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**RELATIONSHIPS BETWEEN WATER QUALITY AND STREAM INVERTEBRATE  
ASSEMBLAGES OF EASTERN ONTARIO AND WESTERN QUÉBEC.**

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## ABSTRACT

Forty-seven riffle zones from 21 streams of Eastern Ontario and Western Québec were sampled in 1998 to describe how characteristics of the benthic invertebrate assemblage (abundance, taxa richness and size distribution) varied as a function of water quality parameters (conductivity, TP, SRP, TSS,  $\text{NO}_3+\text{NO}_2$ ,  $\text{NH}_3$ , TKN,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ) along a gradient of watershed development. A principal components analysis on water quality parameters revealed that there were two groups of correlated water quality variables that explained the majority of the variability among sites. The first group of variables included chloride, sulfate, nitrate+nitrite and conductivity and represented a gradient of urbanization while the second group represented nutrients and included: soluble reactive phosphorus, total phosphorus, ammonia, total suspended solids and total Kjeldahl nitrogen. Simple and multiple regression models predicting invertebrate assemblage characteristics were fitted using water quality principal components scores as independent variables. Overall, invertebrate assemblage characteristics were related to both groups of water quality variables. Abundances per taxon and size classes generally increased with increased nutrients, and overall abundance and the ratio of abundances of sensitive to tolerant taxa declined with increasing chloride, sulfate, nitrate+nitrite and conductivity. Existing information suggests that the water quality gradient found in these streams is more a reflection of anthropogenic sources than the result of geological differences. Therefore, it appears that human activities affect the distribution and abundance of invertebrates in this region. However our models did not

explain a good proportion of the variability. It would seem that stream invertebrates of the Ottawa valley are also affected by other parameters that have yet to be identified.

## RÉSUMÉ

Quarante-sept sites situés dans les eaux rapides de 21 ruisseaux et rivières de l'Est de l'Ontario et de l'Ouest du Québec ont été échantillonnés afin de décrire comment les caractéristiques (abondance, richesse taxonomique et spectre de taille) des assemblages d'invertébrés benthiques variaient en fonction de paramètres décrivant la qualité des eaux (conductivité, TP, SRP, TSS,  $\text{NO}_3+\text{NO}_2$ ,  $\text{NH}_3$ , TKN,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ) le long d'un gradient de développement des bassins hydrographiques. Une analyse par composante principale des paramètres de la qualité des eaux a révélé qu'il y avait deux groupes de paramètres fortement corrélés qui expliquaient une grande partie de la variabilité entre les sites. Le premier groupe de variable représentait un gradient d'urbanisation et comprenait le chlore, le sulfate, le nitrite+nitrate et la conductivité tandis que le second groupe représentait un gradient d'eutrophication et comprenait le phosphore réactif soluble, le phosphore total, l'ammoniac, les solides en suspension et l'azote totale de Kjeldahl. Des modèles de régression simples et multiples ont été ajustés en utilisant les scores des composantes principales de la qualité des eaux comme variables indépendantes. Les caractéristiques de l'assemblage des invertébrés sont généralement affectées par les deux composantes principales de la qualité des eaux. L'abondance par taxon et par classe de taille augmentent avec une augmentation des éléments nutritifs tandis que l'abondance totale et le ratio de l'abondance des

espèces sensibles sur celle des espèces tolérantes diminuent avec une augmentation du chlore, du sulfate, du nitrite et nitrate et de la conductivité. L'information existante suggère que la variabilité de la qualité des eaux est en bonne partie attribuable aux activités humaines plutôt qu'à la géologie des bassins hydrographiques. Ceci semble indiquer que la distribution des invertébrés de la région est en partie affectée par l'être humain. Cependant, une fraction importante de la variabilité des caractéristiques des assemblages d'invertébrés demeure inexplicée. Il semblerait donc que les invertébrés benthiques de la vallée de l'Outaouais soient aussi affectés par des facteurs n'ayant pas encore été isolés.

## INTRODUCTION

Urbanization and agriculture typically result in increased runoff of nutrients and pollutants to surface waters (Lystrom, 1978; Smith, 1987; Lenat and Crawford, 1994; Stark, 1997; Thorne and Williams, 1997). Changes in stream water quality often have detrimental effects on stream organisms and can affect structure and function of the whole ecosystem (Jones and Clark, 1987, Lenat and Crawford, 1994). To prevent such changes that too often reduces the recreational and service value of running waters, it is important to identify how human activities and the resulting changes in water quality affect stream organisms. Moreover, because it is economically unrealistic to implement measures to mitigate or eliminate all changes in water quality due to intense agriculture or urbanization, it is desirable to quantify the effects of these changes so that interventions can be prioritized.

Ideally, the identification of the most deleterious changes in water quality would proceed from time series on water quality and community characteristics from undisturbed and developed watersheds. Unfortunately, such historical data are seldom available. A suboptimal alternative is to conduct a cross-sectional study along a gradient of watershed development to describe the changes in water quality and community structure correlated with the gradient of watershed development. Such correlative descriptions do not allow strict inference about causal relationships but can help identify water quality parameters most strongly associated with community changes.

Changes in benthic macroinvertebrate assemblage characteristics (abundance, taxa richness, and taxonomic composition) have been linked to natural or anthropogenic variations in several water quality characteristics including: total suspended solids (DeWalt and Olive, 1988; Doeg and Koehn, 1994; Ryan, 1991), chloride (Short et al, 1991; Olive et al, 1992; Havas and Hadvokaat, 1995; Srivastava and Singh, 1996), sulfate (Srivastava and Singh, 1996, Plenet and Gibert, 1994; Soulsby et al, 1997), ammonia (Cosser, 1988), conductivity (Marchant et al, 1997), phosphorus (Mundie et al, 1991) and nitrogen (Cosser, 1988). Since these parameters can be affected by watershed development (Lystrom, 1978; Peters, 1984; Smith, 1987, Jones and Clark, 1987, Lenat and Crawford, 1994), they should all be examined to determine which ones are most strongly related to community changes in a particular region.

The response of invertebrate communities to water quality changes is generally described from the changes in taxonomic composition of the assemblage (richness, abundance or diversity). However, this requires strong taxonomic expertise and is extremely time consuming. An alternative is to use size distributions as a method to compare invertebrate assemblages. Previous studies have described how the size distributions of stream macroinvertebrates varied temporally along nutrient gradients and among substrate types (Morin and Nadon, 1991; Bourassa and Morin, 1995; Morin et al, 1995). Moreover, the relationships between the size distributions of stream invertebrates and water quality parameters most frequently changing with urbanization (i.e. suspended solids, ammonia, sulfate, chloride) have yet to be described.

This study describes the variability in water quality and in invertebrate assemblage structure along a gradient of watershed development in the Ottawa-Hull area in order to determine which water quality parameters are most strongly associated with changes in community taxonomic and size structure.

## METHODS

### Study sites.

In June 1998, 47 riffle zones in 21 streams around Ottawa (Ontario, Canada, 45°00'N, 76°20'W - 45°30'N, 75°00'W) were sampled for invertebrates and water quality variables (Tables 1 and 2). Twenty of the sampling sites were located within an urban region, 23 in agricultural areas while 4 sites were in forested areas of the Canadian Shield. The type of watershed (i.e. urban, agricultural or forested) was determined by characterizing the majority of the land located upstream of the sampling station.

### Sampling.

To sample invertebrates, 8 rocks (rock surface 31-259 cm<sup>2</sup>) were taken from the top layer of the stream bottom at random locations within riffle zones at each sampling site. Current velocity 2.5 cm above stream bottom and at 60% of the maximum depth (range 0-2.7 m/s and 0-2.9m/s respectively) and water depth (range 2-47 cm) were measured

where each rock was collected. The velocity was measured using a PVM.2A Montedoro Withney and Price 622A current meter. Rocks were delicately picked up from the water and put into plastic Twirl™ bags with a measured volume of ethanol (95%). Conductivity as well as pH were measured at the time of sampling for every site with the help of a portable HYDROLAB™ (H<sub>2</sub>O multiprobe).

Surface water samples were collected in plastic bottles at each sampling site and the bottles stored into a cooler containing ice packs. At the end of the day, water samples were taken to a water quality laboratory in Ottawa (RMOC, R.O. Pickard Environmental Center) for analysis of Cl (chloride), NO<sub>x</sub> (nitrate and nitrite), NH<sub>3</sub> (ammonia), TP (total phosphorus), TKN (total Kjeldahl nitrogen), TSS (total suspended solids), SRP (soluble reactive phosphorus), and SO<sub>4</sub> (sulfate) concentrations by standard protocols (RMOC, 1996). Annual means of the following parameters: chloride, nitrate and nitrite, ammonia, total phosphorus, total Kjeldahl nitrogen, total suspended solids, soluble reactive phosphorus, and sulfate were obtained using yearly data collected at each sampling sites by the following agencies: Regional Municipality of Ottawa-Carleton and the South Nation River Conservation Authority.

Laboratory methods.

Periphytic algal biomass for each rock was estimated from the chlorophyll extracted by the ethanol used to preserve the samples in the field. After 24 hours in the dark, a 12 ml ethanol aliquot was taken from each bag, centrifuged for 5 minutes and chlorophyll

concentration was determined from spectrophotometer readings according to the formulas of Ostrofsky and Rigler (1987). Afterwards, each bag was emptied of its content (ethanol and rock) over a pair of sieves fitted on top of each other (the size of the sieves were 1000 and 500  $\mu\text{m}$ ). The rocks were brushed over the sieves and all of the invertebrates and residues (organic matter, gravel, sand etc) of the two fractions were put into separate plastic jars and preserved with ethanol (95%). Invertebrates in both fractions were ultimately sorted under a dissecting microscope (12-25X). Samples containing more than 200 individuals were subsampled using a Folsom plankton splitter until there remained at least one hundred individuals. The invertebrates were sorted into broad taxonomic groups: Amphipoda, Bivalvia, Coleoptera, Diptera (Simuliidae, Chironominae, Orthoclaadiinae, Tanypodinae, others), Gastropoda, *Hydra*, Isopoda, Nematoda, Oligochaeta, Platyhelminthes, Plecoptera, Trichoptera, *Dreissena polymorpha* and others.

Individual body lengths of the most abundant taxa (Chironominae, Ephemeroptera, Isopoda, Oligochaeta, Orthoclaadiinae, Tanypodinae and Trichoptera) were measured using an image analysis software. Images of invertebrates were captured from a dissecting microscope by a video camera and projected onto a monitor. On this image, connected vectors were manually created along the central body axis of the invertebrates from the anterior end of its head to the posterior end of its last abdominal segment (excluding appendages). The sum of these vectors yielded the body length of the invertebrates (to the nearest 0.01mm). The mass (M) of the invertebrates was

determined using allometric equations of the form  $M=aL^b$  where L was the body length (in mm) and a,b were taxa specific constants (Appendix 1).

The surface area of each rock was estimated by carefully wrapping the rock with aluminum foil and converting the weight of the aluminum foil to a surface area.

Estimates of the abundance (individuals  $m^{-2}$ ) of the invertebrates and of periphyton standing stock (mg chlorophyll a  $m^{-2}$ ) were calculated using the total surface area of each rock.

#### Statistical analyses.

Patterns of variation in water quality among the sampling sites were described by principal components analysis (PCA). PCA was performed on log transformed water quality parameters (conductivity, Cl (chloride),  $NO_x$  (nitrate and nitrite),  $NH_3$  (ammonia), TP (total phosphorus), TKN (total Kjeldahl nitrogen), TSS (total suspended solids), SRP (soluble reactive phosphorus), and  $SO_4$  (sulfate)), and site scores were compared among sites from urban, rural and forested watersheds. To examine the relationship between water quality and underlying geology, site scores from the PCA on water quality parameters were also compared among grouping of sites based on the surficial and bedrock geology. The underlying geology characterizing each sampling site corresponded to the main geological formations found upstream of the sampling site. The upstream geological formations were assessed using maps of the Geological Survey of Canada.

Analyses of invertebrate community structure were performed using means of log transformed data as dependent variables. Because there were several replicate samples containing 0 individuals of particular taxa or size classes, we added half the density detection limit (i.e. 0.5 individual per 8 rocks, approximately 10 ind. m<sup>-2</sup>) before log transformation.

Patterns of variability in invertebrate community composition were also described using PCA performed on log transformed abundance data.

Multiple regression models were then used to quantify the relationships between invertebrate assemblage structure (abundance per taxa, richness), and water quality parameters (PCA factor scores). Taxa richness was calculated as the total number of taxa present at a given sampling site.

The models had the following form:

$$Y = \text{constant} + PC1_{wq} + PC2_{wq} + PC1_{wq} * PC2_{wq}$$

where Y was either the log transformed abundance values (density + 10) or site scores on factor 1 and 2 of the PCA of density per taxa at each site and PC1<sub>wq</sub>, PC2<sub>wq</sub> were PCA factor scores.

The regression models were then estimated using stepwise multiple regression. The residuals were examined for independence, linearity and homoscedasticity.

Polynomial regression models including interaction terms were used to assess the effects of water quality parameters on the size distributions of invertebrates. The dependent variable was the mean log transformed abundance of invertebrates per size class per sampling site.

Models for the entire assemblage and for dominant taxa were built in two steps. First, a polynomial regression of the form:

$$\text{Log}_{10}(\text{density}+10)=\text{constant}+\log_{10}M+(\log_{10}M)^2+(\log_{10}M)^3+(\log_{10}M)^4$$

was fitted to the data to describe the average size distribution of invertebrates. Second, we tested for significant effects of PCA factor scores on size distribution by including main effects terms and first order interaction terms.

Fitted models had the following form:

$$\begin{aligned} \text{Log}_{10}(\text{density}+10)= & \text{constant} + \log_{10}M + (\log_{10}M)^2 + (\log_{10}M)^3 + (\log_{10}M)^4 + \text{PC1}_{\text{WQ}} + \\ & \log_{10}M * \text{PC1}_{\text{WQ}} + (\log_{10}M)^2 * \text{PC1}_{\text{WQ}} + (\text{PC1}_{\text{WQ}})^2 + \text{PC2}_{\text{WQ}} + \log_{10}M * \text{PC2}_{\text{WQ}} + (\log_{10}M)^2 * \\ & \text{PC2}_{\text{WQ}} + (\text{PC2}_{\text{WQ}})^2 + \text{PC1}_{\text{WQ}} * \text{PC2}_{\text{WQ}} + \log_{10}M * \text{PC1}_{\text{WQ}} * \text{PC2}_{\text{WQ}} + (\log_{10}M)^2 * \text{PC1}_{\text{WQ}} * \\ & \text{PC2}_{\text{WQ}} \end{aligned}$$

where  $\text{PC}_{\text{WQ}}$  are water quality PCA scores.

Precision of the models.

To assess the precision of multiple regressions we compared the RMS of models to estimates of the variance of mean measurements (pure error). Pure error was estimated by fitting a one-way ANOVA of the dependent variable of the model on sampling stations. The residual mean square of the one-way ANOVA was then divided by the number of replicates (8) taken at each site as an estimate of the average variance of the mean, and this value compared to the variance of residuals to the fitted regression.

The statistical analyses were done with Systat™ 7.0 while graphs were obtained with the help of the following software: Systat™ 7.0 and SigmaPlot™ 4.0.

## RESULTS

Water quality characteristics of sampled sites.

The streams ranged from oligotrophic to eutrophic (Table 2) and water quality differed among urban, rural, and forested watersheds, but was not strongly related to underlying geological formations. (Figure 2)

There were two groups of strongly correlated water quality variables (Table 3, Figure 2-A) that accounted for most of the differences in water quality among sites. The first group of variables, loading strongly on the first principal component axis, included chloride, sulfate, nitrate+nitrite and conductivity. The second group, representing nutrients (soluble reactive phosphorus, total phosphorus, ammonia, total suspended solids and total Kjeldahl nitrogen) loaded strongly on the second principal component. Moreover, the PCA on water quality explained more than 75% of the variability in water quality between sampling sites. Forested streams differed from urban and rural streams by having lower nutrient concentrations. Urban sites had typically higher values of Cl, SO<sub>4</sub>, NO<sub>x</sub> and conductivity than the rural sites while agricultural sites had equal or higher values of soluble reactive phosphorus, total phosphorus, ammonia, total suspended solids and total Kjeldahl nitrogen than the urban sites (Figure 2-B).

Bedrock and surficial geology were poorly correlated with water quality of the sampling sites (Figure 2 -C and D) except for gneiss and metamorphic rocks for forested streams of the Canadian Shield. The overall positions of the ellipses (gneiss and metamorphic) in Figure 2-C and 2-D were spatially located at an opposite end of both principal components loadings of water quality (Figure 2-A).

**Taxonomic structure of the invertebrate assemblage.**

Over 100 000 individual invertebrates were sampled and sorted into 18 broad taxonomic groups ranging from order to genus. The most common taxon was

Orthoclaadiinae accounting for 50% of all invertebrates sampled. Other important taxa included Trichoptera, Isopoda, Chironominae, Oligochaeta, Ephemeroptera, *Hydra* and Platyhelminthes with relative densities ranging from 2 to 15% (Figure 3). Taxonomic composition and abundance differed among the urban, rural and forested sites. Urban streams tended to have abundant Isopoda, Oligochaeta and Orthoclaadiinae and low abundance of Plecoptera and Ephemeroptera while forested streams had the opposite tendency (Figure 4-A, B). Meanwhile, abundant Trichoptera, Tanypodinae, Gastropoda, Platyhelminthes, and Coleoptera characterized rural streams (Figure 4-A, B).

Proportion of Orthoclaadiinae and relative abundance of sensitive (Plecoptera, Ephemeroptera) and tolerant taxa (Isopoda and Oligochaeta) were the main axes of variation in invertebrate assemblages. The first 2 principal components ( $PCA_{TAXA}$ ) of the analysis on the 16 most common taxa explained 46% of the variance among sites (Figure 4). The first principal component ( $PC1_{TAXA}$ ) accounted for 30% of the variance and was positively correlated to the abundance of most invertebrate taxa, but negatively correlated to Orthoclaadiinae abundance. In contrast,  $PC2_{TAXA}$  (16%) was correlated to the following ratio:  $(Isopoda + Oligochaeta) / (Plecoptera + Ephemeroptera)$ .

**Invertebrate community structure vs. water quality.**

All invertebrate assemblage characteristics ( $PCA_{TAXA}$ , taxa richness, abundance) responded one way or another to water quality variations ( $PCA_{WQ}$ ). Assemblage composition and abundance, described by scores on the first two PC axes, were

significantly related to the principal components of water quality (PC1<sub>WQ</sub> and PC2<sub>WQ</sub>). Regression models of the principal components on taxa abundance predicted for 16 to 30% of the variance in abundance (Table 4). Factor 1 (PC1<sub>TAXA</sub>), which represents the overall abundance of invertebrates, was negatively related to the first principal component of water quality (PC1<sub>WQ</sub>) and positively related to the second principal component (PC2<sub>WQ</sub>) (Table 4). Factor 2 (PC2<sub>TAXA</sub>), proportional to the ratio: Isopoda + Oligochaeta / Ephemeroptera + Plecoptera, was positively related to the first principal component of water quality (PC1<sub>WQ</sub>) (Table 4).

Taxa richness increased with increasing nutrients and was significantly related to the second principal component of water quality ( $R^2=0.18$ , Table 5).

Abundance of individual taxa also varied with water quality. Ephemeroptera, Chironominae, Tanypodinae, *D. polymorpha*, and Platyhelminthes decreased in density with an increase in PC1<sub>WQ</sub> (water conductivity/ions), whereas Simuliidae, Oligochaeta, Isopoda, and Orthoclaadiinae increased along the same gradient (Table 6). Abundance of Chironominae, Gastropoda, Oligochaeta and Platyhelminthes were also positively related to nutrients (axis 2 of the PCA<sub>WQ</sub>).

Finally, assemblage composition and abundance (described by scores on the first two axes of the PCA on taxa) as well as taxa richness and individual taxa abundance were not significantly related to the interaction between the two principal components of water quality (PC1<sub>WQ</sub>\*PC2<sub>WQ</sub>).

## Size distributions of invertebrates vs. water quality.

The size distribution of the benthic invertebrate assemblage was unimodal with a peak at around 100µg (4.64mm) (Figure 5). The size spectra for individual taxa were also unimodal but mean size and the shape of the distribution varied among taxa. (Figure 5).

Body mass was the single best predictor of abundance per size class. Polynomial models of the size distributions of the different taxa and of the total assemblage accounted for 10 to 77% of the variance in abundance per size class (Table 7). Water quality differences among sites accounted for an additional 3 to 23% of the variability. Responses to water quality differed among taxa. Along the conductivity/ionic gradient (PC1<sub>wq</sub>), Chironominae and Ephemeroptera abundance tended to decrease (Figure 6-E, G) whereas the abundance of Oligochaeta, Orthocladiinae and the total assemblage tended to be greater in sites with higher conductivity/ions (Figure 6-A, B, I, J, M, N) (Table 7). Abundance of Chironominae, Oligochaeta and of the total assemblage was higher in sites with high nutrient concentrations (PC2<sub>wq</sub>) (Figure 6-C, F, K, L). The shape of the size distribution also varied with water quality and responses of taxa differed.

## DISCUSSION

Water quality in streams of the Ottawa valley.

Physico-chemical attributes of streams in the Ottawa valley reflected more the land use than the geology of the watershed. This suggests that human activities are responsible for some of the differences in water quality. Indeed, the two main gradients of water quality (conductivity/ions and nutrient) identified by the PCA<sub>WQ</sub> could be caused by urbanization and agriculture.

Urban streams are often characterized by high dissolved nitrogen (Lenat and Crawford, 1994), sulfate (Smith, 1987) and chloride levels (Jones and Clark, 1987). Increased sulfate levels can be attributed to the combustion of fossil fuels and to localized industrial outfalls (Peters, 1984; Hem, 1985; Smith, 1987) while chloride levels, in a populated northern region, often result from the application of chemical de-icers on roads, especially NaCl and KCl (Fisher, 1968; Hanes et al, 1970; Peters, 1984; Hem, 1985; Smith, 1987). The application of these chemical agents has been shown to increase significantly the chloride levels of nearby streams (Peters and Turk, 1981; Scott, 1981; McBean and Al-Nassri, 1987; Demers and Sage, 1990; Shanley, 1994). Rural streams are often characterized by high nutrients and TSS levels (Lystrom, 1978; Lenat and Crawford, 1994) while forested streams in undeveloped watersheds of the Ottawa valley are characterized by low nutrient levels (Morin and Nadon, 1991; Bourassa and Morin, 1995).

The geological formations (bedrock and surficial) underlying stream watersheds are seldom taken into account in biological surveys. Nevertheless, geological formations are often important non point sources of chemical elements in rivers, for example; Peters (1984) found that limestone basins have higher concentrations of chloride and sulfate than either sandstone or crystalline basins. The geological formations of Eastern Ontario and Western Québec are composed of numerous and distinct geological assemblages including sedimentary rocks (limestone and dolomite) in the southeast and metamorphic rocks in the northwest. However, the sampling sites located within the urban region and agricultural areas have similar bedrock and surficial geology since they were subjected to the same events: glaciation by the Wisconsin sheet, inundation by the Champlain sea and erosion and deposition of early phase of the Ottawa River (Water and Earth Science, 1981). Therefore, we are unable to strongly link either principal components of water quality to the geological formations of urban or agricultural streams.

The geological formation of the forested stream watershed is very different from that of the other rivers (urban and agricultural). The low nutrients in the soil and surface waters can be attributed to the underlying geology since gneiss rocks and metamorphic rocks do not contain or easily leach nutrients to the soil or water (Hem, 1985, Birkeland and Larson, 1989). Since the forested basin is not suitable for agricultural practices little nutrients flow in these rivers.

**Problems associated with the correlations between water quality parameters.**

The ultimate goal in biomonitoring studies is to show causal relationships between invertebrate assemblages and water quality, often described as separate entities (Cl, SO<sub>4</sub>, TP, etc). However, the results of this study and of another similar study (Yu et al, 1995) often reveal strong correlations between various water quality parameters. Since the aquatic invertebrates are exposed to a combination of chemical parameters present in the water, predictive models of invertebrate characteristics (abundance, taxa richness) should include the chemical parameters as groups instead of individual parameters. A principal components analysis (PCA) is an easy and practical way to group the water quality parameters. In this case, not only did the PCA on water quality explain over 75% of the variability of water quality between sites, but it also separated the 9 physico-chemical parameters into only 2 groups. Furthermore, the relationships of the parameters within a group were easily interpretable. Therefore, due to the numerous correlations found between the water quality parameters (Figure 2-A, Table 3) we are unable to predict if the various invertebrate characteristics (PCA<sub>TAXA</sub>, abundance, taxa richness and size distributions) are affected solely by an individual parameter or a combination thereof.

**Taxonomic structure of the invertebrate assemblage.**

The taxonomic composition of the invertebrate assemblages is similar to that previously reported in creeks of the Ottawa valley (Bourassa and Morin, 1995). Orthocladiinae

were found over the entire range of sampling sites and they were the dominant taxon, especially in the most urbanized sites. Orthocladiinae are considered opportunistic and tolerant of physico-chemical disturbances (Jones and Clark, 1987). They also prefer rocky substrates (Peckarsky, 1990) like the cobbles and rocks that were sampled. Abundances of Isopoda, Oligochaeta, and Orthocladiinae were correlated and tended to be highest in the urbanized sites. It has been previously reported that stressed systems are usually dominated by few taxa (Resh and Jackson, 1993; Lenat and Crawford, 1994). These taxa contain species that are rather tolerant to a variety of physico-chemical stresses (Barton and Farmer, 1997; Jones and Clark, 1987).

Agricultural streams had more co-dominant taxa (Trichoptera, Gastropoda, Coleoptera, Platyhelminthes, Chironominae and Tanypodinae) than urban or forested streams probably because of the high nutrients and low physico-chemical stresses associated with urbanization. The increase in nutrients in these waters could accommodate more scrapers as well as herbivore invertebrates (Trichoptera, Gastropoda, Coleoptera and Chironominae).

Gill breathing taxa such as Ephemeroptera and Plecoptera are often absent from highly impacted sites. Both rural and forested streams had high abundances of Plecoptera and Ephemeroptera compared to urban streams maybe because of the lower concentrations of toxic compounds associated with the urban region (Cl, SO<sub>4</sub>, and NO<sub>x</sub>) and low suspended solids (TSS) levels found in forested streams.

Invertebrate assemblages reflect the type of watershed sampled (urban, agricultural or forested) as well as the individual abilities of the invertebrates to withstand physico-chemical stresses (Figure 4). Along the first principal component ( $PC1_{TAXA}$ ), Oligochaeta and Isopoda are clumped together. These two groups dominate urban creeks and are highly tolerant to a variety of physico-chemical stresses (Jones and Clark, 1987). Again, along  $PC1_{TAXA}$ , *Hydra*, Simuliidae and Amphipoda are grouped together and they co-dominate urban and agricultural areas. Platyhelminthes, Gastropoda, Chironominae, Tanypodinae, Bivalvia, Coleoptera and Trichoptera are clumped together along  $PC2_{TAXA}$  and dominate the agricultural streams. These groups contain species that can be either tolerant or sensitive to pollution. Finally, Diptera, Plecoptera and Ephemeroptera are grouped together along  $PC2_{TAXA}$  and co-dominate both agricultural and forested streams. Previous studies suggests that Plecoptera and Ephemeroptera are very sensitive to physico-chemical stresses (Short et al, 1991; Olive et al, 1992).

Invertebrate community structure vs. water quality.

Proportion of Orthoclaadiinae ( $PC1_{TAXA}$ ) increased with an increase in conductivity/ions ( $PC1_{WQ}$ ), and decreased with increasing nutrients ( $PC2_{WQ}$ ). Previous studies have found that chloride negatively affects numerous taxa (Olive et al, 1992, Havas and Hadvokaat, 1995) and the observed pattern suggests that Orthoclaadiinae are less sensitive than average to chloride stress. Increases in nutrients generally translate into increases in algae and other primary producers, which are at the base of the foodweb of herbivore invertebrates (Lenat and Crawford, 1994). Apparently, Orthoclaadiinae do not

respond as strongly as other invertebrates to nutrient increase since their relative abundance declines with eutrophication.

The ratio ( $PC2_{TAXA}$ ) of « tolerant » (Isopoda, Oligochaeta) to « intolerant » taxa was positively related to conductivity/ions ( $PC1_{WQ}$ ). Plenet and Gibert (1994) found that the total abundance of invertebrates was positively related to conductivity. Since Isopoda, Orthocladinae and Oligochaeta dominated the invertebrate assemblages, and since they respond positively to an increase in conductivity, the results of this study support the observations of Plenet and Gibert (1994).

Taxa richness was influenced positively by nutrients ( $PC2_{WQ}$ ). An increase of nutrients in streamwater usually translates into increase in food availability and diversity, which in turn can support a more diverse fauna of invertebrates. Cao et al (1986) also found that species richness increased with a slight increase in organic pollution.

Densities of sensitive taxa such as Ephemeroptera, Platyhelminthes, Chironominae, and Tanyptodinae were all negatively related to conductivity/ions ( $PC1_{WQ}$ ). This is partly in concordance with other studies that have shown different tolerance levels to  $SO_4$ , Cl or conductivity by different taxa (Short et al, 1991; Olive et al, 1992; Plenet and Gibert, 1994; Havas and Hadvokaat, 1995; Soulsby et al. 1997).

Chironominae, Gastropoda, Oligochaeta and Platyhelminthes were positively related to nutrients ( $PC2_{WQ}$ ). Similar increases in abundance with increases in nutrients have been reported and discussed previously.

## Size distributions of the invertebrate assemblage vs. water quality.

Observed size distributions were very similar to previously reported macroinvertebrate size distributions (Morin and Nadon, 1991, Bourassa and Morin, 1995). Bourassa and Morin (1995) also found that mass was the single most important predictor of invertebrate abundance per size class. Water quality accounted for only an additional 3 to 23% of the variability depending on the taxa taken into account.

The size distributions of the total assemblage as well as those of the dominant taxa are slightly affected by changes in water quality (PC1<sub>WQ</sub> and PC2<sub>WQ</sub>) (Table 7). The density per size class of the total assemblage as well as Oligochaeta and Orthocladinae increases with an increase in conductivity/ions (PC1<sub>WQ</sub>) (Figure 6) (Table 7). A high tolerance to urbanization as been previously reported for these groups (Jones and Clark, 1987; Cao et al, 1986; Mulliss et al, 1996). The density per size class of the total assemblage as well as Chironominae and Oligochaeta increases with an increase in nutrients (PC2<sub>WQ</sub>) (Figure 6). Some species of Oligochaeta have been known to thrive under high organic pollution levels (Peckarsky, 1990). In addition, the increase in nutrients in these waters could accommodate more scrapers (Chironominae). The density per size classes of Ephemeroptera decreases with an increase in conductivity/ions (PC1<sub>WQ</sub>). A low tolerance to chloride/sulfate as been previously reported for Ephemeroptera (Short et al, 1991; Soulsby et al, 1997).

Few studies have reported the size distributions of dominant taxa of lotic invertebrates probably because of the time-constraints associated with first identifying the invertebrates and then measuring their mass. However, as the results of this study show, the additional time required to measure the size distribution of individual taxa is warranted. The responses of individual taxa to changes in water quality differed from one another and the size distribution of the total assemblage shifted as the distribution of its dominant taxa. In this case, the size distribution of the total population reflects mainly that of Orthocladiinae (which comprise about 50% of the total population) and Trichoptera. The size distribution of the total assemblage is very similar to the distribution of Orthocladiinae, especially for the invertebrates measuring between 3 and 10mm (Figure 5). Furthermore, the size distribution of the total assemblage is similar to the distribution of Trichoptera for animals measuring between 1 and 2.6 mm as well as those from 14 to 46mm. Therefore, taxon-based size distributions enabled us to evaluate more precisely the effects of water quality on stream invertebrates.

Importance of the taxonomic resolution in the family Chironomidae.

In most biomonitoring studies, midges are only identified at the family level of Chironomidae instead of classifying them into their respective sub-families: Orthocladiinae, Chironominae, Tanypodinae, etc (Thorne and Williams, 1997; Lenat and Crawford, 1994). Because the sub-families have very different responses to water quality, lumping all midges together is not appropriate. Orthocladiinae seem to be very tolerant and thrive despite pollutants (chloride, sulfate) while Chironominae and

Tanypodinae seem much less tolerant. Recent studies have begun to debate the need for higher taxonomic resolution in the Chironomidae family (Resh and Jackson, 1993). The results reported here advocate in favor for identification at least at the sub family level.

Quality of predictions and other factors affecting invertebrate abundance.

The residual variance can be used as a metric of the precision of predictive models and the study by Morin (1997) provides typical ranges for various estimates of invertebrate abundance (both daily-mean and size spectra models). Overall, the precision of the models predicting abundance of invertebrates in this study is generally weak. The precision of the models of invertebrate abundance in this study is much worse than that of typical models and measurements reported by Morin (1997). However, precision of the size spectra models was similar to those reported by Morin (1997). Therefore, the size distribution models could be qualified as precise.

Another way to assess the quality of predictions from predictive models is to compare the magnitude of prediction errors (RMS) to that of measurement errors (pure error). If the RMS approaches pure error, then all of the variability among sites has been accounted for. However, since RMS values were always much larger than the estimates of pure error (Tables 5-7), a large proportion of the variability among sites remained unexplained by the regression models. Therefore, other factors are affecting significantly the stream invertebrate assemblages in the Ottawa valley.

Heavy metals in the water (Timmermans et al, 1989; Bervoets et al, 1994, Schumacher et al. 1993), heavy metals in sediments (Beauvais 1995; Pinochet et al, 1995; Schumacher et al. 1995), pesticides (Cheevaparanapiwat and Menasveta, 1981; Elder and Mattraw, 1984), PCB (Cheevaparanapiwat and Menasveta, 1981; Elder and Mattraw, 1984), insecticides (Greichus et al., 1977) and other unmeasured toxic chemicals may well affect invertebrates. The single or synergetic effects of these parameters may account for compositional differences among sites that are not related to nutrients or conductivity/ions. However, inorganic and organic pollutants in stream waters from the Ottawa Valley are generally at trace levels (RMOC\_A,B, 1993), and it seems unlikely that the unexplained variability in invertebrate abundance among sites could be explained by pollutants.

It seems more likely that stochastic factors, differences in physical factors (pool/riffle ratios, moss cover, etc) or in food availability (detritus, diatoms), or differences in fish predation pressure among sites could account for the variability unexplained by the regression models.

Prioritizing interventions.

The majority of stream invertebrate characteristics (abundance, taxa richness, size distributions) were negatively related to the first principal component of water quality (composed of NO<sub>x</sub>, Cl, SO<sub>4</sub> and conductivity). This leads us to hypothesize that a

decrease of the first principal component of water quality would be beneficial to the invertebrate assemblage of this region. However, since there are strong correlations between the three physico-chemical variables comprising the first principal component of water quality, we are unable to correctly identify the main stressor. Therefore, we suggest that the abatement of all three physico-chemical parameters (chloride, sulfate and nitrate+nitrite) should be a priority of the different levels of municipal, regional, provincial and federal agencies present in the Ottawa valley.

## CONCLUSION

A principal components analysis on the water quality parameters revealed that two groups of correlated variables explained most of the variability among sites. Both principal components were strongly linked to land usage: PC1<sub>wq</sub> represented a kind of urbanization gradient while PC2<sub>wq</sub> represented nutrients. Characteristics of the stream macroinvertebrate assemblages of the Ottawa valley (abundance, taxa richness and size distribution) were shown to be related to water quality. Overall, both principal components of water quality were good predictors of invertebrate characteristics (abundance, taxa richness or size distribution). Given the origin of the ions included in the principal components, it appears that human activities are affecting the distribution of invertebrates in streams of the Ottawa valley.

## FIGURES

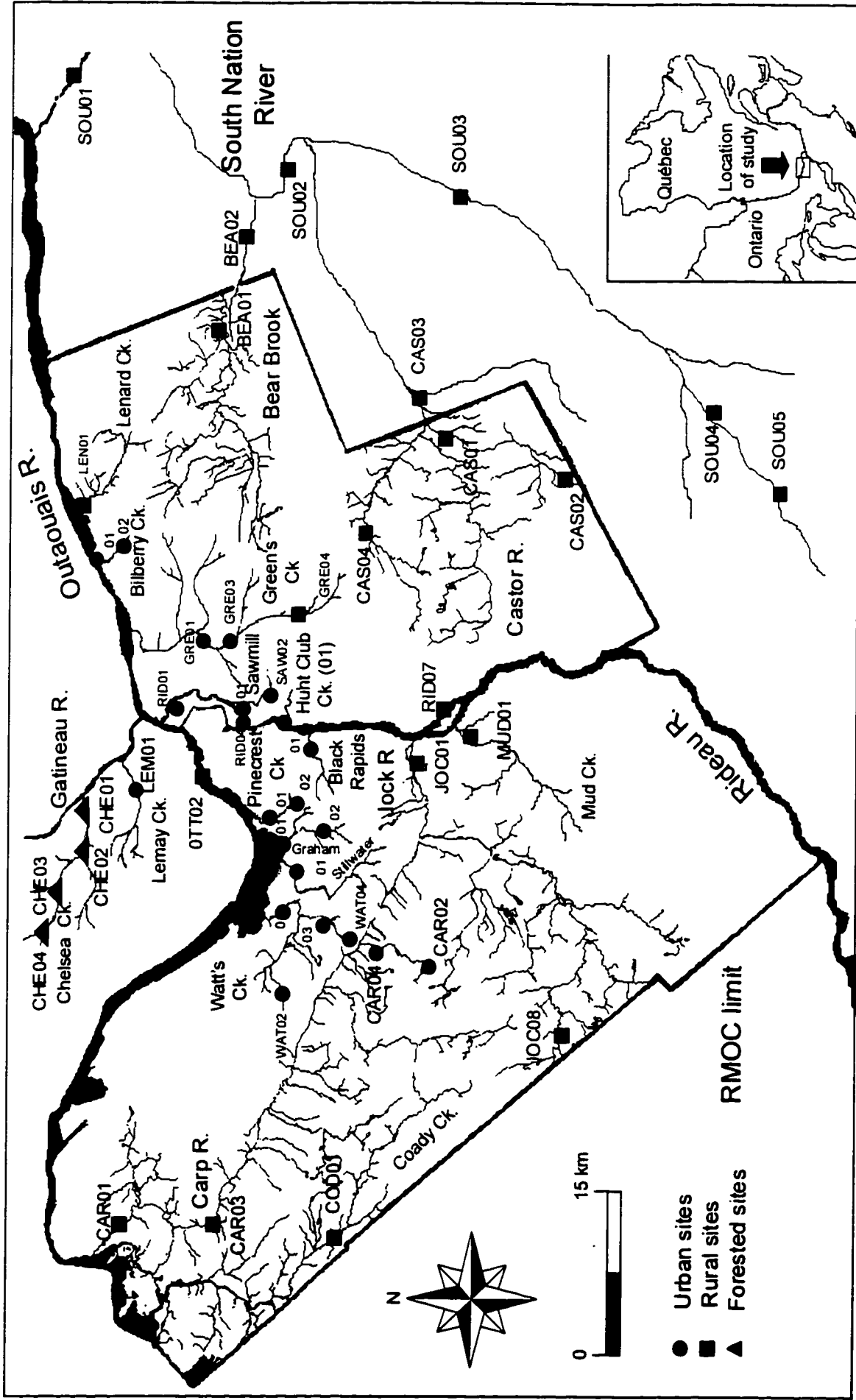
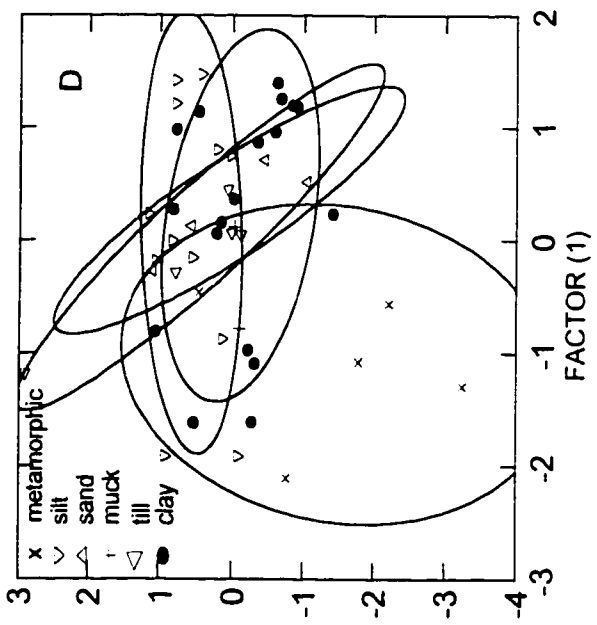
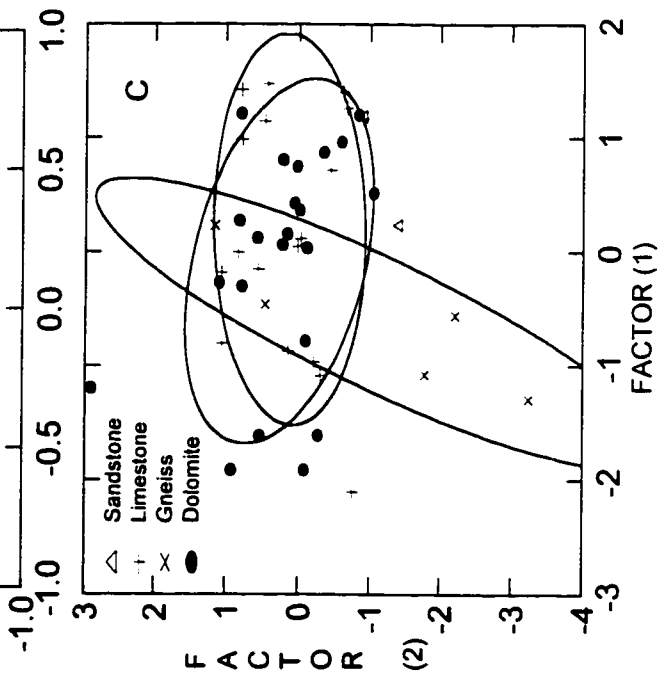
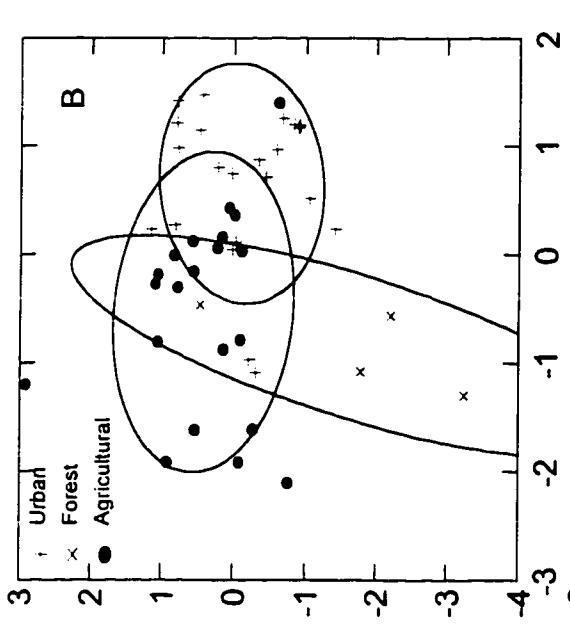
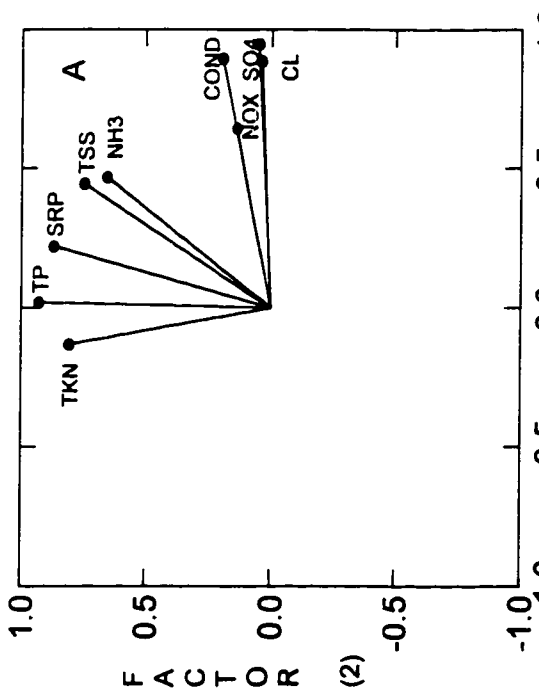


Figure 1. Locations of the sampling sites throughout Eastern Ontario and Western Québec.

**Figure 2. (A) Factor loadings of the water quality parameters on the first two principal components, and (B) ordination of the sampled sites grouped by watershed type, bedrock geology (C), and surficial geology (D). Ellipses are the 68% confidence ellipses.**



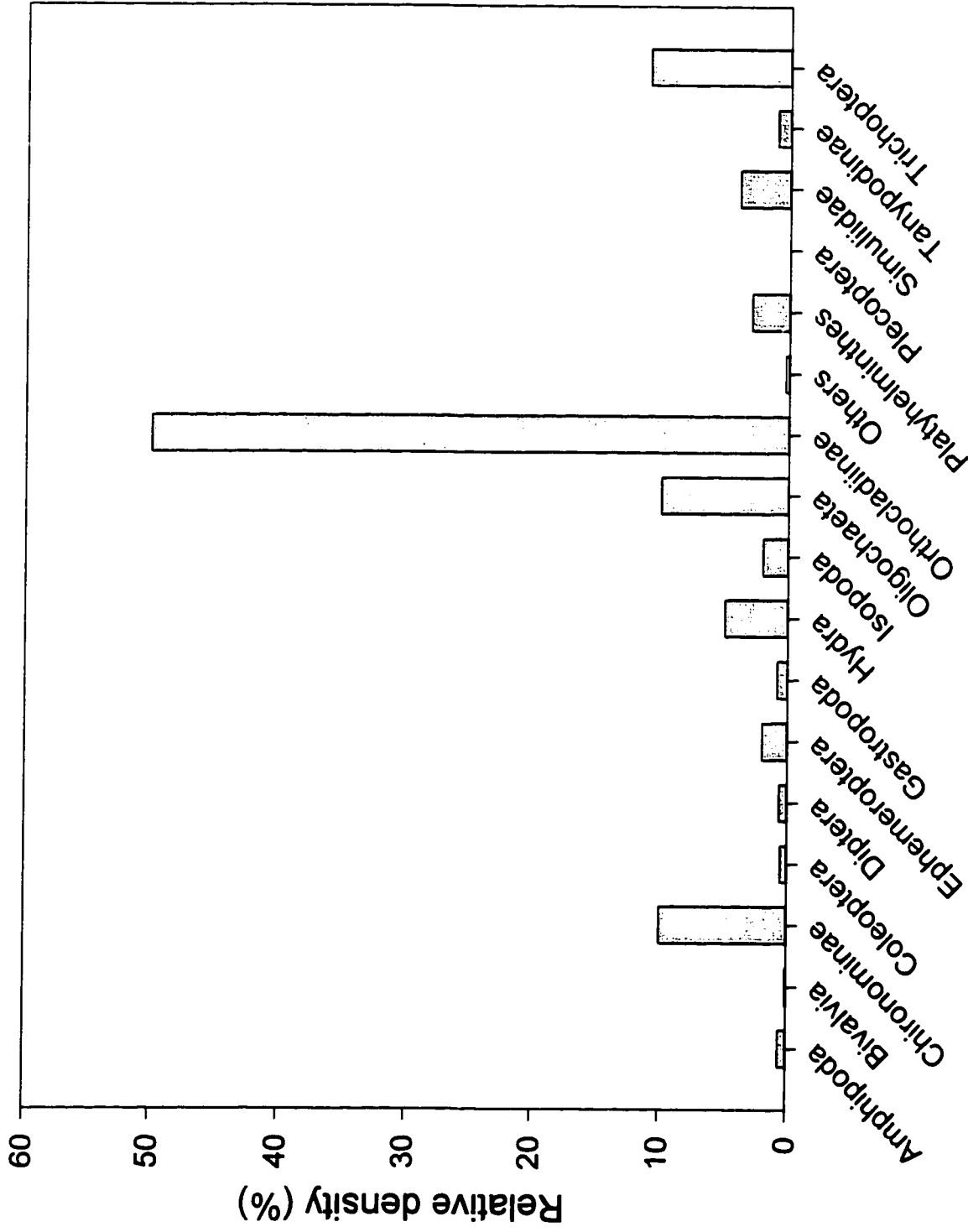


Figure 3. Relative densities of the dominant invertebrate taxa found in streams of Eastern Ontario and Western Québec.

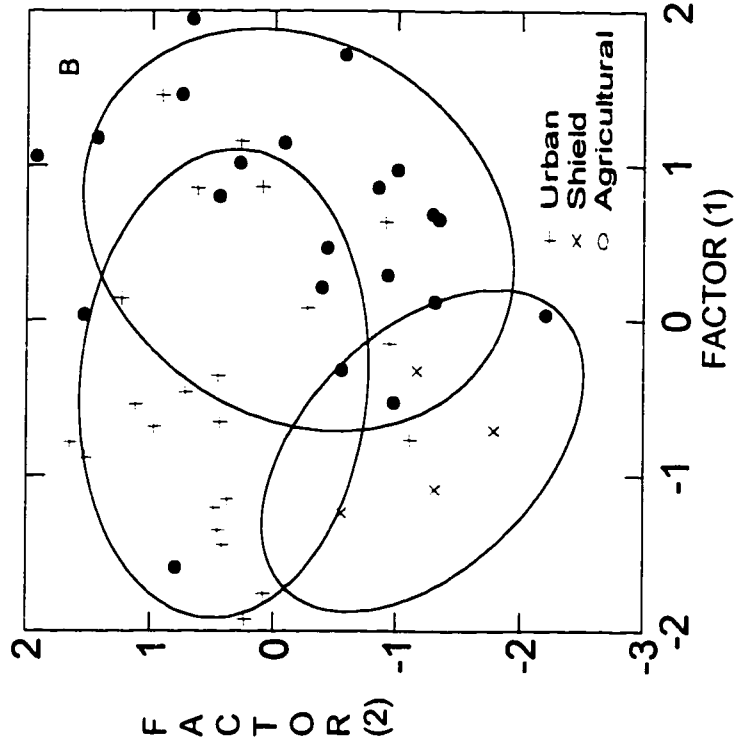
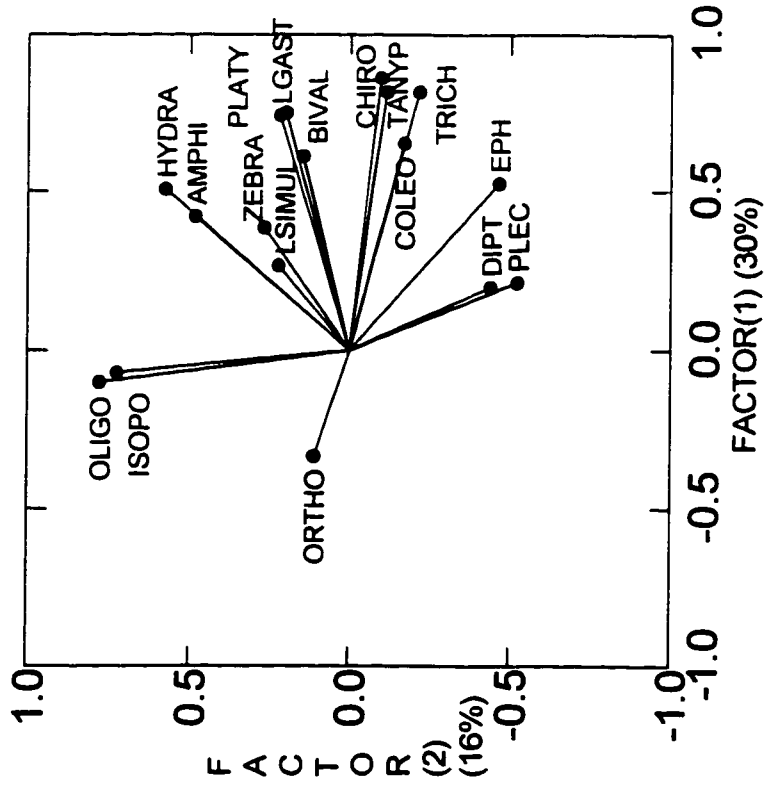


Figure 4. (A) Factor loadings of invertebrate abundance on the first two principal components, and (B) ordination of the sample sites grouped by watershed type.

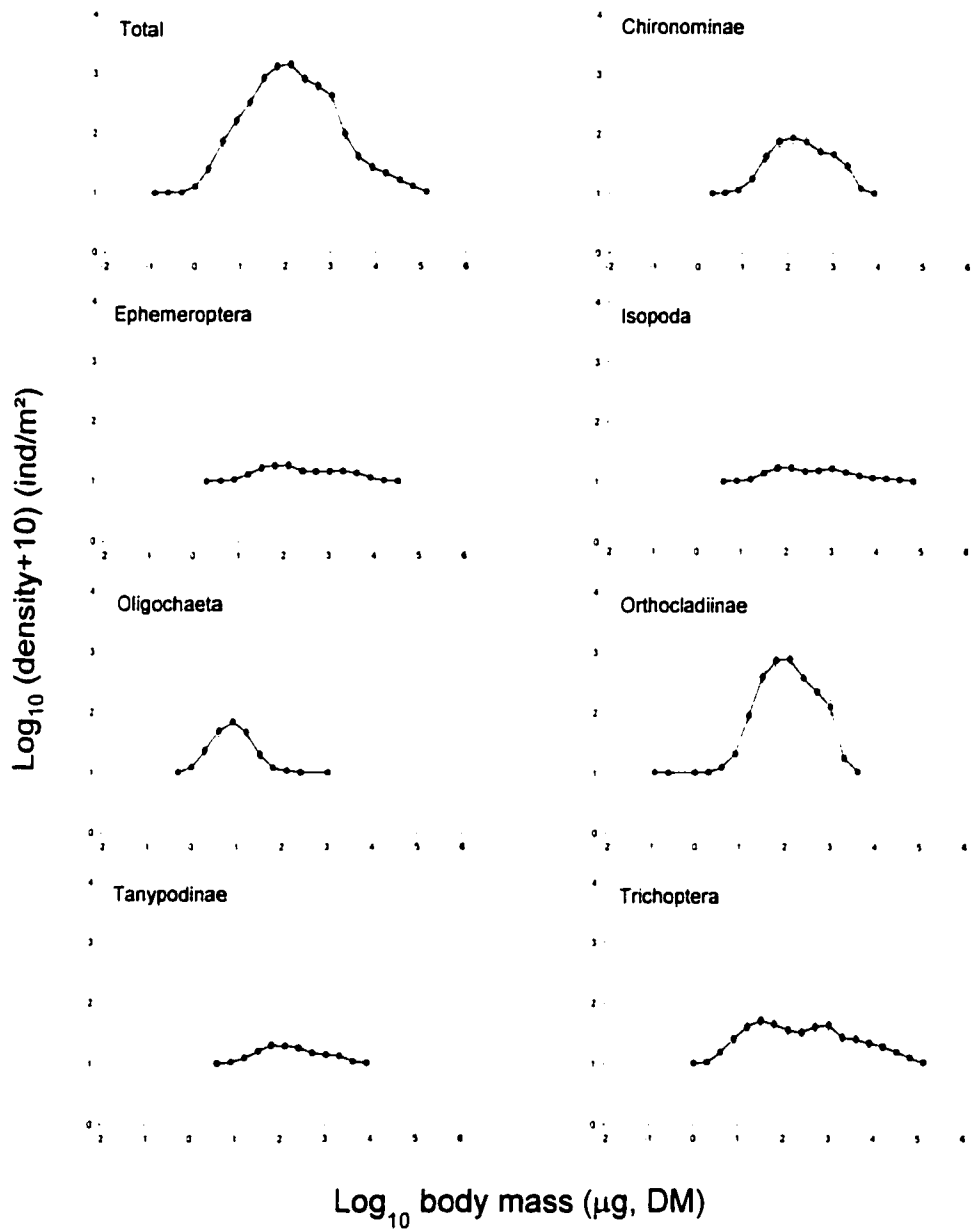
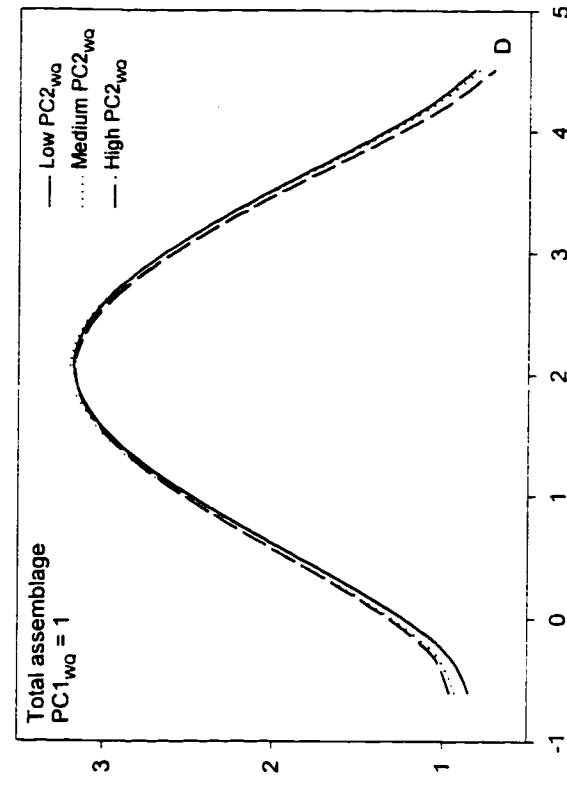
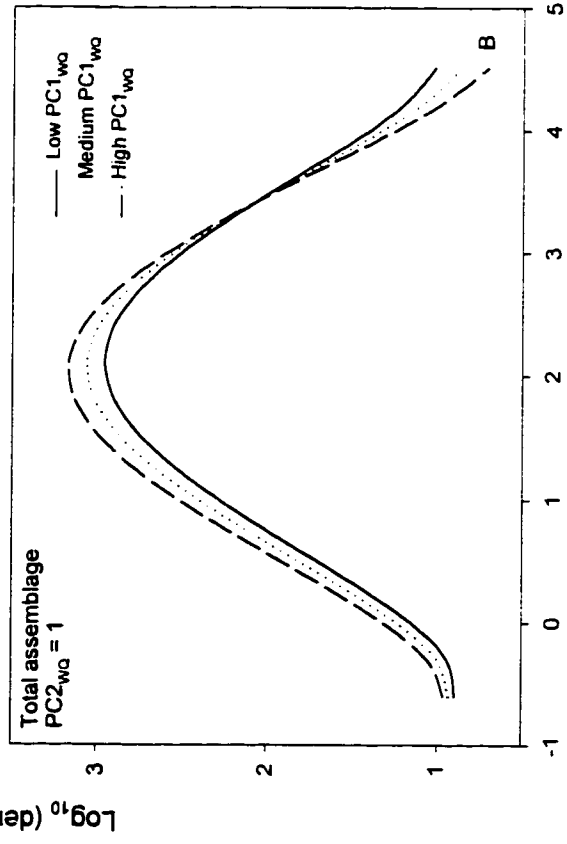
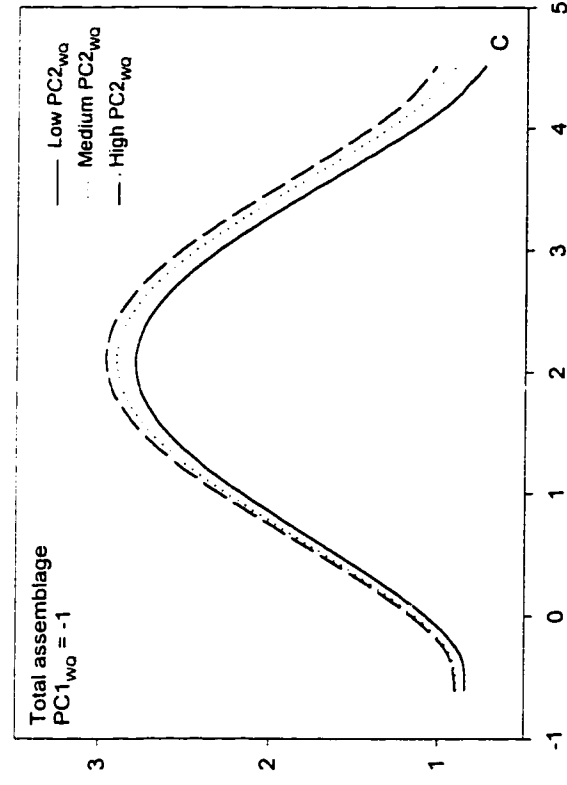
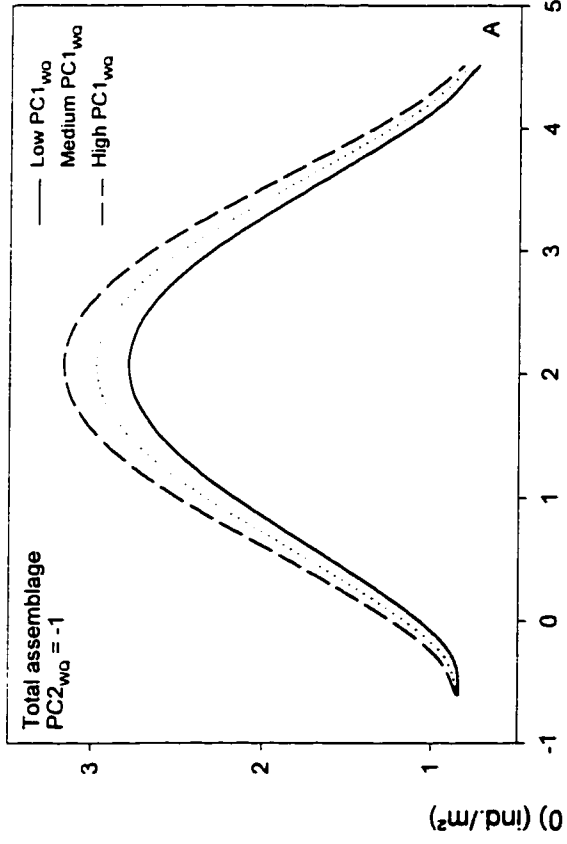
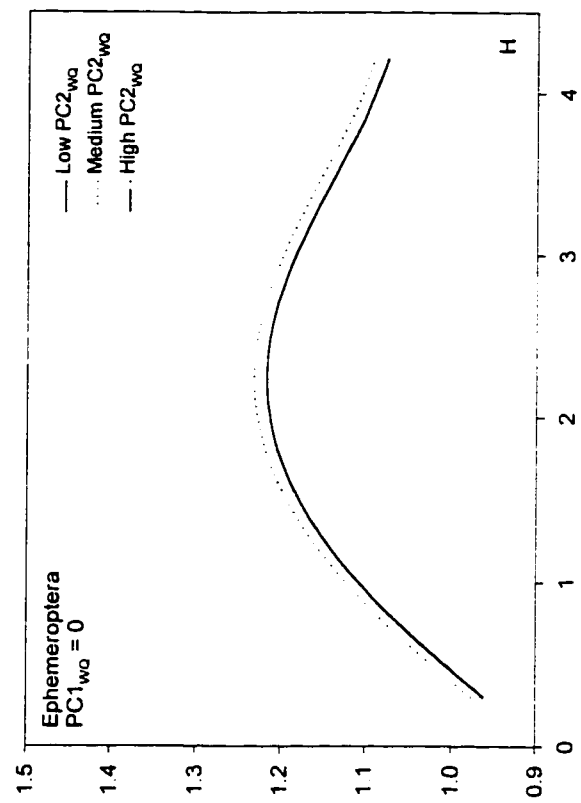
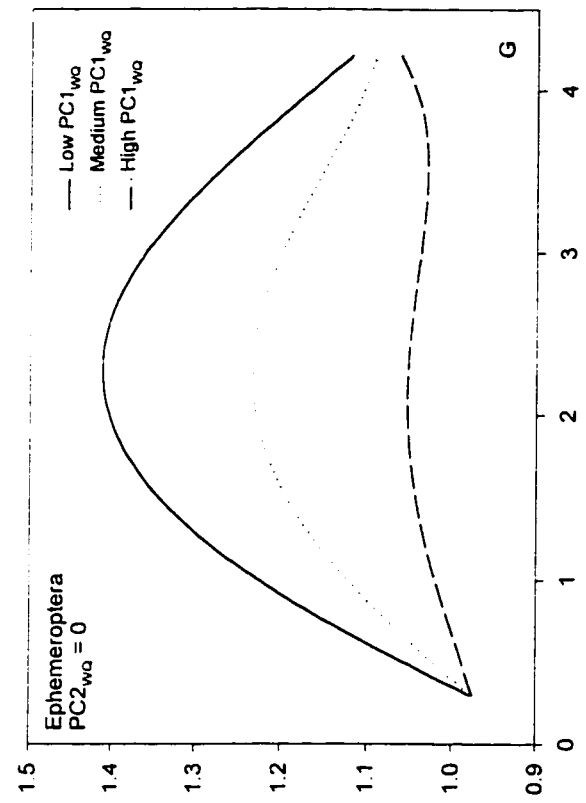
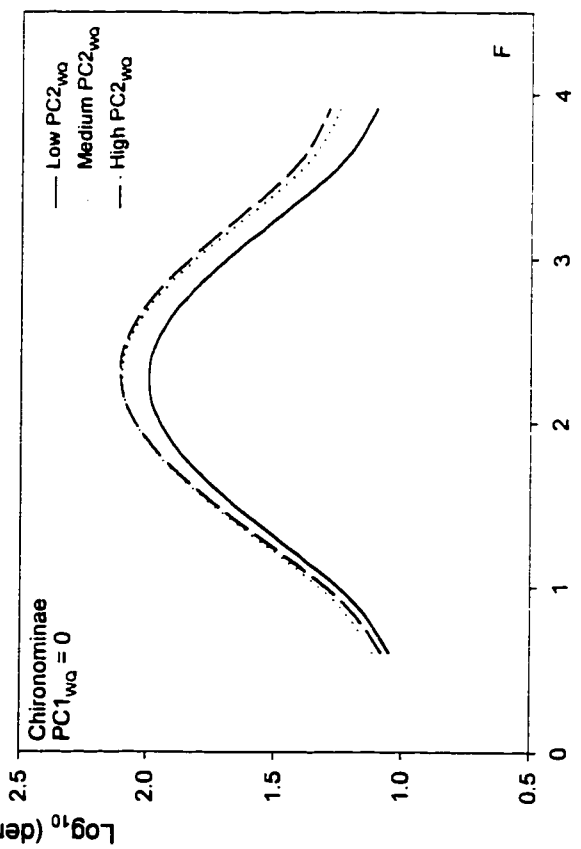
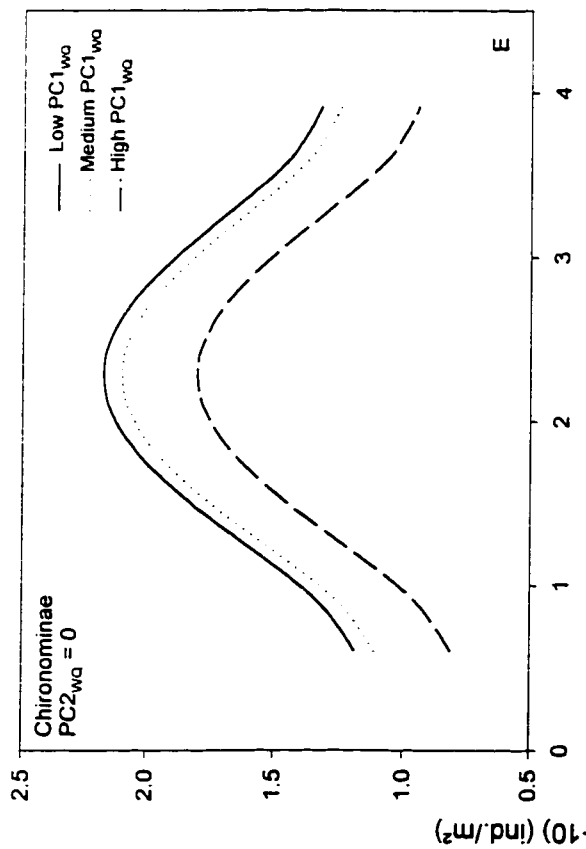


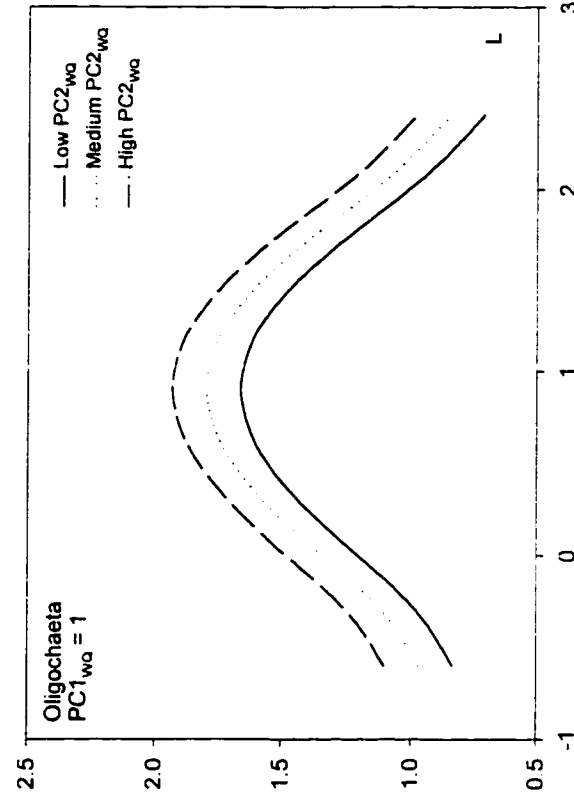
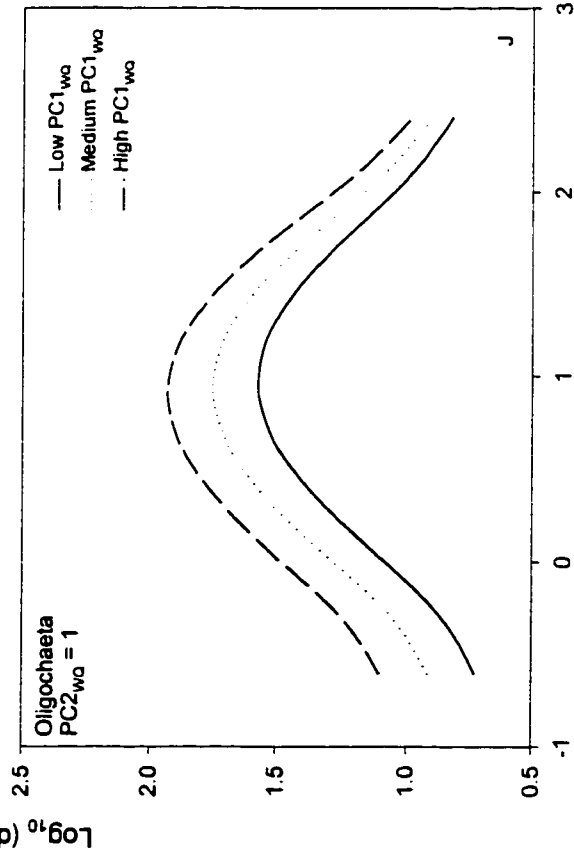
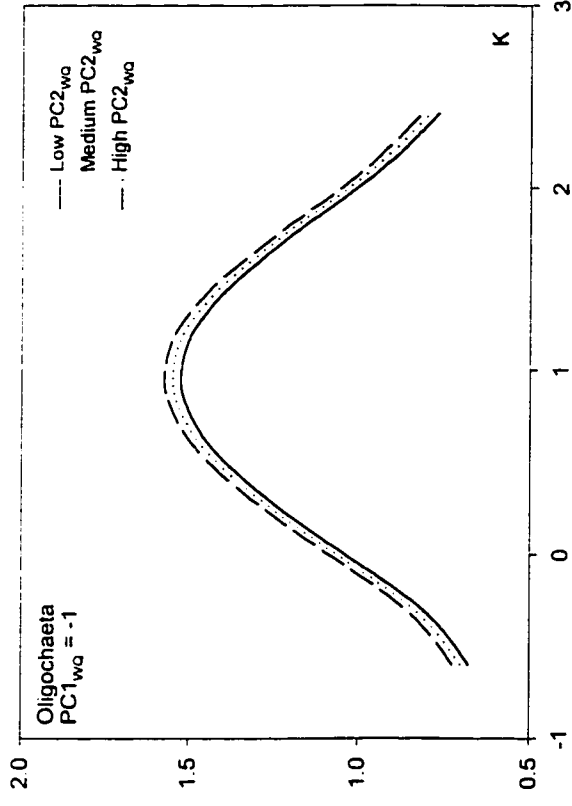
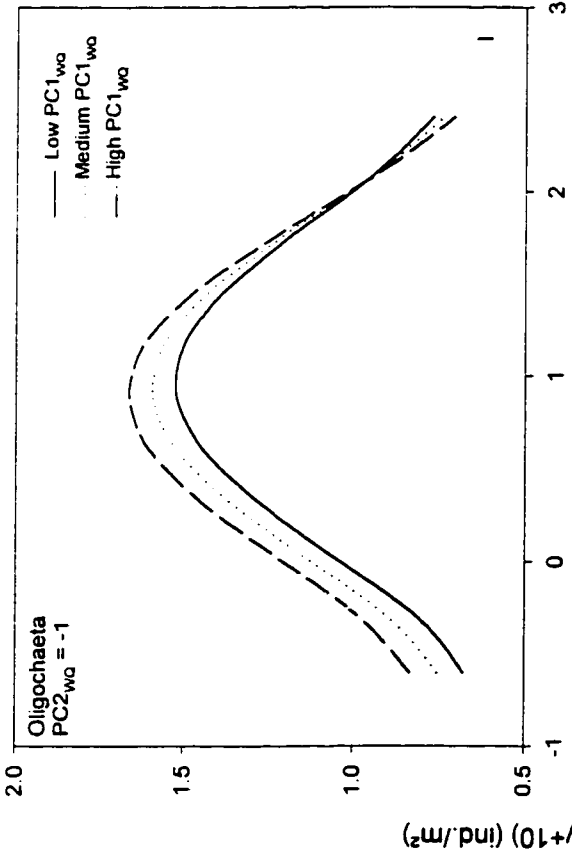
Figure 5. Size distributions of the dominant taxa and of the total assemblage of steam invertebrates. Mean log (density+10) with SE (n=8).

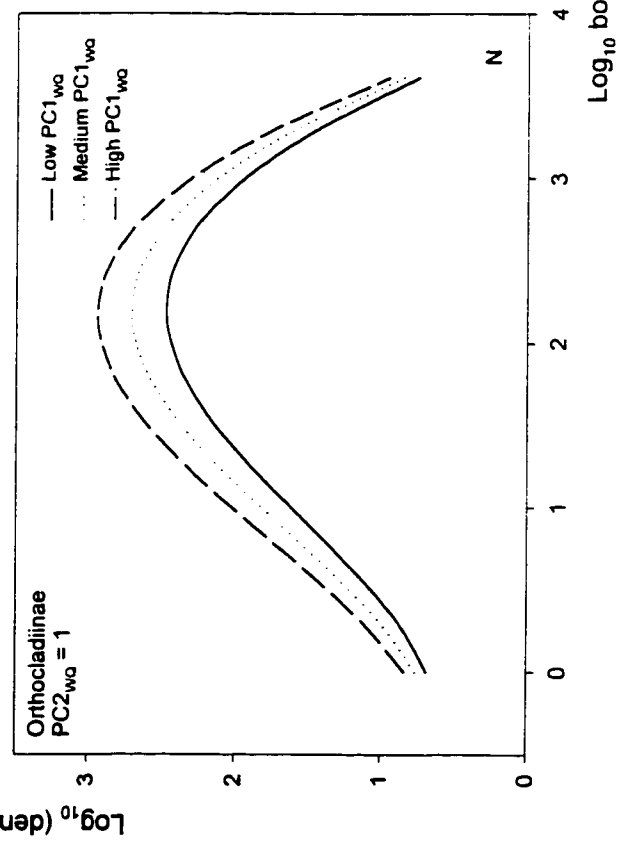
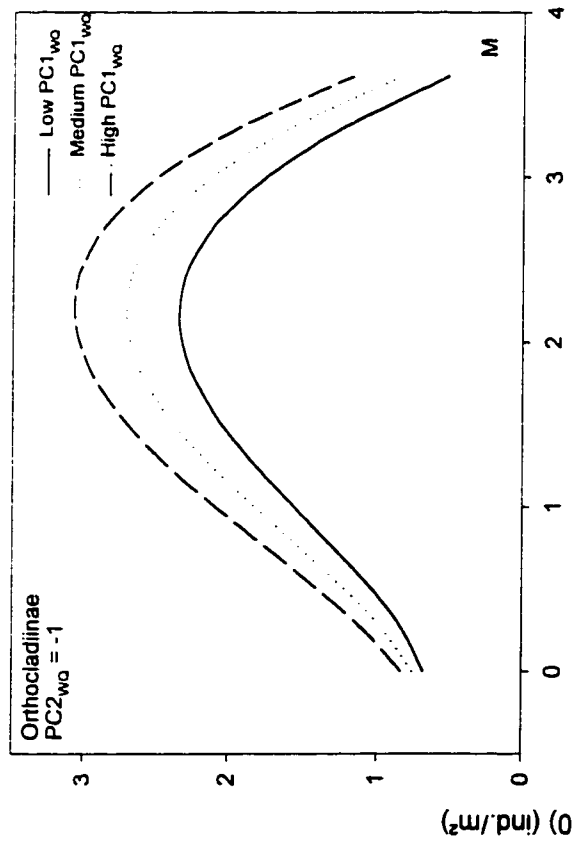
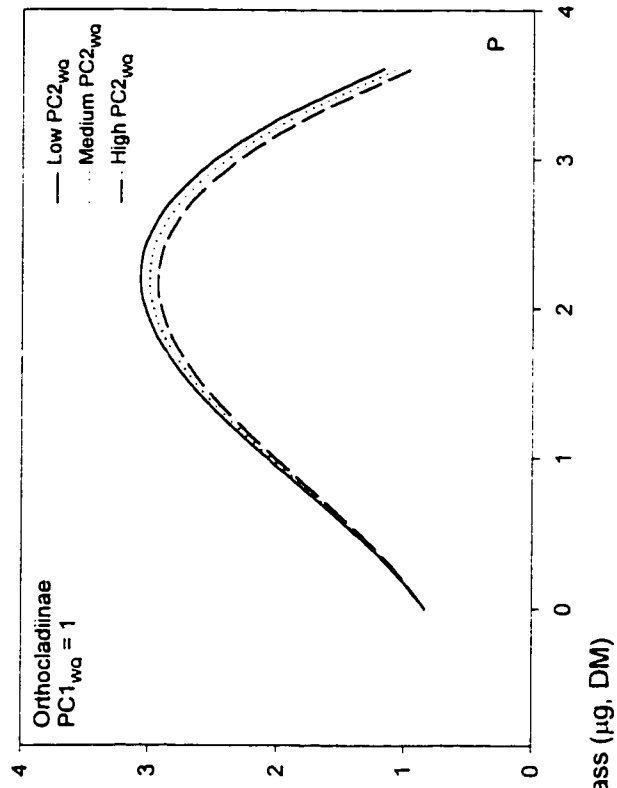
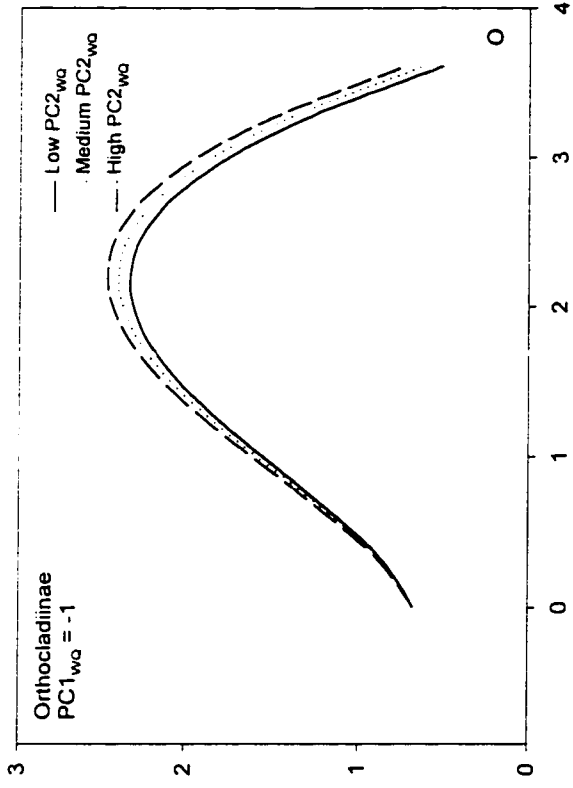
Figure 6. Predicted size distributions of stream invertebrates as a function of water quality. Lines are the densities predicted by the models of Table 7 at low, medium and high values of PC1<sub>wq</sub> (or PC2<sub>wq</sub>) while PC2<sub>wq</sub> (or PC1<sub>wq</sub>) was kept at a mean value. Low values of PC1<sub>wq</sub> are represented by sites with low concentrations of chloride, nitrate and nitrite, conductivity and sulfate while low values of PC2<sub>wq</sub> are represented by sites with low concentrations of total suspended solids, total phosphorus, soluble reactive phosphorus, total Kjeldahl nitrogen and ammonia. High values of PC1<sub>wq</sub> are represented by sites with high concentrations of chloride, nitrate and nitrite, conductivity and sulfate while high values of PC2<sub>wq</sub> are represented by sites with high concentrations of total suspended solids, total phosphorus, soluble reactive phosphorus, total Kjeldahl nitrogen and ammonia.





Log<sub>10</sub> body mass (µg DM)





## TABLES

Table 1. Location and characteristics of the sampling sites.

River	Site #	Latitude	Longitude	Landscape	Geology (generalized bedrock)	Geology (surficial materials)
Bear Brook	BEA01	45°24'N	75°18'W	Agricultural	Shale (thin dolomite)// Black shale	Yellow-fine sand, silt, clay, till
	BEA02	45°25'N	75°05'W	Agricultural	Shale (thin dolomite)// Black shale	Sand, silt, clay
Bilberry Ck.	BIL01	45°29'N	75°32'W	Urban	Limestone// Shale and sandstone	Silt and silty clay
	BIL02	45°27'N	75°30'W	Urban	Limestone	Blue-grey clay, silt
Black Rapids Carp River	BLA01	45°19'N	75°42'W	Urban	Dolomite	Blue-grey clay, silt and silty clay
	CAR01	45°28'N	76°12'W	Agricultural	Dolomite and limestone	Clay, silt and intrusive, metamorphic rocks
Castor Creek	CAR02	45°16'N	75°55'W	Agricultural	Limestone (some sandstone)	Till, clay and sand
	CAR03	45°26'N	76°10'W	Agricultural	Dolomite and limestone	Clay, silt and intrusive, metamorphic rocks
	CAR04	45°17'N	75°54'W	Agricultural	Limestone (some sandstone)	Muck and peat, sand, gravel
	CAS01	45°15'N	75°23'W	Agricultural	Dolomite and sandstone	Till, clay, silt, and sand
Chelsea Ck.	CAS02	45°08'N	75°32'W	Agricultural	Dolomite and sandstone	Till, clay, silt, and sand
	CAS03	45°15'N	75°21'W	Agricultural	Dolomite and sandstone	Till, clay, silt, and sand
	CAS04	45°17'N	75°30'W	Agricultural	Grey shale and dolomite	Till, clay, silt, and sand
	CHE01	45°28'N	75°44'W	Forest	Gneiss	Intrusive and metamorphic rocks
Coady Creek Graham Ck.	CHE02	45°29'N	75°47'W	Forest	Paragneiss	Intrusive and metamorphic rocks
	CHE03	45°30'N	75°49'W	Forest	Gneiss	Intrusive and metamorphic rocks
	CHE04	45°31'N	75°50'W	Forest	Gneiss	Intrusive and metamorphic rocks
	COD01	45°18'N	76°12'W	Agricultural	Limestone and dolomite	Intrusive and metamorphic rocks
Green's Ck.	GRA01	45°20'N	75°48'W	Urban	Dolomite and limestone	Blue-grey clay, silt and silty clay
	GRA02	45°19'N	75°47'W	Urban	Dolomite and limestone	Blue-grey clay, silt and silty clay
	GRE01	45°25'N	75°35'W	Urban	Shale and limestone	Blue-grey clay, silt and silty clay
	GRE03	45°24'N	75°36'W	Urban	Shale and limestone	Blue-grey clay, silt and silty clay
Hunt Club Jock River	GRE04	45°23'N	75°35'W	Agricultural	Shale and limestone	Blue-grey clay, silt and silty clay
	HUN01	45°20'N	75°41'W	Urban	Limestone	Blue-grey clay, silt and silty clay
	JOC01	45°15'N	75°42'W	Agricultural	Dolomite and limestone// Quaternary	Blue-grey clay, silt and silty clay
	JOC08	45°09'N	75°58'W	Agricultural	Dolomite and limestone	Muck and peat, clay and silt
Lemay Creek Lenard Creek	LEM01	45°27'N	75°45'W	Urban	Unknown (Quaternary)	Silt and silty clay
	LEN01	45°30'N	75°30'W	Agricultural	Limestone	Silt and silty clay
Mud Creek Outaouais R.	MUD01	45°13'N	75°42'W	Agricultural	Dolomite	Blue-grey clay, silt and silty clay
	OTT02	45°24'N	75°45'W	Agricultural	Limestone, sandstone	Silt and silty clay
Pinecrest Ck.	PIN01	45°22'N	75°47'W	Urban	Limestone	Till, silt and sand
	PIN02	45°21'N	75°46'W	Urban	Limestone	Silt and silty clay

River	Site #	Latitude	Longitude	Landscape	Geology (generalized bedrock)	Geology (surficial materials)
Rideau River	RID01	45°25'N	75°40'W	Urban	Limestone and shale	Clay and silt
	RID04	45°22'N	75°41'W	Urban	Limestone	Clay and silt
	RID07	45°14'N	75°40'W	Agricultural	Dolomite	Blue-grey clay, silt and silty clay
Sawmill Ck	SAW01	45°23'N	75°40'W	Urban	Black shale and dolomite	Silt and silty clay
	SAW02	45°20'N	75°37'W	Urban	Grey shale	Yellow-fine sand
South Nation	SOU01	45°32'N	74°59'W	Agricultural	Limestone, shale	Silt, clay, sands and silty clay
	SOU02	45°19'N	75°05'W	Agricultural	Limestone and shale	Silt, clay, sands and silty clay
	SOU03	45°13'N	75°09'W	Agricultural	Limestone and shale	Silt, sands and silty clay
	SOU04	44°59'N	75°27'W	Agricultural	Dolomite and sandstone	Silt, sands and silty clay
	SOU05	44°50'N	75°32'W	Agricultural	Dolomite and sandstone	Silt, sands and silty clay
Stillwater Ck.	STI01	45°20'N	75°49'W	Urban	Dolomite and limestone	Silt, blue-grey clay and silty clay
	WAT01	45°20'N	75°53'W	Urban	Dolomite and limestone	Silt and silty clay
Watt's Creek	WAT02	45°19'N	75°55'W	Urban	Dolomite and limestone	Blue-grey clay, silt and silty clay
	WAT03	45°20'N	75°54'W	Urban	Sandstone// Dolomite and limestone	Blue-grey clay, silt and silty clay
	WAT04	45°18'N	75°54'W	Urban	Sandstone// Dolomite and limestone	Blue-grey clay, silt and silty clay

Table 2. Physico-chemical parameters of the rocks sampled and the sampling sites. With the exception of five sampling sites, the concentration of chloride, conductivity, ammonia, nitrate+nitrite, sulfate, soluble reactive phosphorus, total Kjeldahl nitrogen, total phosphorus and total suspended solids are annual means. Legend: \* - (Denotes sites with a single observation), Type - (Type of watershed), A - (Surface area of the rock), D - (Depth where the rock was collected), V<sub>1</sub> - (Water velocity at maximum water depth), V<sub>2</sub> - (Water velocity at 60% of the water depth), Peri - (Periphyton) (mg chla/m<sup>2</sup>), Cl - (Chloride), Con - (Conductivity), NH<sub>3</sub> - (Ammonia), NO<sub>x</sub> - (Nitrite and nitrate), SO<sub>4</sub> - (Sulfate), SRP - (Soluble reactive phosphorus), TC - (Water temperature), TKN - (Total Kjeldahl nitrogen), TP - (Total phosphorus), TSS - (Total suspended solids).

Station	Type	A Cm <sup>2</sup>	D cm	V1 m/s	V2 m/s	Peri	Cl mg/L	Con uS/cm	NH <sub>3</sub> mg/L	NO <sub>x</sub> mg/L	pH	SO <sub>4</sub> mg/L	SRP mg/L	TC °C	TKN mg/L	TP mg/L	TSS mg/L
BEA01	Agricultural	135.5	12.4	1.13	1.08	32.4	93	690	0.063	0.35	8.1	47	0.04	13	0.78	0.067	10.4
BEA02	Agricultural	148	6.25	0.59	0.59	34.1	81	579	0.033	0.378	8.1	24	0.06	17	0.84	0.111	34
BIL01	Urban	113.9	9.88	0.85	0.81	60.9	317	1544	0.117	1.091	8.2	86	0.06	15	0.6	0.087	33.3
BIL02	Urban	98.01	6.88	0.68	0.68	49	270	1489	0.028	0.87	7.7	93	0.05	12	0.35	0.052	2.3
BLA01	Urban	135.2	8.75	0.96	0.79	27.4	92	719	0.108	1.734	7.9	22	0.06	10	0.61	0.085	12.9
CAR01	Agricultural	123.8	11.4	0.96	0.78	23.9	91	666	0.076	0.307	8.3	29	0.01	13	0.67	0.052	12.8
CAR02	Urban	132.3	6.25	0.55	0.55	118	54	707	0.066	0.178	7.8	73	0.01	9.3	0.82	0.041	6.76
CAR03	Agricultural	172.3	17.8	0.6	0.45	28.1	107	745	0.07	0.297	8.1	34	0.02	15	0.69	0.05	7.5
CAR04	Urban	120.7	8.63	0.93	0.93	34.2	113	806	0.055	0.03	7.3	63	0.02	16	0.56	0.046	11.2
CAS01	Agricultural	95.73	7.25	1.18	1.18	76.8	28	552	0.043	0.495	8.2	42	0.05	17	0.64	0.086	21.6
CAS02	Agricultural	108.7	15	1.01	0.73	52.6	27	531	0.039	0.12	8.1	42	0.26	14	1.44	1.7	18.6
CAS03	Agricultural	127.6	12.3	0.45	0.4	33.7	51	668	0.024	0.237	8.5	91	0.01	17	0.73	0.049	9.48
CAS04	Agricultural	130.1	8.88	1.35	1.35	28	69	959	0.045	0.094	8.2	137	0.02	21	0.62	0.044	17.3
CHE01*	Forest	124.4	13.5	1.1	0.96	11.4	57	444	0.034	0.145	7.7	16	0.05	14	0.36	0.076	37
CHE02*	Forest	291	14.1	0.9	0.76	8.95	59	398	0.004	0.149	8.1	17	0	12	0.28	0.011	1.5
CHE03*	Forest	188.8	15.5	1.03	0.99	5.34	40	317	0.007	0.078	8	10	0	13	0.36	0.015	1.6
CHE04*	Forest	117	6.13	0.94	0.94	5.19	13	199	0.005	0.16	8	7.4	0	10	0.12	0.005	0.4
COD01	Agricultural	148.2	9.88	1.33	1.26	37.9	35	518	0.05	0.215	8	12	0.07	13	0.67	0.095	16.1
GRA01	Urban	148.5	17.9	0.85	0.7	74.3	208	1137	0.038	1.181	8.2	74	0.01	12	0.39	0.028	7.89
GRA02	Urban	131.4	13.5	0.49	0.43	18.9	117	816	0.037	1.47	8	63	0.02	6.3	0.36	0.045	21.1
GRE01	Urban	111.6	11.3	0.94	0.93	18.9	300	1380	0.098	0.285	8	112	0.03	11	0.74	0.067	18.3
GRE03	Urban	137.2	9	0.81	0.75	16.6	220	1127	0.23	0.33	7.2	85	0.03	14	0.82	0.06	24
GRE04	Agricultural	124.1	14.4	1.6	1.23	49.5	154	1320	0.135	0.27	7.7	220	0.01	16	0.44	0.022	8.4
HUN01	Urban	251	9.13	0.99	0.93	31.9	139	882	0.062	0.474	8.1	66	0.01	13	0.53	0.033	6.36

Station	Type	A Cm <sup>2</sup>	D cm	V1 m/s	V2 m/s	Peri	Cl mg/L	Con uS/cm	NH <sub>3</sub> mg/L	NO <sub>x</sub> mg/L	pH	SO <sub>4</sub> mg/L	SRP mg/L	TC °C	TKN mg/L	TP mg/L	TSS mg/L
JOC01	Agricultural	135.4	16	0.44	0.28	43.1	35	486	0.029	0.181	8.3	16	0.02	16	0.67	0.041	4.25
JOC08	Agricultural	112.8	7.88	0.65	0.65	32	17	368	0.043	0.074	8.2	6	0.02	16	0.86	0.056	5.07
LEM01*	Urban	157.1	7.5	1.16	1.16	24.4	90	690	0.113	0.56	7	24	0.1	12	0.58	0.068	60
LEN01	Agricultural	92.03	6.5	1.53	1.53	46.7	55	654	0.048	0.548	8.3	32	0.06	16	0.56	0.093	29.8
MUD01	Agricultural	166.8	16.6	1.16	0.56	47.1	67	724	0.067	1.088	8.1	48	0.02	15	0.57	0.046	6.34
OTT02	Agricultural	146.4	9.63	0.59	0.55	8.79	4.2	100	0.02	0.208	7.6	7.1	0.01	5	0.3	0.021	5.15
PIN01	Urban	125.9	9.38	0.5	0.49	68.3	194	1064	0.024	1.757	8.1	81	0.02	16	0.37	0.031	5.94
PIN02	Urban	162.8	19.6	1.88	1.23	41.5	356	1536	0.093	2.117	8	59	0.04	6.9	0.62	0.059	31.6
RID01	Urban	160.5	17.1	1.05	0.7	30.5	27	337	0.073	0.146	7.8	12	0.01	10	0.55	0.033	3.85
RID04	Urban	154.3	15	1.31	0.93	28.3	20	315	0.06	0.169	7.9	10	0.01	11	0.51	0.028	4.42
RID07	Agricultural	155.8	21.9	0.94	0.59	26.8	15	281	0.028	0.079	8.1	7.6	0.02	18	0.56	0.031	1.99
SAW01	Urban	151.8	8	1.19	1.19	38.9	250	1249	0.244	0.716	8.1	88	0.03	11	0.83	0.061	26.9
SAW02	Urban	161.9	8.88	0.95	0.9	31.8	121	944	0.034	0.079	7.7	94	0.01	15	0.43	0.026	3.2
SOU01	Agricultural	133.5	14.6	1.44	1.01	84.6	43	538	0.068	1.177	8.3	34	0.04	18	0.99	0.086	21.8
SOU02	Agricultural	155.8	23.8	0.51	0.19	17	34	574	0.074	1.063	8.4	43	0.02	17	1.01	0.058	9.1
SOU03	Agricultural	150.7	13.5	0.78	0.51	30.2	21	508	0.051	0.325	8.4	20	0.01	18	1.1	0.047	2.8
SOU04	Agricultural	173.4	19.3	0.73	0.58	26.5	17	434	0.02	0.009	8.3	7.3	0.01	17	1.08	0.037	3.1
SOU05	Agricultural	120.8	23.6	1.45	0.85	53.4	22	460	0.052	0.029	8.2	3	0.04	18	1.17	0.061	3.07
STI01	Urban	171.7	8	0.79	0.79	49	208	1092	0.07	0.35	8	45	0.02	15	0.59	0.044	11.6
WAT01	Urban	132.3	9.38	1.14	1.08	48.9	192	1002	0.048	0.589	8.2	61	0.03	17	0.55	0.064	17.3
WAT02	Urban	147	11.5	0.6	0.6	21.8	158	847	0.054	1.252	8.2	76	0.01	5.9	0.47	0.031	7.92
WAT03	Urban	142.7	12.9	0.88	0.85	35.9	85	1248	0.023	0.02	8.1	102	0	21	0.52	0.025	1.5
WAT04	Urban	194.2	14.5	0.61	0.5	24.5	240	806	0.035	1.96	8.1	65	0.02	13	0.36	0.019	10

Table 3. Correlation coefficients (p values) between water quality variables. Legend: Peri – (Periphyton) (mg chla/m<sup>2</sup>), Cl – Log<sub>10</sub> (Chloride) (mg/L), Conduct – Log<sub>10</sub> (Conductivity) (µs/cm), NH<sub>3</sub> – Log<sub>10</sub> (Ammonia) (mg/L), NO<sub>x</sub> – Log<sub>10</sub> (Nitrite and nitrate) (mg/L), SO<sub>4</sub> – Log<sub>10</sub> (Sulfate) (mg/L), SRP – Log<sub>10</sub> (Soluble reactive phosphorus) (mg/L), TKN – Log<sub>10</sub> (Total Kjeldahl nitrogen) (mg/L), TP – Log<sub>10</sub> (Total phosphorus) (mg/L), TSS Log<sub>10</sub> (Total suspended solids) (mg/L).

	Peri	Cl	Conduct	NH <sub>3</sub>	NO <sub>x</sub>	SO <sub>4</sub>	SRP	TKN	TP	TSS
Peri	1.000 (0.0)									
Cl	0.293 (1.000)	1.000 (0.0)								
Conduct	<b>0.521</b> <b>(0.011)</b>	<b>0.917</b> <b>(&lt;0.001)</b>	1.000 (0.0)							
NH <sub>3</sub>	0.477 (0.042)	0.441 (0.069)	<b>0.530</b> <b>(0.005)</b>	1.000 (0.0)						
NO <sub>x</sub>	0.207 (1.000)	<b>0.514</b> <b>(0.008)</b>	0.384 (0.276)	0.355 (0.521)	1.000 (0.0)					
SO <sub>4</sub>	0.381 (0.440)	<b>0.779</b> <b>(&lt;0.001)</b>	<b>0.836</b> <b>(&lt;0.001)</b>	0.400 (0.193)	0.421 (0.116)	1.000 (0.0)				
SRP	0.464 (0.059)	0.262 (1.000)	0.315 (1.000)	<b>0.551</b> <b>(0.002)</b>	0.379 (0.312)	0.158 (1.000)	1.000 (0.0)			
TKN	<b>0.495</b> <b>(0.025)</b>	-0.056 (1.000)	0.178 (1.000)	<b>0.541</b> <b>(0.003)</b>	-0.142 (1.000)	0.002 (1.000)	<b>0.476</b> <b>(0.026)</b>	1.000 (0.0)		
TP	0.462 (0.062)	0.076 (1.000)	0.223 (1.000)	<b>0.462</b> <b>(0.039)</b>	0.115 (1.000)	0.120 (1.000)	<b>0.859</b> <b>(&lt;0.001)</b>	<b>0.709</b> <b>(&lt;0.001)</b>	1.000 (0.0)	
TSS	0.339 (1.000)	0.434 (0.084)	0.426 (0.101)	<b>0.665</b> <b>(&lt;0.001)</b>	<b>0.460</b> <b>(0.042)</b>	0.380 (0.305)	<b>0.780</b> <b>(&lt;0.001)</b>	0.392 (0.231)	<b>0.648</b> <b>(&lt;0.001)</b>	1.000 (0.0)

Table 4. Multiple regression models of the principal components on taxa as a function of the principal components of water quality. Legend: PC1<sub>wq</sub> - (chloride, sulfate, conductivity and nitrate+nitrite), PC2<sub>wq</sub> - (total suspended solids, total phosphorus, soluble reactive phosphorus, total Kjeldahl nitrogen, ammonia), SE - (standard error), p - (p values), n - (number of observations), R<sup>2</sup> - (proportion of the variance in the data explained by the models), RMS - (Residual mean square).

Dependent	Effect	Coefficient	SE	p	n	R <sup>2</sup>	RMS
Factor 1	Constant	0.000	0.125	1.000	47	0.301	0.731
	PC1 <sub>wq</sub>	-0.436	0.126	0.001			
	PC2 <sub>wq</sub>	0.333	0.126	0.011			
Factor 2	Constant	0.000	0.135	1.000	47	0.156	0.862
	PC1 <sub>wq</sub>	0.395	0.137	0.006			

Table 5. Taxa richness as a function of the principal components of water quality. Legend: PC2<sub>wq</sub> – (total suspended solids, total phosphorus, soluble reactive phosphorus, total Kjeldahl nitrogen, ammonia), SE – (Standard Error), p – (p values), n – (number of observations), R<sup>2</sup> – (proportion of the variance in the data explained by the models), RMS – (Residual mean square), PE – (Pure error).

Dependent variable	Independent variables	Coefficient	SE	p	n	R <sup>2</sup>	RMS	PE
Richness	Constant	1.164	0.036	0.000	47	0.182	0.060	0.0016
	PC2 <sub>wq</sub>	0.115	0.036	0.003				

Table 6. Multiple regression models of abundance per taxa as a function of water quality in streams of the Ottawa Valley. Legend: PC1<sub>wq</sub> - (chloride, sulfate, conductivity and nitrate+nitrite), PC2<sub>wq</sub> - (total suspended solids, total phosphorus, soluble reactive phosphorus, total Kjeldahl nitrogen, ammonia) (SE) - (standard error), n - (number of observations), R<sup>2</sup> - (proportion of the variance in the data explained by the models), RMS - (Residual mean square), PE - (Pure error). \* = p<0.05, \*\*=p<0.01, \*\*\*=p<0.001.

Taxa	Constant Coefficient (SE)	PC1 <sub>wq</sub> Coefficient (SE)	PC2 <sub>wq</sub> Coefficient (SE)	n	R <sup>2</sup>	RMS	PE
Ephemeroptera	1.884*** (0.080)	-0.505*** (0.081)	n.s.	47	0.463	0.303	0.020
Chironominae	2.722*** (0.106)	-0.330*** (0.107)	0.320** (0.107)	47	0.296	0.525	0.010
Orthoclaadiinae	3.698*** (0.056)	0.313*** (0.057)	n.s.	47	0.402	0.149	0.022
Tanypodinae	2.065*** (0.069)	-0.179* (0.070)	n.s.	47	0.127	0.226	0.003
Simuliidae	1.947*** (0.118)	0.286* (0.120)	n.s.	47	0.113	0.657	0.050
Gastropoda	1.779*** (0.072)	n.s.	0.316*** (0.073)	47	0.295	0.244	0.011
<i>D. polymorpha</i>	1.120*** (0.046)	-0.127*** (0.047)	n.s.	47	0.139	0.102	0.001
Isopoda	1.786*** (0.110)	0.356** (0.111)	n.s.	47	0.186	0.568	0.004
Oligochaeta	2.550*** (0.111)	0.333** (0.112)	0.247* (0.112)	47	0.237	0.578	0.016
Platyhelminthes	1.984*** (0.113)	-0.297* (0.114)	0.307 (0.114)	47	0.241	0.600	0.078

Table 7. Multiple regression models predicting the density per size class of the total assemblage and of the dominant taxa. Legend: M-Log<sub>10</sub> (dry mass) (µg), PC1<sub>wq</sub> - (chloride, sulfate, conductivity, nitrate+nitrite), PC2<sub>wq</sub> - (soluble reactive phosphorus, total phosphorus, total Kjeldahl nitrogen, total suspended solids, ammonia), Coeff. - (Coefficient), SE - (standard Error), p - (p value), R<sup>2</sup> - (proportion of the variance in the data explained by the models), RMS - (Residual mean square), PE - (Pure error).

Taxa	Effect	Coeff.	SE	p	R <sup>2</sup>	RMS	PE
Total	Constant	1.192	0.029	0.000	0.769	0.179	0.023
	M	0.969	0.030	0.000			
	M <sup>2</sup>	0.532	0.038	0.000			
	M <sup>3</sup>	-0.368	0.016	0.000			
	M <sup>4</sup>	0.044	0.002	0.000			
	Constant	1.215	0.028	0.000	0.803	0.154	0.023
	M	0.969	0.027	0.000			
	M <sup>2</sup>	0.532	0.035	0.000			
	M <sup>3</sup>	-0.368	0.015	0.000			
	M <sup>4</sup>	0.044	0.002	0.000			
	PC1 <sub>wq</sub>	0.081	0.020	0.000			
	PC2 <sub>wq</sub>	0.042	0.014	0.003			
	M*PC1 <sub>wq</sub>	0.087	0.019	0.000			
	M*PC1 <sub>wq</sub> *PC2 <sub>wq</sub>	-0.022	0.005	0.000			
	M <sup>2</sup> *PC1 <sub>wq</sub>	-0.026	0.004	0.000			
PC2 <sub>wq</sub> *PC2 <sub>wq</sub>	-0.023	0.007	0.001				
Chironominae	Constant	1.412	0.160	0.000	0.370	0.210	0.019
	M	-2.026	0.484	0.000			
	M <sup>2</sup>	2.634	0.444	0.000			
	M <sup>3</sup>	-0.965	0.156	0.000			
	M <sup>4</sup>	0.107	0.018	0.000			
	Constant	1.574	0.145	0.000	0.494	0.172	0.019
	M	-2.026	0.435	0.000			
	M <sup>2</sup>	2.634	0.399	0.000			
	M <sup>3</sup>	-0.965	0.140	0.000			
	M <sup>4</sup>	0.107	0.016	0.000			
PC1 <sub>wq</sub>	-0.188	0.019	0.000				
M*PC2 <sub>wq</sub>	0.024	0.007	0.001				
PC1 <sub>wq</sub> *PC1 <sub>wq</sub>	-0.112	0.017	0.000				
PC2 <sub>wq</sub> *PC2 <sub>wq</sub>	-0.049	0.009	0.000				
Ephemeroptera	Constant	0.907	0.031	0.000	0.10	0.058	0.009
	M	0.252	0.030	0.000			
	M <sup>2</sup>	-0.053	0.006	0.000			
	Constant	0.905	0.032	0.000	0.329	0.044	0.009
	M	0.242	0.034	0.000			
	M <sup>3</sup>	-0.028	0.006	0.000			
	M <sup>4</sup>	0.004	0.001	0.001			
	PC1 <sub>wq</sub>	0.055	0.027	0.045			
	M*PC1 <sub>wq</sub>	-0.201	0.026	0.000			
	M <sup>2</sup> *PC1 <sub>wq</sub>	0.043	0.005	0.000			
PC2 <sub>wq</sub> *PC2 <sub>wq</sub>	-0.015	0.004	0.000				

Taxa	Effect	Coeff.	SE	p	R <sup>2</sup>	RMS	PE	
Isopoda	Constant	0.794	0.047	0.000	0.105	0.050	0.009	
	M	0.286	0.043	0.000				
	M <sup>3</sup>	-0.029	0.006	0.000				
	M <sup>4</sup>	0.004	0.001	0.000				
		Constant	0.773	0.045	0.000	0.226	0.044	0.009
		M	0.286	0.040	0.000			
		M <sup>3</sup>	-0.029	0.006	0.000			
		M <sup>4</sup>	0.004	0.001	0.000			
		M*PC1 <sub>wq</sub>	0.097	0.011	0.000			
		M <sup>2</sup> *PC1 <sub>wq</sub>	-0.020	0.003	0.000			
		PC1 <sub>wq</sub> *PC1 <sub>wq</sub>	0.021	0.008	0.008			
	Oligochaeta	Constant	1.204	0.034	0.000	0.302	0.184	0.018
		M	0.797	0.067	0.000			
M <sup>3</sup>		-0.449	0.036	0.000				
M <sup>4</sup>		0.118	0.010	0.000				
		Constant	1.204	0.033	0.000	0.359	0.171	0.018
		M	0.797	0.064	0.000			
		M <sup>3</sup>	-0.449	0.034	0.000			
		M <sup>4</sup>	0.118	0.010	0.000			
		PC1 <sub>wq</sub>	0.141	0.025	0.000			
		PC2 <sub>wq</sub>	0.080	0.022	0.000			
		PC1 <sub>wq</sub> *PC2 <sub>wq</sub>	0.056	0.020	0.006			
		M <sup>2</sup> *PC1 <sub>wq</sub>	-0.020	0.007	0.002			
Orthocladinae		Constant	0.759	0.045	0.000	0.664	0.252	0.018
	M	0.590	0.047	0.000				
	M <sup>2</sup>	0.816	0.064	0.000				
	M <sup>3</sup>	-0.374	0.045	0.000				
		M <sup>4</sup>	0.029	0.008	0.000	0.746	0.191	0.018
		Constant	0.759	0.039	0.000			
		M	0.590	0.041	0.000			
		M <sup>2</sup>	0.816	0.056	0.000			
		M <sup>3</sup>	-0.374	0.040	0.000			
		M <sup>4</sup>	0.029	0.007	0.000			
		PC1 <sub>wq</sub>	0.076	0.024	0.002			
		M*PC1 <sub>wq</sub>	0.201	0.029	0.000			
	M <sup>2</sup> *PC1 <sub>wq</sub>	-0.045	0.009	0.000				
	M*PC1 <sub>wq</sub> *PC2 <sub>wq</sub>	-0.031	0.008	0.000				

Taxa	Effect	Coeff.	SE	p	R <sup>2</sup>	RMS	PE	
Tanypodinae	Constant	0.702	0.054	0.000	0.195	0.041	0.011	
	M	0.445	0.059	0.000				
	M <sup>2</sup>	-0.060	0.012	0.000				
	M <sup>4</sup>	0.009	0.002	0.000				
	Constant	0.741	0.052	0.000	0.273	0.037	0.011	
	M	0.445	0.056	0.000				
	M <sup>2</sup>	-0.060	0.011	0.000				
	M <sup>4</sup>	0.009	0.002	0.000				
	PC1 <sub>wa</sub>	-0.056	0.009	0.000				
	PC1 <sub>wa</sub> *PC2 <sub>wa</sub>	-0.021	0.008	0.007				
	PC1 <sub>wa</sub> *PC1 <sub>wa</sub>	-0.019	0.008	0.020				
	PC2 <sub>wa</sub> *PC2 <sub>wa</sub>	-0.020	0.004	0.000				
	Trichoptera	Constant	0.924	0.043	0.000	0.239	0.155	0.025
		M	0.701	0.063	0.000			
M <sup>2</sup>		-0.181	0.021	0.000				
M <sup>4</sup>		0.002	0.000	0.000				
Constant		1.013	0.042	0.000	0.333	0.136	0.025	
M		0.701	0.059	0.000				
M <sup>2</sup>		-0.181	0.020	0.000				
M <sup>4</sup>		0.002	0.000	0.000				
PC1 <sub>wa</sub>		-0.094	0.014	0.000				
M*PC2 <sub>wa</sub>		0.051	0.017	0.003				
M*PC1 <sub>wa</sub> *PC2 <sub>wa</sub>		-0.016	0.005	0.001				
M <sup>2</sup> *PC2 <sub>wa</sub>		-0.010	0.004	0.019				
PC1 <sub>wa</sub> *PC1 <sub>wa</sub>		-0.089	0.013	0.000				

## APPENDICES

Appendix 1. Taxon-specific intercept (a) and exponent (b) of the formula  $M=aL^b$ , where M is the body mass ( $\mu\text{g}$ , DM) of a specific group of invertebrate and L is the body length (central axis) (in mm)

Taxon	a	b	Source
Chironominae	5.097	2.32	Smock, 1980
Ephemeroptera	6.5979	2.88	Smock, 1980
Isopoda	9.602	2.728	Adcock, 1979
Oligochaeta	1	2	Lindengaard et al, 1994
Orthoclaadiinae	5.097	2.32	Smock, 1980
Tanypodinae	3.8	2.41	Smock, 1980
Trichoptera	1.928	3.12	Smock, 1980
Total Population	1	3	Morin and Nadon, 1991

Appendix 2. Mean Log<sub>10</sub> (density+10) for each taxon at each sampling site. Legend: Station – (sampling station), EPH – (Ephemeroptera), PLEC – (Plecoptera), TRICH – (Trichoptera), COL – (Coleoptera), TRICH – (Trichoptera), CHIR – (Chironominae), ORTH – (Orthocladinae), TANY – (Tanypodinae), SIMU – (Simuliidae), DIPT – (Diptera), GAST – (Gastropoda), ZEBR – (Zebra mussels), BIVA – (Bivalvia), AMPH – (Amphipoda), ISO – (Isopoda), NEM – (Nematoda), OLIG - (Oligochaeta), PLAT – (Platyhelminthes), HYDR – (Hydra), XYZ – (unknown).

Station	EPH	PLEC	TRICH	COL	CHIR	ORTH	TANY	SIMU	DIPT	GAST	ZEBR	BIVA	AMPH	ISO	NEM	OLIG	PLAT	HYDR	XYZ
BEA01	1.89	1.35	3.16	1.92	3.72	4.05	2.40	2.67	1.35	2.06	1.00	1.00	2.38	1.00	1.00	2.13	1.53	1.36	1.38
BEA02	2.15	1.48	2.29	1.73	3.19	3.26	2.50	1.75	1.44	2.29	1.00	1.00	2.20	1.00	1.00	3.34	1.50	1.00	1.71
BIL01	1.00	1.00	2.58	1.00	2.03	3.97	1.46	2.03	1.00	1.58	1.00	1.00	2.84	2.92	1.00	3.46	1.62	1.81	1.00
BIL02	1.00	1.00	2.44	1.40	2.92	4.00	2.00	1.00	1.00	1.51	1.00	1.43	1.00	3.38	1.26	2.09	1.75	2.15	1.00
BLA01	1.00	1.58	3.37	2.37	3.73	3.68	2.68	3.73	2.49	2.81	1.00	1.00	1.00	3.27	1.00	2.82	3.31	2.15	1.45
CAR01	2.91	1.00	3.24	1.94	3.52	3.86	2.88	2.25	1.44	2.07	1.00	1.26	2.11	1.00	1.00	1.50	2.31	1.00	2.15
CAR02	1.00	1.00	1.79	1.40	1.00	3.80	1.72	1.00	1.00	1.41	1.00	1.00	1.00	2.10	1.00	3.03	2.78	1.00	1.00
CAR03	2.53	1.18	3.48	2.36	3.73	3.07	2.70	2.84	1.57	2.48	1.18	2.13	1.79	1.00	1.00	1.65	3.05	1.48	1.96
CAR04	1.95	1.28	2.57	1.28	3.05	4.09	2.33	3.10	1.35	1.92	1.00	1.00	1.00	1.00	1.25	1.40	1.75	1.00	1.56
CAS01	1.33	1.76	3.77	1.56	3.33	3.93	2.18	2.26	2.51	2.44	1.00	1.56	1.00	1.42	1.00	1.36	2.51	1.00	1.72
CAS02	2.13	1.00	3.70	2.28	3.68	3.88	2.28	2.37	2.11	2.92	1.00	1.71	1.45	1.51	1.00	2.83	2.37	1.51	2.00
CAS03	2.61	1.32	3.65	2.13	3.28	3.18	2.64	3.45	1.58	2.43	1.41	2.24	2.53	2.63	1.00	2.31	3.55	2.17	1.87
CAS04	1.82	1.38	3.46	2.45	3.37	3.87	2.68	1.23	1.52	1.56	1.00	1.64	1.84	1.56	1.00	3.51	2.83	2.90	2.02
CHE01	2.23	1.00	1.51	1.00	2.56	3.79	1.67	1.46	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.33	1.00	1.00	1.00
CHE02	2.33	1.33	2.71	1.22	2.41	3.11	1.61	1.08	2.27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.22
CHE03	2.67	1.00	3.14	1.17	3.26	2.91	1.97	1.00	1.88	1.00	1.00	1.00	1.00	1.00	1.00	2.19	1.00	1.41	1.17
CHE04	2.60	1.00	2.05	1.53	1.00	3.16	1.87	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
COD01	2.06	1.78	3.36	1.58	2.92	4.13	2.02	1.00	3.13	1.93	1.00	1.00	1.00	1.00	1.00	1.00	1.57	1.00	1.00
GRA01	1.00	1.00	2.04	1.00	1.00	4.24	1.54	1.95	1.95	1.77	1.00	1.00	1.00	2.41	1.00	3.10	1.00	1.00	1.35
GRA02	1.24	1.00	2.48	1.00	2.76	4.13	1.85	2.22	1.39	2.35	1.00	1.00	1.00	2.54	1.00	3.67	1.00	2.69	1.63
GRE03	1.96	1.00	3.44	1.22	2.39	4.15	1.79	1.81	1.26	2.49	1.00	1.40	1.85	2.93	1.00	3.47	2.33	2.03	2.01
GRE04	1.00	1.00	1.71	1.00	2.19	4.33	1.38	1.67	1.38	1.00	1.00	1.00	1.00	3.00	1.00	3.40	1.00	1.22	1.00
HUN01	1.00	1.00	2.90	1.00	1.62	3.78	1.40	3.33	1.00	1.00	1.00	1.00	2.29	3.32	1.00	2.64	1.28	2.53	1.74
JOC01	3.13	1.42	3.51	1.64	3.42	3.86	2.74	1.26	2.04	1.00	1.31	1.00	1.90	1.00	1.00	1.77	2.70	1.44	1.25
JOC08	2.67	2.07	3.25	1.00	3.10	3.56	2.52	1.00	1.00	1.88	1.00	1.00	1.00	1.78	1.26	1.90	1.36	1.63	1.42
LEM01	1.68	1.00	3.02	1.62	1.86	3.89	1.69	1.20	2.32	1.00	1.00	1.00	1.00	1.00	1.00	1.72	1.63	1.00	1.00
LEN01	2.91	1.92	2.59	1.00	2.12	4.09	1.84	3.10	1.70	1.52	1.00	1.00	1.00	1.00	1.00	3.26	1.00	1.32	1.32
MUD01	1.70	1.26	3.97	2.33	3.76	3.96	2.43	2.08	3.06	2.06	1.00	1.32	1.00	2.04	1.00	1.94	3.16	1.00	1.84
OTT02	1.76	1.00	2.58	1.23	2.38	2.67	1.26	1.00	1.23	1.47	1.26	1.65	1.00	1.00	1.00	1.38	2.51	1.23	1.55
PIN01	1.00	1.00	1.57	1.00	1.00	3.82	1.26	1.00	1.00	1.31	1.00	1.00	1.26	1.54	1.00	2.26	1.00	1.00	1.29
PIN02	1.00	1.00	1.22	1.00	1.24	4.43	1.00	2.08	1.42	1.00	1.00	1.00	1.40	1.00	1.00	2.97	1.00	1.00	1.00

Station	EPH	PLEC	TRICH	COL	CHIR	ORTH	TANY	SIMU	DIPT	GAST	ZEBR	BIVA	AMPH	ISO	NEM	OLIG	PLAT	HYDR	XYZ
RID01	3.45	1.00	3.04	1.86	3.15	3.82	2.23	1.00	1.62	2.03	1.24	1.00	1.29	1.00	1.00	1.39	3.07	2.14	1.17
RID04	2.62	1.00	3.16	2.95	3.37	3.18	2.04	1.00	1.00	2.71	2.53	1.00	1.72	2.00	1.00	2.62	3.34	3.22	1.46
RID07	1.88	1.00	3.18	1.30	3.50	3.50	2.40	1.30	1.98	2.12	2.61	1.23	2.46	2.00	1.00	3.55	3.31	3.05	2.06
SAW01	1.00	1.00	1.83	1.00	2.11	3.61	1.59	2.26	2.12	1.46	1.00	1.00	1.00	1.82	1.00	3.89	1.47	1.00	1.49
SAW02	1.65	1.00	3.60	1.68	3.22	3.83	2.66	2.66	1.00	1.85	1.00	1.00	1.00	1.00	1.00	2.94	1.00	1.36	2.60
SOU01	2.12	1.00	3.59	1.00	3.60	4.19	1.94	3.15	1.33	2.53	1.00	1.85	1.55	2.09	1.00	4.29	3.11	4.44	2.56
SOU02	1.18	1.00	2.28	1.00	3.12	2.38	1.56	1.00	1.00	2.38	1.51	1.00	1.89	2.51	1.00	3.43	2.51	2.96	1.53
SOU03	2.19	1.00	3.16	1.00	3.50	2.82	2.53	1.00	1.00	2.20	1.61	1.00	2.27	1.00	1.00	2.64	2.84	2.69	2.29
SOU04	3.14	1.00	2.74	2.58	2.76	2.63	2.37	2.01	1.00	1.61	1.00	1.00	1.00	1.00	1.00	2.55	1.99	1.00	1.48
SOU05	3.26	1.00	3.03	1.30	3.70	3.19	3.07	2.16	1.00	2.27	1.00	1.74	2.84	2.48	1.00	2.53	3.21	2.44	1.00
STI01	1.00	1.00	2.53	1.00	2.81	4.21	2.16	3.17	1.00	1.39	1.00	1.00	1.76	1.40	1.00	2.96	1.47	1.00	1.40
WAT01	1.96	1.00	3.54	2.68	3.20	3.72	2.21	2.69	1.86	2.33	1.00	1.26	2.56	2.72	1.00	2.91	2.03	1.64	1.36
WAT02	1.49	1.00	3.70	2.27	2.92	3.75	2.81	3.76	2.31	1.51	1.00	1.29	2.43	1.00	1.00	2.07	1.00	3.63	1.22
WAT03	1.00	1.00	3.17	2.03	1.64	4.00	1.83	1.97	1.52	1.00	1.00	1.00	2.51	3.07	1.00	3.52	1.32	1.00	1.39
WAT04	1.00	1.00	2.57	1.00	1.76	4.24	1.36	1.99	1.73	1.00	1.00	1.00	1.58	2.88	1.00	2.48	1.00	1.00	1.46

Appendix 3. Average log<sub>10</sub> (density +10) per size classes (mass, µg) by sampling stations (47) and by taxa (8).

Taxa	Mass Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072	
CHIRO	BEA0102	1.00	1.00	1.00	1.00	1.00	1.00	1.52	2.69	2.98	3.08	2.84	2.67	2.76	2.27	2.27	1.28	1.00					
	BEA0201	1.00	1.00	1.00	1.00	1.00	1.00	1.22	1.50	1.70	1.77	1.68	1.48	1.21	1.21	1.21	1.06	1.00					
	BIL0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.12	1.29	1.29	1.13	1.00	1.00	1.00					
	BIL0202	1.00	1.00	1.00	1.00	1.00	1.00	1.27	1.57	1.57	1.92	1.81	1.88	2.20	1.31	1.14	1.00	1.00					
	BLA0101	1.00	1.00	1.13	1.84	2.02	2.89	2.80	2.71	2.71	2.77	2.71	2.77	2.71	2.71	1.15	1.00	1.00					
	CAR0102	1.00	1.00	1.11	1.41	2.33	2.80	2.98	2.52	2.53	2.29	1.25	1.00	1.00	1.00	1.00	1.00	1.00					
	CAR0202	1.00	1.00	1.16	1.30	1.59	1.74	1.92	1.75	1.28	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	CAR0301	1.00	1.09	1.24	1.69	2.69	3.09	3.09	2.77	2.52	2.07	1.44	1.23	1.00	1.00	1.00	1.00	1.00					
	CAR0401	1.00	1.00	1.00	1.11	1.66	2.21	2.27	1.58	2.08	1.96	1.22	1.00	1.00	1.00	1.00	1.00	1.00					
	CAS0102	1.00	1.00	1.00	1.13	1.53	2.28	2.65	2.08	1.51	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	CAS0202	1.00	1.00	1.00	1.00	1.00	1.16	1.43	2.50	2.66	2.85	2.24	1.10	1.00	1.00	1.00	1.00	1.00					
	CAS0301	1.00	1.00	1.13	1.57	1.49	2.20	2.10	2.06	1.94	2.09	1.92	1.12	1.00	1.00	1.00	1.00	1.00					
	CAS0401	1.00	1.00	1.12	1.43	2.45	2.67	2.67	2.53	1.87	2.14	1.78	1.00	1.00	1.00	1.00	1.00	1.00					
	CHE0102	1.00	1.00	1.13	1.13	1.22	1.72	2.06	1.62	1.13	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	CHE0202	1.00	1.00	1.00	1.03	1.42	1.52	1.18	1.26	1.03	1.19	1.15	1.00	1.00	1.00	1.00	1.00	1.00					
	CHE0302	1.00	1.08	1.30	1.96	2.40	2.69	2.33	1.89	1.61	1.23	1.09	1.00	1.00	1.00	1.00	1.00	1.00					
	CHE0402	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	COD0102	1.00	1.00	1.00	1.00	1.52	1.80	2.14	2.10	1.56	1.83	1.59	1.00	1.00	1.00	1.00	1.00	1.00					
	GRA0101	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	GRA0201	1.00	1.00	1.00	1.28	1.47	1.38	1.76	1.99	1.68	1.68	1.10	1.00	1.00	1.00	1.00	1.00	1.00					
	GRE0104	1.00	1.00	1.00	1.00	1.00	1.15	1.25	1.34	1.00	1.15	1.15	1.00	1.00	1.00	1.00	1.00	1.00					
	GRE0301	1.00	1.00	1.00	1.12	1.20	1.36	1.39	1.26	1.25	1.14	1.25	1.00	1.00	1.00	1.00	1.00	1.00					
	GRE0401	1.00	1.00	1.00	1.00	1.00	1.13	1.22	1.26	1.46	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	HUN0101	1.00	1.00	1.00	1.00	1.00	1.00	1.18	1.09	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	JOC0107	1.00	1.00	1.11	1.49	2.19	2.74	2.76	2.42	2.06	2.11	1.67	1.12	1.00	1.00	1.00	1.00	1.00					
	JOC0804	1.00	1.00	1.00	1.39	1.99	2.09	1.89	1.79	2.06	1.60	1.24	1.00	1.00	1.00	1.00	1.00	1.00					
	LEM0102	1.00	1.00	1.00	1.00	1.00	1.12	1.25	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	LEN0102	1.00	1.00	1.00	1.00	1.00	1.16	1.16	1.43	1.13	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00					
	MUD0101	1.00	1.00	1.32	2.04	3.04	2.99	3.02	2.84	2.40	2.42	2.09	1.11	1.00	1.00	1.00	1.00	1.00					
	OTT0207	1.00	1.00	1.13	1.13	1.34	1.48	1.45	1.32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	PIN0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
	PIN0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00					



Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072			
EPH	GRE0301	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.14	1.00	1.00	1.00	1.12	1.32	1.00	1.00	1.00	1.00	1.00	1.00		
	GRE0401	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
	HUN0101	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	JOC0107	1.00	1.00	1.12	1.54	1.56	1.93	2.34	1.80	1.34	1.84	1.49	1.71	1.59	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	JOC0804	1.00	1.00	1.00	1.27	1.12	1.49	1.33	1.12	1.42	1.10	1.53	1.50	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	LEM0102	1.00	1.00	1.00	1.00	1.00	1.28	1.00	1.00	1.00	1.09	1.00	1.13	1.00	1.00	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	
	LEN0102	1.00	1.00	1.13	1.00	1.72	1.62	1.75	1.47	1.49	1.58	2.17	1.45	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	MUD0101	1.00	1.00	1.00	1.00	1.16	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	OTT0207	1.00	1.00	1.00	1.00	1.00	1.19	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.22	1.00	1.00	1.00	1.00	1.00	1.00	
	PIN0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	PIN0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	RID0107	1.00	1.09	1.77	2.54	2.47	2.75	2.57	2.14	1.88	1.90	1.67	1.47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	RID0407	1.00	1.00	1.00	1.34	1.90	1.42	1.67	1.11	1.37	1.32	1.15	1.11	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	RID0707	1.00	1.00	1.00	1.00	1.10	1.40	1.12	1.00	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	SAW0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	SAW0202	1.00	1.00	1.00	1.00	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	SOU0101	1.00	1.00	1.00	1.00	1.00	1.20	1.00	1.00	1.00	1.13	1.29	1.24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	SOU0201	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	SOU0301	1.00	1.00	1.00	1.00	1.00	1.27	1.24	1.00	1.24	1.12	1.25	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	SOU0401	1.00	1.00	1.10	1.40	2.01	1.96	1.97	2.07	2.10	2.09	1.99	1.52	1.48	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	SOU0501	1.11	1.00	1.26	1.63	2.33	2.01	2.22	2.00	1.77	1.54	1.59	1.27	1.00	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	STI0101	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	WAT0102	1.00	1.00	1.00	1.00	1.00	1.00	1.26	1.13	1.19	1.13	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	WAT0202	1.00	1.00	1.00	1.00	1.00	1.00	1.13	1.00	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	WAT0302	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	WAT0402	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	ISO	BEA0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
		BEA0201	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
		BIL0102	1.00	1.00	1.00	1.48	1.91	1.79	1.63	1.44	1.46	1.32	1.13	1.12	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BIL0202	1.00	1.18	1.40	1.99	2.10	2.29	1.57	1.36	1.28	1.00	1.14	1.33	1.27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		BLA0101	1.00	1.00	1.31	1.65	1.91	1.67	1.67	1.76	1.77	1.66	1.66	1.58	1.45	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		CAR0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		CAR0202	1.00	1.00	1.00	1.00	1.11	1.12	1.16	1.20	1.06	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		CAR0301	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		CAR0401	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CAS0102		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072	
	CAS0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CAS0301	1.00	1.00	1.12	1.13	1.52	1.76	1.24	1.50	1.38	1.49	1.26	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CAS0401	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.12	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0302	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0402	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	COD0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRA0101	1.00	1.00	1.13	1.00	1.14	1.47	1.47	1.22	1.28	1.19	1.09	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRA0201	1.00	1.00	1.00	1.20	1.71	1.66	1.10	1.36	1.72	1.36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRE0104	1.00	1.00	1.00	1.30	1.47	1.33	1.18	1.20	1.48	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRE0301	1.00	1.00	1.14	1.32	1.00	1.59	1.59	1.74	1.77	1.80	1.71	1.24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRE0401	1.00	1.13	1.16	1.54	1.50	1.56	1.64	1.38	1.51	1.13	1.00	1.12	1.13	1.25	1.12	1.34	1.28	1.25	1.29	1.11	1.11	1.11
	HUN0101	1.08	1.08	1.18	1.96	2.53	2.40	2.10	2.34	2.27	1.90	1.34	1.28	1.25	1.29	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	JOC0107	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	JOC0804	1.00	1.00	1.00	1.18	1.00	1.00	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	LEM0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	LEN0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MUD0101	1.00	1.00	1.00	1.22	1.29	1.00	1.00	1.18	1.11	1.00	1.00	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	OTT0207	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	PIN0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.00	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	PIN0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0107	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0407	1.00	1.00	1.00	1.10	1.25	1.17	1.23	1.10	1.00	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0707	1.00	1.00	1.00	1.00	1.00	1.11	1.11	1.12	1.11	1.10	1.11	1.21	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SAW0102	1.00	1.00	1.00	1.11	1.22	1.12	1.10	1.10	1.11	1.10	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SAW0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0101	1.00	1.00	1.00	1.00	1.00	1.00	1.20	1.00	1.13	1.00	1.40	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0201	1.00	1.00	1.00	1.11	1.10	1.22	1.38	1.43	1.89	1.39	1.38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0301	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0401	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0501	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	STI0101	1.00	1.00	1.00	1.00	1.00	1.00	1.27	1.00	1.00	1.21	1.47	1.35	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.00	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0202	1.00	1.00	1.00	1.43	1.55	1.40	1.33	1.11	1.51	1.66	1.62	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0302	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0302	1.00	1.00	1.22	1.37	2.44	2.23	1.61	2.01	1.86	1.22	1.00	1.14	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072
ISO	WAT0402				1.00	1.10	1.50	1.27	1.00	1.42	1.77	1.59	1.43	1.79	1.72	1.39	1.39	1.32	1.48	1.36	1.09	
OLIGO	BEA0102	1.00	1.00	1.00	1.00	1.10	1.50	1.27	1.00	1.13	1.12	1.00	1.00	1.00	1.00							
	BEA0201	1.04	1.06	1.46	1.66	1.66	1.89	1.56	1.13	1.00	1.00	1.00	1.00	1.00	1.00							
	BIL0102	1.00	1.56	1.97	2.35	2.56	2.15	1.61	1.21	1.00	1.12	1.00	1.00	1.00	1.00							
	BIL0202	1.00	1.00	1.00	1.34	1.14	1.00	1.00	1.29	1.00	1.00	1.00	1.00	1.00	1.00							
	BLA0101	1.00	1.16	1.70	2.00	1.91	1.64	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAR0102	1.00	1.00	1.00	1.00	1.00	1.24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAR0202	1.00	1.14	1.29	1.76	2.13	1.77	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAR0301	1.00	1.00	1.00	1.29	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAR0401	1.00	1.00	1.00	1.00	1.00	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAS0102	1.00	1.00	1.00	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAS0202	1.00	1.00	1.00	1.00	1.00	1.20	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAS0301	1.00	1.00	1.24	1.39	1.84	1.22	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAS0401	1.10	1.34	1.70	2.57	3.04	2.61	1.78	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CHE0102	1.00	1.00	1.00	1.24	1.57	1.49	1.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CHE0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CHE0302	1.00	1.00	1.11	1.20	1.52	1.58	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CHE0402	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	COD0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	GRA0101	1.13	1.26	1.93	2.08	2.42	1.98	1.11	1.00	1.00	1.09	1.00	1.00	1.00	1.00							
	GRA0201	1.00	1.17	2.21	2.94	3.23	2.92	1.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	GRE0104	1.00	1.14	1.83	2.55	2.84	2.56	1.34	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	GRE0301	1.00	1.12	1.86	2.30	2.69	2.30	1.64	1.14	1.00	1.00	1.00	1.00	1.00	1.12							
	GRE0401	1.00	1.26	1.71	1.93	2.58	1.91	1.59	1.13	1.00	1.00	1.00	1.00	1.00	1.00							
	HUN0101	1.00	1.09	1.35	1.75	1.76	1.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	JOC0107	1.00	1.00	1.00	1.22	1.00	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	JOC0804	1.00	1.00	1.16	1.38	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	LEM0102	1.00	1.00	1.10	1.13	1.15	1.10	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	LEN0102	1.00	1.13	1.27	1.91	2.17	2.20	1.86	1.41	1.41	1.00	1.00	1.00	1.00	1.00							
	MUD0101	1.00	1.00	1.10	1.10	1.27	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	OTT0207	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	PIN0102	1.00	1.00	1.11	1.26	1.24	1.25	1.14	1.11	1.00	1.00	1.00	1.00	1.00	1.00							
	PIN0202	1.00	1.00	1.33	2.05	2.04	2.01	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	RID0107	1.00	1.11	1.00	1.00	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	RID0407	1.00	1.00	1.22	1.41	1.52	1.74	1.47	1.27	1.00	1.00	1.00	1.00	1.00	1.00							
	RID0707	1.00	1.24	1.66	2.54	2.92	2.73	2.71	2.16	1.45	1.00	1.00	1.00	1.00	1.00							



Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072		
ORTHO	JOC0107	1.00	1.00	1.00	1.00	1.00	1.00	1.37	1.80	2.75	3.15	3.13	2.61	2.31	1.96	1.18	1.00							
	JOC0804	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.90	2.33	3.00	2.83	2.46	2.12	1.25	1.13	1.00							
	LEM0102	1.00	1.00	1.00	1.00	1.10	1.66	2.32	3.10	3.24	3.33	3.33	2.90	2.17	1.62	1.00	1.00							
	LEN0102	1.00	1.00	1.18	1.18	1.74	1.99	2.93	3.40	3.39	3.19	2.52	2.13	2.25	1.29	1.13	1.00							
	MUD0101	1.00	1.00	1.00	1.00	1.00	1.73	2.00	2.90	3.28	3.29	3.29	2.94	2.51	2.35	1.23	1.00							
	OTT0207	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.38	1.54	1.66	1.66	1.10	1.10	1.00	1.00	1.00							
	PIN0102	1.00	1.00	1.00	1.00	1.00	1.14	1.65	2.71	2.74	3.15	2.87	2.91	2.88	1.58	1.00	1.00							
	PIN0202	1.00	1.00	1.00	1.00	1.00	1.57	2.52	3.29	3.62	3.54	3.42	3.47	3.40	1.50	1.00	1.00							
	RID0107	1.00	1.00	1.00	1.00	1.19	1.12	1.85	2.69	2.96	2.71	1.86	1.22	1.50	1.00	1.00	1.00							
	RID0407	1.00	1.00	1.00	1.00	1.00	1.11	1.60	2.12	2.32	2.16	1.78	1.70	1.76	1.00	1.00	1.00							
	RID0707	1.00	1.00	1.00	1.00	1.00	1.13	1.64	2.43	2.88	2.85	2.38	1.94	1.91	1.17	1.00	1.00							
	SAW0102	1.00	1.00	1.00	1.00	1.00	1.00	1.48	1.87	2.50	2.67	2.72	2.91	2.92	1.82	1.00	1.00							
	SAW0202	1.00	1.00	1.00	1.00	1.00	1.49	2.40	2.78	3.07	3.14	2.92	2.72	2.72	2.64	1.26	1.00							
	SOU0101	1.00	1.00	1.00	1.00	1.36	1.49	2.39	3.39	3.42	3.49	3.12	2.92	3.03	2.37	1.16	1.00							
	SOU0201	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.11	1.48	1.70	1.37	1.09	1.00	1.00	1.00	1.00							
	SOU0301	1.00	1.00	1.00	1.00	1.11	1.11	1.13	1.55	1.90	2.01	1.92	1.34	1.30	1.00	1.00	1.00							
	SOU0401	1.00	1.00	1.00	1.00	1.00	1.00	1.18	1.73	1.55	1.88	1.40	1.13	1.54	1.10	1.00	1.00							
	SOU0501	1.00	1.00	1.00	1.00	1.00	1.25	1.62	2.08	2.36	2.50	2.23	1.94	1.00	1.00	1.00	1.00							
	STI0101	1.00	1.00	1.00	1.00	1.12	1.32	2.52	3.25	3.42	3.52	3.36	3.26	3.18	1.73	1.10	1.00							
	WAT0102	1.00	1.00	1.00	1.00	1.32	2.08	2.74	3.01	2.98	2.53	2.50	1.87	1.11	1.00	1.00	1.00							
WAT0202	1.00	1.00	1.00	1.00	1.38	1.84	2.75	3.07	3.04	2.59	2.50	1.87	1.11	1.00	1.00	1.00								
WAT0302	1.00	1.00	1.00	1.00	1.12	1.83	2.99	3.10	3.41	3.03	2.93	2.85	1.23	1.00	1.00	1.00								
WAT0402	1.00	1.00	1.00	1.00	1.27	1.74	2.67	3.05	3.53	3.56	3.33	3.25	2.92	1.18	1.00	1.00								
TANY	BEA0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.23	1.58	1.66	1.10	1.10	1.00	1.00	1.15	1.00							
	BEA0201	1.00	1.00	1.00	1.00	1.09	1.10	1.14	1.14	1.10	1.13	1.25	1.21	1.00	1.10	1.00	1.00							
	BIL0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.12	1.12	1.00	1.00	1.00	1.00	1.00	1.00							
	BIL0202	1.00	1.00	1.00	1.00	1.00	1.14	1.28	1.14	1.28	1.14	1.13	1.00	1.15	1.00	1.00	1.00							
	BLA0101	1.00	1.00	1.00	1.00	1.00	1.00	1.19	1.64	1.66	1.66	1.47	1.59	1.68	1.32	1.12	1.00							
	CAR0102	1.00	1.00	1.22	1.43	1.99	2.11	2.06	1.67	1.25	1.48	1.27	1.27	1.00	1.00	1.00	1.00							
	CAR0202	1.00	1.00	1.00	1.07	1.19	1.19	1.25	1.43	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00							
	CAR0301	1.00	1.00	1.00	1.52	1.67	1.88	1.93	1.54	1.13	1.21	1.12	1.13	1.00	1.00	1.00	1.00							
	CAR0401	1.00	1.00	1.00	1.39	1.14	1.37	1.15	1.50	1.26	1.12	1.11	1.00	1.00	1.00	1.00	1.00							
	CAS0102	1.00	1.00	1.00	1.12	1.14	1.12	1.41	1.28	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	CAS0202	1.00	1.00	1.00	1.00	1.00	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10							
	CAS0301	1.00	1.14	1.13	1.39	1.53	1.42	1.62	1.28	1.35	1.26	1.12	1.00	1.00	1.00	1.00	1.00							
CAS0401	1.00	1.00	1.00	1.00	1.52	1.64	1.55	1.77	1.71	1.37	1.36	1.11	1.00	1.00	1.00	1.00								

Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072	
TANY	CHE0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.30	1.00	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0202	1.00	1.00	1.00	1.00	1.00	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0302	1.00	1.00	1.09	1.08	1.30	1.12	1.20	1.00	1.00	1.09	1.00	1.00	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0402	1.00	1.00	1.00	1.00	1.00	1.30	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	COD0102	1.00	1.15	1.00	1.26	1.12	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRA0101	1.00	1.00	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRA0201	1.00	1.00	1.13	1.12	1.00	1.13	1.10	1.00	1.00	1.00	1.13	1.10	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRE0104	1.00	1.00	1.00	1.10	1.00	1.10	1.40	1.15	1.00	1.15	1.00	1.15	1.00	1.00	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRE0301	1.00	1.00	1.00	1.12	1.00	1.00	1.14	1.26	1.00	1.00	1.00	1.14	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GRE0401	1.00	1.00	1.00	1.00	1.00	1.00	1.13	1.00	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	HUN0101	1.00	1.00	1.00	1.00	1.00	1.09	1.00	1.09	1.00	1.00	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	JOC0107	1.00	1.00	1.26	1.40	1.98	1.70	1.81	1.55	1.44	1.39	1.00	1.00	1.00	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	JOC0804	1.00	1.00	1.12	1.43	1.63	1.54	1.27	1.18	1.12	1.16	1.12	1.09	1.00	1.00	1.44	1.39	1.00	1.00	1.00	1.00	1.00	1.00
	LEM0102	1.00	1.00	1.00	1.13	1.12	1.12	1.12	1.09	1.00	1.00	1.12	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	LEN0102	1.00	1.00	1.13	1.00	1.16	1.13	1.00	1.13	1.00	1.13	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MUD0101	1.00	1.00	1.15	1.27	1.69	1.49	1.31	1.26	1.21	1.36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	OTT0207	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	PIN0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	PIN0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0107	1.00	1.00	1.12	1.48	1.26	1.26	1.20	1.10	1.00	1.00	1.12	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0407	1.00	1.00	1.12	1.22	1.30	1.14	1.11	1.11	1.11	1.10	1.11	1.11	1.11	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0707	1.00	1.00	1.28	1.23	1.39	1.23	1.25	1.12	1.12	1.33	1.00	1.12	1.12	1.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SAW0102	1.00	1.00	1.00	1.00	1.11	1.12	1.00	1.12	1.00	1.00	1.12	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SAW0202	1.00	1.25	1.25	1.32	1.73	1.48	1.88	1.52	1.37	1.49	1.00	1.00	1.00	1.37	1.49	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0101	1.00	1.00	1.00	1.16	1.00	1.20	1.00	1.11	1.00	1.00	1.20	1.00	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0201	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.00	1.00	1.11	1.12	1.00	1.00	1.11	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0301	1.09	1.00	1.09	1.62	1.28	1.61	1.09	1.33	1.39	1.67	1.61	1.09	1.33	1.39	1.67	1.13	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0401	1.00	1.00	1.00	1.35	1.31	1.23	1.38	1.61	1.00	1.12	1.23	1.38	1.61	1.00	1.12	1.23	1.20	1.00	1.00	1.00	1.00	1.00
	SOU0501	1.00	1.51	1.83	1.85	2.24	1.96	1.85	1.77	2.01	1.31	1.96	1.85	1.77	2.01	1.31	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	STI0101	1.00	1.00	1.12	1.11	1.22	1.24	1.29	1.45	1.11	1.00	1.24	1.29	1.45	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0102	1.00	1.00	1.00	1.31	1.25	1.12	1.70	1.00	1.00	1.00	1.12	1.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0202	1.00	1.12	1.00	1.48	1.82	1.57	1.94	1.46	1.44	1.46	1.57	1.94	1.46	1.44	1.46	1.26	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0302	1.00	1.00	1.00	1.00	1.23	1.34	1.00	1.12	1.11	1.00	1.34	1.00	1.12	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0402	1.00	1.00	1.00	1.00	1.00	1.10	1.00	1.10	1.00	1.10	1.00	1.10	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TOTAL	BEA0102	1.00	1.00	1.00	1.10	1.10	1.53	1.73	2.80	3.38	3.49	3.54	3.20	3.13	3.10	2.61	2.30	1.68	1.68	1.26	1.00	1.00	1.00
	BEA0201	1.00	1.00	1.04	1.06	1.46	1.66	1.90	1.75	1.90	2.01	2.07	1.94	1.74	1.39	1.28	1.23	1.13	1.12	1.00	1.00	1.00	1.00
	BIL0102	1.00	1.00	1.00	1.56	1.97	2.35	2.57	2.40	2.73	3.04	3.24	3.13	3.11	2.93	2.07	1.13	1.12	1.38	1.00	1.10	1.00	1.00

Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072	
TOTAL	BIL0202	1.00	1.00	1.00	1.00	1.00	1.34	1.52	2.35	2.89	3.20	3.44	3.20	3.18	3.00	1.31	1.18	1.14	1.49	1.59	1.59	1.16	1.00
	BLA0101	1.00	1.00	1.00	1.16	1.70	2.00	2.20	2.78	3.17	3.41	3.38	3.16	3.09	3.15	3.03	2.24	1.88	1.47	1.30	1.30	1.10	1.00
	CAR0102	1.11	1.11	1.00	1.14	1.19	1.59	1.97	2.66	3.23	3.46	3.45	3.06	2.81	2.58	1.80	1.76	1.43	1.27	1.58	1.24	1.00	1.00
	CAR0202	1.00	1.00	1.00	1.14	1.36	1.83	2.37	2.56	2.81	2.99	3.15	3.01	2.58	2.07	1.34	1.00	1.00	1.05	1.05	1.05	1.00	1.00
	CAR0301	1.00	1.00	1.00	1.00	1.00	1.72	1.68	2.49	3.10	3.32	3.28	2.91	2.77	2.52	2.61	2.47	2.30	2.14	1.58	1.11	1.00	1.00
	CAR0401	1.00	1.00	1.00	1.00	1.00	1.27	1.38	2.69	3.19	3.52	3.45	3.17	3.00	2.93	1.57	1.14	1.12	1.12	1.12	1.12	1.00	1.00
	CAS0102	1.00	1.00	1.00	1.00	1.00	1.89	2.31	2.90	3.34	3.45	3.45	3.02	2.20	1.12	1.00	1.00	1.12	1.00	1.00	1.00	1.00	1.00
	CAS0202	1.00	1.00	1.00	1.00	1.00	1.00	1.20	1.51	1.53	1.91	2.18	3.05	3.36	3.37	3.01	2.83	2.61	2.33	1.72	1.48	1.25	1.00
	CAS0301	1.00	1.00	1.00	1.00	1.28	1.64	2.03	2.05	2.66	2.95	2.96	2.76	2.53	2.79	2.50	2.65	2.09	1.93	1.52	1.00	1.13	1.00
	CAS0401	1.00	1.00	1.10	1.34	1.70	2.77	3.12	3.10	3.44	3.46	3.27	3.02	2.81	2.78	2.35	2.11	1.24	1.12	1.20	1.00	1.10	1.00
	CHE0102	1.00	1.00	1.00	1.00	1.11	1.37	1.94	2.15	2.75	2.99	3.16	2.89	2.83	2.50	1.58	1.24	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0202	1.00	1.00	1.00	1.00	1.12	1.18	1.44	1.90	2.51	2.67	2.39	1.97	2.19	1.82	1.18	1.11	1.00	1.09	1.00	1.00	1.00	1.00
	CHE0302	1.00	1.00	1.00	1.00	1.11	1.70	1.95	2.55	2.87	3.02	2.79	2.47	2.06	1.90	1.25	1.20	1.09	1.00	1.00	1.00	1.00	1.00
	CHE0402	1.00	1.00	1.00	1.00	1.00	1.00	1.18	1.91	2.62	2.73	2.52	1.65	1.54	1.28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	COD0102	1.00	1.00	1.00	1.00	1.00	1.57	2.33	2.81	3.26	3.53	3.49	3.23	3.17	2.91	2.28	1.54	1.63	1.50	1.13	1.00	1.00	1.00
	GRA0101	1.00	1.00	1.13	1.26	1.93	2.09	2.45	2.79	3.08	3.44	3.54	3.39	3.19	3.01	1.45	1.09	1.09	1.10	1.52	1.00	1.00	1.00
	GRA0201	1.00	1.00	1.00	1.17	2.21	2.96	3.25	3.16	3.18	3.47	3.45	3.14	3.03	2.69	1.88	1.11	1.25	1.00	1.00	1.00	1.00	1.00
	GRE0104	1.00	1.00	1.00	1.14	1.83	2.59	2.91	3.03	3.26	3.39	3.33	3.14	3.05	2.83	1.78	1.00	1.10	1.10	1.00	1.00	1.00	1.00
	GRE0301	1.00	1.00	1.00	1.12	1.86	2.31	2.73	2.54	3.18	3.45	3.48	3.30	3.28	3.16	2.14	1.90	1.26	1.10	1.00	1.00	1.11	1.11
	GRE0401	1.00	1.00	1.00	1.26	1.71	1.93	2.68	2.30	2.95	3.38	3.63	3.62	3.58	3.61	2.58	1.13	1.12	1.26	1.39	1.12	1.00	1.00
	HUN0101	1.00	1.00	1.00	1.09	1.35	1.87	2.02	2.38	2.89	3.17	3.12	3.07	2.98	2.52	1.91	1.35	1.43	1.25	1.45	1.51	1.00	1.00
	JOC0107	1.00	1.00	1.00	1.00	1.16	1.42	2.14	2.54	2.93	3.43	3.40	2.92	2.80	2.84	2.32	2.02	1.99	1.68	1.16	1.14	1.00	1.00
	JOC0804	1.00	1.00	1.00	1.10	1.39	1.60	1.98	2.37	2.79	3.17	2.98	2.85	2.65	2.03	1.87	1.83	1.75	1.96	1.12	1.12	1.00	1.00
	LEM0102	1.00	1.00	1.00	1.00	1.10	1.25	1.84	2.39	3.18	3.27	3.34	2.94	2.47	1.79	1.10	1.13	1.00	1.00	1.00	1.27	1.26	1.00
	LEN0102	1.00	1.00	1.00	1.31	1.33	2.40	2.70	3.05	3.46	3.43	3.26	2.64	2.29	2.35	2.28	1.78	1.13	1.00	1.00	1.00	1.26	1.00
	MUD0101	1.00	1.00	1.00	1.14	1.10	1.96	2.83	3.19	3.54	3.61	3.56	3.30	3.11	3.02	2.72	2.42	2.29	1.66	1.51	1.33	1.00	1.00
	OTT0207	1.00	1.00	1.00	1.00	1.00	1.00	1.13	1.23	1.69	1.86	1.95	1.35	1.43	1.85	1.57	1.54	1.19	1.08	1.19	1.00	1.00	1.00
	PIN0102	1.00	1.00	1.00	1.00	1.11	1.26	1.38	1.67	2.72	2.74	3.15	2.89	2.91	2.89	1.58	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	PIN0202	1.00	1.00	1.00	1.00	1.33	2.05	2.14	2.72	3.31	3.62	3.54	3.42	3.47	3.40	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0107	1.00	1.00	1.00	1.11	1.09	1.60	2.08	2.76	3.09	3.27	3.13	2.67	2.46	2.21	1.90	1.71	1.36	1.54	1.44	1.15	1.00	1.00
	RID0407	1.00	1.00	1.00	1.00	1.22	1.53	1.78	2.50	2.82	2.93	2.99	2.77	2.64	2.62	2.45	2.05	1.69	1.11	1.00	1.00	1.00	1.00
	RID0707	1.00	1.00	1.00	1.24	1.66	2.59	3.00	3.02	3.15	3.18	3.12	3.02	2.81	2.91	2.71	1.84	1.79	1.45	1.12	1.22	1.00	1.00
	SAW0102	1.00	1.00	1.09	1.47	2.57	3.33	3.38	2.73	2.01	2.58	2.72	2.74	2.92	2.93	1.91	1.00	1.12	1.00	1.12	1.00	1.00	1.00
	SAW0202	1.00	1.00	1.00	1.00	1.67	2.58	2.71	2.75	3.00	3.27	3.30	3.21	3.36	3.06	1.62	1.13	1.32	1.18	1.33	1.00	1.00	1.00
	SOU0101	1.00	1.00	1.20	1.80	2.94	3.60	3.84	3.71	3.65	3.57	3.60	3.35	3.31	3.34	3.11	2.51	1.83	1.76	1.52	1.36	1.00	1.00
	SOU0201	1.00	1.00	1.11	1.22	1.98	2.47	2.90	2.87	2.62	2.48	2.48	2.34	2.09	2.25	2.11	1.83	1.25	1.00	1.00	1.00	1.00	1.00

Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072
TOTAL	SOU0301	1.00	1.00	1.00	1.24	1.55	2.04	2.00	2.60	2.64	2.96	2.83	2.71	2.61	2.59	2.46	2.25	1.51	1.27	1.00	1.00	1.00
	SOU0401	1.00	1.00	1.00	1.11	1.29	1.80	2.02	1.71	2.45	2.49	2.44	2.42	2.28	2.37	2.10	1.84	1.19	1.33	1.31	1.00	1.00
	SOU0501	1.00	1.00	1.00	1.27	1.74	2.32	2.72	3.16	3.25	3.29	3.00	2.76	2.54	2.35	1.95	1.73	2.03	1.15	1.12	1.00	1.00
	STI0101	1.00	1.00	1.00	1.30	1.34	1.72	2.23	2.67	3.28	3.45	3.55	3.39	3.30	3.21	2.23	1.45	1.11	1.00	1.00	1.00	1.00
	WAT0102	1.00	1.00	1.00	1.16	1.84	2.55	2.68	3.17	3.34	3.24	2.99	2.80	2.71	2.19	2.02	1.65	1.33	1.12	1.40	1.30	1.00
	WAT0202	1.00	1.00	1.00	1.29	1.48	2.36	2.56	3.12	3.32	3.28	2.88	2.83	2.41	2.19	1.44	1.14	1.48	1.46	1.12	1.00	1.00
	WAT0302	1.00	1.00	1.00	1.68	2.45	2.40	2.71	3.11	3.26	3.47	3.08	3.07	3.16	1.61	1.12	1.40	1.49	1.19	1.00	1.00	1.00
	WAT0402	1.00	1.00	1.00	1.10	1.71	2.01	2.76	3.11	3.55	3.57	3.35	3.29	3.01	1.63	1.39	1.32	1.51	1.36	1.09	1.00	1.00
TRICH	BEA0102	1.00	1.00	1.00	1.00	1.13	1.23	1.60	1.65	1.75	1.42	1.66	1.94	1.99	2.04	2.07	1.50	1.68	1.26	1.00	1.00	1.00
	BEA0201	1.00	1.00	1.00	1.00	1.06	1.00	1.13	1.12	1.14	1.06	1.00	1.18	1.07	1.06	1.00	1.12	1.00	1.00	1.00	1.00	1.00
	BIL0102	1.00	1.00	1.00	1.00	1.00	1.00	1.23	1.25	1.15	1.00	1.27	1.52	1.88	1.24	1.00	1.00	1.00	1.13	1.00	1.10	1.00
	BIL0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.28	1.76	1.14	1.00	1.14	1.00	1.00	1.27	1.42	1.16	1.00
	BLA0101	1.00	1.00	1.00	1.00	1.00	1.00	1.42	1.87	2.06	2.02	2.06	1.83	2.06	1.88	1.66	1.30	1.11	1.15	1.10	1.00	1.00
	CAR0102	1.00	1.00	1.00	1.00	1.50	1.83	2.03	2.07	1.94	1.86	1.39	1.00	1.58	1.67	1.56	1.38	1.27	1.58	1.24	1.00	1.00
	CAR0202	1.00	1.00	1.00	1.07	1.22	1.70	1.81	1.78	1.75	1.54	1.19	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CAR0301	1.00	1.00	1.00	1.00	1.46	1.63	1.96	1.76	2.06	2.08	1.90	2.09	2.18	2.42	2.42	2.30	2.14	1.58	1.11	1.00	1.00
	CAR0401	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.50	1.43	1.46	1.15	1.15	1.31	1.28	1.11	1.00	1.12	1.12	1.12	1.00	1.00
	CAS0102	1.00	1.00	1.00	1.00	1.76	2.29	2.67	2.77	2.73	2.39	1.85	1.00	1.00	1.00	1.00	1.00	1.12	1.00	1.00	1.00	1.00
	CAS0202	1.00	1.00	1.00	1.00	1.00	1.00	1.15	1.53	1.41	1.54	2.36	2.59	2.79	2.72	2.80	2.61	2.33	1.72	1.48	1.25	1.00
	CAS0301	1.00	1.12	1.45	1.50	1.71	2.03	2.04	2.05	1.99	2.05	1.99	1.90	2.23	2.21	2.46	2.07	1.93	1.52	1.00	1.13	1.00
	CAS0401	1.00	1.00	1.29	1.70	2.17	2.38	2.19	2.17	2.38	2.19	2.17	1.61	2.14	2.49	2.03	1.94	1.24	1.12	1.20	1.00	1.10
	CHE0102	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	CHE0202	1.00	1.12	1.18	1.29	1.30	1.54	1.29	1.62	1.38	1.65	1.38	1.65	1.38	1.03	1.00	1.00	1.09	1.00	1.00	1.00	1.00
	CHE0302	1.00	1.00	1.44	1.60	2.08	1.99	1.88	1.80	1.54	1.39	1.47	1.18	1.18	1.18	1.00	1.09	1.00	1.00	1.00	1.00	1.00
	CHE0402	1.00	1.00	1.00	1.00	1.00	1.16	1.37	1.00	1.00	1.00	1.00	1.00	1.28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	COD0102	1.00	1.00	1.12	1.49	2.06	2.32	2.11	1.94	1.92	1.98	1.92	1.98	1.63	2.13	1.54	1.63	1.50	1.13	1.00	1.00	1.00
	GRA0101	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.11	1.23	1.00	1.00	1.00	1.10	1.10	1.52	1.00	1.00
	GRA0201	1.00	1.00	1.00	1.00	1.00	1.12	1.62	1.68	1.35	1.10	1.00	1.00	1.00	1.19	1.13	1.00	1.25	1.00	1.00	1.00	1.00
	GRE0104	1.00	1.00	1.11	1.42	1.59	1.57	1.67	1.58	1.21	1.55	1.65	1.59	1.00	1.10	1.00	1.10	1.00	1.00	1.00	1.00	1.00
	GRE0301	1.00	1.00	1.14	1.28	1.75	2.22	2.00	2.01	1.80	1.89	2.59	1.53	1.11	1.11	1.11	1.11	1.11	1.00	1.00	1.11	1.11
	GRE0401	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.13	1.13	1.00	1.00
	HUN0101	1.00	1.00	1.09	1.37	1.86	1.99	2.07	1.60	1.61	1.45	1.11	1.00	1.00	1.00	1.00	1.00	1.20	1.00	1.29	1.40	1.00
	JOC0107	1.00	1.16	1.36	1.81	2.08	1.87	1.94	1.67	1.79	1.82	2.28	1.64	1.67	1.63	1.56	1.63	1.56	1.16	1.14	1.00	1.00
	JOC0804	1.10	1.23	1.30	1.98	1.90	2.13	1.73	1.49	1.83	1.60	1.47	1.13	1.44	1.49	1.96	1.12	1.12	1.12	1.12	1.00	1.00
	LEM0102	1.00	1.00	1.18	1.53	1.64	2.09	1.71	1.25	1.64	2.05	1.27	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.27	1.26	1.00
	LEN0102	1.00	1.00	1.00	1.00	1.13	1.13	1.13	1.29	1.29	1.24	1.20	1.20	1.00	1.00	1.29	1.16	1.00	1.00	1.00	1.00	1.26

Taxa	Station	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072	
TRICH	MUD0101	1.14	1.00	1.93	2.75	3.06	3.11	2.90	2.62	2.48	2.63	2.66	2.46	2.41	2.17	1.66	1.51	1.33	1.00	1.00	1.00	1.00	1.00
	OTT0207	1.00	1.00	1.00	1.00	1.00	1.19	1.10	1.00	1.00	1.33	1.85	1.57	1.46	1.19	1.08	1.19	1.00	1.00	1.00	1.00	1.00	1.00
	PIN0102	1.00	1.00	1.00	1.00	1.11	1.11	1.00	1.00	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	PIN0202	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0107	1.00	1.00	1.55	1.52	1.86	2.04	1.83	1.73	1.47	1.69	1.34	1.26	1.42	1.36	1.54	1.44	1.15	1.00	1.00	1.00	1.00	1.00
	RID0407	1.00	1.00	1.12	1.46	1.58	1.89	1.98	1.85	1.81	1.59	2.14	1.68	2.03	1.56	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	RID0707	1.00	1.00	1.38	2.12	2.05	1.99	1.32	1.77	1.63	1.75	1.50	1.52	1.64	1.76	1.45	1.12	1.22	1.00	1.00	1.00	1.00	1.00
	SAW0102	1.00	1.00	1.00	1.00	1.11	1.12	1.00	1.00	1.00	1.00	1.23	1.00	1.00	1.12	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00
	SAW0202	1.00	1.10	2.01	2.04	1.88	1.99	1.94	1.61	2.54	3.11	2.61	1.35	1.00	1.11	1.16	1.33	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0101	1.00	1.00	1.21	1.22	1.66	2.17	2.41	2.47	2.33	2.20	2.36	2.04	2.00	1.83	1.76	1.52	1.36	1.00	1.00	1.00	1.00	1.00
	SOU0201	1.00	1.00	1.11	1.31	1.39	1.26	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0301	1.00	1.00	1.00	1.00	1.26	1.32	1.30	1.85	1.57	1.99	1.85	1.80	2.39	2.25	1.51	1.27	1.00	1.00	1.00	1.00	1.00	1.00
	SOU0401	1.00	1.00	1.09	1.38	1.17	1.53	1.33	1.20	1.35	1.46	1.25	1.39	1.28	1.42	1.19	1.23	1.31	1.00	1.00	1.00	1.00	1.00
	SOU0501	1.00	1.00	1.18	1.69	1.70	1.79	1.40	1.26	1.42	1.38	1.13	1.58	1.80	1.57	1.89	1.15	1.12	1.00	1.00	1.00	1.00	1.00
	STI0101	1.00	1.00	1.00	1.16	1.26	1.54	1.54	1.46	1.28	1.31	1.46	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0102	1.00	1.00	1.20	1.78	2.17	2.49	2.68	2.20	1.85	1.97	1.96	1.62	1.67	1.61	1.33	1.12	1.40	1.30	1.00	1.00	1.00	1.00
	WAT0202	1.00	1.15	1.46	1.98	2.19	2.37	2.53	2.36	1.98	2.19	1.74	1.55	1.15	1.14	1.48	1.46	1.12	1.00	1.00	1.00	1.00	1.00
	WAT0302	1.00	1.00	1.00	1.00	1.58	1.26	1.50	1.52	1.54	1.78	2.26	1.31	1.12	1.26	1.33	1.19	1.00	1.00	1.00	1.00	1.00	1.00
	WAT0402	1.00	1.00	1.00	1.00	1.50	1.27	1.10	1.30	1.50	1.57	1.85	1.00	1.00	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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