Environmental RTDI Programme 2000–2006

WATER FRAMEWORK DIRECTIVE – Characterisation of Reference Conditions and Testing of Typology of Rivers

(2002-W-LS-7)

Final Report

Prepared for the Environmental Protection Agency

by

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ACKNOWLEDGEMENTS

This report has been prepared as part of the Environmental Research Technological Development and Innovation Programme under the Productive Sector Operational Programme 2000–2006. The programme is financed by the Irish Government under the National Development Plan 2000–2006. It is administered on behalf of the Department of the Environment and Local Government by the Environmental Protection Agency which has the statutory function of co-ordinating and promoting environmental research.

Thanks to Martyn Kelly (diatoms), Nigel Holmes (macrophyte training), Richard Lansdown (macrophytes species confirmation) and the Environment & Heritage Service of Northern Ireland.

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ENVIRONMENTAL RTDI PROGRAMME 2000–2006

Published by the Environmental Protection Agency, Ireland

ISBN: 1-84095-161-3

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Executive Summary

To fulfil the obligations of the Water Framework Directive, a river typology within Ecoregion 17 had to be produced. The objective of this study was to survey 50 sites within the Republic of Ireland that had been previously classified as high quality by the Irish EPA, to determine whether they were of high ecological status (and thus could be used as reference conditions) and to use these spatial reference sites to develop the river typology.

The biological elements (macroinvertebrates, phytobenthos and macrophytes) were surveyed at all 50 sites during 2002/2003. Chemistry (ammonia, phosphate, nitrate, nitrite, hardness, alkalinity, dissolved oxygen, pH, temperature, calcium, magnesium, potassium, chloride and sulphate) and basic hydromorphological variables (sediment, bank slope, etc.) were measured during the same period to ensure reference status. Q-values, TDI and MTR scores were applied to the biological elements to judge reference status, although it was acknowledged that these methods may not be appropriate since different river types cannot be directly compared using these measures.

Potential deviations from reference status were identified by the biological elements, chemistry and hydromorphology at 23 sites, although coincidence of impact indication from the different elements only occurred at six sites. Agreement of a biological response with chemistry only occurred at one site (MOY2). Despite potential minor impacts, it was considered that the development of the typology would suffer more from the omission of river types than from the effect of the potential impacts. Thus, no sites were excluded, though the status of MOY2 and OGLIN1 should be reviewed in future developments.

Several typologies were developed from this dataset: Expert based, Canonical Correspondence Analysis (CCA) based, the WFD System A Typology, and typologies developed from permutations of different environmental variables and variable boundaries. The permutation-based typologies best segregated the biological elements across all groups, and with combined biological data. A 12-category permutation-based typology was recommended as the best typology, and has now been accepted by the EPA. Categorisation of the 50 sites, indicator species, and the frequency of different species are shown for the 12 different river types within this typology.

1 Introduction

The Water Framework Directive (WFD) requires Member States to measure the ecological status of surface waters by comparison of monitoring sites with unimpacted reference conditions specific to that river or lake type. Reference conditions must be of high ecological status and thus show "*no, or only very minor, evidence of distortion*" (Council of the European Communities, 2000). Ecological status for biological quality elements is to be a measure of "*changes in the composition and abundance*" of different taxonomic groups.

The RIVTYPE project addressed the development of reference conditions and a typology for rivers within the Republic of Ireland (part of Ecoregion 17). The specific objectives were:

1. To describe the composition and abundance of the macroinvertebrate, macrophyte and phytobenthos communities of 50 potential reference river sites, which were designated by the EPA.

2. To verify that these sites are of high biological, chemical and hydromorphological status and thereby could be used as reference conditions.

3. To determine and validate a river typology. River types should have distinct biological communities and a range of environmental variables which would be expected under unimpacted conditions.

1.1 Sites Surveyed

Fifty potential reference sites, which were likely to be of high ecological status, were selected by the EPA for macroinvertebrate, phytobenthos and macrophyte surveys. The locations of these sites are shown in Fig. 1.1 and Table 1.1 provides the Irish grid references.

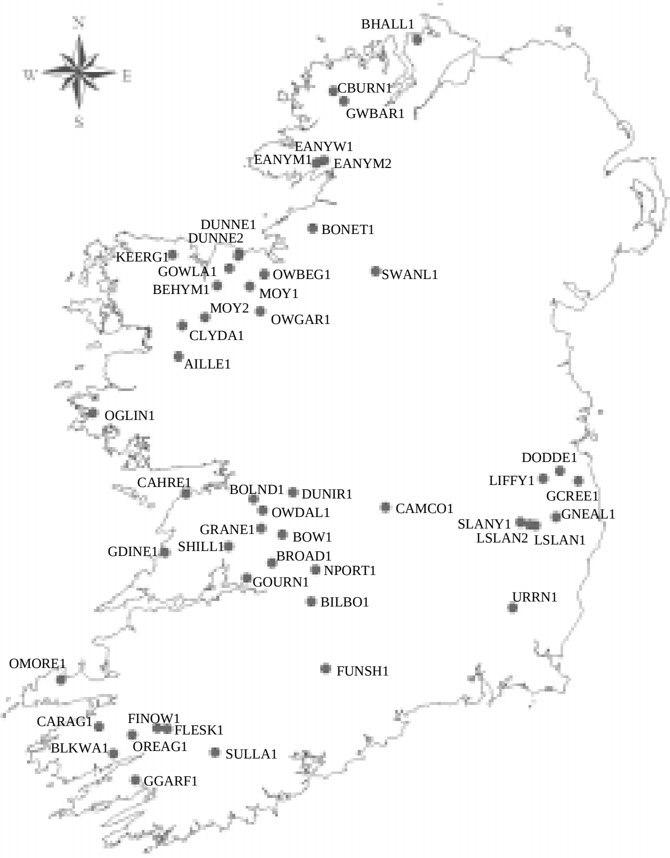

Figure 1.1. Location of the 50 potential reference sites chosen by the EPA.

Table 1.1. Irish Grid References (IGR) of the 50 potential reference sites.

EPA code	River name	Location	Site code	IGR
09D010010	Dodder	1.3 km u/s Reservoir u/s distributary	DODDE1	O11015 20233
09L010250	Liffey	0.5 km d/s Ballyward Br.	LIFFY1	O02276 16126
10G010200	Glencree	Bridge u/s Dargle River confl	GCREE1	O20272 14884
10G050100	Glenealo	Ford u/s Upper Lake	GNEAL1	T08822 96227
12L020100	Little Slaney	Ford S of Coan	LSLAN1	S98485 91766
12L020400	Little Slaney	Ford d/s Rostyduff Br.	LSLAN2	S94946 92339
12S020400	Slaney	Waterloo Br.	SLANY1	S90222 93468
12U010050	Urrin	Ballycrystal Br.	URRN1	S86396 48578
18F050030	Funshion	Brackbaun Br. – NE of Kilbeheny	FUNSH1	R88965 16817
19S020400	Sullane	Linnamilla Br.	SULLA1	W31293 72793
21B030100	Blackwater (Kerry)	Gearha Br.	BLKWA1	V78267 72138
21G030100	Glengarriff	Bridge W of Skehil	GGARF1	V89708 58327
22C020600	Caragh	Blackstones Br.	CARAG1	V70947 86350
22F020100	Flesk (Kerry)	Bridge nr Glenflesk – Curreal Br.	FLESK1	W06619 85385
22F040100	Finow	Bridge 0.3 km u/s L. Guitane – Finow Br.	FINOW1	W01152 85692
22O030400	Owenreagh	Bridge u/s Upper Lake (Lord Brandon's cottage)	OREAG1	V88412 82085
23O030300	Owenmore (Kerry)	Bridge at Boherboy	OMORE1	Q51307 10690
25B030080	Bilboa	Bridge u/s Blackboy Br. – Bilboa Br.	BILBO1	R81537 51863
25B100100	Bow	Bow River Br.	BOW1	R66568 87096
25D070400	Duniry	Just u/s Cappagh River confl, SW of Duniry	DUNIR1	M72142 09014
25G040025	Graney (Shannon)	Caher Br., S of L. Graney	GRANE1	R55410 90143
25G210010	Camcor	Bridge 3 km E of Longford	CAMCO1	N20100 01428
25N020060	Newport (Tipperary)	Bridge nr Glanculloo Old School	NPORT1	R83753 68327
27B020300	Broadford	Just u/s South Branch confl – Scott's Br.	BROAD1	R61044 72104
27G020600	Gourna	Bridge u/s Owenogarney River confl	GOURN1	R48104 64137
27S030200	Spancelhill	Bridge NW, near Spancelhill	SHILL1	R38640 80848
28C010200	Caher (Clare)	Bridge 2 km d/s Formoyle	CAHRE1	M16322 08228
28G020200	Glendine (Clare)	Knockloskeraun Br., S of Milltown Malbay	GDINE1	R05316 77429
29B040300	Boleyneendorrish	Bridge N of Doonally West – Kenny's Br.	BOLND1	M51419 05626
29O010700	Owendalulleegh	Ford at Inchamore, N of L. Graney	OWDAL1	R56160 99594
30A020110	Aille (Mayo)	Bridge NW of Claureen – E of Killavally	AILLE1	M12252 80132
32O030200	Owenglin	Bridge SW of Clifden Lodge	OGLIN1	L67737 50422
33K010200	Keerglen	Bridge NE of Doondragon	KEERG1	G09386 33317
34B080300	Behy (North Mayo)	Bridge SW of Oatlands House	BEHYM1	G32513 17108
34C050030	Clydagh (Castlebar)	Bridge u/s confl of East Branch	CLYDA1	M14276 96564
34M020100	Moy	Bridge SE of Cloonacool	MOY1	G49380 16842
34M020750	Moy	At Bleanmore	MOY2	G26177 00854
34O030050	Owengarve (Sligo)	Ford NW of Srah Upper	OWGAR1	G55121 03986
35B060010	Bonet	Bridge u/s Glenade Lough	BONET1	G82228 47138
35D060100	Dunneill	Bridge 2 km u/s Dromore West	DUNNE2	G43769 32718
35D060200	Dunneill	Donaghintraine Br.	DUNNE1	G43852 34411
35G030100	Gowlan (Sligo)	Ford u/s Easky River confl	GOWLA1	G38816 26532
35O010070	Owenbeg (Coolaney)	700 m u/s Ford SW Shancough (Bridge)	OWBEG1	G56983 23193
36S010100	Swanlinbar	Commas Br. (Br. nr Altbrean/Tullydermot)	SWANL1	H14890 24876
37E020150	Eanymore Water	Bridge SW of Letterbarra	EANYM2	G88298 82357
37E020250	Eanymore Water	Eanymore Br.	EANYM1	G84570 81582
37E030300	Eany Water	Just d/s Eany Beg/More confl	EANYW1	C84054 81396
38C060100	Cronaniv Burn	Bridge u/s Dunlewy Lough	CBURN1	B92899 18963
38G020100	Gweebarra	Pollglass Br.	GWBAR1	B94839 13968
40B010200	Ballyhallan	Bridge u/s Clonmany River	BHALL1	C36887 46019

2 Sampling Procedures

2.1 Macroinvertebrates

2.1.1 Sampling method

Macroinvertebrate samples were taken at each of the 50 sites in autumn (9 October 2002 to 29 November 2002), spring (10 February 2003 to 19 March 2003) and summer (3 June 2003 to 3 July 2003). Due to flooding in the autumn of 2002, additional samples were taken in the following autumn (7 and 8 October 2003).

Macroinvertebrates were collected using a 3-min, multi-habitat kick-sampling technique (Wright, 1995). This involved surveying a 50-m reach for different habitat types – riffle, glide, pool, backwater, vegetated area and margin. The time allotted to sampling each habitat type depended upon the percentage representation of each in the 50-m reach. Habitats contributing less than 5% of the stable habitat in the reach were generally not sampled (Barbour *et al*., 1997). Three replicate samples were collected, labelled and preserved in 70% alcohol. Hand searches were also undertaken to provide intact specimens for species confirmation.

2.1.2 Laboratory procedures

In the laboratory, samples were sieved through an 850-µm sieve and transferred to a white tray. All macroinvertebrates were removed and stored in labelled glass tubes containing 70% alcohol. The macroinvertebrates were counted and identified to the lowest possible taxon using standard Freshwater Biological Association (FBA) identification keys. Species/genus-level identification was achieved for all groups with the exception of some dipteran larvae and immature Oligochaeta.

2.2 Phytobenthos

Benthic diatoms were sampled and analysed following draft CEN methododologies (EN 13946, 2002; prEN 14407, 2003). Macroalgal sampling also followed draft CEN guidelines (CEN/TC230/WG2/TG3, 2003). All three draft guidelines have since been updated (but not yet accepted) (EN 13946, 2003; CEN/TC230/WG2/TG3, 2004; EN 14407, 2004).

2.2.1 Sampling method

Diatoms

Diatoms were sampled from cobbles which were free from sediments and filamentous algal growths. Benthic diatoms were removed from approximately five cobbles at each site by brushing with a toothbrush and washing with distilled water into a plastic tray. Up to ten cobbles were sampled on some occasions when the sample appeared to be too dilute. The bulk sample from each site was stored in a plastic tube. Each sample was oxidised in the laboratory with concentrated sulphuric acid, oxalic acid and potassium permanganate. The resulting diatom solutions were mounted onto glass microscope slides using Naphrax® (RI = 1.7, Northern Biological Supplies, UK).

The guidance standard on the identification, enumeration and pre-treatment of benthic diatoms (prEN 14407, 2003) recommends that 300–500 diatom units (valves in this case) are enumerated for diatom surveys. It was decided after preliminary examination of the diatom component to enumerate 500 diatom valves due to the dominance of one particular taxon. This ensured that the chance of encountering rarer species would be increased. One permanent diatom slide was prepared for each river site sampled in each season. Identifications of prepared diatoms were made primarily with the monographs of Krammer and Lange-Bertalot (1986, 1988, 1991a,b).

Counting also followed the draft CEN standard (prEN 14407, 2003):

1. Random fields of view were chosen using the vernier scales on the microscope and counted in traverses. Diatoms valves that were more than half in view at the edges of a field of view were counted, while those with less than half the valve in view were not counted. Broken valves were included if approximately three-quarters of the valve were present.
2. Treatment of unidentifiable diatoms: a diatom may be difficult to identify for a number of reasons, including orientation in girdle view, and the presence of obscuring material and overlapping valves. If many valves were obscured, more dilute

suspensions were prepared, or the sample was re-oxidised. Unidentified girdle views were recorded at the lowest taxonomic level to which they could be assigned with confidence (e.g. '*Achnanthes* sp. 1' or 'unidentified, pennate girdle view').

3. Photographs of identified and unidentified species were also taken and recorded for future reference. Characteristics such as shape and dimensions of the diatom, striae density and arrangement (at centre and poles), shape and size of central area, number and position of punctae and arrangement of raphe endings were recorded. Taxonomic verification was sought for a number of diatom slides (see Acknowledgements).

Macroalgae

All visible algae in a 20-m stretch at each site were collected and preserved in Lugol's iodine in plastic tubes. Algae from both depositing and eroding habitats were included. The recent draft standard recommends that samples be collected from the permanently submerged zone in the main flow of the river and that the flood zone should be avoided. A visual estimate of the percentage abundance of visible macroalgae was made in the field using a six-point scale (Table 2.1) and detailed notes on the appearance, colour and abundance of the visible macroalgae were made at each site. The composition of the macroalgal assemblage, primarily to genus level, was determined by microscopic examination of preserved samples in the laboratory using manuals by John *et al.* (2002), Whitton *et al.* (2002, 2003) and Wehr and Sheath (2003). In the laboratory, a semi-quantitative estimate of the abundance of phytobenthos (minus the diatoms) was also carried out based on the six-point scale. Filamentous algae are well known as being difficult to identify to species level. As a result, operational taxa were employed in this study, identifying taxa to genus level and also defining filament width. A similar approach has been adopted in other studies (Kinross *et al.*, 1993).

Table 2.1. Abundance scale estimates for macroalgae (CEN, 2003b).

Scale	Abundance	% Cover in the field
1	Occasional	<1%
2	Rare	1–5%
3	Common	5.01–10%
4	Abundant	10.01–25%
5	Very abundant	25.01–50%
6	Dominating	>50%

2.3 Macrophytes

2.3.1 Sampling method

Macrophyte surveying followed the draft CEN standard (CEN, 2002), which has now been accepted (CEN, 2003a). The survey included all aquatic vascular plants, bryophytes, Characeae and macroalgae. They were surveyed at all locations at or below the normal water level. Also, bank species which are strongly influenced by the river channel were separately recorded. Cover was recorded as categories in accordance with CEN guidelines (Table 2.2).

Table 2.2. Macrophyte cover categories (CEN, 2003a).

Value	Visual cover estimate (% of channel or bank)
0	0
1	<0.1
2	0.1–1
3	1–5
4	5–10
5	>10

The sites were assessed by surveying two 50-m lengths along representative sections of the channel. One stretch, where possible, coincided with the invertebrate sampling location and one was nearby, but at a section which appeared to have a different character. Often these two stretches covered each of a pool/riffle or an open/shaded reach. Sites where physical impact was evident were avoided and sections with a more natural character located up or downstream were selected (although the distance between the stretches was short enough to ensure that they were of similar altitude, had similar chemistry and did not have interceding tributaries).

All sites permitted wading, although this was restricted to shallow areas near the bank for a few deep-water sites. The sampling season was from June to August (inclusive) although there was a minor overrun into September. River flows tended to decrease throughout this period. Reduced visibility due to heavy rainfall and subsequent high flows was not a problem during this survey period. Low flows permitted high visibility, especially of mosses in large rivers, where they are usually less obvious.

A species survey sheet, organised by habitat type, was used to record species although additional aquatic macrophytes were recorded. Vouchers were retained for laboratory identification on the rare occasions where field identification was not possible, particularly with *Ranunculus* spp. Taxonomic confirmations were sought for certain species (see Acknowledgements).

Macrophyte data for channel and bank species were combined for subsequent analyses. Bank species cover was estimated as a percentage of the bank to be regularly (more than annually) flooded and it was believed that certain bank species could aid with the identification of hydromorphological impacts if their low reliability is down-weighted, e.g. in methods such as CBAS (Dodkins *et al.*, 2005). Bank species were also considered to be an important aspect of the riverine ecology.

2.4 Hydrochemistry

2.4.1 Sampling method

In order to validate the chemical and pollution status of each site it was decided that at least two sets of chemical analyses would be completed per site. Physico–chemical measurements such as water temperature, dissolved oxygen, % oxygen saturation, pH and conductivity were recorded in the field using automatic probes.

Water was collected in 1-litre polyethylene bottles, which were pre-rinsed with water from the site prior to sample collection. Two separate snap-cap vials were filled with water for anion and cation analyses. In the laboratory, analyses for alkalinity, total hardness, cations: sodium (Na^+), magnesium (Mg^{2+}), calcium (Ca^{2+}) and potassium (K^+), anions: sulphate (SO_4^{2-}), chloride (Cl^-) and nitrate (NO_3^-) and nutrients: orthophosphate, ammonia, nitrite and nitrate were carried out using the methodologies listed in Table 2.3.

2.5 Hydromorphology

2.5.1 Sampling method

Hydromorphological survey methods were not developed in time so instead simple hydromorphological observations were recorded in the field. All variables were estimated by eye and therefore accuracy may be low. The hydromorphological survey locations coincided with the macrophyte monitoring locations, and therefore were also conducted along two representative 50-m stretches at each site. Physically impacted stretches were avoided. The data collected in the field included shade (four categories), connection with bank (bank slope; five categories), estimated stream power (nine categories) and mean substrate diameter (phi scale). Additional hydromorphological and geographical data were derived from Geographical Information Systems and provided by the EPA and Compass Informatics. These included slope, distance from source, altitude, catchment area, stream order and valley slope.

Table 2.3. Standard methods used for chemical analysis.

Parameter	Units	Method
Temperature	°C	Thermistor
Conductivity	µS/cm	Electrometric
Dissolved oxygen	mg/l O_2	Electrometric
Oxygen saturation	% Sat.	Electrometric
pH	pH	Electrometric
Alkalinity	mg $CaCO_3$/l	Acid Titration Method
Total hardness	mg $CaCO_3$/l	Calculation
Total ammonia	mg N/l	Colorimetry (Phenol-Hypochlorite Method)
Nitrate	mg N/l	Dionex (Filtered)
Nitrite	mg N/l	Colorimetry (Sulphanilamide–N-1-Naphthylethyenediamine Dihydrochloride Method)
Orthophosphate	mg P/l	Colorimetry (Ascorbic Acid Method)
Chlorinity	mg Cl^-/l	Dionex
Sulphate	mg SO_4^{2-}/l	Dionex
Calcium	mg Ca^{2+}/l	Dionex
Magnesium	mg Mg^{2+}/l	Dionex
Sodium	mg Na^{2+}/l	Dionex
Potassium	mg K^+/l	Dionex

Note: all samples for Dionex analyses were filtered.

3 Verification of Ecological Status

3.1 Macroinvertebrates

Q-values were assigned to all sites for each season (Tables 3.1, 3.2 and 3.3). The majority of sites scored a Q5 value indicating that these sites were of good or excellent quality. Seasonal differences were obvious at some sites.

In autumn, the number of Class A scoring taxa (genus level) ranged from three (AILLE1, CARAG1) to 11 (GGARF1). Only one Class A taxon was observed at OGLIN1 in autumn 2003, whereas four taxa were observed at this site in the previous autumn but in low numbers (eight). Sites BLKWA1 and OWDAL1 both had ten Class A taxa. The percentage abundance of Class A taxa varied between the sites, ranging from 0.11% (OGLIN1) to >60% abundance at sites such as CAMCO1, FUNSH1 and DODDE1. Class A abundance at 18 of the 50 sites was less than 20% of the total fauna, while ten of those sites had less than 10% Class A representatives.

As expected, the number of Class A taxa increased in spring at most sites, due mainly to the Ephemeroptera. The number of taxa ranged from five (AILLE1) to 12 (MOY1). Forty-three of the sites had at least six Class A taxa. Five sites, including FLESK1, GOWLA1, KEERG1, OWGAR1 and MOY1, had at least ten Class A scoring taxa. The percentage abundance of Class A taxa ranged from 0.80% (AILLE1) to >50% (FUNSH1 and DODDE1). Thirteen of the sites had less than 10% total Class A taxa representation.

In the summer, the total Class A taxa recorded ranged from two (EANYM1, EANYW1) to ten (DODDE1). Only one Class A taxon was again observed at OGLIN1. Furthermore, a lower percentage abundance of Class A taxa was recorded, ranging from 0.17% (AILLE1) to 38% (BROAD1). Thirty-three of the 50 sites had less than 10% Class A abundance, while 20 of these sites had less than 5% representation of Class A taxa.

In summary, the majority of sites scored a Q5 value indicating that these sites were of good quality. Several sites deviated slightly from the expected Q5 status during some sampling seasons. Site AILLE1 always exhibited a low percentage abundance of Class A taxa, although at least three taxa were observed in each season (five in spring) resulting in a Q4–5 score. Five sites (CARAG1, EANYM1, EANYW1, FINOW1 and OREAG1) were given a Q4–5 in the summer season due to low percentage abundances of Class A taxa and/or in some sites where less than three Class A taxa occurred. The status of the biological community at the OGLIN1 site remains questionable. Here, the Q-values ranged from Q4–5 (autumn 2002) to Q5 in spring 2003, falling to Q4 in the summer and to the lowest value (Q3–4) in autumn 2003. The difficulty associated with taking kick-samples at this site may have contributed in part to the low scores. However, additional information obtained from discussions with Martin McGarrigle, EPA, and Fiona Kelly, Central Fisheries Board, lead to the conclusion that this site may be deviating from reference condition.

3.2 Phytobenthos

To assess ecological status the Trophic Diatom Index (TDI) (Kelly and Whitton, 1995; Kelly *et al.*, 2001) was used. There are three drawbacks to this method: (i) it utilises only the diatom component of the phytobenthos, (ii) it was designed for the purposes of the Urban Waste Water Treatment Directive and may not be valid in less nutrient-rich rivers, and (iii) it was developed in the UK and may not be applicable to Ireland. However, as there are no complete phytobenthos methods available in Europe and there is no equivalent to the TDI in Ireland, this was the best available method for indicating departure from reference status.

The DARES project (Diatom Assessment of River Ecological Status – Environment Agency (England and Wales), the Scottish Environmental Protection Agency, Bowburn Consultancy, the Natural History Museum, and the Universities of Bristol, Newcastle and Ulster) is evaluating past diatom collections on the basis of the TDI and has so far agreed that good status sites have a TDI score between 0 and 50 and impacted sites have a TDI score between 50 and 100 (Dr Martyn Kelly, Bowburn Consultancy, personal communication).

The TDI was applied to the combined spring and summer diatom data set. Results are presented in Table 3.4. Five sites had low diatom species richness and density,

Table 3.1. Autumn EPA Q-value ratings at the potential reference sites (Q-value scores less than Q5 are highlighted in bold).

Site	% of scoring taxa in each class (zero decimal places)					Number of Class A:		Q-value
	A	B	C	D	E	Species	Genera	
AILLE1	0	2	93	1	0	3	3	**Q4–5**
BEHYM1	22	2	73	0	0	7	7	Q5
BHALL1	12	14	71	0	0	4	4	Q5
BILBO1	25	4	69	0	0	9	8	Q5
BLKWA1	19	9	49	1	1	10	10	Q5
BOLND1	26	8	64	1	0	8	8	Q5
BONET1	37	6	55	0	0	8	8	Q5
BOW1	38	6	56	0	0	8	7	Q5
BROAD1	45	7	44	1	0	8	8	Q5
CAHER1	7	12	63	0	0	5	5	Q5
CAMCO1	65	11	21	0	0	8	8	Q5
CARAG1	5	14	77	1	0	3	3	Q5
CARAG1A2*	9	12	75	3	0	4	4	Q5
CBURN1	25	26	37	0	0	9	7	Q5
CLYDA1	30	12	54	0	0	7	7	Q5
DODDE1	68	9	20	0	0	7	7	Q5
DUNIR1	11	18	65	1	1	10	9	Q5
DUNNE1	3	2	95	0	0	6	6	Q5
DUNNE2	5	3	89	0	0	8	8	Q5
EANYM1	12	7	72	1	0	8	7	Q5
EANYM2	4	7	83	0	0	8	7	Q5
EANYW1	8	10	66	1	10	7	6	Q5
FINOW1	9	19	58	2	0	7	7	Q5
FLESK1	7	9	79	1	0	10	9	Q5
FUNSH1	67	6	24	0	0	9	8	Q5
GCREE1	46	16	34	0	0	7	7	Q5
GDINE1	16	7	75	1	1	6	5	Q5
GGARF1	28	17	50	0	0	12	11	Q5
GNEAL1	28	29	41	0	0	8	7	Q5
GOURN1	6	6	83	0	0	7	7	Q5
GOWLA1	11	4	80	0	0	9	8	Q5
GRANE1	38	6	51	1	2	8	7	Q5
GWBAR1	26	25	42	0	0	7	7	Q5
KEERG1	18	4	75	0	0	6	6	Q5
LIFFY1	35	4	54	0	0	8	7	Q5
LSLAN1	53	9	36	0	0	7	7	Q5
LSLAN2	32	14	48	0	0	6	6	Q5
MOY1	19	6	71	0	1	8	8	Q5
MOY2	6	4	88	1	0	7	7	Q5
NPORT1	30	10	54	2	0	9	8	Q5
OGLIN1	1	17	72	1	0	4	4	**Q4–5**
OGLIN1A2*	0	5	81	1	1	1	1	**Q3–4**
OMORE1	4	6	85	3	0	8	8	Q5
OREAG1	5	15	68	2	0	8	7	Q5
OWBEG1	27	4	65	0	0	9	9	Q5
OWDAL1	12	16	69	0	0	10	10	Q5
OWGAR1	7	5	85	1	0	9	8	Q5
SHILL1	10	5	81	2	0	5	5	Q5
SLANY1	7	6	69	1	0	6	6	Q5
SULLA1	19	7	70	1	0	9	9	Q5
SWANL1	44	6	46	0	0	8	7	Q5

*Indicates the scores for the additional autumn sample at this site.

Table 3.2. Spring EPA Q-value ratings at the potential reference sites (Q-value scores less than Q5 are highlighted in bold).

Site	% of scoring taxa in each class (zero decimal places)					Number of Class A:		Q-value
	A	B	C	D	E	Species	Genera	
AILLE1	1	6	90	0	0	5	5	**Q4–5**
BEHYM1	12	9	77	0	1	10	10	Q5
BHALL1	12	18	65	1	0	8	8	Q5
BILBO1	20	7	71	0	1	8	8	Q5
BLKWA1	5	10	72	1	1	8	8	Q5
BOLND1	40	4	52	1	0	11	10	Q5
BONET1	42	7	50	0	0	10	10	Q5
BOW1	47	5	47	1	0	9	9	Q5
BROAD1	27	12	54	3	3	9	9	Q5
CAHER1	19	15	53	0	0	6	6	Q5
CAMCO1	47	11	41	0	0	10	10	Q5
CARAG1	6	21	66	0	0	7	7	Q5
CBURN1	23	26	45	0	0	10	9	Q5
CLYDA1	21	10	67	0	0	8	8	Q5
DODDE1	63	13	22	0	0	10	10	Q5
DUNIR1	25	16	55	2	1	8	8	Q5
DUNNE1	10	4	84	0	0	7	7	Q5
DUNNE2	4	4	91	0	0	10	10	Q5
EANYM1	15	15	56	1	1	10	10	Q5
EANYM2	9	7	76	2	2	10	10	Q5
EANYW1	10	14	71	1	1	8	8	Q5
FINOW1	10	26	41	5	0	8	8	Q5
FLESK1	4	10	78	1	2	11	11	Q5
FUNSH1	57	6	36	0	0	10	10	Q5
GCREE1	44	8	46	0	0	8	8	Q5
GDINE1	32	5	58	0	0	10	10	Q5
GGARF1	22	10	57	5	6	6	6	Q5
GNEAL1	21	24	54	0	0	10	10	Q5
GOURN1	16	4	76	1	1	6	6	Q5
GOWLA1	8	8	80	0	2	11	11	Q5
GRANE1	35	10	54	0	0	9	9	Q5
GWBAR1	21	11	60	0	0	8	8	Q5
KEERG1	17	6	76	0	0	11	11	Q5
LIFFY1	27	5	66	0	0	9	9	Q5
LSLAN1	38	8	50	0	0	10	10	Q5
LSLAN2	38	12	48	0	0	7	7	Q5
MOY1	23	10	62	0	3	12	12	Q5
MOY2	2	4	88	4	0	8	8	Q5
NPORT1	21	8	67	1	1	8	8	Q5
OGLIN1	2	7	85	0	1	8	8	Q5
OMORE1	2	7	84	1	0	7	7	Q5
OREAG1	5	7	70	2	2	9	9	Q5
OWBEG1	35	6	56	0	2	10	9	Q5
OWDAL1	13	6	78	0	1	10	10	Q5
OWGAR1	14	3	79	0	1	11	11	Q5
SHILL1	12	7	78	3	0	6	6	Q5
SLANY1	7	1	64	0	5	7	7	Q5
SULLA1	15	11	60	1	1	10	10	Q5
SWANL1	40	7	51	0	0	10	10	Q5

Table 3.3. Summer EPA Q-value ratings at the potential reference sites (Q-value scores less than Q5 are highlighted in bold).

Site	% of scoring taxa in each class (zero decimal places)					Number of Class A:		Q-value
	A	B	C	D	E	Species	Genera	
AILLE1	0	1	97	0	0	5	4	**Q4–5**
BEHYM1	6	8	79	0	0	7	6	Q5
BHALL1	3	22	74	0	0	4	3	Q5
BILBO1	9	2	85	0	0	5	4	Q5
BLKWA1	5	3	88	0	0	4	4	Q5
BOLND1	12	3	83	1	0	6	5	Q5
BONET1	23	20	56	0	0	8	8	Q5
BOW1	17	2	78	1	0	6	5	Q5
BROAD1	38	1	57	1	0	6	6	Q5
CAHER1	3	22	62	0	0	4	4	Q5
CAMCO1	12	6	74	0	0	9	7	Q5
CARAG1	1	3	95	1	0	3	3	**Q4–5**
CBURN1	9	12	67	0	0	6	6	Q5
CLYDA1	17	13	66	0	0	7	7	Q5
DODDE1	14	14	71	0	0	10	10	Q5
DUNIR1	10	13	73	0	0	5	4	Q5
DUNNE1	7	3	87	0	0	5	4	Q5
DUNNE2	6	7	82	0	0	4	3	Q5
EANYM1	5	11	82	0	0	3	2	**Q4–5**
EANYM2	4	5	89	0	0	6	5	Q5
EANYW1	1	8	89	0	0	2	2	**Q4–5**
FINOW1	1	8	83	0	0	3	3	**Q4–5**
FLESK1	1	8	90	0	0	7	5	Q5
FUNSH1	24	3	69	0	0	8	8	Q5
GCREE1	6	5	86	0	0	7	7	Q5
GDINE1	11	11	76	0	0	8	8	Q5
GGARF1	11	4	83	2	0	3	3	Q5
GNEAL1	9	13	73	0	0	8	8	Q5
GOURN1	6	5	86	0	0	7	6	Q5
GOWLA1	5	4	88	0	0	6	4	Q5
GRANE1	12	4	82	1	0	7	7	Q5
GWBAR1	5	19	68	0	0	5	5	Q5
KEERG1	12	7	79	0	0	7	5	Q5
LIFFY1	9	9	73	2	0	8	7	Q5
LSLAN1	10	4	76	0	0	9	8	Q5
LSLAN2	3	5	88	0	0	7	6	Q5
MOY1	3	2	94	0	0	6	6	Q5
MOY2	3	7	87	0	0	6	5	Q5
NPORT1	6	4	88	1	0	7	6	Q5
OGLIN1	8	1	89	0	0	1	1	**Q4**
OMORE1	2	2	93	0	0	6	5	Q5
OREAG1	1	6	89	1	1	5	5	**Q4–5**
OWBEG1	4	3	91	0	0	6	5	Q5
OWDAL1	15	6	77	0	0	6	6	Q5
OWGAR1	8	6	82	0	0	5	4	Q5
SHILL1	4	7	86	1	0	7	6	Q5
SLANY1	2	2	93	0	0	5	4	Q5
SULLA1	13	4	82	0	0	7	7	Q5
SWANL1	19	6	74	0	0	6	6	Q5

Table 3.4. Results for the Trophic Diatom Index.

River	TDI	Comments
AILLE1	50	
BHALL1	28	
BEHYM1	30	
BILBO1	53	*Achnanthidium minutissimum* 51%. *Gomphonema minutum* and *Gomphonema olivaceum* reached 7.8% and 8.5% in spring and summer, respectively
BLKWA1	31	
BOLND1	56	*A. minutissimum* 47%. *Navicula lanceolata* 16%. *Gomphonema parvulum* 5%
BONET1	37	
BOW1	63	*A. minutissimum* 40%. *N. lanceolata* 29%
BROAD1	*	
CAHRE1	*	
CAMCO1	36	
CARAG1	32	
CLYDA1	52	*A. minutissimum* 48%. *Reimeria sinuata* 30%
CBURN1	33	
DODDE1	28	
DUNIR1	40	High abundance of *C. glomerata* in spring and summer
DUNNE1	70	*A. minutissimum* 16%. *G. olivaceum* 25% (1 season only)
DUNNE2	43	
EANYW1	33	
EANYM1	30	
EANYM2	34	
FINOW1	26	
FLESK1	29	
FUNSH1	37	
GCREE1	76	*G. olivaceum* 29% (1 season only)
GDINE1	*	
GNEAL1	21	
GGARF1	27	
GOURN1	72**	*Navicula gregaria* 16%. *A. minutissimum* 10% (1 season only)
GOWLA1	28	
GRANE1	71	*G. olivaceum* 20%. *A. minutissimum* 13% (1 season only)
GWBAR1	28	
KEERG1	32	
LIFFY1	43	
LSLAN1	29	
LSLAN2	42	
MOY1	33	
MOY2	49	
NPORT1	46	
OWBEG1	29	
OWDAL1	44	
OWGAR1	42	
OGLIN1	25	
OMORE1	33	
OREAG1	27	
SLANY1	67	*A. minutissimum* 9%. *N. lanceolata* 14% (1 season only)
SHILL1	*	High abundance of *Hildenbrandia rivularis*
SULLA1	47	
SWANL1	*	
URRN1	44	

*Indicates river samples with low diatom density such that quantitative counts could not be made and TDI could not be calculated. Underlined sites indicate rivers with questionable high quality status.

precluding the calculation of a TDI value. Rivers with TDI scores of 50 or less were presumed to be of 'good' quality. Rivers with TDI scores greater than 50, and therefore of questionable quality, were BILBO1, BOLND1, BOW1, CLYDA1, DUNNE1, GCREE1, GOURN1, GRANE1 and SLANY1. Sites underlined had TDI scores only slightly above 50, and therefore were considered acceptable. BOW1 scored above 50 in spring but not in summer. For all the other sites, the TDI could not be calculated in summer due to the low density of diatom valves, making a quantitative count impossible. It may be possible that these rivers would score within the acceptable limits in future surveys. All sites were included in the data analysis and the determination of typology, but it is recommended that the status of the sites listed above be reviewed as part of future monitoring.

Little work has been carried out on the use of macroalgae for water quality monitoring. An exception is *Cladophora*, which is tolerant of high nutrient concentrations, and thus an increase in abundance has often been considered to signal eutrophication (Whitton, 1970; Bolas and Lund, 1974), although, at lower population densities, it is a natural component of many water systems (Whitton, 1970). *Cladophora glomerata* was abundant at DUNNE1 during the summer, and attained a high abundance at DUNIR1 in both spring and summer, indicating that both of these sites may be of questionable quality. DUNNE1 also scored above 50 in the TDI. The status of both these sites should be further reviewed.

Filamentous algae including *Spirogyra* spp., *Mougeotia* spp., *Oedogonium* spp. and *Zygnema* spp. did reach high abundance at some of these sites, but there is little evidence of their relationship with water quality. They are commonly found at the littoral edges of rivers and are favoured by the lower flows and higher water temperatures that prevail during the summer.

The diatom *Didymosphenia geminata*, which forms visible brownish mats, was found in a number of rivers in Donegal, Mayo and Sligo, particularly during summer sampling, but rarely reached over 5% abundance. Although this species thrives in clear, warm, shallow and nutrient-poor water, an increase in its abundance may reduce rearing habitats for salmonids due to changes in invertebrate communities, physical impacts such as gill irritations and clogging, and displacement of fish species (Ministry of Water, Land and Air, British Columbia, 2004).

3.3 Macrophytes

Within Ecoregion 17 (specifically N. Ireland), the Mean Trophic Rank (MTR) (Holmes *et al.*, 1999) has been shown to have only a weak relationship with phosphate: $r^2 = 0.239$ with a significance of P = 0.1 (Dawson *et al.*, 1999). Also, macrophytes are strongly affected by the physical environment (Haury, 1996; Wilby *et al.*, 1998), which is why the MTR is not recommended when comparing sites that are physically dissimilar (Dawson *et al.*, 1999). In addition, MTR scores would naturally be lower for lowland rivers, and thus cannot be directly compared between different river types. Despite this, MTR values are presented in Table 3.5. The five sites identified in this table as likely to be affected by eutrophication (i.e. having an MTR score below 45) are all lowland sites, below an altitude of 55 m with slopes less than 0.016 m/m (mean slope for the 50 sites being 0.03 m/m). High silt cover in the channel can falsely suggest eutrophication within the MTR, which is likely to be the case with BROAD1 (100% silt) and SHILL1 (38% silt).

Table 3.5. MTR scores for the 50 sites. Sites in bold have an MTR score below 45 and "*are likely to be affected by eutrophication*" (Holmes *et al.*, 1999).

Site	MTR	Site	MTR	Site	MTR	Site	MTR	Site	MTR
AILLE1	56	CAMCO1	67	EANYW1	64	GRANE1	55	OMORE1	72
BEHYM1	**42**	CARAG1	74	FINOW1	75	GWBAR1	93	OREAG1	68
BHALL1	58	CBURN1	71	FLESK1	65	KEERG1	59	OWBEG1	78
BILBO1	51	CLYDA1	58	FUNSH1	68	LIFFY1	73	OWDAL1	57
BLKWA1	74	DODDE1	87	GCREE1	74	LSLAN1	77	OWGAR1	57
BOLND1	52	DUNIR1	68	GDINE1	55	LSLAN2	68	**SHILL1**	**40**
BONET1	65	DUNNE1	62	GGARF1	67	MOY1	66	SLANY1	73
BOW1	70	DUNNE2	53	GNEAL1	81	**MOY2**	**44**	SULLA1	59
BROAD1	**30**	EANYM1	71	GOURN1	57	NPORT1	53	SWANL1	83
CAHER1	62	EANYM2	57	GOWLA1	59	**OGLIN1**	**44**	URRN1	76

Sites MOY2, OGLIN1 and BEHYM1 recorded MTR scores only slightly below 45, and despite being lowland sites they may have minor nutrient impacts and should be considered for review in future studies.

Due to the shortcomings of evaluating the sites with MTR, a site-by-site ecological assessment was also undertaken. It was apparent that *Fuchsia* and *Crocosmia* (Montbretia) were invasive species along many river banks, including many of the reference sites, throughout Ireland. Finding spatial reference sites without these species would be difficult; however, the species were not considered to have had a large effect on the cover of naturally occurring species. These species together with the invasive aliens *Impatiens glandulifera* and *Reynoutria japonica* were removed from the survey data (Table 3.6).

Access to the river channel by cattle and sheep was also evident at many sites (from faeces and hoof prints), and, although attempts were made to avoid these areas, it was not always possible. These sites included GGARF1, GOWLA1, KEERG1, LIFFY1, MOY2 and OWBEG1. The growth of *Fontinalis antipyretica* at some sites may suggest that some local and mild eutrophication may be occurring (AILLE 1 and OWDAL1). Although some sites had species that may be indicative of eutrophication, this was not supported by the water chemistry data, suggesting that either low summer flows or a localised event resulted in their growth. Despite invasive species and local enrichment, it was considered that all of the chosen sites had only very minor anthropogenic alterations and should be retained within subsequent analyses.

Table 3.6. Impacts on reference sites indicated from the macrophytes; (a) and (b) are each of the two 50-m stretches surveyed at the sites.

Site	Invasive species*
BILBO1a	<0.1% *I. glandulifera*
BILBO1b	0.1–1% *I. glandulifera;* 1–5% *R. japonica*
BOW1a	<0.1% *R. japonica*
BOW1b	<0.1% *R. japonica*
BROAD1b	0.1–1% *R. japonica*
DUNNE2a	*Fuchsia*
OGLIN1a	*Fuchsia*, *Crocosmia*
OGLIN1b	0.1–1% *I. glandulifera*
OMORE1b	*Crocosmia*

*Removed from survey data prior to data analysis.

3.3.1 Representativeness of sites

A total of 114 aquatic macrophyte species (not including invasive aliens) were found during this survey and are used in the analyses. To determine whether a sufficient range of species was detected, species from this survey were compared with species lists previously surveyed in Northern Ireland by the Environment and Heritage Service (EHS) and also by Dodkins (2003). Species missing from this survey and suggested reasons why they were missing are listed in Table 3.7.

The absence of several species suggests that the extreme ranges of habitat have not been represented. *Nardia compressa*, characteristic of very acidic areas, did not occur. *Rumex hydrolapathum* and *Potamogeton lucens*, which are both found in lowland calcareous rivers, were also not found. In addition, species that occur in rivers with associated wetlands were not found, i.e. *Menyanthes trifoliata* and *Veronica anagallis-aquatica*. The relatively low number of reference sites may have reduced the chance of finding less common species.

Agrostis stolonifera, Barbarea vulgaris, Cardamine spp., *Cirsium palustre, Epilobium hirsutum, Epilobium palustre, Galium palustre* and *Rhytidiadelphus* were not considered sufficiently associated with waterbodies for this survey and were not recorded. Riparian trees (e.g. alder and willow) were also ignored during surveying.

3.4 Hydrochemistry

In order to determine whether these 50 sites represent reference conditions, the chemical status of each was assessed paying particular attention to the level of nutrients: ammonia, nitrite, nitrate and phosphate (McGarrigle *et al.*, 2002).

3.4.1 Ammonia

Total ammonia levels were generally below 0.01 mg/l N for the majority of sites. Nine sites had higher ammonia values ranging from 0.0014 (CAMCO1) to 0.126 mg/l N (EANYW1) mostly occurring on single occasions (Table 3.8). The MOY2 site, however, recorded ammonia values ranging from 0.017 to 0.037 mg/l N on three of the four sampling occasions. However, all of the sites contained less than 0.025 mg/l N as unionised ammonia.

3.4.2 Nitrite and nitrate

Nitrite levels in unpolluted waters are normally low, below 0.01 mg/l N (Flanagan, 1992). Concentrations were below this value at the majority of the sites (Table 3.8) except for

Table 3.7. Species found in N. Ireland surveys but not found within the RIVTYPE survey, with suggested reasons for differences.

Species missing from survey	Suggested reason for omission
Azolla filiformis	Invasive alien and characteristic of eutrophic waters
Barbarea vulgaris	Not considered sufficiently associated with waterbodies for this survey
Cicuta virosa	
Elodea nuttallii	Characteristic of eutrophic waters
Glyceria maxima	Often on nutrient-rich substrates
Heracleum mantagazzianum	Invasive alien
Hydrocharis morsus-ranae	Tends to exist in ponds
Lemna gibba	Characteristic of eutrophic waters
Lemna polyrhiza	Base-rich lowlands, often eutrophic, not common in the Republic of Ireland
Menyanthes trifoliata	At fringes of slow rivers/lakes
Nardia compressa	Liverwort associated with very acidic conditions
Orthotrichum rivulare	Quite a rare upland moss
Phragmites australis	Associated with slow-flowing lowland areas which don't have a fluctuating water level. Unusual that it wasn't found
Potamogeton gramineus	Found in slow-flowing meso–eutrophic base-rich sites, though not ubiquitous
Potamogeton lucens	Calcareous slow-flowing locations
Ranunculus aquatilis	Still or slow-flowing marginal. Not common in Ireland
Rumex hydrolapathum	Calcareous, slow-flowing locations, though not common in Ireland
Sagittaria sagittifolia	Associated with eutrophic waters
Schistidium alpicola	Moss of basic rocks
Sium latifolium	Lowland, rare in Ireland
Solanum dulcamara	Marginal plant whose omission unlikely to be important
Symphytum officinale	Marginal plant whose omission unlikely to be important
Veronica anagallis-aquatica	Lowland plant of shallow margins

EANYW1 (0.0258 mg/l N) where the recommended limit of 0.015 mg/l N set in the Freshwater Fish Directive (78/659/EEC) for Salmonid Waters was exceeded on a single occasion. All readings were, however, below the newly proposed limit of 0.061 mg/l N (EPA, 1997). Nitrate is a plant growth promoter and therefore can contribute to eutrophication. Nitrate levels were low, ranging from 1.04 mg/l N (GGARF1) to a moderate 9.08 mg/l N (which was maximum concentration recorded at MOY2).

3.4.3 Phosphate

Phosphate concentrations generally remained below the 0.01 mg/l P detection level at the majority of sites on most occasions (Table 3.8). Twelve sites had phosphate values greater than the Q5 – 0.015 mg/l P limit (EPA, 1997). Seven of these sites (AILLE1, BOLND1, DODDE1, DUNNE1, GDINE1, GOURN1 and OWGAR1) had phosphate values greater than 0.02 mg/l P on single occasions.

3.4.4 Chemical status of the 50 sites

The majority of sites exhibited a low nutrient content and therefore a high quality chemical status. Most of the higher nutrient readings occurred on single occasions in the summer or autumn 2003 sampling period. Three sites (GDINE1, OWGAR1 and MOY2) in particular may warrant further investigation. The phosphate value at GDINE1 ranged from 0.0409 mg/l P in the summer to 0.0281 mg/l P in the autumn. At the OWGAR1 site, the phosphate value was elevated at 0.0516 mg/l P in the summer while the ammonia value (0.0280 mg/l N) was also high in the autumn 2003 period. Finally, the MOY2 site had high ammonia (0.0333 mg/l N), nitrate (9.08 mg/l N) and phosphate (0.0165 mg/l P) values in the summer sampling period in comparison to the remaining sites. As

Table 3.8. Summary results of nutrients: ammonia, nitrite, nitrate and phosphate[a].

Site		Ammonia mg/l N	Nitrite mg/l N	Nitrate mg/l N	Phosphate mg/l P	Site		Ammonia mg/l N	Nitrite mg/l N	Nitrate mg/l N	Phosphate mg/l P
AILLE1	**Mean**	0.0031	0.0059	1.77	0.0193	**DUNNE1**	**Mean**				
	Min	0.0005	0.002	1.32	0.0055		**Min**	<0.01	<0.001	<5	<0.01
	Max	0.0083	0.0121	2.32	0.0453		**Max**	0.0052	0.0085		0.0287
BEHYM1	**Mean**			6.33		**DUNNE2**	**Mean**				
	Min	0.0144	0.0011	4.82	<0.01		**Min**	<0.01	0.0074	1.31	0.0132
	Max			7.85			**Max**				
BHALL1	**Mean**					**EANYM1**	**Mean**				
	Min	<0.01	<0.001	<5	<0.01		**Min**	<0.01	<0.001	<5	<0.01
	Max	0.0022	0.0017		0.0093		**Max**	0.0049	0.0041		0.0117
BILBO1	**Mean**			2.69		**EANYM2**	**Mean**				
	Min	<0.01	<0.001	2.51	<0.01		**Min**	<0.01	<0.001	<5	<0.01
	Max	0.0001	0.0006	2.87	0.0028		**Max**	0.0017	0.0034		0.0115
BLKWA1	**Mean**					**EANYW1**	**Mean**				
	Min	<0.01	<0.001	<5	<0.01		**Min**	<0.01	<0.001	<5	<0.01
	Max	0.0083	0.0008		0.001		**Max**	0.0054	0.0258		0.013
BOLND1	**Mean**	<0.01	0.0074		0.0313	**FINOW1**	**Mean**				
	Min	<0.01	0.0053	<5	0.0166		**Min**	<0.01	<0.001	<5	<0.01
	Max	<0.01	0.0095		0.0459		**Max**	0.0044	<0.001		<0.01
BONET1	**Mean**			1.92		**FLESK1**	**Mean**				
	Min	<0.01	<0.001	1.35	<0.01		**Min**	0.0001	<0.001	1.17	<0.01
	Max	0.002	0.0015	2.49	0.0062		**Max**	0.0093	<0.001		<0.01
BOW1	**Mean**					**FUNSH1**	**Mean**			2.1	
	Min	<0.01	<0.001	<5	<0.01		**Min**	<0.01	<0.001	1.91	<0.01
	Max	0.0022	0.0032		0.0141		**Max**	<0.01	<0.001	2.29	<0.01
BROAD1	**Mean**			3.83		**GCREE1**	**Mean**				
	Min	n/r	<0.001	3.42	<0.01		**Min**	<0.01	0.0018	1.68	0.0054
	Max	0.003	0.0011	4.24	0.0087		**Max**				
CAHER1	**Mean**					**GDINE1**	**Mean**	0.0036	0.0069	1.59	0.0345
	Min	<0.01	<0.001	<5	<0.01		**Min**	0.0008	<0.001	1.21	<0.01
	Max	0.0218	<0.001	2.05	<0.01		**Max**	0.0063	0.0082	1.97	0.0409
CAMCO1	**Mean**					**GGARF1**	**Mean**			1.54	
	Min	<0.01	<0.001	n/a	<0.01		**Min**	<0.01	<0.001	1.04	<0.01
	Max	0.0014	<0.001	1.64	<0.01		**Max**			2.04	
CARAG1	**Mean**					**GNEAL1**	**Mean**				
	Min	<0.01	<0.001	<5	<0.01		**Min**	<0.01	<0.001	1.78	<0.01
	Max	0.0012	0.0003		0.0047		**Max**	0.0206	0.0032		0.0072
CBURN1	**Mean**					**GOURN1**	**Mean**				
	Min	<0.01	<0.001	<5	<0.01		**Min**	<0.01	<0.001	1.53	<0.01
	Max	<0.01	0.0014		0.004		**Max**	0.0092	0.0043	<5	0.0244
CLYDA1	**Mean**					**GOWLA1**	**Mean**	0.1258	0.0052		0.014
	Min	0.0002	0.0101	<5	0.0188		**Min**	<0.01	<0.001	1.7	<0.01
	Max						**Max**	0.1258	0.0068	<5	0.0197
DODDE1	**Mean**					**GRANE1**	**Mean**				
	Min	<0.01	0.0028	<5	0.026		**Min**	0.0015	0.0032	1.52	0.0084
	Max						**Max**			<5	
DUNIR1	**Mean**			1.48		**GWBAR1**	**Mean**				
	Min	<0.01	<0.001	1.38	<0.01		**Min**	<0.01	<0.001	2.81	<0.01
	Max	0.0018	0.0031	1.59	0.0036		**Max**	<0.01	0.002		0.0051

Table 3.8. ***Contd***

Site		Ammonia mg/l N	Nitrite mg/l N	Nitrate mg/l N	Phosphate mg/l P	Site		Ammonia mg/l N	Nitrite mg/l N	Nitrate mg/l N	Phosphate mg/l P
KEERG1	**Mean**					**OREAG1**	**Mean**				
	Min	<0.01	<0.001	<5	<0.01		**Min**	<0.01	<0.001	<5	<0.01
	Max	<0.01	0.0068		0.009						
LIFFY1	**Mean**					**OWBEG1**	**Mean**				
	Min	<0.01	0.0027	2.52	0.0085		**Min**	<0.01	<0.001	<5	<0.01
	Max			<5			**Max**	<0.01	0.0022		<0.01
LSLAN1	**Mean**					**OWDAL1**	**Mean**				
	Min	<0.01	0.001	1.29	0.0028		**Min**	<0.01	0.0078	<5	0.0165
LSLAN2	**Mean**					**OWGAR1**	**Mean**	0.0121	0.0071		0.0297
	Min	<0.01	0.0044	2.26	0.0175		**Min**	0.0003	<0.001	2.86	0.0077
MOY1	**Mean**					**SHILL1**	**Mean**	0.0156		4.75	
	Min	<0.01	<0.001	2.18	<0.01		**Min**	0.005	<0.001	2.39	<0.01
MOY2	**Mean**	0.0188	0.0058	5.08	0.0125	**SLANY1**	**Mean**			3.42	
	Min	0.007	0.0038	1.89	0.006		**Min**	<0.01	<0.001	2.13	<0.01
NPORT1	**Mean**			1.5		**SULLA1**	**Mean**			4.79	
	Min	<0.01	<0.001	1.3	<0.01		**Min**	0.0003	0.0018	4.57	0.0054
OGLIN1	**Mean**					**SWANL1**	**Mean**				
	Min	<0.01	0.0015	<5	0.0022		**Min**	<0.01	<0.001	2.62	<0.01
OMORE1	**Mean**					**URRN1**	**Mean**			2.88	
	Min	<0.01	<0.001	<5	<0.01		**Min**	<0.01	<0.001	2.11	0.0074

[a]Where only a minimum value is reported, only one sample was available for that particular analysis; otherwise two or three samples were analysed to produce the mean value.

most of the sites exhibiting the higher nutrient values did so only on single occasions and our sampling protocol only allowed two to four sampling periods, it was decided that no sites should be omitted from the analysis unless impact was also indicated by the biological status. From these sites only MOY2 may have a biological impact (for macrophytes) (see Section 3.6).

3.4.5 Representativeness of the sites

Various other chemical parameters were measured to characterise the sites. The frequency distribution of key measurements across the 50 sites is illustrated in Fig. 3.1.

Temperature and pH

The temperature readings were typical of the sampling season ranging from 3.0°C (OWGAR1) in the spring to 17.9°C (OREAG1) in the summer. The pH values ranged from 4.80 (URRN1) to 8.78 (CAHRE1), both recorded in autumn 2002. The majority of the sites studied had pH values >7 (Fig. 3.1).

Dissolved oxygen

The dissolved oxygen concentrations were satisfactory at all sites, ranging from 9.26 mg/l O_2 (OREAG1) in the summer to 17.6 mg/l O_2 at OWDAL1 in the spring. Each of the sites had oxygen saturation readings above the 9 mg/l level required for salmonid waters (Salmonid Water Regulations, 1988). Values ranged from 90% (BHALL1) in the autumn to 139% (OWDAL1) in the spring. The high values at OWDAL1 are indicative of eutrophication.

Conductivity

Conductivity values ranged from 24 µS/cm at GNEAL1, which is influenced by hard geology and nutrient-poor peaty soils, to high values of 489 µS/cm at SHILL1, which is influenced by underlying limestone and fertile soils. The majority of sites had a mean conductivity value below

Table 3.9. Potential hydromorphological impacts at potential reference sites.

Site	Potential hydromorphological impact
DUNIR1a	Over-widened?
DUNIR1b	Over-widened?
EANYM1b	Disturbed bank; may be cause of *Petasites* occurrence
LIFFY1a	Banks altered/eroded?
LIFFY1b	Banks altered/eroded?
OGLIN1a	Old wall forms part of bank
OGLIN1b	Evidence of management for fisheries (boulders across channel to create pools)
MOY2	Arterial drainage – spoil heaps on banks

200 µS/cm. The low representation of high conductivity waters is apparent in Fig. 3.1.

Alkalinity

The mean alkalinity values ranged from below 1 mg/l $CaCO_3$, at sites such as GWBAR1 (–0.19 mg/l $CaCO_3$) and CBURN (0.17 mg/l $CaCO_3$) where there is a low buffering capacity, to values above 200 mg/l $CaCO_3$ at sites such as DUNNE1 (247.5 mg/l $CaCO_3$), BEHYM1, CAHRE1, MOY2 and SHILL1. The majority of the sites (43) had mean alkalinity values below 100 mg/l $CaCO_3$, with 34 of these sites having mean alkalinity values below 50 mg/l $CaCO_3$ (Fig. 3.1). Eleven of these sites had alkalinity values of 10 mg/l or less. These sites were all influenced by peat deposits in their catchments and included CBURN1, DODDE1, FINOW1, GNEAL1, GWBAR1, LSLAN1, URRN1 (flowing over siliceous rock formations), BLKWA1, CARAG1, GGARF1 and OREAG1 (with calcareous formations in their catchments).

Total hardness

The total hardness values ranged from 3.24 mg/l $CaCO_3$ (DODDE1) to 427 mg/l $CaCO_3$ (MOY2). The majority of sites (46) sampled were soft waters with total hardness values below 100 mg/l $CaCO_3$ (Fig. 3.1).

The calcium, magnesium, potassium, sodium and chloride values for all the sites sampled fell within the ranges expected given the geological and geographical conditions. Limestone sites with high alkalinity and total hardness values were however under-represented in the study.

3.5 Hydromorphology

Each of the two stretches at the 50 sites was visually assessed for suitability as reference conditions based on their hydromorphology. Major alterations (weirs, bridges, channelised sections) were avoided but some minor bank and channel modifications could not be avoided. It was considered that anything greater than a minor alteration would also affect the biology. The sites listed in Table 3.9 were determined as potentially having hydromorphological impacts.

It was difficult to determine whether the DUNIR1 has been affected by over-widening. OGLIN1a was considered to have only a very minor alteration. OGLIN1b had pools that had been formed by boulders being placed across the channel, presumably for fisheries. However, it was also possible to survey a riffle section (OGLIN1a) and therefore, despite the exact location having a different character to that which would normally be expected, the two sections were still representative of a pool/riffle sequence which would be characteristic within this type of river. Natural boulders were also evident at the banks, and therefore the substrate was not artificial, even though its arrangement was. Impacts were considered to be very minor at these sites and therefore none was rejected.

The LIFFY stretches were probably the most impacted in this survey. Flood flows appeared to have eroded the banks on the outside of the river bends. Although the flood flows may have been natural, the level of erosion could be from destabilisation of the bank due to removal of the natural riparian vegetation. Apart from these areas, the river seemed to possess a natural character that may be unlikely to be replicated by other cobble rivers of this size. Therefore, the retention of this site as a potential reference site is recommended, although future development on the reference network may suggest its removal at a later date. Silt cover may have been elevated in these sections, but at the locations surveyed the hydromorphological impact could be considered minor.

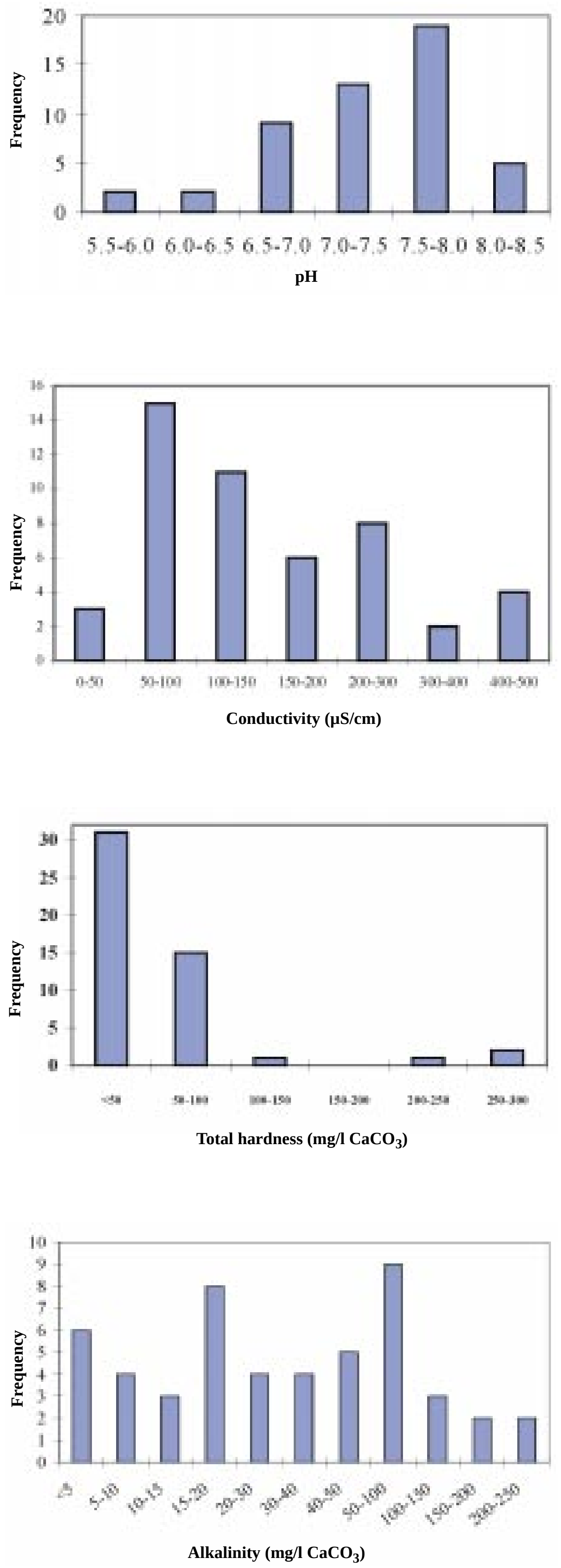

Figure 3.1. Frequency distributions for the mean pH, conductivity, alkalinity and hardness values.

Table 3.10. A summary of sites which potentially have minor impacts within this survey (suggested impacts indicated by ☑).

Site	Macroinvertebrates	Phytobenthos	Macrophytes	Hydrochemistry	Hydromorphology
AILLE1	☑		☑		
BEHYM1			☑		
BILBO1		☑			
BOLND1		☑			
BOW1		☑			
CARAG1	☑				
CLYDA1		☑			
DUNIR1		☑			☑
DUNNE1		☑			
EANYM1	☑				☑
EANYW1	☑				
FINOW1	☑				
GCREE1		☑			
GDINE1				☑	
GOURN1		☑			
GRANE1		☑			
LIFFY1					☑
MOY2			☑	☑	☑
OGLIN1	☑		☑		☑
OREAG1	☑				
OWDAL1			☑	☑	
OWGAR1				☑	
SLANY1		☑			

3.6 Reference Site Validation Summary

Sites can only be accepted for reference conditions if they have "*no or only very minor anthropogenic alteration*" for all of the biological elements, and for chemistry and hydromorphology (WFD, Annex V, Table 1.2). Several sites were identified as potentially having minor impacts within the surveys (Table 3.10). It was considered that the spatial reference network would suffer more from the removal of sites representative of different river types than from the effects of the possible minor impacts occurring at these sites. There was agreement of potential impacts between two different elements at six sites (AILLE1, DUNIR1, EANYM1, EANYM2, OGLIN1 and MOY2) and agreement between three elements at only two sites (OGLIN1 and MOY2).

A difficulty with using measures of trophic status such as TDI, Q-values and MTR is that they were not designed for use within a typology, i.e. lowland rivers would normally be expected to be naturally more enriched than upland rivers, and conversely upland rivers which appear to pass the standard may still be relatively impacted. Therefore, direct comparisons cannot be made until a river typology is developed. From the experience with RIVPACS (Reynoldson and Wright, 2000; Wright, 2000) it is evident that any spatial reference network should, over time, be iteratively improved by both removing and including additional sites. RIVTYPE should be no exception, and the sites listed in Table 3.10 in particular should be considered for replacement by higher quality sites within the same river type, if they can be found.

Fifty reference sites were also considered to be a low number for representing the complete biological diversity of high ecological status sites. Some of the chosen survey sites were also quite close together and on the same river system. This could result in pseudo-replication of reference conditions and a lower range of species and habitats being detected. The spatial reference network should be expanded in future to include more sites, particularly more acidic upland rivers and large lowland rivers with adjacent wetlands.

3.7 Artificial Intelligence

Artificial intelligence, specifically MIR-max (O'Connor, 2002), was used to classify the biological data. An attempt was made to produce a River Pollution Diagnostic System (RPDS) model like that produced for the Environment Agency (Walley *et al*., 2002); however, there were insufficient data to produce an effective model. Classification of biological data with MIR-max tended to be slightly worse than that produced by TWINSPAN (Hill and Minchin, 1997). A typology based on this classification method was considered to be inappropriate for species prediction, although prediction with any classification method was brought into question, given the limited range of variables available within the WFD and the high temporal variation in species.

4 Typology Production

A System A Typology (based on fixed boundaries of altitude, size and geology) is defined in the WFD, but there is allowance for development of alternative (System B) typologies which can use additional optional factors to delineate river types. If a System B Typology is used, it must achieve "*at least the same degree of differentiation as would be achieved using System A*" (WFD, Annex II 1.1 (iv)).

Four methods of classifying the sites into river types were evaluated:

1. The System A Typology.
2. Typologies based on expert opinion of the North South Technical Advisory Group (NSTAG) for rivers which included *inter alia* river biologists from the EPA and EHS (referred to as Expert-64, 32, 16, etc.).
3. A typology developed by examining the most important environmental gradients within the biological data using CCA.
4. Typologies derived from permutation tests; assessment of biological similarities within and between groups of many different typologies.

4.1 Combining Taxonomic Data

As well as assessing the biological differentiation achieved within each biological group, it is important to combine all the biological elements to determine the overall ability of each typology to segregate distinct biological communities.

4.1.1 Method

If the numbers of taxa in one biological element greatly exceed that in the others, analysis following a combination of these elements would unduly weight the analysis towards that group. Therefore, phytobenthos data were reduced to 129 taxa, and macroinvertebrates to 122 taxa, to combine with the 114 macrophyte taxa. The phytobenthos taxa number was reduced by removing all unidentified taxa, only including taxa which occurred in five or more river samples, and including taxa that reached an abundance level of two or more in the combined spring and summer data set. The reduced macroinvertebrate data set contained only spring data, identified predominantly to the genus level.

The abundance data for the different biological elements also had to be at the same scale. This is especially important for CCA as it utilises relative abundances. The abundance values recorded for macrophytes and phytobenthos were already approximately equivalent to a log transformation. A square-root transformation was applied to the macroinvertebrate data since it was desirable to retain the zero values; the phytobenthos and macrophyte data also had zero values. The maximum values for the macrophyte, phytobenthos and invertebrate (square-root transformed) abundance data were 5, 6 and 46, respectively; the minimum was 0. The data for these taxonomic groups were therefore standardised to the same scale by multiplying by 10/5, 10/6 and 10/46, respectively, to ensure that the abundance values for each taxonomic group ranged from 0 to 10.

4.2 Developing the CCA Typology

A site conditional bi-plot with the combined taxonomic group species data was constructed using only those variables which are available within WFD System B and which enable simple visualisation within a typology (Fig. 4.1). Temperature, chloride and substrate were not included since they were considered to be subject to impacts and therefore unsuitable for determining a river typology. Rare species were down-weighted to make the CCA more robust (Cao and Larsen, 2001; Marchant, 2002).

Forward selection was performed on the combined data set to determine the variables that explained the most additional variance, and thus are likely to be the best at structuring the typology. This was only done with the first four variables to ensure that the typology was kept simple. Environmental boundaries were to be determined by visually assessing clusters; however, peat and calcareous variables were the first to be selected, which are already coded as binary categories.

4.2.1 Results

Figure 4.1 shows the site-conditional CCA biplot created from the combined macrophyte, phytobenthos and

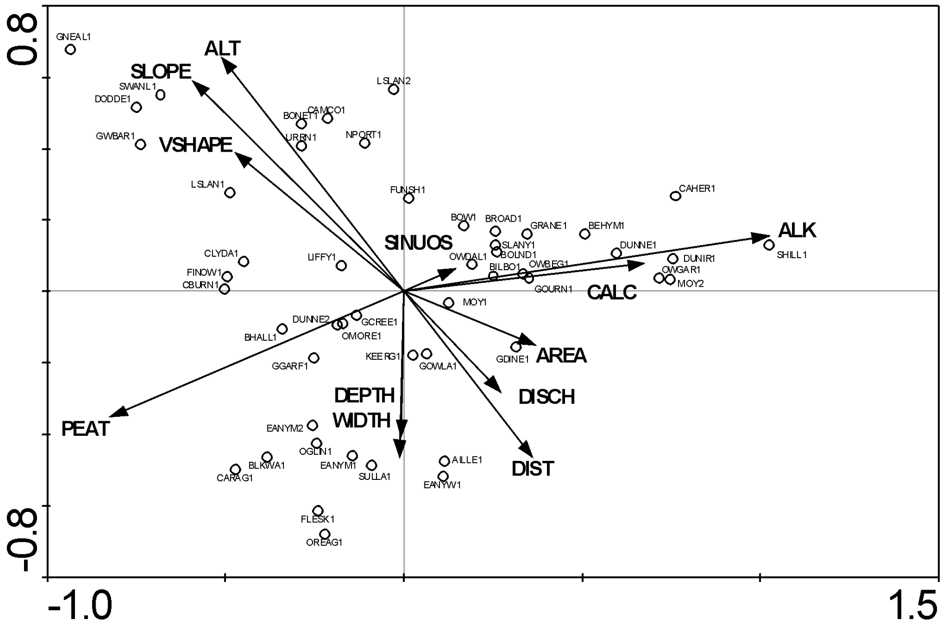

Figure 4.1. CCA site conditional bi-plot of combined biological data, using appropriate WFD variables. For the first two axes, the eigenvalues are 0.176 and 0.107, respectively, % variance explained out of total inertia is 7.1 and 4.3, respectively, and % variance explained out of canonical axes is 22.7 and 13.8, respectively. ALK, alkalinity; ALT, altitude of site; AREA, catchment area draining to site; CALC, binary calcareous category; DEPTH, channel depth; DISCH, discharge category; DIST, distance from source; PEAT, binary peat category; SINUOUS, sinuosity; VSHAPE, valley shape category; WIDTH, channel width.

invertebrate data and the appropriate WFD variables. Clearly defined clusters cannot be distinguished in the ordination, and therefore distinct river types are not evident.

Alkalinity was most correlated with the biological variance (eigenvalue = 0.136, explaining 5.5% of the variation). However, the combined (binary) categories of peat and calcareousness were selected instead (explaining together 7.5%) since it was difficult within the analysis to determine where appropriate boundaries may lie along an alkalinity gradient. Table 4.1 shows the results of the manual forward selection, following the removal of alkalinity in preference for calcareousness.

Categorical divisions were kept the same as those used in the Expert-64 Typology (Table 4.2). Catchment area boundaries were determined such that they produced a better segregation of the sites than the System A catchment area boundaries. Figure 4.2 shows the allocation of sites to the CCA Typology.

In total, 14.2% variance (out of total species variance) was explained using the variables selected from the CCA Typology.

4.3 Typologies Derived from Permutation Tests

Choosing the best category boundaries for a fixed typology is highly subjective. The choice of category boundaries for one variable may influence the best choice of category boundaries for another variable, or even the next choice of variable. The method applied here in developing the Permutation-48 Typology overcomes this by using a large number of permutation tests with different combinations of variables and category boundaries.

Table 4.1. Condition effects (additional variance explained) in manual forward selection of WFD environmental variables and combined biological data, without alkalinity.

	Eigenvalue (total variance = 2.484)	% of additional variance explained
Geology (peat and calcareousness)	0.187	7.5
Slope	0.096	3.9
Area	0.069	2.8

Table 4.2. The CCA Typology variables derived from forward selection of the combined taxonomic group data.

Peat	(1/0)
Calcareous	(1/0)
Slope (using the same categories as the NSTAG Typology)	<0.005 m/m
	0.05–0.02 m/m
	0.02–0.04 m/m
	0.04 m/m
Catchment area (using a spread of categories more appropriate to the 50 sites)	<20 km^2
	21–100 km^2
	101–1000 km^2
	>1000 km^2 (none present in data)

Olden and Jackson (2000) found that permutation tests are more likely to select inappropriate variables than forward selection within gradient analysis. However, permutation tests enable different combinations of category boundaries to be assessed simultaneously, which cannot be achieved within gradient analysis.

The BIOENV routine within PRIMER (Clarke and Gorley, 2001) was used to carry out the permutation tests in this method. A similarity matrix for the biological data is first prepared. This is calculated as the similarity between different sites based on the species found at the sites. Data for all the environmental variables that could be associated with the biology are also provided, with corresponding site names. The BIOENV routine produces a similarity matrix based on all the different combinations of the environmental variables, i.e. the similarity between sites based on the environmental variables at the site. Rank correlation coefficients between each environmental similarity matrix and the similarity matrix based on species are calculated. Rank coefficients are appropriate since the environmental and species similarities that are being compared are based on entirely different similarity coefficients (in our case, Bray–Curtis and Euclidean, respectively). The correlation coefficient is reported as a rho (ρ) value. Once the ρ values for all the possible combinations of environmental variables have been calculated, the results are ordered and displayed with the highest correlation at the top. The combination of environmental variables with the highest ρ value is that which best explains the similarities in species between sites. Therefore, it is likely that these variables are the most strongly associated with the species distributions.

4.3.1 Method

The number of potential variables for producing the typology had to be reduced since the computing power increases exponentially with the number of variables within permutation tests. Therefore, continuous data for the variables listed in Table 4.3 were selected as the environmental data, and the combined biological data were selected as biological data. The BIOENV routine was used to find the combination of variables that best explained the Bray–Curtis similarities between sites. Variables that were repeatedly important in explaining the species similarities between sites were selected for subsequent analysis.

Once the important environmental variables had been determined, each of these variables could be divided into a range of different category types. The category boundaries were selected by considering where ecological changes would occur or enabling an even number of sites in categories. Based on the CCA analysis, it was considered that specific ecological boundary conditions did not exist, except perhaps for alkalinity and hardness. The alkalinity classes were <25 mg $CaCO_3$/l and >100 mg $CaCO_3$/l boundaries. A scatter plot of alkalinity against hardness for the site data suggested that the equivalent boundaries for hardness are <35 mg $CaCO_3$/l and >100 mg $CaCO_3$/l. Table 4.4 shows the environmental variables with their category boundaries.

A single BIOENV analysis was applied to the combined biological data (with Bray–Curtis similarity) and the complete set of categorised environmental data (with Euclidean distance similarity). Different categorical classifications of a single variable were not analysed separately; they were all included in this single permutation test. A maximum of four variable combinations was selected for the routine, although two and three variable combinations occurred within the top ten correlations.

System A TYPOLOGY

		Catchment Area		
		<10 km^2	10-100 km^2	100-1000 km^2
Non-peaty	Siliceous	BROAD1 CAMCO1 URRN1	BILBO1 BOLND1 BOW1 DUNNE1 FUNSH1 GOURN1 GRANE1 LSLAN2 NPORT1 OWBEG1 OWDAL1 SLANY1	SULLA1
	Calcareous	SHILL1	CAHRE1 GDINE1 OWGAR1	DUNIR1 MOY2
Peaty	Siliceous	BEHYM1 BHALL1 CBURN1 CLYDA1 GWBAR1 DODDE1 LSLAN1	AILLE1 BLKWA1 DUNNE2 EANYM1 EANYM2 EANYW1 FINOW1 GCREE1 GGARF1 GNEAL1 LIFFY1 MOY1 OGLIN1 OMORE1 OREAG1 SWANL1	CARAG1 FLESK1
	Calcareous	BONET1	GOWLA1 KEERG1	

Altitude (m)
<200
>200

13 groups

expert-64 TYPOLOGY

		Discharge			
		<0.25 m^3/s	0.25-2.5 m^3/s	2.5-25 m^3/s	25-250 m^3/s
Non-peaty	Siliceous	BROAD1 GRANE1 CAMCO1 BOW1 URRN1	GOURN1 SLANY1 BILBO1 BOLND1 FUNSH1 OWBEG1 OWDAL1 DUNNE1 LSLAN1 NPORT1	SULLA1	(none)
	Calcareous	SHILL1	DUNIR1 GDINE1 OWGAR1 CAHER1	MOY2	
Peaty	Siliceous	BEHYM1 BHALL1 CBURN1 CLYDA1 DODDE1 GWBAR1 LSLAN2	EANYM1 LIFFY1 MOY1 DUNNE2 EANYM2 FINOW1 GCREE1 GGARF1 OGLIN1 OMORE1 SWANL1 GNEAL1	AILLE1 BLKWA1 CARAG1 OREAG1 EANYW1 FLESK1	
	Calcareous	BONET1	GOWLA1 KEERG1		

slope category (m/m)
< 0.005
0.005 - 0.02
0.02 - 0.04
>0.04

25 groups

permutation-48 TYPOLOGY

Hardness mg CaCO3/l	Discharge m^3/s	Slope (m/m) <0.005	0.005-0.02	0.02-0.04	>0.04
<35	<0.25		CBURN1 LSLAN1		URRN1 DODDE1 GWBAR1
	0.25+	BLKWA1 FLESK1 LIFFY1 OREAG1	CARAG1 EANYM1 GCREE1 GGARF1 OGLIN1 OMORE1	LSLAN2 FINOW1 SWANL1	GNEAL1
35-100	<0.25		BOW1 BROAD1 GRANE1	CAMCO1 BHALL1 CLYDA1	BONET1
	<0.25	DUNIR1 OWGAR1 SLANY1 SULLA1 AILLE1 MOY1	BILBO1 BOLND1 DUNNE1 FUNSH1 GDINE1 GOURN1 NPORT1 OWBEG1 OWDAL1 DUNNE2 EANYM2 EANYW1 GOWLA1 KEERG1		
>100	<0.25		SHILL1 BEHYM1		
	0.25+	MOY2		CAHER1	

non-peaty
peaty

20 groups

CCA TYPOLOGY

		Slope (m/m)			
		<0.005	0.005-0.02	0.02-0.04	>0.04
Non-peaty	Siliceous	BROAD1 GOURN1 GRANE1 SLANY1 SULLA1	CAMCO1 FUNSH1 BILBO1 BOLND1 OWBEG1 OWDAL1	BOW1 URRN1 DUNNE1	LSLAN2 NPORT1
	Calcareous	GDINE1 SHILL1 OWGAR1 DUNIR1 MOY2	CAHER1		
Peaty	Siliceous	AILLE1 BLKWA1 EANYM1 LIFFY1 MOY1 OREAG1 CARAG1	BEHYM1 BHALL1 CBURN1 DUNNE2 FINOW1 GGARF1 EANYM2 EANYW1 GCREE1 OGLIN1	CLYDA1 SWANL1 OMORE1	DODDE1 GNEAL1 GWBAR1 LSLAN1 FLESK1
	Calcareous		GOWLA1	KEERG1	BONET1

area (km^2)
<20
20-100
>100

(none >1000)

24 groups

Figure 4.2. The 50 sites classified by the System A, expert-64, CCA and permutation-48 typologies.

Table 4.3. Full variable set used in the initial BIOENV analysis.

Alkalinity	Catchment slope	Peaty
Altitude	Depth	Relief ratio
Bank slope	Discharge	Sinuosity
Calcareous	Distance from source	Slope
Catchment altitude	Drainage density	Stream order
Catchment area	Elongation ratio	Temperature
Catchment shape	Hardness	Width

Table 4.4. Reduced variable set used in the BIOENV analysis with category boundaries.

Variable code	Variable	Categories	Units
1	3 Alkalinity	<25, 25–100, >100	mg $CaCO_3$/l
2	2 Alkalinity	<25, 25+	mg $CaCO_3$/l
3	4 Hardness	<20, 20–50, 50–100, >100	mg $CaCO_3$/l
4	3 Hardness	<35, 35–100, >100	mg $CaCO_3$/l
5	2 Hardness	<35, 35+	mg $CaCO_3$/l
6	2 Geology (calcareous)	Calcareous/non-calcareous	–
7	2 Peat	Peaty/non-peaty	–
8	4 Discharge	<0.25, 0.25–2.5, 2.5–25, >25*	m^3/s
9	2 Discharge	<0.25, 0.25 +	m^3/s
10	3 Catchment area	<10, 10–100, >100	km^2
11	3 Altitude	<50, 50–150, 150+	m
12	2 Altitude	<50, 50+	m
13	3 Catchment slope	<10, 10–25, >25	m/km
14	2 Catchment slope	<10, 10+	m/km
15	4 Drainage density	0, 1, 2, 3	
16	3 Distance from source	< 10, 10–30, >30	km
17	2 Distance from source	<10, 10+	km
18	4 Slope	<0.005, 0.005–0.02, 0.02–0.04, >0.04	m/m
19	3 Slope	<0.005, 0.005–0.02, >0.02	m/m
20	2 Slope	<0.02, 0.02+	m/m

*Only three discharge categories are actually represented by the site data.

It is possible that the same variable is selected twice for a single typology if the boundaries between the categories do not coincide. This suggests that both sets of boundaries are important and a different set of boundary conditions or an increased categorisation of that variable should be used. This occurred with two hardness variables (Nos 3 and 5), but could not occur with any other variables since, even though there were different numbers of categories, they had coincident boundaries. BIOENV analyses using only one of the categorical hardness variables in turn showed the three category hardness variable to repeatedly explain the most variance, so this was retained. Table 4.5 shows the results of the BIOENV analysis.

4.3.2 Results

Hardness (var. 4), was the most important variable occurring in every suggested combination. Four-category slope (var. 18), also occurred in all of the top six results, suggesting that this is the next most important variable.

The highest correlation between the species and environment data was found to be with hardness (var. 4), slope (var. 18), peat (var. 7) and discharge (var. 9), producing a 48-category Typology. Coincidentally, the best three-variable combination was the same excluding peat, and the best two-variable combination was the same excluding both peat and discharge. Therefore, in order of importance the typology structure (Permutation-48) is:

3 hardness categories: <35, 35–100, >100

4 slope categories: <0.005, 0.005–0.02, 0.02–0.04, >0.04

2 discharge categories:<0.25, 0.25+

2 peat categories: 1/0.

Based on the BIOENV results in Table 4.5, a typology with fewer river types is produced by removing the variables consecutively from the bottom of the 48-Typology hierarchy, i.e. a 24-category Typology is formed by removing peat, and a 12-category Typology is formed by removing peat and discharge.

The allocation of sites to the Permutation-48 Typology is shown in Fig. 4.2. The allocation of sites for the 24- and 12-category typologies can also be derived from this figure.

4.3.3 Conclusions

Hardness was found to be more important in forming a typology than either alkalinity or geology (calcareousness). Slope was the next most important variable, and requires all four categories to optimise the typology. Discharge, which is estimated from catchment area and rainfall, only required two categories. Possibly this allows differentiation between the small lowland, low-slope streams and the large lowland, low-slope rivers. Peat amount has some use in the typology, but could be ignored if a smaller typology is required.

Table 4.5. BIOENV results showing correlations of variable combinations with species similarities between sites, using the combined species data set. The variable set was restricted to a maximum of four variables. Variable codes are listed in Table 4.4.

Number of variables	Correlation	Selections
4	0.477	4, 7, 9, 18
4	0.473	2, 4, 9, 18
3	0.470	4, 9, 18
3	0.463	4, 8, 18
4	0.460	4, 7, 8, 18
4	0.460	1, 4, 8, 18
3	0.459	4, 8, 20
4	0.458	4, 7, 9, 20
2	0.458	4, 18
4	0.458	4, 7, 8, 20

5 Assessing Typology Performance

5.1 Introduction

The performance of the typologies was determined by assessing how well they predict type-specific reference conditions. It is important to remember that classifications are subjective since a decision always has to be made on the elements of a community which have to be classified, e.g. changes in ecological integrity could be represented by changes at the family level, changes in ratios of one functional group of species to another or other assessments of the ecological functioning (Angermeier and Karr, 1994) rather than species change. However, species are usually the most sensitive indicators of impact (Angermeier and Karr, 1994) and, within the WFD, measurement of composition and abundance within the taxonomic group is specified. Classifications also depend on a similarity measure for comparing sites or groups of sites. Within TWINSPAN (and ordination methods) this is the chi-squared value, whereas within other traditional classifications the more biologically applicable Bray–Curtis similarity measure is usually used. The MIR-max artificial intelligence classification utilises Mutual Information as a similarity measure. Classifications assessed using the similarity index that was used to create them are inevitably going to appear to perform better and so care must be taken in interpretation.

5.2 Methods

Concordance between the typologies and the biological data can be assessed using the method of Paavola *et al.* (2003) with ANOSIM (Clarke and Warwick, 1994; Clarke and Gorley, 2001). The hypothesis is that if a classification is imposed on species data the within-group variability should be less than the between-group variability if there is any concordance between the classification and the biological community.

Each typology under test was used to classify the sites and ANOSIM (using Bray–Curtis similarity) was used to determine whether the within-group variability was greater than the between-group variability for each of these typologies. The typologies being tested were the Permutation-48 Typology and the 23 and 12 river type derivatives of this, the Expert-64 Typology, determined by the NSTAG, and the 32 and 16 river type derivatives, the CCA-based Typology (48 potential river types) and the System A Typology from the WFD (24 potential river types in Ecoregion 17) (Fig. 4.2).

5.3 Results

The CCA, expert-32 and expert-16 typologies did not produce a significant classification of the invertebrate biology (Table 5.1). Although the Expert-64 Typology produced good results for combined and individual taxonomic group data, the Permutation-48 Typology and its derivatives out-performed all other typologies. There was not a large decrease in effectiveness between the Permutation-48 and Permutation-12 typologies, except for phytobenthos. The Expert-64 Typology and the Permutation-48, -24 and -12 typologies all performed better than the System A Typology.

Table 5.1. Effectiveness of the typologies in segregating the biological data. Values are Global-R values from ANOSIM. Significance (Sig.) is calculated from 999 permutations. Only spring data were used for the macroinvertebrates. Results are ordered by effectiveness with the combined data.

Typology	Biological data							
	Combined		Macrophyte		Phytobenthos		Macroinvertebrates	
		Sig.		Sig.		Sig.		Sig.
Permutation-48	0.489	0.001	0.333	0.001	0.464	0.001	0.365	0.001
Permutation-24	0.467	0.001	0.333	0.001	0.384	0.001	0.383	0.001
Permutation-12	0.402	0.001	0.276	0.001	0.333	0.001	0.382	0.001
Expert-64	0.333	0.001	0.224	0.012	0.299	0.002	0.195	0.015
System A	0.330	0.001	0.173	0.015	0.349	0.001	0.145	0.042
Expert-32	0.308	0.001	0.185	0.010	0.346	0.001	0.049	0.265
CCA	0.304	0.001	0.193	0.023	0.308	0.002	0.111	0.103
Expert-16	0.251	0.002	0.152	0.032	0.291	0.001	0.059	0.229

5.4 Discussion

Although the Expert-64 Typology performed better than the System A Typology, by far the best were the Permutation-48, -24 and -12 typologies(in that order). The Permutation-24 Typology only had a minor drop in Global-R values compared to the Permutation-48 Typology. The CCA, Expert-32 and Expert-16 typologies performed very poorly in the concordance test with the combined and individual taxonomic data and none of these significantly segregated macroinvertebrate data.

There was only a single site in a large proportion of the river types within the typologies examined. Therefore, the biological range within this river type may not be represented. Also, since there was only one site, statistical analyses will suggest that there is no biological variation within these river types and therefore may over-estimate the ability to classify or predict the biology.

The 50 sites may be too few or too unevenly distributed throughout the biological response gradients to represent all the different river types. RIVPACS in Northern Ireland uses 110 reference sites to characterise a much smaller and less diverse area. The typologies have been optimised for the 50 sites, and the reliability of the analyses when extrapolated to the whole of Ireland is highly dependent on the representativeness of this sub-sample.

5.5 Additional Comments

It is not likely that a typology will lead directly to the derivation of species lists for each river type, but measures of biological condition could be derived. Any single typology is likely to be sub-optimal for species prediction for one or more of the taxonomic groups. Although species are often good early indicators of impacts, more robust predictions could be made by using simpler biological elements such as functional groups of species (Willby *et al.*, 2000), family-level predictions, or the prediction of metrics (Dodkins *et al.*, 2005). If metrics are used, characterisation of the river types by metric values would require far fewer river types. However, in this case the typology would be best optimised by reducing the variance in metric scores for a river type, rather than the variance in species.

The Trophic Diatom Index (Kelly, 1998), Mean Trophic Ranking (Holmes *et al.*, 1999), BMWP scores (Armitage *et al.*, 1983) or other metrics (Dodkins *et al.*, 2005) could be used to produce characteristic scores for each river type within a typology. It is unlikely that a simple typology will be useful in a RIVPACS (Wright *et al.*, 1984) modelling approach, since WFD-required typologies use only a small number of variables, and are fixed rather than probabilistic. Characterisation of metric values for even quite a large number of river types into five ecological status classes seems feasible. Interpolation of reference conditions using the same variables as the accepted (fixed-boundary) typology could improve metric predictions whilst still enabling the submission of ecological status values to the EU within the structure of the (fixed-boundary) typology.

5.6 Conclusions and Recommendations

There is little difference in performance between the best three typologies, which are the permutation-48, 24 and 12 Typologies. These typologies were substantially better than any other environmental typologies in segregating the biological data and they performed equally well with each of the taxonomic groups. The only other typology to perform better than the System A Typology was the Expert-64 Typology.

Typology optimisation was only carried out using 50 sites. Validation with biological data for all the taxonomic groups from additional sites may be required to ensure that the best typologies work well on a larger scale. Some sites, particularly MOY2, GDINE1 and OGLIN1, have questionable status as reference sites. Potentially the typology may have to be expanded for river types that are dissimilar to the 50 reference sites used in this study and additional high status sites should be examined within Ecoregion 17.

Out of the top three performing typologies it is suggested that the Permutation-12 Typology is adopted since (i) there is little difference in performance compared to the Permutation-48 and -24 typologies and (ii) there are far fewer river types than the other typologies. Adopting a low number of river types within a typology also suggests that some form of metric scores will need to be used to assess impact, rather than species predictions.

5.7 Recent Developments

The Permutation-12 Typology was adopted by the EPA for the purposes of the WFD Article 5 Characterisation Report. Table 5.2 presents the assignment of sites in the Permutation-12 Typology based on GIS-derived slope values.

Table 5.2. Assignment of sites in the Permutation-12 Typology based on GIS-derived slope values. Code refers to the two-digit code used to define the river type, the first digit indicating geology and the second digit the river slope (e.g. River Type 23 has a hardness value in the range 35–100 mg/l $CaCO_3$ and a slope of 0.02–0.04 m/m).

Hardness code	Code values	Slope			
		1	**2**	**3**	**4**
		≤0.005 m/m	**0.005–0.02 m/m**	**0.02–0.04 m/m**	**>0.04 m/m**
1	<35 mg/l	BLKWA1	CARAG1	CBURN1	DODDE1
		EANYM1	GGARF1	GWBAR1	LSLAN1
		FINOW1	LSLAN2	OMORE1	
		FLESK1	OGLIN1	SWANL1	
		GCREE1		URRN1	
		GNEAL1			
		LIFFY1			
		OREAG1			
2	35–100 mg/l	AILLE1	BHALL1	BOW1	BONET1
		BROAD1	BILBO1	CLYDA1	
		DUNIR1	BOLND1	DUNNE1	
		EANYW1	CAMCO1	KEERG1	
		GOURN1	DUNNE2		
		GRANE1	EANYM2		
		MOY1	FUNSH1		
		OWGAR1	GDINE1		
		SLANY1	GOWLA1		
		SULLA1	NPORT1		
			OWBEG1		
			OWDAL1		
3	>100 mg/l	MOY2	BEHYM1		
			CAHER1		
			SHILL1		

6 Composition of Biological Elements within River Types

Species occurring at the 50 sites that characterise river types within the Permutation-12 Typology are summarised in Table 6.1.

INDVAL within PC-ORD (McCune and Mefford, 1999) was used to determine the indicator species associated with the different river types for each biological element (Table 6.1) (based on the new allocation of sites). For each river type, these are ordered as macroinvertebrates, phytobenthos, then macrophytes. Indicator species cannot be derived for river types with zero or one site. Indicator values range from 0 to 100, indicating the strength of the association with the river type (100 being a perfect indicator of that river type). All the species listed are significant indicators at P = 0.05.

Table 6.2 shows the range of chemistry associated with these river types. Ranges are likely to vary less with river types that have fewer sites, and therefore may not reflect the true range of high status sites within the whole of Ireland. Where the sample was below the limit of detection (LoD), a value equal to half the LoD value was used to enable mean values to be generated.

An expected species list is difficult to construct for river types since natural variation (e.g. due to natural disturbance) is likely to result in some species not occurring. Also, perfect indicator species are unlikely to exist since biological communities are not discrete, but more likely to be a patchy continuum (Poole, 2002), and thus an environmental typology with discrete boundaries can never precisely define the communities. Therefore, lists were constructed which show frequency of occurrence of species within each different river type (Appendix).

Table 6.1. Indicator species (from INDVAL) for each river type. Macrophyte species in bold are confined to banks, and are likely to be more indicative of neighbouring landscape and land-use than type-specific river chemistry or hydromorphology.

12-Typology group	Indicator species	Indicator value	P-value
11	*Phormidium fragile*	27	0.032
	Tabellaria flocculosa	32	0.042
12	*Rhyacophila munda*	40	0.041
	Gomphonema clavatum	35	0.050
13	*Lyngbya aestuarii*	49	0.018
14	*Plectrocnemia* spp.	39	0.015
	Diura bicaudata	92	0.000
	Ameletus inopinatus	100	0.000
	Achnanthes peterserii	41	0.046
	Eunotia bidentula	50	0.015
	Racometrium	35	0.048
	Lemanea	50	0.040
	Scapania undulata	57	0.003
21	*Limnius volckmari*	18	0.039
	Nitzschia dissipata	23	0.013
	Navicula gregaria	28	0.032
	Cladophora glomerata	37	0.034
22	*Cocconeis placentula*	23	0.006
23	*Lasiocephala basalis*	36	0.034
	Rhynchostegium riparioides	26	0.035
	Plagiomnium rostratum	44	0.031
24	INSUFFICIENT SITES	–	–
31	INSUFFICIENT SITES	–	–
32	*Chironominae*	25	0.025
	Sericostoma personatum	26	0.033
	Tanypodinae	26	0.041
	Baetis muticus	32	0.002
	Chelifera spp.	36	0.033
	Gongrosira sp.	34	0.017
	Heribaudiella fluviatilis	41	0.049
	Amphora pediculus	42	0.017
	Rhoicosphenia abbreviata	45	0.010
	Phormidium ambiquum	50	0.042
	Navicula sp. 7	50	0.043
	Stephanodiscus hantzschii	50	0.043
	Hildenbrandia rivularis	78	0.004
	Filipendula ulmaria	24	0.044
	Angelica sylvestris	33	0.037
	Hypericum tetrapterum	42	0.029
	Amblystegium riparium	56	0.012
	Veronica beccabunga	60	0.001
	Apium nodiflorum	64	0.002
	Rorippa nasturtium-aquaticum	80	0.001
33	INSUFFICIENT SITES	–	–
34	INSUFFICIENT SITES	–	–
		= macroinvertebrates	
		= phytobenthos	
		= macrophytes	

Table 6.2. Chemistry at each of the river types from the Permutation-12 Typology. Mean values are presented, with ranges (minimum to maximum) in parentheses.

River type	pH		Ammonia (mg/l N)		Phosphate (mg/l P)		Nitrite (mg/l N)		Nitrate (mg/l N)	
11	6.81	(5.11–8.08)	0.006	(<0.01– 0.021)	0.005	(<0.01– 0.012)	0.001	(<0.001– 0.004)	2.216	(<5)
12	7.06	(6.45–8.47)	0.005	(0.001–0.005)	0.006	(0.002–0.017)	0.001	(<0.001– 0.004)	2.139	(<5)
13	6.90	(4.8–7.91)	0.005	(0.001–0.005)	0.006	(0.004–0.014)	0.002	(0.001–0.007)	2.698	(<5)
14	6.08	(4.97–6.64)	0.005	(0.005–0.005)	0.014	(0.003–0.026)	0.002	(0.001–0.003)	2.096	(<5)
21	7.58	(6.31–8.43)	0.007	(<0.01– 0.028)	0.012	(0.004–0.052)	0.004	(0.001–0.026)	2.647	(<5–5.017)
22	7.55	(6.51–8.51)	0.009	(<0.01– 0.126)	0.011	(0.003–0.046)	0.003	(0.001–0.010)	2.050	(<5)
23	7.92	(7.15–8.69)	0.004	(<0.01– 0.005)	0.012	(0.005–0.029)	0.004	(0.001–0.010)	2.500	(<5)
24	8.27	(8.17–8.43)	0.004	(0.002–0.005)	0.006	(0.005–0.006)	0.001	(0.001–0.002)	1.919	(<5)
31	8.23	(8.06–8.46)	0.019	(0.007–0.033)	0.011	(0.005–0.016)	0.004	(0.001–0.008)	5.078	(<5–9.081)
32	8.00	(7.46–8.78)	0.014	(0.005–0.026)	0.005	(0.005–0.005)	0.001	(0.001–0.002)	4.454	(<5–7.847)

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Appendix Species Frequencies for Each River Type

River Type 11 (8 sites).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq
Ancylus fluviatilis	100	*Chloroperla tripunctata*	75	*Mystacides azurea*	38	*Diura bicaudata*	13
Lumbriculus variegatus	100	*Plectrocnemia conspersa*	75	*Oecetis testacea*	38	*Calopteryx splendens*	13
Tubificidae indet.	100	*Agapetus* spp.	75	*Ecclisopteryx guttulata*	38	*Velia caprai*	13
Enchytraeidae indet.	100	*Athripsodes* spp.	75	*Halesus digitatus*	38	*Gerris najas*	13
Lumbricidae indet.	100	*Eloeophila* spp.	75	*Atherix marginata*	38	*Micronecta poweri*	13
Serratella ignita	100	*Hemerodromia* spp.	75	*Chelifera* spp.	38	*Hydraena testacea*	13
Baetis rhodani	100	*Lymnaea peregra*	63	*Simulium variegatum*	38	*Gyrinus caspius*	13
Centroptilum luteolum	100	*Glossiphonia complanata*	63	Tricladidia indet.	25	*Dryops* spp.	13
Ecdyonurus venosus	100	*Heptagenia sulphurea*	63	*Bathyomphalus contortus*	25	*Haliplus lineatocollis*	13
Protonemura meyeri	100	*Ecdyonurus insignis*	63	*Lymnaea truncatula*	25	*Hydroporus pubescens*	13
Leuctra hippopus	100	*Brachyptera risi*	63	*Pisidium nitidum*	25	*Hydroporus discretus*	13
Elmis aenea	100	*Nemoura* spp.	63	*Pisidium personatum*	25	*Stictonectes lepidus*	13
Oulimnius tuberculatus	100	*Oreodytes septentrionalis*	63	*Margaritifera margaritifera*	25	*Agabus paludosus*	13
Limnius volckmari	100	*Hydrocyphon* spp.	63	*Aulodrilus pluriseta*	25	*Nebrioporus depressus elegans*	13
Hydraena gracilis	100	*Polycentropus kingi*	63	*Tubifex ignotus*	25	*Nebrioporus depressus elegans* complex	13
Orectochilus villosus	100	*Antocha* spp.	63	*Glossiphonia hereroclita*	25	*Helophorus* spp.	13
Hydropsyche siltalai	100	*Simulium argyreatum/ variegatum* group	63	*Procloeon bifidum*	25	*Osmylus fulvicephalus*	13
Lepidostoma hirtum	100	Prodiamesinae indet.	63	*Ecdyonurus dispar*	25	*Wormaldia occipitalis*	13
Halesus radiatus	100	Chironominae indet.	63	*Paraleptophlebia cincta*	25	*Wormaldia subnigra*	13
Sericostoma personatum	100	*Pisidium casertanum*	50	*Caenis luctuosa*	25	*Chimarra marginata*	13
Tipula spp.	100	Nematoda indet.	50	*Calopteryx virgo*	25	*Neureclipsis bimaculata*	13
Ceratopogonidae indet.	100	*Erpobdella octoculata*	50	*Hydraena riparia*	25	*Plectrocnemia geniculata*	13
Simuliidae indet.	100	*Nemoura avicularis*	50	*Limnebius truncatellus*	25	*Polycentropus irrorata*	13
Tanypodinae indet.	100	*Perla bipunctata*	50	*Gyrinus urinator*	25	*Holocentropus dubius*	13
Orthocladiinae indet.	100	*Oreodytes davisii*	50	*Hydroporus tessellatus*	25	*Cheumatopsyche lepida*	13
Potamopyrgus antipodarum	88	*Psychomyia pusilla*	50	Curculionidae indet.	25	*Hydropsyche instabilis/ pellucidula*	13
Baetis muticus	88	*Lype phaeopa*	50	*Agapetus ochripes*	25	*Glossosoma boltoni*	13
Rhithrogena semicolorata	88	*Glossosoma* spp.	50	*Lasiocephala basalis*	25	*Agapetus fuscipes*	13
Amphinemura sulcicollis	88	*Goera pilosa*	50	*Athripsodes cinereus*	25	*Silo nigricornis*	13
Isoperla grammatica	88	*Ithytrichia* spp.	50	*Chaetopteryx villosa*	25	*Agraylea* spp.	13
Siphonoperla torrentium	88	*Odontocerum albicorne*	50	*Limnephilus* spp.	25	*Crunoecia irrorata*	13
Esolus parallelepipedus	88	*Pisidium subtruncatum*	38	*Potamophylax latipennis*	25	*Anabolia nervosa*	13
Oreodytes sanmarkii	88	*Rhyacodrilus coccineus*	38	*Pedicia* spp.	25	*Drusus annulatus*	13
Rhyacophila dorsalis	88	*Spirosperma ferox*	38	*Limnophora* spp.	25	*Limnephilus lunatus*	13
Polycentropus flavomaculatus	88	*Helobdella stagnalis*	38	*Simulium dunfellense/ urbanum* group	25	*Limnephilus marmoratus*	13
Hydropsyche pellucidula	88	*Asellus aquaticus*	38	*Simulium reptans*	25	*Beraea maurus*	13
Silo pallipes	88	*Siphlonurus lacustris*	38	*Lymnaea palustris*	13	*Limonia* spp.	13
Oxyethira spp.	88	*Baetis vernus*	38	*Pisidium hibernicum*	13	*Dixa puberula*	13
Hydroptila spp.	88	*Ecdyonurus torrentis*	38	*Pisidium milium*	13	*Ptychoptera* spp.	13
Potamophylax cingulatus	88	*Nemoura cinerea*	38	*Sphaerium corneum*	13	Stratiomyidae indet.	13
Dicranota spp.	88	*Haliplus* spp.	38	*Limnodrilus hoffmeisteri*	13	Athericidae indet.	13
Psychodidae indet.	88	*Stictotarsus duodecimpustulatus*	38	*Theromyzon tessulatum*	13	Empididae indet.	13
Stylodrilus heringianus	75	*Elodes* spp.	38	*Piscicola geometra*	13	*Simulium vernum*	13
Gammarus duebeni	75	*Rhyacophila munda*	38	*Haemopis sanguisuga*	13	*Simulium argyreatum*	13
Hydracarina indet.	75	*Philopotamus monatus*	38	*Gammarus pulex*	13	*Simulium noelleri*	13
Baetis scambus	75	*Cyrnus trimaculatus*	38	*Austropotamobius pallipes*	13	*Simulium rostratum*	13
Electrogena lateralis	75	*Lype reducta*	38	*Ameletus inopinatus*	13	*Eukiefferiella coerulescens*	13
Caenis rivulorum	75	*Tinodes waeneri*	38	*Leptophlebia vespertina*	13	*Microtendipes pedellus*	13
Leuctra inermis	75	*Agapetus delicatulus*	38	*Nemurella picteti*	13	*Stictochironomous* spp.	13

River Type 11 *contd.*

Phytobenthos	% freq	Phytobenthos *contd.*	% freq	Macrophytes	% freq	Macrophytes *contd.*	% freq
Achnanthes oblongella	100	*Achnanthes lanceolata*	25	*Juncus articulatus*	75	*Montia fontana*	13
Achnanthidium minutissimum	100	*Cladophora glomerata*	25	*Juncus effusus*	75	*Myriophyllum alternifolium*	13
Fragilaria capucina	100	*Cyclotella meneghiniana*	25	*Racometrium*	75	*Persicaria hydropiper*	13
Fragilaria capucina var. *vaucheriae*	100	*Cymbella microcephala*	25	*Ranunculus flammula*	75	*Petasites hybridus*	13
Gomphonema parvulum	100	*Diatoma mesodon*	25	*Chiloscyphus polyanthos*	63	*Phalaris arundinacea*	13
Tabellaria flocculosa	100	*Diatoma tenuis*	25	*Oenanthe crocata*	63	*Plagiomnium undulatum*	13
Cymbella silesiaca	88	*Eunotia minor*	25	*Pellia epiphylla*	63	*Polytrichum commune*	13
Nitzschia palea	88	*Gomphonema acuminatum*	25	*Callitriche hamulata*	50	*Potamogeton filiformis*	13
Cymbella minuta	75	*Gomphonema angustum*	25	*Cladophora* spp.	50	*Ranunculus peltatus*	13
Navicula cryptotenella	75	*Gomphonema gracile*	25	*Filipendula ulmaria*	50	*Rorippa amphibia*	13
Nitzschia dissipata	75	*Meridion circulare*	25	*Fontinalis antipyretica*	50	*Sphagnum*	13
Phormidium fragile	75	*Navicula halophila*	25	*Lythrum salicaria*	50	*Spirogyra*	13
Synedra ulna	75	*Navicula rhynchocephala*	25	*Angelica sylvestris*	38	*Stachys palustris*	13
Brachysira vitrea	63	*Oedogonium* W2	25	*Callitriche stagnalis*	38	*Valeriana*	13
Chamaesiphon incrustans	63	*Oedogonium* W4	25	*Conocephalum conicum*	38		
Cymbella gracilis	63	*Oedogonium* W5	25	*Glyceria fluitans*	38		
Eunotia implicata	63	*Oscillatoria agardhii*	25	*Mnium hornum*	38		
Gomphonema minutum	63	*Oscillatoria brevis*	25	*Rhizomnium punctatum*	38		
Gomphonema olivaceum	63	*Oscillatoria sancta*	25	*Scapania undulata*	38		
Hannea arcus	63	*Spirogyra* W2	25	*Butomus umbellatus*	25		
Lemanea fluviatilis	63	*Stigeoclonium* sp.	25	*Calliergon cuspidatum*	25		
Monostroma sp.	63	*Tabellaria fenestrata*	25	Filamentous green algae	25		
Navicula gregaria	63	*Ulothrix tenerrima*	25	*Fortinalis squamosa*	25		
Audouinella hermannii	50	*Zygnema* W1	25	*Hyocomium armoricum*	25		
Bulbochaete sp.	50	*Zygnema* W3	25	*Jungermannia*	25		
Diatoma moniliformis	50	*Caloneis bacillum*	13	*Lychnis*	25		
Fragilaria capucina var. *perminuta*	50	*Chamaesiphon confervicolus*	13	*Mentha aquatica*	25		
Gomphonema truncatum	50	*Cocconeis pediculus*	13	*Potamogeton natans*	25		
Mougeotia W4	50	*Cyclotella radiosa*	13	*Rhynchostegium ripariodes*	25		
Phormidium favosum	50	*Cymbella affinis*	13	*Riccardia*	25		
Phormidium retzii	50	*Diatoma vulgaris*	13	*Riccia*	25		
Reimeria sinuata	50	*Didymosphenia geminata*	13	*Senecio aquaticus*	25		
Spirogyra W1	50	*Eunotia arcus*	13	*Alisma plantago-aquatica*	13		
Achnanthes flexella	38	*Eunotia bilunaris*	13	*Berula erecta*	13		
Achnanthidium biasolettiana	38	*Eunotia pectinalis*	13	*Blindia acuta*	13		
Ankistrodesmus falcatus	38	*Fragilaria pulchella*	13	*Brachythecium rivulare*	13		
Cocconeis placentula	38	*Gomphonema micropus*	13	*Bryum pseudotriquetrum*	13		
Frustulia rhomboides	38	*Lyngbya martensiana*	13	*Callitriche platycarpa*	13		
Frustulia rhomboides var. *viridula*	38	*Microspora irregularis*	13	*Caltha palustris*	13		
Gomphonema clavatum	38	*Microspora tumidula*	13	*Carex rostrata*	13		
Gongrosira sp.	38	*Mougeotia* W1	13	*Dichodontium*	13		
Meridion circulare var. *constrictum*	38	*Mougeotia* W5	13	*Dicranella palustris*	13		
Mougeotia W3	38	*Navicula tripunctata*	13	*Eleocharis*	13		
Navicula cryptocephala	38	*Nitzschia fonticola*	13	*Equisetum fluviatile*	13		
Navicula lanceolata	38	*Nitzschia linearis*	13	*Geum rivulare*	13		
Oedogonium W3	38	*Oedogonium* W7	13	*Hydrocotyle vulgaris*	13		
Rhoicosphenia abbreviata	38	*Phormidium autumnale*	13	*Juncus bulbosus*	13		
Spirogyra W3	38	*Pinnularia subcapitata*	13	*Littorella uniflora*	13		
Surirella brebissonii	38	*Surirella angusta*	13	*Lunularia*	13		
Ulothrix zonata	38	*Zygnema* W5	13	*Marsupella emarginata*	13		

River Type 12 (4 sites).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq
Lumbriculus variegatus	100	*Simulium argyreatum*	75	*Piscicola geometra*	25
Stylodrilus heringianus	100	Tricladidia indet.	50	*Siphlonurus lacustris*	25
Tubificidae indet.	100	*Pisidium subtruncatum*	50	*Baetis vernus*	25
Enchytraeidae indet.	100	Nematoda indet.	50	*Centroptilum luteolum*	25
Lumbricidae indet.	100	*Glossiphonia complanata*	50	*Heptagenia sulphurea*	25
Serratella ignita	100	*Erpobdella octoculata*	50	*Ecdyonurus torrentis*	25
Baetis rhodani	100	*Asellus aquaticus*	50	*Nemurella picteti*	25
Rhithrogena semicolorata	100	*Baetis scambus*	50	*Nemoura* spp.	25
Ecdyonurus venosus	100	*Baetis muticus*	50	*Perla bipunctata*	25
Protonemura meyeri	100	*Electrogena lateralis*	50	*Dinocras cephalotes*	25
Esolus parallelepipedus	100	*Ecdyonurus dispar*	50	*Ischnura elegans*	25
Elmis aenea	100	*Ecdyonurus insignis*	50	*Pyrrhosoma nymphula*	25
Oulimnius tuberculatus	100	*Paraleptophlebia cincta*	50	*Velia* spp.	25
Limnius volckmari	100	*Caenis luctuosa*	50	*Dryops* spp.	25
Elodes spp.	100	*Caenis rivulorum*	50	*Haliplus* spp.	25
Rhyacophila dorsalis	100	*Leuctra inermis*	50	*Brychius* sp.	25
Polycentropus flavomaculatus	100	*Chloroperla tripunctata*	50	*Hydroporus* sp.	25
Hydropsyche siltalai	100	*Calopteryx virgo*	50	*Stictonectes lepidus*	25
Lepidostoma hirtum	100	*Oreodytes sanmarkii*	50	*Helophorus* spp.	25
Halesus radiatus	100	*Oreodytes septentrionalis*	50	*Chimarra marginata*	25
Sericostoma personatum	100	*Stictotarsus duodecimpustulatus*	50	*Plectrocnemia geniculata*	25
Tipula spp.	100	*Hydrocyphon* sp.	50	*Polycentropus irrorata*	25
Dicranota spp.	100	*Wormaldia occipitalis*	50	*Tinodes waeneri*	25
Ceratopogonidae indet.	100	*Philopotamus monatus*	50	*Hydropsyche instabilis*	25
Hemerodromia spp.	100	*Plectrocnemia conspersa*	50	*Glossosoma* spp.	25
Simulium argyreatum/variegatum group	100	*Polycentropus kingi*	50	*Goera pilosa (Fbr)*	25
Tanypodinae indet.	100	*Lype reducta*	50	*Ithytrichia* spp.	25
Orthocladiinae indet.	100	*Hydroptila* spp.	50	*Oxyethira* spp.	25
Chironominae indet.	100	*Mystacides* spp.	50	*Crunoecia irrorata*	25
Potamopyrgus antipodarum	75	*Chaetopteryx villosa*	50	*Lasiocephala basalis*	25
Ancylus fluviatilis	75	*Limnephilus rhombicus*	50	*Athripsodes* spp.	25
Lymnaea peregra	75	*Odontocerum albicorne*	50	*Oecetis testacea*	25
Pisidium casertanum	75	*Eloeophila* spp.	50	*Ceraclea* spp.	25
Gammarus duebeni	75	*Antocha* spp.	50	*Anabolia nervosa*	25
Hydracarina indet.	75	*Atherix marginata*	50	*Drusus annulatus*	25
Brachyptera risi	75	*Limnophora* spp.	50	*Halesus digitatus*	25
Amphinemura sulcicollis	75	*Simulium cryophilum*	50	*Limnephilus flavicornis*	25
Leuctra hippopus	75	*Simulium vernum*	50	*Limnephilus lunatus*	25
Isoperla grammatica	75	*Simulium armoricanum*	50	*Potamophylax latipennis*	25
Siphonoperla torrentium	75	*Simulium reptans*	50	*Pedicia* spp.	25
Hydraena gracilis	75	Prodiamesinae indet.	50	*Tricyphona* spp.	25
Orectochilus villosus	75	*Valvata piscinalis*	25	*Helius* spp.	25
Rhyacophila munda	75	*Pisidium milium*	25	*Euphylidorea/Phylidorea* spp.	25
Hydropsyche pellucidula	75	*Pisidium nitidum*	25	Dolichopodidae indet.	25
Agapetus spp.	75	*Margaritifera margaritifera*	25	Syrphidae indet.	25
Silo pallipes (Fabricius)	75	*Spirosperma ferox*	25	*Simulium ornatum/intermedium/ trifasciatum*	25
Potamophylax cingulatus	75	*Stylaria lacustris*	25	*Eukiefferiella* spp.	25
Psychodidae indet.	75	Naididae indet.	25	*Microtendipes pedellus*	25
Chelifera spp.	75	*Glossiphonia hereroclita*	25		

River Type 12 *contd.*

Phytobenthos	% freq	Phytobenthos *contd.*	% freq	Macrophytes	% freq
Achnanthes oblongella	100	*Oedogonium* W2	25	*Conocephalum conicum*	75
Achnanthidium minutissimum	100	*Oedogonium* W7	25	*Filipendula ulmaria*	75
Cymbella minuta	100	*Oscillatoria sancta*	25	*Fortinalis squamosa*	75
Cymbella silesiaca	100	*Phormidium autumnale*	25	*Oenanthe crocata*	75
Fragilaria capucina	100	*Phormidium favosum*	25	*Rhynchostegium ripariodes*	75
Fragilaria capucina var. *vaucheriae*	100	*Stigeoclonium* sp.	25	*Angelica sylvestris*	50
Gomphonema parvulum	100	*Surirella angusta*	25	*Brachythecium plumosum*	50
Tabellaria flocculosa	100	*Surirella brebissonii*	25	*Bryum pseudotriquetrum*	50
Gomphonema angustum	75	*Tabellaria fenestrata*	25	*Dichodontium*	50
Hannea arcus	75	*Ulothrix tenerrima*	25	*Fontinalis antipyretica*	50
Nitzschia dissipata	75			*Hyocomium armoricum*	50
Nitzschia palea	75			*Iris pseudacorus*	50
Reimeria sinuata	75			*Juncus articulatus*	50
Achnanthes lanceolata	50			*Juncus effusus*	50
Achnanthidium biasolettiana	50			*Lythrum salicaria*	50
Audouinella hermannii	50			*Mnium hornum*	50
Chamaesiphon incrustans	50			*Myriophyllum alternifolium*	50
Cocconeis placentula	50			*Pellia epiphylla*	50
Eunotia implicata	50			*Racometrium*	50
Gomphonema acuminatum	50			*Ranunculus flammula*	50
Gomphonema clavatum	50			*Rhizomnium punctatum*	50
Gomphonema minutum	50			*Scapania undulata*	50
Gongrosira sp.	50			*Senecio aquaticus*	50
Lemanea fluviatilis	50			*Thamnobryum*	50
Oedogonium W5	50			*Valeriana*	50
Phormidium fragile	50			*Alisma plantago-aquatica*	25
Spirogyra W1	50			*Apium nodiflorum*	25
Spirogyra W3	50			*Brachythecium rivulare*	25
Spirogyra W4	50			*Brachythecium rutabulum*	25
Synedra ulna	50			*Callitriche hamulata*	25
Ulothrix zonata	50			*Callitriche stagnalis*	25
Achnanthes flexella	25			*Chiloscyphus polyanthos*	25
Brachysira vitrea	25			*Cladophora* spp.	25
Bulbochaete sp.	25			*Equisetum arvense*	25
Cladophora glomerata	25			Filamentous green algae	25
Cymbella affinis	25			*Glyceria fluitans*	25
Cymbella gracilis	25			*Hygrohypnum*	25
Diatoma moniliformis	25			*Littorella uniflora*	25
Frustulia rhomboides var. *viridula*	25			*Mentha aquatica*	25
Gomphonema gracile	25			*Montia fontana*	25
Gomphonema micropus	25			*Myosotis scorpioides*	25
Gomphonema olivaceum	25			*Myriophyllum spicatum*	25
Gomphonema truncatum	25			*Nuphar lutea*	25
Hildenbrandia rivularis	25			*Persicaria hydropiper*	25
Meridion circulare	25			*Phalaris arundinacea*	25
Meridion circulare var. *constrictum*	25			*Plagiomnium rostratum*	25
Microspora crassior	25			*Potamogeton alpinus*	25
Monostroma sp.	25			*Potamogeton natans*	25
Mougeotia W4	25			*Ranunculus peltatus*	25
Navicula gregaria	25			*Ranunculus penicillatus*	25
Navicula lanceolata	25			*Riccardia*	25
Navicula rhynchocephala	25			*Veronica beccabunga*	25

River Type 13 (5 sites).

Macroinvertebrates	**% freq**	**Macroinvertebrates *contd.***	**% freq**	**Macroinvertebrates *contd.***	**% freq**
Lumbriculus variegatus	100	*Electrogena lateralis*	60	*Paraleptophlebia cincta*	20
Stylodrilus heringianus	100	*Velia caprai*	60	*Nemoura cinerea*	20
Tubificidae indet.	100	*Oreodytes sanmarkii*	60	*Nemurella picteti*	20
Enchytraeidae indet.	100	*Philopotamus monatus*	60	*Chloroperla tripunctata*	20
Lumbricidae indet.	100	*Glossosoma boltoni*	60	*Hesperocorixa sahlbergi*	20
Serratella ignita	100	*Agapetus* spp.	60	*Haliplus lineatocollis*	20
Baetis rhodani	100	*Sericostoma personatum*	60	*Hydroporus nigrita*	20
Rhithrogena semicolorata	100	*Odontocerum albicorne*	60	*Hydroporus planus*	20
Ecdyonurus venosus	100	*Tipula* spp.	60	*Hydroporus tessellatus*	20
Protonemura meyeri	100	*Pedicia* spp.	60	*Oreodytes septentrionalis*	20
Leuctra hippopus	100	*Eloeophila* spp.	60	*Anacaena limbata*	20
Leuctra inermis	100	*Chelifera* spp.	60	Galerucinae indet.	20
Isoperla grammatica	100	*Simulium argyreatum*	60	*Wormaldia occipitalis*	20
Siphonoperla torrentium	100	Chironominae indet.	60	*Plectrocnemia geniculata*	20
Esolus parallelepipedus	100	*Potamopyrgus antipodarum*	40	*Lype reducta*	20
Elmis aenea	100	*Aulodrilus pluriseta*	40	*Tinodes waeneri*	20
Oulimnius tuberculatus	100	Collembola indet.	40	*Diplectrona felix*	20
Limnius volckmari	100	*Heptagenia sulphurea*	40	*Glossosoma conformis*	20
Hydraena gracilis	100	*Ecdyonurus torrentis*	40	*Ithytrichia* spp.	20
Elodes spp.	100	*Caenis rivulorum*	40	*Oxyethira* spp.	20
Rhyacophila dorsalis	100	*Nemoura avicularis*	40	*Drusus annulatus*	20
Plectrocnemia conspersa	100	*Perla bipunctata*	40	*Ecclisopteryx guttulata*	20
Polycentropus flavomaculatus	100	*Limnebius truncatellus*	40	*Halesus digitatus*	20
Hydropsyche siltalai	100	*Orectochilus villosus*	40	*Micropterna/Stenophylax* group	20
Hydropsyche pellucidula	100	*Agabus* spp.	40	*Dicronomyia/Neolimonia* spp.	20
Chaetopteryx villosa	100	*Helophorus* spp.	40	*Dixa puberula*	20
Halesus radiatus	100	*Anacaena globulus*	40	Ceratopogonidae indet.	20
Dicranota spp.	100	*Hydrocyphon* spp.	40	*Dasyhelea* spp.	20
Wiedemannia/Clinocera spp.	100	*Wormaldia subnigra*	40	Culicidae indet.	20
Simuliidae indet.	100	*Psychomyia pusilla*	40	Rhagionidae indet.	20
Tanypodinae indet.	100	*Hydropsyche instabilis*	40	*Limnophora* spp.	20
Orthocladiinae indet.	100	*Potamophylax cingulatus*	40	*Simulium cryophilum*	20
Tricladidia indet.	80	*Antocha* spp.	40	*Simulium vernum*	20
Ancylus fluviatilis	80	Dolichopodidae indet.	40	*Simulium armoricanum*	20
Pisidium casertanum	80	*Hemerodromia* spp.	40	*Simulium angustipes/velutinum* group	20
Brachyptera risi	80	*Simulium dunfellense/urbanum* group	40		
Amphinemura sulcicollis	80	*Simulium ornatum/intermedium* group	40		
Rhyacophila munda	80	*Simulium tuberosum*	40		
Polycentropus kingi	80	Prodiamesinae indet.	40		
Silo pallipes	80	*Lymnaea peregra*	20		
Hydroptila spp.	80	*Pisidium personatum*	20		
Lepidostoma hirtum	80	*Pisidium subtruncatum*	20		
Psychodidae indet.	80	*Margaritifera margaritifera*	20		
Simulium argyreatum/variegatum group	80	*Spirosperma ferox*	20		
Simulium variegatum	80	*Glossiphonia complanata*	20		
Gammarus duebeni	60	*Siphlonurus lacustris*	20		
Hydracarina indet.	60	*Centroptilum luteolum*	20		
Baetis scambus	60	*Ecdyonurus insignis*	20		
Baetis muticus	60	*Leptophlebia vespertina*	20		

River Type 13 *contd.*

Phytobenthos	% freq	Phytobenthos *contd.*	% freq	Macrophytes	% freq
Achnanthes oblongella	100	*Cosmarium* sp.17	20	*Juncus articulatus*	100
Achnanthidium minutissimum	100	*Cymbella helvetica*	20	*Fortinalis squamosa*	80
Fragilaria capucina	100	*Cymbella microcephala*	20	*Racometrium*	80
Fragilaria capucina var. *vaucheriae*	100	*Diatoma mesodon*	20	*Rhynchostegium ripariodes*	80
Gomphonema parvulum	100	*Eunotia minor*	20	*Brachythecium plumosum*	60
Cymbella gracilis	80	*Fragilaria pulchella*	20	*Brachythecium rivulare*	60
Eunotia bilunaris	80	*Gomphonema clavatum*	20	*Chiloscyphus polyanthos*	60
Hannea arcus	80	*Gongrosira* sp.	20	*Conocephalum conicum*	60
Nitzschia dissipata	80	*Lemanea fluviatilis*	20	*Hygrohypnum*	60
Tabellaria flocculosa	80	*Meridion circulare* var. *constrictum*	20	*Polytrichum commune*	60
Brachysira vitrea	60	*Microspora* sp.8	20	*Ranunculus flammula*	60
Bulbochaete sp.	60	*Navicula gregaria*	20	*Rhizomnium punctatum*	60
Cocconeis placentula	60	*Navicula rhynchocephala*	20	*Blindia acuta*	40
Cymbella silesiaca	60	*Oedogonium* W3	20	*Callitriche stagnalis*	40
Frustulia rhomboides	60	*Oedogonium* W4	20	*Dicranella palustris*	40
Gomphonema olivaceum	60	*Oedogonium* W5	20	*Fissidens*	40
Lyngbya martensiana	60	*Oscillatoria brevis*	20	*Hyocomium armoricum*	40
Mougeotia W4	60	*Phormidium autumnale*	20	*Juncus effusus*	40
Navicula lanceolata	60	*Phormidium favosum*	20	*Oenanthe crocata*	40
Audouinella hermannii	40	*Phormidium retzii*	20	*Pellia epiphylla*	40
Chamaesiphon incrustans	40	*Pinnularia subcapitata*	20	*Scapania undulata*	40
Cymbella minuta	40	*Staurastrum* sp.6	20	*Alisma plantago-aquatica*	20
Diatoma moniliformis	40	*Surirella angusta*	20	*Angelica sylvestris*	20
Diatoma tenuis	40	*Ulothrix tenerrima*	20	*Bryum pseudotriquetrum*	20
Eunotia implicata	40	*Ulothrix zonata*	20	*Butomus umbellatus*	20
Frustulia rhomboides var. *viridula*	40	*Zygnema* W1	20	*Callitriche platycarpa*	20
Gomphonema angustum	40	*Zygnema* W4	20	*Carex rostrata*	20
Gomphonema minutum	40			*Carex versicaria*	20
Gomphonema truncatum	40			*Cladophora* spp.	20
Meridion circulare	40			*Dichodontium*	20
Microspora tumidula	40			*Equisetum arvense*	20
Monostroma sp.	40			Filamentous green algae	20
Mougeotia W3	40			*Filipendula ulmaria*	20
Mougeotia W5	40			*Fontinalis antipyretica*	20
Navicula cryptotenella	40			Globular algae	20
Nitzschia palea	40			*Jungermannia*	20
Oscillatoria agardhii	40			*Lunularia*	20
Oscillatoria limosa	40			*Lythrum salicaria*	20
Reimeria sinuata	40			*Marsupella emarginata*	20
Spirogyra W2	40			*Mentha aquatica*	20
Synedra ulna	40			*Mnium hornum*	20
Tabellaria fenestrata	40			*Montia fontana*	20
Achnanthes flexella	20			*Pellia endiviifolia*	20
Achnanthes petersenii	20			*Persicaria hydropiper*	20
Achnanthidium biasolettiana	20			*Senecio aquaticus*	20
Ankistrodesmus falcatus	20			*Sphagnum*	20
Calothrix sp.3	20			*Valeriana*	20
Closterium parvulum	20				
Cocconeis pediculus	20				

River Type 14 (2 sites).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Phytobenthos	% freq	Macrophytes	% freq
Ancylus fluviatilis	100	*Stylodrilus heringianus*	50	*Achnanthes oblongella*	100	*Fortinalis squamosa*	100
Lumbriculus variegatus	100	Nematoda indet.	50	*Achnanthidium minutissimum*	100	*Hyocomium armoricum*	100
Enchytraeidae indet.	100	*Asellus aquaticus*	50	*Audouinella hermannii*	100	*Racometrium*	100
Lumbricidae indet.	100	Hydracarina indet.	50	*Chamaesiphon incrustans*	100	*Scapania undulata*	100
Ameletus inopinatus	100	*Siphlonurus lacustris*	50	*Diatoma mesodon*	100	*Brachythecium plumosum*	50
Serratella ignita	100	*Baetis scambus*	50	*Fragilaria capucina*	100	*Brachythecium rivulare*	50
Baetis vernus	100	*Baetis muticus*	50	*Fragilaria capucina* var. *vaucheriae*	100	Globular algae	50
Baetis rhodani	100	*Ecdyonurus dispar*	50	*Gomphonema parvulum*	100	*Hygrohypnum*	50
Rhithrogena semicolorata	100	*Velia caprai*	50	*Gongrosira* sp.	100	*Juncus effusus*	50
Electrogena lateralis	100	*Helophorus* spp.	50	*Meridion circulare*	100	*Lemanea*	50
Ecdyonurus venosus	100	*Wormaldia occipitalis*	50	*Microspora tumidula*	100	*Marsupella emarginata*	50
Brachyptera risi	100	*Plectrocnemia conspersa*	50	*Mougeotia* W3	100	*Mnium hornum*	50
Amphinemura sulcicollis	100	*Hydropsyche pellucidula*	50	*Mougeotia* W4	100	*Pellia epiphylla*	50
Protonemura meyeri	100	*Agapetus* spp.	50	*Synedra ulna*	100	*Polytrichum commune*	50
Leuctra hippopus	100	*Oxyethira* spp.	50	*Tabellaria flocculosa*	100	*Rhizomnium punctatum*	50
Leuctra inermis	100	*Hydroptila* spp.	50	*Zygnema* W3	100	*Thamnobryum*	50
Isoperla grammatica	100	*Lepidostoma hirtum*	50	*Achnanthes petersenii*	50		
Diura bicaudata	100	*Drusus annulatus*	50	*Brachysira vitrea*	50		
Chloroperla tripunctata	100	*Halesus digitatus*	50	*Bulbochaete* sp.	50		
Siphonoperla torrentium	100	*Beraea maurus*	50	*Chamaesiphon confervicolus*	50		
Esolus parallelepipedus	100	*Tipula* spp.	50	*Cladophora glomerata*	50		
Elmis aenea	100	*Pedicia* spp.	50	*Cymbella gracilis*	50		
Oulimnius tuberculatus	100	*Cheilotrichia* spp.	50	*Cymbella minuta*	50		
Limnius volckmari	100	Dolichopodidae indet.	50	*Cymbella silesiaca*	50		
Hydraena gracilis	100	*Hemerodromia* spp.	50	*Eunotia bilunaris*	50		
Dryops spp.	100	*Simulium cryophilum*	50	*Eunotia implicata*	50		
Oreodytes sanmarkii	100	*Simulium armoricanum*	50	*Eunotia minor*	50		
Curculionidae indet.	100	Chironominae indet.	50	*Eunotia* sp.1	50		
Elodes spp.	100			*Frustulia rhomboides*	50		
Rhyacophila dorsalis	100			*Frustulia rhomboides* var. *viridula*	50		
Rhyacophila munda	100			*Gomphonema clavatum*	50		
Philopotamus monatus	100			*Gomphonema gracile*	50		
Plectrocnemia geniculata	100			*Gomphonema olivaceum*	50		
Polycentropus flavomaculatus	100			*Gomphonema truncatum*	50		
Tinodes waeneri	100			*Microspora* sp.5	50		
Hydropsyche siltalai	100			*Monostroma* sp.	50		
Silo pallipes	100			*Mougeotia* W5	50		
Chaetopteryx villosa	100			*Nitzschia dissipata*	50		
Halesus radiatus	100			*Nitzschia palea*	50		
Potamophylax cingulatus	100			*Oedogonium* W3	50		
Sericostoma personatum	100			*Oedogonium* W4	50		
Odontocerum albicorne	100			*Oscillatoria agardhii*	50		
Dicranota spp.	100			*Oscillatoria brevis*	50		
Eloeophila spp.	100			*Oscillatoria limosa*	50		
Psychodidae indet.	100			*Phormidium fragile*	50		
Wiedemannia/Clinocera spp.	100			*Pinnularia subcapitata*	50		
Chelifera spp.	100			*Spirogyra* W1	50		
Simulium argyreatum/ variegatum group	100			*Surirella angusta*	50		
Tanypodinae indet.	100			*Ulothrix tenerrima*	50		
Orthocladiinae indet.	100			*Zygnema* W1	50		

River Type 21 (10 sites).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq
Potamopyrgus antipodarum	100	*Ecdyonurus insignis*	70	*Ecdyonurus dispar*	30	*Gyraulus albus*	10
Ancylus fluviatilis	100	*Amphinemura sulcicollis*	70	*Paraleptophlebia cincta*	30	*Arminger crista*	10
Tubificidae indet.	100	*Oreodytes septentrionalis*	70	*Caenis luctuosa*	30	*Pisidium hibernicum*	10
Enchytraeidae indet.	100	Curculionidae indet.	70	*Brychius elevatus*	30	*Pisidium milium*	10
Lumbricidae indet.	100	*Agapetus* spp.	70	*Cyrnus trimaculatus*	30	Lumbriculidae indet.	10
Gammarus duebeni	100	*Potamophylax latipennis*	70	*Plectrocnemia geniculata*	30	*Aulodrilus pluriseta*	10
Serratella ignita	100	*Odontocerum albicorne*	70	*Lype reducta*	30	*Tubifex ignotus*	10
Baetis rhodani	100	Psychodidae indet.	70	*Lasiocephala basalis*	30	*Stylaria lacustris*	10
Baetis muticus	100	*Wiedemannia/Clinocera* spp.	70	*Anabolia nervosa*	30	Gordioidae indet.	10
Rhithrogena semicolorata	100	Prodiamesinae indet.	70	*Drusus annulatus*	30	*Asellus meridianus*	10
Ecdyonurus venosus	100	*Bathyomphalus contortus*	60	*Limnephilus lunatus*	30	Collembola indet.	10
Protonemura meyeri	100	*Lymnaea peregra*	60	*Beraeodes minutus*	30	*Nemurella picteti*	10
Leuctra hippopus	100	*Asellus aquaticus*	60	*Antocha* spp.	30	*Leuctra nigra*	10
Esolus parallelepipedus	100	*Centroptilum luteolum*	60	*Simulium cryophilum*	30	*Dinocras cephalotes*	10
Elmis aenea	100	*Heptagenia sulphurea*	60	*Simulium variegatum*	30	*Gerris lacustris*	10
Limnius volckmari	100	*Nemoura avicularis*	60	*Ansius leucostoma*	20	*Gerris najas*	10
Hydraena gracilis	100	*Orectochilus villosus*	60	*Lymnaea truncatula*	20	*Notonecta glauca*	10
Rhyacophila dorsalis	100	*Stictotarsus duodecimpustulatus*	60	*Pisidium nitidum*	20	*Callicorixa praeusta*	10
Hydropsyche pellucidula	100	*Elodes* spp.	60	*Pisidium personatum*	20	*Hydraena puchella*	10
Silo pallipes	100	*Rhyacophila munda*	60	*Spirosperma ferox*	20	*Gyrinus caspius*	10
Halesus radiatus	100	*Polycentropus flavomaculatus*	60	*Gordius* sp.	20	*Hydroporus pubescens*	10
Potamophylax cingulatus	100	*Psychomyia pusilla*	60	*Siphlonurus lacustris*	20	*Hydroporus tessellatus*	10
Tipula spp.	100	*Glossosoma* spp.	60	*Ephemera danica*	20	*Hydroporus obsoletus*	10
Dicranota spp.	100	*Athripsodes* spp.	60	*Capnia bifrons*	20	*Stictonectes lepidus*	10
Simuliidae indet.	100	*Simulium ornatum/ intermedium/trifasciatum* group	60	*Calopteryx virgo*	20	*Nebrioporus depressus elegans* complex	10
Orthocladiinae indet.	100	*Simulium argyreatum/ variegatum* group	60	*Hesperocorixa sahlbergi*	20	*Megasternum obscurum*	10
Pisidium casertanum	90	Tricladidia indet.	50	*Micronecta poweri*	20	*Laccobius sinuatus*	10
Caenis rivulorum	90	*Pisidium subtruncatum*	50	*Gyrinus substriatus*	20	*Paracymus scutellaris*	10
Leuctra inermis	90	*Rhyacodrilus coccineus*	50	*Gyrinus urinator*	20	*Osmylus fulvicephalus*	10
Perla bipunctata	90	Nematoda indet.	50	*Dryops* spp.	20	*Wormaldia subnigra*	10
Siphonoperla torrentium	90	*Helobdella stagnalis*	50	*Dytiscus* spp.	20	*Polycentropus irrorata*	10
Oulimnius tuberculatus	90	*Velia* spp.	50	*Helophorus* spp.	20	*Tinodes waeneri*	10
Hydropsyche siltalai	90	*Haliplus lineatocollis*	50	*Anacaena globulus*	20	*Tinodes maculicornis*	10
Sericostoma personatum	90	*Plectrocnemia conspersa*	50	Chrysomelidae indet.	20	*Hydropsyche angustipennis*	10
Ceratopogonidae indet.	90	*Hydropsyche instabilis*	50	*Hydrocyphon* spp.	20	*Crunoecia irrorata*	10
Chelifera spp.	90	*Goera pilosa*	50	*Philopotamus monatus*	20	*Glyphotaelius pellicidus*	10
Tanypodinae indet.	90	*Chaetopteryx villosa*	50	*Polycentropus kingi*	20	*Beraea maurus*	10
Lumbriculus variegatus	80	*Limnophora* spp.	50	*Lype phaeopa*	20	*Pedicia* spp.	10
Stylodrilus heringianus	80	*Glossiphonia hereroclita*	40	*Diplectrona felix*	20	*Dixa* spp.	10
Hydracarina indet.	80	*Piscicola geometra*	40	*Silo nigricornis*	20	Syrphidae indet.	10
Brachyptera risi	80	*Electrogena lateralis*	40	*Mystacides* spp.	20	*Atherix marginata*	10
Isoperla grammatica	80	*Chloroperla tripunctata*	40	*Oecetis testacea*	20	*Simulium vernum*	10
Oreodytes sanmarkii	80	*Hydraena riparia*	40	*Ecclisopteryx guttulata*	20	*Simulium armoricanum*	10
Ithytrichia spp.	80	*Limnebius truncatellus*	40	*Limnephilus rhombicus*	20	*Simulium equinum/lineatum* group	10
Lepidostoma hirtum	80	*Nebrioporus depressus elegans*	40	*Micropterna/Stenophylax* group	20	*Simulium argyreatum*	10
Eloeophila spp.	80	*Hydroptila* spp.	40	*Orimarga* spp.	20	*Simulium tuberosum*	10
Hemerodromia spp.	80	*Halesus digitatus*	40	*Dixa nebulosa*	20	*Brilla* spp.	10
Chironominae indet.	80	*Simulium ornatum/intermedium* group	40	*Dixa maculata/nubilipennis*	20	*Eukiefferiella gracei*	10
Glossiphonia complanata	70	*Simulium reptans*	40	Stratiomyidae indet.	20	*Psectrocladius (Psectrocladius) sordidellus*	10
Erpobdella octoculata	70	*Limnodrilus hoffmeisteri*	30	*Simulium equinum*	20	*Microtendipes pedellus*	10
Baetis scambus	70	*Ecdyonurus torrentis*	30	*Eukiefferiella claripennis*	20		

River Type 21 *contd.*

Phytobenthos	% freq	Phytobenthos *contd.*	% freq	Macrophytes	% freq	Macrophytes *contd.*	% freq
Achnanthidium minutissimum	100	Didymosphenia geminata	20	Filipendula ulmaria	100	Sparganium emersum	20
Cocconeis placentula	100	Frustulia rhomboides	20	Valeriana	80	Thamnobryum	20
Cymbella minuta	100	Gomphonema micropus	20	Chiloscyphus polyanthos	70	Alisma lanceolatum	10
Gomphonema parvulum	100	Heribaudiella fluviatilis	20	Cinclidotus fontinaloides	70	Alisma plantago-aquatica	10
Navicula gregaria	100	Hildenbrandia rivularis	20	Conocephalum conicum	70	Brachythecium rivulare	10
Nitzschia palea	100	Lemanea fluviatilis	20	Juncus effusus	70	Callitriche hamulata	10
Fragilaria capucina var. vaucheriae	90	Microspora crassior	20	Angelica sylvestris	60	Cladophora spp.	10
Navicula lanceolata	90	Monostroma sp.	20	Equisetum arvense	60	Dichodontium	10
Nitzschia dissipata	90	Phormidium retzii	20	Fontinalis antipyretica	60	Eleocharis	10
Reimeria sinuata	90	Surirella angusta	20	Mentha aquatica	60	Equisetum palustre	10
Cymbella silesiaca	80	Tabellaria flocculosa	20	Oenanthe crocata	60	Glyceria plicata	10
Gomphonema olivaceum	80	Achnanthes petersenii	10	Rhynchostegium ripariodes	60	Hyocomium armoricum	10
Meridion circulare	80	Brachysira vitrea	10	Apium nodiflorum	50	Lemna minor	10
Achnanthes oblongella	70	Cymbella helvetica	10	Caltha palustris	50	Mnium hornum	10
Fragilaria capucina	70	Cymbella proxima	10	Juncus articulatus	50	Myosotis scorpioides	10
Gomphonema angustum	70	Diatoma ehrenbergii	10	Glyceria fluitans	40	Pellia epiphylla	10
Synedra ulna	70	Eunotia arcus	10	Butomus umbellatus	30	Potamogeton crispus	10
Ulothrix zonata	70	Eunotia bilunaris	10	Callitriche stagnalis	30	Scapania undulata	10
Achnanthes lanceolata	60	Fragilaria capucina var. capitellata	10	Filamentous green algae	30	Senecio palustre	10
Amphora pediculus	60	Fragilaria capucina var. perminuta	10	Geum rivulare	30	Sparganium erectum	10
Audouinella hermannii	60	Frustulia rhomboides var. viridula	10	Hypericum tetrapterum	30	Stachys palustris	10
Chamaesiphon incrustans	60	Gomphonema acuminatum	10	Lychnis	30		
Cladophora glomerata	60	Meridion circulare var. constrictum	10	Lythrum salicaria	30		
Navicula cryptotenella	60	Microspora irregularis	10	Marchantia polymorpha	30		
Navicula halophila	60	Mougeotia W3	10	Myriophyllum alternifolium	30		
Navicula tripunctata	60	Mougeotia W5	10	Phalaris arundinacea	30		
Surirella brebissonii	60	Navicula cryptocephala	10	Rhizomnium punctatum	30		
Cocconeis pediculus	50	Oedogonium W3	10	Scrophularia	30		
Gomphonema minutum	50	Oedogonium W4	10	Veronica beccabunga	30		
Phormidium fragile	50	Oedogonium W5	10	Amblystegium riparium	20		
Achnanthes flexella	40	Oscillatoria agardhii	10	Brachythecium plumosum	20		
Achnanthidium biasolettiana	40	Oscillatoria limosa	10	Calliergon cuspidatum	20		
Diatoma moniliformis	40	Oscillatoria sancta	10	Callitriche obtusangula	20		
Hannea arcus	40	Spirogyra W3	10	Callitriche platycarpa	20		
Phormidium favosum	40	Stigeoclonium sp.	10	Carex versicaria	20		
Cymbella affinis	30			Equisetum fluviatile	20		
Cymbella gracilis	30			Fissidens	20		
Diatoma vulgaris	30			Fortinalis squamosa	20		
Fragilaria pulchella	30			Hygrohypnum	20		
Gomphonema truncatum	30			Juncus inflexus	20		
Gongrosira sp.	30			Persicaria hydropiper	20		
Microspora tumidula	30			Plagiomnium undulatum	20		
Navicula rhynchocephala	30			Potamogeton natans	20		
Nitzschia linearis	30			Racometrium	20		
Oscillatoria brevis	30			Ranunculus flammula	20		
Phormidium autumnale	30			Ranunculus peltatus	20		
Rhoicosphenia abbreviata	30			Riccia	20		
Caloneis bacillum	20			Rorippa amphibia	20		
Cyclotella meneghiniana	20			Rorippa nasturtium-aquaticum	20		
Diatoma tenuis	20			Senecio aquaticus	20		

River Type 22 (12 sites).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq
Ancylus fluviatilis	100	*Glossosoma* spp.	75	*Gyrinus urinator*	25	*Lype phaeopa*	8
Lumbricidae indet.	100	*Lepidostoma hirtum*	75	*Stictotarsus duodecimpustulatus*	25	*Tinodes waeneri*	8
Gammarus duebeni	100	*Drusus annulatus*	75	*Helophorus* spp.	25	*Diplectrona felix*	8
Ephemerella ignita	100	*Hemerodromia* spp.	75	*Wormaldia occipitalis*	25	*Hydropsyche contubernalis*	8
Baetis rhodani	100	*Pisidium casertanum*	67	*Cyrnus trimaculatus*	25	*Goera pilosa*	8
Baetis muticus	100	*Perla bipunctata*	67	*Pedicia* spp.	25	*Oxyethira* spp.	8
Rhithrogena semicolorata	100	*Orectochilus villosus*	67	*Simulium cryophilum*	25	*Lasiocephala basalis*	8
Ecdyonurus venosus	100	*Oreodytes septentrionalis*	67	*Simulium reptans*	25	*Limnephilus lunatus*	8
Protonemura meyeri	100	*Rhyacophila munda*	67	*Lymnaea peregra*	17	*Stenophylax permistus*	8
Leuctra hippopus	100	*Ithytrichia* spp.	67	*Pisidium personatum*	17	*Beraea pullata*	8
Leuctra inermis	100	*Athripsodes* spp.	67	*Limnodrilus hoffmeisteri*	17	*Pilaria* spp.	8
Isoperla grammatica	100	*Odontocerum albicorne*	67	*Glossiphonia hereroclita*	17	*Orimarga* spp.	8
Siphonoperla torrentium	100	Psychodidae indet.	67	*Ecdyonurus dispar*	17	*Lipsothrix* spp.	8
Esolus parallelepipedus	100	Tricladidia indet.	58	*Ephemera danica*	17	*Rhypholophus varius*	8
Elmis aenea	100	*Rhyacodrilus coccineus*	58	*Leuctra nigra*	17	*Dixa puberula*	8
Limnius volckmari	100	*Electrogena lateralis*	58	*Gerris najas*	17	Rhagionidae indet.	8
Hydraena gracilis	100	*Psychomyia pusilla*	58	*Gyrinus substriatus*	17	Muscidae indet.	8
Rhyacophila dorsalis	100	*Simulium argyreatum*	58	*Haliplus lineatocollis*	17	Empididae indet.	8
Hydropsyche pellucidula	100	*Heptagenia sulphurea*	50	*Brychius elevatus*	17	Sciomyzidae indet.	8
Agapetus spp.	100	*Ecdyonurus torrentis*	50	*Agabus* spp.	17	*Simulium armoricanum*	8
Silo pallipes	100	*Paraleptophlebia cincta*	50	Curculionidae indet.	17	*Simulium ornatum/ intermedium* group	8
Halesus radiatus	100	*Limnebius truncatellus*	50	*Plectrocnemia geniculata*	17	*Simulium tuberosum*	8
Sericostoma personatum	100	*Hydroptila* spp.	50	*Lype reducta*	17		
Simuliidae indet.	100	*Chaetopteryx villosa*	50	*Halesus digitatus*	17		
Tanypodinae indet.	100	Ceratopogonidae indet.	50	*Micropterna/Stenophylax* group	17		
Orthocladiinae indet.	100	*Pisidium subtruncatum*	42	*Beraea maurus*	17		
Tubificidae indet.	92	Nematoda indet.	42	*Simulium vernum*	17		
Ecdyonurus insignis	92	*Glossiphonia complanata*	42	*Lymnaea palustris*	8		
Oreodytes sanmarkii	92	*Erpobdella octoculata*	42	*Pisidium nitidum*	8		
Elodes spp.	92	*Centroptilum luteolum*	42	*Aulodrilus pluriseta*	8		
Hydropsyche siltalai	92	*Chloroperla tripunctata*	42	*Stylaria lacustris*	8		
Potamophylax cingulatus	92	*Philopotamus monatus*	42	*Gordius* spp.	8		
Dicranota spp.	92	*Ecclisopteryx guttulata*	42	*Erpobdella testacea*	8		
Eloeophila spp.	92	*Limnophora* spp.	42	*Asellus aquaticus*	8		
Chironominae indet.	92	*Simulium ornatum/ intermedium/trifasciatum* group	42	*Siphlonurus* spp.	8		
Lumbriculus variegatus	83	*Baetis scambus*	33	*Caenis luctuosa*	8		
Enchytraeidae indet.	83	*Nemoura avicularis*	33	*Nemoura cinerea*	8		
Hydracarina indet.	83	*Hydraena riparia*	33	*Nemurella picteti*	8		
Caenis rivulorum	83	*Dryops* spp.	33	*Capnia bifrons*	8		
Brachyptera risi	83	*Hydrocyphon* spp.	33	*Hesperocorixa sahlbergi*	8		
Amphinemura sulcicollis	83	*Polycentropus kingi*	33	*Micronecta poweri*	8		
Tipula spp.	83	*Hydropsyche instabilis*	33	*Hydraena minutissima*	8		
Wiedemannia/Clinocera spp.	83	*Potamophylax latipennis*	33	*Hydraena testacea*	8		
Chelifera spp.	83	*Antocha* spp.	33	*Ochthebius exsculptus*	8		
Simulium argyreatum/ variegatum group	83	*Simulium variegatum*	33	*Gyrinus caspius*	8		
Potamopyrgus antipodarum	75	Prodiamesinae indet.	33	*Haliplus confinis*	8		
Stylodrilus heringianus	75	*Lymnaea truncatula*	25	*Hydroporus erythrocephalus*	8		
Oulimnius tuberculatus	75	*Spirosperma ferox*	25	*Anacaena globulus*	8		
Plectrocnemia conspersa	75	*Dinocras cephalotes*	25	*Laccobius* spp.	8		
Polycentropus flavomaculatus	75	*Velia* spp.	25	*Wormaldia subnigra*	8		

River Type 22 *contd.*

Phytobenthos	% freq	Phytobenthos *contd.*	% freq	Macrophytes	% freq	Macrophytes *contd.*	% freq
Achnanthidium minutissimum	100	*Oscillatoria sancta*	25	*Rhynchostegium ripariodes*	100	*Riccia*	17
Cocconeis placentula	100	*Stigeoclonium* sp.	25	*Conocephalum conicum*	83	*Rorippa amphibia*	17
Cymbella minuta	100	*Achnanthidium biasolettiana*	17	*Filipendula ulmaria*	75	*Scapania undulata*	17
Fragilaria capucina	100	*Chamaesiphon confervicolus*	17	*Fontinalis antipyretica*	67	*Sparganium erectum*	17
Cymbella silesiaca	92	*Cymbella helvetica*	17	*Angelica sylvestris*	58	*Amblystegium fluviatile*	8
Fragilaria capucina var. *vaucheriae*	92	*Cymbella microcephala*	17	*Chiloscyphus polyanthos*	58	*Carex riparia*	8
Gomphonema parvulum	92	*Diatoma mesodon*	17	*Juncus effusus*	58	*Carex versicaria*	8
Navicula gregaria	83	*Eunotia minor*	17	*Mentha aquatica*	58	*Eleocharis*	8
Nitzschia dissipata	83	*Frustulia rhomboides* var. *viridula*	17	*Cladophora* spp.	50	*Fissidens*	8
Nitzschia palea	83	*Gomphonema acuminatum*	17	*Equisetum arvense*	50	*Hydrocotyle vulgaris*	8
Reimeria sinuata	83	*Hildenbrandia rivularis*	17	*Juncus articulatus*	50	*Hyocomium armoricum*	8
Achnanthes oblongella	75	*Lemanea fluviatilis*	17	*Marchantia polymorpha*	50	*Juncus inflexus*	8
Navicula lanceolata	75	*Meridion circulare* var. *constrictum*	17	*Brachythecium rivulare*	42	*Jungermannia*	8
Phormidium fragile	75	*Microspora crassior*	17	*Cinclidotus fontinaloides*	42	*Lychnis*	8
Gomphonema angustum	67	*Mougeotia* W3	17	*Pellia endiviifolia*	42	*Lysimachia vulgaris*	8
Gomphonema olivaceum	67	*Mougeotia* W4	17	*Pellia epiphylla*	42	*Mimulus guttatus*	8
Achnanthes flexella	58	*Mougeotia* W5	17	*Ranunculus flammula*	42	*Montia fontana*	8
Achnanthes lanceolata	58	*Navicula cryptocephala*	17	*Brachythecium plumosum*	33	*Myosotis scorpioides*	8
Cladophora glomerata	58	*Navicula halophila*	17	*Callitriche stagnalis*	33	*Phalaris arundinacea*	8
Gomphonema minutum	58	*Navicula rhynchocephala*	17	*Brachythecium rutabulum*	25	*Philonotis fontana*	8
Surirella brebissonii	58	*Navicula tripunctata*	17	*Caltha palustris*	25	*Senecio aquaticus*	8
Synedra ulna	58	*Oedogonium* W2	17	*Dichodontium*	25	*Senecio palustre*	8
Chamaesiphon incrustans	50	*Oedogonium* W5	17	Filamentous green algae	25	*Sparganium emersum*	8
Cocconeis pediculus	50	*Oscillatoria brevis*	17	Globular algae	25		
Diatoma moniliformis	50	*Oscillatoria limosa*	17	*Hygrohypnum*	25		
Fragilaria pulchella	50	*Phormidium autumnale*	17	*Iris pseudacorus*	25		
Gongrosira sp.	50	*Phormidium retzii*	17	*Lythrum salicaria*	25		
Ulothrix zonata	50	*Spirogyra* W3	17	*Oenanthe crocata*	25		
Amphora pediculus	42	*Surirella angusta*	17	*Persicaria hydropiper*	25		
Audouinella hermannii	42	*Ulothrix tenuissima*	17	*Racometrium*	25		
Gomphonema truncatum	42	*Achnanthes exigua*	8	*Rhizomnium punctatum*	25		
Lyngbya martensiana	42	*Bulbochaete* sp.	8	*Rorippa nasturtium-aquaticum*	25		
Meridion circulare	42	*Caloneis bacillum*	8	*Stachys palustris*	25		
Oscillatoria agardhii	42	*Closterium parvulum*	8	*Thamnobryum*	25		
Phormidium favosum	42	*Diatoma vulgaris*	8	*Valeriana*	25		
Tabellaria flocculosa	42	*Eunotia bilunaris*	8	*Veronica beccabunga*	25		
Cymbella gracilis	33	*Eunotia pectinalis*	8	*Apium nodiflorum*	17		
Diatoma tenuis	33	*Fragilaria capucina* var. *perminuta*	8	*Bryum pseudotriquetrum*	17		
Nitzschia linearis	33	*Frustulia rhomboides*	8	*Carex rostrata*	17		
Rhoicosphenia abbreviata	33	*Gomphonema micropus*	8	*Equisetum fluviatile*	17		
Spirogyra W1	33	*Microspora irregularis*	8	*Fortinalis squamosa*	17		
Spirogyra W2	33	*Microspora* sp.11	8	*Geum rivulare*	17		
Brachysira vitrea	25	*Monostroma* sp.	8	*Glyceria fluitans*	17		
Cymbella affinis	25	*Navicula* sp.12	8	*Mnium hornum*	17		
Didymosphenia geminata	25	*Nitzschia fonticola*	8	*Myriophyllum alternifolium*	17		
Eunotia arcus	25	*Oedogonium* W3	8	*Plagiomnium rostratum*	17		
Hannea arcus	25	*Oedogonium* W4	8	*Plagiomnium undulatum*	17		
Microspora tumidula	25			*Ranunculus peltatus*	17		
Navicula cryptotenella	25			*Ranunculus penicillatus*	17		

River Type 23 (4 sites).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq
Potamopyrgus antipodarum	100	*Polycentropus flavomaculatus*	75	*Gyrinus substriatus*	25
Lumbricidae indet.	100	*Psychomyia pusilla*	75	*Gyrinus caspius*	25
Gammarus duebeni	100	*Hydropsyche pellucidula*	75	*Dryops* spp.	25
Ephemerella ignita	100	*Ithytrichia* spp.	75	*Haliplus lineatocollis*	25
Baetis rhodani	100	*Odontocerum albicorne*	75	*Hydroporus nigrita*	25
Baetis muticus	100	Tricladidia indet.	50	*Stictonectes lepidus*	25
Rhithrogena semicolorata	100	*Lymnaea peregra*	50	*Stictotarsus duodecimpustulatus*	25
Electrogena lateralis	100	*Pisidium casertanum*	50	*Agabus bipustulatus*	25
Ecdyonurus venosus	100	Enchytraeidae indet.	50	*Helophorus* spp.	25
Ecdyonurus insignis	100	Nematoda indet.	50	*Laccobius striatulus*	25
Caenis rivulorum	100	*Heptagenia sulphurea*	50	*Cyrnus trimaculatus*	25
Brachyptera risi	100	*Paraleptophlebia cincta*	50	*Polycentropus kingi*	25
Protonemura meyeri	100	*Limnebius truncatellus*	50	*Lype reducta*	25
Leuctra hippopus	100	*Orectochilus villosus*	50	*Tinodes waeneri*	25
Leuctra inermis	100	*Oreodytes septentrionalis*	50	*Tinodes maculicornis*	25
Isoperla grammatica	100	Curculionidae indet.	50	*Hydropsyche instabilis*	25
Perla bipunctata	100	*Hydrocyphon* spp.	50	*Silo nigricornis*	25
Esolus parallelepipedus	100	*Wormaldia* spp.	50	*Ecclisopteryx guttulata*	25
Elmis aenea	100	*Agapetus fuscipes*	50	*Potamophylax latipennis*	25
Limnius volckmari	100	*Oxyethira* spp.	50	*Tricyphona* spp.	25
Hydraena gracilis	100	*Hydroptila* spp.	50	*Antocha* spp.	25
Oreodytes sanmarkii	100	*Lepidostoma hirtum*	50	*Dixa puberula*	25
Elodes spp.	100	*Lasiocephala basalis*	50	Ceratopogonidae indet.	25
Rhyacophila dorsalis	100	*Chaetopteryx villosa*	50	Stratiomyidae indet.	25
Plectrocnemia conspersa	100	*Drusus annulatus*	50	*Limnophora* spp.	25
Hydropsyche siltalai	100	*Sericostoma personatum*	50	*Chelifera* spp.	25
Glossosoma spp.	100	*Pedicia* spp.	50	Scatophagidae indet.	25
Silo pallipes	100	*Eloeophila* spp.	50	*Simulium vernum*	25
Halesus radiatus	100	*Hemerodromia* spp.	50	*Simulium armoricanum*	25
Potamophylax cingulatus	100	Sciomyzidae indet.	50	*Simulium ornatum/intermedium/trifasciatum* group	25
Tipula spp.	100	*Simulium cryophilum*	50	*Simulium ornatum/intermedium* group	25
Dicranota spp.	100	*Simulium argyreatum*	50	*Simulium tuberosum*	25
Psychodidae indet.	100	*Simulium variegatum*	50	*Simulium noelleri*	25
Wiedemannia/Clinocera spp.	100	*Pisidium personatum*	25	Prodiamesinae indet.	25
Simulium argyreatum/variegatum group	100	*Pisidium subtruncatum*	25	*Eukiefferiella claripennis*	25
Tanypodinae indet.	100	*Stylodrilus heringianus*	25		
Orthocladiinae indet.	100	*Rhyacodrilus coccineus*	25		
Chironomidae indet.	100	*Erpobdella octoculata*	25		
Chironominae indet.	100	*Piscicola geometra*	25		
Ancylus fluviatilis	75	*Haemopis sanguisuga*	25		
Lymnaea truncatula	75	*Siphlonurus lacustris*	25		
Lumbriculus variegatus	75	*Centroptilum luteolum*	25		
Tubificidae indet.	75	*Ecdyonurus torrentis*	25		
Hydracarina indet.	75	*Ecdyonurus dispar*	25		
Baetis scambus	75	*Nemoura avicularis*	25		
Amphinemura sulcicollis	75	*Leuctra nigra*	25		
Siphonoperla torrentium	75	*Dinocras cephalotes*	25		
Oulimnius tuberculatus	75	*Velia* spp.	25		
Rhyacophila munda	75	*Gerris lacustris*	25		
Philopotamus monatus	75	*Callicorixa praeusta*	25		

River Type 23 *contd.*

Phytobenthos	% freq	Phytobenthos *contd.*	% freq	Macrophytes	% freq
Achnanthidium minutissimum	100	*Meridion circulare* var. *constrictum*	25	*Rhynchostegium ripariodes*	100
Cocconeis pediculus	100	*Mougeotia* W4	25	*Chiloscyphus polyanthos*	75
Cocconeis placentula	100	*Navicula cryptotenella*	25	*Cladophora* spp.	75
Cymbella minuta	100	*Navicula* sp.12	25	*Conocephalum conicum*	75
Cymbella silesiaca	100	*Navicula* sp.8	25	*Filipendula ulmaria*	75
Gomphonema olivaceum	100	*Oscillatoria agardhii*	25	*Mnium hornum*	75
Gomphonema parvulum	100	*Phormidium fragile*	25	*Plagiomnium rostratum*	75
Navicula lanceolata	100	*Phormidium retzii*	25	*Thamnobryum*	75
Reimeria sinuata	100	*Rhoicosphenia abbreviata*	25	*Brachythecium rivulare*	50
Achnanthes oblongella	75	*Spirogyra* W1	25	*Calliergon cuspidatum*	50
Audouinella hermannii	75	*Surirella brebissonii*	25	*Cinclidotus fontinaloides*	50
Cladophora glomerata	75	*Tabellaria fenestrata*	25	*Equisetum arvense*	50
Fragilaria capucina	75	*Ulothrix tenuissima*	25	*Pellia epiphylla*	50
Gomphonema angustum	75			*Riccardia*	50
Hildenbrandia rivularis	75			*Amblystegium fluviatile*	25
Meridion circulare	75			*Angelica sylvestris*	25
Monostroma sp.	75			*Apium nodiflorum*	25
Navicula gregaria	75			*Brachythecium plumosum*	25
Navicula halophila	75			*Dichodontium*	25
Nitzschia dissipata	75			*Dicranella palustris*	25
Nitzschia palea	75			Filamentous green algae	25
Synedra ulna	75			*Fontinalis antipyretica*	25
Ulothrix zonata	75			*Geum rivulare*	25
Amphora pediculus	50			*Hygrohypnum*	25
Diatoma moniliformis	50			*Hyocomium armoricum*	25
Fragilaria capucina var. *vaucheriae*	50			*Juncus articulatus*	25
Fragilaria pulchella	50			*Juncus effusus*	25
Gomphonema minutum	50			*Lunularia*	25
Gomphonema truncatum	50			*Lychnis*	25
Gongrosira sp.	50			*Marchantia polymorpha*	25
Navicula tripunctata	50			*Myosotis scorpioides*	25
Tabellaria flocculosa	50			*Oenanthe crocata*	25
Achnanthes flexella	25			*Pellia endiviifolia*	25
Achnanthes lanceolata	25			*Philonotis fontana*	25
Achnanthidium biasolettiana	25			*Ranunculus flammula*	25
Ankistrodesmus falcatus	25			*Rorippa amphibia*	25
Caloneis bacillum	25				
Chamaesiphon confervicolus	25				
Cymbella helvetica	25				
Cymbella microcephala	25				
Cymbella proxima	25				
Diatoma tenuis	25				
Didymosphenia geminata	25				
Eunotia bilunaris	25				
Eunotia minor	25				
Fragilaria construens aff. F. construens	25				
Gomphonema micropus	25				
Hannea arcus	25				
Lyngbya martensiana	25				

River Type 24 (1 site).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Phytobenthos	% freq	Macrophytes	% freq
Potamopyrgus antipodarum	100	*Allotrichia* spp.	100	*Achnanthes lanceolata*	100	*Calliergon cuspidatum*	100
Ancylus fluviatilis	100	*Chaetopteryx villosa*	100	*Achnanthes petersenii*	100	*Chiloscyphus polyanthos*	100
Lymnaea truncatula	100	*Drusus annulatus*	100	*Achnanthidium minutissimum*	100	*Cinclidotus fontinaloides*	100
Pisidium casertanum	100	*Halesus radiatus*	100	*Amphora pediculus*	100	*Cladophora* spp.	100
Stylodrilus heringianus	100	*Potamophylax cingulatus*	100	*Aulacoseira granulata*	100	*Dichodontium*	100
Tubificidae indet.	100	*Beraea maurus*	100	*Cocconeis pediculus*	100	*Filipendula ulmaria*	100
Enchytraeidae indet.	100	*Sericostoma personatum*	100	*Cocconeis placentula*	100	*Hygrohypnum*	100
Lumbricidae indet.	100	*Odontocerum albicorne*	100	*Cyclotella radiosa*	100	*Hyocomium armoricum*	100
Gammarus duebeni	100	*Dicranota* spp.	100	*Cymbella minuta*	100	*Iris pseudacorus*	100
Hydracarina indet.	100	*Dixa puberula*	100	*Cymbella silesiaca*	100	*Juncus articulatus*	100
Collembola indet.	100	Ceratopogonidae indet.	100	*Diatoma moniliformis*	100	*Juncus effusus*	100
Serratella ignita	100	Psychodidae indet.	100	*Diatoma tenuis*	100	*Juncus inflexus*	100
Baetis scambus	100	*Limnophora* spp.	100	*Fragilaria capucina*	100	*Lychnis*	100
Baetis rhodani	100	*Wiedemannia/Clinocera* spp.	100	*Fragilaria capucina* var. *vaucheriae*	100	*Marchantia polymorpha*	100
Baetis muticus	100	*Simulium argyreatum/ variegatum* group	100	*Gomphonema angustum*	100	*Pellia endiviifolia*	100
Rhithrogena semicolorata	100	Tanypodinae indet.	100	*Gomphonema gracile*	100	*Plagiomnium undulatum*	100
Electrogena lateralis	100	Orthocladiinae indet.	100	*Gomphonema olivaceum*	100	*Polytrichum commune*	100
Ecdyonurus venosus	100	Chironominae indet.	100	*Gomphonema parvulum*	100	*Rhynchostegium riparioides*	100
Caenis rivulorum	100			*Heribaudiella fluviatilis*	100	*Thamnobryum*	100
Brachyptera risi	100			*Hildenbrandia rivularis*	100		
Amphinemura sulcicollis	100			*Navicula cryptotenella*	100		
Protonemura meyeri	100			*Nitzschia dissipata*	100		
Leuctra hippopus	100			*Nitzschia linearis*	100		
Leuctra inermis	100			*Nitzschia palea*	100		
Isoperla grammatica	100			*Synedra ulna*	100		
Dinocras cephalotes	100						
Chloroperla tripunctata	100						
Siphonoperla torrentium	100						
Esolus parallelepipedus	100						
Elmis aenea	100						
Oulimnius tuberculatus	100						
Limnius volckmari	100						
Hydraena gracilis	100						
Limnebius truncatellus	100						
Gyrinus substriatus	100						
Anacaena globulus	100						
Galerucinae indet.	100						
Elodes spp.	100						
Hydrocyphon spp.	100						
Rhyacophila dorsalis	100						
Rhyacophila munda	100						
Philopotamus monatus	100						
Plectrocnemia conspersa	100						
Polycentropus spp.	100						
Tinodes dives	100						
Diplectrona felix	100						
Hydropsyche instabilis	100						
Agapetus fuscipes	100						
Silo pallipes	100						
Hydroptila spp.	100						

River Type 31 (1 site).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Phytobenthos	% freq	Macrophytes	% freq
Theodoxus fluviatilis	100	*Oulimnius tuberculatus*	100	*Achnanthes lanceolata*	100	*Alisma plantago-aquatica*	100
Bithynia tentaculata	100	*Limnius volckmari*	100	*Achnanthes oblongella*	100	*Amblystegium riparium*	100
Potamopyrgus antipodarum	100	*Hydraena riparia*	100	*Achnanthidium biasolettiana*	100	*Brachythecium rivulare*	100
Ancylus fluviatilis	100	*Orectochilus villosus*	100	*Achnanthidium minutissimum*	100	*Butomus umbellatus*	100
Gyraulus albus	100	*Dryops* spp.	100	*Amphora pediculus*	100	*Callitriche platycarpa*	100
Lymnaea peregra	100	*Brychius elevatus*	100	*Caloneis bacillum*	100	*Caltha palustris*	100
Physa fontinalis	100	*Hydroporus tessellatus*	100	*Chamaesiphon incrustans*	100	*Cinclidotus fontinaloides*	100
Pisidium casertanum	100	*Oreodytes sanmarkii*	100	*Chamaesiphon confervicolus*	100	*Cladophora* spp.	100
Pisidium nitidum	100	*Nebrioporus depressus elegans*	100	*Cladophora glomerata*	100	*Eleocharis*	100
Pisidium subtruncatum	100	*Rhyacophila dorsalis*	100	*Cocconeis pediculus*	100	*Elodea canadensis*	100
Lumbriculus variegatus	100	*Rhyacophila munda*	100	*Cocconeis placentula*	100	*Equisetum arvense*	100
Stylodrilus heringianus	100	*Polycentropus flavomaculatus*	100	*Cyclotella meneghiniana*	100	*Filipendula ulmaria*	100
Limnodrilus hoffmeisteri	100	*Psychomyia pusilla*	100	*Cymbella helvetica*	100	*Fissidens*	100
Spirosperma ferox	100	*Cheumatopsyche lepida*	100	*Cymbella silesiaca*	100	*Fontinalis antipyretica*	100
Tubifex ignotus	100	*Hydropsyche siltalai*	100	*Diatoma tenuis*	100	*Hygrohypnum*	100
Stylaria lacustris	100	*Hydropsyche angustipennis*	100	*Diatoma vulgaris*	100	*Juncus articulatus*	100
Lumbricidae indet.	100	*Hydropsyche pellucidula*	100	*Eunotia bilunaris*	100	*Juncus inflexus*	100
Nematoda indet.	100	*Hydropsyche contubernalis*	100	*Fragilaria capucina*	100	*Lythrum salicaria*	100
Glossiphonia complanata	100	*Glossosoma* spp.	100	*Fragilaria capucina* var. *vaucheriae*	100	*Mentha aquatica*	100
Helobdella stagnalis	100	*Goera pilosa*	100	*Gomphonema minutum*	100	*Persicaria amphibia*	100
Erpobdella octoculata	100	*Ithytrichia* spp.	100	*Gomphonema olivaceum*	100	*Phalaris arundinacea*	100
Gammarus duebeni	100	*Lepidostoma hirtum*	100	*Gomphonema parvulum*	100	*Potamogeton pectinatus*	100
Asellus aquaticus	100	*Lasiocephala basalis*	100	*Hannea arcus*	100	*Potamogeton perfoliatus*	100
Hydracarina indet.	100	*Athripsodes cinereus*	100	*Meridion circulare*	100	*Potamogeton pusillus*	100
Serratella ignita	100	*Drusus annulatus*	100	*Meridion circulare* var. *constrictum*	100	*Rhynchostegium ripariodes*	100
Baetis scambus	100	*Halesus radiatus*	100	*Navicula cryptocephala*	100	*Riccia*	100
Baetis rhodani	100	*Limnephilus lunatus*	100	*Navicula cryptotenella*	100	*Schoenoplectus lacustris*	100
Baetis atrebatinus	100	*Stenophylax permistus*	100	*Navicula gregaria*	100	*Senecio palustre*	100
Baetis muticus	100	*Sericostoma personatum*	100	*Navicula halophila*	100	*Valeriana*	100
Centroptilum luteolum	100	*Dicranota* spp.	100	*Navicula lanceolata*	100		
Rhithrogena semicolorata	100	*Antocha* spp.	100	*Navicula tripunctata*	100		
Heptagenia sulphurea	100	Ceratopogonidae indet.	100	*Nitzschia dissipata*	100		
Ecdyonurus venosus	100	*Limnophora* spp.	100	*Nitzschia palea*	100		
Ecdyonurus insignis	100	*Hemerodromia* spp.	100	*Rhoicosphenia abbreviata*	100		
Ephemera danica	100	*Wiedemannia/Clinocera* spp.	100	*Surirella angusta*	100		
Caenis luctuosa	100	*Chelifera* spp.	100	*Surirella brebissonii*	100		
Caenis rivulorum	100	*Simulium ornatum/ intermedium/trifasciatum* group	100	*Synedra ulna*	100		
Amphinemura sulcicollis	100	*Simulium ornatum/intermedium* group	100	Unidentified	100		
Nemoura avicularis	100	Tanypodinae indet.	100				
Protonemura meyeri	100	Prodiamesinae indet.	100				
Leuctra hippopus	100	Orthocladiinae indet.	100				
Leuctra inermis	100	Chironominae indet.	100				
Perla bipunctata	100						
Siphonoperla torrentium	100						
Calopteryx splendens	100						
Velia spp.	100						
Aphelocheirus aestivalis	100						
Callicorixa praeusta	100						
Esolus parallelepipedus	100						
Elmis aenea	100						

River Type 32 (3 sites).

Macroinvertebrates	% freq	Macroinvertebrates *contd.*	% freq	Macroinvertebrates *contd.*	% freq
Pisidium casertanum	100	*Caenis rivulorum*	67	*Velia caprai*	33
Tubificidae indet.	100	*Brachyptera risi*	67	*Nepa cinerea*	33
Lumbricidae indet.	100	*Amphinemura sulcicollis*	67	*Hesperocorixa sahlbergi*	33
Erpobdella octoculata	100	*Leuctra inermis*	67	*Gyrinus substriatus*	33
Gammarus duebeni	100	*Siphonoperla torrentium*	67	*Brychius elevatus*	33
Serratella ignita	100	*Hydraena gracilis*	67	*Hydroporus tessellatus*	33
Baetis rhodani	100	*Hydrocyphon* spp.	67	*Oreodytes sanmarkii*	33
Baetis muticus	100	*Wormaldia* spp.	67	*Oreodytes septentrionalis*	33
Ecdyonurus venosus	100	*Plectrocnemia conspersa*	67	*Stictotarsus duodecimpustulatus*	33
Protonemura meyeri	100	*Polycentropus kingi*	67	*Agabus* spp.	33
Leuctra hippopus	100	*Psychomyia pusilla*	67	*Nebrioporus depressus elegans*	33
Isoperla grammatica	100	*Lype reducta*	67	*Helophorus* spp.	33
Esolus parallelepipedus	100	*Agapetus* spp.	67	*Sialis lutaria*	33
Elmis aenea	100	*Hydroptila* spp.	67	*Rhyacophila munda*	33
Oulimnius tuberculatus	100	*Chaetopteryx villosa*	67	*Polycentropus irrorata*	33
Limnius volckmari	100	*Halesus digitatus*	67	*Metalype fragilis*	33
Orectochilus villosus	100	*Potamophylax cingulatus*	67	*Lype phaeopa*	33
Elodes spp.	100	*Tipula* spp.	67	*Hydropsyche instabilis*	33
Rhyacophila dorsalis	100	*Dixa nebulosa*	67	*Hydropsyche pellucidula*	33
Polycentropus flavomaculatus	100	*Wiedemannia* spp.	67	*Glossosoma* spp.	33
Hydropsyche siltalai	100	*Simulium ornatum/intermedium/trifasciatum* group	67	*Goera pilosa*	33
Silo pallipes	100	*Ancylus fluviatilis*	33	*Silo nigricornis*	33
Ithytrichia spp.	100	*Planorbis planorbis*	33	*Lepidostoma hirtum*	33
Halesus radiatus	100	*Bathyomphalus contortus*	33	*Lasiocephala basalis*	33
Sericostoma personatum	100	*Lymnaea palustris*	33	*Athripsodes* spp.	33
Odontocerum albicorne	100	*Lymnaea truncatula*	33	*Drusus annulatus*	33
Dicranota spp.	100	*Physa fontinalis*	33	*Ecclisopteryx guttulata*	33
Eloeophila spp.	100	*Aplexa hypnorum*	33	*Limnephilus lunatus*	33
Psychodidae indet.	100	*Pisidium milium*	33	*Limnephilus marmoratus*	33
Limnophora spp.	100	*Pisidium nitidum*	33	*Potamophylax latipennis*	33
Hemerodromia spp.	100	*Pisidium subtruncatum*	33	*Beraea maurus*	33
Chelifera spp.	100	*Stylodrilus heringianus*	33	*Pedicia* spp.	33
Simulium argyreatum/variegatum group	100	*Rhyacodrilus coccineus*	33	*Tricyphona* spp.	33
Tanypodinae indet.	100	*Spirosperma ferox*	33	*Pilaria* spp.	33
Orthocladiinae indet.	100	*Gordius* spp.	33	*Antocha* spp.	33
Chironominae indet.	100	*Glossiphonia complanata*	33	*Erioptera* spp.	33
Tricladidia indet.	67	*Asellus aquaticus*	33	Ceratopogonidae indet.	33
Potamopyrgus antipodarum	67	*Asellus meridianus*	33	Syrphidae indet.	33
Lymnaea peregra	67	Hydracarina indet.	33	*Simulium angustitarse*	33
Pisidium pulchellum	67	*Baetis scambus*	33	*Simulium cryophilum*	33
Lumbriculus variegatus	67	*Heptagenia sulphurea*	33	*Simulium armoricanum*	33
Enchytraeidae indet.	67	*Electrogena lateralis*	33	*Simulium ornatum/intermedium* group	33
Nematoda indet.	67	*Paraleptophlebia cincta*	33	*Simulium argyreatum*	33
Helobdella stagnalis	67	*Caenis luctuosa*	33	*Simulium variegatum*	33
Piscicola geometra	67	*Nemoura cinerea*	33	Prodiamesinae indet.	33
Haemopis sanguisuga	67	*Perla bipunctata*	33		
Centroptilum luteolum	67	*Dinocras cephalotes*	33		
Rhithrogena semicolorata	67	*Chloroperla tripunctata*	33		
Ecdyonurus insignis	67	*Calopteryx virgo*	33		
Leptophlebidae indet.	67	Coenagrionidae indet.	33		

River Type 32 *contd.*

Phytobenthos	% freq	Phytobenthos *contd.*	% freq	Macrophytes	% freq
Achnanthidium minutissimum	100	*Spirogyra* W1	33	*Angelica sylvestris*	100
Amphora pediculus	100	*Ulothrix zonata*	33	*Apium nodiflorum*	100
Cocconeis placentula	100			*Filipendula ulmaria*	100
Cymbella minuta	100			*Fontinalis antipyretica*	100
Gongrosira sp.	100			*Juncus articulatus*	100
Reimeria sinuata	100			*Rorippa nasturtium-aquaticum*	100
Achnanthes lanceolata	67			*Veronica beccabunga*	100
Achnanthidium biasolettiana	67			*Amblystegium riparium*	67
Audouinella hermannii	67			*Caltha palustris*	67
Cladophora glomerata	67			*Cladophora* spp.	67
Cymbella silesiaca	67			*Conocephalum conicum*	67
Diatoma moniliformis	67			*Hypericum tetrapterum*	67
Fragilaria capucina	67			*Mentha aquatica*	67
Gomphonema angustum	67			*Rhynchostegium ripariodes*	67
Gomphonema olivaceum	67			*Thamnobryum*	67
Hildenbrandia rivularis	67			*Valeriana*	67
Navicula cryptotenella	67			*Brachythecium rivulare*	33
Navicula gregaria	67			*Butomus umbellatus*	33
Navicula lanceolata	67			*Callitriche obtusangula*	33
Nitzschia dissipata	67			*Callitriche platycarpa*	33
Rhoicosphenia abbreviata	67			*Chara*	33
Synedra ulna	67			*Chiloscyphus polyanthos*	33
Achnanthes flexella	33			*Cinclidotus fontinaloides*	33
Achnanthes oblongella	33			*Dicranella palustris*	33
Brachysira vitrea	33			*Equisetum arvense*	33
Chamaesiphon confervicolus	33			*Equisetum fluviatile*	33
Cocconeis pediculus	33			Filamentous green algae	33
Cymbella affinis	33			Globular algae	33
Cymbella helvetica	33			*Glyceria fluitans*	33
Cymbella microcephala	33			*Hygrohypnum*	33
Diatoma tenuis	33			*Iris pseudacorus*	33
Dichothrix gypsophila	33			*Juncus effusus*	33
Fragilaria capucina var. *vaucheriae*	33			*Juncus inflexus*	33
Gomphonema acuminatum	33			*Jungermannia*	33
Gomphonema minutum	33			*Lemna minor*	33
Gomphonema parvulum	33			*Lemna trisulca*	33
Heribaudiella fluviatilis	33			*Lythrum salicaria*	33
Lyngbya martensiana	33			*Myosotis scorpioides*	33
Meridion circulare	33			*Pellia endiviifolia*	33
Meridion circulare var. *constrictum*	33			*Pellia epiphylla*	33
Microspora irregularis	33			*Petasites hybridus*	33
Mougeotia W4	33			*Phalaris arundinacea*	33
Navicula cryptocephala	33			*Philonotis fontana*	33
Navicula halophila	33			*Plagiomnium rostratum*	33
Navicula tripunctata	33			*Plagiomnium undulatum*	33
Nitzschia fonticola	33			*Potamogeton lanceolatus*	33
Nitzschia palea	33			*Ranunculus flammula*	33
Oscillatoria brevis	33			*Rorippa amphibia*	33
Rivularia biasolettiana	33				