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St. Marys River Biological Assessment 2008: East of Bellevue Park and Lake George Channel

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EXECUTIVE SUMMARY

Sediments in depositional areas in the St. Marys River downstream (east) of Bellevue Park from the Algoma Sailing Club Embayment to downstream of Partridge Point in Lake George Channel were found to be elevated in petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) at surface and at depth; however, biological data were limited in this area. In 2008, sediment samples were taken from these areas and the quality of sediments were assessed using multivariate data analysis. Data analysed included benthic invertebrate community structure, functional responses of benthic invertebrates in toxicity tests, and the physical and chemical attributes of the sediment and overlying water. Conditions in these areas were compared with those in Great Lakes reference locations. Data were applied to the sediment decision-making framework for contaminated sediment to determine environmental risk. Fifteen sites were assessed: 11 east of Bellevue Park and 4 in Lake George Channel.

Surficial sediment PAH concentrations exceeded the Sediment Quality Guidelines Lowest Effect Level (LEL) at all sites; concentrations ranged from 4.5 to 52 μg/g dry weight and most concentrations were below 20 μg/g. Petroleum hydrocarbon concentration (the F4 fraction) ranged from 117 to 6510 mg/kg and was elevated above Canada-Wide Standards (for soil) at one site by 1.2 times. From one to nine metals (As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn) and nutrients (total organic carbon, total Kjeldahl nitrogen, total phosphorus) exceeded LELs; exceedences of Severe Effect Level were mainly limited to iron.

There was no strong evidence of benthic community impairment; six sites were categorized as *equivalent* to reference and nine sites as *possibly different*. Differences were associated primarily with increased abundances of oligochaete worms and chironomids. Half the sites east of Bellevue Park had diverse communities while the other half displayed low taxon diversity.

Severe toxicity was observed at three sites. Correlation of toxicological response to trace metals, nutrients and particle size was weak ($r^2 \leq 0.16$). Minor toxicity was observed at several other sites. In Lake George Channel, reproduction effects on the worm *Tubifex* (low percentage of hatched cocoons and young production) were observed. Further regressions (which in included organic contaminants as well as trace metals, nutrients and particle size) revealed that metals could partially explain toxicity in some cases although metal concentrations were not unusually high in the sediment. The cause of toxicity remains unclear.

Application of the decision-making framework indicated *no further actions needed* at six sites; *determine reason(s) for sediment toxicity* or *benthos alteration* at seven sites, and; *management actions required* at two sites. To further define biological conditions, specifically around locations where severe toxicity and low taxon diversity were observed, additional sampling was recommended.

RÉSUMÉ

On a constaté que les sédiments déposés dans les aires de sédimentation de la rivière St. Marys, en aval (à l'est) du parc Bellevue, entre l'échancrure du Algoma Sailing Club et un point situé en aval de Partridge Point, dans le chenal Lake George, présentent des concentrations élevées d'hydrocarbures pétroliers et d'hydrocarbures aromatiques polycycliques (HAP), tant en surface qu'en profondeur. Toutefois, les données biologiques dont nous disposons pour cette zone sont limitées. En 2008, des échantillons de sédiments ont été prélevés dans cette zone et la qualité des sédiments a été évaluée à l'aide de l'analyse multivariée. Les données analysées comprenaient la structure des communautés d'invertébrés benthiques, les réactions fonctionnelles des invertébrés benthiques aux tests de toxicité, et les caractéristiques physiques et chimiques des sédiments et de la couche d'eau sous-jacente. Les conditions observées dans cette zone ont été comparées à celles de sites de référence situés dans les Grands Lacs. Les résultats ont été intégrés au cadre de prise de décisions concernant les sédiments contaminés pour déterminer le risque environnemental. Quinze sites ont ainsi été évalués : 11 à l'est du parc Bellevue et 4 dans le chenal Lake George.

Les concentrations de HAP dans les sédiments superficiels dépassaient la concentration minimale avec effet (CMAE) des lignes directrices sur la protection et la gestion des sédiments aquatiques à tous les sites. Elles variaient de 4,5 à 52 µg/g (poids sec), la plupart étant inférieures à 20 µg/g. Les concentrations d'hydrocarbures pétroliers (fraction F4) variaient de 117 à 6 510 mg/kg; dans un des sites, elles correspondaient à 1,2 fois le seuil prescrit par les standards pancanadiens (pour les sols). Les concentrations de un à neuf métaux (As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn) et de nutriments (carbone organique total, azote Kjeldahl, phosphore total) dépassaient la CMAE; seules les concentrations de fer dépassaient en règle générale la concentration avec effet grave (CEG).

Il n'y avait aucun signe évident de perturbation de la communauté benthique; six sites ont été jugés « équivalents » au site de référence, et neuf ont été qualifiés de « possiblement différents ». Les différences observées ont été attribuées principalement à une plus grande

abondance d'oligochètes et de larves de moucherons. La moitié des sites situés à l'est du parc Bellevue présentaient des communautés biologiques diversifiées tandis que l'autre moitié se caractérisait par une faible diversité taxonomique.

Trois sites à l'est du parc Bellevue présentaient une toxicité grave. La corrélation des réactions toxicologiques aux oligoéléments, aux nutriments et à la taille des particules était faible ($r^2 \leq 0{,}16$). Plusieurs autres sites ont laissé constater une légère toxicité. Dans le chenal Lake George, des effets sur la reproduction des vers *Tubifex* (faible pourcentage d'éclosion des cocons et de production de jeunes) ont été observés. Une analyse de régression plus poussée (tenant compte des contaminants organiques, des oligoéléments, des nutriments et de la taille des particules) a révélé que les métaux pouvaient expliquer en partie la toxicité observée dans certains cas, même si les concentrations de métaux dans les sédiments n'étaient pas exagérément élevées. Les causes de cette toxicité demeurent obscures.

L'application du cadre de prise de décisions a conduit aux conclusions suivantes : *aucune mesure supplémentaire requise* dans six sites; *élucidation requise des causes de la toxicité des sédiments ou de la perturbation des communautés benthiques* dans sept sites; et *mesures de gestion requises* dans deux sites. On a recommandé que des échantillonnages supplémentaires soient effectués aux endroits caractérisés par une toxicité grave et une diversité taxonomique réduite afin de définir plus clairement les conditions biologiques à ces endroits.

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1 INTRODUCTION

Background

Sediments in depositional areas in the lower St. Marys River east of Bellevue Park (BP) (in the Algoma Sailing Club embayment) and in Lake George Channel (LGC) were found to be elevated in petroleum hydrocarbons (PHCs) and polycyclic aromatic hydrocarbons (PAHs) both at surface and at depth (Biberhofer, unpublished; Burniston, 2007; Milani and Grapentine, 2006; 2009). In 2006, biological sampling east of BP by Environment Canada was limited to two sites. Elevated sediment PHCs, reduced survival in the midge *Chironomus* and mayfly *Hexagenia* in laboratory toxicity tests, and low benthic invertebrate taxon diversity were observed at both sites (Milani and Grapentine 2009). Sampling in LGC in 2006 was limited to three sites; two were toxic to the amphipod *Hyalella* and had elevated sediment PHCs while the other site, located at Partridge Point, was elevated in oil and grease and had low benthic invertebrate taxon diversity (Milani and Grapentine 2009).

Purpose of Study

The purpose of this study was to contrast biological conditions in the lower St. Marys River, from east of BP (in the Algoma Sailing Club Embayment) to LGC (downstream of Partridge Point) with reference locations and to increase sampling coverage in these areas of the river. The *Canada-Ontario Decision Making Framework for Assessment of Great Lakes Contaminated Sediment* was used to determine whether sediments posed an environmental risk and whether management action was required.

2 EXPERIMENTAL DESIGN

Sampling Design

One site from the 2006 survey was re-sampled (EC64) and an additional 14 sites were added: 10 east of BP and 4 in LGC. Sites in LGC included two between the Algoma sailing club embayment and Partridge Point, one at Partridge Point and one downstream of Partridge Point.

Of the 14 additional sites, those designated by “EC + number” were new sites and those designated by “CS + number” were sites where core samples were previously taken (Biberhofer, unpublished). The site downstream of Partridge Point (DBCR1) was a core station where elevated sediment petroleum hydrocarbons were found (Burniston, 2007). Sampling sites are shown in Figures 1a and 1b.

Measurement Endpoints

At each site, sediment, water and invertebrates were collected for (a) chemical and physical analysis of sediment and overlying water, (b) analysis of benthic invertebrate community structure, and (c) whole sediment toxicity tests. Sediment was obtained from the top 0 - 10 cm layer of river bed.

The benthic invertebrate community structure (taxonomic composition and relative abundances) was described based on identifications of macroinvertebrates to family level. Sediment toxicity was quantified based on acute and chronic responses of four invertebrate taxa (10 endpoints in total) in laboratory tests.

3 METHODS

Sample Collection and Handling

Overlying water, sediment (for physicochemical analysis and toxicity testing) and benthic invertebrate community samples were collected from 15 sites October 4-6, 2008. Methods for the collection and handling of all samples were identical as those in Milani and Grapentine (2009). Stations were positioned using a CDGPS-enabled GPS receiver resulting in approximately 1 to 5 m level accuracy. Site positions are provided in Table 1 and environmental variables measured at each site provided in Table 2.

Sample Analysis

Overlying water analyses (alkalinity, total phosphorus, nitrate+nitrite-N, ammonia-N and total Kjeldahl N) were performed by Environment Canada’s National Laboratory for Environmental

Testing (NLET) (Burlington, ON) by procedures equivalent to those described in Cancilla (1994) and EC (2008).

Sediments were analyzed for total mercury, 29 trace elements, major oxides, loss on ignition (LOI), total organic carbon (TOC), total phosphorus, and total Kjeldahl nitrogen (TKN) by Caduceon Environmental Laboratories (Ottawa, ON), using standard techniques outlined by the USEPA/CE (1981) or by in-house laboratory procedures.

Particle size analysis was performed at Environment Canada's Sedimentology Laboratory (Burlington, ON) following the procedures of Duncan and LaHaie (1979).

Sediments were analyzed for petroleum hydrocarbons (PHCs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and oil and grease by ALS Environmental Group (Mississauga, ON). PHCs were analyzed by GC/FIC based on CCME Canada-Wide Standards (CCME 2008). Oil and grease was determined by gravimetric extraction based on EPA method 8015 (USEPA 1992). PAHs and PCBs (Aroclors 1242, 1248, 1254, 1260) were analyzed by GC/MS based on EPA SW846 8270 (USEPA 1992).

Taxonomic Identification

Sorting, enumeration, identification and verification of benthic invertebrate samples were performed by EcoAnalysts, Inc. (Moscow, Idaho, USA). Certain taxa and microinvertebrates (e.g., poriferans, nematodes, copepods, and cladocerans) were excluded. Material was sorted under a dissecting microscope (minimum magnification = 10×), and organisms were enumerated and placed in vials for identification to family level by a qualified taxonomist.

Sediment Toxicity Tests

Four sediment toxicity tests were performed at Environment Canada's Ecotoxicology Laboratory (Burlington, ON):

- *Chironomus riparius* 10-day survival and growth test;
- *Hyalella azteca* 28-day survival and growth test;
- *Hexagenia* spp. 21-day survival and growth test;

- *Tubifex tubifex* 28-day adult survival and reproduction test.

Sediment handling procedures and toxicity test methods are described in Milani and Grapentine (2009).

4 DATA ANALYSIS

Multivariate procedures used in the analysis of benthic community structure and toxicity (BEAST approach) are provided in detail in Reynoldson et al. (1995, 2000) and described in Milani and Grapentine (2009).

General and Individual Contaminant Descriptor Relationships

As the BEAST approach does not incorporate information on organic contaminants in the sediment, relationships between toxicological response and contaminant concentrations (e.g., PAHs, PHCs, oil and grease, as well as sediment metals, nutrients and grain size) were examined by regression. To determine whether toxicity was better explained by joint consideration of the contaminant descriptors, multiple linear regression involving the contaminant descriptors as predictors was calculated with toxicity endpoints as the response variables. The degree to which individual sediment variables account for toxicity was assessed by fitting regression models using "best subset" procedures (Draper and Smith 1998; Minitab 2000). Models were fitted for (a) all combinations of metals, (b) all combinations of nutrients and grain size, (c) all combinations of PAHs (d) all combinations of PHCs, PCBs and oil and grease, and then (e) all combinations of the best predictors from the groups. (This procedure was used to avoid computational difficulties arising from working with many predictors simultaneously.) The best models were those having maximum explanatory power (based on adjusted R^2), minimum number of nonsignificant predictors, and minimum amount of predictor multicollinearity, expressed as a variance inflation factor (VIF). (A VIF greater than 5-10 indicates that the regression coefficients are poorly estimated (Minitab 2000)).

Analyses were conducted using the original measurement variables (i.e., concentrations of individual compounds) as well integrated contaminant descriptors. For integration of metal contaminants, extractable concentrations of 11 metals (As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn) were ordinated by principal components analysis (PCA). The eigenanalysis was performed on the correlation matrix. The first principal component from the PCA of sediment metals, which accounted for 87% of the total variation, was used in the general contaminant descriptor relationship determinations. Petroleum hydrocarbons were integrated by summing the concentrations of the C6 to C50 compounds, PAHs by summing 20 individual compounds and PCBs by summing the four Aroclors. Non-normally distributed data were log(x) or arcsine square root(x)-transformed. Where data were normally distributed or where transforming did not improve normality, these data were left untransformed.

5 QUALITY ASSURANCE/QUALITY CONTROL

One site was randomly selected as a QA/QC station. At this site, triplicate sediment, water, and benthic community samples were collected for determination of within-site and among-sample variability. Coefficients of variation (CV = standard deviation ÷ mean × 100) were examined for the analytical data.

Each laboratory employed procedures such as analyses of sample duplicates and repeats, matrix spikes and certified reference materials, as well as evaluations of sample recoveries. Details are provided in Milani and Grapentine (2009).

For benthic invertebrate identification and enumeration performed by EcoAnalysts, Inc., 20-25% of every sample was re-sorted to achieve the 95% level sorting efficiency. At least one specimen of each taxon encountered was kept in a separate vial to comprise a project reference collection. Internal quality assurance of the identifications involved examination of the reference collection by a second taxonomist to verify accuracy of all taxa identified. Additionally, 10% of samples were randomly selected and re-identified by a QA taxonomist. Data entry involved visual confirmations on the taxonomic identification and number of specimens in each taxon and the data was entered directly on a computer database. Variability in family counts between box core samples was examined by comparing positions of sites in the ordination plots.

6 RESULTS AND DISCUSSION

6.1 Quality Assurance/Quality Control

Field Replication

Among-site variability in a measured analyte can be broken down into three sources: natural within-site heterogeneity in the distribution of the analyte in sediment or water, differences in handling among samples, and laboratory measurement error. Among-site variability indicates the overall "error" associated with conditions at a site based on a single sample.

Variability among field-replicated sites, expressed as the CV, is provided in Appendix A; Tables A1 and A2. The CVs for trace metal and nutrient analysis were mostly low, ranging from 0 to 59% (median 10.5%) (Appendix A, Table A1). Most CVs (77%) were below 20%, indicating homogeneous conditions within a site that that a box core sample is a good representation of chemical conditions of a site. The CVs for organic contaminant measurements (e.g., PAHs, PHCs, oil and grease) were higher overall, ranging from 0 to 69% (median 29%) (Appendix A, Table A2).

Caducean Environmental Laboratory

Laboratory duplicate measurements for sediment variables are provided in Appendix A, Table A1. Sample duplicates were performed for two sites (EC25 and CS10). The RPDs ranged from 0 to 178%, with some high values for oxide compounds (e.g., TiO_2, P_2O_5 and Cr_2O_3 for site CS10). Median RPDs ranged from 1.1 to 2.3% and most RPDs (81 to 100%) were <20%, however. This indicated that there was generally good agreement between sample duplicates and that a high level of precision was achieved for sample measurements.

Analyses and recoveries for reference materials or standards (LKSD-3 (trace metals), STSD-2 (Hg), WH89-1 (major oxides), D053-542 (total Kjeldahl N and total P), and TOC QC (TOC) are provided in Appendix A, Table A3. Recoveries were mostly high, ranging from 36 to 113% (median 97%). While the recovery was low for Molybdenum (36%), it was within the control limits (0 to 260) for this variable. Recoveries for all other variables were well within the control limits for each parameter. These results were very similar to those found for the 2006 samples (Milani and Grapentine 2009).

ALS Laboratory Group

To test the effects of the matrix and precision of the laboratories sample preparation, surrogate spikes were performed. Prior to sample preparation, samples were spiked with the surrogate. The percent recovery for surrogate concentrations in the final sample extracts is provided in Appendix A, Table A4. Recoveries ranged from 77 to 125% (median 87%) for the BTEX surrogate (2,5-dibromotoluene), from 61 to 102% (median 84%) for the PHC surrogate (octacosane), from 102 to 125% (median 115%) for the PAH surrogates (2-fluorobiphenyl, p-Terphenyl d14) and from 104 to 138% (median 114%) for the PCB surrogate (d14-Terphenyl). Recoveries were generally high, indicating a good ability of the laboratory to analyze organic compounds.

Benthic Community Variability

The replicate sites of CS9 (CS900, CS901 and CS902) as well as the average of the three box cores (CS0avg) were in very close proximity to each other in ordination space, indicating good agreement in benthic community composition for the field replicates (Appendix A, Figure A1). Two of the three replicates fell in Band 1, and 1 replicate (CS901) fell in Band 2. These results indicated that the benthic invertebrate community within a site was well represented by the box core sample.

6.2 Sediment and Water Physico-Chemical Properties

6.2.1 Overlying Water

Physicochemical conditions in the overlying water (0.5 m above the sediment) were similar among sites (Table 3), suggesting homogeneity in water mass across these sampling sites. Ranges across sites (maximum – minimum value) were 8.5 mg/L for alkalinity, 2.0 µS/cm for conductivity, 1.3 mg/L for dissolved oxygen, 0.1 mg/L for NH_3, 0.03 mg/L for NO_3/NO_2, 0.2 mg/L for total Kjeldahl N, 0.2 for pH, 0.7°C for bottom temperature, and 12.6 µg/L for total phosphorus. Total phosphorus (range: 4.6 to 17.2 µg/L) did not exceed the interim Provincial Water Quality Objective of 20 µg/L at any site.

6.2.2 Sediment Particle Size

With the exception of site EC25, test sediments consisted mainly of fines (silty clay) (Figure 2; Table 4). Silt ranged from 24 to 87% (median 75%) and clay ranged from 11 to 33% (median 20%). Sand ranged from 0.9 to 64% (median 2.6%). There was no gravel present at any site. Site EC25 was comprised of mostly sand (64%). Particle size data for Great Lakes Reference Group 1 (which were best matched to test sites based on habitat predictors – see Section 6.3) are also shown in Figure 2 for comparison. Reference sites consisted of a higher percentage of sand than most tests sites, but percents sand, silt and clay fractions were within the range observed for test sites; median values for sand, silt, and clay are 7%, 40% and 33%, respectively.

6.2.3 Sediment Nutrients and Trace Metals

Sediment nutrient concentrations are provided in Table 5 and TOC is shown graphically in Figure 3. With the exception of sites EC22 and EC25 - TOC of 2.5 to 2.9%, TOC concentrations were quite high, ranging from 5.7 to 9.9% (median 7.1%) and were higher than the Great Lakes Reference Group 1 mean of 3.1%. Total Kjeldahl nitrogen (TKN) ranged from 943 to 5890 µg/g (median 3460 µg/g) and total phosphorus from 397 to 770 µg/g (median 684 µg/g). The Severe Effect Level (SEL) for TKN (4800 µg/g; Fletcher et al. 2008) was exceeded slightly at one site (EC15). Reference site TKN and total phosphorus concentrations were similar overall; median values for TKN and TP are 2416 µg/g and 572 µg/g, respectively (EC, unpublished data).

Metal exceedences of the PSQG Lowest Effect Level (LEL) (Fletcher et al. 2008) occurred at all sites for 1 to 9 metals (Table 5). The sandier sites (EC25 and EC22) had the lowest number of LEL exceedences (1 or 2 metals) while remaining sites had 7 to 9 metals exceeding LELs. The SEL was exceeded for iron (Fe) at 10 of the 15 sites, and for arsenic and copper marginally at 1 site. Site CS12 had the highest concentration of most metals. Exceedences of LELs also occurred at the majority of reference sites for most metals except mercury (EC, unpublished data).

6.2.4 PAHs

Total PAH concentrations (sum of 20 individual PAHs) ranged from 4.5 to 52.1 mg/kg (Table 6) with exceedences of the LEL (4 µg/g) occurring at all 15 sites (Figure 4). The highest concentration was observed at CS12, which exceeded the median for remaining sites (13.5 mg/kg) by 3.9 times. (CS12 also had the highest concentration of most metals – see Section 6.2.3.) Higher concentrations were observed east of BP (range: 10.9 to 52.1 mg/kg) compared to Lake George Channel (range: 4.5 to 10.1 mg/kg). Total PAH concentrations at sites east of BP were elevated compared to concentrations observed at regional and upstream reference sites (range: non detect to 1 mg/kg) and at sites EC63 and EC64 in 2006, which were 4.2 and 3.4 mg/kg, respectively (Milani and Grapentine 2009).

Individual PAH concentrations are also provided in Table 6. The LEL, where available (12 PAHs), are indicated; concentrations that exceeded the LEL are highlighted in the table. All 15 sites had individual PAH congener concentrations that exceeded the LEL (from 9 to all 12 PAHs where guidelines exist). Several PAHs including methylnaphthalene, acenaphthene, acridine, and quinoline were below method detection levels (MDL) at most sites.

6.2.5 BTEX and Petroleum Hydrocarbons

Benzene, toluene, ethylbenzene and xylene (BTEX) and petroleum hydrocarbons (PHC) concentrations are provided in Table 6. The BTEX and F1 (C6-C10 hydrocarbons) PHC compounds were mostly below method detection limits (MDLs, values preceded by "<"). (MDLs for BTEX and PHCs are provided in Appendix A, Table A5.) Total PHCs (C6 to C50 hydrocarbons) were most elevated east of BP, ranging from 700 to 7570 mg/kg (median: 1230 mg/kg) compared to LGC, which ranged from 340 to 1150 mg/kg (median: 591 mg/kg). North Channel reference site PHC concentrations were low, ranging from <100 to 120 mg/kg. The F2 (C10-C16 hydrocarbons) PHCs were detected at four of the 15 test sites in fairly low concentrations, ranging from 25 to 93 mg/kg. The F3 (C16-C34 hydrocarbons) PHCs were present at all sites and ranged from 210 to 1170 mg/kg (Table 6). The F4 fraction PHCs (C34-C50 hydrocarbons) were detected at all sites with concentrations ranging from 117 to 6510 mg/kg; the highest concentration was east of Bellevue Park at site EC15 (Figure 5), which was 16.5 times higher than the median value for all other sites (395 mg/kg). (EC15 was not the same site where the highest [PAH] was observed – see Section 6.2.4.) The gravimetric heavy hydrocarbons (F4G: ~C24-C50+), which typically include the very heavy hydrocarbons (e.g., heavy lubrication oils, asphaltenes) were detected at all sites. The chromatogram did not reach baseline at C50 (i.e., there were PHC with carbon chain lengths >50) at three of the 15 sites (CS10, CS11, CS12), indicating the presence of very heavy hydrocarbons at these sites. The concentration of the F4G fraction ranged from 300 to 2100 mg/kg.

In 2006, 10 sites were sampled at BP and 2 sites were sampled east of BP, one of which was repeated in the current study (EC64). The F3 fraction ranged from 140 to 1600 mg/kg at BP and from 1200 to 1800 mg/kg east of BP (Milani and Grapentine 2009). The F3 [PHC]s east of BP were higher than those found in the current study (480 to 1170 mg/kg, Table 6). In 2006, the F4 [PHC] east of BP ranged from 1100 to 1500 mg/kg and did not reach baseline at C50 (Milani and Grapentine 2009). In 2008, F4 [PHC]s were mostly lower except for site EC15; excluding EC15, concentrations ranged from 117 to 680 mg/kg with 8 of the 11 sites reaching baseline at C50 (Table 6).

Sediment PHC concentrations were compared to the PHC Canada-wide standard (CWS), a remedial standard for contaminated surface soil for different land use categories (industrial, residential/parkland, commercial, agricultural) and soil textures (coarse=median grain size > 75 µm; fine=median grain size ≤75 µm) (CCME 2008). (PHC concentrations were compared to these soil remedial standards since no such standards exist for sediments.) In cases where both the F4 and F4G results are reported (as for this study), the greater of the two was compared to the

F4 guideline. For this study PHC concentrations were compared to the numerical levels for the residential/parkland land use category. The CWS for each PHC fraction (fine-grained) are provided in Table 6. There were no exceedences of CWS for F1 to F3 fractions. One site east of BP (EC15) exceeded the F4 fraction CWS by 1.2 times (Table 6).

6.2.6 Oil and Grease

Oil and grease concentrations ranged from 300 to 1300 mg/kg; the highest concentration was at EC26 (east of BP) (Table 6). In 2006, oil and grease was elevated at test sites compared to the upstream reference site, and ranged from 361 to 648 μg/g east of BP (n=2) and from 108 to 2360 μg/g in LGC (n=3) (Milani and Grapentine 2009).

6.2.7 PCBs

Total PCBs (sum of Aroclors 1242, 1248, 1254 and 1260) concentrations were below MDLs at all sites (Table 6). In 2006, [PCB]s were low at sites east of BP (n=2) and in LGC (n=3), ranging from 0.10 to 0.14 μg/g and from 0.02 to 0.03 μg/g, respectively (Milani and Grapentine 2009).

6.3 Benthic Invertebrate Community

All 15 St. Marys River sites had the highest probability of belonging to Great Lakes (GL) Reference Group 1, based on the BEAST 38-family bioassessment model and five habitat attributes (alkalinity, depth, total organic carbon, latitude and longitude) (Table 7). The probabilities of test sites belonging to Group 1 were high, ranging from 81 to 97%. GL Reference Group 1 has a total of 108 sites: 39 from Georgian Bay, 24 from North Channel, 21 from Lake Ontario, 16 from Lake Erie, 4 from Lake Huron, and 4 from Lake Michigan. This reference group is characterized mainly by Chironomidae (midge, ~40% occurrence), Tubificidae (oligochaete worm, ~17% occurrence), and Sphaeriidae (fingernail clam, ~15% occurrence). To a lesser degree, Asellidae (isopod), Naididae (oligochaete worm), and Sabellidae (polychaete worm) are also present (between ~4 to 6% occurrence). Other families such as Pontoporeiidae (amphipod), Valvatidae (snail), Dreissenidae (zebra mussel) and Gammaridae (amphipod) are present occasionally (≤ 2% occurrence). Table 8 shows the mean abundance of the predominant GL Reference Group 1 families for the St. Marys River sites. Complete invertebrate family identification and average counts for all taxa found in St. Marys River samples are provided in Appendix B; Table B1.

St. Marys River samples consisted mainly of chironomids and oligochaete worms (tubificids and naidids) (Table 8). Chironomids and tubificid worms were mostly present in increased abundances compared to the GL reference means (from 1.4 to 7× for chironomids and from 1.9 to 19 times for tubificids) (Table 8). The highest density of tubificid worms and chironomids was in Lake George Channel (LGC). Naidid worms were also present at all sites; most sites had increased abundances compared to reference (from 1.4 to 66 times the reference mean). Sphaeriids and sabellids were absent or present in low abundance for the most part, and asellids were present at most sites in relatively good numbers. The generally more pollution sensitive groups such as ephemeropterans (mayflies), trichopterans (caddisflies) and amphipods were present at 3 to 5 sites east of BP and at 2 to 4 sites in LGC in mostly low abundance with some exceptions (e.g., EC25 – Ephemeridae; CS12 – Hyalellidae; Appendix B, Table B1).

Figure 6(A) shows the mean relative abundance of several taxa for different areas of the river (east of BP, LGC) as well as for the GL reference group. The benthic composition for LGC sites and reference sites were most similar while the area east of BP contained a higher percentage of worms and a lower percentage of all other taxa such as snails, amphipods, mayflies and caddisflies. Figure 6(B) shows the relative abundance of taxa for each individual site. East of BP, there was a mixture of sites that were fairly diverse (e.g., CS9, CS12, EC15, EC26, EC64) and sites that had a greater percentage of tubificids and were less diverse (e.g., CS6-CS8, CS10-CS11). Sites in LGC were quite diverse with the exception of DBCR1. The number of families present (based on the 38-family bioassessment model) ranged from 4 to 15 for sites east of BP; 4 of the 11 sites had an equal or greater number of families than the GL reference mean (8) (Table 8). Site EC64 had 3 taxa present in 2006 (Milani and Grapentine 2009) compared to 8 in 2008 (Table 8). For sites in LGC, the number of taxa present ranged from 6 to 18; 4 to 16 taxa were present at LGC sites in 2006 (Milani and Grapentine 2009).

The results of the BEAST multivariate assessment of St. Marys River sites are summarized in Table 9. Three axes adequately described the variation in data. Stress, which is a measure of the goodness of fit between the distances among points in ordination space and the matrix input distances, is indicated in Table 9. The larger the disparity the larger the stress and stress > 0.20 is considered poor (Belbin 1993). The stress for site assessments was between 0.157 and 0.162, which is considered fair. Of the 15 sites, 6 were categorized as *equivalent* (Band 1) and 9 as *possibly different* (Band 2). No sites were *different* or *very different* than reference (Band 3 or 4). Seven of the nine *possibly different* sites are east of BP and two are in LGC. Categories for sites east of Bellevue Park are mapped in Figure 7 and ordination plots for the nine sites that were *possibly different* to reference are provided in Appendix C, Figures C1 to C3; each subfigure representing one test site. In some cases, the movement of *possibly different* sites outside of reference was associated with increased abundance of tubificid or naidid worms and/or chironomids as indicated in the ordination plot by the shift of these sites away from the reference centroid in the same direction as these vectors (Appendix C, Figures C1 to C3). Chironomidae was the most highly correlated family in the assessments ($r^2 = 0.51$ to 0.62), followed by Tubificidae ($r^2 = 0.16$ to 0.54).

The relationship between the benthic community response and habitat variables was examined by correlation of the ordination of the community data and the habitat information. Between 10 and 18 variables were significantly correlated ($p<0.01$) to ordination axes scores. The most highly correlated are shown in each figure (Appendix C, Figures C1 to C3) and included Hg (sediment), sample depth, alkalinity (water) and NO_3/NO_2 (water). Sites did not appear to be associated with any particular habitat variable (i.e., there were no variables oriented in the position of the St. Marys River sites), and correlations of above mentioned habitat variables were not high ($r^2=0.11$ to 0.17).

Site EC64 was categorized as *possibly different* (Band 2), which differed from 2006 results, where it was categorized as *different* (Band 3) (Milani and Grapentine 2009). The difference was likely due to the decreased abundance of tubificid worms in 2008 (36/33 cm^2 in 2008 vs. 113/33 cm^2 in 2006) as well as higher taxon diversity in 2008 (8 taxa present in 2008 vs. 3 in 2006). The differences between years at this site could reflect small scale heterogeneity (between years sites were ~7 m apart). Small scale heterogeneity was also observed in other areas of the river (Bellevue Park, Lake George Channel; Milani and Grapentine 2009).

6.4 Sediment Toxicity

Mean species survival, growth and reproduction from toxicity tests are provided in Table 10. Ordinations are provided in Appendix D, Figures D1 to D3; each figure representing a subset of St. Marys River test data (4 to 7 site data) summarized on two of three axes. Stress was ≤ 0.113, indicating that the resultant three axes represented the original 10-dimensional among-site resemblances well. Overall results are as follows and toxicity categories for sites east of Bellevue Park are mapped in Figure 8.

- Non-toxic (4 sites): CS11, CS12, EC15, EC22
- Potentially toxic (7 sites): CS6, CS7, CS8, CS9, CS10, EC25, EC29
- Toxic (1 site): DBCR1
- Severely toxic (3 sites): EC16, EC26, EC64

The *severely toxic* sites east of BP (EC16, EC26 and EC64) had low *Chironomus* survival ($r^2 = 0.90$) as well as low *Tubifex* cocoon production, although this correlation was weak ($r^2 = 0.10$). Multiple endpoints were affected at these sites (Table 10).

Potentially toxic/*toxic* sites in LGC (EC25, EC29, DBCR1) had low *Tubifex* cocoon hatch ($r^2 = 0.77$) and young production ($r^2 = 0.80$). This was indicated in the ordination plots by the shift of these sites away from the reference centroid in the opposite direction to these vectors (Appendix D, Figures D2 and D3). No other organisms were affected at these sites (Table 10). *Toxic* site DBCR1 (Band 3) had only one test endpoint exhibiting a major toxicological effect (% *Tubifex* cocoon hatch) and a subsequent effect in young production (Table 10). *Potentially toxic* sites east of BP had a low percentage of hatched *Tubifex* cocoons and low amphipod survival

(Appendix D, Figure D1). Some *potentially toxic* sites had a minor toxicological affect in only one endpoint (i.e., CS6, CS7, CS9, and EC25) (Table 10).

General and Individual Contaminant Descriptor Relationships

Examination of the relationships between sediment toxicity and *integrated* sediment contaminants by multiple regression analysis revealed weak or non-significant relationships for the most affected toxicity endpoints: survival of *Chironomus*; growth of *Hexagenia*, and; *Tubifex* percent cocoons hatched. Examination of relationships between sediment toxicity and *individual* sediment contaminants revealed some significant relationships:

Chironomus survival = - 3.58 - 1.25 *log*As + 1.16 *log*Pb + 0.0543 Alk - 0.664 *log*Total P(water); adjusted r^2= 0.79, p<0.00, VIF <7.8

log Hexagenia growth = 0.943 + 0.0273 Cr - 0.000062 Fe; adjusted r^2 =0.46, p=0.01, VIF=6.5

Tubifex %cocoon hatch = - 89.3 - 101 *log*Hg + 0.169 Zn; adjusted r^2= 0.52, p=0.005, VIF=6.9

Endpoints were most strongly correlated to metal contaminants. Negative coefficients indicated that a decrease survival, growth or reproduction was associated with an increased concentration of contaminant or nutrient while positive coefficients indicated that decreased survival, growth or reproduction was associated with decreased concentrations. Predictors with coefficients indicating decrease in toxicity with increase in contaminant concentration (positive) do not suggest causal relationships. After excluding predictors not indicative of toxicity relationships, toxicity was most strongly associated with As, Fe or Hg, although these metals were not overly elevated in the sediment (Table 5).

Examination of toxicity-contaminant relationships from the 2006 St. Marys River study revealed that variability in mayfly growth was almost equally explained by elevated sediment zinc concentrations (r^2=0.47, p=0.005) or elevated TOC (r^2=0.47, p=0.002) (Milani and Grapentine 2009). For the chironomid model, elevated zinc concentrations in overlying water explained most of the variability in growth (r^2=0.63, p<0.0001). (Overlying metal concentrations were not measured in the current study.) In 1995 and 2002 toxicity studies, it was found that elevated PHCs best explained most of the toxicity occurring at Bellevue Park and that a combination of chemical and physical characteristics of the sediment were also required to explain toxicity (Bedard and Petro 1997; Milani and Grapentine 2006). The cause of toxicity east of BP and in LGC remains unclear.

6.5 Integration of Lines of Evidence

Based on the data from three lines of evidence (sediment chemistry, toxicity, benthic invertebrate community structure), a decision matrix was developed (Table 11). The information obtained allowed for the assessment of three possibilities (EC/MOE 2007):

1. the contaminated sediments pose an environmental risk;
2. the contaminated sediments may pose an environmental risk, but further assessment is required before a definitive decision can be made;
3. the contaminated sediments pose a negligible environmental risk.

Interpretation of the overall assessment considered the degree of degradation for each line of evidence. For the sediment chemistry column, sites with exceedences of a high Sediment Quality Guideline (SGQ), e.g., Severe Effect Level or Probable Effect Level, were indicated by "■"; sites with exceedences of the Lowest Effect Level (LEL) or the Canada Wide Standards (CWS) for petroleum hydrocarbons (soil) by "◘". For the benthos alteration column, sites determined from the BEAST analysis as *different* or *very different* from reference were indicated by "■"; sites determined as *possibly different* from reference by "◘". For the toxicity column, sites that had multiple endpoints exhibiting major toxicological effects were indicated by "■"; sites that had multiple endpoints exhibiting minor toxicological effect and/or one endpoint exhibiting a major effect by "◘". Sites with no SQG exceedences, minor toxicological effects observed in no more than one endpoint and benthic communities that were equivalent to reference conditions were indicated by "☐". Some sites showed possible benthos alteration but were not recommended for further action. For these sites, the benthos alteration was not judged to be detrimental (e.g., decreased taxon richness, reduced average abundance).

Based on the framework, *management actions required* was indicated at two sites: CS10 (east of BP) and DBCR1 (LGC). *Determine reason(s) for benthos alteration* was indicated at two sites (CS7 and CS11) and *determine reason(s) for sediment toxicity* at five sites (CS8, EC16, EC26, EC64, EC29). The assessment outcome for site EC64 sampled in 2006 was *management actions required* due to elevated PHCs, toxicity and an altered benthic community (Milani and Grapentine 2009). Toxicity was more severe to *Chironomus* and *Hexagenia* at EC64 in 2008 (Note: only two organisms were tested in 2006 vs. four in 2008); however, the benthic communities sampled in 2008 were not considered degraded. *No further actions needed* were indicated at the remaining six sites (four east of BP and two in LGC).

7 CONCLUSIONS

Sediment Chemistry

- PAH concentrations were elevated compared to regional and local reference sites and above the low guideline (LEL); most concentrations were below 20 mg/kg.
- Petroleum hydrocarbons were elevated compared to regional reference sites. The Canada-Wide Standard for the F4 fraction (soil) was marginally exceeded at one site east of Bellevue Park.
- Metals (1 to 9) were above low guidelines (LELs) and mostly below high guidelines (SELs) except for iron.
- PCBs were not detected.
- Total organic carbon was generally high throughout.

Benthic Invertebrate Community

- Benthic communities were not considered degraded. Sites were either *equivalent* to reference or at most *possibly different* to reference. Results were consistent with past studies in the river.
- Increased abundance of worms and chironomids compared to reference was likely driving sites into *possibly different* category and may reflect organic enrichment.

Sediment Toxicity

- Acute toxicity was observed at three sites east of Bellevue Park while minor toxicity was observed at several other sites. *Tubifex* reproduction was affected in Lake George Channel.
- The cause of toxicity was not clear but in some cases could be partially explained by metal contaminants; however, metal contaminants were not overly high.

Decision-making Framework

- *Management action required* was indicated at two sites due to elevated sediment contaminants above sediment guidelines, benthos alteration and sediment toxicity.
- *Determine reason(s) for benthos alteration* or *toxicity* was indicated at seven sites. However, benthic communities were not considered degraded therefore further action for this line of evidence is not needed.
- *No further action needed* was indicated at six sites.

8 RECOMMENDATIONS

Additional sampling is recommended east of Bellevue Park and in Lake George Channel, specifically around locations where severe toxicity or possibly benthic impairment (low taxon diversity and increased abundances of worms and chironomids) were observed. This additional sampling would better define biological conditions in these areas. Locations for further assessment (sampling took place fall 2009) are shown in Figure 9.

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Tables

Table 1. St. Marys River 2008 sampling site positions and depth.

Location	Site	Latitude	Longitude	Depth (m)
East of Bellevue Park	CS6	46.49638748	-84.2940826	4.9
	CS7	46.49499893	-84.2946396	4.1
	CS8	46.49499893	-84.2916641	4.1
	CS9	46.49694443	-84.2899323	4.0
	CS10	46.49527740	-84.2891083	8.5
	CS11	46.49555588	-84.2877121	6.7
	CS12	46.49694443	-84.2922211	2.6
	EC15	46.49777603	-84.2946091	1.7
	EC16	46.49611282	-84.2907486	5.3
	EC26	46.49555588	-84.2858353	5.4
	EC64	46.49527740	-84.2933350	4.2
Lake George Channel	EC22	46.50166702	-84.2572250	4.5
	EC25	46.51861191	-84.2426147	5.3
	EC29	46.52444458	-84.2376099	4.3
	DBCR1	46.53416824	-84.2305527	4.4

Table 2. Environmental variables measured at St. Marys River sites.

Field	**Water**	**Sediment**
Northing	Alkalinity	Suite of Metals
Easting	Conductivity	Major Oxides
Site depth	Dissolved Oxygen	Total Kjeldahl Nitrogen
	pH	Total Phosphorus
	Temperature	Total organic Carbon
	Total Kjeldahl Nitrogen	Loss on Ignition
	Total Phosphorus	% Sand, Silt, Clay, Gravel
	Ammonia	Polychlorinated Biphenyls
	Nitrates/Nitrites	Polycyclic Aromatic Hydrocarbons
		Petroleum Hydrocarbons
		Oil and Grease

Table 3. Characteristics of overlying water at St. Marys River sites. Values are in mg/L unless otherwise noted.

Site	Alkalinity	Conductivity (µS/cm)	Dissolved O_2	NH_3	NO_3/NO_2	TKN	pH	Temp (°C)	Total P µg/L
CS6	43.4	99	10.2	0.028	0.288	0.147	8.0	12.2	6.9
CS7	43.7	99	10.2	0.063	0.304	0.247	8.1	12.3	5.1
CS8	41.2	99	10.8	0.046	0.319	0.186	8.1	12.6	5.7
CS9	43.1	99	10.6	0.020	0.312	0.207	8.0	12.9	7.2
CS10	42.5	99	10.5	0.021	0.304	0.179	8.0	12.6	6.8
CS11	42.1	99	10.3	0.018	0.312	0.192	8.0	12.9	4.6
CS12	43.2	98	10.5	0.003	0.297	0.138	8.0	12.6	5.1
EC15	44.6	100	10.5	0.073	0.294	0.231	8.0	12.2	10.6
EC16	42.6	98	10.3	0.012	0.318	0.175	8.0	12.6	17.2
EC26	43.1	98	10.4	0.006	0.309	0.140	8.2	12.5	4.9
EC64	36.1	99	10.3	0.020	0.294	0.301	8.0	12.4	5.8
EC22	43.5	98	11.1	0.012	0.308	0.150	8.1	12.8	4.6
EC25	43.0	100	10.9	0.010	0.311	0.161	8.0	12.6	6.1
EC29	42.6	100	11.2	0.003	0.305	0.152	8.0	12.3	5.4
DBCR1	42.7	100	10.0	0.007	0.318	0.153	8.1	12.3	7.9

Table 4. St. Marys River sediment grain size analysis.

Site	% Sand	% Silt	% Clay	% Gravel	Particle Size Mean (µm)
CS6	1.1	76.5	22.5	0.0	16.4
CS7	1.1	65.9	33.0	0.0	12.7
CS8	0.9	73.2	25.9	0.0	14.3
CS9	3.4	76.8	19.9	0.0	22.0
CS10	0.9	78.8	20.3	0.0	19.5
CS11	2.6	81.8	15.6	0.0	23.4
CS12	3.8	74.5	21.7	0.0	18.1
EC15	2.3	71.9	25.9	0.0	15.3
EC16	8.9	73.6	17.6	0.0	23.6
EC26	19.1	48.2	32.7	0.0	26.3
EC64	0.9	76.1	23.0	0.0	17.7
EC22	34.9	48.1	17.1	0.0	49.6
EC25	64.3	24.2	11.6	0.0	88.7
EC29	3.5	78.8	17.7	0.0	20.9
DBCR1	1.9	87.0	11.1	0.0	23.5

Table 5. Sediment trace metal and nutrient concentrations (dry weight) at St. Marys River sites. Values > the provincial Sediment Quality Guideline Severe Effect Level (SEL) are indicated in red; values greater than the Lowest Effect Level (LEL) are italicized and bolded.

Parameter	**Units**	**M.D.L.**	**Reference Method**	**LEL**	**SEL**	**CS6**	**CS7**	**CS8**	**CS9**[b]	**CS10**[a]	**CS11**	**CS12**	**EC15**	**EC16**	**EC26**	**EC64**	**EC22**	**EC25**[a]	**EC29**	**DBCR01**
Aluminum	µg/g	10	EPA 6010			8840	8680	8100	7030	7875	6240	7990	9460	7740	3870	8330	4700	2600	6740	6960
Antimony	µg/g	5	EPA 6010			< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Arsenic	µg/g	5	EPA 6010	6	33	***12***	***11***	***13***	***9***	***9***	***7***	39	***10***	***10***	***15***	***10***	< 5	< 5	***7***	5
Barium	µg/g	1	EPA 6010			65	81	66	53	61.5	49	49	77	59	28	69	32	17	55	57
Beryllium	µg/g	0.2	EPA 6010			0.5	0.5	0.5	0.4	0.4	0.4	0.5	0.5	0.4	0.3	0.5	0.2	< 0.2	0.4	0.4
Bismuth	µg/g	5	EPA 6010			< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Cadmium	µg/g	0.5	EPA 6010	0.6	10	***1.5***	***1.3***	***1.3***	***0.8***	***1.2***	***0.8***	***1.4***	***1.6***	***1.1***	***0.7***	***1.2***	< 0.5	< 0.5	***0.9***	***1.2***
Calcium	µg/g	10	EPA 6010			4200	4300	3900	3903	4030	3530	4860	5240	3870	2920	3900	2750	1860	3850	4000
Chromium	µg/g	1	EPA 6010	26	110	***79***	***76***	***76***	***81***	***71***	***73***	***109***	***85***	***73***	***57***	***77***	***28***	19	***63***	***58***
Cobalt	µg/g	1	EPA 6010			10	10	10	8	9	8	13	10	9	7	9	5	3	8	8
Copper	µg/g	1	EPA 6010	16	110	***93***	***84***	***89***	***66***	***81***	***63***	111	***93***	***79***	***54***	***83***	***27***	***20***	***65***	***74***
Iron	%	10	EPA 6010	2	4	**5.0**	**4.2**	**5.1**	**4.1**	**4.8**	**4.7**	**6.6**	***4.0***	**4.7**	**4.3**	**4.5**	1.7	1.5	***3.6***	***3.5***
Lead	µg/g	5	EPA 6010	31	250	***101***	***89***	***91***	***55***	***71***	***55***	***238***	***100***	***77***	***52***	***81***	20	19	***53***	***58***
Magnesium	µg/g	10	EPA 6010			4760	4710	4390	3847	4315	3510	4330	5120	4350	2150	4470	2480	1350	3460	3650
Manganese	µg/g	1	EPA 6010	460	1100	***618***	***498***	***614***	***477***	***572***	***544***	***1000***	***466***	***559***	***516***	***529***	227	141	423	384
Mercury	µg/g	0.005	EPA 7471A	0.2	2	0.196	0.160	0.168	0.116	0.142	0.129	0.421	0.192	0.139	0.143	0.150	0.050	0.083	0.150	0.167
Molybdenum	µg/g	1	EPA 6010			3	2	3	3	2.5	2	4	2	3	2	2	< 1	< 1	1	1
Nickel	µg/g	1	EPA 6010	16	75	***30***	***29***	***31***	***25***	***27***	***23***	***44***	***30***	***28***	***22***	***28***	12	8	***21***	***22***
Phosphorus	µg/g	5	EPA 6010			752	788	718	693	807	809	615	828	688	589	747	540	498	771	755
Potassium	µg/g	30	EPA 6010			1200	1200	1120	1053	1090	940	1090	1380	1050	550	1180	660	360	1090	990
Silicon	µg/g	1	EPA 6010			278	136	212	186	232.5	189	203	305	181	247	273	168	179	236	137
Silver	µg/g	0.2	EPA 6010			0.6	0.4	0.6	0.3	0.4	0.3	1.3	0.5	0.4	0.3	0.4	< 0.2	< 0.2	0.7	0.8
Sodium	µg/g	20	EPA 6010			710	720	630	653	645	640	590	700	690	730	730	690	630	700	710
Strontium	µg/g	1	EPA 6010			15	15	13	12	13	12	14	17	12	11	13	8	6	12	13
Tin	µg/g	10	EPA 6010			< 10	< 10	< 10	< 10	< 10	< 10	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Titanium	µg/g	1	EPA 6010			515	500	469	455	478.5	394	432	503	465	291	476	361	229	421	420
Vanadium	µg/g	1	EPA 6010			35	35	34	32	34	29	34	39	33	22	34	21	14	27	28
Yttrium	µg/g	0.5	EPA 6010			9	9	8.6	8.2	8.8	7.8	8.4	9.2	8.5	6.6	8.8	6.0	5.1	7.9	8.0
Zinc	µg/g	1	EPA 6010	120	820	***380***	***334***	***362***	***228***	***287***	***229***	***632***	***355***	***283***	***226***	***320***	89	79	***207***	***245***
Zirconium	µg/g	0.1	EPA 6010			0.3	0.5	0.3	1.0	0.75	0.7	< 0.1	0.7	0.6	< 0.1	0.5	1.0	0.6	< 0.1	0.7
Aluminum (Al2O3)	%	0.01	IN-HOUSE			10.6	11.0	10.4	10	10.8	9.92	10.2	10.6	10.7	8.37	10.5	9.58	9.245	9.97	10.3
Barium (BaO)	%	0.001	IN-HOUSE			0.052	0.052	0.052	0.061	0.062	0.078	0.052	0.052	0.052	0.078	0.052	0.078	0.091	0.078	0.078
Calcium (CaO)	%	0.01	IN-HOUSE			1.78	1.83	1.82	1.63	1.37	1.65	1.65	1.87	1.77	1.38	1.81	0.49	1.34	1.74	1.78
Chromium (Cr2O3)	%	0.01	IN-HOUSE			0.05	0.04	0.04	0.05	0.025	0.05	0.10	0.05	0.04	0.05	0.05	0.01	0.04	0.05	0.04
Iron (Fe2O3)	%	0.05	IN-HOUSE			10.8	9.11	10.8	8.6	10.2	10.4	14.5	8.68	9.78	9.91	9.66	3.80	3.825	7.86	7.45
Magnesium (MgO)	%	0.01	IN-HOUSE			1.57	1.60	1.44	1.20	1.54	1.10	1.60	1.53	1.44	0.79	1.51	0.78	0.645	1.30	1.30
Manganese (MnO)	%	0.01	IN-HOUSE			0.10	0.10	0.10	0.09	0.1	0.10	0.17	0.10	0.10	0.10	0.10	0.05	0.05	0.08	0.08
Phosphorus (P2O5)	%	0.03	IN-HOUSE			0.21	0.09	< 0.04	< 0.04	0.135	0.1	< 0.04	< 0.04	0.09	< 0.04	< 0.04	0.27	0.09	0.21	0.10
Potasium (K20)	%	0.01	IN-HOUSE			2.30	2.09	2.16	2.22	2.615	2.24	1.98	2.08	1.88	2.09	2.13	2.86	3.25	2.25	2.39
Silica (SiO2)	%	0.01	IN-HOUSE			54.2	53.8	54.2	56.5	58.4	57.3	48.8	53.6	57.7	56.4	55.7	70.7	66.8	59.9	59.4
Sodium (Na2O)	%	0.01	IN-HOUSE			2.03	1.95	1.96	1.86	3.025	1.86	1.75	1.78	2.03	1.73	2.00	3.69	2.145	2.30	2.05
Titanium (TiO2)	%	0.01	IN-HOUSE			0.07	0.69	0.69	0.65	0.37	0.68	0.68	0.69	0.69	0.56	0.69	0.52	0.49	0.69	0.69
Loss on Ignition	%	0.05	IN-HOUSE			19.60	20.2	19.7	17.2	16.7	15.8	23.1	23.3	15.7	22.1	19.2	7.28	7.52	15.7	15.8
Whole Rock Total	%		IN-HOUSE			103	103	103	100	105.5	101	105	104	102	104	103	100	95.55	102	101
Total Organic Carbon	% by wt	0.1	LECO	1	10	***7.7***	***7.6***	***8.1***	***6.3***	***6.8***	***6.6***	***9.9***	***8.4***	***6.6***	***9.7***	***7.1***	***2.5***	***2.9***	***5.7***	***5.9***
Total Kjeldahl Nitrogen	µg/g	0.05	EPA 351.2	550	4800	***4210***	***4630***	***4080***	***3367***	***3520***	***2970***	***2510***	5890	***3130***	***2160***	***4140***	***1690***	***943***	***3460***	***3920***
Phosphorus-Total	µg/g	0.01	EPA 365.4	600	2000	***702***	***733***	***700***	***684***	***722***	***743***	584	***770***	600	397	***701***	514	424	487	***648***

[a] Mean of laboratory duplicate samples; [b] Mean of three field replicates; MDL = Method Detection Limit

Table 6. Sediment petroleum hydrocarbon, PAH, oil and grease and PCB concentrations (mg/kg dw) at St. Marys River sites. Values below method detection limits are indicated by "<". [Method detection limits are provided in Appendix A, Table A5]. Values exceeding guidelines or standards are indicated in red.

	Guideline	East of Bellevue Park											Lake Geroge Channel			
Analyte	mg/kg	**CS6**	**CS7**	**CS8**	**CS9a**	**CS10**	**CS11**	**CS12**	**EC15**	**EC16**	**EC26**	**EC64**	**EC22**	**EC25**	**EC29**	**DBCR01**
BTEX																
Benzene		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethyl Benzene		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
m+p-Xylenes		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
o-Xylene		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene		<0.05	0.15	<0.05	0.15	<0.05	0.11	<0.05	0.12	<0.05	<0.05	0.16	<0.05	<0.05	0.1	0.08
Xylene, (total)		<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
CCME Total Hydrocarbons	CWS[b]															
F1 (C6-C10)	210	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F1-BTEX		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10-C16)	150	<20	<20	<20	<20	29	<20	93	<20	25	27	<20	<20	<10	<20	<20
F2-Naphth		<20	<20	<20	<20	28	<20	92	<20	24	26	<20	<20	<10	<20	<20
F3 (C16-C34)	1300	480	760	860	543	940	480	1170	1060	570	820	730	210	275	750	490
F3-PAH		470	750	850	530	930	470	1130	1050	560	810	720	210	269	740	480
F4 (C34-C50)	5600	260	470	610	333	680	220	550	**6510**	470	570	390	130	117	400	300
F4G-SG (GHH-Silica)		600	1300	1600	833	400	800	1100	2100	1100	1300	1000	400	300	1400	800
Total Hydrocarbons (C6-C50)		740	1230	1470	877	1650	700	1810	7570	1070	1420	1120	340	392	1150	790
Chromatogram to baseline at nC50		YES	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES
CCME PAHs	LEL[c]															
1-Methylnaphthalene		<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.1	<0.1
2-Methylnaphthalene		<0.1	<0.1	0.1	0.15	0.1	0.1	0.2	<0.1	0.1	0.2	<0.1	<0.05	<0.05	<0.1	<0.1
Acenaphthene		<0.1	<0.1	0.1	0.2	<0.1	<0.1	0.3	<0.1	0.1	0.1	<0.1	<0.05	<0.05	<0.1	<0.1
Acenaphthylene		0.3	0.2	0.2	0.2	0.3	0.2	0.7	0.2	0.2	0.3	0.2	0.06	0.13	0.2	0.2
Acridine		<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<0.8	<0.8	<2	<2
Anthracene	0.22	**0.3**	0.2	0.2	**0.3**	**0.3**	0.2	**1.0**	0.2	0.2	**0.4**	0.2	0.1	0.2	0.2	0.2
Benzo(a)anthracene	0.32	**1.4**	**1.2**	**1.2**	**1.4**	**1.2**	**0.8**	**4.9**	**1.1**	**1**	**1.5**	**1.2**	**0.39**	**0.81**	**1**	**0.9**
Benzo(a)pyrene	0.37	**1.54**	**1.27**	**1.31**	**1.4**	**1.35**	**0.94**	**4.35**	**1.26**	**1.07**	**1.55**	**1.27**	**0.41**	**0.72**	**0.93**	**0.86**
Benzo(b)fluoranthene		1.8	1.4	1.5	1.5	1.6	1	5	1.5	1.2	1.7	1.4	0.43	0.84	1	1
Benzo(g,h,i)perylene	0.17	**1.2**	**1**	**1**	**1.0**	**1.1**	**0.8**	**3.1**	**1**	**0.9**	**1.1**	**1**	**0.29**	**0.45**	**0.7**	**0.7**
Benzo(k)fluoranthene	0.24	**1.1**	**1**	**1**	**1**	**0.9**	**0.8**	**3.4**	**0.9**	**0.7**	**1**	**1**	**0.31**	**0.54**	**0.7**	**0.7**
Chrysene	0.34	**1.4**	**1.3**	**1.3**	**1.4**	**1.3**	**1.1**	**5.4**	**1.2**	**1**	**1.6**	**1.3**	**0.4**	**0.84**	**0.9**	**0.9**
Dibenzo(ah)anthracene	0.06	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.6**	**0.2**	**0.1**	**0.2**	**0.2**	0.06	**0.08**	**0.1**	**0.1**
Fluoranthene	0.75	**2.2**	**1.9**	**2**	**2.3**	**2**	**1.5**	**8.5**	**1.8**	**1.6**	**2.4**	**1.9**	0.64	**1.19**	**1.4**	**1.3**
Fluorene	0.19	0.1	0.1	0.1	0.17	0.1	<0.1	**0.3**	<0.1	0.1	**0.2**	0.1	<0.05	0.06	<0.1	<0.1
Indeno(1,2,3-cd)pyrene	0.20	**1.4**	**1.2**	**1.2**	**1.2**	**1.3**	**0.9**	**3.7**	**1.3**	**1**	**1.3**	**1.2**	**0.35**	**0.53**	**0.8**	**0.8**
Naphthalene		0.5	0.4	0.6	1.1	0.8	0.6	0.8	0.4	0.6	1.3	0.6	0.26	0.32	0.4	0.3
Phenanthrene	0.56	**0.8**	**0.7**	**0.8**	**1**	**0.8**	**0.6**	**2.5**	**0.7**	**0.7**	**1**	**0.7**	0.28	0.44	**0.6**	0.5
Pyrene	0.49	**1.9**	**1.7**	**1.8**	**1.9**	**1.7**	**1.3**	**7.3**	**1.5**	**1.5**	**2.1**	**1.6**	**0.52**	**1.05**	**1.2**	**1.1**
Quinoline		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.1	<0.1
Total PAHs (sum)	4.0	**16.1**	**13.8**	**14.6**	**16.4**	**15.1**	**10.9**	**52.1**	**13.3**	**12.1**	**18.0**	**13.9**	**4.5**	**8.2**	**10.1**	**9.6**
Individual Analytes																
% Moisture		70.4	71.9	70.4	71.2	67.6	64.1	70.4	76.3	65.3	63.7	72.9	53.3	41.6	71.3	67.7
Oil and Grease, Total		500	300	400	500	500	300	600	300	500	1300	500	300	400	500	800
PCBs	LEL[c]															
Aroclor 1242	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.1	<0.1
Aroclor 1248	0.03	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.1	<0.1
Aroclor 1254	0.06	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.1	<0.1
Aroclor 1260	0.005	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.1	<0.1
Total PCBs	0.07	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.05	<0.05	<0.1	<0.1

[a] Mean of 3 field replicates; [b] For fine textured, residential/parkland land use category (CCME 2008); [c] Fletcher et al. (2008)

Table 7. Probabilities of test sites belonging to Great Lakes faunal groups.

	Probability of Group Membership				
Site	Group 1	Group 2	Group 3	Group 4	Group 5
CS6	**0.93**	0.00	0.00	0.00	0.06
CS7	**0.94**	0.00	0.00	0.00	0.06
CS8	**0.94**	0.00	0.00	0.00	0.05
CS9	**0.92**	0.01	0.00	0.00	0.07
CS10	**0.88**	0.01	0.00	0.00	0.11
CS11	**0.90**	0.01	0.00	0.00	0.09
CS12	**0.97**	0.00	0.00	0.00	0.03
EC15	**0.96**	0.00	0.00	0.00	0.04
EC16	**0.91**	0.01	0.00	0.00	0.08
EC26	**0.95**	0.00	0.00	0.00	0.05
EC64	**0.94**	0.00	0.00	0.00	0.06
EC22	**0.81**	0.02	0.02	0.00	0.14
EC25	**0.81**	0.02	0.02	0.00	0.15
EC29	**0.91**	0.01	0.00	0.00	0.08
DBCR1	**0.91**	0.01	0.00	0.00	0.08

Table 8. Mean abundance (per 33 cm^2) and taxon diversity (based on 38-family bioassessment model) of predominant macroinvertebrate families in St. Marys River samples. Mean abundance and percent occurrence of these families for Great Lakes Reference Group 1 is shown for comparison. Families expected to be present that were absent are highlighted yellow.

Family	Gp. 1 Mean	Gp. 1 Occur. (%)	East of Bellevue Park						
			CS6	CS7	CS8	CS9[a]	CS10	CS11	CS12
No. Taxa (±2 SD)	**8 (2 – 14)**	-	**4**	**5**	**5**	**15**	**3**	**4**	**15**
Chironomidae	13.4	39.9	15.6	71.4	29.4	39.4	14.8	30.2	62.0
Tubificidae	5.6	16.7	29.4	73.4	40.2	63.8	52.8	65.8	67.0
Sphaeriidae	4.9	14.7	0.2	0.2	0	2.3	0	0	1.4
Asellidae	1.8	5.5	0	1.0	0.2	10.5	0	0	3.6
Naididae	1.4	4.3	2.4	1.2	2.8	3.2	5.8	2.4	12.6
Sabellidae	1.2	3.6	0	0	0	0	0	0	0.2

Family	Gp. 1 Mean	Gp. 1 Occur. (%)	East of Bellevue Park				Lake George Channel			
			EC15	EC16	EC26	EC64	EC22	EC25	EC29	DBCR1
No. Taxa (±2 SD)	**8 (2 – 14)**	-	**11**	**7**	**13**	**8**	**18**	**13**	**10**	**6**
Chironomidae	13.4	39.9	52.2	12.2	22.8	19.0	26.1	53.6	95.6	87.0
Tubificidae	5.6	16.7	39.6	76.6	37.4	36.4	10.5	41	58.4	107.6
Sphaeriidae	4.9	14.7	0	0.4	0.4	0	0.4	1.4	4.6	0
Asellidae	1.8	5.5	6.0	0.2	4.0	3.4	3.3	0.2	5.2	0
Naididae	1.4	4.3	20.2	2.0	4.0	93.0	0.5	16.0	12.4	3.2
Sabellidae	1.2	3.6	0	0	15.8	0	0.1	0.4	0.2	0

[a] QA/QC site (3 box cores taken); average of 15 reps

Table 9. Site assessment summary for St. Marys River benthic community data. Overall site categorizations are colour-coded for ease of comparison.

Site	Stress[a]	Vector 1 vs. 2	Vector 1 vs. 3	Vector 2 vs. 3	Overall Category
CS6	0.159	Equivalent	Equivalent	Equivalent	Equivalent
CS7	0.161	Possibly different	Equivalent	Possibly different	Possibly different
CS8	0.160	Equivalent	Equivalent	Equivalent	Equivalent
CS9[b]	0.162	Possibly different	Possibly different	Possibly different	Possibly different
CS10	0.162	Possibly different	Equivalent	Equivalent	Possibly different
CS11	0.160	Possibly different	Equivalent	Possibly different	Possibly different
CS12	0.157	Possibly different	Equivalent	Equivalent	Possibly different
EC15	0.157	Equivalent	Possibly different	Equivalent	Possibly different
EC16	0.160	Equivalent	Equivalent	Equivalent	Equivalent
EC26	0.160	Equivalent	Equivalent	Equivalent	Equivalent
EC64	0.161	Possibly different	Possibly different	Equivalent	Possibly different
EC22	0.159	Equivalent	Equivalent	Equivalent	Equivalent
EC25	0.162	Equivalent	Equivalent	Equivalent	Equivalent
EC29	0.159	Possibly different	Possibly different	Equivalent	Possibly different
DBCR1	0.157	Possibly different	Equivalent	Possibly different	Possibly different

[a] HMDS of a subset of 4-7 sites with Great Lakes reference Group 1 sites (n=108)

[b] QA/QC site - average of 3 box core drops

Table 10. Mean percent survival, growth (mg dry weight) and reproduction per individual in sediment toxicity tests. Toxicity, based on numerical guidelines (Reynoldson and Day 1998), is indicated in red and potential toxicity in blue.

Site	***C. riparius***		***H. azteca***		***Hexagenia* spp.**		***T. tubifex***			
	% survival	growth	% survival	growth	% survival	growth	% survival	No. cocoons/ adult	% hatch	No. young/ adult
GL Reference Mean[a]	87.1	0.35	85.6	0.50	96.2	3.03	97.9	9.9	57.0	29.0
CS6	84.0	0.301	76.0	0.497	82	***0.736***	100	10.6	40.5	10.7
CS7	92.0	0.331	***61.3***	0.399	96	2.086	100	10.7	43.8	16.4
CS8	***61.3***	***0.199***	74.7	0.579	84	***0.242***	100	10.4	57.1	17.9
CS9	81.3	0.363	74.7	0.300	100	5.102	100	11.6	***37.3***	15.7
CS10	89.3	0.360	***61.7***	0.224	98	1.970	100	10.8	***36.8***	13.8
CS11	92.0	0.381	82.7	0.258	100	2.156	100	10.5	50.9	23.1
CS12	69.3	0.320	85.3	0.416	100	1.902	100	11.0	53.6	21.0
EC15	92.0	0.291	97.3	0.502	100	5.264	100	11.2	58.1	25.2
EC16	**48.0**	0.268	***65.3***	0.322	90	***0.830***	100	9.5	40.5	***8.9***
EC26	**56.0**	***0.177***	81.3	0.532	90	***0.438***	100	**4.2**	39.7	10.0
EC64	**57.3**	0.246	**42.7**	***0.186***	**56**	***0.490***	100	10.3	49.0	14.5
EC22	92.0	0.437	90.7	0.605	100	5.244	100	11.2	56.5	29.9
EC25	82.7	0.452	89.3	0.495	100	4.020	100	10.4	***34.7***	11.9
EC29	82.7	0.411	80.0	0.365	100	4.570	100	11.1	**26.3**	***5.2***
DBCR1	93.3	0.372	88.0	0.283	100	4.412	100	10.9	**21.6**	***3.0***
Non-toxic[b]	≥67.7	0.49-0.21	≥67.0	0.75- 0.23	≥85.5	5.0 – 0.9	≥88.9	12.4 – 7.2	78.1-38.1	46.3 – 9.9
Pot. toxic	67.6-58.8	0.20-0.14	66.9-57.1	0.22-0.10	85.4-80.3	0.89 – 0	88.8-84.2	7.1 – 5.9	38.0-28.1	9.8 – 0.8
Toxic	**< 58.8**	**< 0.14**	**< 57.1**	**< 0.10**	**< 80.3**	**negative**	**< 84.2**	**< 5.9**	**< 28.1**	**< 0.8**

[a] Environment Canada, unpublished data; [b] The upper limit for non-toxic category is set using 2 × standard deviation of the mean and indicates excessive growth or reproduction (Reynoldson and Day 1998)

Table 11. Decision matrix for weight-of-evidence categorization of 2008 St. Marys River sites based on three lines of evidence. For the sediment chemistry column, sites with exceedences of the Probable Effect Level (PEL) are indicated by "■"; sites with exceedences of the Lowest Effect Level (LEL) or the Canada Wide Standards (CWS) for PHCs by "◘". For the toxicity column, sites that had multiple endpoints exhibiting major toxicological effects were indicated by "■"; sites that had multiple endpoints exhibiting minor toxicological effect and/or one endpoint exhibiting a major effect by "◘". For the benthos alteration column, sites determined from BEAST analyses as *different/very different* are indicated by "■"; sites determined as *possibly different* by "◘". Sites with no sediment quality guideline exceedences, benthic communities equivalent to reference conditions, and sites that had no or minor toxicity in no more than one endpoint are indicated by "□". Some sites that were possibly different than reference according to the BEAST assessment were not recommended for further action. For these sites the benthic community was not considered degraded based on abundance or taxa richness.

Site	Sediment Chemistry	Toxicity[a]	Benthos Alteration	>LEL or CWS	Total PAHs	F4 or F4G PHC[1]	Oils & Grease	Assessment
CS6	◘	□	□	PAHs, 9 metals	**16.1**	600	500	No further actions needed
CS7	◘	□	◘	PAHs, 9 metals	**13.8**	1300	300	Determine reason(s) for benthos alteration
CS8	◘	◘	□	PAHs, 9 metals	**14.6**	1600	400	Determine reason(s) for sediment toxicity
CS9	◘	□	◘[b]	PAHs, 9 metals	**16.4**	833	500	No further actions needed
CS10	◘	◘	◘	PAHs, 9 metals	**15.1**	680	500	Management actions required
CS11	◘	□	◘	PAHs, 9 metals	**10.9**	800	300	Determine reason(s) for benthos alteration
CS12	◘	□	◘[b]	PAHs, 9 metals	**52.1**	1100	600	No further actions needed
EC15	◘	□	◘[b]	PAHs, 9 metals, F4 PHC	**13.3**	**6510**	300	No further actions needed
EC16	◘	■	□	PAHs, 9 metals	**12.1**	1100	500	Determine reason(s) for sediment toxicity
EC26	◘	■	□	PAHs, 9 metals	**18.0**	1300	1300	Determine reason(s) for sediment toxicity
EC64	◘	■	◘[b]	PAHs, 9 metals	**13.9**	1000	500	Determine reason(s) for sediment toxicity
EC22	◘	□	□	PAHs, 2 metals	**4.5**	400	300	No further actions needed
EC25	◘	□	◘[b]	PAHs, 1 metal	**8.2**	300	400	No further actions needed
EC29	◘	◘	□	PAHs, 8 metals	**10.1**	1400	500	Determine reason(s) for sediment toxicity
DBCR1	◘	◘	◘	PAHs, 7 metals	**9.6**	800	800	Management actions required

[1] Higher of the F4 and F4G fractions.

[a] contaminant-response relationship should exist before recommending management actions

[b] Benthos not considered degraded based on abundance and/or taxa richness.

Figures

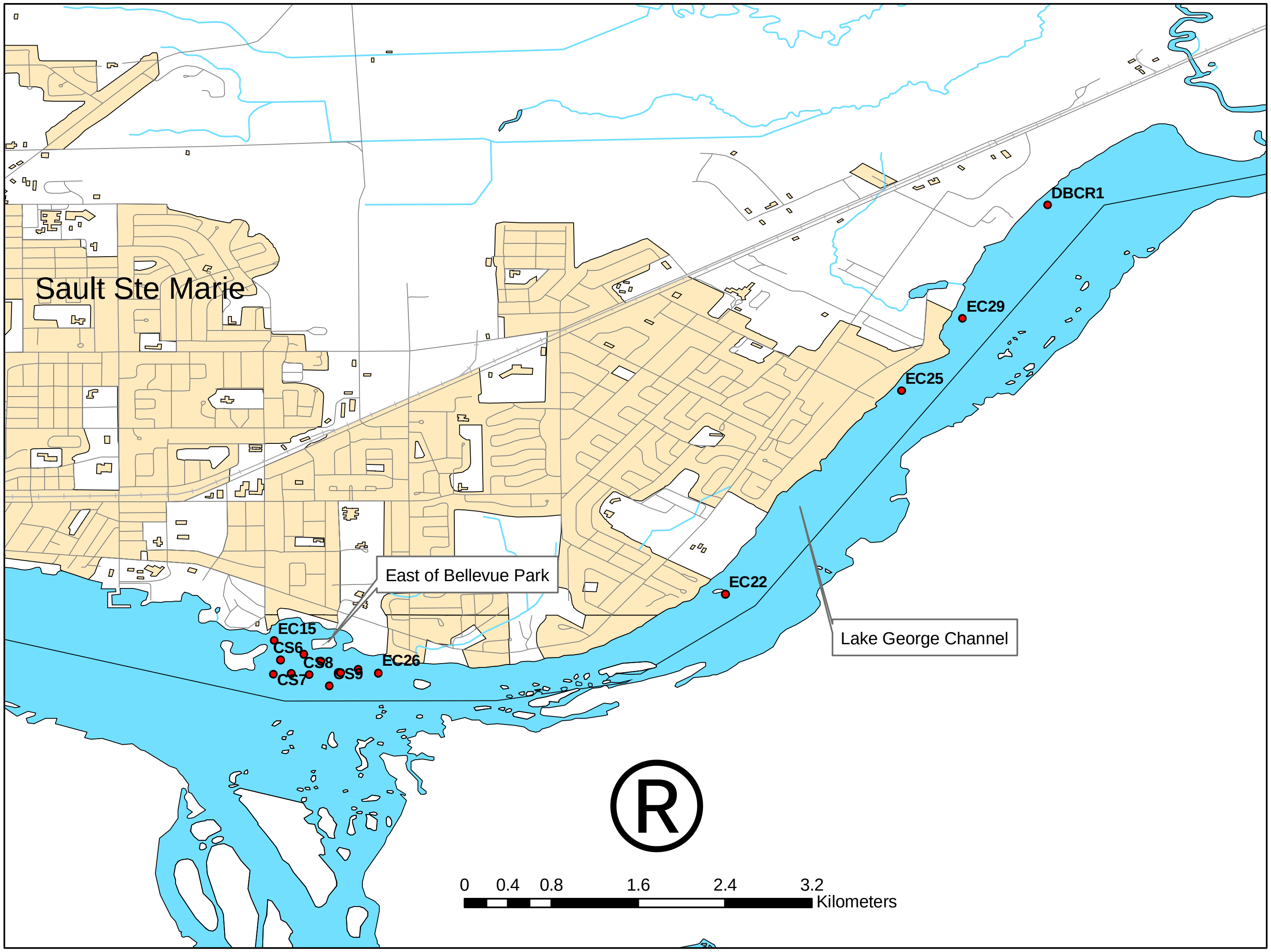

Figure 1a. St. Marys River 2008 sampling locations (n=15).

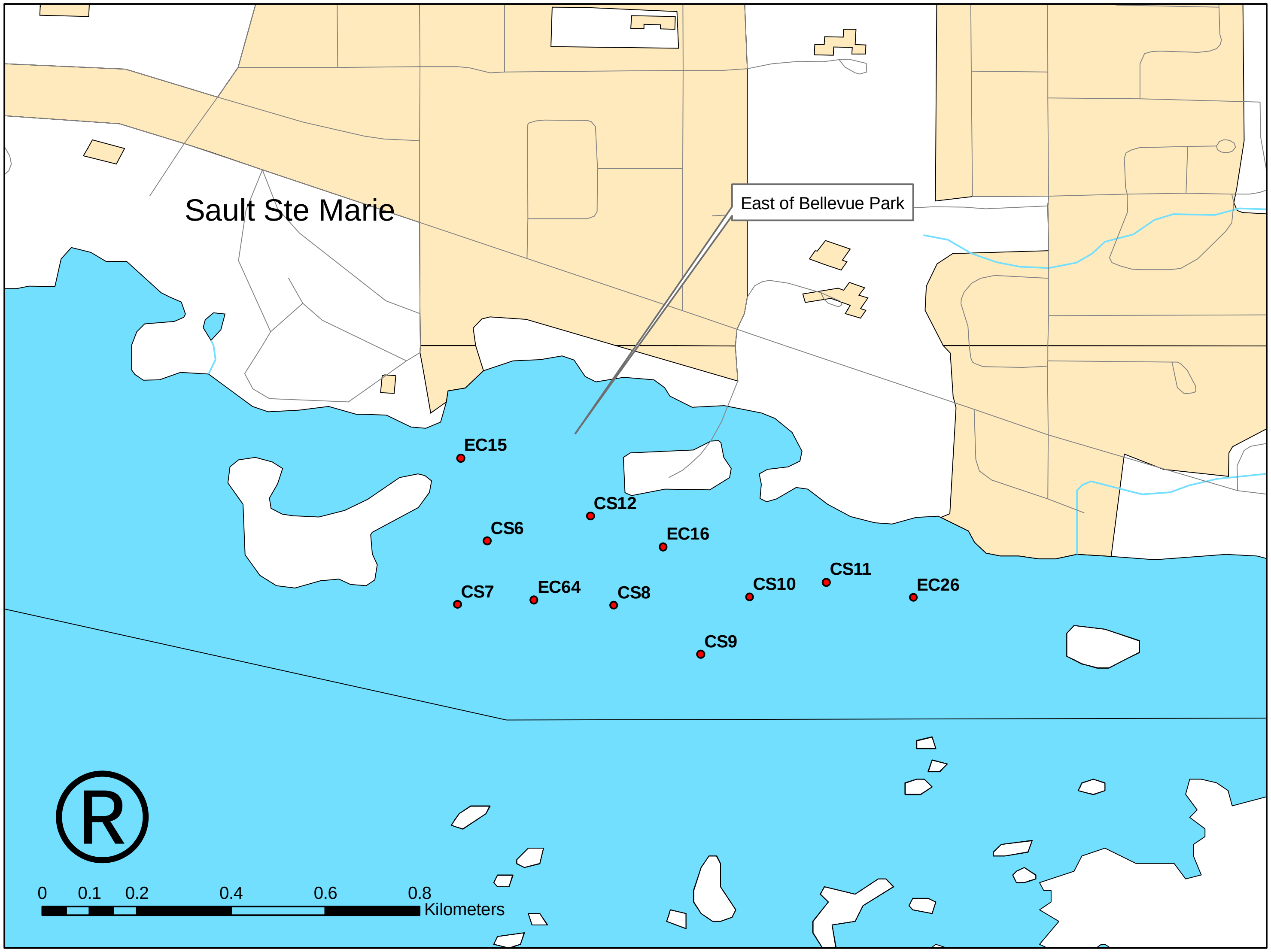

Figure 1b. Sampling locations east of Bellevue Park enlarged (n=11).

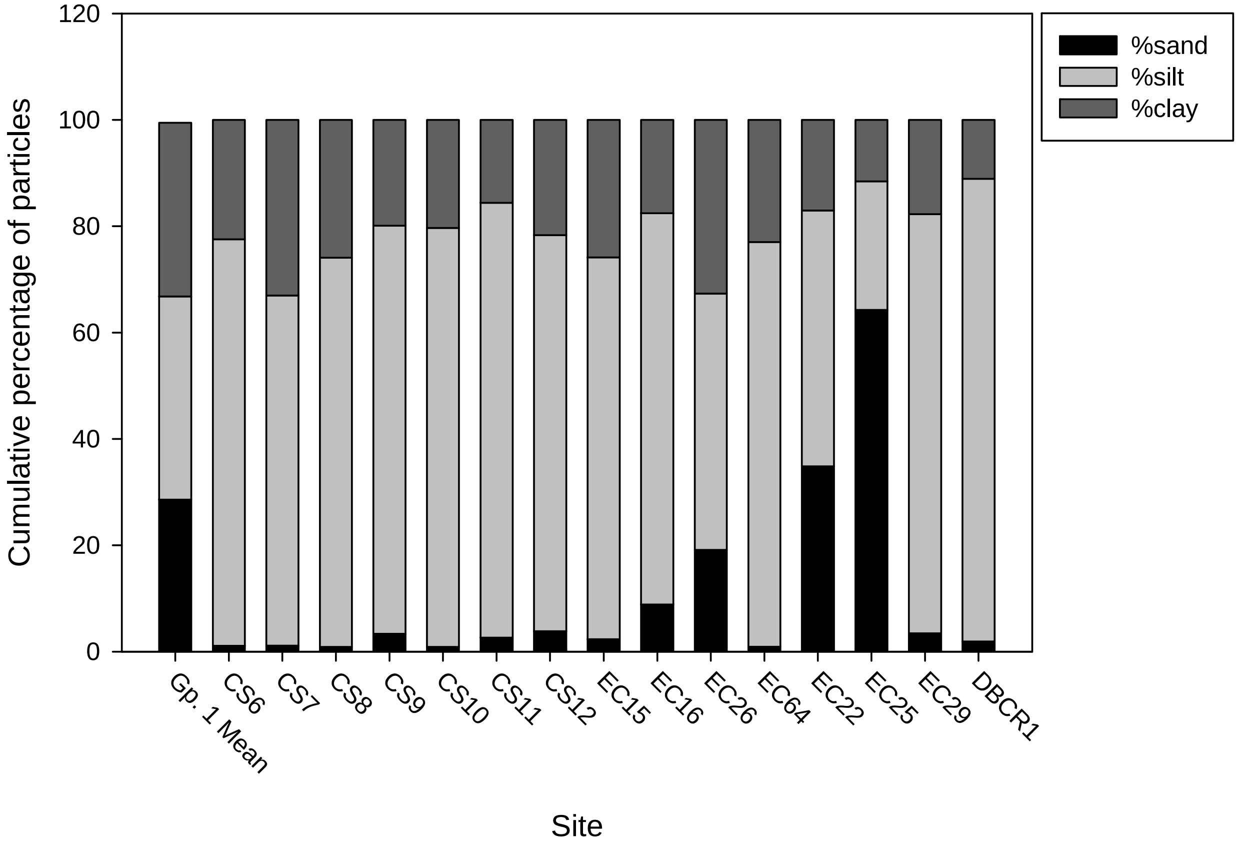

Figure 2. Particle size distributions for St. Marys River and Reference Group 1 sediment.

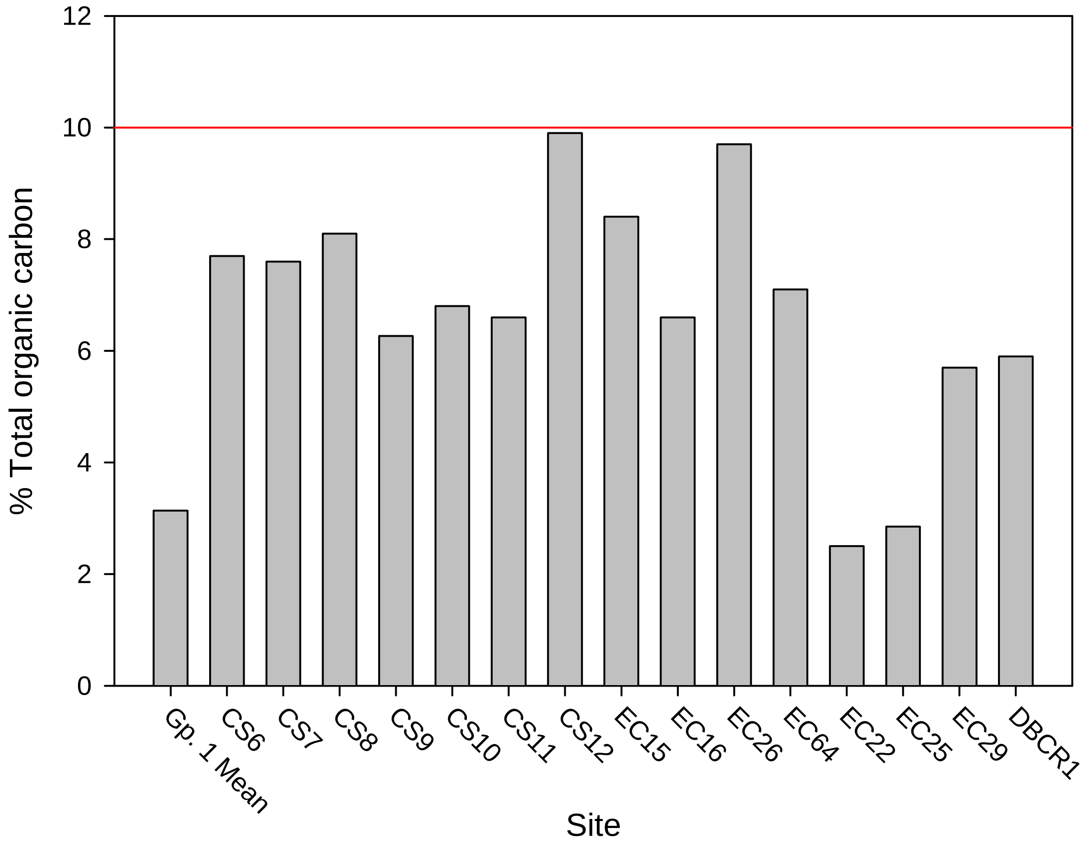

Figure 3. Total organic carbon (%) in St. Marys River sediments. The Great Lakes Reference Group 1 average is shown. The horizontal red line indicates the Severe Effect Level (10%).

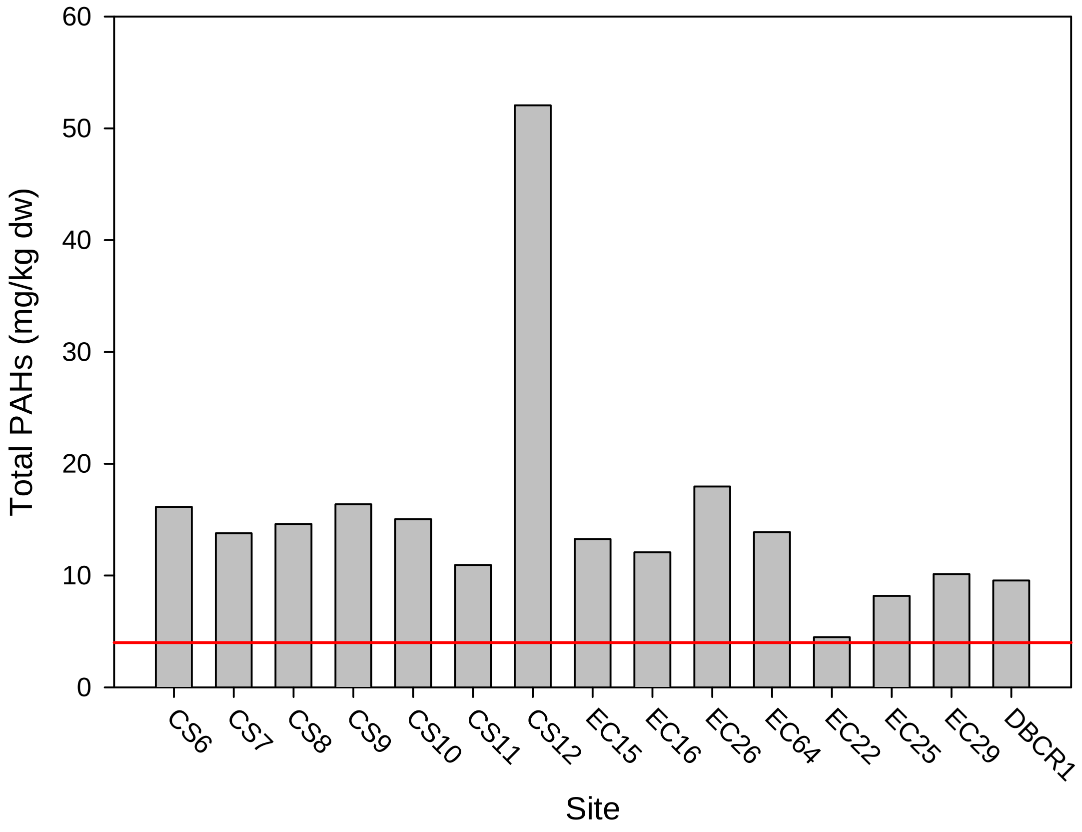

Figure 4. Total PAH concentrations in St. Marys River sediments. The horizontal red line indicates the Lowest Effect Level for PAHs (4µg/g).

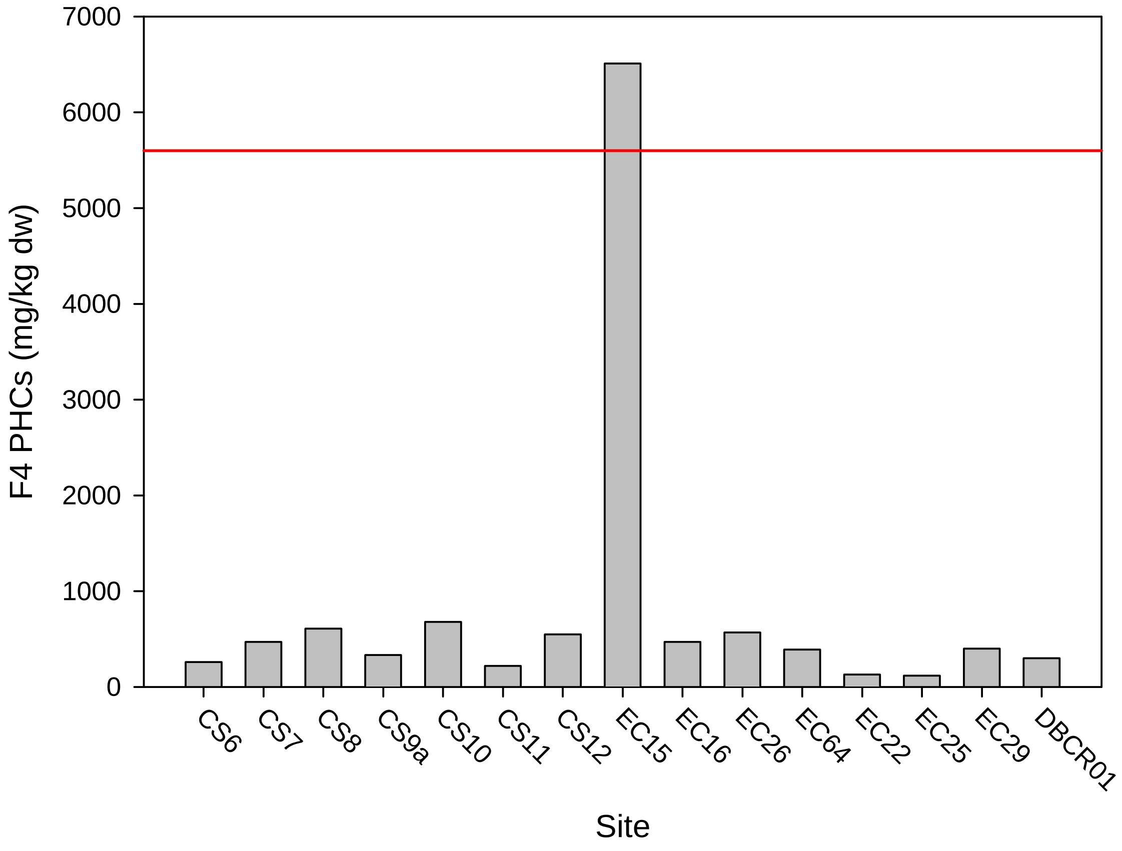

Figure 5. Petroleum hydrocarbon (F4 fraction) concentration in St. Marys River sediments. The horizontal red line indicates the Canada-Wide standard (for soil) for the F4 fraction for the residential/parkland land use category (5600 mg/kg).

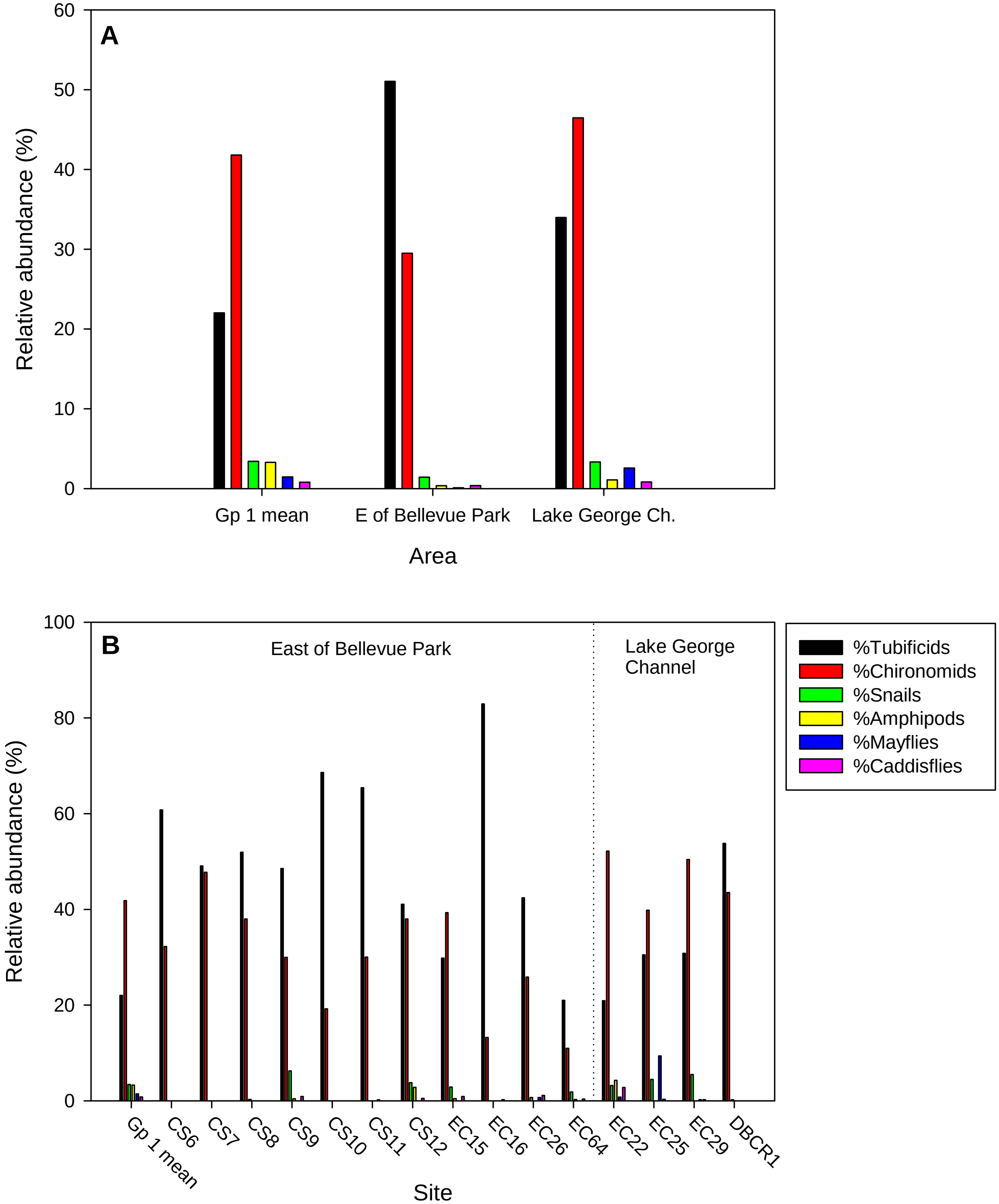

Figure 6. Mean relative abundance of predominant benthic macroinvertebrate taxa found per area (A) and per site (B) in the St. Marys River.

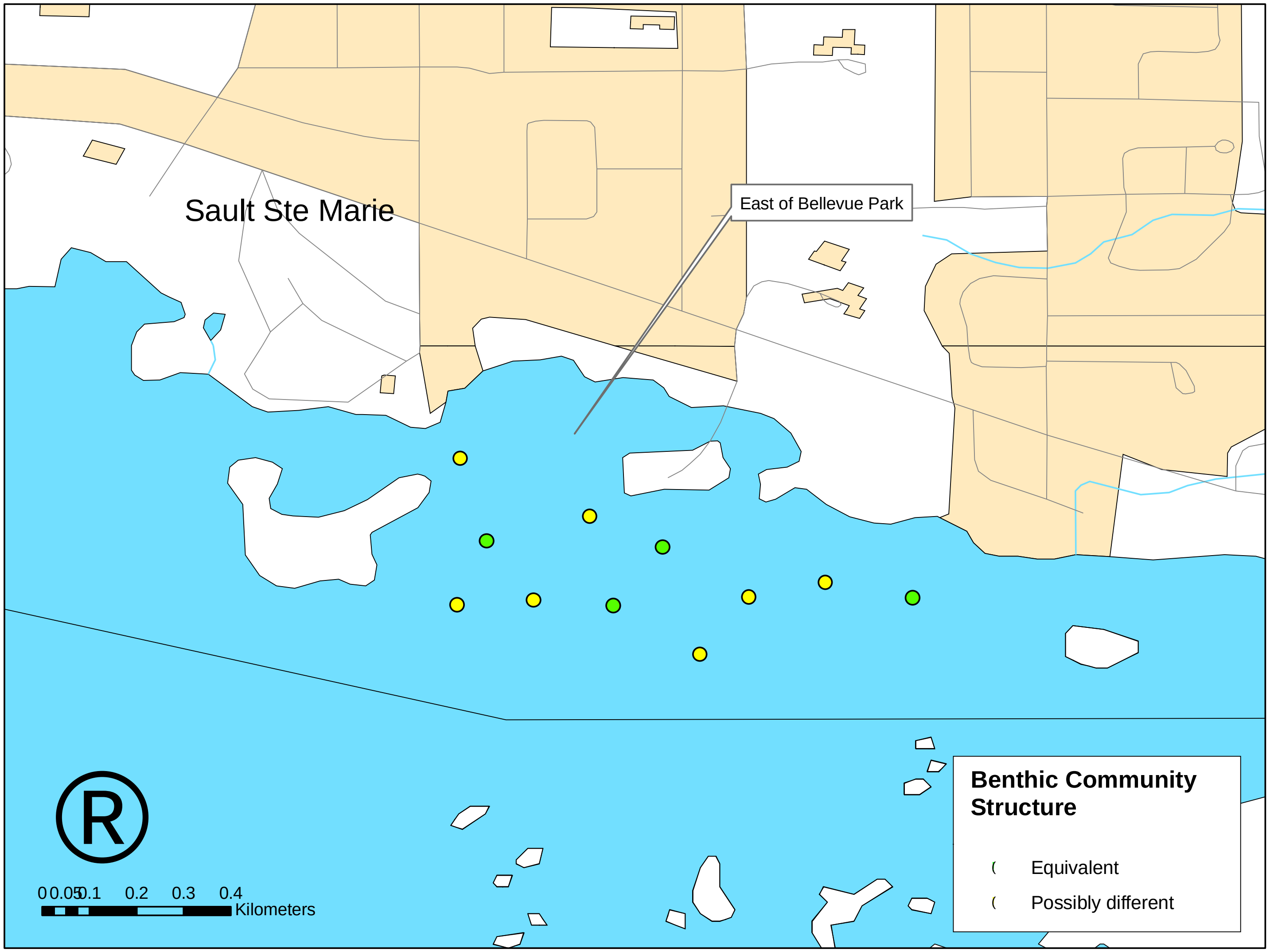

Figure 7. Benthic community structure categories for sites east of Bellevue Park (n=11).

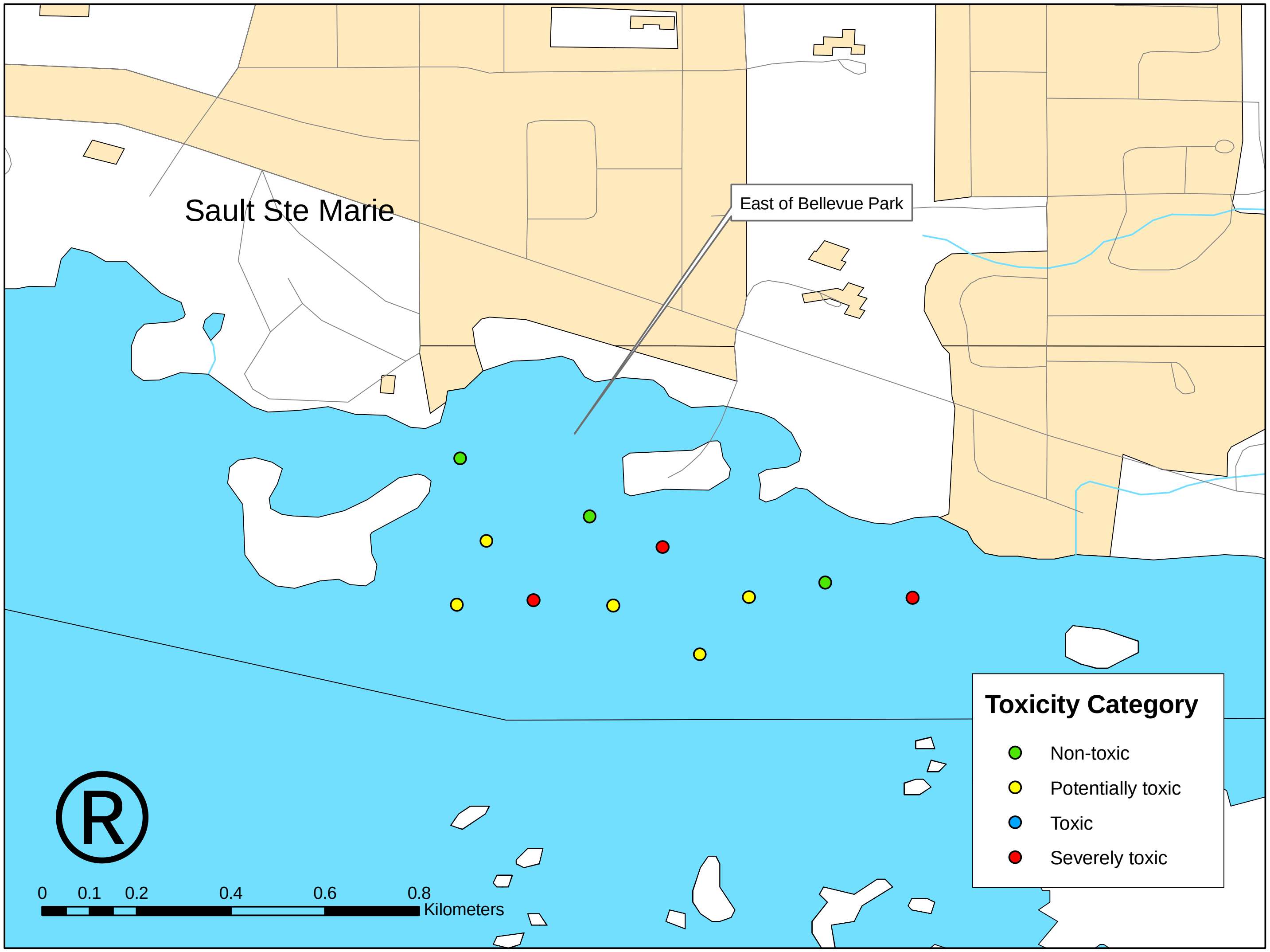

Figure 8. Toxicity categories for sites east of Bellevue Park (n=11).

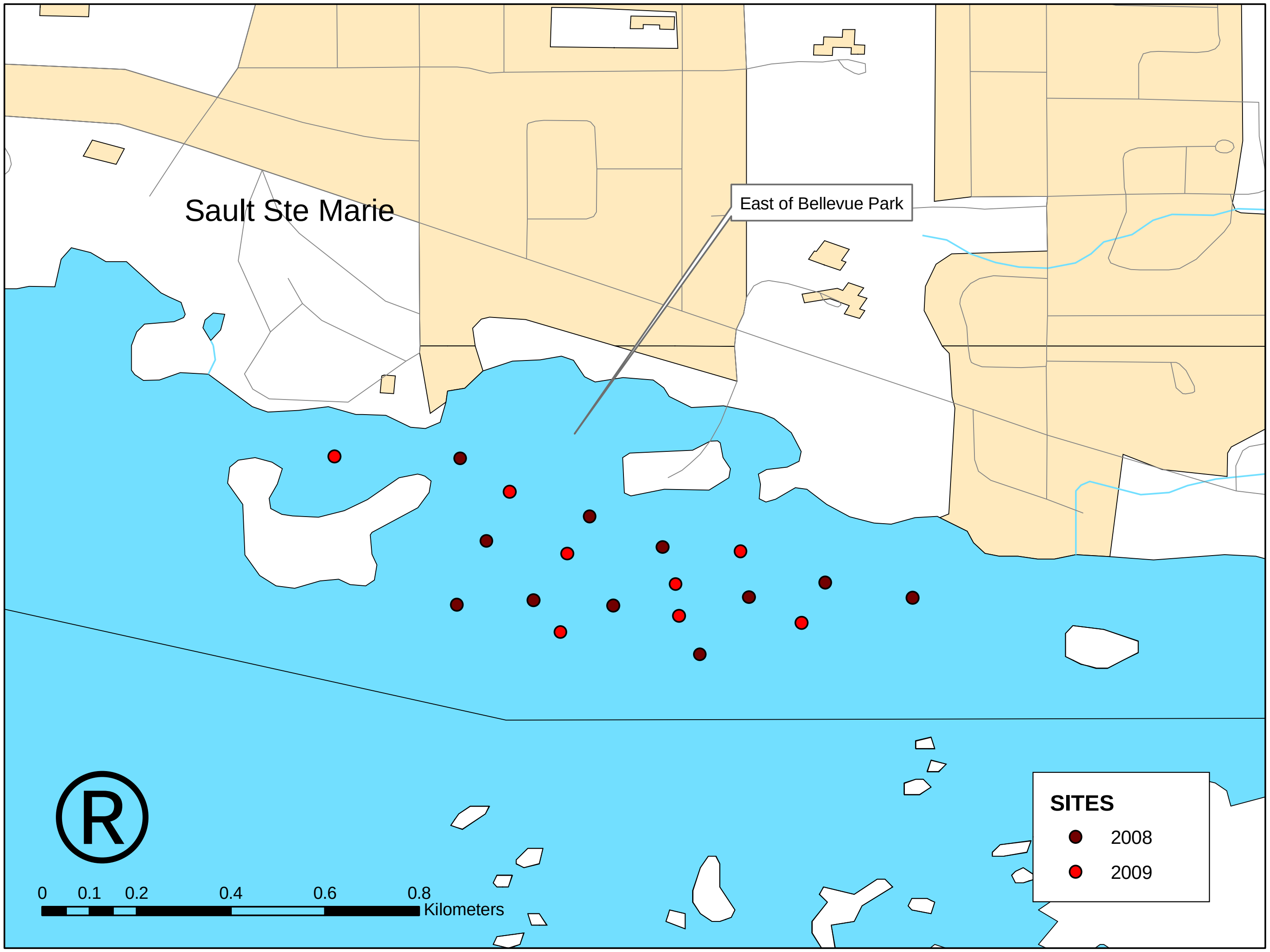

Figure 9. St. Marys River 2009 sampling locations east of Bellevue Park (red dots, n=8); 2008 sites are also shown (brown dots, n=11).

Appendices

Appendix A QA/QC Results

Table A1. Coefficient of variation (CV) for trace metals and nutrients in field-replicated samples and relative percent difference (RPD) for laboratory duplicates (Caduceon Environmental Laboratory data). “<” = below method detection limit.

Parameter	Units	M.D.L.	Date Analyzed	EC25	EC25 Dup	**R.P.D.**	CS900	CS901	CS902	CS9avg	SD	**CV**	CS10	CS10 Dup	**R.P.D.**
Aluminum	µg/g	10	15-Jan-09	2550	2650	**3.8**	7360	7520	6210	7030	715	**10**	7970	7780	**2.4**
Antimony	µg/g	5	15-Jan-09	< 5	< 5	**0.0**	< 5	< 5	< 5	< 5	0	**0**	< 5	< 5	**0.0**
Arsenic	µg/g	5	15-Jan-09	< 5	< 5	**0.0**	7	5	15	9	5	**59**	9	9	**0.0**
Barium	µg/g	1	15-Jan-09	17	17	**0.0**	58	59	43	53	9	**17**	62	61	**1.6**
Beryllium	µg/g	0.2	15-Jan-09	< 0.2	< 0.2	**0.0**	0.4	0.4	0.4	0.4	0.0	**0**	0.4	0.4	**0.0**
Bismuth	µg/g	5	15-Jan-09	< 5	< 5	**0.0**	< 5	< 5	< 5	< 5	0	**0**	< 5	< 5	**0.0**
Cadmium	µg/g	0.5	15-Jan-09	< 0.5	< 0.5	**0.0**	0.8	0.9	0.8	0.8	0.1	**7**	1.2	1.1	**8.7**
Calcium	µg/g	10	15-Jan-09	1870	1850	**1.1**	4110	4080	3520	3903	332	**9**	4010	4050	**1.0**
Chromium	µg/g	1	15-Jan-09	20	18	**10.5**	62	105	76	81	22	**27**	71	70	**1.4**
Cobalt	µg/g	1	15-Jan-09	3	3	**0.0**	7	8	9	8	1	**13**	9	9	**0.0**
Copper	µg/g	1	15-Jan-09	20	20	**0.0**	62	65	71	66	5	**7**	82	79	**3.7**
Iron	µg/g	10	15-Jan-09	15000	14900	**0.7**	35800	35400	50500	40567	8605	**21**	48000	47600	**0.8**
Lead	µg/g	5	15-Jan-09	19	18	**5.4**	50	47	69	55	12	**22**	71	70	**1.4**
Magnesium	µg/g	10	15-Jan-09	1340	1360	**1.5**	4050	4110	3380	3847	405	**11**	4330	4300	**0.7**
Manganese	µg/g	1	15-Jan-09	140	142	**1.4**	416	416	600	477	106	**22**	575	569	**1.0**
Mercury	µg/g	0.005	15-Jan-09	0.080	0.086	**7.2**	0.111	0.100	0.138	0.116	0.020	**17**	0.137	0.147	**7.0**
Molybdenum	µg/g	1	15-Jan-09	< 1	< 1	**0.0**	2	2	4	2.7	1.2	**43**	3	2	**40.0**
Nickel	µg/g	1	15-Jan-09	8	7	**13.3**	22	24	28	25	3	**12**	27	27	**0.0**
Phosphorus	µg/g	5	15-Jan-09	501	495	**1.2**	738	696	646	693	46	**7**	816	798	**2.2**
Potassium	µg/g	30	15-Jan-09	360	360	**0.0**	1100	1190	870	1053	165	**16**	1090	1090	**0.0**
Silicon	µg/g	1	15-Jan-09	167	191	**13.4**	146	156	256	186	61	**33**	200	265	**28.0**
Silver	µg/g	0.2	15-Jan-09	< 0.2	< 0.2	**0.0**	0.2	0.3	0.4	0.3	0.1	**33**	0.4	0.4	**0.0**
Sodium	µg/g	20	15-Jan-09	630	630	**0.0**	680	760	520	653	122	**19**	670	620	**7.8**
Strontium	µg/g	1	15-Jan-09	6	6	**0.0**	12	13	11	12	1	**8**	13	13	**0.0**
Tin	µg/g	10	15-Jan-09	< 10	< 10	**0.0**	< 10	< 10	< 10	< 10	0	**0**	< 10	< 10	**0.0**
Titanium	µg/g	1	15-Jan-09	220	238	**7.9**	460	473	431	455	22	**5**	484	473	**2.3**
Vanadium	µg/g	1	15-Jan-09	14	14	**0.0**	33	32	30	32	2	**5**	34	34	**0.0**
Yttrium	µg/g	0.5	15-Jan-09	5.1	5.1	**0.0**	8.5	8.4	7.7	8.2	0.4	**5**	8.9	8.7	**2.3**
Zinc	µg/g	1	15-Jan-09	86	71	**19.1**	206	209	270	228	36	**16**	284	290	**2.1**
Zirconium	µg/g	0.1	15-Jan-09	0.6	0.6	**0.0**	0.9	1.1	< 0.1	1.0	0.1	**14**	0.7	0.8	**40.0**
Aluminum (Al2O3)	%	0.01	26-Jan-09	8.94	9.55	**6.6**	9.88	10.4	9.36	9.9	0.5	**5**	10.8	10.8	**0.0**
Barium (BaO)	%	0.001	26-Jan-09	0.091	0.091	**0.0**	0.052	0.078	0.052	0.1	0.0	**25**	0.052	0.072	**32.3**
Calcium (CaO)	%	0.01	26-Jan-09	1.30	1.38	**6.0**	1.65	1.68	1.56	1.6	0.1	**4**	0.86	1.88	**74.5**
Chromium (Cr2O3)	%	0.01	26-Jan-09	0.04	0.04	**0.0**	0.04	0.05	0.05	0.0	0.0	**12**	0.04	0.01	**120.0**
Iron (Fe2O3)	%	0.05	26-Jan-09	3.80	3.85	**1.3**	7.32	7.67	10.7	8.6	1.9	**22**	10.4	10.0	**3.9**
Magnesium (MgO)	%	0.01	26-Jan-09	0.60	0.69	**14.0**	1.20	1.31	1.10	1.2	0.1	**9**	1.42	1.66	**15.6**
Manganese (MnO)	%	0.01	26-Jan-09	0.05	0.05	**0.0**	0.08	0.08	0.10	0.1	0.0	**13**	0.10	0.10	**0.0**
Phosphorus (P2O5)	%	0.03	26-Jan-09	0.09	0.09	**0.0**	< 0.04	< 0.04	< 0.04	< 0.04	0	**0**	0.21	0.06	**111.1**
Potasium (K20)	%	0.01	26-Jan-09	3.12	3.38	**8.0**	2.20	2.39	2.07	2.2	0.2	**7**	2.69	2.54	**5.7**
Silica (SiO2)	%	0.01	26-Jan-09	65.5	68.1	**3.9**	54.9	59.4	55.3	56.5	2.5	**4**	59.2	57.6	**2.7**
Sodium (Na2O)	%	0.01	26-Jan-09	1.87	2.42	**25.6**	1.85	1.92	1.82	2	0	**3**	3.67	2.38	**42.6**
Titanium (TiO2)	%	0.01	26-Jan-09	0.49	0.49	**0.0**	0.65	0.69	0.62	1	0	**5**	0.04	0.70	**178.4**
Loss on Ignition	%	0.05	26-Jan-09	8.01	7.03	**13.0**	16.6	16.1	18.8	17	1	**8**	17.4	16.0	**8.4**
Whole Rock Total	%		26-Jan-09	93.9	97.2	**3.5**	96.4	102	102	100	3	**3**	107	104	**2.8**
Total Organic Carbon	% by wt	0.1	22-Jan-09	2.8	2.9	**3.5**	5.9	5.1	7.8	6.3	1.4	**22.1**	6.9	6.7	**2.9**
Total Kjeldahl Nitrogen	µg/g	0.05	19-Jan-09	970	916	**5.7**	3810	3650	2640	3367	634	**18.8**	3470	3570	**2.8**
Phosphorus-Total	µg/g	0.01	19-Jan-09	397	451	**12.7**	817	659	577	684	122	**17.8**	718	725	**1.0**

min	**0.0**	**0.0**	**0.0**
max	**25.6**	**58.8**	**178.4**
median	**1.1**	**10.5**	**2.3**

Table A2. Coefficients of variation (CV) for organic contaminants in field-replicated sample (CS9) (ALS Laboratory Group data). “<” = below method detection limit.

Sample ID		**CS900**	**CS901**	**CS902**	**Mean**	**SD**	**CV**
Description		SEDIMENT	SEDIMENT	SEDIMENT			
Date Sampled		10/5/2008	10/5/2008	10/5/2008			
BTEX, F1-F4							
Benzene	mg/kg	<0.05	<0.05	<0.05	<0.05	0	0
Ethyl Benzene	mg/kg	<0.05	<0.05	<0.05	<0.05	0	0
m+p-Xylenes	mg/kg	<0.1	<0.1	<0.1	<0.1	0	0
o-Xylene	mg/kg	<0.05	<0.05	<0.05	<0.05	0	0
Toluene	mg/kg	<0.05	0.23	0.07	0.15	-	-
Xylene, (total)	mg/kg	<0.15	<0.15	<0.15	<0.15	0	0
CCME Total Hydrocarbons							
F1 (C6-C10)	mg/kg	<5	<5	<5	<5	0	0
F1-BTEX	mg/kg	<5	<5	<5	<5	0	0
F2 (C10-C16)	mg/kg	<20	<20	<20	<20	0	0
F2-Naphth	mg/kg	<20	<20	<20	<20	0	0
F3 (C16-C34)	mg/kg	460	430	740	543	171	31
F3-PAH	mg/kg	450	420	720	530	165	31
F4 (C34-C50)	mg/kg	240	250	510	333	153	46
F4G-SG (GHH-Silica)	mg/kg	700	600	1200	833	321	39
Total Hydrocarbons (C6-C50)	mg/kg	700	680	1250	877	323	37
CCME PAHs							
1-Methylnaphthalene	mg/kg	<0.1	<0.1	0.1	0.1	-	-
2-Methylnaphthalene	mg/kg	<0.1	0.1	0.2	0.2	0.1	47.1
Acenaphthene	mg/kg	<0.1	<0.1	0.2	0.2	-	-
Acenaphthylene	mg/kg	0.2	0.2	0.3	0.2	0.1	24.7
Acridine	mg/kg	<2	<2	<2	<2	0.0	0.0
Anthracene	mg/kg	0.2	0.3	0.5	0.3	0.2	45.8
Benzo(a)anthracene	mg/kg	1	1.1	2.1	1.4	0.6	43.4
Benzo(a)pyrene	mg/kg	1.04	1.14	1.92	1.4	0.5	35.3
Benzo(b)fluoranthene	mg/kg	1.1	1.2	2.2	1.5	0.6	40.6
Benzo(g,h,i)perylene	mg/kg	0.8	0.9	1.4	1.0	0.3	31.1
Benzo(k)fluoranthene	mg/kg	0.8	0.9	1.3	1.0	0.3	26.5
Chrysene	mg/kg	1	1.1	2	1.4	0.6	40.3
Dibenzo(ah)anthracene	mg/kg	0.2	0.2	0.3	0.2	0.1	24.7
Fluoranthene	mg/kg	1.5	1.7	3.7	2.3	1.2	52.9
Fluorene	mg/kg	0.1	0.1	0.3	0.2	0.1	69.3
Indeno(1,2,3-cd)pyrene	mg/kg	0.9	1.1	1.7	1.2	0.4	33.8
Naphthalene	mg/kg	0.7	1	1.6	1.1	0.5	41.7
Phenanthrene	mg/kg	0.7	0.8	1.5	1.0	0.4	43.6
Pyrene	mg/kg	1.3	1.4	3	1.9	1.0	50.2
Quinoline	mg/kg	<0.1	<0.1	<0.1	<0.1	0.0	-
Individual Analytes							
% Moisture	%	69.5	72.5	71.6	71.2	1.5	2.2
Oil and Grease, Total	mg/kg	600	200	700	500	265	53
PCBs							
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	0	0
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	0	0
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	0	0
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	0	0
Total PCBs	mg/kg	<0.1	<0.1	<0.1	<0.1	0	0
						Min	0
						Max	69
						Median	29

Table A3. Sample recoveries for laboratory standards and reference material (Caduceon Environmental Laboratory data).

CADUCEON ENVIRONMENTAL LABORATORIES, 2378 HOLLY LANE, OTTAWA, ONTARIO, K1V 7P1

QC I.D.:	Various	**CLIENT:**	Environment Canada, Can. Ctr. For Inland Waters
SAMPLE MATRIX:	Sediment	**BATCH NUMBER:**	B09-00757
DATE SUBMITTED:	9-Jan-09	**DATE ANALYZED:**	Various
DATE REPORTED:	30-Jan-09	**REPORT TO:**	Danielle Milani

PARAMETERS	**QC Sample Recovery Calculation**				
	Raw Data (µg/g)			**QC Sample Recovery**	
LKSD-3 (15-Jan-09)	**QC Result**	**Reference Value**	**Lab Mean**	**% Recovery**	**Control Limits**
Silver	2.7	2.4	2.3	**113**	50 - 117
Arsenic	24.6	23	23.0	**107**	83 - 121
Barium	169	N/A	169	**100**	81 - 118
Beryllium	0.5	N/A	0.5	**100**	47 - 153
Cadmium	0.6	0.6	0.6	**100**	83 - 114
Cobalt	29.2	30	28.9	**97**	51 - 114
Chromium	49.1	51	48.4	**96**	54 - 125
Copper	35.1	34	33.8	**103**	79 - 116
Iron	30063	35000	29815	**86**	74 - 102
Manganese	1319	1220	1247	**108**	76 - 124
Molybdenum	0.712	2	1.0	**36**	0 - 260
Nickel	43.9	44.0	42.4	**100**	75 - 125
Lead	25	26	24.9	**96**	72 - 107
Strontium	24	N/A	25.4	**94**	76 - 124
Titanium	1058	N/A	980	**108**	49 - 151
Vanadium	48	55	48.5	**87**	63 - 113
Zinc	137	139	136	**99**	76 - 124
STSD-2 (15-Jan-09)					
Mercury	0.138	0.160	0.144	**86**	77 - 122
WH89-1 (26-Jan-08)					
Aluminum (Al2O3)	13.7	12.1	11.6	**113**	75 - 125
Barium (BaO)	0.29	0.29	0.28	**100**	75 - 125
Calcium (CaO)	5.29	5.9	5.7	**90**	75 - 125
Chromium (Cr2O3)	0.03	0.03	0.03	**100**	50 - 150
Iron (Fe2O3)	7.45	6.9	6.62	**108**	75 - 125
Magnesium (MgO)	3.15	3.5	3.4	**90**	75 - 125
Manganese (MnO)	1.17	1.38	1.34	**85**	75 - 125
Phosphorus (P2O5)	2.10	2.48	2.43	**85**	75 - 125
Potasium (K20)	3.62	4.51	4.43	**80**	75 - 125
Silica (SiO2)	59.60	60.5	59	**99**	75 - 125
Sodium (Na2O)	3.51	4.0	4.09	**88**	75 - 125
Titanium (TiO2)	2.15	2.57	2.47	**84**	75 - 125
D053-542 (19-Jan-09)					
Total Kjeldahl Nitrogen	1280	1300	1372	**93**	57 - 143
Phosphorus-Total	875	811	939	**93**	53 - 147
TOC QC (22-Jan-09)					
TOC	4.69	4.84		**97**	91 - 109

min	35.6
max	113
median	96.9

Table A4. Percent recoveries in surrogate spikes – sediment samples (ALS Laboratory Group data).

	BTEX	CCME Hydrocarbons	CCME PAHs		PCBs
	2,5-Dibromotoluene	Octacosane	2-Fluorobiphenyl	p-Terphenyl d14	d14-Terphenyl
SMR DBCR01	91	72	107	114	130
SMR EC64	83	102	107	118	132
SMR EC29	86	84	115	124	138
SMR EC26	94	90	115	121	120
SMR EC25	95	89	102	109	110
SMR EC22	85	85	110	118	107
SMR EC16	87	84	105	112	104
SMR EC15	83	95	113	120	118
SMR CS6	86	69	111	116	106
SMR CS7	99	80	113	123	119
SMR CS8	82	91	109	115	114
SMR CS900	77	85	108	115	111
SMR CS901	87	83	116	124	111
SMR CS902	85	80	116	125	119
SMR CS10	88	93	113	121	108
SMR CS11	98	65	108	114	104
SMR CS12	125	61	113	115	117
Min	**77**	**61**	**102**	**109**	**104**
Max	**125**	**102**	**116**	**125**	**138**
Median	**87**	**84**	**111**	**118**	**114**

Table A5. Method detection limits for organic contaminant analyses (ALS Laboratory Group data).

Sample ID	**CS6**	**CS7**	**CS8**	**CS900**	**CS901**	**CS902**	**CS10**	**CS11**	**CS12**	**EC15**	**EC16**	**EC26**	**EC64**	**EC22**	**EC25**	**EC29**	**DBCR01**
Description	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
BTEX																	
Benzene	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ethyl Benzene	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
m+p-Xylenes	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
o-Xylene	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Toluene	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Xylene, (total)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
CCME Total Hydrocarbons																	
F1 (C6-C10)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
F1-BTEX	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
F2 (C10-C16)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	10	20	20
F2-Naphth	20	20	20	20	20	20	20	20	20	20	20	20	20	20	10	20	20
F3 (C16-C34)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100
F3-PAH	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100
F4 (C34-C50)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100
F4G-SG (GHH-Silica)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total Hydrocarbons (C6-C50)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100
CCME PAHs																	
1-Methylnaphthalene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
2-Methylnaphthalene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Acenaphthene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Acenaphthylene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Acridine	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.8	0.8	1.6	1.6
Anthracene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Benzo(a)anthracene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Benzo(a)pyrene	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.02	0.04	0.04
Benzo(b)fluoranthene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Benzo(g,h,i)perylene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Benzo(k)fluoranthene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Chrysene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Dibenzo(ah)anthracene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Fluoranthene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Fluorene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Indeno(1,2,3-cd)pyrene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Naphthalene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Phenanthrene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Pyrene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Quinoline	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
PCBs																	
Aroclor 1242	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Aroclor 1248	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Aroclor 1254	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Aroclor 1260	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1
Total PCBs	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.05	0.05	0.1	0.1

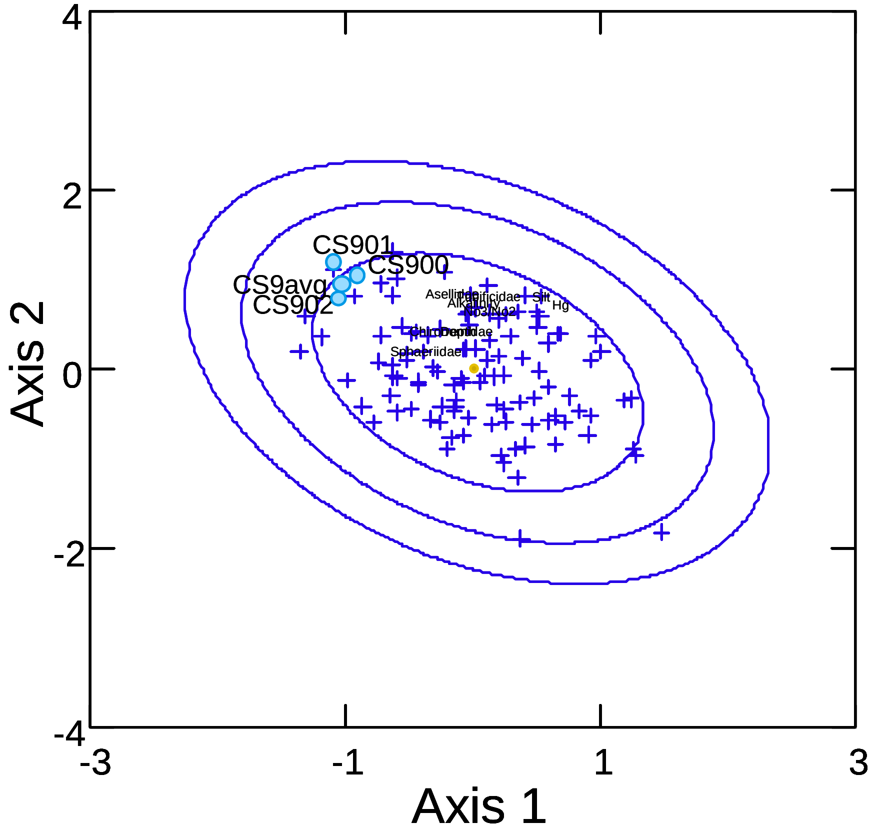

Figure A1. Assessment of field-replicated QA/QC site CS9. Three separate box cores were taken at the site, indicated by CS900, CS901 and CS902. The mean (CS9avg) of the three box core is also shown.

Appendix B Benthic Invertebrate Identifications and Counts

Table B1. Benthic invertebrate identifications and mean counts (per 33.14 cm^2) for St. Marys River sites, 2008.

		East of Bellevue Park											Lake George Channel			
	Site	**CS6**	**CS7**	**CS8**	**CS9**[a]	**CS10**	**CS11**	**CS12**	**EC15**	**EC16**	**EC26**	**EC64**	**EC22**	**EC25**	**EC29**	**DBCR1**
Ephemeroptera	Baetidae	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0
	Caenidae	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
	Ephemeridae	0	0	0	0.1	0	0.2	0	0	0	0.6	0	0.3	12.6	0.4	0
Coleoptera	Dytiscidae	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Plecoptera	Chloroperlidae	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera-Chironomidae	Chironomidae	15.6	71.4	29.4	39.4	14.8	30.2	62	52.2	12.2	22.8	19	26.1	53.6	95.6	87
Diptera	Ceratopogonidae	0	0	0	0	0	0	0	0	0	0.6	0	2.4	2	0	0.2
	Simuliidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
Trichoptera	Helicopsychidae	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
	Hydropsychidae	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
	Hydroptilidae	0	0	0	0.2	0	0	0.4	0.2	0	0.4	0.4	0.1	0.2	0	0
	Leptoceridae	0	0	0	0	0	0	0.2	0.2	0	0.2	0	0.3	0.2	0	0
	Polycentropodidae	0	0	0	1.0	0	0	0.2	0.8	0	0.2	0.2	1.0	0	0.4	0
Gastropoda	Ancylidae	0	0	0	1.7	0	0	0.8	0.4	0	0	0.2	0.3	0	0	0
	Hydrobiidae	0	0	0	2.8	0	0	0.8	0.4	0	0.2	0.2	0.6	5.2	4.2	0
	Physidae	0	0	0	0.3	0	0	0.2	0	0	0.2	0	0.3	0	0	0
	Planorbidae	0	0	0	3.3	0	0	3.8	3.0	0	0	2.8	0.2	0.6	5.0	0
	Valvatidae	0	0	0	0	0	0	0.6	0	0	0.2	0	0	0	1.2	0.4
	Viviparidae	0	0	0.2	0.1	0	0	0	0	0	0	0	0.2	0.2	0	0
Bivalvia	Sphaeriidae	0.2	0.2	0	2.3	0	0	1.4	0	0.4	0.4	0	0.4	1.4	4.6	0
Annelida	Erpobdellidae	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0
	Glossiphoniidae	0	0	0	0.2	0	0	0.2	0.4	0.2	0	0	0.1	0	0	0
	Lumbriculidae	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0
	Naididae	2.4	1.2	2.8	3.2	5.8	2.4	12.6	20.2	2	4	93	0.5	16	12.4	3.2
	Sabellidae	0	0	0	0	0	0	0.2	0	0	15.8	0	0.1	0.4	0.2	0
	Tubificidae	29.4	73.4	40.2	63.8	52.8	65.8	67	39.6	76.6	37.4	36.4	10.5	41	58.4	107.6
Acari	Acari	0.8	2	4.6	1.1	3.4	1.8	3.4	7.8	0.6	0	16.8	0	0.2	1.4	1
	Feltriidae	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0
	Hygrobatidae	0	0	0	0.5	0	0	0	0	0	1.0	0	0.5	0.2	0	0
	Lebertiidae	0	0	0	0	0	0	0	0.2	0	0	0	0	0.2	0	0
	Limnesiidae	0	0	0	0	0	0	0.6	0	0	0	0.2	0	0	0.4	0
	Mideopsidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
	Oribatei	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
	Oxidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	Pionidae	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0
	Torrenticolidae	0	0	0	0.2	0	0	0	0	0	0	0	0	0.2	0	0
Crustacea	Asellidae	0	1.0	0.2	10.5	0	0	3.6	6.0	0.2	4.0	3.4	3.3	0.2	5.2	0
	Gammaridae	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0
	Hyalellidae sp.	0	0	0	0.5	0	0	4.6	0.4	0	0	0.4	2.1	0	0	0.2
Other Organisms	Hydridae	0	0	0	0.1	0	0	0.2	0	0	0	0	0	0	0	0
	Tetrastemmatidae	0	0.2	0	0.1	0.2	0.2	0.2	0.8	0	0	0.2	0.1	0	0	0
	Total Abundance	**48**	**150**	**77**	**131**	**77**	**101**	**163**	**133**	**92**	**88.2**	**173**	**50**	**135**	**190**	**200**
	Total No. Taxa	**5**	**8**	**6**	**22**	**5**	**6**	**21**	**16**	**8**	**16**	**14**	**25**	**18**	**14**	**9**

[a] QA/QC site (3 box cores taken); average of 15 replicates

Appendix C Benthic Invertebrate Community Structure Ordinations

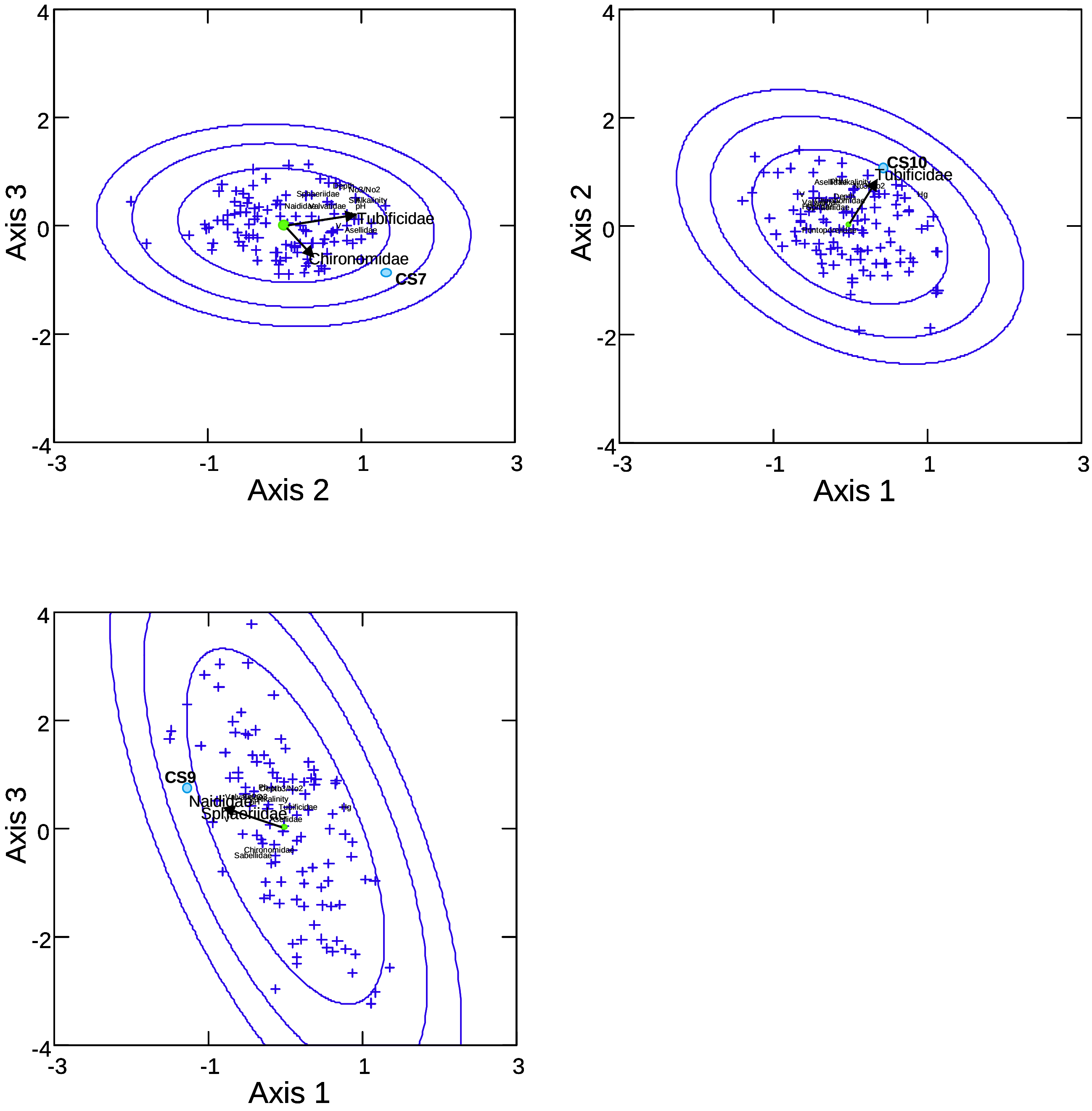

Figure C1. Ordination of 3 test sites (CS7, CS9 & CS10) using benthic community data (family level), summarized on two axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.16.

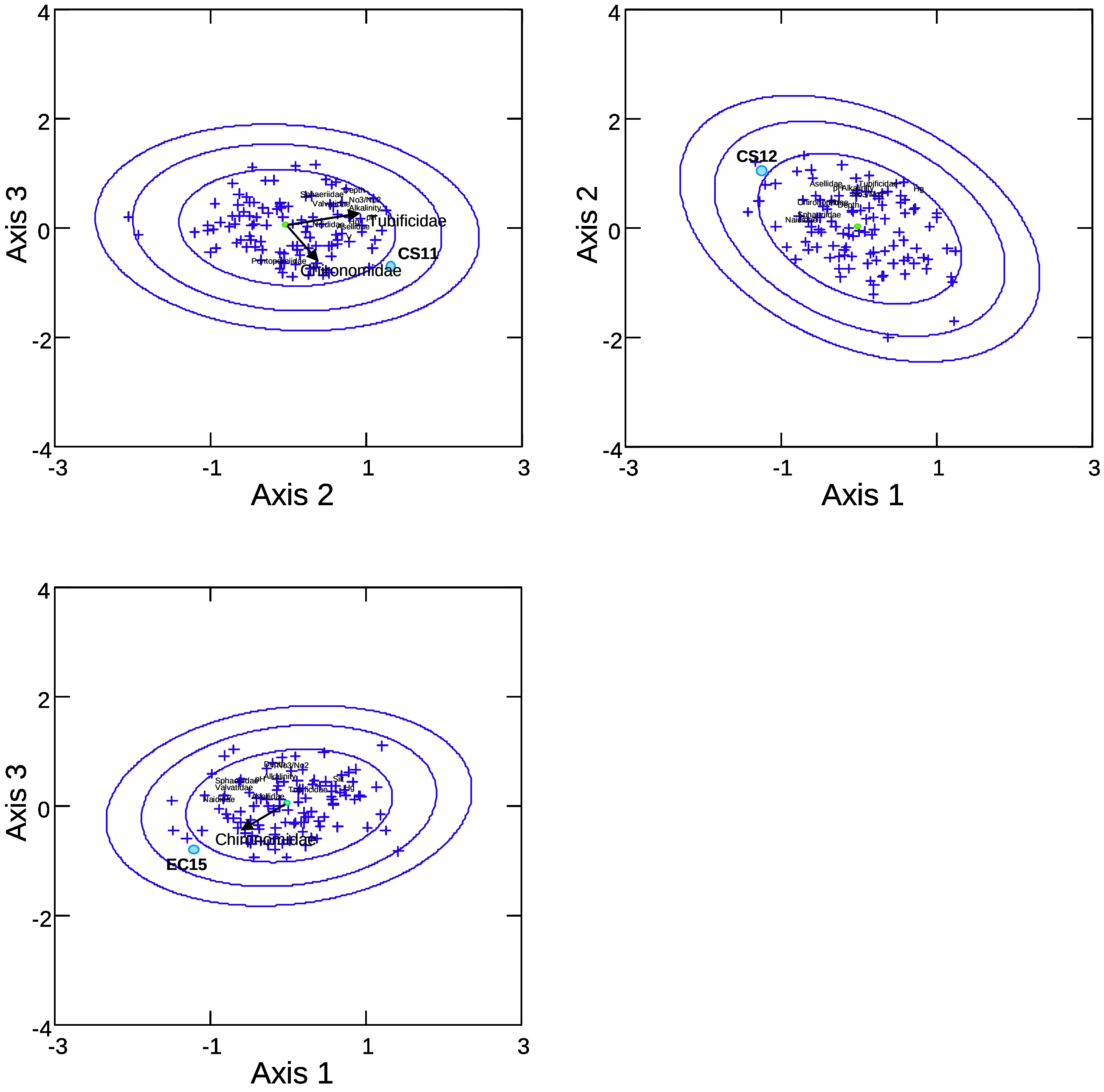

Figure C2. Ordination of 3 test sites (CS11, CS12, EC15) using benthic community data (family level), summarized on two axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.16.

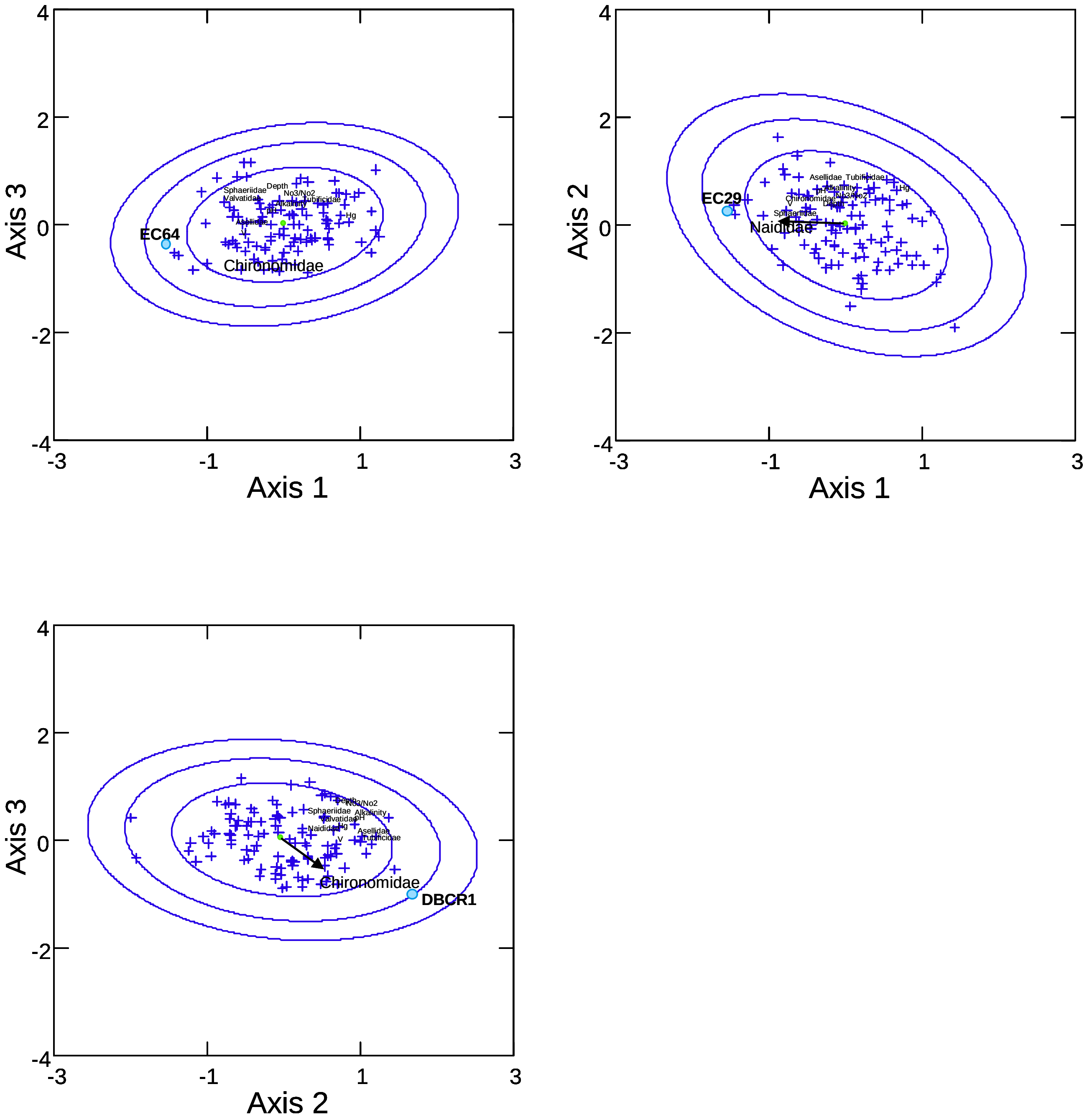

Figure C3. Ordination of 3 test sites (EC64, EC29 & DBCR1) using benthic community data (family level), summarized on two axes, with 90%, 99%, and 99.9% probability ellipses around reference sites (shown as cross hairs) indicated. Invertebrate families that are most correlated to axes scores are shown as vectors. Stress = 0.16.

Appendix D Toxicity Ordinations

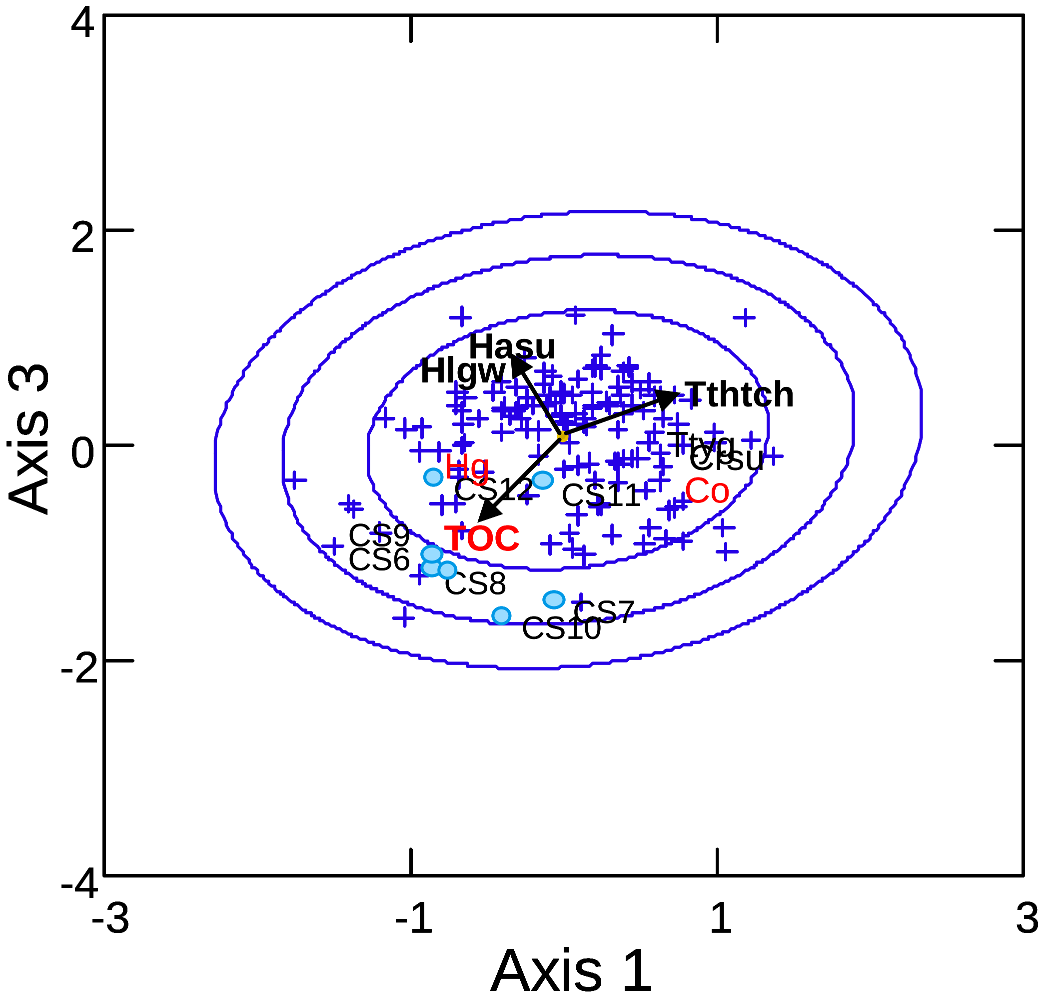

Figure D1. Ordination of subset of sites East of Bellevue Park using 10 toxicity test endpoints, summarized on Axes 1 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Hasu = *Hyalella azteca* survival; Ttyg and Tthtch= = *Tubifex tubifex* young production and percent cocoons hatched; Crsu = *Chironomus riparius* survival; Hlgw = *Hexagenia* spp. growth. Remaining endpoints were not significant in the ordination. Stress = 0.11.

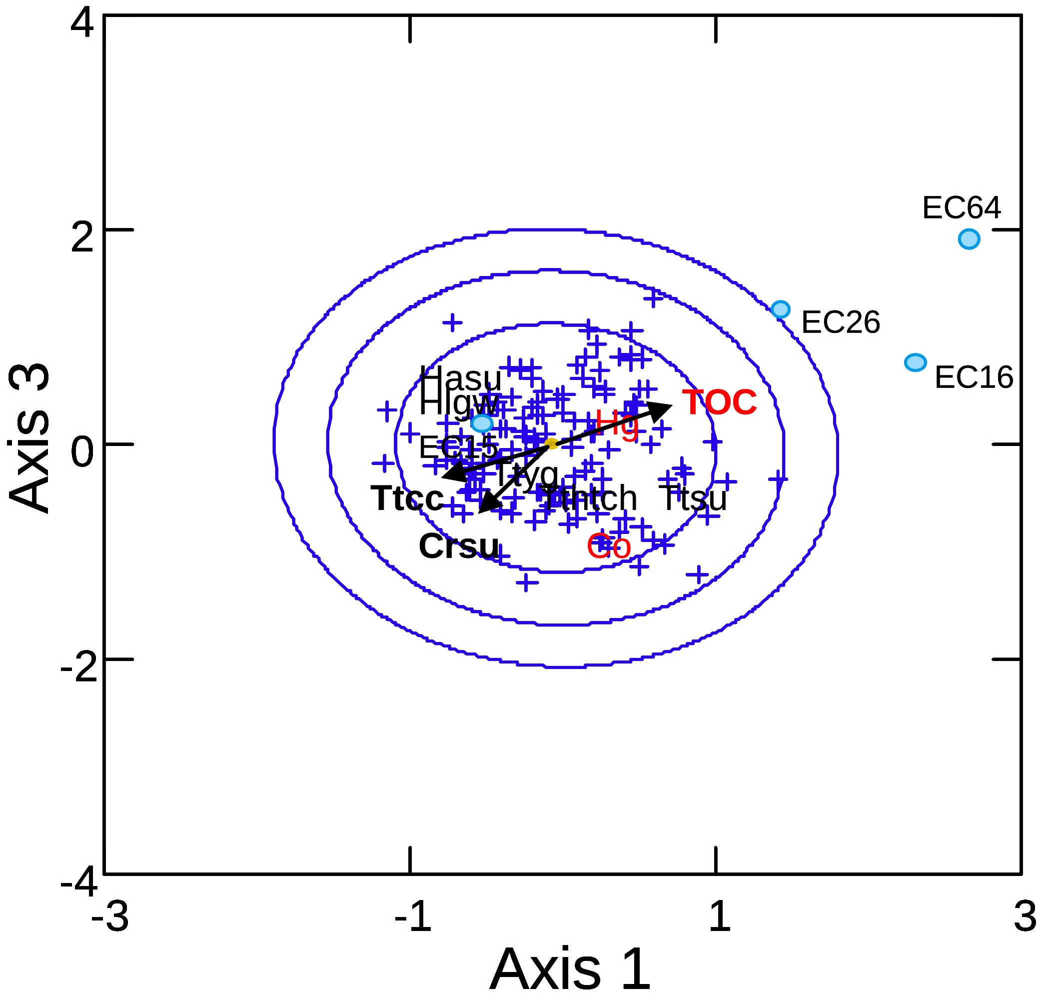

Figure D2. Ordination of subset of sites East of Bellevue Park using 10 toxicity test endpoints, summarized on Axes 1 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Crsu = *Chironomus riparius* survival; Hasu = *Hyalella azteca* survival; Ttsu, Ttcc, Ttyg, Tthtch= = *Tubifex tubifex* survival, cocoon production, young production and percent cocoons hatched; Hlgw = *Hexagenia* spp. growth. Remaining endpoints were not significant in the ordination. Stress = 0.11.

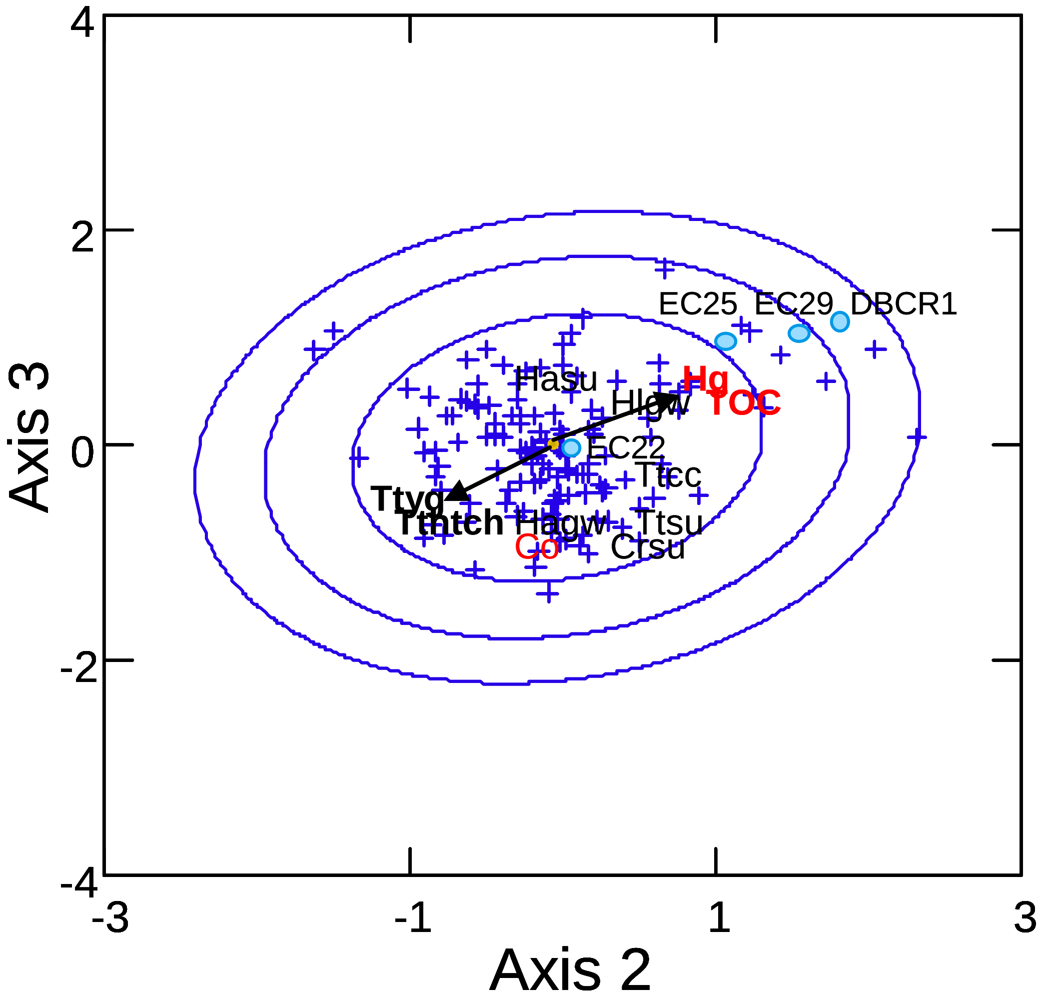

Figure D3. Ordination of subset of sites in Lake George Channel using 10 toxicity test endpoints, summarized on Axes 2 and 3, with 90%, 99%, and 99.9% probability ellipses around reference sites (reference site scores shown as cross hairs). Hasu, Hagw = *Hyalella azteca* survival, growth; Crsu = *Chironomus riparius* survival; Ttsu, Ttcc, Ttyg, Tthtch= = *Tubifex tubifex* survival, cocoon production, young production and percent cocoons hatched; Hlgw = *Hexagenia* spp. growth. Remaining endpoints were not significant in the ordination. Stress = 0.11.

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