf 5	26.8	60.4	12.8
A3 cf 6	2.6	26.2	71.2
A3 cf 7	4.6	38.0	57.4
B1 cf 1	79.6	18.8	1.6
B1 cf 2	19.6	54.6	25.8
B1 cf 3	54.0	41.8	4.2
B1 cf 4	37.2	56.4	6.4
B1 cf 5	33.6	59.6	6.8
B1 cf 6	4.8	28.6	66.6
B1 cf 7	8.2	40.0	51.8
B2 cf 1	99.4	0.6	0.0
B2 cf 2	74.8	25.0	0.2
B2 cf 3	98.0	2.0	0.0
B2 cf 4	97.0	3.0	0.0
B2 cf 5	96.6	3.4	0.0
B2 cf 6	31.6	66.6	1.8
B2 cf 7	46.2	52.4	1.4
B3 cf 1	98.0	2.0	0.0
B3 cf 2	63.4	33.6	3.0
B3 cf 3	92.4	7.4	0.2
B3 cf 4	90.2	9.4	0.4
B3 cf 5	85.6	13.8	0.6
B3 cf 6	18.8	69.2	12.0
B3 cf 7	34.2	57.4	8.4
C1 cf 1	91.0	8.8	0.2
C1 cf 2	43.2	46.2	10.6
C1 cf 3	76.8	22.4	0.8
C1 cf 4	69.2	30.0	0.8
C1 cf 5	66.4	32.6	1.0
C1 cf 6	67.4	32.0	0.6
C1 cf 7	77.0	22.4	0.6
C2 cf 1	96.0	4.0	0.0
C2 cf 2	56.2	37.6	6.2
C2 cf 3	89.2	10.6	0.2
C2 cf 4	84.6	14.4	1.0
C2 cf 5	82.6	16.2	1.2
C2 cf 6	85.6	14.2	0.2
C2 cf 7	34.6	57.4	8.0
C3 cf 1	99.2	0.8	0.0
C3 cf 2	67.4	31.6	1.0
C3 cf 3	94.6	5.2	0.2
C3 cf 4	92.2	7.8	0.0
C3 cf 5	91.2	8.6	0.2
C3 cf 6	20.6	73.4	6.0
C3 cf 7	39.4	57.2	3.4

Based on O/E overall quality band

	Better	Same	Worse
A1 cf 1	68.0	30.4	1.6
A1 cf 2	19.0	51.8	29.2
A1 cf 3	58.2	40.0	1.8
A1 cf 4	32.4	56.0	11.6
A1 cf 5	27.0	56.4	16.6
A1 cf 6	3.8	35.6	60.6
A1 cf 7	11.8	48.6	39.6
A2 cf 1	70.6	28.0	1.4
A2 cf 2	19.6	56.0	24.4
A2 cf 3	63.4	32.8	3.8
A2 cf 4	40.0	47.6	12.4
A2 cf 5	34.4	49.6	16.0
A2 cf 6	6.2	39.6	54.2
A2 cf 7	15.8	48.4	35.8
A3 cf 1	65.6	33.2	1.2
A3 cf 2	14.0	55.8	30.2
A3 cf 3	55.0	43.6	1.4
A3 cf 4	25.2	64.2	10.6
A3 cf 5	20.2	61.6	18.2
A3 cf 6	4.8	33.4	61.8
A3 cf 7	12.0	45.2	42.8
B1 cf 1	70.2	28.0	1.8
B1 cf 2	17.8	55.8	26.4
B1 cf 3	58.8	39.0	2.2
B1 cf 4	28.4	61.0	10.6
B1 cf 5	23.8	59.8	16.4
B1 cf 6	3.6	32.0	64.4
B1 cf 7	11.2	43.4	45.4
B2 cf 1	99.2	0.8	0.0
B2 cf 2	74.2	25.8	0.0
B2 cf 3	98.8	1.2	0.0
B2 cf 4	90.8	9.2	0.0
B2 cf 5	86.0	14.0	0.0
B2 cf 6	42.8	56.0	1.2
B2 cf 7	61.2	38.4	0.4
B3 cf 1	94.2	5.6	0.2
B3 cf 2	52.2	43.6	4.2
B3 cf 3	93.4	6.6	0.0
B3 cf 4	79.6	18.8	1.6
B3 cf 5	69.0	27.2	3.8
B3 cf 6	12.8	75.0	12.2
B3 cf 7	36.2	56.6	7.2
C1 cf 1	85.2	14.8	0.0
C1 cf 2	38.6	47.8	13.6
C1 cf 3	81.6	18.0	0.4
C1 cf 4	62.2	33.6	4.2
C1 cf 5	54.8	38.0	7.2
C1 cf 6	11.0	60.2	28.8
C1 cf 7	28.4	53.8	17.8
C2 cf 1	91.6	8.0	0.4
C2 cf 2	47.8	44.6	7.6
C2 cf 3	89.4	10.4	0.2
C2 cf 4	74.6	22.6	2.8
C2 cf 5	66.8	29.2	4.0
C2 cf 6	84.6	15.2	0.2
C2 cf 7	35.6	56.6	7.8
C3 cf 1	98.0	2.0	0.0
C3 cf 2	64.6	34.0	1.4
C3 cf 3	96.4	3.4	0.2
C3 cf 4	83.6	16.0	0.4
C3 cf 5	77.2	21.8	1.0
C3 cf 6	16.8	79.2	4.0
C3 cf 7	42.6	55.6	1.8

FIGURES

Figure 1: LOCATIONS OF SITES SURVEYED ON RIVER DART NR BUCKFASTLEIGH IN SUMMERS 1990-1997

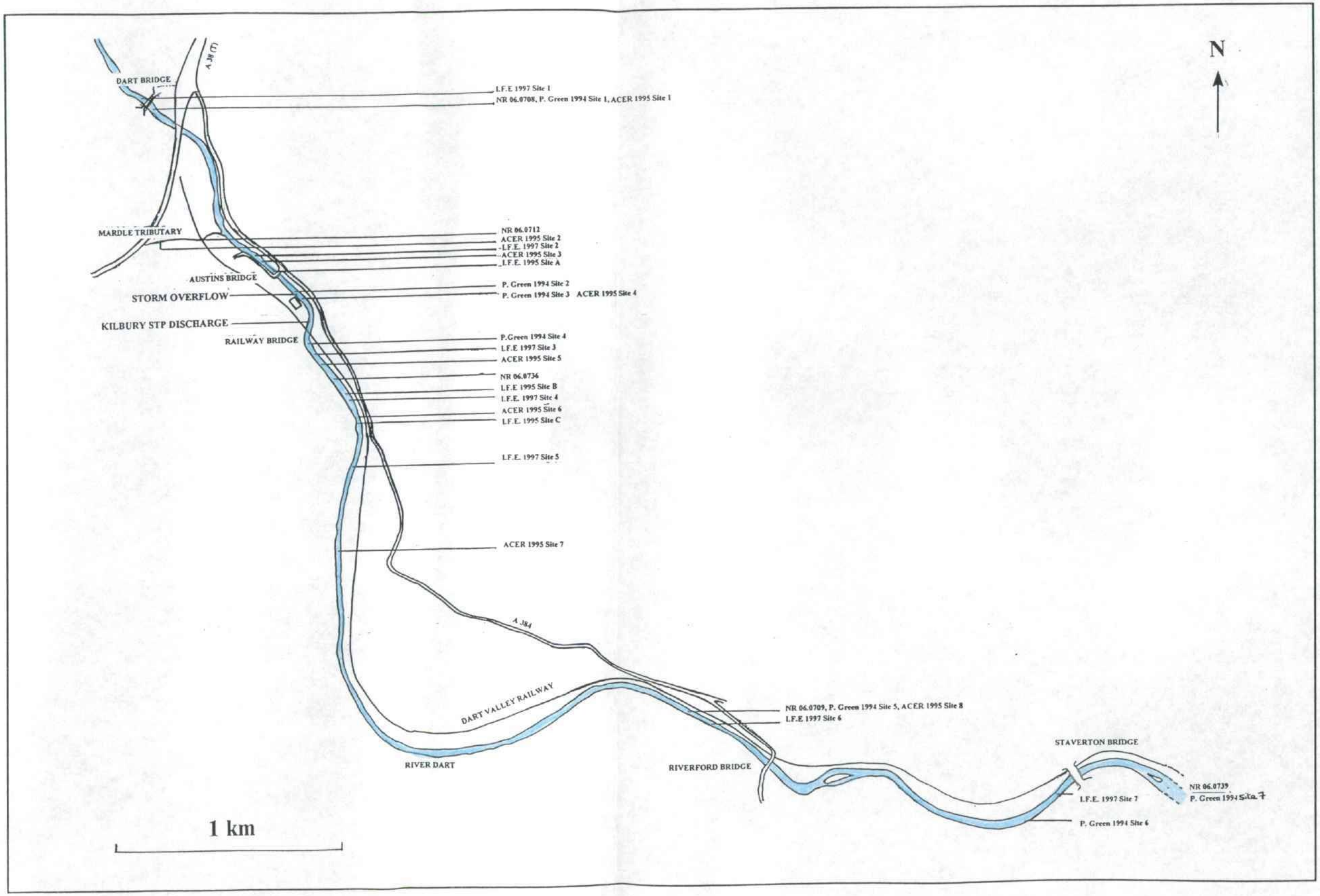
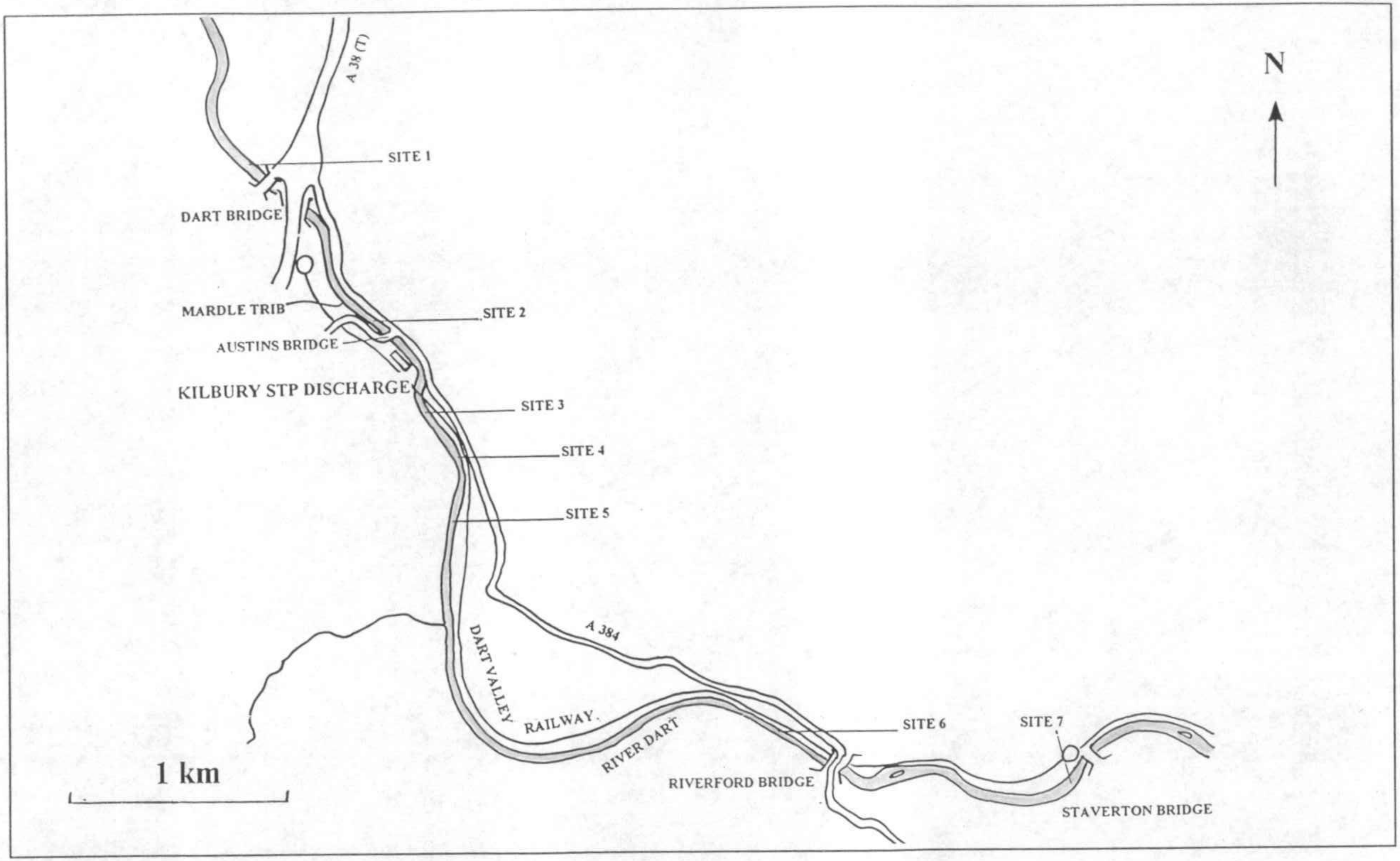


Figure 2: LOCATIONS OF SITES SURVEYED ON RIVER DART NEAR BUCKFASTLEIGH BY IFE JULY 1997



Buckfastleigh STW Biological Assessment IFE July 1997
BMWP SCORES AND ASPT FOR COMBINED REPLICATE SURBER SAMPLES

Figure 3 : BMWP scores for combined replicate surber samples

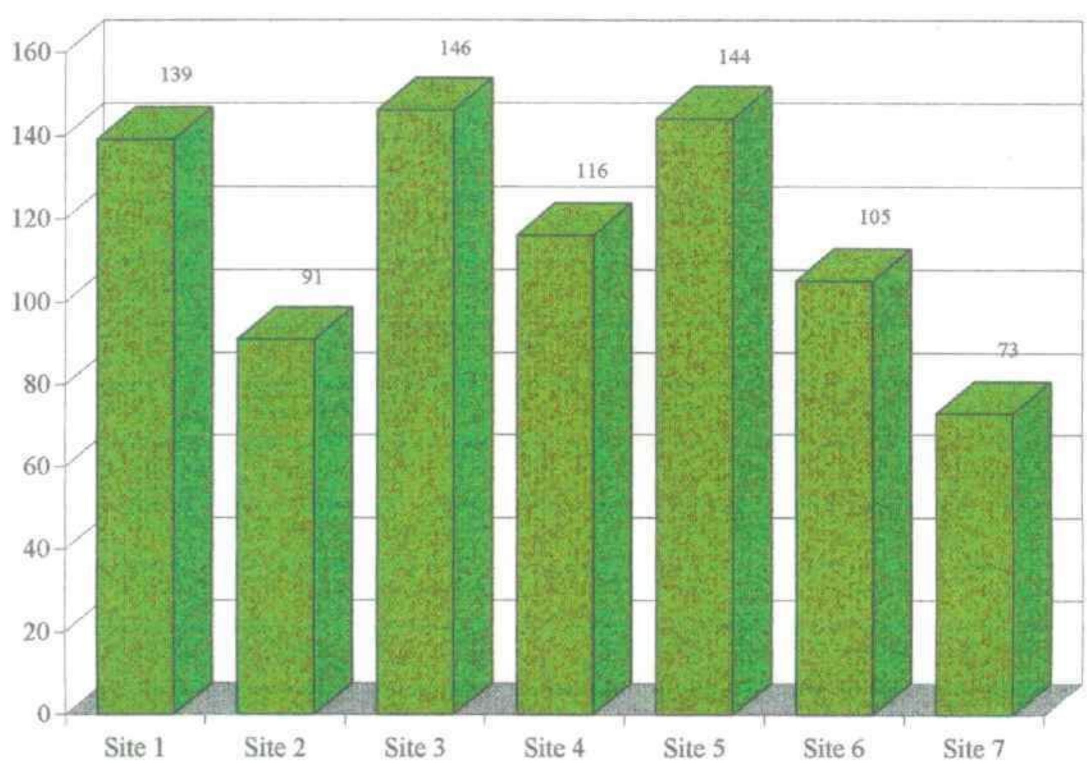


Figure 4: ASPT for combined replicate surber samples

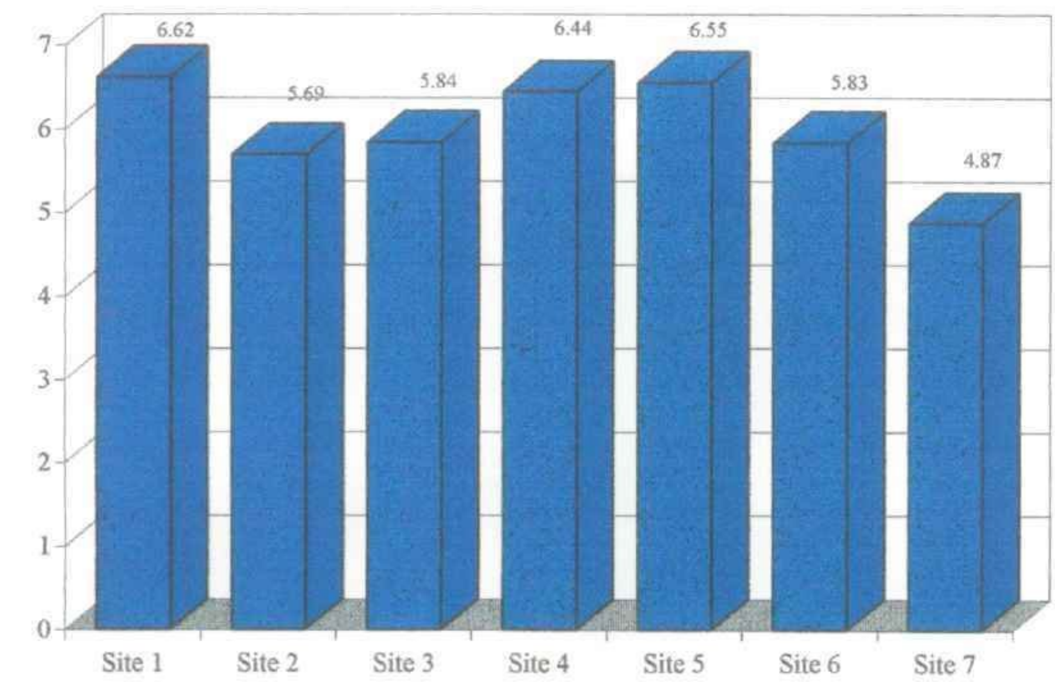


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Figure 5: PROPORTIONS OF ORDERS OR GROUPS IN REPLICATE SURBER SAMPLES

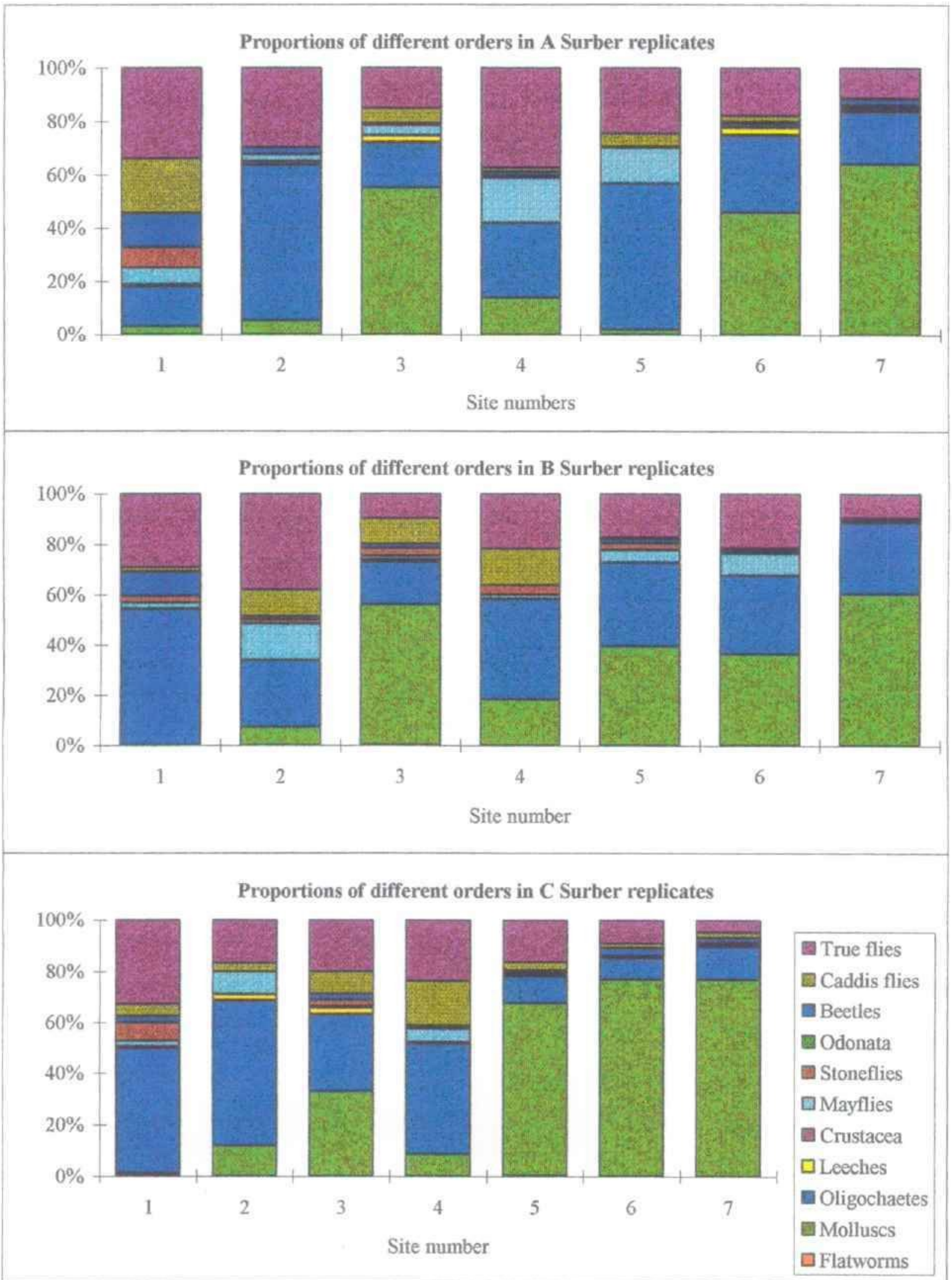
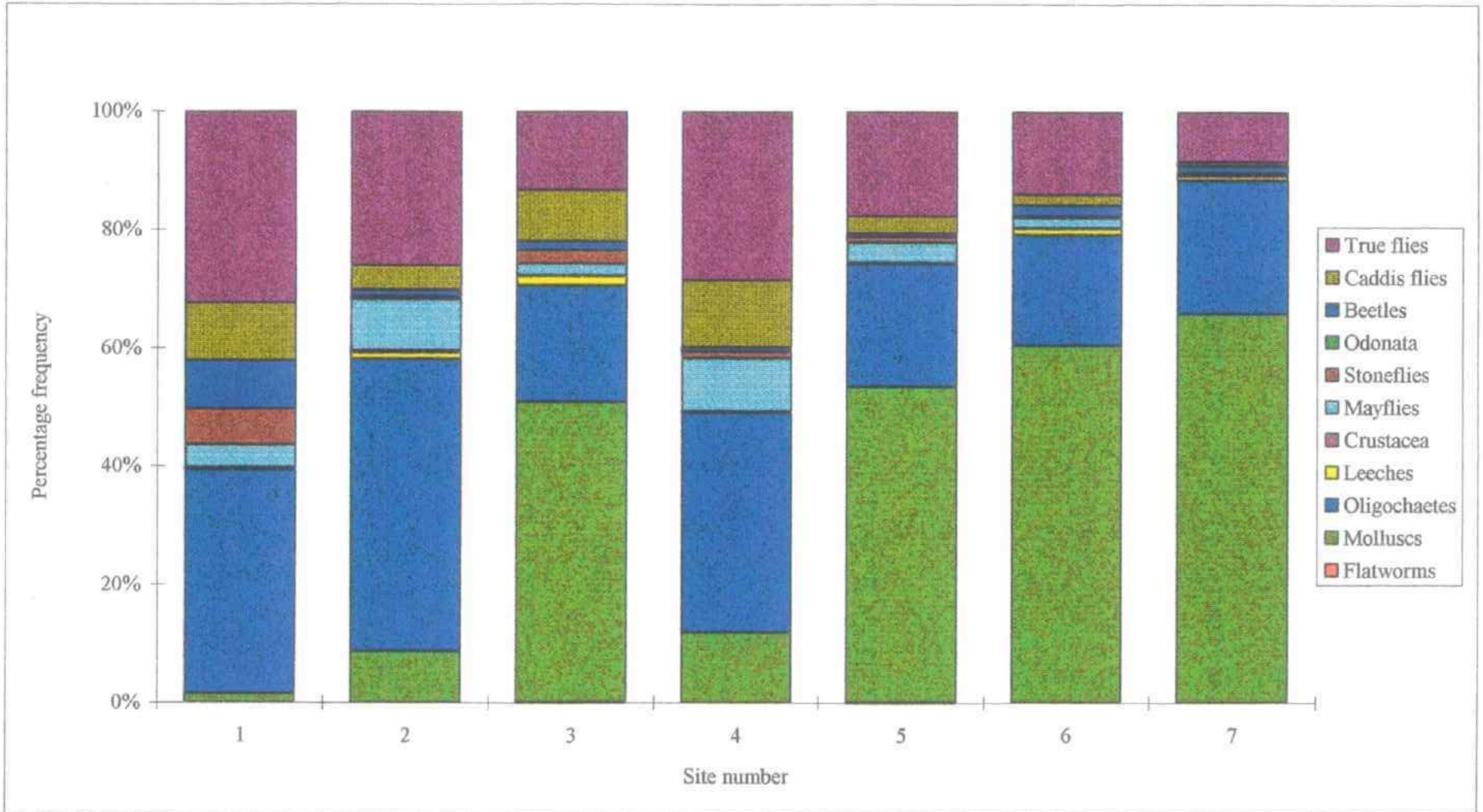


Figure 6: PROPORTIONS OF ORDERS IN COMBINED REPLICATE SURBER SAMPLES



Buckfastleigh STW Biological Assessment IFE July 1997
INSECTS AND NON-INSECTS, AND CHIRONOMIDS IN COMBINED SURBER SAMPLES

Figure 7: Relative abundance of insect and non-insect taxa from combined replicate Surber samples

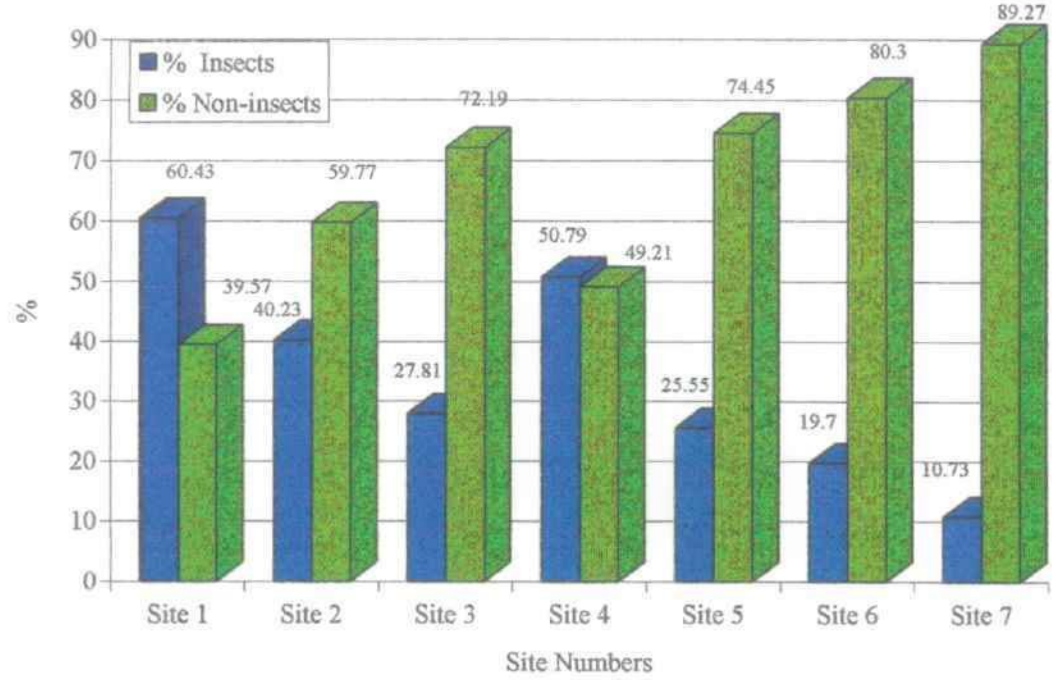


Figure 8: Relative Abundance of Chironomids in Combined Surber Replicates

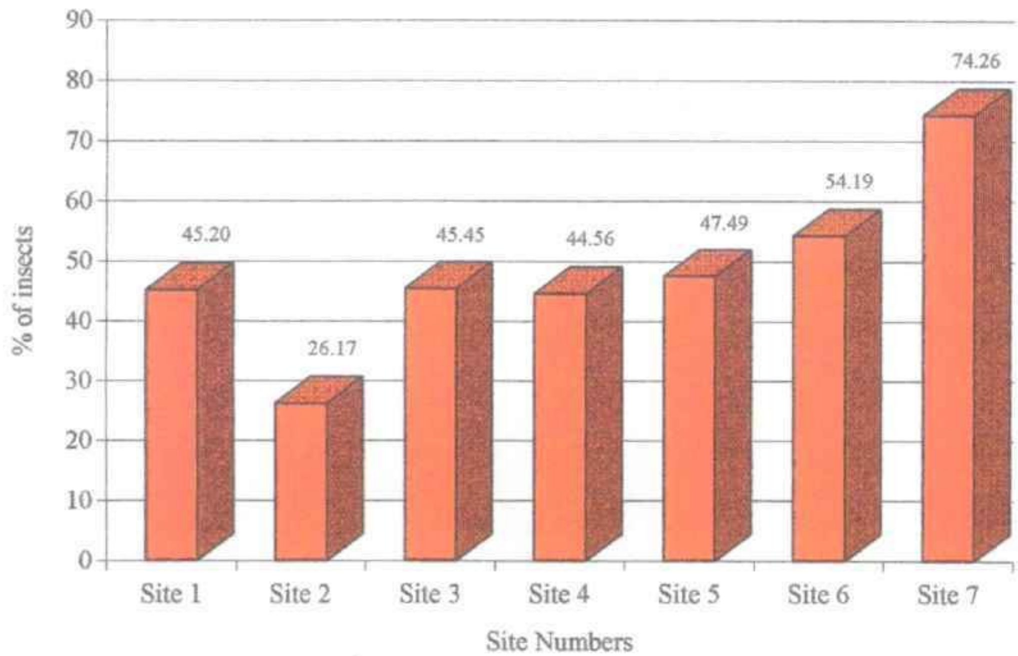


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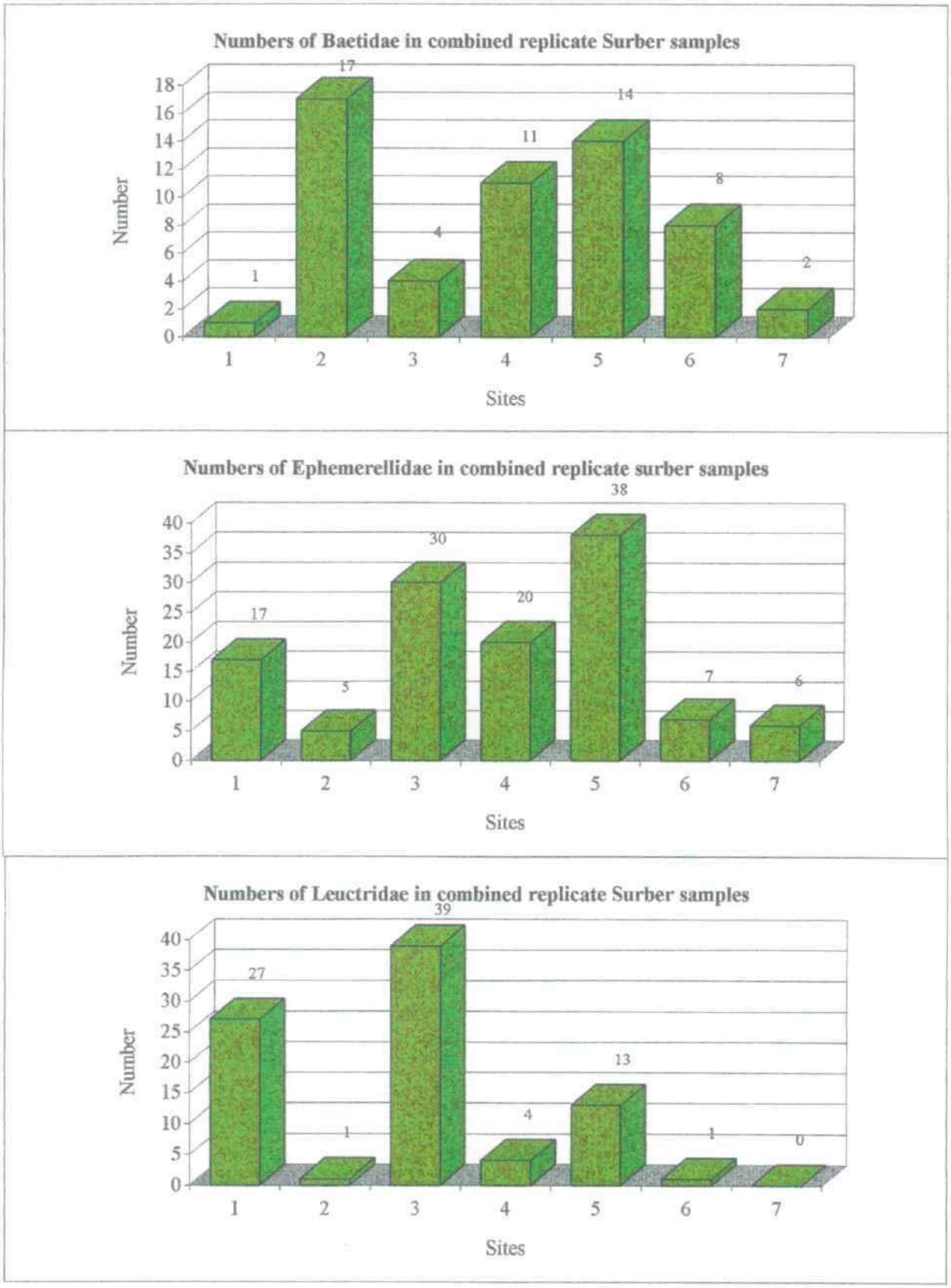
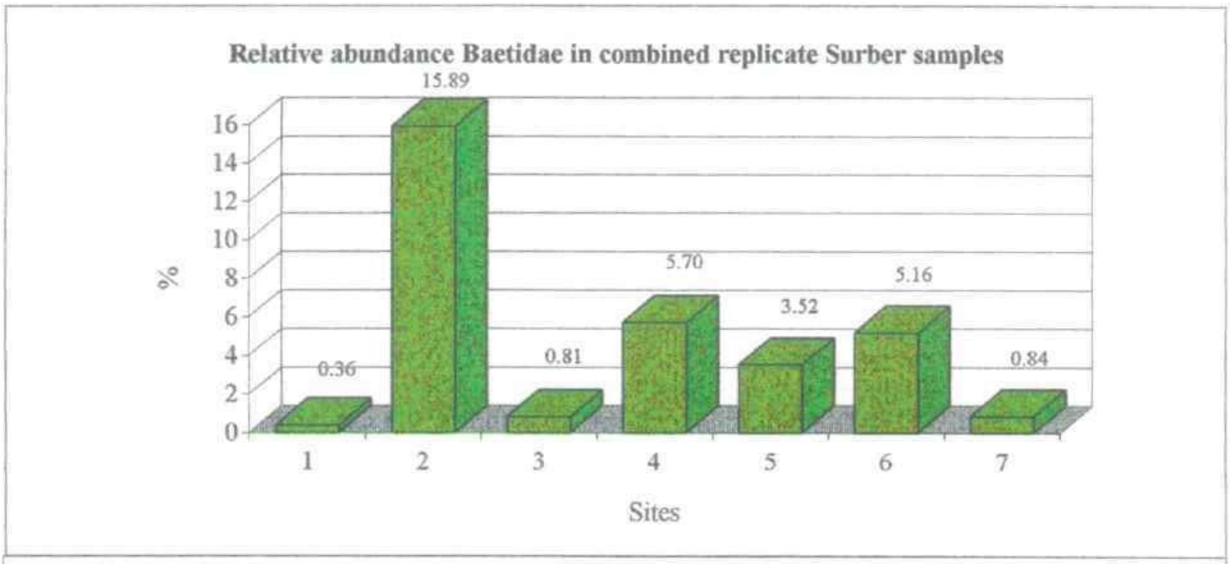
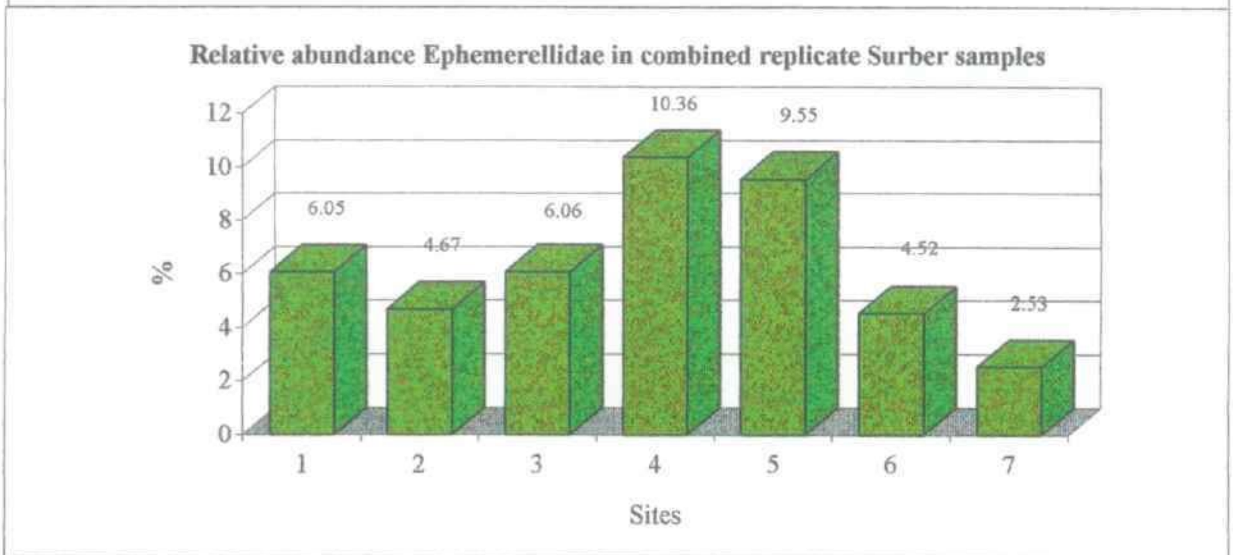
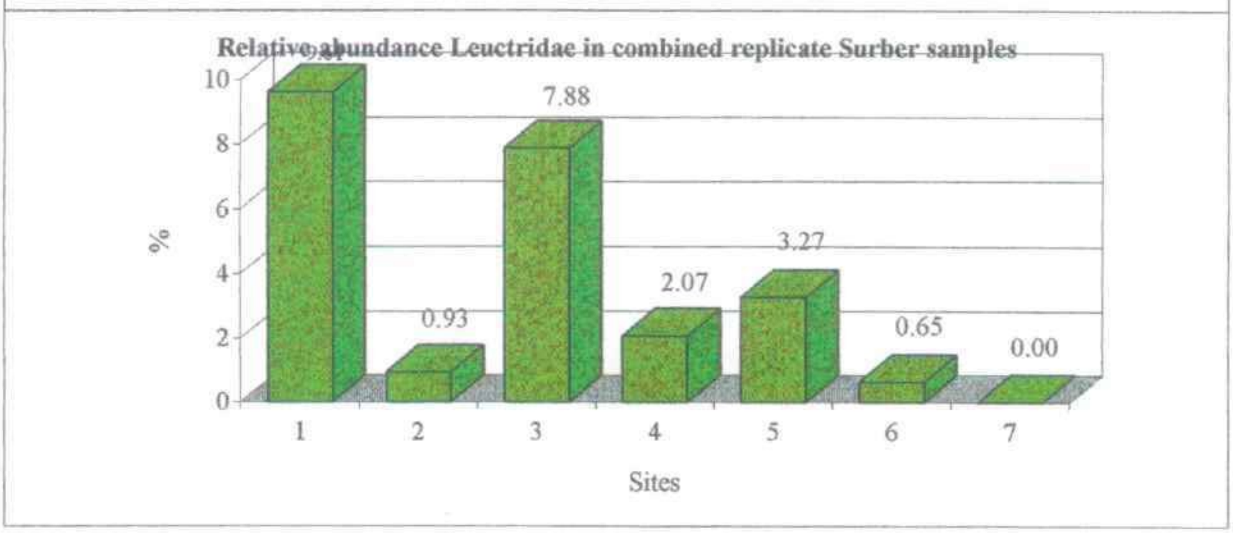
Figure 9: NUMBERS OF FAMILIES SENSITIVE TO PESTICIDES IN SURBER SAMPLES



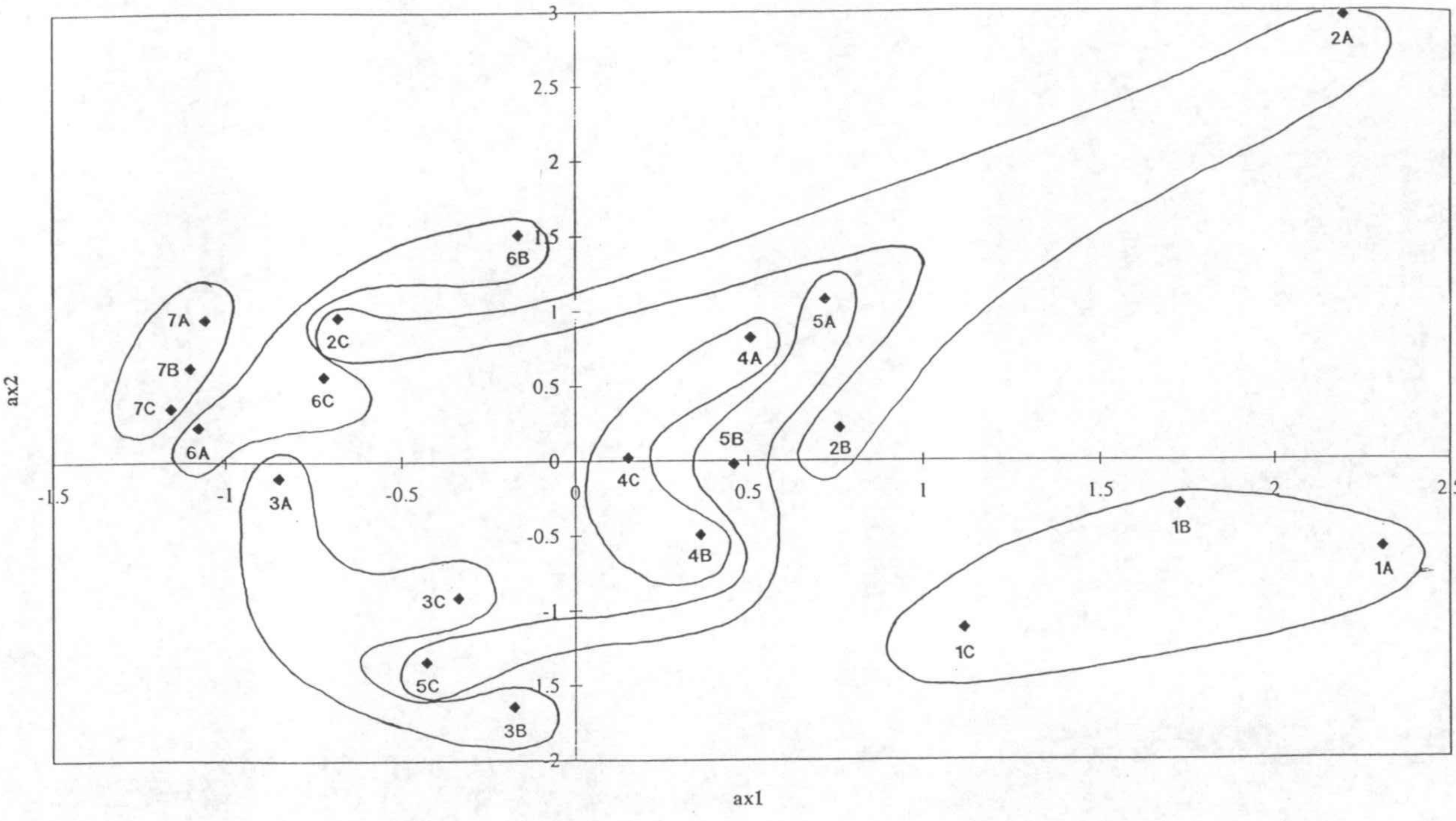
Buckfastleigh STW Biological Assessment IFE July 1997
Figure 10: RELATIVE ABUNDANCE OF FAMILIES SENSITIVE TO PESTICIDES
(combined replicate Surber samples)







Fugure 11: CORRESPONDENCE ANALYSIS PLOT OF MACROINVERTEBRATE GROUPS IN SURBER SAMPLES, BUCKFASTLEIGH, R. DART



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Figures 12 & 13: BMWP SCORES AND ASPT IN RIVPACS SAMPLES

Figure 12: BMWP scores for RIVPACS samples

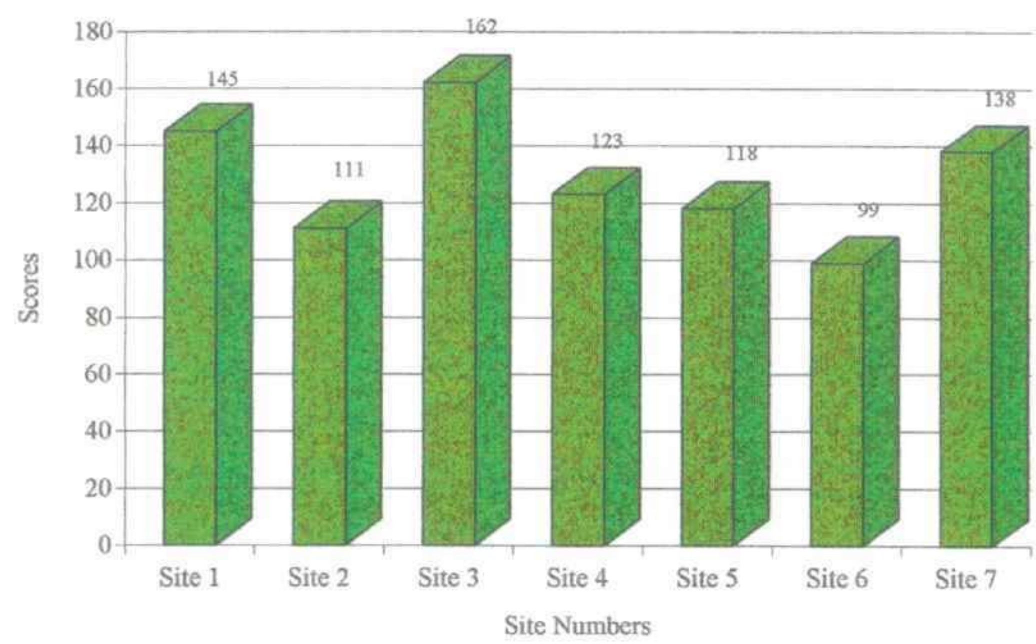

Figure 13: ASPT for RIVPACS samples

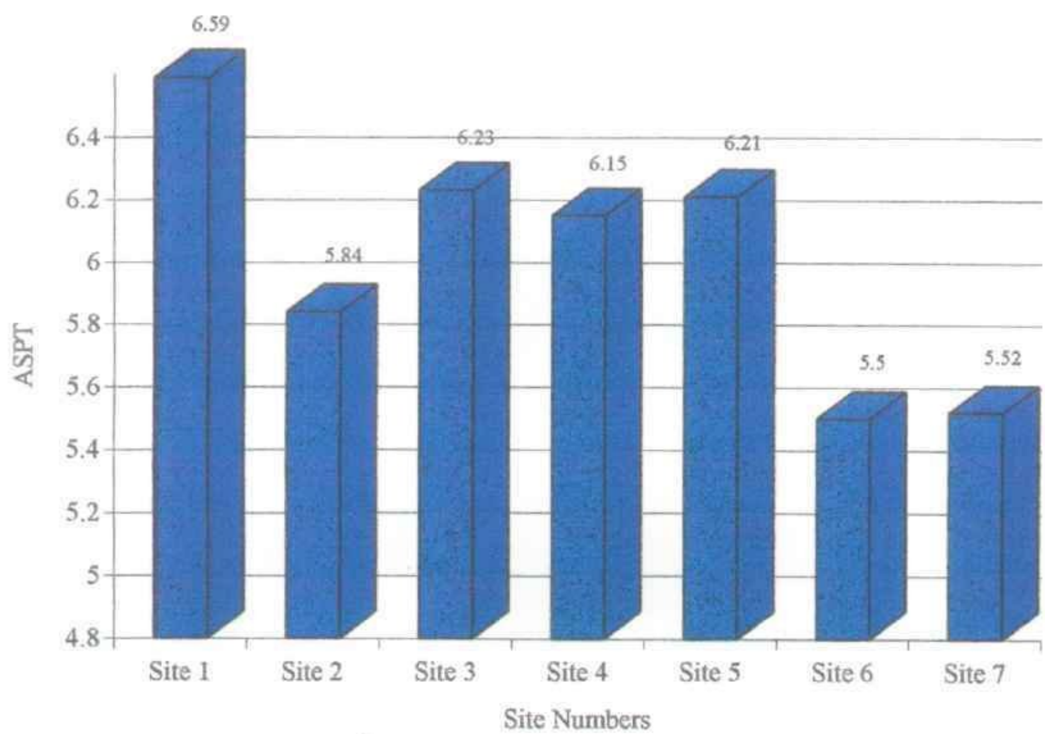

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Figure 14: PROBABILITY OF GROUP MEMBERSHIP IN RIVPACS SAMPLES

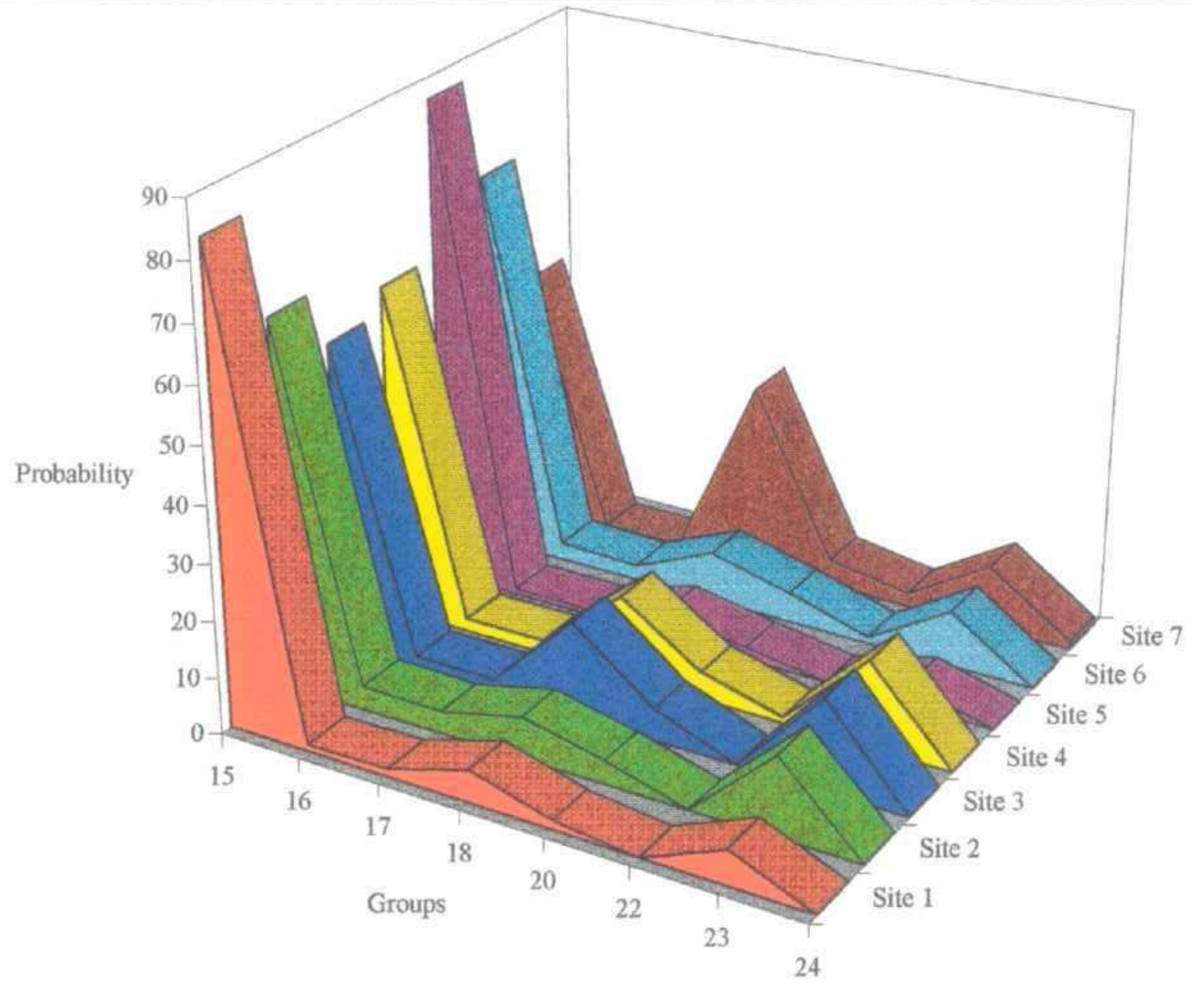

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Figure 15: PROBABILITY OF DIFFERENCE IN QUALITY BAND O/E NO. TAXA

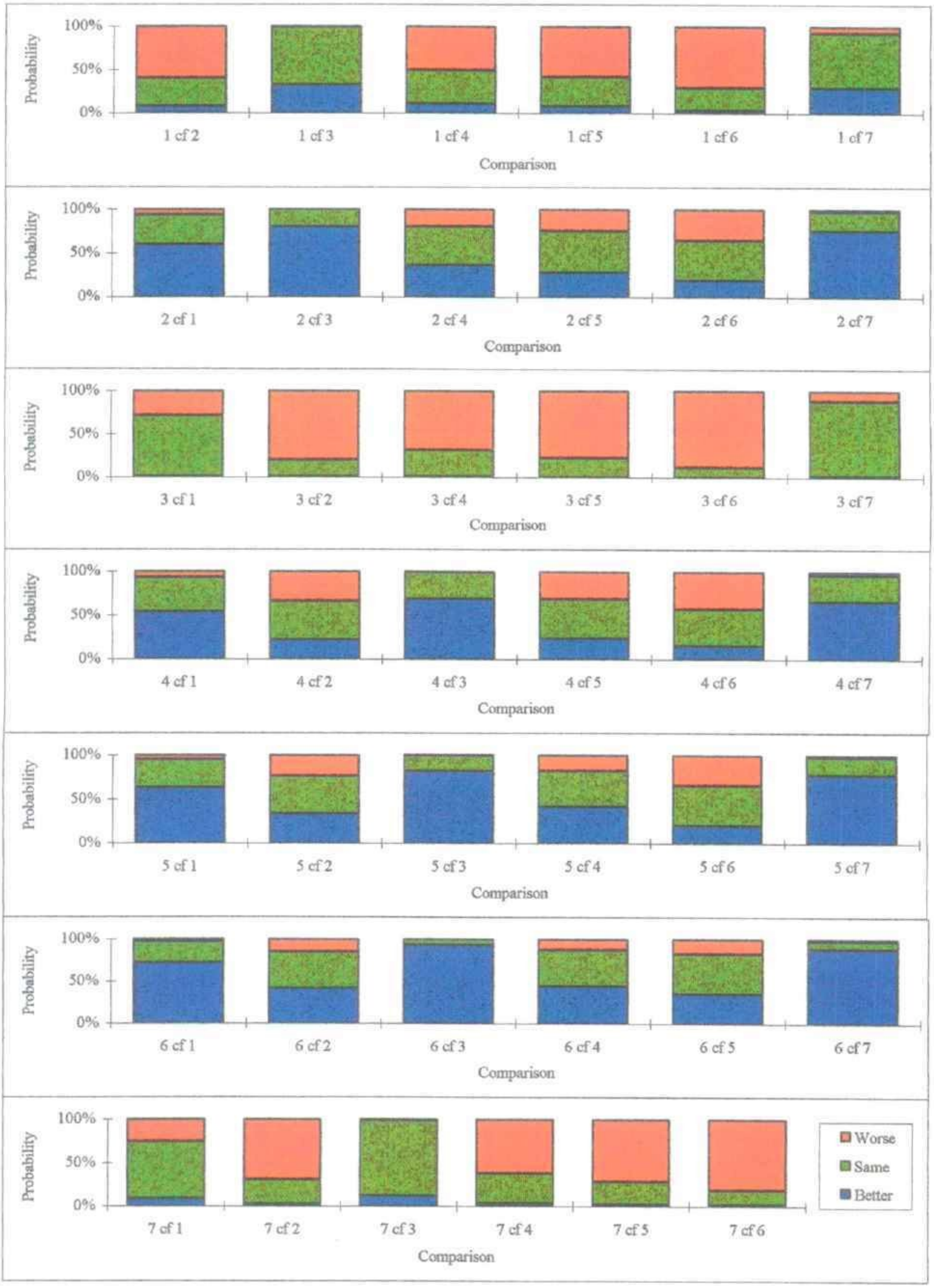

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Figure 16: PROBABILITY OF DIFFERENCE IN QUALITY BAND O/E ASPT

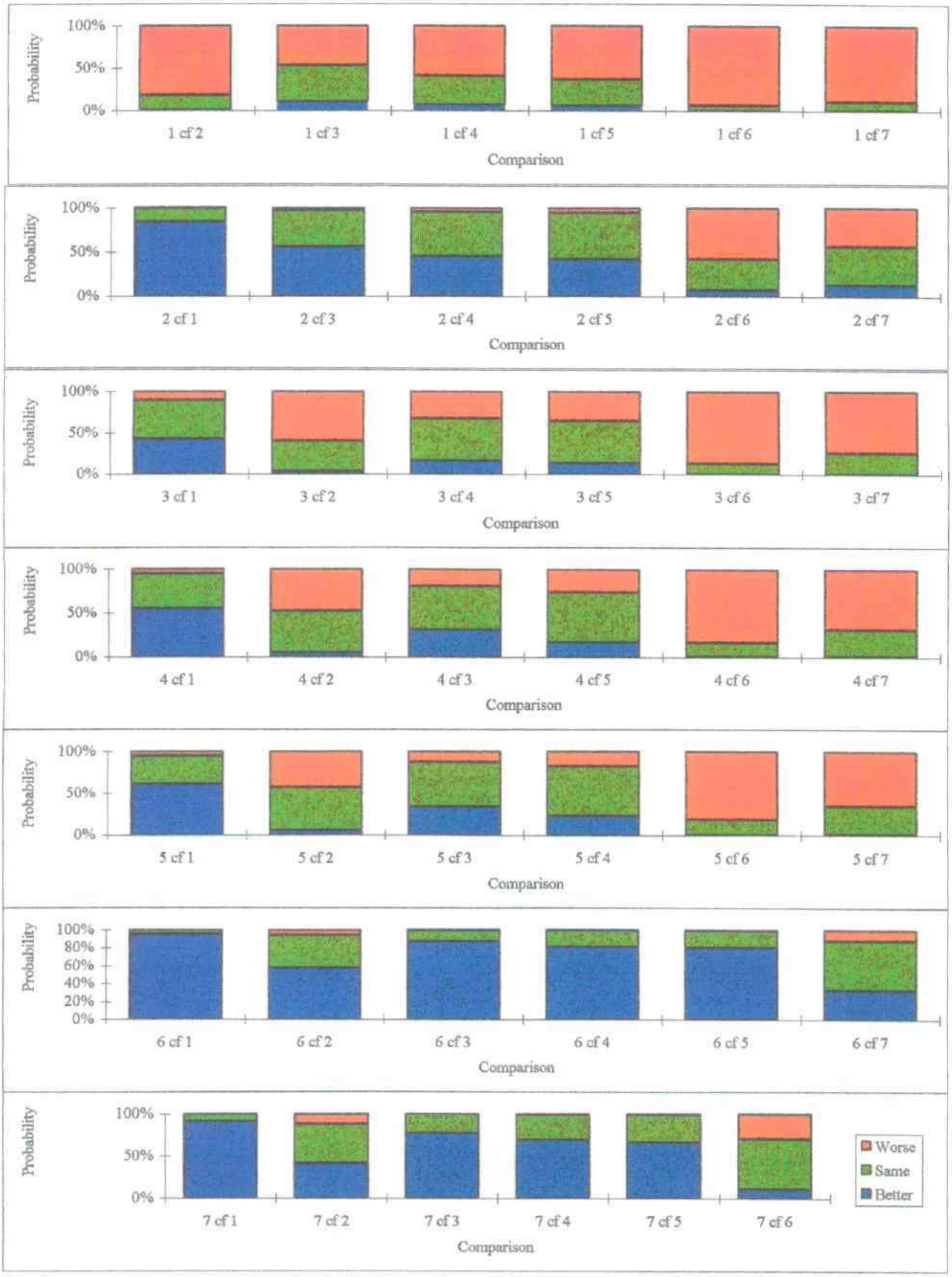

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Figure 17: PROBABILITY OF DIFFERENCE IN OVERALL QUALITY BAND (GQA)

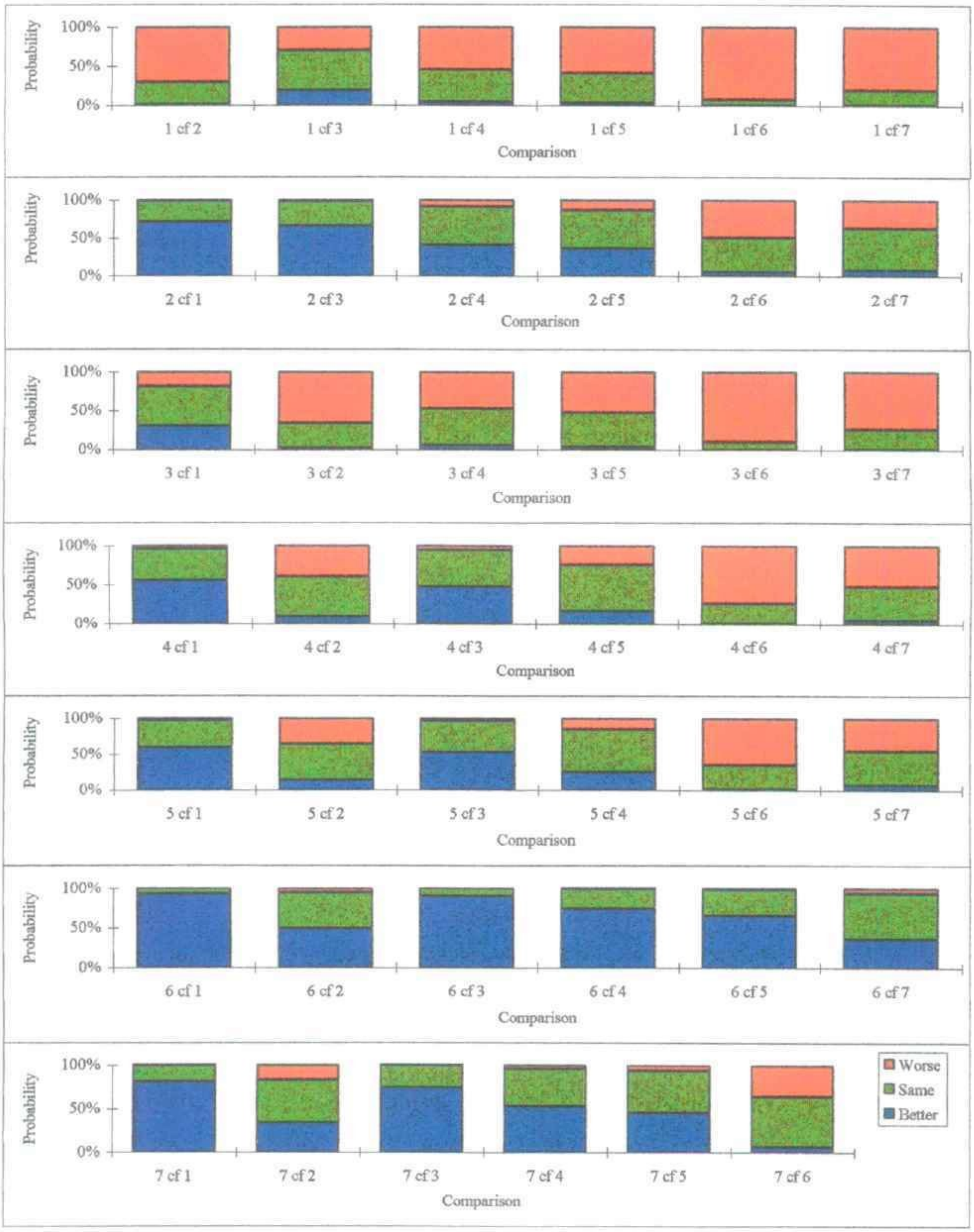

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Figure 18: RELATIVE PROPORTIONS OF DIFFERENT ORDERS IN RIVPACS SAMPLES

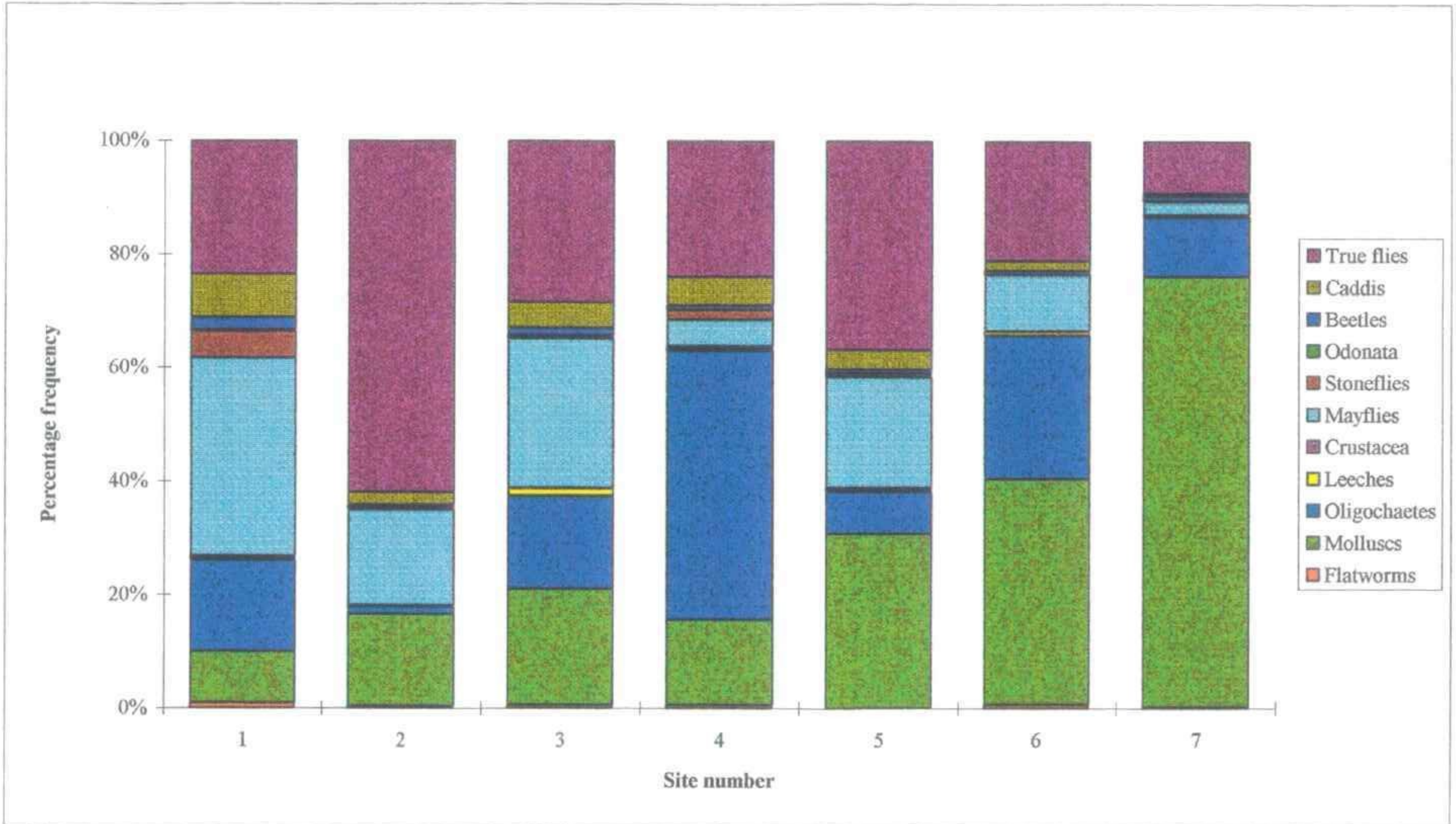

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Figure 19: INSECTS AND NON-INSECTS IN RIVPACS SAMPLES

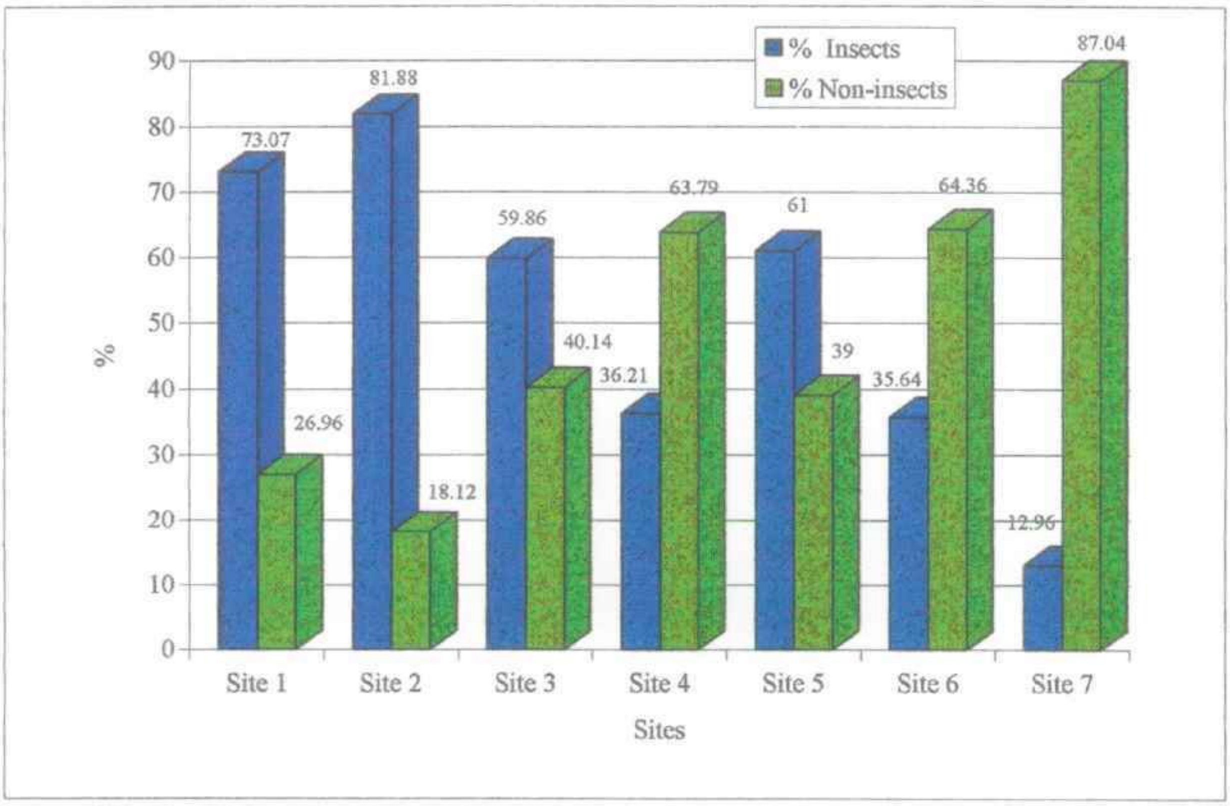

Figure 20: CHIRONOMIDS IN RIVPACS SAMPLES

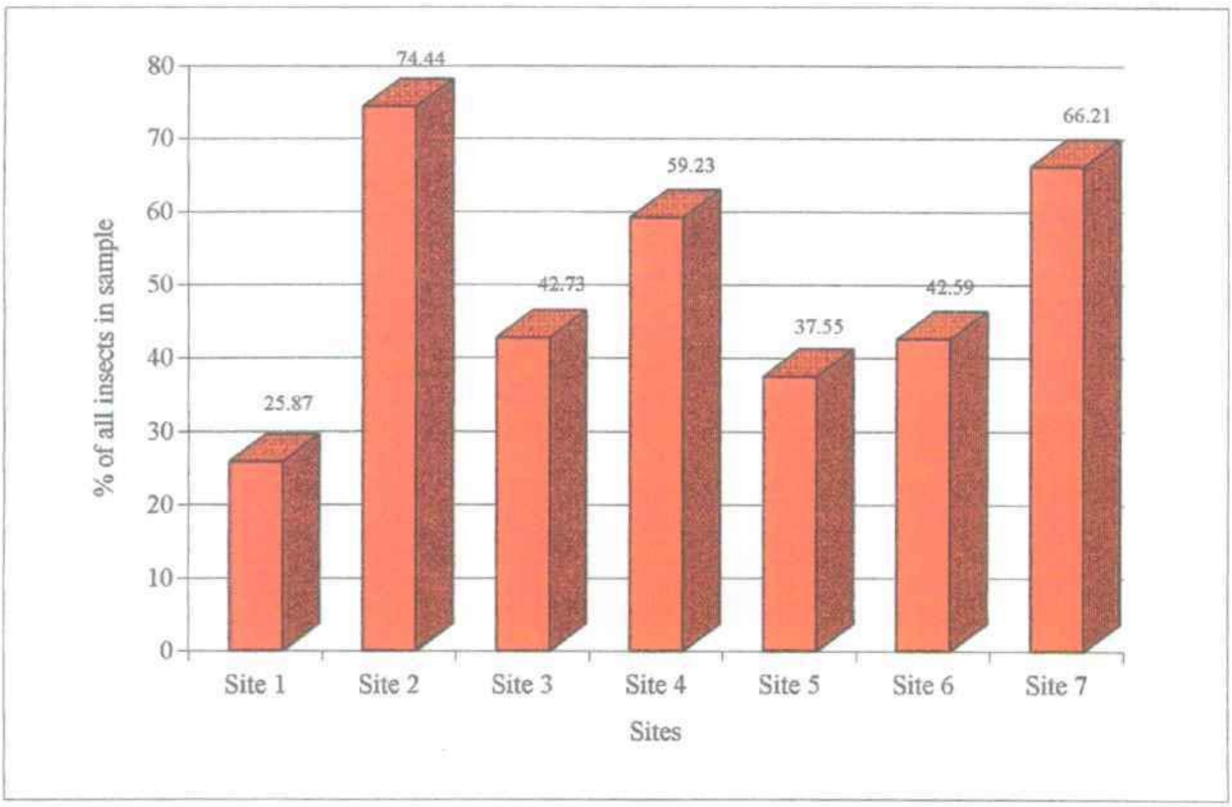

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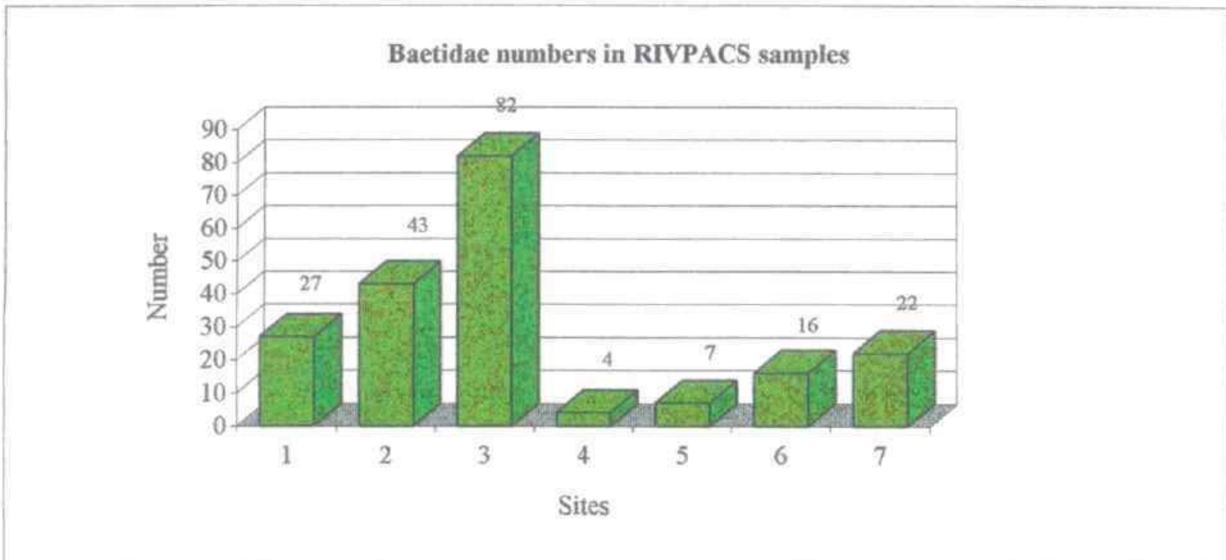
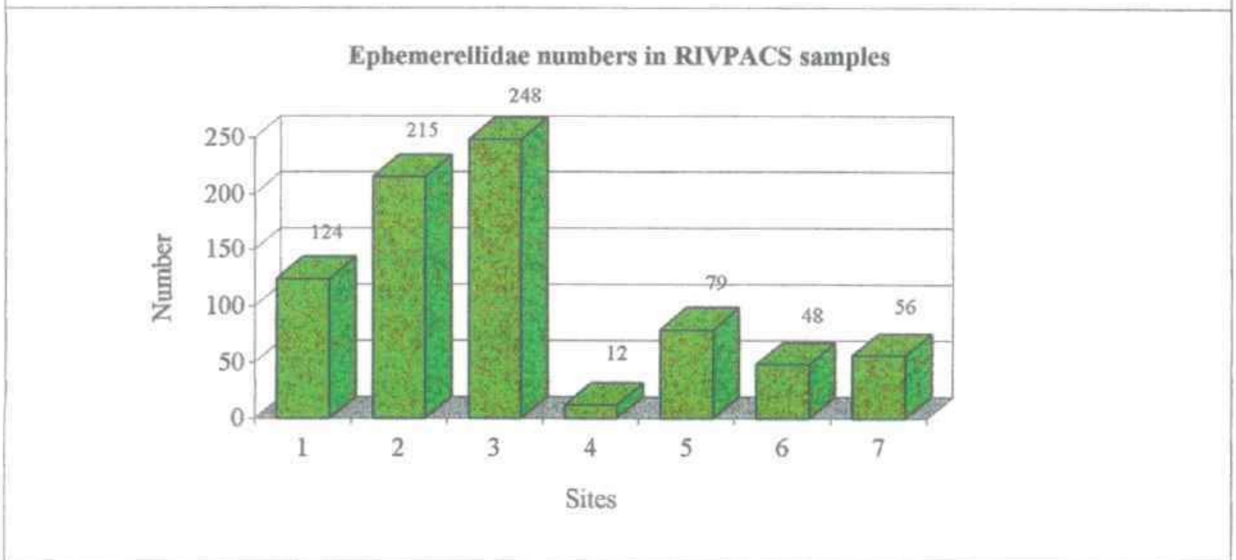
Figure 21: NUMBERS OF SOME FAMILIES SENSITIVE TO PESTICIDES (RIVPACS)





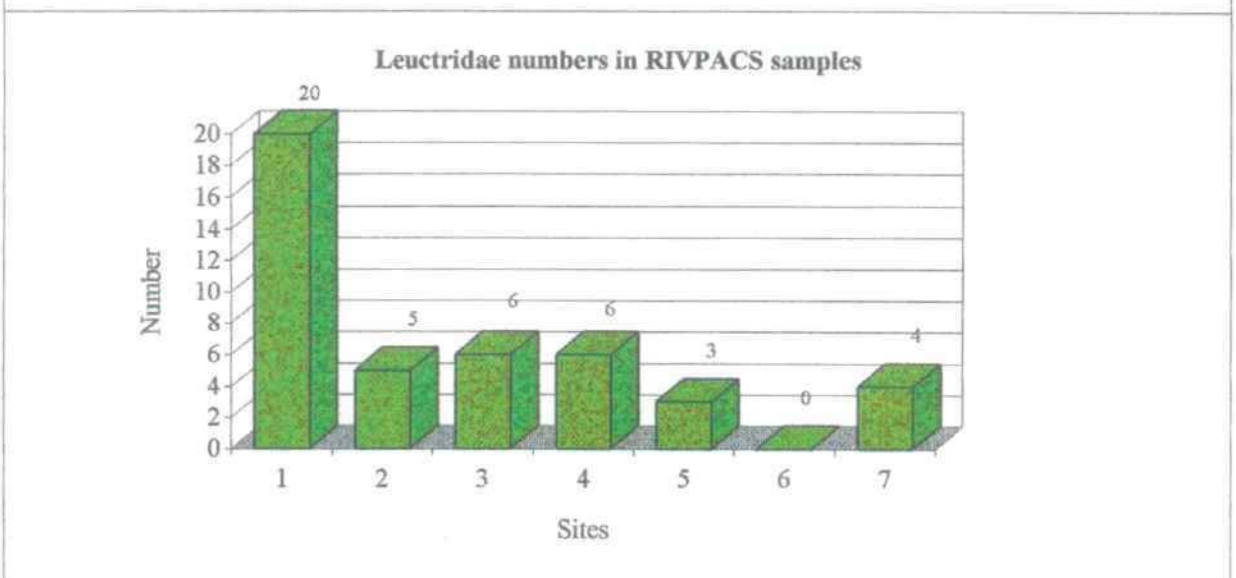


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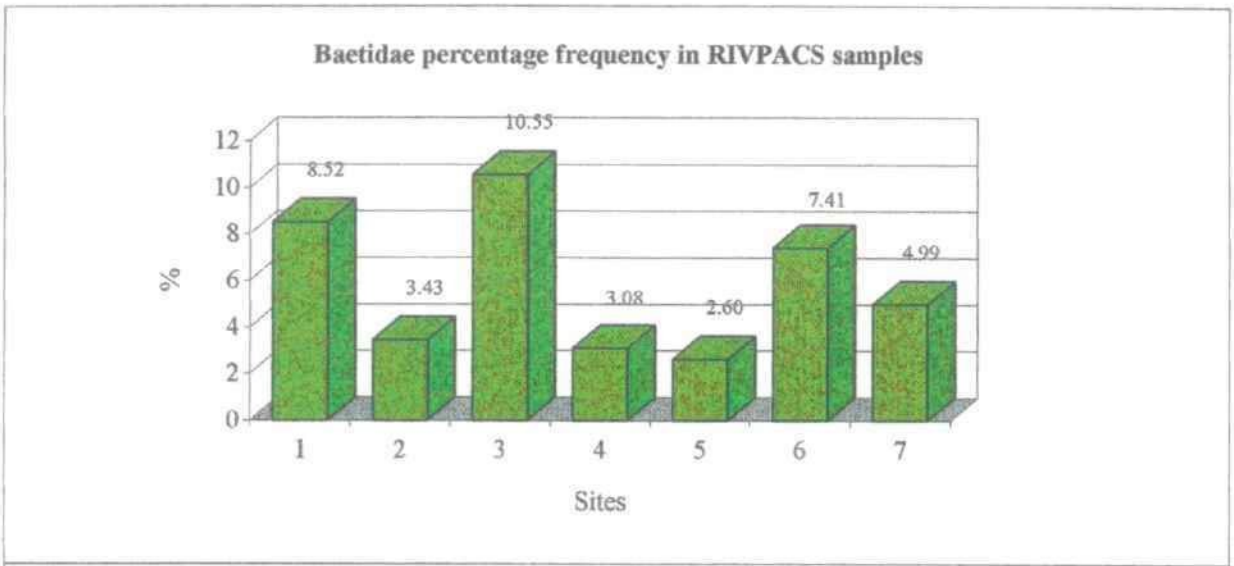
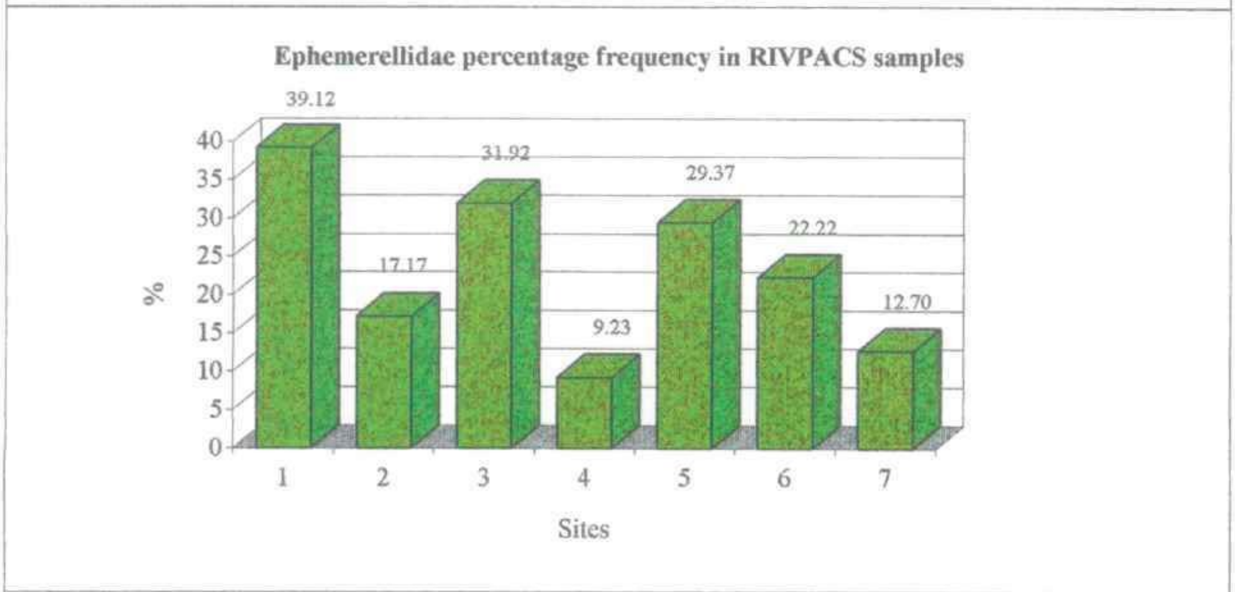
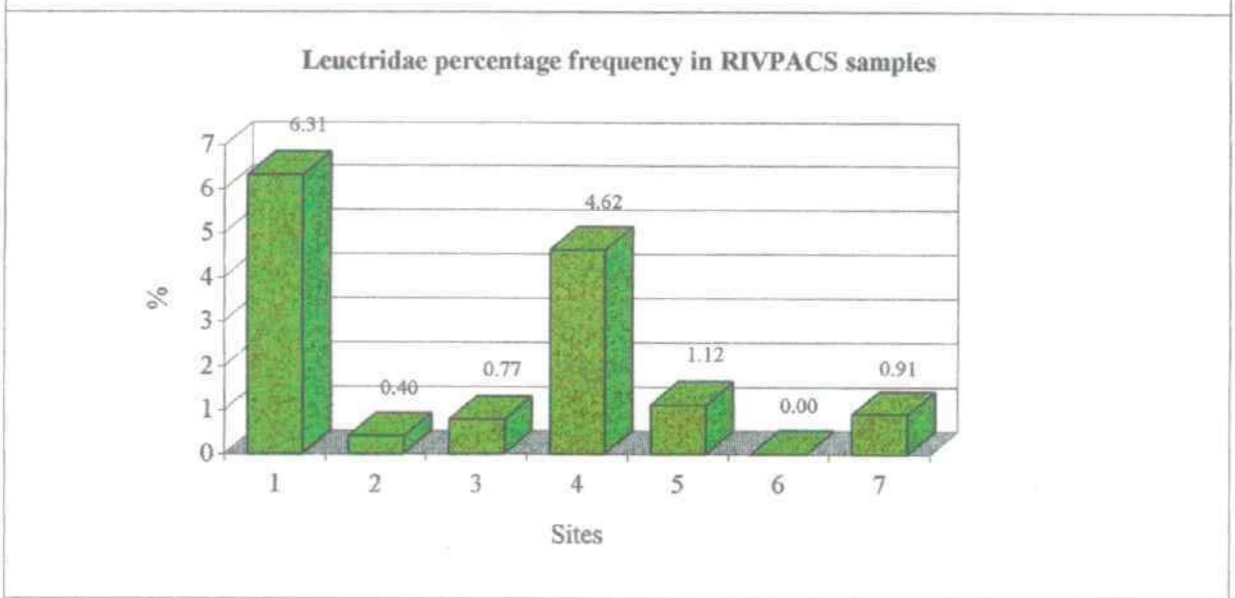
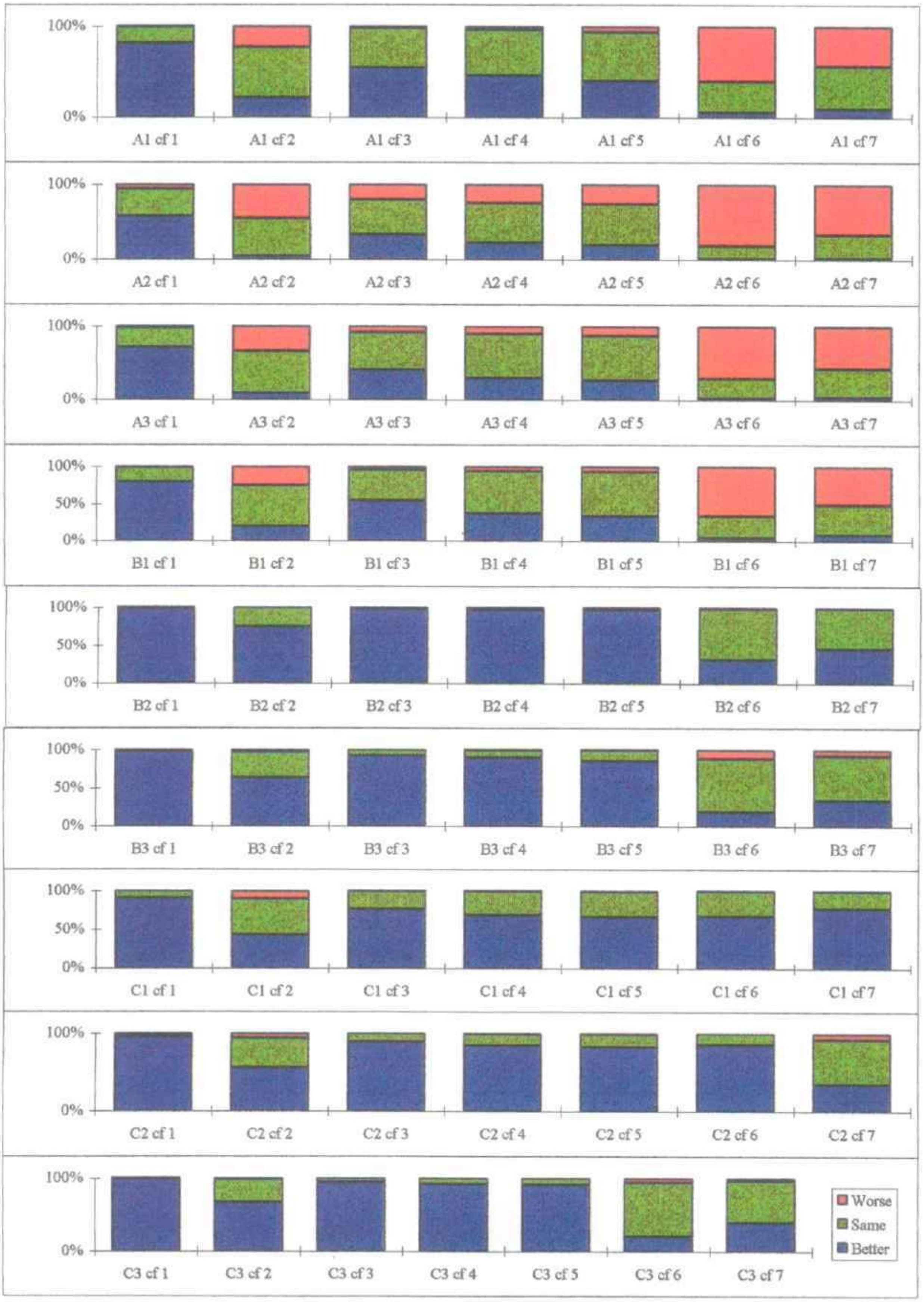
Figure 22: PERCENTAGE FREQUENCY OF SOME FAMILIES SENSITIVE TO PESTICIDES







Buckfastleigh STW Biological Assessment IFE 1995 cf IFE 1997
Figure 23: % PROBABILITY OF DIFFERENCE IN QUALITY BAND (O/E ASPT)



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