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**Benthic Conditions in the Nipigon Bay Area
of Concern in 2009 and Comparison to 2003**

Danielle Milani and Lee Grapentine

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EXECUTIVE SUMMARY

To evaluate whether benthic conditions in Nipigon Bay continue to improve over time, sediment contaminant concentrations, sediment toxicity, and benthic invertebrate communities were assessed in 2009. Conditions were examined to assess the spatial differences between contaminated and reference sediments, and the temporal differences between conditions after 2003, when a similar study was conducted. The Nipigon data were applied to the decision-making framework developed under the Canada-Ontario Agreement to determine if sediments pose an environmental risk.

Overlying water, surficial sediment (0-10 cm) and benthic invertebrates were sampled from 15 sites in Nipigon Bay in October 2009. Sediments and overlying water were analyzed for a series of physicochemical variables. Toxicity tests were conducted in the laboratory for 9 of the 15 sites. The toxicological responses of four benthic invertebrates and the benthic invertebrate community structure were compared to biological criteria developed for the Laurentian Great Lakes using multivariate analysis.

Metal contamination in the sediment was generally low, similar to that found in 2003. From 1 to 8 metals were elevated above the provincial Sediment Quality Guideline Lowest Effect Level at all sites but exceedences of the Severe Effect Level were limited to a few sites for manganese. Concentrations of organic contaminants (petroleum hydrocarbons, PAHs, PCBs, dioxins/furans, oil and grease) were low (or below detection limits) with the exception of oil and grease, which was elevated (up to 3420 mg/kg) at a few sites south of the town of Red Rock. Organic contaminants were not measured in the 2003 study.

Benthic communities at sites in the western bay near industrial discharges and in the southwestern channel were generally different from those found at Great Lakes reference sites. These communities were characterized by increased abundance of pollution tolerant taxa (tubificids, chironomids) and the absence or low abundance of a dominant reference group amphipod (Pontoporeiidae). Sites in the eastern bay were similar or equivalent to reference. Some improvements from 2003 were evident, however, with significantly less tubificid worms

present south of the mill and in the southwest bay and more amphipods present in the midwest and east bays. Potential toxicity was evident at two sites below Red Rock due to reduced amphipod *Hyalella* survival; the cause of this toxicity was not clear. In the eastern bay, positive changes were noted at concomitant sites; acute toxicity to *Hyalella* in 2003 was absent in 2009.

Application of the Nipigon data to the decision-making framework indicated that the 2009 sites did not require management actions; the same that was found in 2003. The 2009 outcomes were *determine reason(s) for benthos alteration* at 5 sites (south of the mill and in the southwest bay), *determine reason(s) for sediment toxicity* at 1 site (south of the mill) and *no further actions* at remaining 9 sites. This is an improvement over 2003 outcomes, specifically in the eastern bay/Kama Pt (due to the absence of toxicity), at an upstream site (due to reduced tubificid and chironomid abundances), and at a site in the southwest bay (due to increased taxon diversity/reduced tubificids). The outcomes for remaining parts of the bay were generally similar to those from 2003.

Additional yearly data collected in western Nipigon Bay (2006-2010) may assist in determining if changes in benthic communities are occurring as well as recovery rates. It is recommended at this time that benthic conditions in Nipigon Bay continue to be monitored periodically.

RÉSUMÉ

Afin de vérifier si l'état du milieu benthique de la baie Nipigon continue de s'améliorer au fil du temps, les concentrations de contaminants dans les sédiments, la toxicité des sédiments et les communautés d'invertébrés benthiques ont été examinées en 2009. On a évalué pour ces éléments les différences spatiales entre les sédiments contaminés et les sédiments de référence de même que les différences temporelles par rapport à 2003, année durant laquelle une étude semblable avait été menée. On a appliqué aux données de la baie Nipigon le cadre décisionnel élaboré dans le contexte de l'Accord Canada-Ontario afin de déterminer si les sédiments posaient un risque pour l'environnement.

Les eaux sus-jacentes, les sédiments superficiels (0-10 cm) et les invertébrés benthiques ont fait l'objet d'un échantillonnage dans 15 sites de la baie Nipigon en octobre 2009. Une série de variables physicochimiques ont été mesurées dans les sédiments et dans les eaux sus-jacentes. Des essais de toxicité ont été effectués en laboratoire pour neuf des 15 sites. L'analyse multivariable a été utilisée pour comparer la réaction toxicologique de quatre invertébrés benthiques et la structure des communautés d'invertébrés benthiques aux critères biologiques élaborés pour les Grands Lacs laurentiens.

La contamination des sédiments par les métaux était en général faible, ce qui correspond aux résultats obtenus en 2003. Dans tous les sites, de un à huit métaux avaient des concentrations supérieures à la concentration minimale avec effet des recommandations provinciales pour la qualité des sédiments; seule la concentration de manganèse dépassait la concentration avec effet grave, et ce, dans quelques sites. Les concentrations de contaminants organiques (hydrocarbures pétroliers, HAP, BPC, dioxines/furanes, huiles et graisses) étaient faibles (ou inférieures aux seuils de détection), à l'exception des concentrations d'huiles et de graisses qui étaient élevées (jusqu'à 3420 mg/kg) à quelques sites situés au sud de la ville de Red Rock. Les contaminants organiques n'avaient pas été mesurés dans le cadre de l'étude de 2003.

Les communautés benthiques dans les sites du secteur ouest de la baie à proximité des sources de rejets industriels ainsi que dans le chenal sud-ouest étaient en général différentes de celles des

sites de référence des Grands Lacs. Ces communautés étaient caractérisées par une abondance plus grande de taxons tolérants à la pollution (tubificidés, chironomidés) et par l'absence ou la faible abondance d'un taxon d'amphipode (*Pontoporeiidae*) dominant dans le groupe de référence. Les communautés benthiques des sites situés dans le secteur est de la baie étaient semblables ou équivalentes à celles des sites de référence. Cependant, certaines améliorations par rapport à 2003 ont été observées : diminution importante de l'abondance des vers tubificidés au sud de l'usine de pâtes et papiers et dans le secteur sud-ouest de la baie et présence accrue des amphipodes dans les secteurs centre-ouest et est de la baie. En deux sites situés au sud de Red Rock, une baisse des taux de survie de l'amphipode *Hyalella* mettait en évidence une toxicité possible; la cause de cette toxicité n'était pas claire. Dans le secteur est de la baie, des changements positifs ont été notés à des sites concomitants; l'effet toxique aigu observé chez *Hyalella* en 2003 n'a pas été observé en 2009.

L'application du cadre décisionnel aux données de la baie Nipigon a indiqué qu'aucune mesure de gestion n'était nécessaire dans les sites échantillonnés en 2009; cela correspond au résultat obtenu en 2003. Les résultats obtenus en 2009 étaient les suivants : *déterminer la ou les raisons des changements survenus dans les communautés benthiques* de cinq sites (au sud de l'usine de pâtes et papiers et dans le secteur sud-ouest de la baie); *déterminer la ou les raisons de la toxicité des sédiments* en un site (au sud de l'usine); et *aucune mesure nécessaire*, pour les neuf autres sites. Cela représente une amélioration par rapport aux résultats de 2003, en particulier dans le secteur est de la baie (pointe Kama – en raison de l'absence de toxicité), dans un site situé en amont (en raison de la diminution de l'abondance des tubificidés et des chironomidés), ainsi que dans un site situé dans le secteur sud-ouest de la baie (en raison de l'augmentation de la diversité des taxons et de la diminution de l'abondance des tubificidés). Les résultats obtenus pour les autres parties de la baie étaient en général semblables à ceux obtenus en 2003.

Les données supplémentaires recueillies chaque année dans la partie ouest de la baie Nipigon (2006-2010) pourraient aider à déterminer si les communautés benthiques changent et à établir les taux de rétablissement. À l'heure actuelle, il est recommandé que l'état du milieu benthique de la baie Nipigon continue à faire l'objet d'une surveillance périodique.

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ABBREVIATIONS, ACRONYMS AND SYMBOLS

AOC	Area of Concern
BEAST	Benthic Assessment of Sediment
BTEX	benzene, toluene, ethylbenzene and xylene
CCGS	Canadian Coast Guard Ship
CCME	Canadian Council of Ministers of the Environment
CDGPS	Canada-wide differential global positioning system
CV	coefficient of variation
DL	detection limit
dw	dry weight
EC	Environment Canada
GL	Great Lakes
HMDS	hybrid multidimensional scaling
LEL	lowest effect level
LKSD	lake sediment standard
max	maximum
min	minimum
MOE	Ministry of the Environment (Ontario)
OCD	octachlorodioxins
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD/F	polychlorinated dibenzodioxin/dibenzofuran
PeCDD	pentachlorodioxin
PEL	probable effect level
PHC	petroleum hydrocarbon
QA/QC	quality assurance/quality control
RPD	relative percent difference
SEL	severe effect level
SQG	sediment quality guideline
TCDD	tetrachlorodioxin
TEF	toxic equivalency factor
TEQ	toxic equivalency unit
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TP	total phosphorus
WAAS	Wide Area Augmentation System
wt	weight

1 INTRODUCTION

Background

Benthic conditions in Nipigon Bay were assessed in 2003 by Environment Canada (EC) as part of the Great Lakes (GL) 2020 Action Plan to assess Areas of Concern (AOCs). Metal contamination in the surficial sediment was generally low with exceedences of the Severe Effect Levels limited to a few sites for manganese and iron. Benthic communities at the majority of sites, especially in the western bay near the industrial discharge and in the southwest channel, were different from those at reference sites. These communities were characterized by the absence of a dominant reference group amphipod (Pontoporeiidae) and enrichment of other pollution tolerant taxa (tubificids, chironomids). Severe toxicity was observed in the east part of the bay and the cause of this toxicity was not clear. The contribution of organic contaminants was unknown as they were not measured. It was thought that industrial discharges were not likely responsible because toxicity occurred in the east portion of the bay but was low or absent in the western area of the bay closer to outfalls. According to the decision-making framework for sediment contamination, developed under the Canada-Ontario Agreement respecting the GL Basin Ecosystem, management actions were not indicated for any site. A recommendation from the 2003 study was to continue to monitor benthic communities for change in status.

Purpose of Study

The purpose of this study was to assess current benthic conditions (i.e., sediment contaminant concentrations, sediment toxicity, and invertebrate communities) in Nipigon Bay, and to determine the degree to which these conditions differed from those of reference locations. The overall goal of the study plan was to evaluate whether benthic conditions in the AOC continue to improve over time.

The assessment of Milani et al. (2006) conducted in 2003 offers the most recent and extensive data against which changes in benthic conditions through time can be compared. Benthic conditions will be examined at previously sampled stations to assess:

- (a) Spatial differences between contaminated and reference sediments, and
- (b) Temporal differences between conditions in and after 2003.

The methods described in Milani et al. (2006) were applied. These included assessments of sediment chemistry and grain size, sediment toxicity, and benthic invertebrate community composition based on the original "BEAST" methodology (Reynoldson et al. 1995, 2000). The analysis of sediment organic contaminants, which was not performed in the 2003 study, was added to the current study to fill data gaps with respect to sediment contaminant levels. Integration of these data and assessment of overall benthic conditions followed the framework of EC/MOE (2007).

2 EXPERIMENTAL DESIGN

Sampling Design

The sampling design mostly repeated the array applied in 2003 (Milani et al. 2006), except six stations were dropped for toxicity testing. This sampling design allowed analyses of both spatial patterns and temporal trends in benthic conditions.

Stations were located in the following parts of the bay:

- Upstream - 2 sites
- South of the mill (downstream of Red Rock) - 4 sites
- Midwest bay (between 5 mile point and La Grange Island) - 1 site
- Southwest bay (deep straight) - 4 sites
- Kama Pt - 2 sites
- East bay - 2 sites

All stations (=sites) sampled in 2003 were revisited (as closely as possible) in 2009 (Table 1).

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 (subset of 9 sites). Sediment was obtained from

the top 0 - 10 cm layer of lake bed. Environmental variables measured/analyzed are provided in Table 2.

The benthic invertebrate community structure (taxonomic composition and relative abundances) was described based on identifications of macroinvertebrates to family level; however, identifications to lowest practical level were included. 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 benthic invertebrate community samples were collected from 15 sites October 3-4, 2009 aboard the *Stickleback* (5 sites) or *CCGS Griffon* (10 sites). Sediment for toxicity test purposes was collected at a subset of nine sites. Site positions aboard the *Stickleback* were obtained using a differentially corrected global positioning receiver (Northstar 951x), receiving corrections from CD-GPS (accuracy of $\leq 5\text{m}$) or WAAS if the CD-GPS did not lock in. Site positions aboard the *CCGS Griffon* were obtained using a differentially corrected global positioning receiver using an offset calculation from the antenna to the sampling location. Station positions are provided in Table 1 and sites are shown in Fig. 1. Methods for the collection and handling of samples are described in Milani et al. (2006).

Sample Analyses

Overlying water analyses (alkalinity, total phosphorus, nitrate+nitrite-N, ammonia-N and total Kjeldahl N) were performed by EC's National Laboratory for Environmental Testing (NLET) (Burlington, ON) by procedures equivalent to those described in Cancilla (1994) and EC (2008). Surficial sediments (0-10 cm) were analyzed for trace elements (hot aqua regia extracted), 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.

Sediment particle size analysis was performed at EC'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), oil and grease, and dioxins and furans by ALS Environmental Group (Waterloo, 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). Total PCBs was determined by the sum of the four Aroclors and total PAHs by the sum of 20 PAHs. Dioxins and furans were determined by high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) based on EPA method 1613B (USEPA 1994). Environmental variables measured/analyzed at each site are provided in Table 2.

Taxonomic Identification

Sorting, enumeration, identification and verification of benthic invertebrate community samples were performed by Craig Logan Consulting (Troy, ON). Certain taxa and microinvertebrates (e.g., poriferans, nematodes, copepods, and cladocerans) were excluded. Material was sorted under a dissecting microscope (minimum magnification = 10 \times), and organisms were enumerated and placed in vials for identification to lowest practical level. Slide mounts were made of oligochaetes and chironomids.

Sediment Toxicity Tests

Four toxicity tests (bioassays) were conducted under standardized laboratory conductions at EC's Ecotoxicology Laboratory (Burlington, ON):

- 1) *Chironomus riparius* 10-day survival and growth test;
- 2) *Hyalella azteca* 28-day survival and growth test;
- 3) *Hexagenia* spp. 21-day survival and growth test; and
- 4) *Tubifex tubifex* 28-day adult survival and reproduction test.

Prior to testing, sediments were sieved through a 250 µm mesh screen to remove indigenous organisms. Water chemistry variables (pH, dissolved oxygen (mg/L), conductivity (µS/cm), temperature (°C), and total ammonia (mg/L)) were measured for each test in each replicate test beaker on day 0 (start of test – prior to introduction of organisms) and at completion of the test. Tests consisted of a 4 to 1 ratio of overlying water to sediment for *Chironomus*, *Hyalella* and *Hexagenia*, and a 1.5 to 1 ratio for *Tubifex*. Tests were run under static conditions in environmental chambers at 23 ± 1 °C, under a photoperiod of 16L: 8D and an illumination of 500 - 1000 Lux, except the *Tubifex* test, which was run in the dark. All tests passed acceptability criteria for their data to be used in the site assessments. The criteria are based on percent control survival in a reference sediment (Long Point Marsh, Lake Erie): i.e., $\geq 80\%$ for *H. azteca* and $\geq 70\%$ for *C. riparius*; $\geq 80\%$ for *Hexagenia* spp., and $\geq 75\%$ for *T. tubifex* (Reynoldson et al. 1999). Individual test methods are described in Milani et al. (2006).

4 DATA ANALYSIS

BEAST Analysis

Test sites were assessed using BEAST methodology (Reynoldson et al. 2000). The BEAST model predicts the invertebrate community group that should occur at a test site based on natural environmental conditions. Multiple discriminant analysis was used to predict the test sites to one of five GL reference community groups using a previously computed relationship between five environmental variables (latitude, longitude, depth, total organic carbon, and alkalinity) and the community groups (Reynoldson et al. 1995; 2000). For each test site, the model assigned a probability of it belonging to each of five reference faunal groups. Benthic community assessments were conducted at the family level, as this taxonomic detail is shown to be sensitive for the determination of stress (Reynoldson et al. 2000). The 2009 community data were merged with the reference site invertebrate data of the best matched reference group (group to which the test site has the highest probability of belonging) and ordinated using hybrid multidimensional scaling (HMDS) (Belbin 1993), with Bray-Curtis distance site × site association matrices calculated from raw data. Test sites were assessed by comparison to confidence bands of appropriate reference sites. Probability ellipses were constructed around reference sites, establishing four categories of difference from reference: equivalent/unstressed (within the 90%

probability ellipse), possibly different/possibly stressed (between the 90 and 99% ellipses), different/stressed (between the 99 and 99.9% ellipses), and very different/very stressed (outside the 99.9% ellipse).

Toxicity data were analysed using HMDS, with Euclidean distance site × site association matrices calculated from standardized data. Toxicity endpoints for the test sites were compared to those for all reference sites. (There are no distinct groups as with the invertebrate community assessment.) Probability ellipses were constructed around all reference sites, establishing four categories of difference from reference: equivalent /non-toxic (within the 90% probability ellipse), potentially toxic (between the 90 and 99% ellipses), toxic (between the 99 and 99.9% ellipses), and severely toxic (outside the 99.9% ellipse). Test site toxicological responses were also compared to numerical criteria previously established for each category (non-toxic, potentially toxic and toxic) and species from reference site data (Reynoldson and Day 1998).

Principal axis correlation (Belbin 1993) was used to identify relationships between habitat attributes and community or toxicity responses. This did not include organic contaminant data, which were not measured in the reference sediments. Significant endpoints and environmental attributes were identified using Monte-Carlo permutation tests (Manly 1991). Multiple discriminant analysis was performed using the software SYSTAT (Systat Software, Inc. 2007). HMDS, principal axis correlation, and Monte-Carlo tests were performed using the software PATN (Blatant Fabrications Pty Ltd. 2001).

Comparison of Key Taxa Abundances

Paired t-tests (95% confidence level) were used to compare mean differences in tubificid, chironomid and amphipod abundances between 2009 and 2003. T-tests were performed using the software MINITAB (Minitab Inc. 2007).

Dioxin and Furan (PCDD/F) Distribution in Sediment

PCDD/Fs have been reported to cause a number of toxic responses similar to the most toxic dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) (Van den Berg et al., 1998). Using toxic equivalency factors (TEFs) for each congener determined by the World Health Organization, the

toxicity of PCDD/Fs relative to the toxicity of the most toxic dioxin congener (2,3,7,8-TCDD; TEF=1) was determined using the following equation:

$$\text{TEQ} = \sum_{n1} [\text{PCDD}_i \times \text{TEF}_i] + \sum_{n2} [\text{PCDF}_i \times \text{TEF}_i]$$

For values that were below detection limits, the calculation of the TEQs was performed two ways: 1) assigning a value of zero to the value (lower bound TEQ), and 2) using the reporting limit itself (upper bound TEQ). Thus, the actual TEQ would be bounded by the two values. Sediment TEQs were compared to the CCME Probable Effect Level (PEL) of 21.5 ng TEQ/kg (CCME 2001).

5 QUALITY ASSURANCE/QUALITY CONTROL

Two sites were randomly selected as QA/QC stations (E12, R7). At these sites, triplicate sediment, water, and benthic community samples were collected for determination of within-site and among-sample variability. The coefficient of variation ($CV = \text{standard deviation} \div \text{mean} \times 100$) was examined for the analytical data. Variability in family counts between box core samples was examined by paring positions of sites in the ordination plots.

Each laboratory employed quality control procedures such as analyses of sample blanks, duplicates, repeats and certified reference materials, as well as evaluation of standard and surrogate sample recoveries. Precision was assessed by the analyses of laboratory duplicates. The relative percent difference ($RPD = [(x_1 - x_2) / (x_1 + x_2)/2] \times 100$) was calculated to determine differences in two or more measurements. Further details are provided in Milani et al. (2006). Additionally, a batch of samples was rerun for PCDD/F determinations for confirmation only.

For benthic invertebrate identification and enumeration performed by Craig Logan Consulting, approximately 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 second 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.

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 36% (median 4%) (Appendix A, Table A1). Most CVs (98%) were below 20%, indicating homogeneous conditions within a site and that the 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 similar to those for trace metals and nutrients, ranging from 0.2 to 40% (median 7%) with 90% of values less than 20% (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 (E1202 and R10). The RPDs ranged from 0 to 49% (median 2.3%), with higher values for the oxide compounds; 78% of values were <20%. 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 and standards are provided in Appendix A, Table A3. Recoveries ranged from 20 to 133% (median 93%) and values were mostly >80%. While

the recovery was low for molybdenum (Mo) in the lake sediment standard (LKSD) (20%), it was within the control limits (0 to 260), and this result is typical for this variable (similar values for Mo were observed in other studies for this standard). Recoveries for all other variables were well within the control limits for each parameter.

ALS Laboratory Group

Laboratory replicate measurements for sediment variables are provided in Appendix A, Table A4. The RPDs were quite low, ranging from 0 to 48% (median 4%); 92% of values were <15%. To test the effects of the matrix and precision of the laboratories sample preparation, surrogate spikes were performed (samples were spiked with the surrogate prior to sample preparation). The percent recovery for surrogate concentrations in the final sample extracts is provided in Appendix A, Table A5. Recoveries ranged from 72 to 101% (median 82%) for the BTEX surrogate (2, 5-dibromotoluene), from 71 to 107% (median 96%) for the PHC surrogate (octacosane), from 85 to 120% (median 102%) for the PAH surrogates (2-fluorobiphenyl, p-Terphenyl d14) and from 83 to 112% (median 96%) for the PCB surrogate (d14-Terphenyl). These recoveries were generally high, indicating a good ability of the laboratory to analyze organic compounds. PCDD/F extraction standard recoveries for Nipigon Bay samples were mostly high, ranging from 46 to 123% (median 92 %) (Appendix A, Table A6). Target analyte recoveries for PCDD/Fs for the laboratory control standard (LCS) and extraction standards were also good, ranging from 94 to 119% (median 107%) and from 50 to 104% (median 76%), respectively; all recoveries were within control limits (Appendix A, Table A7).

Benthic Invertebrate Community Variability

All replicates of site E12 (E1200, E1201, E1202) fell in Band 2 and were in very close proximity to each other, indicating good agreement in benthic community composition between box cores (Appendix A, Fig. A1). For site R7, two of the three replicates fell in Band 2, and 1 replicate (R701) fell in Band 1; however, sites were in the same general location in ordination space (Appendix A, Fig. A2). 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 fairly similar among sites (Table 3), suggesting homogeneity in water mass across these sampling sites. Generally higher concentrations of alkalinity, TKN, and TP were noted in the western bay (north of 5 mile point) and the highest NO₃/NO₂ was found in the eastern bay, similar to that found in the 2003 study (Milani et al. 2006). Ranges across sites (maximum – minimum value) were 20 mg/L for alkalinity, 41 µS/cm for conductivity, 2.4 mg/L for dissolved oxygen, 0.03 mg/L for NH₃, 0.3 mg/L for NO₃/NO₂, 0.6 mg/L for total Kjeldahl N, 0.4 for pH, 1.8°C for bottom temperature, and 0.02 µg/L for total phosphorus. Total P ranged from 8 to 32 µg/L, exceeding the Interim Provincial Water Quality Objective (20 µg/L - to avoid nuisance concentrations of algae in lakes) slightly at 1 site in each of the midwest (R4) and southwest bay (E14) (31 and 32 µg/L). In 2003, TP ranged from ~6 to 17 µg/L, except for 2 sites downstream of the mill and Red Rock WPCP (E6 and E8), where concentrations were 35 and 58 µg/L (Milani et al. 2006).

6.2.2 Sediment particle size

With the exception of sites 6974 (Nipigon River) and E6 (south of the town of Red Rock), test sediments consisted mainly of fines (silty clay) (Table 4). Silt ranged from 32 to 58% (median 41%), and clay from 39 to 68% (median 58%). Sand ranged from 0.3 to 6.8% (median 1.2%). Sites 6974 and E6 were comprised of mostly sand (98% and 79%, respectively) with little or no silt (0%, 8%) and clay (2%, 13%). There was no gravel present (at any site). These results were generally similar to those found in the 2003 study, where sediments were dominated by clay (4.1 to 63.8%, median 51.8%), and silt (10.3 to 72.1%, median 43.4%) and most sites had <7% sand (Milani et al. 2006). However, there were some differences in substrate type between sampling years. In 2003, site 6974 was comprised of 59% sand (Milani et al. 2006) compared to 98% in the current study (Table 4). (Note: sampling depth for site 6974 was recorded at 8.7 m in 2009 compared to 11.5 m in 2003 (Table 1), which could explain why the substrate differed between years.)

6.2.3 Sediment nutrients

Total organic carbon ranged from 0.2 to 3.8%; most sites had $\leq 1.5\%$ and the highest TOC was just below the town of Red Rock (Table 5). Total Kjeldahl nitrogen (TKN) ranged from 306 to 2110 $\mu\text{g/g}$ (median 1060 $\mu\text{g/g}$) and total phosphorus (TP) from 344 to 965 $\mu\text{g/g}$ (median 645 $\mu\text{g/g}$). Most sites exceeded the provincial Sediment Quality Guideline (PSQG) Lowest Effect Level (LEL) for TOC, TKN, and TP; none exceeded the Severe Effect Level (SEL). Results are similar to those found in 2003, where TOC ranged from 0.6 to 5.5% (median 1.2%), TKN from 473 to 2300 $\mu\text{g/g}$ (median 1180 $\mu\text{g/g}$) and TP from 458 to 981 $\mu\text{g/g}$ (median 709 $\mu\text{g/g}$) (Milani et al. 2006). The highest TOC concentrations were also at sites downstream of Red Rock. Visual observations at the time of sampling noted approximately 9-10 cm of woody debris at site E4, the same as that observed in 2003. Sediment nutrient concentrations at Nipigon Bay sites were within the range observed for Lake Superior reference sites (range 0.2 to 2.9%, n = 31; Reynoldson and Day 1998), with the exception of site E4.

6.2.4 Trace metals

All sites had exceedences of the LEL for 1 to 8 metals (Table 5). Sites at Kama Pt and in the eastern bay had the greatest number of LEL exceedences. Exceedences of the SEL were limited to Mn at three sites in the east bay and at Kama Pt, identical to 2003 results and the 1999 MOE study of Richman (2004). Richman (2004) attributed the metal concentrations as typical in some cases for Lake Superior because comparison of test site concentrations to background values for the GL basin and Lake Superior (pre-colonial sediment horizons) showed test sites to be below or similar to background. All trace metal concentrations for Nipigon Bay sites were within the range observed for Lake Superior reference sites (n = 31; Reynoldson and Day 1998) (Table 5). The RAP Stage 1 report (Nipigon Bay RAP Team 1991) states that contaminants in the east part of the bay are thought to be deposited in this area as a result of transport from the lake rather than from the mill (due to distance from industrial discharge, predominant currents in the bay, and the nature of contaminants).

6.2.5 PAHs

PAH concentrations were below detection limits (DLs, values preceded by “<”) with the exception of Phenanthrene at site E5 (0.032 µg/g) (Table 6), which was well below the LEL for this compound (0.56 µg/g; Fletcher et al. 2008). (DLs are provided in Appendix A, Table A8.) PAHs were not measured in the 2003 study; however, a MOE study conducted in 1999 reported elevated total PAHs at a site 30 m south of the mill outfall compared to other stations in Nipigon Bay; total PAHs at this site ranged from 0.5 to 0.74 µg/g (Richman 2004).

6.2.6 BTEX and petroleum hydrocarbons

The BTEX (benzene, toluene, ethylbenzene and xylene) F1 (C6-C10 hydrocarbons), F2 (C10-C16 hydrocarbons) and F4 (C34-C50 hydrocarbons) compounds were below DLs (Table 6). (DLs for BTEX and PHCs are provided in Appendix A, Table A8.) The F3 (C10-C16 hydrocarbons) were detected in the western bay at sites E4, E5 and E12, ranging from 110 to 350 mg/kg (Table 6). The gravimetric heavy hydrocarbons (F4G: ~C24-C50+), which typically include the very heavy hydrocarbons (e.g., heavy lubrication oils) were not detected and the chromatogram reached baseline at C50 for all sites (i.e., there were no PHCs with carbon chain lengths >50). The F3 PHC concentrations observed in Nipigon Bay were well below the Canada-wide numerical standards for contaminated surface soil for all the land use categories for the F3 fraction (\geq 1300 mg/kg; CCME 2008). PHCs were not measured in the 2003 study.

6.2.7 Oil and grease

Oil and grease concentrations were above the DL at a third of the sites, ranging from <500 to 3420 mg/kg; the highest concentrations were at sites south of the (former) mill outfall (sites E4 and E5) (Table 6). Oil and grease was not measured in the 2003 study. Concentrations at E4 and E5 were higher than those reported for Jackfish Bay in 2008 (100 to 1400 mg/kg; Milani and Grapentine 2009) but lower than those reported for Hamilton Harbour (353 to 8717 mg/kg; Milani, unpublished).

6.2.8 PCBs

PCB concentrations (Aroclors 1242, 1248, 1254 and 1260) were below DLs at all sites (Table 6). PCBs were not measured in the 2003 study; however a 1999 MOE study reported total PCBs

ranging from 0.08 to 0.2 µg/g, with higher concentrations observed just south of the former mill outfall (Richman 2004).

6.2.9 Dioxins and furans

Dioxin concentrations (total homologues) generally increased with increasing chlorine atoms, from the tetrachlorodioxins (TCDD) to the octachlorodioxins (OCD) (Table 7). The most toxic dioxin, 2,3,7,8-TCDD, was below DLs at all sites except 1 and 1,2,3,7,8-PeCDD, was below DLs at about half the sites (Table 7). OCDs were most elevated south of the mill (152 to 757 pg/g), followed by Kama Pt and the east bay (103 to 172 pg/g). For furans, the same pattern was not followed; median and average concentrations were generally similar for all homologue groups. One of the most toxic furan congeners, 2,3,4,7,8-PeCDF, was below DLs at 9 sites (Table 7). The lower homologue groups were highest in the east bay (Sites R9, R10) whereas the higher homologue groups were highest south of the mill (Site E4) for both dioxins and furans (Table 7).

Toxic Equivalent Concentrations (TEQs)

The upper bound and lower bound TEQs are provided in Table 7 and are shown in Fig. 2. Dioxin and furan TEQs were low, ranging from 0.001 to 3.3 (both lower and upper bound values taken into consideration). Sites at Kama Pt and in the east bay had the highest TEQs. All TEQs were well below the Probable Effect Level of 21.5 ng TEQ/kg (CCME 2001) (Fig. 2). Dioxins and furans were not analyzed in the 2003 study; however, the 1999 MOE study reported dioxin-like PCBs and octachlorodioxin ($n = 1$) elevated in sediment south of the town of Red Rock compared to other stations in Nipigon Bay (Richman 2004). The dioxin-like PCBs were reported to make up more than half of the toxic equivalency value (TEQ) near Red Rock, while in other Lake Superior AOCs (Jackfish Bay, Thunder Bay, Peninsula Harbour) and the Spanish Harbour AOC, dioxin-like PCBs represented a small fraction of the TEQ. Dioxin-like PCBs were not analyzed in the current study.

6.3 Benthic Invertebrate Community Structure

The mean abundance (per 33 cm^2 – the area of the sampling core tube) of the key taxa found in Nipigon Bay is provided for 2009 sites as well as the 2003 sites in Table 8. Complete family level and lowest level identifications and counts for 2009 sites are provided in Appendix B, Table B1 and B2, respectively. (Identifications and counts for the 2003 study are found in Milani et al. 2006.) Nipigon Bay samples were dominated by Tubificidae and Chironomidae, which were present at all sites in 2009. Tubificids were in greatest abundance in the deep southwest bay, up to 41 times the Great Lakes (GL) reference mean (Table 8), and consisted mainly of unidentified immature worms (with and without chaetal hairs) (Appendix B, Table B2). Nine tubificid species were identified, mainly: *Aulodrilus* (4 species), *Limnodrilus* (2 species) and one species each of *Potamothrix*, *Quistradrilus*, and *Spirosperma* (Appendix B, Table B2). In 2003, samples were also dominated by tubificids and chironomids, and the tubificid worms consisted mainly of the unidentifiable immatures, followed by *Aulodrilus* (4 species), *Potamothrix* (3 species) and *Limnodrilus* (2 species) (Milani et al. 2006). Chironomids were represented by 43 genera (Appendix B, Table B2) and were present in increased abundance compared to GL reference sites with the exception of the sites in the east bay (sites R9 and R10) (Table 8). *Procladius* sp. was the dominant midge, present at all sites, similar to that found in 2003. Sphaeriids, which were present at all sites except one (R10), were represented by 11 identified species, dominated by *Pisidium* sp. (Appendix B, Table B2), also similar to that found in 2003. The greatest densities of tubificids, chironomids, sphaeriids as well as naidids were in the western bay (Table 8). Pontoporeiidae, the dominant GL reference group taxa, was mostly absent or in low abundance in the western bay south of the town of Red Rock and in the deep southwest bay (Nipigon Channel); abundances at these sites ranged from 0 to $2.2/33\text{ cm}^2$ (0 to $664/\text{m}^2$). Pontoporeiids were more prevalent in the east bay and at Kama Pt where they ranged from 2.7 to $12.2/33\text{ cm}^2$ (815 to $3681/\text{m}^2$) (Table 8). Results are very similar to those in 2003, where pontoporeiids were absent at the upstream sites (6974, R1) at the sites south of the mill (E4 and E5) and in low abundance at remaining sites in the western bay; sites in the east bay and at Kama Pt had the highest abundances (0.6 to $9.2/33\text{cm}^2$). Overall, sites in the southwest bay (deep channel) had the highest abundance of taxa present (43 to $231/33\text{ cm}^2$) compared to upstream (32 to $70/33\text{cm}^2$), midwest bay ($\sim 18/33\text{ cm}^2$), south of the mill (14 to $99/33\text{ cm}^2$), Kama Pt (17 to $41/33\text{ cm}^2$), and the east bay (23 to $28/33\text{ cm}^2$) (Appendix B, Table B1). A

comparison of taxa and abundances between 2009 and 2003 is summarized in Table 9. Community assemblage was fairly similar between years. In 2003, Tubificidae was represented by 13 identified species, Chironomidae by 36 genera, and Sphaeriidae by 8 species in 2003, compared to 9 tubificid species, 43 chironomid genera and 11 sphaeriid species in 2009 (Table 9). A total of 41 benthic families were identified in 2009 compared to 42 in 2003. Macroinvertebrate family diversity (based on the 38-family model) ranged from 5 to 21 taxa in 2009 and from 4 to 19 taxa in 2003. Sites 6974 (upstream) and E6 (south of the mill) had the highest diversity in 2009 and 2003 (Table 8). Some differences observed in benthic composition/abundance between years (e.g., 6974, E4; Table 8) may be due to small scale heterogeneity. Although site positions were essentially the same between years (Table 1), site 6974 was recorded at 8.7 m in 2009 compared to 11.5 m in 2003; E4 was recorded at 3.9 m in 2009 vs. 7.7 m in 2003 (Table 1). Site depths at remaining sites were more consistent between sampling years. Differences in substrate type were evident at site 6974 as well (see Section 6.2.2) which could account for differences in benthic composition.

The mean relative abundances of tubificids, chironomids, sphaeriids, amphipods, and mayflies for 2009 and 2003 sites are shown in Figs. 3a and 3b, respectively. In 2009, sites in the midwest bay ($n=1$) and east bay ($n=2$) were most similar to GL reference sites (Group 5, $n=75$), consisting mainly of amphipods (40 to 47 %), tubificids (15 to 18%) and chironomids (6 to 24%) (Fig. 3a). The southwest bay sites ($n=4$) were most dissimilar to reference, with tubificid worms dominating the benthic community (71 %) with a low percentage of amphipods present (1.3%). Upstream ($n=2$), south of the mill ($n=4$), and Kama Pt ($n=2$) sites consisted predominantly of chironomids (24 to 43%), followed by tubificids (21 to 31%), although Kama Pt sites also had a fair percentage of amphipods as well (16%). Mayflies, which were expected to be in low abundance (0.1% occurrence in GL reference group 5), were present south of the mill (except E5) in higher abundance than reference (0.9%), but absent or in low abundance (0.03 to 0.05%) in the rest of Nipigon Bay. In 2003, the benthic community was also dominated by chironomids and tubificids in the upstream area, the western bay dominated by tubificids, and the eastern bay dominated by amphipods (Fig. 3b). However, there were some changes in abundances of key taxa (tubificids, chironomids, and pontoporeiids) between years (Figs. 4a-4c). (The bars indicate 2009 minus 2003 abundances.) Tubificids were less abundant in 2009 at upstream, midwest,

south of the mill and southwest bay sites (with the exception of site E16) while remained unchanged in the eastern bay (Fig. 4a). Paired t-tests indicated significant differences in abundances at some sites (indicated by an asterix in Figs. 4a-4c). Lower tubificid abundances were noted south of the mill at E4 ($t=-8.6$; $p=0.001$) and E5 ($t=-6.8$; $p=0.002$) and in the southwest bay at E12 ($t=-4.1$; $p=0.014$) and E15 ($t=-3.9$; $p=0.017$), while an increase was noted at E16 ($t=2.8$; $p=0.05$). Pontoporeiid densities remained generally similar south of the mill and in the southwest bay while increased in the midwest bay, Kama Pt and the east bay (Fig. 4c). While Fig. 4c shows the change in pontoporeiid abundances, the paired t-tests were performed on total amphipod abundances (included gammarid and hyalellid abundances where present). Increased amphipod densities were evident in the midwest bay at R4 ($t=3.7$; $p=0.021$) as well as in the eastern bay at sites R7 ($t=7.3$; $p=0.002$) and R10 ($t=4.1$; $p=0.015$). Chironomids were generally less abundant at the upstream, midwest bay and south of the mill sites (3 of the 4) and more abundant in the southwest bay ($t=3.9, 11.7$; $p\leq 0.018$) in 2009 (Fig. 4b).

All 15 Nipigon Bay sites had the highest probability of belonging to GL Reference Group 5, based on the BEAST 38-family bioassessment model and five habitat attributes (alkalinity, depth, total organic carbon, latitude and longitude) (Table 10); probabilities of test sites belonging to Group 5 were very high, ranging from 81.2 to 99.6% (mean 94%). The 2003 sites also had the highest probability (mean 92%) of belonging to Group 5 (Milani et al. 2006). Group 5 has a total of 75 sites from Lake Superior (30), Georgian Bay (19), the North Channel (12), Lake Michigan (7), Lake Ontario (5) and Lake Huron (2). The group is characterized by the amphipod family Pontoporeiidae (44.3% occurrence), followed by Tubificidae (oligochaete worm - 16.6% occurrence), Sphaeriidae (fingernail clam - 11.5% occurrence) and Chironomidae (midge - 9.9% occurrence). These 7 families make up 96% of the total benthos found in Reference Group 5. To a lesser degree, Group 5 also consists of Lumbriculidae, Enchytraeidae, and Naididae (oligochaete worms - 1.9 to 6.8% occurrence).

The BEAST results for 2009 (and 2003) Nipigon Bay sites are summarized in Table 8. Four separate ordinations were performed with a subset of 3 or 4 sites. 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, was between 0.143

and 0.162 (Figs. 5a-5d), which was an acceptable level. The larger the disparity the larger the stress and stress > 0.20 is considered poor (Belbin 1993). Of the 15 sites, 3 were categorized as *equivalent* (Band 1), 3 as *possibly different* (Band 2), 5 as *different* (Band 3), and 4 as *very different* (Band 4) to reference.

The two upstream sites (6974 and R1) were *different* and associated in increased abundance of Chironomidae as indicated in the ordination plot by the shift of sites away from the reference centroid in the same direction as these vectors (Fig. 5a). The relationship between the community response and habitat variables was examined by correlation of the ordination of the community data and the habitat information. Three habitat variables were significantly ($p \leq 0.01$) correlated with the three ordination axes scores: sample depth, TKN (water) and silt, although correlations were not strong ($r^2 = 0.11$ to 0.21). Overlying water TKN was oriented with the position of the upstream sites indicating that these sites are associated with elevated levels of this variable (Fig. 5a); site 6974 had the highest concentration in the bay (0.686 mg/L; Table 3). Midwest bay site (R4) was equivalent to reference (Fig. 5a).

South of the mill sites (E4, E5, E6, E8) were *different* or *very different* (Fig. 5b). Two of these four sites (E5 and E6) were associated with increased abundance of several taxa such as leptocerids (caddisflies), valvatids (snails), tubificids and chironomids, while the other two (E4 and E8) were associated with decreased abundance of pontoporeiids, as indicated in the plots by the direction of these invertebrate family vectors (Fig. 5b). Two habitat variables were significantly correlated ($p \leq 0.01$) to axes scores: sample depth and lead (Pb) ($r^2=0.17$ and 0.26, respectively), although correlations were weak. Test sites south of the town of Red Rock (E4, E6, E8) were the most shallow (0.9 to 7.7 m; Table 1) and more shallow than most of the GL reference sites (median 28 m), indicated by the orientation of the depth vector (Fig. 5b).

Sites in the deeper southwest bay were associated with increased abundance of several taxa, primarily tubificids, as well as naidids and chironomids (vectors in the same direction as these sites) (Fig. 5c). Three of the four sites were *different* or *very different* than reference. Five habitat variables were significantly correlated ($p \leq 0.05$) to axes scores: TKN (water), MgO, total P (water), Hg and TKN (sediment) ($r^2=0.1$ to 0.16). (Note: no habitat variables were significant

at $p \leq 0.01$.) Total P and TKN (water) and MgO were oriented with the site positions (Fig. 5c), although correlations were weak.

Sites at Kama Pt (R7 and R8) and in the east bay (R9 and R10) were *equivalent* to reference or *possibly different* to reference (Fig. 5d) and therefore cannot be described as degraded.

The 2009 BEAST results were the same as those found in 2003 for Kama Pt and east bay sites, 3 of the 4 sites in the southwest bay, and 1 of the 4 sites south of the mill (Table 8). For remaining sites, those that were in Bands 3 or 4 (*different/very different*) or Bands 1 and 2 (*equivalent/possibly different*) tended to remain as such, with the exception of R1 (upstream), which fell in Band 3 in 2009 vs. Band 2 in 2003 and site E12 (southwest bay), which was less degraded in 2009 than 2003. For E12, difference in outcomes were likely due to the 3-fold decrease in tubificid density and the ~4-fold increase in amphipod density in 2009 compared to 2003 (Fig. 5c). The spatial distribution of 2009 and 2003 sites indicating the level of benthic alteration compared to Great Lakes reference sites is shown in Figs. 6a and 6b, respectively. Additional data collected in south of the mill and in the deep southwest bay (5 sites) from 2006 to 2010 by EC may help determine whether changes in benthic communities are occurring over time and recovery rates. This data forms part of a separate EC study (to be reported in the future).

6.4 Sediment Toxicity

Mean species survival, growth and reproduction from toxicity tests for concurrent sites sampled in 2009 and 2003 are provided in Table 11. The established numerical criteria for each category (non-toxic, potentially toxic and toxic) for each species are included. In 2009, reduced *Hyalella* survival was evident south of the mill at 3 sites: E4, E6 and E8 (survival: 57 to 68%); survival at remaining sites was $\geq 83\%$ (Table 11). There were no effects on *Chironomus*, *Hexagenia* or *Tubifex*. Toxicity results were inconsistent in some cases with those from six years previous (2003). The 2009 results showed an improvement in the eastern bay with 59-87% increased *Hyalella* survival, but there was also up to a 20-25% decrease in survival south of the mill (Table 11, Fig. 7a). *Tubifex* cocoon production was slightly decreased south of the mill at 3 of the 4 sites in 2009 but showed increased production at all other sites (Fig. 7b).

Results of the BEAST toxicity evaluation are summarized in Table 11 and ordinations are shown in Figs. 8a, 8b. Each figure represents a separate ordination on a subset of 3 or 6 Nipigon Bay site data. Three axes adequately described the variation in data and stress values were 0.11 and 0.12 (good). Of the nine sites, two were *potentially toxic* (E4 and E8; Fig. 8a), and remaining sites were *non-toxic* (Figs. 8a, 8b). Potential toxicity at sites E4 and E8 was associated with low amphipod survival as indicated by the shift of these two sites away from the reference centroid in the opposite direction as the *Hyalella* survival (Hasu) vector (Fig. 8a). The relationship between the toxicological response and habitat variables (excluding organic contaminants) was examined by correlation of the ordination of the toxicity data and the habitat information. There were no high correlations ($r^2 \leq 0.16$). Those variables oriented with the site positions in ordination space included copper (Cu, Fig. 8a), although the correlation was very weak ($r^2=0.08$). (Copper concentrations were low at sites E4 and E8, ranging from 22 to 33 µg/g; Table 5.) The cause of toxicity to *Hyalella* at sites south of the mill is unclear. Most organic contaminants were low, other than the oil and grease concentration, which was highest at E4 (3420 mg/kg; Table 6), which may help explain the reduced *Hyalella* survival; however, oil and grease concentration was low (<500 mg/kg) at site E8 where amphipod survival was lower than that at E4. The spatial distribution of 2009 and 2003 sites indicating the level of toxicity compared to Great Lakes reference sites is shown in Figs. 9a and 9b, respectively.

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 for 2009 and 2003 data (Table 12). The information obtained allows 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 exceedances of a high Sediment Quality Guideline (SGQ), e.g., Severe Effect Level or Probable Effect Level, are 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* and *very different* from reference are indicated by “■”; sites determined as *possibly different* from reference by “□”. For the toxicity column, sites that have multiple endpoints exhibiting major toxicological effects are indicated by “■”; sites that have 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 are indicated by “□”. Some sites showed benthos alteration but are not recommended for further action. For these sites, the benthos alteration is not judged detrimental (decreased taxon richness, reduced average abundance).

No 2009 sites required *management actions*, the same that was found in 2003 (Table 12). Sites E5, E6, E14, E15, E16 indicated *determine reason(s) for benthos alteration* and E4 indicated *determine reason(s) for sediment toxicity*. Remaining sites indicated *no further action required*. This was an improvement over 2003 where:

- 8 sites indicated *determine reason(s) for benthos alteration* (5 in 2009).
- 4 sites indicated *determine reason(s) for sediment toxicity* (1 in 2009)
- 3 sites indicated *no further action needed* (9 in 2009)

7 CONCLUSIONS

Sediment Chemistry

- Metals (1 to 8) were above the Lowest Effect Levels but mostly below Severe Effect Levels (except for manganese); metal concentrations were similar to those found in 2003, indicating little change overall in surface metal concentrations.
- Total organic carbon was generally less than 1.5%; the site closest to mill/WPCP was highest at 3.8%.
- PAHs were below detection limits or well below Lowest Effect Levels.
- PCBs were below detection limits.

- Petroleum hydrocarbons concentrations were low.
- Oil and grease concentrations were low except for two sites below mill/WPCP, where it was up to 3-6 times higher than rest of bay.
- Dioxin and furan TEQs were well below the Probable Effect Level.

Benthic Invertebrate Community

- Benthic communities at sites in the southwest bay (Nipigon Straight) showed impairment due primarily to the increased abundance of tubificid worms and low or no abundance of pontoporeiid amphipods compared to reference.
- Communities south of the mill were generally less severely impaired than those in the southwest bay with fewer tubificids and higher diversity.
- Some improvement was noted from 2003 with significant decreases in tubificid abundances south of the mill/southwestern bay and increases in amphipod abundances in the eastern and midwest bays.
- Benthic communities in the east Bay and at Kama Pt were similar to Great Lakes reference.

Sediment Toxicity

- Potential toxicity was evident south of the mill at two sites due to low amphipod survival; the cause of toxicity is not clear.
- No toxicity was evident in the east bay and at Kama Pt, an improvement over the 2003 study where acute toxicity to *Hyalella* was evident in both these areas.

Decision-making Framework

- No sites required management actions, the same that was determined in 2003.
- Assessment outcomes were improved in 2009 due to the lack of toxicity (in the east bay and at Kama Pt) or to reduced abundances of pollution tolerant species (upstream/southwest bay) and higher taxon diversity (southwest bay).

8 RECOMMENDATIONS/NEXT STEPS

- Continue to monitor the AOC periodically for changes in benthic conditions and to assess whether positive changes are consistent and/or conditions improve with time.
- Assess the recovery of degraded benthic communities in the AOC. Yearly data were collected at five sites in western Nipigon Bay (2006-2010) to determine changes in zoobenthic conditions and recovery rates (separate EC study).

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Figures

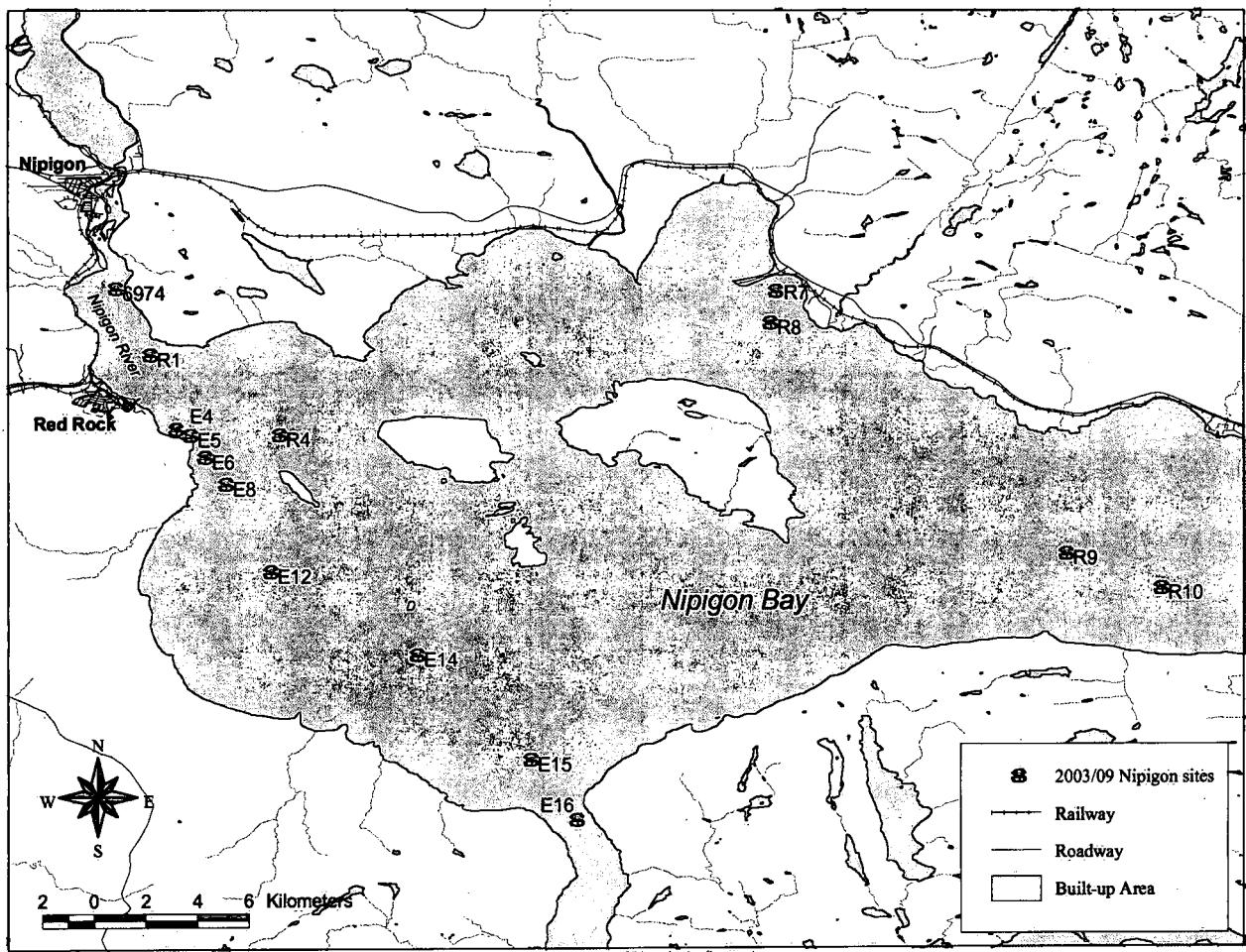


Figure 1. Sampling locations in Nipigon Bay, 2009 and 2003.

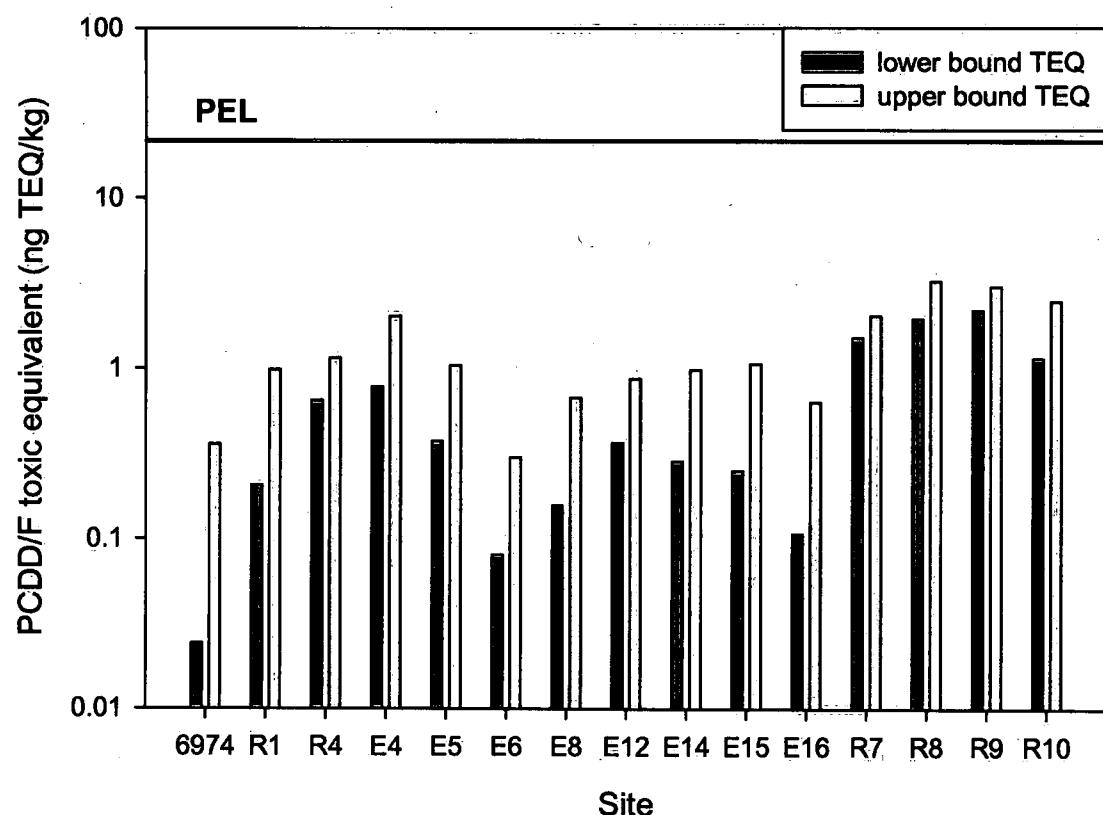


Figure 2. Dioxin and furan (PCDD/Fs) toxic equivalent (TEQ) concentrations in Nipigon Bay sediment (2009). For congener values that were below detection limits, the detection limit itself was used in the calculation of the upper TEQ; values were assigned a zero for the lower TEQ. The red solid line represents the Probable Effect Level (PEL) for dioxins/furans (21.5 ng TEQ/kg).

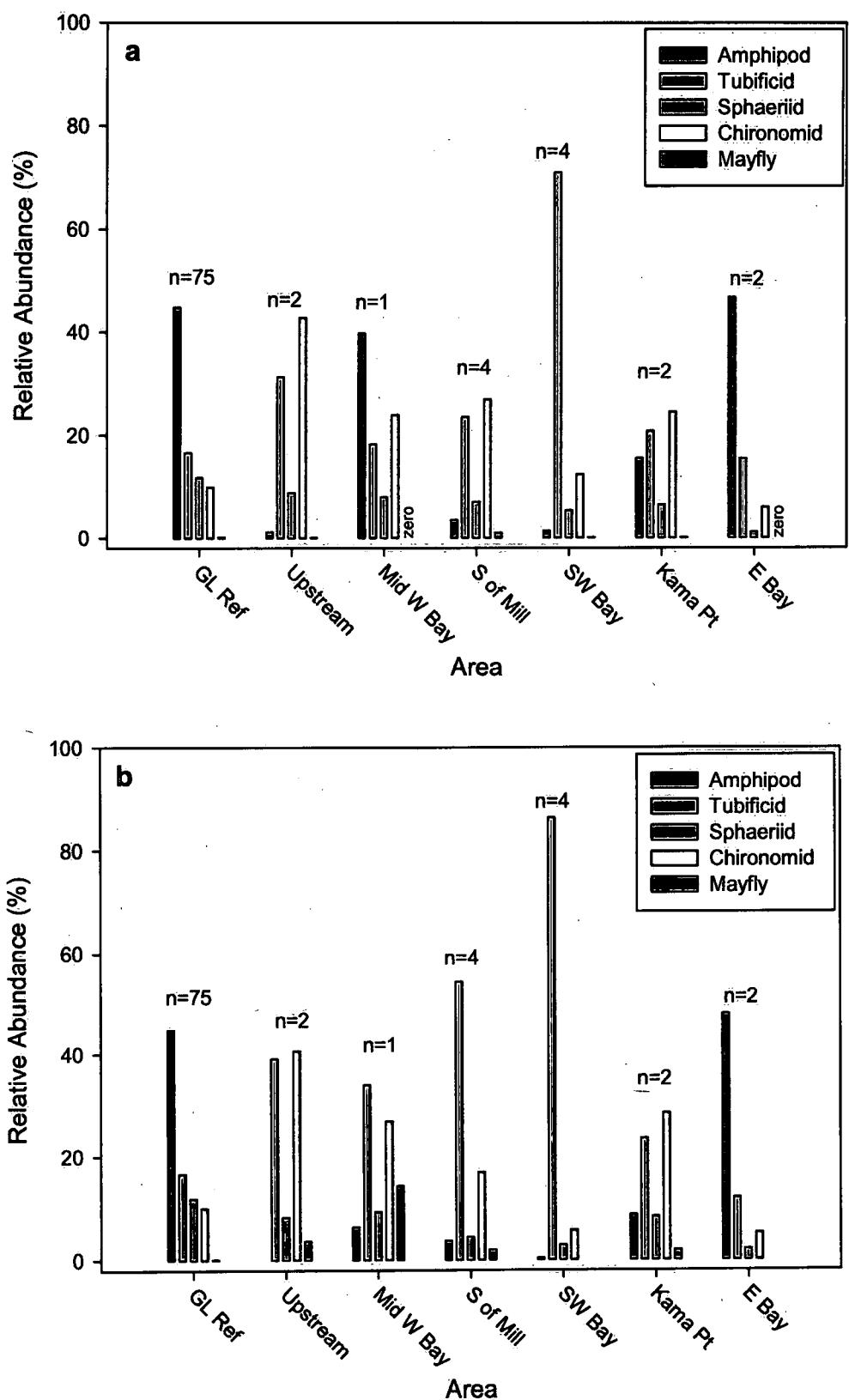


Figure 3. Relative abundance of predominant benthic macroinvertebrate taxa per area of Nipigon Bay in (a) 2009, and (b) 2003.

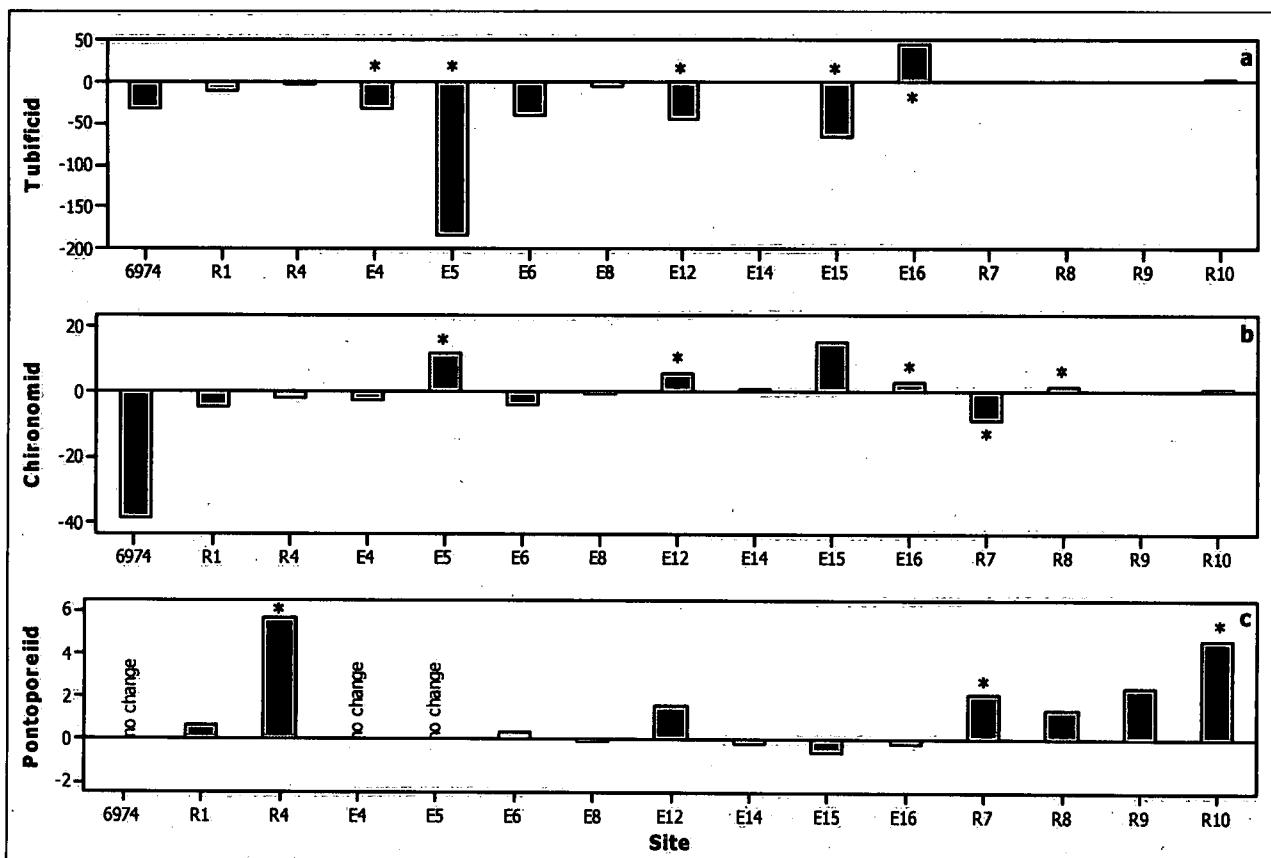


Figure 4. Change in (a) tubificid, (b) chironomid, and (c) pontoporeiid densities between 2009 and 2003 sampling years. Bars represent abundance for 2009 minus abundance for 2003 with decreases in red and increases in green. An asterisk denotes a significant difference in abundances between 2009 and 2003 (paired t-test, confidence level = 95%).

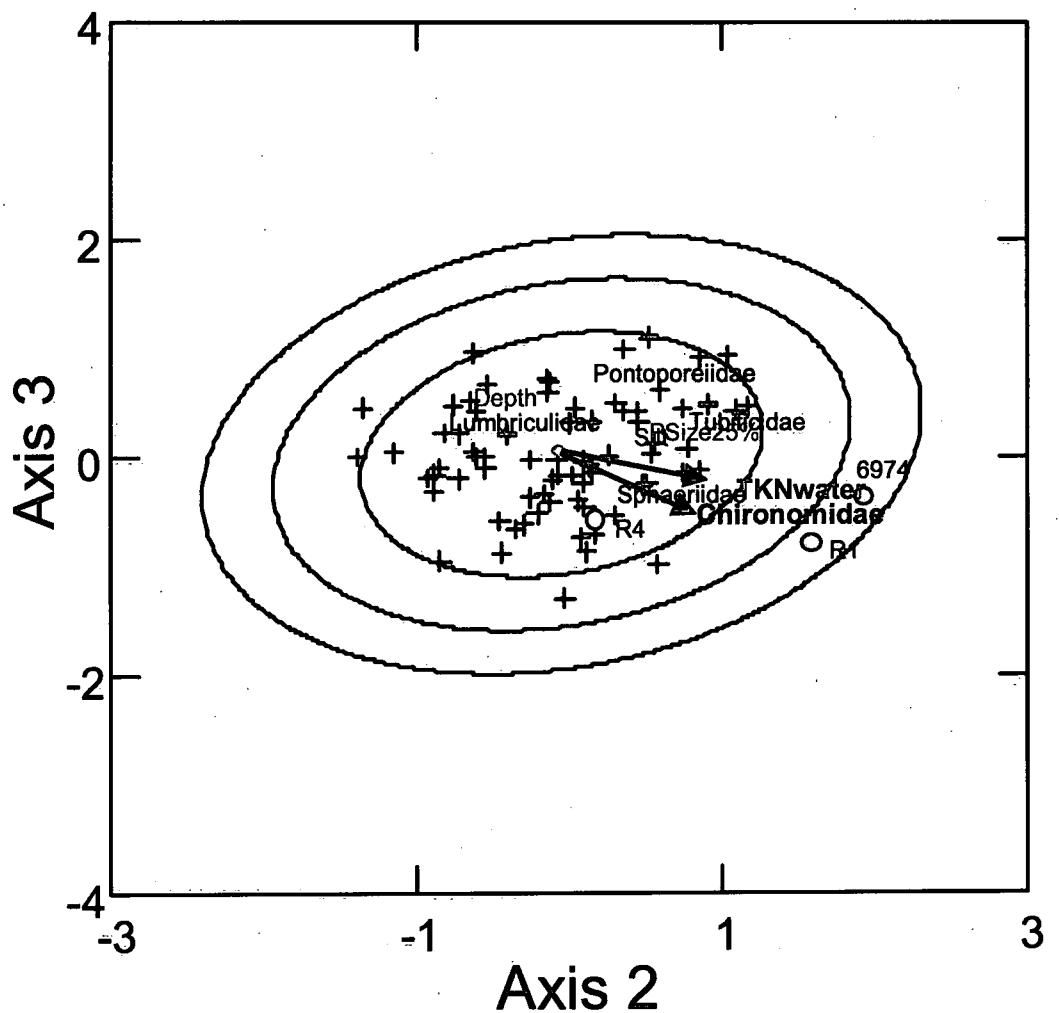


Figure 5a. Ordination and assessment of upstream ($n=2$) and midwest ($n=1$) sites using benthic invertebrate community data (family abundance). Site scores are summarized on Axes 2 & 3, with 90% (smallest ellipse), 99% (middle ellipse), and 99.9% (largest ellipse) probability ellipses around Great Lakes reference sites (reference site scores shown as cross hairs). Stress = 0.152.

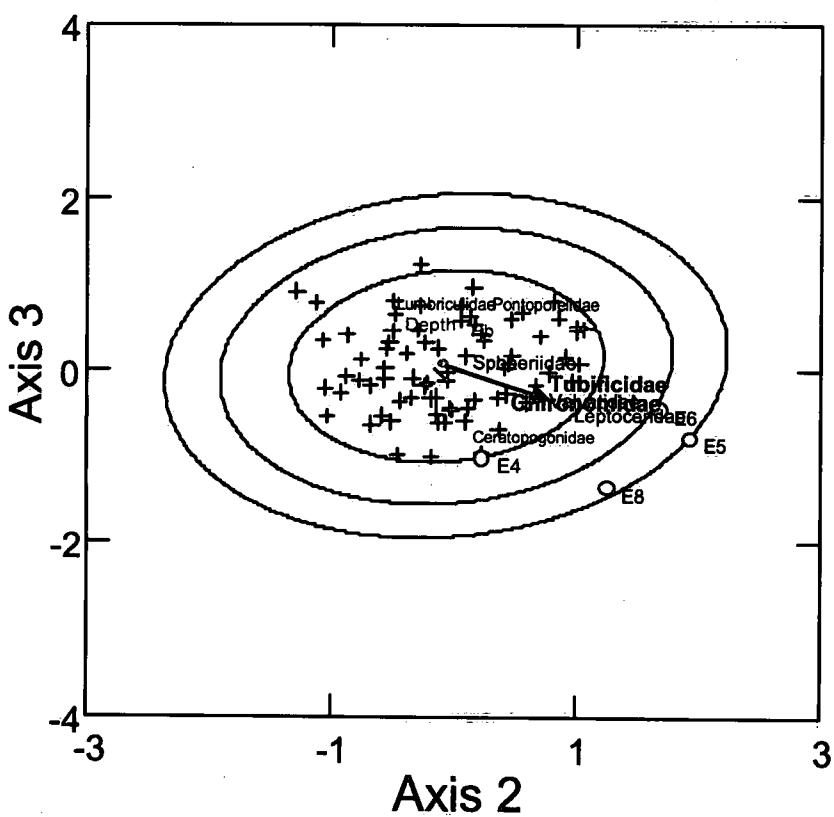
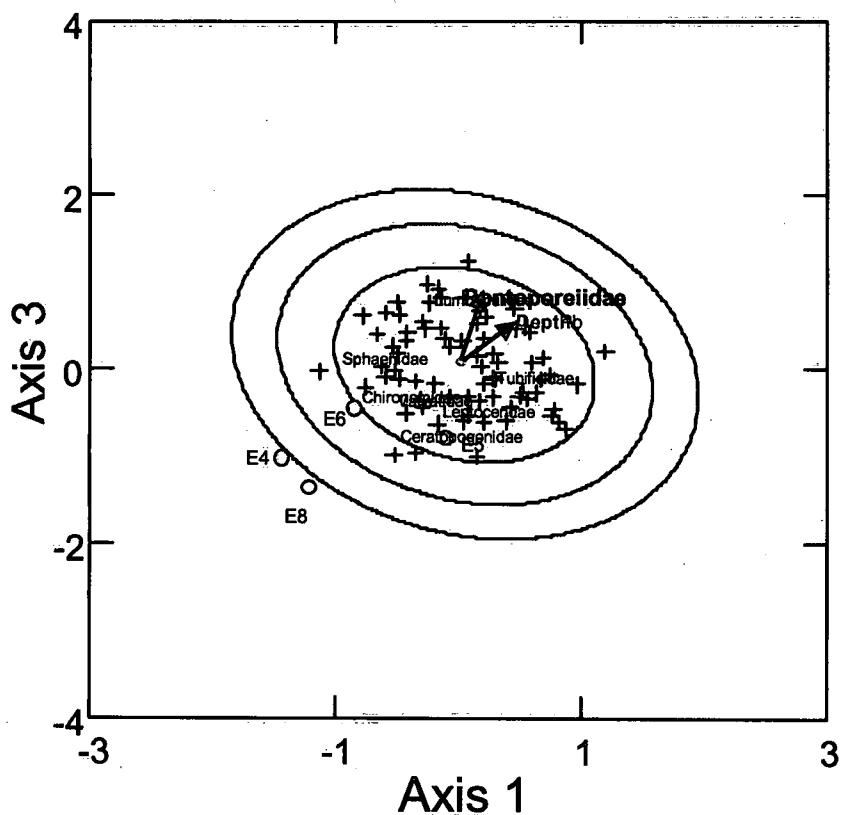


Figure 5b. Ordination and assessment of south of the mill sites ($n=4$) using benthic invertebrate community data (family abundance). Site scores are summarized on Axes 1 & 3 (top) and 2 & 3 (bottom), with 90% (smallest), 99% (middle), and 99.9% (largest) probability ellipses around Great Lakes reference sites (reference site scores shown as cross hairs). Stress = 0.152.

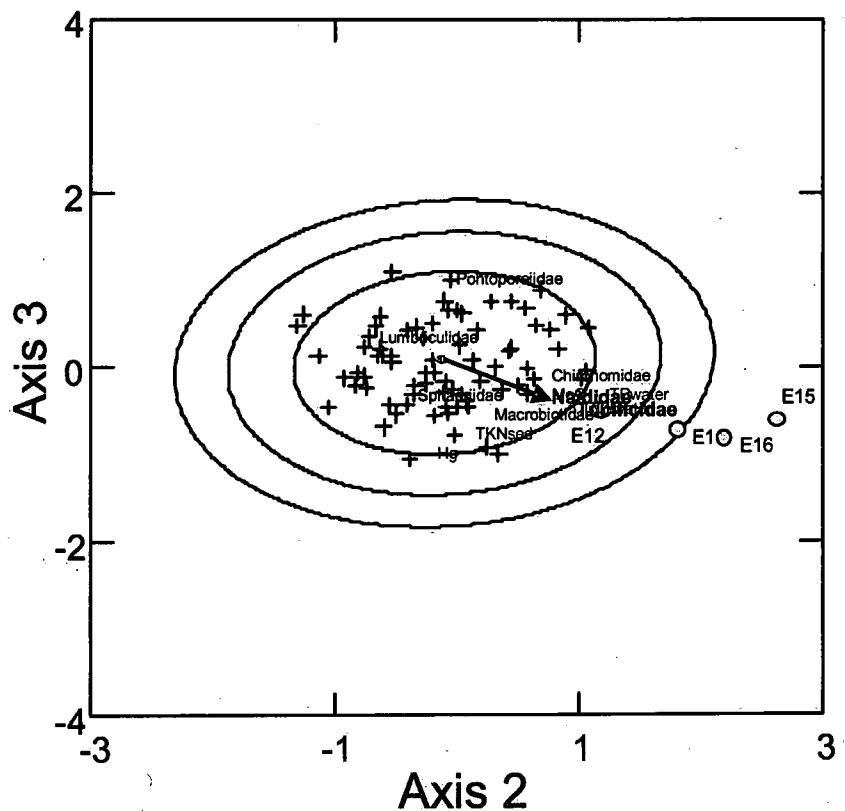


Figure 5c. Ordination and assessment of southwest bay sites ($n=4$) using benthic invertebrate community data (family abundance). Site scores are summarized on Axes 2 & 3, with 90% (smallest ellipse), 99% (middle ellipse), and 99.9% (largest ellipse) probability ellipses around Great Lakes reference sites (reference site scores shown as cross hairs). Stress = 0.148.

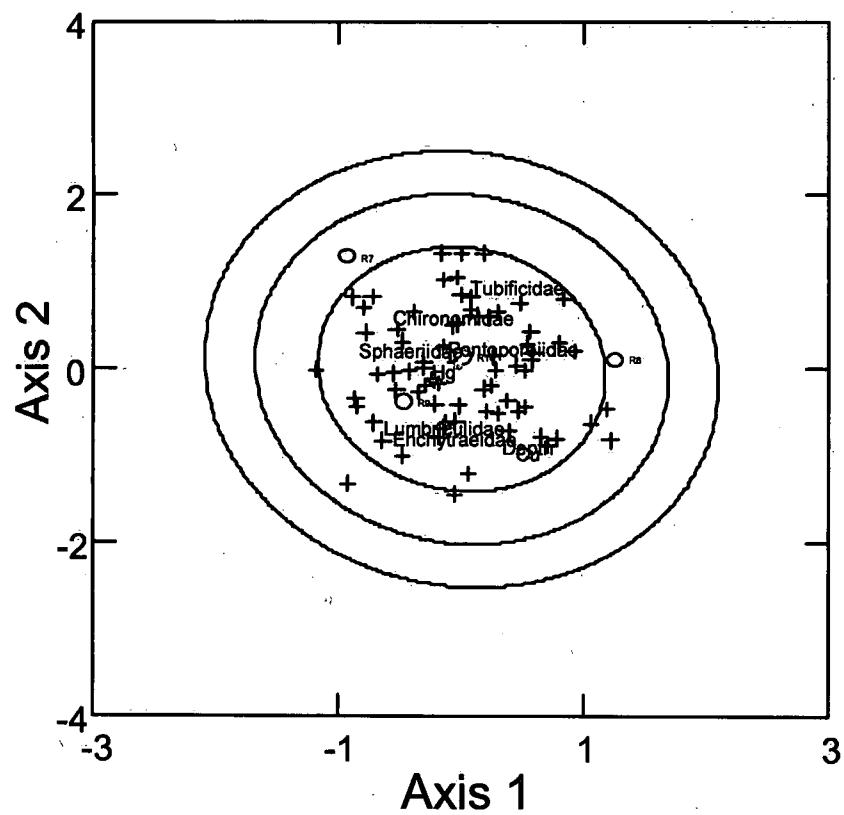


Figure 5d. Ordination and assessment of Kama Pt (n=2) and east bay (n=2) sites using benthic invertebrate community data (family abundance). Site scores are summarized on Axes 1 & 2, with 90% (smallest ellipse), 99% (middle ellipse), and 99.9% (largest ellipse) probability ellipses around Great Lakes reference sites (reference site scores shown as cross hairs). Stress = 0.162.

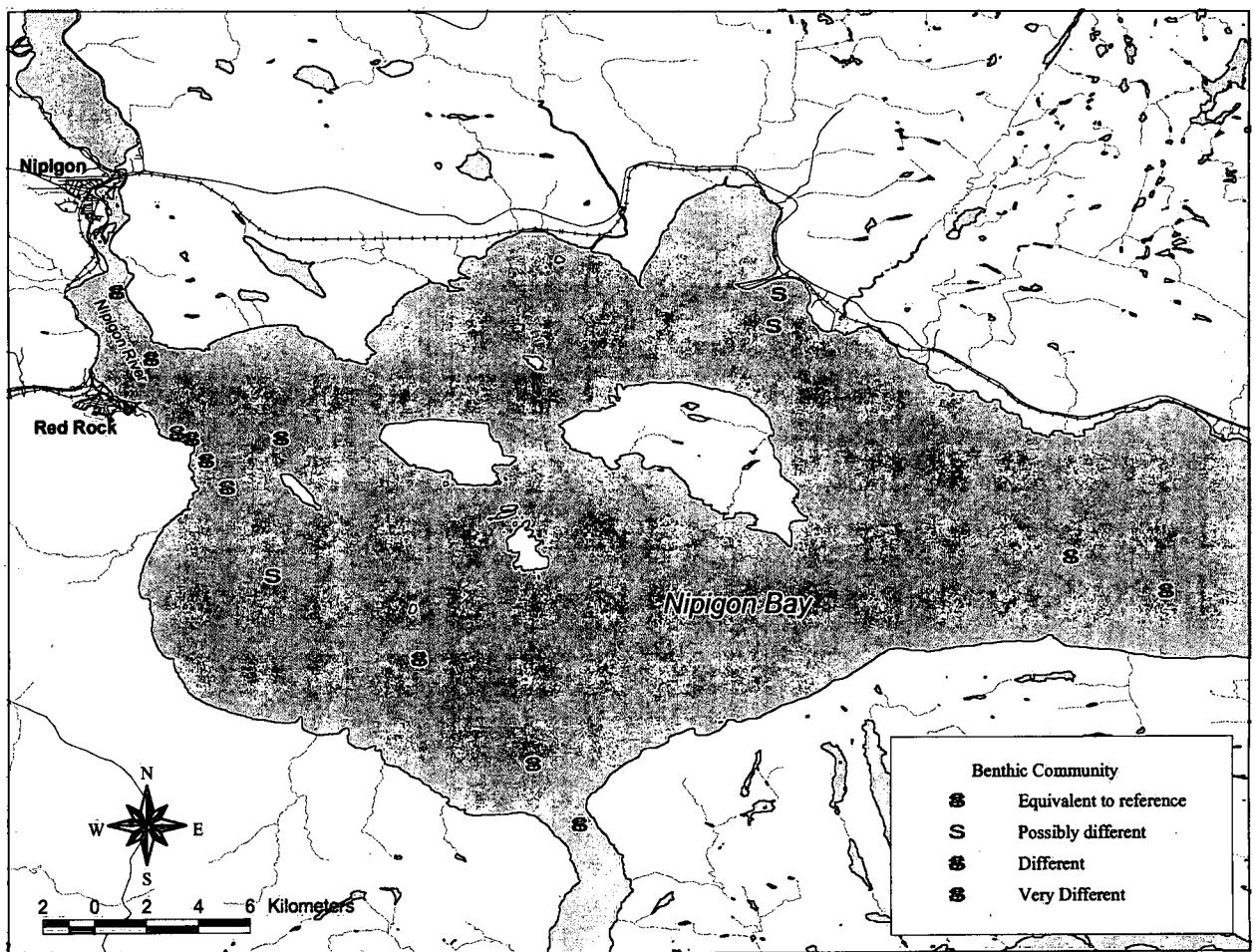


Figure 6a. Spatial distribution of 2009 sites indicating the level of benthic community alteration compared to Great Lakes reference sites.

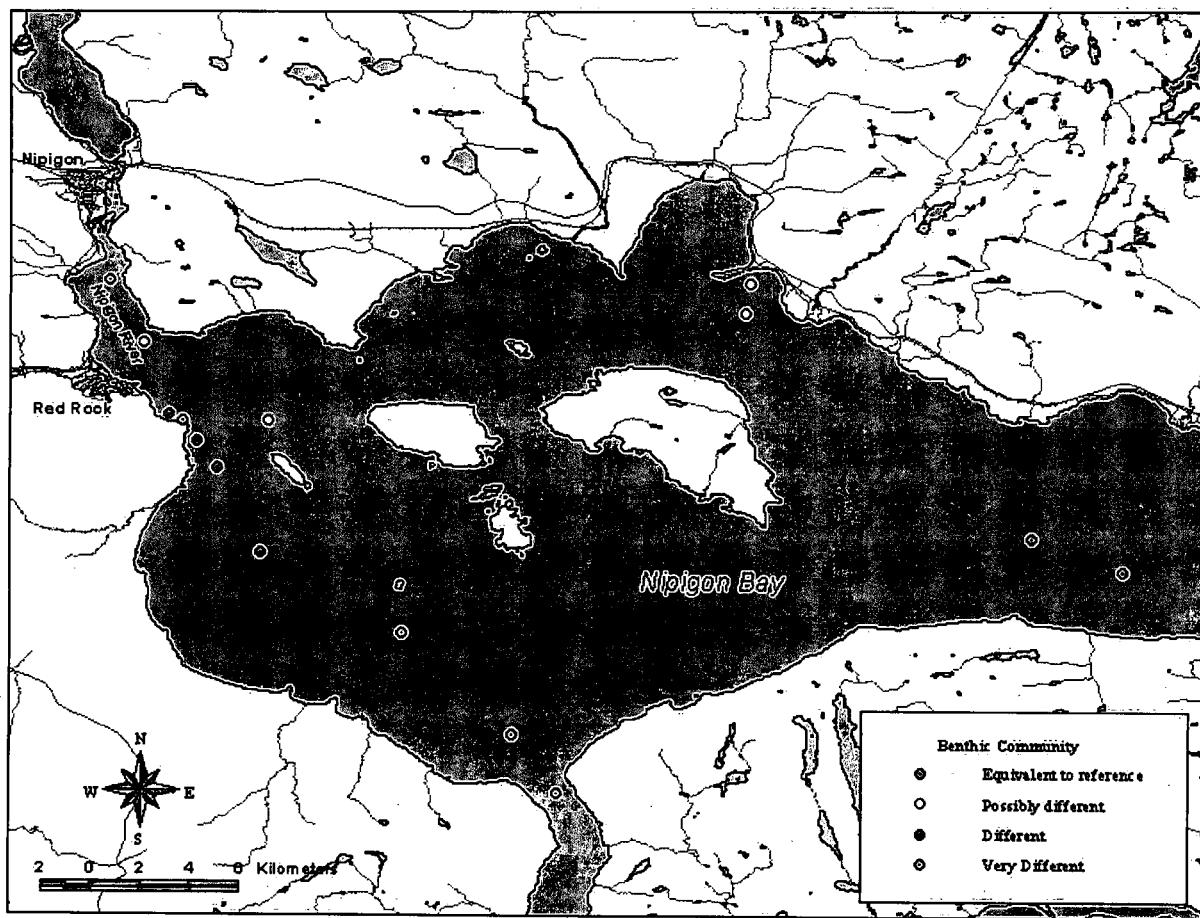


Figure 6b. Spatial distribution of 2003 sites indicating the level of benthic community alteration compared to Great Lakes reference sites.

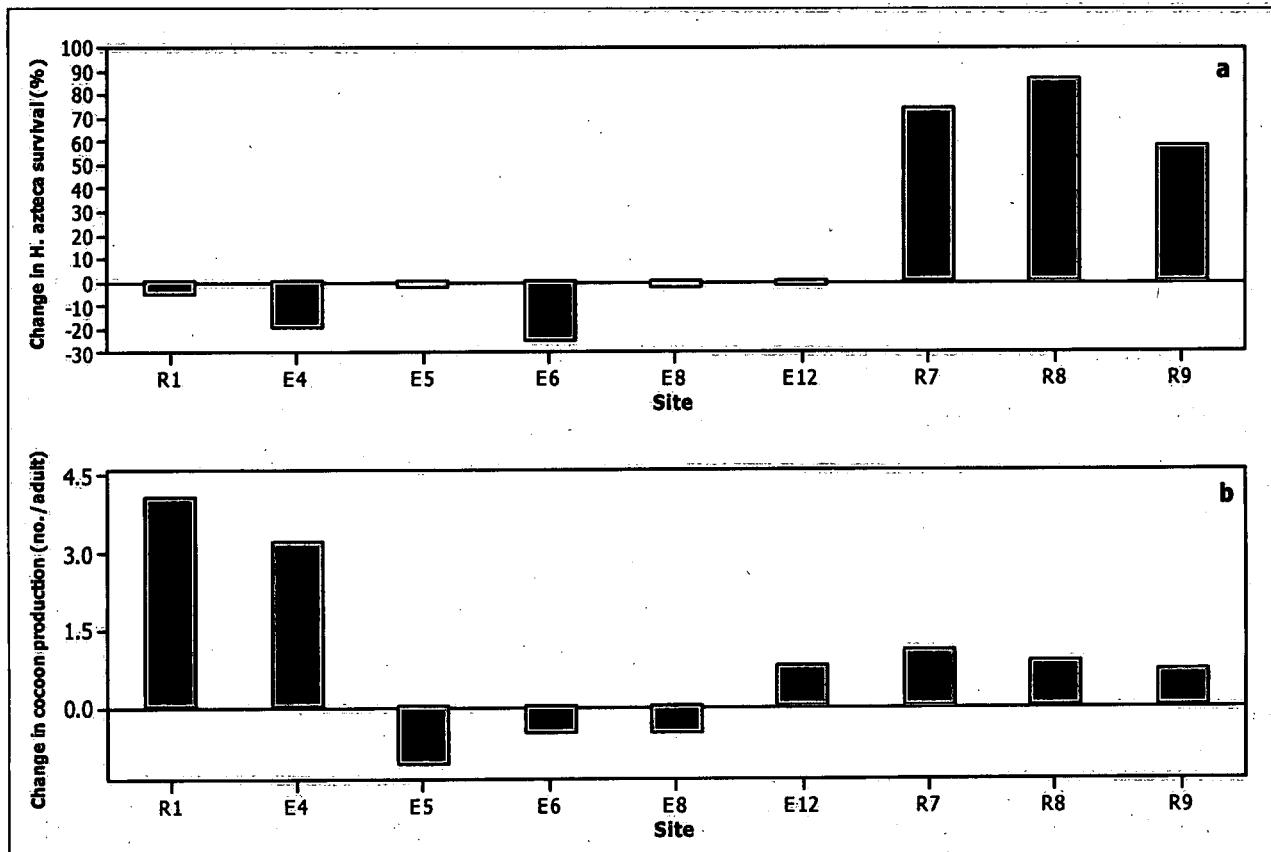


Figure 7. Change in (a) *Hyalella* survival (%) and (b) *Tubifex* cocoon production at sites sampled in 2009 and 2003. Bars represent % survival or number of cocoon produced per adult for 2009 minus that for 2003. Decreases are in red and increases in green.

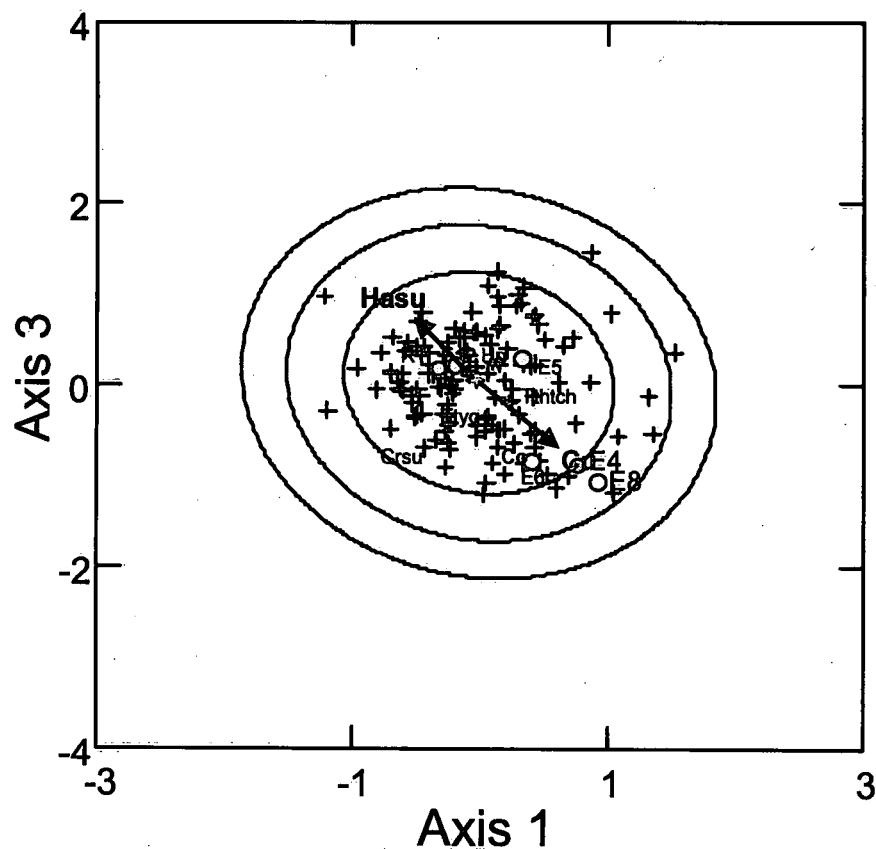


Figure 8a. Ordination and assessment of upstream ($n=1$), south of the mill ($n=4$) and southwest bay ($n=1$) sites using 10 toxicity test endpoints, summarized on Axes 1 and 3, with 90%, 99%, and 99.9% probability ellipses around Great Lakes reference sites (reference site scores shown as cross hairs). Most significant endpoints and habitat variables are shown. Those correlated to site positions are shown as vectors. Hasu, =*Hyalella* survival; Tthtch, Ttyg = *Tubifex* percent cocoons hatched, no. young/adult; Crsu = *Chironomus* survival. Stress = 0.12.

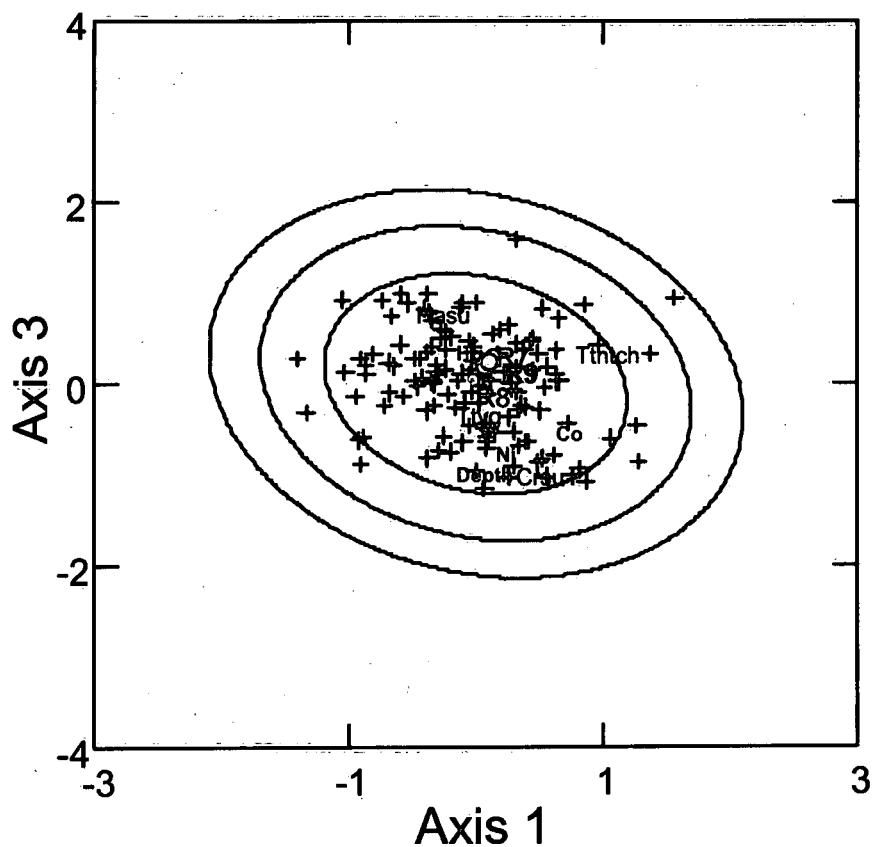


Figure 8b. Ordination and assessment of Kama Pt (n=2) and east bay (n=1) sites using 10 toxicity test endpoints, summarized on Axes 1 and 3, with 90%, 99%, and 99.9% probability ellipses around Great Lakes reference sites (reference site scores shown as cross hairs). Most significant endpoints and habitat variables are shown. Hasu = *Hyalella* survival; Tthtch, Ttyg = *Tubifex* hatch, young; Crsu = *Chironomus* survival. Stress = 0.11.

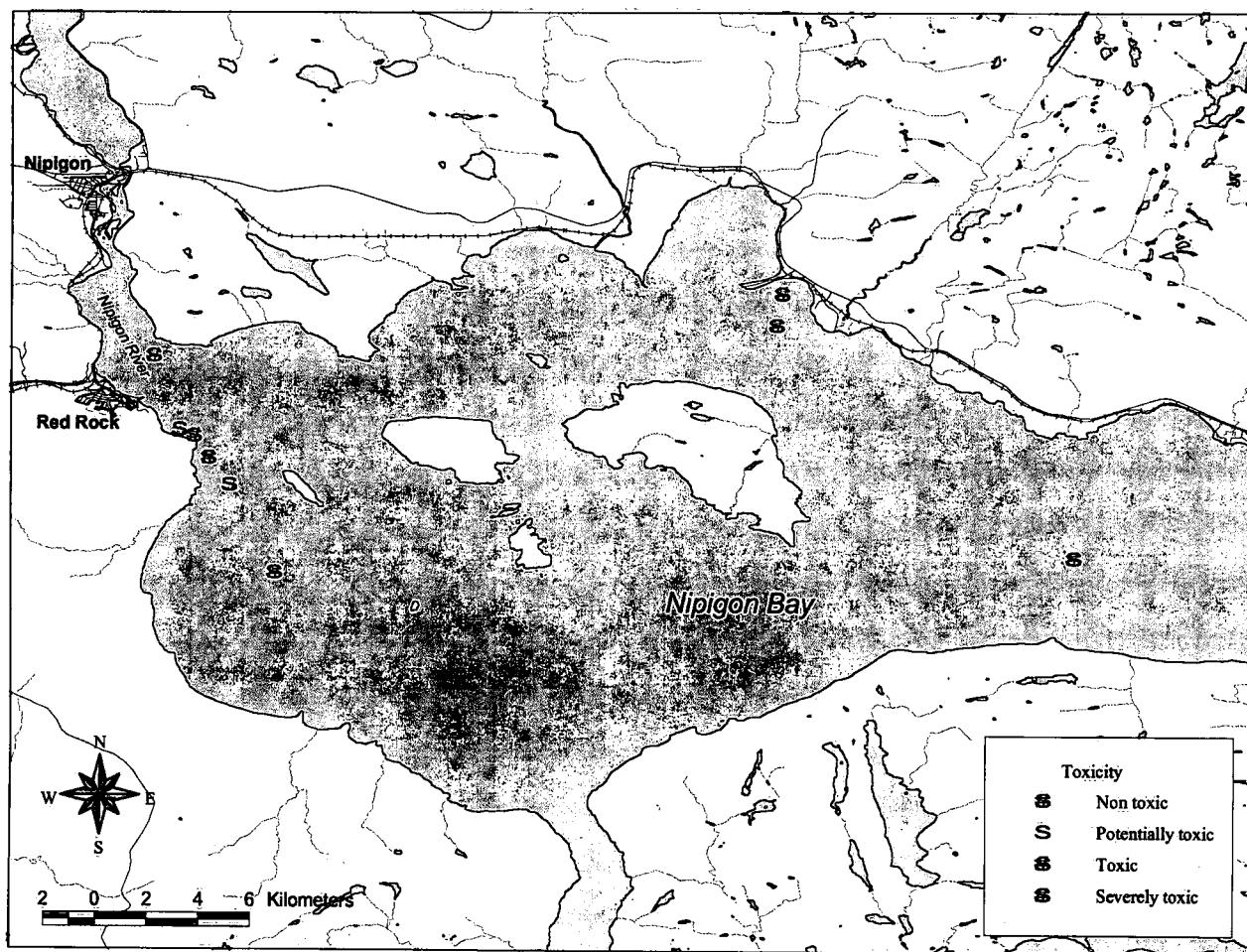


Figure 9a. Spatial distribution of 2009 sites indicating the level of toxicity compared to Great Lakes reference sites.

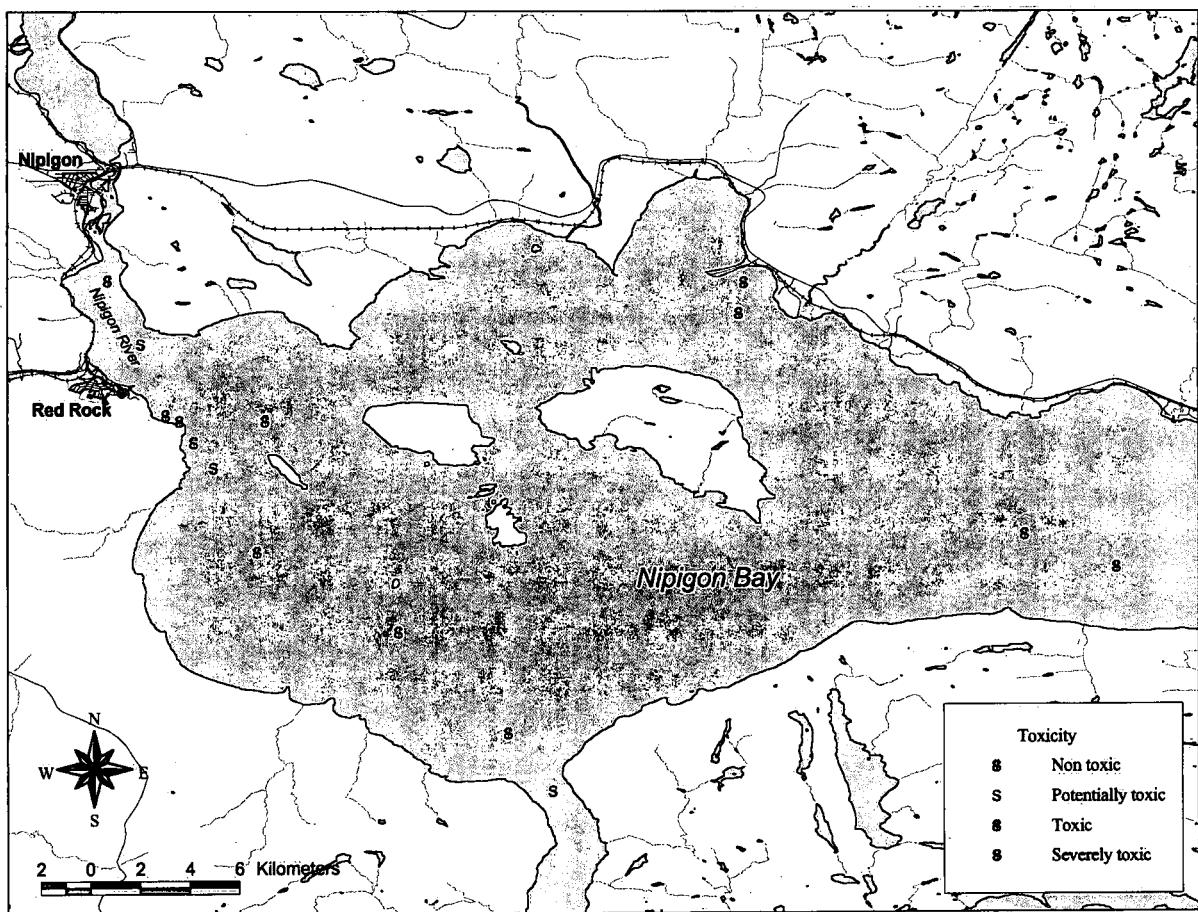


Figure 9b. Spatial distribution of 2003 sites indicating the level of toxicity compared to Great Lakes reference sites.

Tables

Table 1. Nipigon Bay sampling positions (UTM Zone 16) and depth for 2009 and 2003 studies. Sites in the same row are in the same or similar locations.

2003				2009					
Site	Sampling Device	Site Depth (m)	Northing	Easting	Site	Sampling Device	Site Depth (m)	Northing	Easting
6974	Ponar	8.7	5425917	408211	6974	Ponar	11.5	5425917	408213
R1	Mini-box core	15.9	5423366	409045	R1	Mini-box core	14.2	5423382	409042
R4	Mini-box core	14.6	5420241	412301	R4	Mini-box core	15.2	5420241	412308
E4	Mini-box core	3.9	5420504	409663	E4	Mini-box core	7.7	5420503	409666
E5	Mini-box core	17.0	5420275	410027	E5	Mini-box core	19.2	5420270	410028
E6	Mini-box core	0.9	5419419	410382	E6	Ponar	0.9	5419413	410384
E8	Mini-box core	4.7	5418389	410902	E8	Mini-box core	5.3	5418386	410906
E12	Mini-box core	32.9	5414993	412007	E12	Mini-box core	33.0	5414965	412001
E14	Mini-box core	49.0	5411739	415713	E14	Mini-box core	49.4	5411695	415720
E15	Mini-box core	49.3	5407651	418569	E15	Mini-box core	49.0	5407638	418576
E16	Mini-box core	60.8	5405334	419721	E16	Mini-box core	60.0	5405305	419725
R7	Mini-box core	10.1	5425544	425109	R7	Mini-box core	9.8	5425552	425119
R8	Mini-box core	20.6	5424324	424958	R8	Mini-box core	20.4	5424349	424981
R9	Mini-box core	36.4	5415343	432422	R9	Mini-box core	38.7	5415360	432415
R10	Mini-box core	39.5	5413982	434842	R10	Mini-box core	39.4	5413972	434823

Table 2. Environmental variables measured/analyzed at each site (2009).

Field	Overlying Water	Sediment
Northing	Alkalinity	Trace Metals + Major Oxides
Easting	Conductivity	Total Kjeldahl Nitrogen
Site Depth	Dissolved Oxygen	Total Phosphorus
	pH	Total Organic Carbon
	Temperature	Loss on Ignition
	Total Kjeldahl Nitrogen	Sand, Silt, Clay, Gravel
	Total Phosphorus	PCBs, PAHs
	Ammonia-N	Dioxins/Furans
	Nitrates + Nitrites-N	Petroleum Hydrocarbons
		Oil and Grease

Table 3. Characteristics of sampling site overlying water (2009). 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
6974	69.8	134	11.2	0.039	0.042	0.686	8.1	12.6	0.009
R1	68.1	131	10.6	0.015	0.074	0.221	8.1	12.7	0.011
R4	60.5	118	10.4	0.009	0.188	0.184	8.1	12.7	0.032
E4	69.9	130	11.1	0.012	0.084	0.225	8.1	12.7	0.008
E5	68.8	132	11.2	0.019	0.079	0.234	8.1	12.6	0.008
E6	67.7	133	11.4	0.019	0.060	0.205	8.2	12.7	0.009
E8	59.1	118	11.1	0.009	0.188	0.418	8.1	12.7	0.012
E12	54.1	115	10.4	0.025	0.254	0.174	8.2	12.6	0.013
E14	62.4	124	9.6	0.010	0.179	0.292	8.2	12.0	0.031
E15	60.2	144	9.2	0.006	0.216	0.176	8.3	12.4	0.013
E16	61.1	124	9.0	0.007	0.216	0.183	8.4	12.8	0.014
R7	54.1	119	10.1	0.006	0.246	0.156	8.1	13.2	0.009
R8	54.4	113	10.0	0.009	0.261	0.260	8.0	13.4	0.011
R9	56.3	121	9.9	0.007	0.237	0.162	8.0	13.1	0.015
R10	47.9	103	10.0	0.005	0.324	0.131	8.0	11.6	0.008

Table 4. Physical characteristics of Nipigon Bay surficial (0-10 cm) sediment (2009).

Site	% Sand	% Silt	% Clay	% Gravel	Particle size mean
6974	98.1	0.0	1.9	0	346.4
R1	1.3	53.7	45.0	0	9.8
R4	1.2	40.7	58.1	0	7.4
E4	1.1	56.0	42.9	0	9.8
E5	3.6	57.4	39.0	0	11.7
E6	79.4	7.7	12.9	0	130.6
E8	3.0	57.5	39.5	0	12.1
E12	2.3	37.4	60.3	0	6.9
E14	0.9	34.1	65.0	0	6.0
E15	0.3	32.3	67.5	0	5.8
E16	1.2	39.7	59.1	0	8.1
R7	6.8	42.3	50.9	0	10.9
R8	2.0	42.0	56.0	0	7.9
R9	1.1	36.4	62.6	0	7.3
R10	0.6	40.0	59.4	0	6.7

Table 5. Trace metal and nutrient concentrations in Nipigon Bay sediment (2009). Values exceeding the Sediment Quality Guideline Severe Effect Level (SEL) and Lowest Effect Level (LEL) are highlighted red and blue, respectively.

Parameter	Units	M.D.L. ^a	Reference Method ^b	LEL	SEL	8674	R1	R4	E4	E5	E6	E8	E12 ^{ab}	E14	E15	E16	R7 ^a	R8	R9	R10 ^b	
Aluminum	µg/g	10	EPA 6010			6000	12000	16000	12000	10000	5000	9000	14667	17000	15000	12000	15333	21000	22000	21000	
Antimony	µg/g	0.5	EPA 6020			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Arsenic	µg/g	0.5	EPA 6020	6	33	1.2	2.4	3.4	2.0	1.7	1.2	1.1	2.5	2.3	2.1	1.6	8.4	13.1	9.1	8.4	
Barium	µg/g	1	EPA 6010			18	63	81	59	47	21	40	72	79	75	58	93	150	164	153	
Beryllium	µg/g	0.2	EPA 6010			<0.2	0.4	0.5	0.4	0.3	<0.2	0.2	0.4	0.5	0.5	0.3	0.6	0.8	0.9	0.8	
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	0.9	1.5	1.8	1.6	1.2	1.4	1.2	1.8	1.8	1.8	1.4	2.4	3.2	3.5	3.3	
Calcium	µg/g	10	EPA 6010			7000	27000	0	22000	19000	23000	6850	36000	24667	28000	33000	36000	5733	7510	8330	9910
Chromium	µg/g	1	EPA 6010	26	110	19	34	40	35	27	17	22	38	42	39	30	49	59	62	60	
Cobalt	µg/g	1	EPA 6010			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Copper	µg/g	1	EPA 6010	16	110	16	26	31	33	27	6	22	29	31	31	30	32	48	51	50	
Iron	%	10	EPA 6010	20000	40000	11000	22000	28000	21000	16000	20000	17000	26000	29000	26000	21000	28867	38000	38000	38500	
Lead	µg/g	5	EPA 6010	31	250	<5	8	11	8	6	<5	<5	.9	10	9	7	18	24	25	24	
Magnesium	µg/g	10	EPA 6010			7200	24000	24000	20000	19000	4440	21000	24333	26000	25000	23000	9980	13000	13000	14500	
Manganese	µg/g	1	EPA 6010	460	1100	150	674	832	335	326	160	360	600	627	557	450	936	2600	2500	2350	
Mercury	µg/g	0.005	EPA 7471A	0.2	2	0.008	0.054	0.057	0.063	0.052	0.009	0.036	0.043	0.039	0.033	0.026	0.073	0.092	0.077	0.073	
Molybdenum	µg/g	1	EPA 6010			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Nickel	µg/g	1	EPA 6010	16	75	16	23	29	24	20	16	18	27	30	28	23	33	43	45	43	
Phosphorus	µg/g	5	EPA 6010			315	616	640	666	601	477	523	594	599	585	554	702	824	817	819	
Potassium	µg/g	30	EPA 6010			550	2050	2580	1840	1410	430	1190	2457	2830	2630	1830	2603	3760	4130	4020	
Silicon	µg/g	1	EPA 6010			147	1340	409	334	232	159	219	300	422	521	265	207	377	448	404	
Silver	µg/g	0.2	EPA 6010			<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	0.3	
Sodium	µg/g	20	EPA 6010			830	700	1070	1000	880	900	1160	1022	1100	1100	1110	783	950	800	840	
Strontium	µg/g	1	EPA 6010			13	25	25	22	22	10	27	26	27	30	30	17	23	25	25	
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			538	940	1140	883	818	1550	820	1097	1210	1160	1010	1067	1370	1450	1445	
Vanadium	µg/g	1	EPA 6010			33	42	50	43	48	164	47	49	50	49	49	49	61	64	63	
Yttrium	µg/g	0.5	EPA 6010			3.0	8.2	9.4	8.1	7.0	4.4	6.5	8.6	9.0	8.7	7.5	10.6	12.5	13.0	12.6	
Zinc	µg/g	1	EPA 6010	120	820	21	47	60	64	40	31	30	55	59	55	41	87	111	118	112	
Zirconium	µg/g	0.1	EPA 6010			2.4	5.1	6.0	5.7	4.4	3.4	6.4	7.7	8.9	8.3	8.4	4.7	5.5	6.1	6.5	
Aluminum (Al2O3)	%	0.01	IN-HOUSE			13.2	13.1	16.1	11.0	11.5	14.1	10.0	14.7	16.8	13.8	10.1	15.6	17.8	20.6	15.3	
Barium (BaO)	%	0.001	IN-HOUSE			0.040	0.070	0.080	0.060	0.040	0.030	0.040	0.072	0.08	0.07	0.04	0.08	0.09	0.10	0.08	
Calcium (CaO)	%	0.01	IN-HOUSE			7.18	8.69	8.70	6.83	8.51	8.65	10.1	8.87	9.97	9.47	8.30	2.98	3.09	3.79	3.38	
Chromium (Cr2O3)	%	0.01	IN-HOUSE			<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	0.03	<0.01	<0.01	<0.01	0.03	0.03	0.03	0.03	
Iron (Fe2O3)	%	0.05	IN-HOUSE			5.70	5.89	7.76	5.00	5.30	10.4	4.70	6.91	7.93	6.45	4.73	7.10	8.98	10.9	8.13	
Magnesium (MgO)	%	0.01	IN-HOUSE			3.76	6.90	7.69	5.54	5.79	5.27	5.84	7.30	8.42	6.60	5.39	3.28	4.29	5.19	4.17	
Manganese (MnO)	%	0.01	IN-HOUSE			0.09	0.14	0.19	0.08	0.09	0.15	0.09	0.14	0.17	0.13	0.09	0.20	0.48	0.53	0.38	
Phosphorus (P2O5)	%	0.03	IN-HOUSE			0.23	0.44	0.30	0.44	0.37	0.18	0.37	0.42	0.39	0.25	0.21	0.47	0.32	0.5	0.45	
Potassium (K2O)	%	0.01	IN-HOUSE			1.48	2.46	3.04	1.89	1.81	1.01	1.49	2.64	3.13	2.52	1.67	3.36	3.59	4.13	3.08	
Silica (SiO2)	%	0.01	IN-HOUSE			74.0	67.0	75.5	49.2	56.7	68.2	52.0	65.8	76.2	62.9	48.6	73.9	79.2	88.8	66.2	
Sodium (Na2O)	%	0.01	IN-HOUSE			3.87	2.97	3.40	2.37	2.75	3.50	2.62	3.09	3.45	2.88	2.37	3.46	3.13	3.32	2.70	
Titanium (TiO2)	%	0.01	IN-HOUSE			0.57	0.63	0.82	0.53	0.62	1.82	0.55	0.71	0.80	0.65	0.50	0.72	0.83	1.03	0.78	
Loss on Ignition	%	0.05	IN-HOUSE			3.10	10.9	9.6	13.8	11.2	1.68	9.91	10.2	10.5	10.9	10.6	5.77	7.39	7.42	7.48	
Whole Rock Total	%		IN-HOUSE			113	119	133	96.7	105	115	97.7	121	138	117	92.5	117	129	146	112	
Total Organic Carbon	% by wt	0.1	LECO	1	10	0.2	1.4	1.4	3.8	1.7	0.4	0.5	0.8	1.9	1.5	1.1	1.2	1.4	1.4	1.3	
Total Kjeldahl Nitrogen	µg/g	0.05	EPA 351.2	550	4800	306	1060	971	2110	1410	427	620	1048	1080	1010	777	1603	1810	1890	1695	
Phosphorus-Total	µg/g	0.01	EPA 365.4	600	2000	344	610	645	621	432	569	638	647	643	611	777	899	965	888		

^a mean of three field replicates

^b mean of sample duplicate

MDL = method detection limit

LEL, SEL = Lowest Effect Level, Severe Effect Level (Fletcher et al. 2008)

Table 6. Concentrations of oil and grease, petroleum hydrocarbons, PAHs and PCBs (mg/kg dw) in Nipigon Bay sediment (2009).

Values below detection limits are indicated by " $<$ ". [detection limits are provided in Appendix A, Table A8].

Table 7. Dioxin and furan concentrations (pg/g dw) in Nipigon Bay sediment (2009). Values below detection limits are indicated by “<”.

Area	Upstream				Midwestern Bay				South of Mill					
	Site	6974	6974 rerun	R1	R1 rerun	R4	R4 rerun	E4	E4 rerun	E5	E5 rerun	E6	E6 rerun	E8
Target Analytes	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	<0.26	<0.064	<0.50	0.121	<0.050	<0.11	<0.15	<0.17	<0.31	<0.11	<0.18	<0.028	<0.20	<0.24
1,2,3,7,8-PeCDD	<0.087	<0.065	<0.23	<0.24	<0.41	0.562	0.653	<0.55	0.301	<0.26	<0.079	0.0969	0.206	<0.16
1,2,3,4,7,8-HxCDD	<0.072	<0.050	<0.15	<0.25	<0.33	0.236	<0.56	<0.65	<0.28	<0.26	<0.093	<0.037	<0.14	<0.18
1,2,3,6,7,8-HxCDD	<0.078	0.106	<0.76	0.867	<0.97	1.10	6.53	7.74	2.45	1.51	<0.099	0.228	<0.18	<0.29
1,2,3,7,8,9-HxCDD	<0.075	<0.085	0.371	0.590	0.828	0.787	1.59	2.41	<0.52	<0.49	<0.097	<0.098	<0.20	<0.19
1,2,3,4,6,7,8-HpCDD	<0.97	0.869	<6.6	8.69	15.0	13.3	94.2	110	36.3	24.5	<1.4	1.38	5.75	12.0
OCDD	5.87	4.93	38.7	47.2	96.7	76.4	757	746	282	152	9.93	8.13	31.5	105
2,3,7,8-TCDF	<0.21	<0.15	<0.24	<0.39	0.497	0.537	1.01	0.998	<0.47	<0.43	<0.13	<0.068	<0.23	<0.21
1,2,3,7,8-PeCDF	<0.035	<0.046	0.299	<0.39	<0.21	0.362	<0.31	0.507	<0.25	0.199	<0.038	0.0669	0.108	<0.13
2,3,4,7,8-PeCDF	<0.032	<0.063	<0.22	<0.34	<0.37	0.426	<0.32	<0.66	<0.25	0.251	<0.058	0.0923	<0.14	<0.12
1,2,3,4,7,8-HxCDF	0.222	<0.23	0.394	0.500	0.432	0.439	<1.1	<0.95	<0.38	0.410	<0.049	<0.074	0.334	<0.13
1,2,3,6,7,8-HxCDF	<0.060	<0.086	0.358	0.342	0.432	0.426	<0.42	<0.54	<0.32	<0.20	<0.049	<0.053	0.189	<0.12
2,3,4,6,7,8-HxCDF	<0.060	<0.062	0.225	<0.27	0.324	<0.27	<0.56	<0.67	0.377	<0.28	<0.056	0.0513	<0.15	<0.13
1,2,3,7,8,9-HxCDF	<0.079	<0.025	<0.087	<0.089	<0.10	<0.15	<0.61	<0.38	<0.31	<0.27	<0.063	<0.041	<0.20	<0.18
1,2,3,4,6,7,8-HpCDF	1.12	1.05	2.61	2.89	3.66	3.11	11.0	11.2	5.39	3.55	<0.31	0.313	1.55	<1.3
1,2,3,4,7,8,9-HpCDF	<0.12	0.0924	<0.11	0.156	<0.18	<0.11	1.33	0.716	<0.49	<0.23	<0.087	0.0615	<0.13	<0.32
OCDF	1.90	2.07	2.42	2.55	3.43	3.11	30.2	24.4	13.4	8.27	<0.42	0.411	1.80	1.83
Homologue Group Totals	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
Total-TCDD	<0.26	<0.064	2.55	1.79	3.31	2.44	2.63	1.71	1.13	0.780	<0.18	<0.028	1.02	<0.24
Total-PeCDD	<0.087	0.146	1.95	3.28	4.34	3.26	4.51	4.11	3.18	1.26	0.193	0.324	1.34	1.50
Total-HxCDD	0.357	0.292	0.371	6.72	11.1	9.51	31.1	45.5	13.0	2.90	0.985	0.228	1.95	2.68
Total-HpCDD	1.28	2.03	9.05	19.0	29.8	26.3	164	254	65.8	47.4	<0.11	2.85	11.3	12.0
Total-TCDF	<0.21	0.0731	2.08	4.67	4.13	6.07	6.95	6.97	1.16	0.787	<0.13	0.228	1.06	0.958
Total-PeCDF	<0.035	<0.046	3.40	1.16	4.10	5.26	7.79	6.68	3.69	2.78	0.247	0.227	0.935	0.798
Total-HxCDF	0.366	<0.025	3.09	1.17	4.32	2.66	24.1	16.4	8.65	4.08	0.0771	0.352	1.64	1.32
Total-HpCDF	1.12	1.67	2.61	5.02	6.45	5.46	45.5	40.1	18.6	11.7	<0.087	0.375	2.88	<0.32
Toxic Equivalency WHO														
Lower Bound PCDD/F TEQ	0.034	0.014	0.147	0.264	0.214	1.096	1.081	0.483	0.483	0.268	0.001	0.160	0.288	0.023
Upper Bound PCDD/F TEQ	0.469	0.251	1.098	0.874	1.056	1.249	1.955	2.112	1.205	0.871	0.373	0.227	0.680	0.667

Table 7. Continued.

Area	Southwestern Bay						Kama Pt				East Bay		
	Site	E1200	E1201	E1202	E14	E15	E16	R700	R701	R702	R8	R9	R10
Target Analytes		pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	<0.082	<0.15	<0.14	<0.14	<0.35	<0.12	<0.27	<0.17	<0.23	0.330	<0.19	<0.20	
1,2,3,7,8-PeCDD	<0.23	<0.27	0.250	<0.32	<0.23	<0.28	0.687	0.727	0.637	1.15	1.17	<0.76	
1,2,3,4,7,8-HxCDD	<0.22	<0.24	0.356	0.318	<0.32	<0.10	<0.60	0.823	0.731	<1.3	<0.94	<0.78	
1,2,3,6,7,8-HxCDD	1.20	1.18	<0.77	<0.79	<0.55	0.335	1.89	<1.6	<1.7	<2.6	2.65	2.48	
1,2,3,7,8,9-HxCDD	0.877	0.674	0.369	0.562	<0.33	<0.16	1.68	<1.2	<1.2	2.42	2.58	1.94	
1,2,3,4,6,7,8-HpCDD	11.6	12.8	10.6	9.93	7.22	3.98	19.1	20.4	20.5	31.3	31.2	27.7	
OCDD	84.0	91.8	66.1	69.6	39.0	25.2	103	111	107	172	154	144	
2,3,7,8-TCDF	<0.48	<0.37	<0.22	0.587	<0.27	<0.26	1.39	1.12	1.38	2.24	<1.7	2.10	
1,2,3,7,8-PeCDF	0.349	0.310	0.256	<0.24	0.309	<0.16	<0.48	0.478	0.613	<0.80	0.824	0.808	
2,3,4,7,8-PeCDF	0.375	0.246	<0.22	<0.30	0.265	0.159	0.638	<0.62	0.712	<0.90	1.05	1.05	
1,2,3,4,7,8-HxCDF	<0.40	0.421	<0.44	0.389	<0.29	<0.18	0.906	0.888	0.848	<1.1	1.25	1.15	
1,2,3,6,7,8-HxCDF	<0.37	0.416	<0.31	<0.40	0.354	<0.20	<0.57	0.730	0.790	1.06	1.17	0.868	
2,3,4,6,7,8-HxCDF	0.307	<0.27	<0.28	<0.15	0.283	<0.079	0.729	<0.55	<0.64	1.04	1.13	0.891	
1,2,3,7,8,9-HxCDF	<0.081	<0.064	<0.23	<0.14	<0.16	<0.10	<0.091	<0.064	0.226	<0.29	<0.30	0.204	
1,2,3,4,6,7,8-HpCDF	3.18	3.37	3.19	3.37	2.75	1.71	5.57	4.83	5.41	8.41	<7.1	7.75	
1,2,3,4,7,8,9-HpCDF	0.169	<0.22	<0.20	<0.095	<0.40	<0.11	<0.13	0.476	<0.23	<0.59	<0.63	<0.098	
OCDF	<3.2	3.28	3.29	2.70	1.65	1.16	4.27	4.45	4.64	7.79	6.08	5.46	
Homologue Group Totals	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	
Total-TCDD	3.36	0.872	1.90	3.99	3.52	1.55	5.25	3.91	3.75	6.54	5.89	9.16	
Total-PeCDD	2.46	5.61	4.87	5.51	1.37	2.08	7.78	9.00	6.38	16.1	12.3	11.5	
Total-HxCDD	11.3	5.65	7.35	8.09	5.18	5.13	20.3	17.5	18.9	30.3	27.1	31.4	
Total-HpCDD	23.9	26.6	21.2	21.9	14.7	9.13	40.9	43.0	43.2	68.2	67.8	61.3	
Total-TCDF	4.11	1.75	2.72	4.80	2.46	1.66	12.3	8.50	13.6	16.0	12.7	19.3	
Total-PeCDF	2.95	2.98	4.12	4.61	1.75	1.65	5.59	5.64	10.5	12.6	10.6	13.2	
Total-HxCDF	4.30	3.18	1.45	4.24	3.54	1.23	3.96	7.10	6.57	10.3	6.06	11.2	
Total-HpCDF	5.92	5.71	3.19	5.05	2.75	1.71	5.57	7.45	8.36	11.8	3.88	10.4	
Toxic Equivalency WHO													
Lower Bound PCDD/F TEQ	0.310	0.297	0.494	0.284	0.250	0.107	1.360	1.465	1.730	1.960	2.191	1.146	
Upper Bound PCDD/F TEQ	0.841	0.891	0.891	0.984	1.062	0.636	2.022	2.035	2.056	3.270	3.043	2.497	

Table 8. Mean abundance of dominant macroinvertebrate families (per 33 cm²) and taxon diversity for 2009 and 2003 Nipigon Bay sites (based on 38-family bioassessment model) and overall BEAST results. Families expected to be at test sites that are absent are highlighted yellow. The Reference Group 5 taxa means and percent taxa occurrences are provided.

Family	Gp. 5 Mean	Gp 5 Occur. (%)	Upstream				Midwest Bay		South of the Mill							
Site	-	-	6974				R1		R4		E4		E5		E6	
Year(s)	1991-93	-	2009	2003	2009	2003	2009	2003	2009	2003	2009	2003	2009	2003	2009	2003
No. Taxa (\pm SD)	6 \pm 2	-	13	19	8	9	5	11	9	11	7	4	21	19	10	11
Pontoporeiidae	12.1	44.3	0	0	0.6	0	7.0	1.4	0	0	0	0	0.7	0.4	0	0.1
Tubificidae ^b	4.5	16.6	22.0	54.4	9.8	20.0	3.2	7.7	1.0	33.4	41.4	225.8	21.8	62.4	3.0	8.4
Sphaeridae	3.1	11.5	7.8	10.6	2.0	4.4	1.4	2.1	1.2	0.6	1.8	0	14.2	18.2	2.0	2.1
Chironomidae	2.7	9.9	33.3	72.2	12.0	16.4	4.2	6.1	7.0	9.2	18.2	6.4	14.0	17.6	13.8	14.1
Lumbriculidae	1.8	6.8	1.3	4.0	0	0	0	0	0	0	0	0	0.7	0.2	0	0
Enchytraeidae	1.4	5.3	0.6	2.3	0	0	0	0	0	0	0	0	0	0	0	0
Naididae	0.5	1.9	2.1	2.2	2.6	0.4	1.4	0.7	0.2	0.2	2.4	25.8	5.1	0.2	1.4	1.3
BEAST BAND^b	-	-	3	4	3	2	1	2	4	3	3	4	3	3	4	3

^aQA/QC site; value represent the mean of three field replicates; ^b includes immatures with and without chaetal hairs

^bHMDS of a subset of 4-6 sites with Great Lakes reference group 5 sites (n=75).

Table 8. Continued.

Family	Gp. 5 Mean	Gp 5 Occur. (%)	Southwest Bay								Kama Point				East Bay			
Site	-	-	E12		E14		E15		E16		R7		R8		R9		R10	
Year(s)	1991-93	-	2009	2003	2009	2003	2009	2003	2009	2003	2009	2003	2009	2003	2009	2003	2009	2003
No. taxa (\pm SD)	6 \pm 2	-	10	6	6	6	5	6	8	5	10	10	6	8	7	7	4	5
Pontoporeiidae	12.1	44.3	2.2	0.6	0.2	0.4	0	0.6	0	0.2	2.7	0.6	4.2	2.8	11.6	9.2	12.2	7.6
Tubificidae ^b	4.5	16.6	22.2	66.8	119.0	120.4	146.2	214.2	183.2	138.8	13.7	15.0	1.4	2.4	3.6	3.8	4.2	1.2
Sphaeriidae	3.1	11.5	4.9	3.0	8.2	6.2	3.2	3.3	5.8	2.4	1.5	2.6	1.6	2.0	0.6	0.2	0	0.4
Chironomidae	2.7	9.9	9.7	4.0	5.2	4.4	48.4	33.3	4.8	2.0	9.6	18.4	4.4	2.8	1.4	1.0	1.6	0.8
Lumbriculidae	1.8	6.8	0.1	0	0	0	0	0	0	0	0	0	0	1.2	3.8	3.2	0	0
Enchytraeidae	1.4	5.3	0.1	0	0	0	0	0	0.2	0	0	0	0	0.2	5.4	9.8	5.0	2.2
Naididae	0.5	1.9	1.5	1.6	9.4	0.2	31.4	8.8	11.6	20.4	11.1	3.2	4.6	7.4	1.0	0	0	0
BEAST BAND^b	-	-	2	3	3	4	4	4	4	4	2	2	2	2	1	1	1	1

^a QA/QC site; value represent the mean of three field replicates; ^b includes immatures with and without chaetal hairs

^b HMDS of a subset of 4-6 sites with Great Lakes Reference Group 5 sites (n=75).

Table 9. Comparison of 2009 and 2003 benthic community composition for Nipigon Bay.
Abundances are per 33.14 cm² (area of core tube).

	2009	2003
No. families (macroinvertebrates)	5 – 25	5 – 29
No. families (38-family model)	5 – 21	4 – 19
No. families (total)	41	42
No. tubificid species	9	13
No. chironomid genera	43	36
No. sphaeriid species	11	8
Total abundance (macroinvertebrates)	13.6 – 231.4	12.2 – 325.1
Tubificid abundance	1.0 – 183.2	1.2 – 225.8
Chironomid abundance	1.4 – 48.4	0.8 – 72.2
Pontoporeiid abundance	0 – 12.2	0 – 9.2

Table 10. Probabilities of Great Lakes faunal group membership for Nipigon Bay sites (2009).

Site	Probability of Group Membership				
	Group 1	Group 2	Group 3	Group 4	Group 5
6974	0.047	0.005	0.000	0.001	0.948
R1	0.045	0.003	0.000	0.001	0.951
R4	0.047	0.003	0.000	0.000	0.950
E4	0.144	0.004	0.000	0.000	0.852
E5	0.026	0.002	0.000	0.001	0.970
E6	0.177	0.010	0.001	0.000	0.812
E8	0.131	0.007	0.001	0.000	0.862
E12	0.005	0.001	0.000	0.001	0.993
E14	0.001	0.000	0.000	0.020	0.979
E15	0.001	0.000	0.000	0.014	0.985
E16	0.000	0.000	0.000	0.051	0.949
R7	0.094	0.003	0.000	0.000	0.902
R8	0.028	0.001	0.000	0.000	0.970
R9	0.003	0.000	0.000	0.002	0.995
R10	0.003	0.000	0.000	0.001	0.996

Table 11. Mean percent survival, growth (mg dry weight) and reproduction per individual in sediment toxicity tests for 2009 and 2003 (9 co-located sites) and overall BEAST results. Based on the numerical guidelines (Reynoldson and Day 1998), toxicity is indicated in red; potential toxicity in blue. (Grey shading is for ease of comparison.)

Site	Year	<i>C. riparius</i>		<i>H. azteca</i>		<i>Hexagenia</i> spp.		<i>T. tubifex</i>			BEAST Band ^b	
		% survival	growth	% survival	growth	% survival	growth	% survival	No. cocoons/adult	% hatch	No. young/adult	
GL reference		87.1	0.35	85.6	0.50	96.2	3.03	97.9	9.9	57.0	29.0	
Mean ^a												
R1	2009	92.0	0.34	93.3	0.25	100	3.52	100	10.6	58.8	22.0	1
	2003	94.7	0.38	98.7	0.64	100	3.32	100	6.5	80.1	24.4	2
E4	2009	88.0	0.40	61.7	0.22	100	2.76	100	10.3	55.8	23.6	2
	2003	97.3	0.35	81.3	0.32	100	2.99	100	7.1	39.9	31.6	1
E5	2009	80.0	0.42	82.7	0.35	100	4.12	100	9.9	49.3	16.6	1
	2003	85.3	0.39	85.3	0.42	100	3.86	100	11.0	55.0	30.6	1
E6	2009	94.7	0.43	68.0	0.24	100	4.77	100	10.6	56.5	23.5	1
	2003	90.7	0.54	93.3	0.27	100	3.84	100	11.1	53.2	25.9	1
E8	2009	89.3	0.43	57.3	0.33	100	2.78	100	9.9	58.7	20.9	2
	2003	89.3	0.49	60.0	0.33	100	2.37	100	10.4	73.8	28.3	2
E12	2009	90.7	0.34	90.7	0.24	100	3.72	100	9.6	54.3	17.5	1
	2003	93.3	0.38	92.0	0.52	100	3.10	100	8.8	60.7	24.9	1
R7	2009	84.0	0.35	88.0	0.34	100	2.74	100	10.4	62.4	25.9	1
	2003	82.7	0.43	13.3	0.58	98	2.66	100	9.3	62.9	19.5	4
R8	2009	94.7	0.26	94.7	0.29	100	2.91	100	10.6	60.6	27.1	1
	2003	86.7	0.39	8.0	0.20	100	2.84	100	9.7	60.6	17.3	4
R9	2009	86.7	0.24	89.3	0.33	100	2.85	100	10.5	61.7	24.9	1
	2003	83.9	0.39	30.7	0.40	98	2.98	100	9.8	59.5	21.4	4
Non-toxic ^c	-	≥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 HMDS of a subset of 3-6 sites with Great Lakes reference sites (n=136).

^cThe upper limit for non-toxic category is set using 2 × standard deviation of the mean and indicates excessive growth or reproduction

Table 12. Decision matrix table for weight-of-evidence categorization of Nipigon Bay sites (2009 and 2003) based on three lines of evidence. For the sediment chemistry column, sites with metal exceedences of the Severe Effect Level (SEL) organic contaminant exceedences of the Probable Effect Level (PEL) are indicated by “■”; sites with exceedences of the Lowest Effect Level (LEL) “□”. 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 or toxic/severely toxic are indicated by “■”; sites determined as possibly different or potentially toxic by “□”. Sites with no SQG exceedences, benthic communities equivalent to reference conditions, or non-toxic sites are indicated by “□”. Some sites show benthos alteration but were not recommended for further action (see text for explanation for these sites).

Site	Year	Sediment Chemistry	Toxicity	Benthos Alteration	Metal(s) exceeding LEL	Assessment
Upstream						
6974	2009	□	- ^a	■ ^b	Cd	No further actions needed
	2003	□	□	■	Cr, Cu, Ni	Determine reason(s) for benthos alteration
R1	2009	□	□	■ ^b	Cd, Cr, Cu, Fe, Mn, Ni	No further actions needed
	2003	□	□	□ ^b	Cr, Cu, Fe, Mn, Ni	No further actions needed
Midwest Bay						
R4	2009	□	- ^a	□	Cd, Cr, Cu, Fe, Mn, Ni	No further actions needed
	2003	□	□	□ ^b	Cr, Cu, Fe, Mn, Ni	No further actions needed
South of the Mill						
E4	2009	□	□	■ ^b	Cd, Cr, Cu, Fe, Ni	Determine reason(s) for toxicity
	2003	□	□	■	Cr, Cu, Ni	Determine reason(s) for benthos alteration
E5	2009	□	□	■	Cd, Cr, Cu, Ni	Determine reason(s) for benthos alteration
	2003	□	□	■	Cd, Cr, Cu, Fe, Ni	Determine reason(s) for benthos alteration
E6	2009	□	□	■	Cd	Determine reason(s) for benthos alteration
	2003	□	□	■	Ni	Determine reason(s) for benthos alteration
E8	2009	□	□	■ ^b	Cd, Cu, Ni	No further actions needed
	2003	□	□	■ ^b	Cr, Cu, Ni	No further actions needed

Table 12. Continued.

Site	Year	Sediment Chemistry	Toxicity	Benthos Alteration	Metal(s) exceeding LEL	Assessment
Southwest Bay						
E12	2009	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> ^b	Cd, Cr, Cu, Fe, Mn, Ni	No further actions needed.
	2003	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Cr, Cu, Fe, Mn, Ni	Determine reason(s) for benthos alteration
E14	2009	<input type="checkbox"/>	- ^a	<input checked="" type="checkbox"/>	Cd, Cr, Cu, Fe, Mn, Ni	Determine reason(s) for benthos alteration
	2003	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Cr, Cu, Fe, Mn, Ni	Determine reason(s) for benthos alteration
E15	2009	<input type="checkbox"/>	- ^a	<input checked="" type="checkbox"/>	Cd, Cr, Cu, Fe, Mn, Ni	Determine reason(s) for benthos alteration
	2003	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Cr, Cu, Fe, Mn, Ni	Determine reason(s) for benthos alteration
E16	2009	<input type="checkbox"/>	- ^a	<input checked="" type="checkbox"/>	Cd, Cr, Cu, Fe, Ni	Determine reason(s) for benthos alteration
	2003	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Cr, Cu, Fe, Mn, Ni	Determine reason(s) for benthos alteration
Kama Pt						
R7	2009	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> ^b	As, Cd, Cr, Cu, Fe, Mn, Ni	No further actions needed
	2003	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> ^b	Cd, Cr, Cu, Fe, Mn, Ni	Determine reason(s) for sediment toxicity
R8	2009	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> ^b	As, Cd, Cr, Cu, Fe, Mn, Ni	No further actions needed
	2003	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> ^b	As, Cd, Cr, Cu, Fe, Mn, Ni, Zn	Determine reason(s) for sediment toxicity
East Bay						
R9	2009	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	As, Cd, Cr, Cu, Fe, Mn, Ni	No further actions needed
	2003	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	As, Cd, Cr, Cu, Fe, Mn, Ni, Zn	Determine reason(s) for sediment toxicity
R10	2009	<input type="checkbox"/>	- ^a	<input type="checkbox"/>	As, Cd, Cr, Cu, Fe, Mn, Ni	No further actions needed
	2003	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	As, Cd, Cr, Cu, Fe, Mn, Ni, Zn	Determine reason(s) for sediment toxicity

^a toxicity tests not performed; ^b benthic community not deemed impaired based on taxon diversity and abundance

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 (2009).

Parameter	Date Analyzed	E1200	E1201	E1202	E1202-Dup	R.P.D.	CV	R700	R701	R702	CV	R10	R10-Dup	R.P.D.
Aluminum	29-Jan-10	14000	15000	15000	15000	0.0	3.9	15000	16000	15000	3.8	21000	21000	0.0
Antimony	29-Jan-10	< 0.5	< 0.5	< 0.5	< 0.5	0.0	N/A	< 0.5	< 0.5	< 0.5	N/A	< 0.5	< 0.5	0.0
Arsenic	29-Jan-10	2.5	2.3	2.5	2.6	3.9	5.4	8.4	8.6	8.1	3.0	8.4	8.4	0.0
Barium	28-Jan-10	72	71	72	72	0.0	0.8	92	95	91	2.2	152	153	0.7
Beryllium	28-Jan-10	0.4	0.4	0.4	0.5	22.2	6.9	0.6	0.6	0.6	0.0	0.8	0.8	0.0
Bismuth	28-Jan-10	< 5	< 5	< 5	< 5	0.0	N/A	< 5	< 5	< 5	N/A	< 5	< 5	0.0
Cadmium	28-Jan-10	1.7	1.8	1.8	1.9	5.4	4.3	2.3	2.4	2.4	2.4	3.2	3.3	3.1
Calcium	28-Jan-10	24000	25000	25000	25000	0.0	2.3	5790	5860	5550	2.8	9840	9980	1.4
Chromium	28-Jan-10	38	38	38	39	2.6	0.8	49	50	49	1.2	59	61	3.3
Cobalt	28-Jan-10	< 1	< 1	< 1	< 1	0.0	N/A	< 1	< 1	< 1	N/A	< 1	< 1	0.0
Copper	28-Jan-10	29	29	29	29	0.0	0.0	32	33	32	1.8	49	50	2.0
Iron	29-Jan-10	26000	26000	26000	26000	0.0	0.0	28000	30000	28000	4.0	38000	39000	2.6
Lead	28-Jan-10	10	9	9	9	0.0	6.2	19	18	17	5.6	23	24	4.3
Magnesium	28-Jan-10	24000	24000	25000	25000	0.0	2.4	9960	10000	9980	0.2	14000	15000	6.9
Manganese	28-Jan-10	605	576	615	623	1.3	3.7	939	934	934	0.3	2300	2400	4.3
Mercury	29-Jan-10	0.055	0.037	0.038	0.037	2.7	23.7	0.061	0.075	0.082	14.7	0.073	0.073	0.0
Molybdenum	28-Jan-10	< 1	< 1	< 1	< 1	0.0	N/A	< 1	< 1	< 1	N/A	< 1	< 1	0.0
Nickel	28-Jan-10	27	27	28	28	0.0	2.1	33	34	32	3.0	42	44	4.7
Phosphorus	28-Jan-10	593	587	596	606	1.7	1.2	698	723	685	2.8	815	822	0.9
Potassium	28-Jan-10	2490	2430	2450	2450	0.0	1.2	2590	2660	2560	2.0	4000	4040	1.0
Silicon	28-Jan-10	272	340	312	265	16.3	11.8	210	207	205	1.2	404	403	0.2
Silver	28-Jan-10	< 0.2	< 0.2	< 0.2	< 0.2	0.0	N/A	< 0.2	< 0.2	< 0.2	N/A	< 0.2	0.3	0
Sodium	28-Jan-10	1030	1020	1060	970	8.8	0.7	790	870	690	11.5	770	910	16.7
Strontium	28-Jan-10	26	25	25	26	3.9	2.0	17	18	17	3.3	25	25	0
Tin	28-Jan-10	< 10	< 10	< 10	< 10	0.0	N/A	< 10	< 10	< 10	N/A	< 10	< 10	0
Titanium	28-Jan-10	1100	1080	1100	1120	1.8	1.4	1070	1090	1040	2.4	1430	1460	2.1
Vanadium	28-Jan-10	49	48	48	49	2.1	1.0	48	50	48	2.4	62	63	1.8
Yttrium	28-Jan-10	8.6	8.5	8.6	8.7	1.2	0.9	10.5	10.8	10.4	2.0	12.5	12.7	1.6
Zinc	28-Jan-10	55	54	55	55	0.0	1.1	85	91	86	3.7	111	112	0.9
Zirconium	28-Jan-10	8.2	6.7	7.5	9.1	19.3	11.6	5.5	4.6	3.9	17.2	6.3	6.6	4.7
Aluminum (Al2O3)	1-Feb-10	12.4	15.7	12.7	19.3	41.3	13.6	16.8	13.5	16.6	11.8	13.5	17.10	23.5
Barium (BaO)	1-Feb-10	0.060	0.080	0.060	0.090	40.0	14.5	0.09	0.07	0.08	12.5	0.07	0.09	25.0
Calcium (CaO)	1-Feb-10	7.64	9.56	7.44	11.40	42.0	12.1	3.19	2.48	3.27	14.6	3.22	3.53	9.2
Chromium (Cr2O3)	1-Feb-10	< 0.01	0.03	< 0.01	0.03	0.0	0.0	< 0.01	< 0.01	< 0.01	N/A	< 0.01	0.03	0.0
Iron (Fe2O3)	1-Feb-10	5.78	7.43	6.03	8.99	39.4	14.1	7.76	6.10	7.43	12.4	7.26	8.99	21.3
Magnesium (MgO)	1-Feb-10	6.22	7.88	6.10	9.52	43.8	12.9	3.68	2.79	3.37	13.8	3.66	4.68	24.5
Manganese (MnO)	1-Feb-10	0.12	0.14	0.13	0.19	37.5	14.3	0.21	0.20	0.19	5.0	0.34	0.41	18.7
Phosphorus (P2O5)	1-Feb-10	0.48	0.34	0.32	0.53	49.4	17.0	0.41	0.66	0.34	35.8	0.41	0.48	15.7
Potassium (K2O)	1-Feb-10	2.24	2.77	2.41	3.40	34.1	13.3	3.43	3.35	3.29	2.1	2.67	3.49	26.6
Silica (SiO2)	1-Feb-10	51.3	72.9	59.0	87.3	38.7	19.1	81.5	63.3	76.8	12.8	57.5	74.9	26.3
Sodium (Na2O)	1-Feb-10	2.56	3.37	2.74	3.94	35.9	14.9	3.72	2.93	3.73	13.3	2.40	2.99	21.9
Titanium (TiO2)	1-Feb-10	0.58	0.77	0.62	0.92	39.0	15.5	0.73	0.74	0.68	4.5	0.68	0.87	24.5
Loss on Ignition	1-Feb-10	10.1	10.2	10.2	10.1	1.0	0.5	5.79	5.83	5.69	1.2	7.47	7.49	0.3
Whole Rock Total	1-Feb-10	99.6	131	108	156	36.4	15.2	127	102	121	11.2	99.2	125	23.0
Total Organic Carbon	3-Feb-10	0.8	0.8	0.8	0.8	0.0	0.0	< 0.1	1.2	1.1	6.1	1.3	1.2	8.0
Total Kjeldahl Nitrogen	1-Feb-10	947	1060	1160	1100	5.3	8.8	1530	1810	1470	11.3	1810	1580	13.6
Phosphorus-Total	1-Feb-10	587	645	700	661	5.7	7.4	761	844	727	7.7	924	851	6.2

R.P.D. = Relative Percent Difference

min	0.0	0.0	0.0
max	49.4	23.7	35.8
median	2.1	4.3	3.7

Table A2. Coefficient of variation (CV) for organic contaminants in field-replicated sample (CS9) (ALS Laboratory Group data). “<” = below method detection limit (2009).

Sample ID	E1200	E1201	E1202	CV	R700	R701	R702	CV
Matrix	SEDIMENT	SEDIMENT	SEDIMENT		SEDIMENT	SEDIMENT	SEDIMENT	
Sampling Date	3-Oct-09	3-Oct-09	3-Oct-09		4-Oct-09	4-Oct-09	4-Oct-09	
Extraction Date	29-Dec-09	29-Dec-09	29-Dec-09		29-Dec-09	29-Dec-09	29-Dec-09	
Target Analytes	pg/g	pg/g	pg/g		pg/g	pg/g	pg/g	
2,3,7,8-TCDD	<0.082	<0.15	<0.14	N/A	<0.27	<0.17	<0.23	N/A
1,2,3,7,8-PeCDD	<0.23	<0.27	0.25	N/A	0.687	0.727	0.637	6.6
1,2,3,4,7,8-HxCDD	<0.22	<0.24	0.356	N/A	<0.60	0.823	0.731	8.4
1,2,3,6,7,8-HxCDD	1.2	1.18	<0.77	1.2	1.89	<1.6	<1.7	N/A
1,2,3,7,8,9-HxCDD	0.877	0.674	0.369	40.0	1.68	<1.2	<1.2	N/A
1,2,3,4,6,7,8-HpCDD	11.6	12.8	10.6	9.4	19.1	20.4	20.5	3.9
OCDD	84	91.8	66.1	16.3	103	111	107	3.7
2,3,7,8-TCDF	<0.48	<0.37	<0.22	N/A	1.39	1.12	1.38	11.8
1,2,3,7,8-PeCDF	0.349	0.31	0.256	15.3	<0.48	0.478	0.613	17.5
2,3,4,7,8-PeCDF	0.375	0.246	<0.22	29.4	0.638	<0.62	0.712	7.8
1,2,3,4,7,8-HxCDF	<0.40	0.421	<0.44	N/A	0.906	0.888	0.848	3.4
1,2,3,6,7,8-HxCDF	<0.37	0.416	<0.31	N/A	<0.57	0.73	0.79	5.6
2,3,4,6,7,8-HxCDF	0.307	<0.27	<0.28	N/A	0.729	<0.55	<0.64	N/A
1,2,3,7,8,9-HxCDF	<0.081	<0.064	<0.23	N/A	<0.091	<0.064	0.226	N/A
1,2,3,4,6,7,8-HpCDF	3.18	3.37	3.19	3.3	5.57	4.83	5.41	7.4
1,2,3,4,7,8,9-HpCDF	0.169	<0.22	<0.20	N/A	<0.13	0.476	<0.23	N/A
OCDF	<3.2	3.28	3.29	0.2	4.27	4.45	4.64	4.2
				Min	0.2			3.4
				Max	40.0			17.5
				Median	12.4			6.6

Table A3. Sample recoveries for laboratory standards and reference material (Caduceon Environmental Laboratory data) (2009).

CADUCEON ENVIRONMENTAL LABORATORIES, 2378 HOLLY LANE, OTTAWA, ONTARIO, K1V 7P1					
QC I.D.:	Various	CLIENT:	Environment Canada		
SAMPLE MATRIX:	Sediment	BATCH NUMBER:	B10-02364		
DATE SUBMITTED:	27-Jan-10	DATE ANALYZED:	Various		
DATE REPORTED:	24-Feb-10	REPORT TO:	Danielle Milani		
PARAMETERS	QC Sample Recovery Calculation				
	QC Result	Raw Data ($\mu\text{g/g}$)	Reference Value	Lab Mean	QC Sample Recovery
LKSD-3 (28-Jan-10)	QC Result	Reference Value	Lab Mean	% Recovery	Control Limits
Silver	2.1	2.4		86	50 - 117
Antimony	1.4	1.3		111	75 - 125
Arsenic	24.2	23		105	83 - 121
Barium	155	N/A	169	92	81 - 118
Beryllium	0.6	N/A	0.5	115	47 - 153
Cobalt	25.0	30		83	51 - 114
Chromium	41.9	51		82	54 - 125
Copper	32.0	34		94	79 - 116
Iron	32000	35000		91	74 - 102
Manganese	1210	1220		99	76 - 124
Molybdenum	0.4	2		20	0 - 260
Nickel	38.5	44.0		88	75 - 125
Lead	24.9	26		96	72 - 107
Strontium	22.3	N/A	25.4	88	76 - 124
Titanium	813	N/A	980	83	49 - 151
Vanadium	43.3	55		79	63 - 113
Zinc	125	139		90	76 - 124
SS-1 (28-Jan-10)	QC Result	Reference Value	Lab Mean	% Recovery	Control Limits
Silver	1.8	1.9		96	50 - 117
Aluminum	6015	9518		63	34 - 166
Arsenic	17.2	18		96	72 - 128
Barium	86.7	102		85	68 - 132
Cadmium	30.5	34		90	71 - 129
Cobalt	26.8	28		96	68 - 132
Chromium	40.6	64		63	20 - 180
Copper	740	690		107	73 - 127
Iron	18639	20406		91	62 - 138
Lithium	8.81	11		80	27 - 173
Magnesium	5791	6088		95	65 - 135
Manganese	378	425		89	76 - 124
Molybdenum	3.1	5		62	40 - 160
Nickel	211	231		91	68 - 132
Phosphorus	1073	1070		100	78 - 122
Lead	229	233		98	65 - 135
Strontium	172	202		85	84 - 116
Titanium	212	248		85	75 - 125
Vanadium	16.1	19		85	42 - 158
Yttrium	7.6	8		95	70 - 130
Zinc	6289	6775		93	75 - 125
LKSD-2 (29-Jan-10)	QC Result	Reference Value	Lab Mean	% Recovery	Control Limits
Mercury	0.141	0.160	0.144	88	77 - 122
WH89-1 (01-Feb-10)	QC Result	Reference Value	Lab Mean	% Recovery	Control Limits
Aluminum (Al_2O_3)	12.9	12.1	11.6	107	75 - 125
Barium (BaO)	0.35	0.29	0.28	121	75 - 125
Calcium (CaO)	6.81	5.9	5.7	115	75 - 125
Chromium (Cr_2O_3)	0.04	0.03	0.03	133	50 - 150
Iron (Fe_2O_3)	7.75	6.9	6.62	112	75 - 125
Magnesium (MgO)	3.98	3.5	3.4	114	75 - 125
Manganese (MnO)	0.10	0.14	0.13	71	60 - 140
Phosphorus (P_2O_5)	0.39	0.4	0.4	98	75 - 125
Potassium (K_2O)	2.23	2.5	2.2	89	75 - 125
Silica (SiO_2)	67.4	60.5	59	111	75 - 125
Sodium (Na_2O)	1.98	2.0		99	75 - 125
Titanium (TiO_2)	0.97	1.0		97	75 - 125
D053-542 (01-Feb-10)	QC Result	Reference Value	Lab Mean	% Recovery	Control Limits
Total Kjeldahl Nitrogen	1540	1300	1372	112	57 - 143
Phosphorus-Total	1048	811	939	112	53 - 147
TOC QC (03-Feb-10)	QC Result	Reference Value	Lab Mean	% Recovery	Control Limits
TOC	4.66	4.84		96	91 - 109
			min	20	
			max	133	
			median	93	

Table A4. Relative percent difference (RPD) for sample replicates for organic contaminants (ALS Laboratory Group data) (2009).

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD
Aggregate Organics							
L831113-1	Soil	WG1029191-4	Oil and Grease, Total	4500	4760	mg/kg	-
Polycyclic Aromatic Hydrocarbons							
L831113-1	Soil	WG1025657-4	Acenaphthene	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1025657-4	Acenaphthylene	0.20	0.18	mg/kg	-
L831113-1	Soil	WG1025657-4	Acridine	<1.6	<1.6	mg/kg	N/A
L831113-1	Soil	WG1025657-4	Anthracene	0.22	0.22	mg/kg	-
L831113-1	Soil	WG1025657-4	Benz(a)anthracene	0.77	0.79	mg/kg	-
L831113-1	Soil	WG1025657-4	Benz(a)pyrene	0.777	0.800	mg/kg	3.0
L831113-1	Soil	WG1025657-4	Benz(b)fluoranthene	0.92	0.89	mg/kg	-
L831113-1	Soil	WG1025657-4	Benz(g,h,i)perylene	0.55	0.54	mg/kg	-
L831113-1	Soil	WG1025657-4	Benz(k)fluoranthene	0.591	0.611	mg/kg	3.3
L831113-1	Soil	WG1025657-4	Chrysene	0.76	0.77	mg/kg	-
L831113-1	Soil	WG1025657-4	Dibenzo(ah)anthracene	0.11	0.11	mg/kg	-
L831113-1	Soil	WG1025657-4	Fluoranthene	1.07	1.13	mg/kg	5.2
L831113-1	Soil	WG1025657-4	Fluorene	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1025657-4	Indeno(1,2,3-cd)pyrene	0.69	0.70	mg/kg	-
L831113-1	Soil	WG1025657-4	1-Methylnaphthalene	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1025657-4	2-Methylnaphthalene	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1025657-4	Naphthalene	0.511	0.436	mg/kg	16
L831113-1	Soil	WG1025657-4	Phenanthrene	0.521	0.536	mg/kg	-
L831113-1	Soil	WG1025657-4	Pyrene	0.89	0.93	mg/kg	-
L831113-1	Soil	WG1025657-4	Quinoline	<0.10	<0.10	mg/kg	N/A
Polychlorinated Biphenyls							
L831113-1	Soil	WG1023287-4	Aroclor 1242	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1023287-4	Aroclor 1248	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1023287-4	Aroclor 1254	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1023287-4	Aroclor 1260	<0.10	<0.10	mg/kg	N/A
L831113-1	Soil	WG1023287-4	Total PCBs	<0.10	<0.10	mg/kg	N/A
Physical Tests							
L831113-21	Soil	WG1023282-3	% Moisture	66.9	66.5	%	0.63
Aggregate Organics							
L831113-21	Soil	WG1030476-4	Oil and Grease, Total	12800	11000	mg/kg	15
Volatile Organic Compounds							
L831113-30	Soil	WG1023028-2	Benzene	<0.050	<0.050	mg/kg	N/A
L831113-30	Soil	WG1023028-2	Ethyl Benzene	<0.050	<0.050	mg/kg	N/A
L831113-30	Soil	WG1023028-2	Toluene	<0.050	<0.050	mg/kg	N/A
L831113-30	Soil	WG1023028-2	o-Xylene	<0.050	<0.050	mg/kg	N/A
L831113-30	Soil	WG1023028-2	m+p-Xylenes	<0.10	<0.10	mg/kg	N/A
Aggregate Organics							
L831113-41	Soil	WG1030479-4	Oil and Grease, Total	<500	<500	mg/kg	N/A
Physical Tests							
L831113-42	Soil	WG1023286-3	% Moisture	55.5	54.3	%	2.1
Aggregate Organics							
WG1029191-2	Soil	WG1029191-3	Oil and Grease, Total	98		%	4.8
WG1030476-2	Soil	WG1030476-3	Oil and Grease, Total	94		%	4.0
WG1030479-2	Soil	WG1030479-3	Oil and Grease, Total	90		%	0.67

Table A4. Continued.

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD
Polycyclic Aromatic Hydrocarbons							
WG1023287-2	Soil	WG1023287-3	Acenaphthene	98		%	3.4
WG1023664-2	Soil	WG1023664-3	Acenaphthene	83		%	1.6
WG1025465-2	Soil	WG1025465-3	Acenaphthene	97		%	7.2
WG1026349-2	Soil	WG1026349-3	Acenaphthene	98		%	14
WG1027104-2	Soil	WG1027104-3	Acenaphthene	95		%	2.8
WG1027627-2	Soil	WG1027627-3	Acenaphthene	97		%	4.4
WG1027719-2	Soil	WG1027719-3	Acenaphthene	91		%	5.9
WG1023287-2	Soil	WG1023287-3	Acenaphthylene	93		%	0.54
WG1023664-2	Soil	WG1023664-3	Acenaphthylene	70		%	9.9
WG1025465-2	Soil	WG1025465-3	Acenaphthylene	90		%	5.8
WG1026349-2	Soil	WG1026349-3	Acenaphthylene	88		%	0.27
WG1027104-2	Soil	WG1027104-3	Acenaphthylene	94		%	3.7
WG1027627-2	Soil	WG1027627-3	Acenaphthylene	96		%	4.1
WG1027719-2	Soil	WG1027719-3	Acenaphthylene	89		%	6
WG1023287-2	Soil	WG1023287-3	Acridine	101		%	3.9
WG1023664-2	Soil	WG1023664-3	Acridine	86		%	8.4
WG1025465-2	Soil	WG1025465-3	Acridine	102		%	5.8
WG1026349-2	Soil	WG1026349-3	Acridine	96		%	1.1
WG1027104-2	Soil	WG1027104-3	Acridine	99		%	5.6
WG1027627-2	Soil	WG1027627-3	Acridine	99		%	1.8
WG1027719-2	Soil	WG1027719-3	Acridine	99		%	6.5
WG1023287-2	Soil	WG1023287-3	Anthracene	94		%	3.8
WG1023664-2	Soil	WG1023664-3	Anthracene	78		%	11
WG1025465-2	Soil	WG1025465-3	Anthracene	90		%	5.1
WG1026349-2	Soil	WG1026349-3	Anthracene	91		%	3.1
WG1027104-2	Soil	WG1027104-3	Anthracene	94		%	3.6
WG1027627-2	Soil	WG1027627-3	Anthracene	96		%	5.8
WG1027719-2	Soil	WG1027719-3	Anthracene	89		%	9.1
WG1023287-2	Soil	WG1023287-3	Benz(a)anthracene	108		%	6
WG1023664-2	Soil	WG1023664-3	Benz(a)anthracene	87		%	12
WG1025465-2	Soil	WG1025465-3	Benz(a)anthracene	101		%	3.5
WG1026349-2	Soil	WG1026349-3	Benz(a)anthracene	88		%	1.2
WG1027104-2	Soil	WG1027104-3	Benz(a)anthracene	93		%	2.5
WG1027627-2	Soil	WG1027627-3	Benz(a)anthracene	96		%	1.8
WG1027719-2	Soil	WG1027719-3	Benz(a)anthracene	95		%	8.6
WG1023287-2	Soil	WG1023287-3	Benz(a)pyrene	107		%	3.6
WG1023664-2	Soil	WG1023664-3	Benz(a)pyrene	87		%	12
WG1025465-2	Soil	WG1025465-3	Benz(a)pyrene	106		%	6.4
WG1026349-2	Soil	WG1026349-3	Benz(a)pyrene	106		%	1.1
WG1027104-2	Soil	WG1027104-3	Benz(a)pyrene	101		%	18
WG1027627-2	Soil	WG1027627-3	Benz(a)pyrene	103		%	2
WG1027719-2	Soil	WG1027719-3	Benz(a)pyrene	107		%	6.9
WG1023287-2	Soil	WG1023287-3	Benz(b)fluoranthene	91		%	4.1
WG1023664-2	Soil	WG1023664-3	Benz(b)fluoranthene	77		%	10
WG1025465-2	Soil	WG1025465-3	Benz(b)fluoranthene	101		%	2.7
WG1026349-2	Soil	WG1026349-3	Benz(b)fluoranthene	86		%	2.4
WG1027104-2	Soil	WG1027104-3	Benz(b)fluoranthene	90		%	15
WG1027627-2	Soil	WG1027627-3	Benz(b)fluoranthene	84		%	1
WG1027719-2	Soil	WG1027719-3	Benz(b)fluoranthene	83		%	5.4
WG1023287-2	Soil	WG1023287-3	Benz(g,h,i)perylene	89		%	2.5
WG1023664-2	Soil	WG1023664-3	Benz(g,h,i)perylene	72		%	12
WG1025465-2	Soil	WG1025465-3	Benz(g,h,i)perylene	90		%	7.1
WG1026349-2	Soil	WG1026349-3	Benz(g,h,i)perylene	95		%	2.4
WG1027104-2	Soil	WG1027104-3	Benz(g,h,i)perylene	91		%	3.8
WG1027627-2	Soil	WG1027627-3	Benz(g,h,i)perylene	93		%	1.1
WG1027719-2	Soil	WG1027719-3	Benz(g,h,i)perylene	99		%	2.6
WG1023287-2	Soil	WG1023287-3	Benz(k)fluoranthene	82		%	1.7
WG1023664-2	Soil	WG1023664-3	Benz(k)fluoranthene	76		%	15
WG1025465-2	Soil	WG1025465-3	Benz(k)fluoranthene	78		%	11
WG1026349-2	Soil	WG1026349-3	Benz(k)fluoranthene	109		%	0.81
WG1027104-2	Soil	WG1027104-3	Benz(k)fluoranthene	94		%	1.5
WG1027627-2	Soil	WG1027627-3	Benz(k)fluoranthene	97		%	2.3
WG1027719-2	Soil	WG1027719-3	Benz(k)fluoranthene	89		%	6.6
WG1023287-2	Soil	WG1023287-3	Chrysene	90		%	4.3
WG1023664-2	Soil	WG1023664-3	Chrysene	78		%	11
WG1025465-2	Soil	WG1025465-3	Chrysene	91		%	5.1
WG1026349-2	Soil	WG1026349-3	Chrysene	96		%	3.5
WG1027104-2	Soil	WG1027104-3	Chrysene	92		%	1.3
WG1027627-2	Soil	WG1027627-3	Chrysene	97		%	3.5
WG1027719-2	Soil	WG1027719-3	Chrysene	90		%	6.5

Table A4. Continued.

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD
Polycyclic Aromatic Hydrocarbons							
WG1023287-2	Soil	WG1023287-3	Dibenz(a,h)anthracene	97	%	3.4	
WG1023664-2	Soil	WG1023664-3	Dibenz(a,h)anthracene	79	%	12	
WG1025465-2	Soil	WG1025465-3	Dibenz(a,h)anthracene	100	%	4.9	
WG1026349-2	Soil	WG1026349-3	Dibenz(a,h)anthracene	89	%	0.48	
WG1027104-2	Soil	WG1027104-3	Dibenz(a,h)anthracene	94	%	5.5	
WG1027627-2	Soil	WG1027627-3	Dibenz(a,h)anthracene	97	%	2.2	
WG1027719-2	Soil	WG1027719-3	Dibenz(a,h)anthracene	98	%	1.5	
WG1023287-2	Soil	WG1023287-3	Fluoranthene	95	%	4	
WG1023664-2	Soil	WG1023664-3	Fluoranthene	78	%	11	
WG1025465-2	Soil	WG1025465-3	Fluoranthene	91	%	5.2	
WG1026349-2	Soil	WG1026349-3	Fluoranthene	89	%	1.3	
WG1027104-2	Soil	WG1027104-3	Fluoranthene	92	%	4.9	
WG1027627-2	Soil	WG1027627-3	Fluoranthene	93	%	1.2	
WG1027719-2	Soil	WG1027719-3	Fluoranthene	93	%	6.5	
WG1023287-2	Soil	WG1023287-3	Fluorene	99	%	3.4	
WG1023664-2	Soil	WG1023664-3	Fluorene	79	%	8.8	
WG1025465-2	Soil	WG1025465-3	Fluorene	95	%	3.7	
WG1026349-2	Soil	WG1026349-3	Fluorene	89	%	11	
WG1027104-2	Soil	WG1027104-3	Fluorene	94	%	3.7	
WG1027627-2	Soil	WG1027627-3	Fluorene	96	%	4.4	
WG1027719-2	Soil	WG1027719-3	Fluorene	89	%	6	
WG1023287-2	Soil	WG1023287-3	Indeno(1,2,3-cd)pyrene	118	%	13	
WG1023664-2	Soil	WG1023664-3	Indeno(1,2,3-cd)pyrene	81	%	1.1	
WG1025465-2	Soil	WG1025465-3	Indeno(1,2,3-cd)pyrene	106	%	3.1	
WG1026349-2	Soil	WG1026349-3	Indeno(1,2,3-cd)pyrene	89	%	2.2	
WG1027104-2	Soil	WG1027104-3	Indeno(1,2,3-cd)pyrene	90	%	16	
WG1027627-2	Soil	WG1027627-3	Indeno(1,2,3-cd)pyrene	90	%	4.3	
WG1027719-2	Soil	WG1027719-3	Indeno(1,2,3-cd)pyrene	107	%	1.6	
WG1023287-2	Soil	WG1023287-3	1-Methylnaphthalene	104	%	1.9	
WG1023664-2	Soil	WG1023664-3	1-Methylnaphthalene	81	%	11	
WG1025465-2	Soil	WG1025465-3	1-Methylnaphthalene	95	%	5.4	
WG1026349-2	Soil	WG1026349-3	1-Methylnaphthalene	78	%	33	
WG1027104-2	Soil	WG1027104-3	1-Methylnaphthalene	96	%	1.7	
WG1027627-2	Soil	WG1027627-3	1-Methylnaphthalene	99	%	4.3	
WG1027719-2	Soil	WG1027719-3	1-Methylnaphthalene	89	%	7	
WG1023287-2	Soil	WG1023287-3	2-Methylnaphthalene	106	%	3.1	
WG1023664-2	Soil	WG1023664-3	2-Methylnaphthalene	79	%	19	
WG1025465-2	Soil	WG1025465-3	2-Methylnaphthalene	93	%	8.2	
WG1026349-2	Soil	WG1026349-3	2-Methylnaphthalene	90	%	15	
WG1027104-2	Soil	WG1027104-3	2-Methylnaphthalene	94	%	2.9	
WG1027627-2	Soil	WG1027627-3	2-Methylnaphthalene	94	%	2.7	
WG1027719-2	Soil	WG1027719-3	2-Methylnaphthalene	88	%	5.5	
WG1023287-2	Soil	WG1023287-3	Naphthalene	95	%	4	
WG1023664-2	Soil	WG1023664-3	Naphthalene	76	%	19	
WG1025465-2	Soil	WG1025465-3	Naphthalene	96	%	7.2	
WG1026349-2	Soil	WG1026349-3	Naphthalene	105	%	48	
WG1027104-2	Soil	WG1027104-3	Naphthalene	95	%	3.2	
WG1027627-2	Soil	WG1027627-3	Naphthalene	98	%	2.2	
WG1027719-2	Soil	WG1027719-3	Naphthalene	87	%	4.1	
WG1023287-2	Soil	WG1023287-3	Phenanthrene	91	%	2.5	
WG1023664-2	Soil	WG1023664-3	Phenanthrene	78	%	11	
WG1025465-2	Soil	WG1025465-3	Phenanthrene	90	%	6.0	
WG1026349-2	Soil	WG1026349-3	Phenanthrene	95	%	1.1	
WG1027104-2	Soil	WG1027104-3	Phenanthrene	96	%	3.2	
WG1027627-2	Soil	WG1027627-3	Phenanthrene	93	%	0.89	
WG1027719-2	Soil	WG1027719-3	Phenanthrene	91	%	7.1	
WG1023287-2	Soil	WG1023287-3	Pyrene	96	%	4.2	
WG1023664-2	Soil	WG1023664-3	Pyrene	79	%	11	
WG1025465-2	Soil	WG1025465-3	Pyrene	92	%	5.5	
WG1026349-2	Soil	WG1026349-3	Pyrene	91	%	1.7	
WG1027104-2	Soil	WG1027104-3	Pyrene	93	%	5.8	
WG1027627-2	Soil	WG1027627-3	Pyrene	96	%	2.5	
WG1027719-2	Soil	WG1027719-3	Pyrene	95	%	6.4	
WG1023287-2	Soil	WG1023287-3	Quinoline	113	%	2.1	
WG1023664-2	Soil	WG1023664-3	Quinoline	94	%	11	
WG1025465-2	Soil	WG1025465-3	Quinoline	106	%	12	
WG1026349-2	Soil	WG1026349-3	Quinoline	113	%	34	
WG1027104-2	Soil	WG1027104-3	Quinoline	109	%	2.1	
WG1027627-2	Soil	WG1027627-3	Quinoline	109	%	1.7	
WG1027719-2	Soil	WG1027719-3	Quinoline	100	%	4.1	

Table A4. Continued.

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD
Polychlorinated Biphenyls							
WG1023287-2	Soil	WG1023287-3	Aroclor 1242	80		%	4.5
WG1023664-2	Soil	WG1023664-3	Aroclor 1242	70		%	15
WG1025465-2	Soil	WG1025465-3	Aroclor 1242	101		%	2.3
WG1026349-2	Soil	WG1026349-3	Aroclor 1242	91		%	9.9
WG1027104-2	Soil	WG1027104-3	Aroclor 1242	85		%	3.4
WG1027627-2	Soil	WG1027627-3	Aroclor 1242	93		%	0.45
WG1027719-2	Soil	WG1027719-3	Aroclor 1242	86		%	0.0
WG1023287-2	Soil	WG1023287-3	Aroclor 1248	89		%	0.0
WG1023664-2	Soil	WG1023664-3	Aroclor 1248	81		%	0.0
WG1025465-2	Soil	WG1025465-3	Aroclor 1248	98		%	0.0
WG1026349-2	Soil	WG1026349-3	Aroclor 1248	94		%	0.0
WG1027104-2	Soil	WG1027104-3	Aroclor 1248	90		%	0.0
WG1027627-2	Soil	WG1027627-3	Aroclor 1248	93		%	0.0
WG1027719-2	Soil	WG1027719-3	Aroclor 1248	85		%	0.0
WG1023287-2	Soil	WG1023287-3	Aroclor 1254	75		%	3.8
WG1023664-2	Soil	WG1023664-3	Aroclor 1254	67		%	18
WG1025465-2	Soil	WG1025465-3	Aroclor 1254	97		%	4.2
WG1026349-2	Soil	WG1026349-3	Aroclor 1254	87		%	7.3
WG1027104-2	Soil	WG1027104-3	Aroclor 1254	81		%	2.6
WG1027627-2	Soil	WG1027627-3	Aroclor 1254	90		%	1.5
WG1027719-2	Soil	WG1027719-3	Aroclor 1254	87		%	1.1
WG1023287-2	Soil	WG1023287-3	Aroclor 1260	76		%	2.6
WG1023664-2	Soil	WG1023664-3	Aroclor 1260	70		%	18
WG1025465-2	Soil	WG1025465-3	Aroclor 1260	94		%	0.56
WG1026349-2	Soil	WG1026349-3	Aroclor 1260	87		%	6.3
WG1027104-2	Soil	WG1027104-3	Aroclor 1260	79		%	5.3
WG1027627-2	Soil	WG1027627-3	Aroclor 1260	94		%	0.66
WG1027719-2	Soil	WG1027719-3	Aroclor 1260	91		%	2
WG1023287-2	Soil	WG1023287-3	Total PCBs	80		%	2.7
WG1023664-2	Soil	WG1023664-3	Total PCBs	72		%	13
WG1025465-2	Soil	WG1025465-3	Total PCBs	97		%	1.8
WG1026349-2	Soil	WG1026349-3	Total PCBs	90		%	5.7
WG1027104-2	Soil	WG1027104-3	Total PCBs	84		%	2.7
WG1027627-2	Soil	WG1027627-3	Total PCBs	93		%	0.097
WG1027719-2	Soil	WG1027719-3	Total PCBs	87		%	0.79
Volatile Organic Compounds							
L831113-50	Soil	WG1023032-2	Benzene	<0.050	<0.050	mg/kg	N/A
L831113-50	Soil	WG1023032-2	Ethyl Benzene	<0.050	<0.050	mg/kg	N/A
L831113-50	Soil	WG1023032-2	Toluene	<0.050	<0.050	mg/kg	N/A
L831113-50	Soil	WG1023032-2	o-Xylene	<0.050	<0.050	mg/kg	N/A
L831113-50	Soil	WG1023032-2	m+p-Xylenes	<0.10	<0.10	mg/kg	N/A
Physical Tests							
L831113-63	Soil	WG1023288-3	% Moisture	56.5	57.0	%	0.88
Volatile Organic Compounds							
L831113-70	Soil	WG1023035-2	Benzene	<0.050	<0.050	mg/kg	N/A
L831113-70	Soil	WG1023035-2	Ethyl Benzene	<0.050	<0.050	mg/kg	N/A
L831113-70	Soil	WG1023035-2	Toluene	<0.050	<0.050	mg/kg	N/A
L831113-70	Soil	WG1023035-2	o-Xylene	<0.050	<0.050	mg/kg	N/A
L831113-70	Soil	WG1023035-2	m+p-Xylenes	<0.10	<0.10	mg/kg	N/A

Table A4. Continued.

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD
Polycyclic Aromatic Hydrocarbons							
L831113-71	Soil	WG1027719-4	Acenaphthene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Acenaphthylene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Acridine	<1.6	<1.6	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Anthracene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Benzo(a)anthracene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Benzo(a)pyrene	<0.040	<0.040	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Benzo(b)fluoranthene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Benzo(g,h,i)perylene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Benzo(k)fluoranthene	<0.040	<0.040	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Chrysene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Dibenz(a,h)anthracene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Fluoranthene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Fluorene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Indeno(1,2,3-cd)pyrene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	1-Methylnaphthalene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	2-Methylnaphthalene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Naphthalene	<0.020	<0.020	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Phenanthrene	<0.060	<0.060	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Pyrene	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Quinoline	<0.10	<0.10	mg/kg	N/A
Polychlorinated Biphenyls							
L831113-71	Soil	WG1027719-4	Aroclor 1242	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Aroclor 1248	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Aroclor 1254	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Aroclor 1260	<0.10	<0.10	mg/kg	N/A
L831113-71	Soil	WG1027719-4	Total PCBs	<0.10	<0.10	mg/kg	N/A
				Overall	Min	0	
					Max	48	
					Median	4	

Table A5. Surrogate recoveries (ALS Laboratory Group data) (2009).

Sample ID	6974	R1	R4	E4	E5	E6	E8	E1200	E1201	E1202	E14	E15	E16	R700	R701	R702	R8	R9	R10	min	max	med
Volatile Organic Compounds																						
Surrogate: 2,5-Dibromotoluene	101	91	90	93	87	84	83	83	82	72	81	79	78	75	82	85	82	78	82	72	101	82
Hydrocarbons																						
Surrogate: Octacosane	95	95	93	94	105	94	96	96	71	104	102	103	95	92	105	107	106	99	94	71	107	96
Polycyclic Aromatic Hydrocarbons																						
Surrogate: 2-Fluorobiphenyl	102	99	97	108	102	116	120	104	85	117	94	100	98	98	101	95	95	99	99	85	120	102
Surrogate: p-Terphenyl d14	109	108	100	103	102	106	106	105	97	101	102	103	107	106	100	96	95	99	104	83	112	96
Polychlorinated Biphenyls																						
Surrogate: d14-Terphenyl	109	100	106	112	101	110	102	97	87	89	95	93	95	99	94	93	83	87	96	83	112	96

Table A6. Laboratory extraction standard recoveries for Nipigon Bay samples (ALS Laboratory Group data) (2009).

Sample Name	6974	R1	R4	E4	E5	E6	E8	E8 DUP	E1200	E1201	E1202	E14	E15	E16	R700	R701	R702	R8	R9	R10	min	max	med
Extraction Standards	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	% Rec	
13C12-2,3,7,8-TCDD	75	76	82	78	86	80	103	96	99	73	102	99	92	101	100	101	98	91	98	99	96	96	
13C12-1,2,3,7,8-PeCDD	100	101	95	67	76	89	105	88	99	75	102	104	72	97	96	96	90	76	84	84	84	84	
13C12-1,2,3,4,7,8-HxCDD	80	82	77	81	79	74	101	93	98	78	98	95	95	104	94	102	90	90	94	92	103	103	
13C12-1,2,3,6,7,8-HxCDD	74	82	76	73	78	77	93	99	88	75	92	94	96	100	99	97	89	95	99	95	95	99	
13C12-1,2,3,4,6,7,8-HpCDD	77	82	77	74	76	69	91	72	88	63	84	95	83	84	83	98	84	86	90	93	93	93	
13C12-OCDD	68	74	65	64	57	58	80	50	68	46	63	76	68	58	60	83	63	62	66	64	64	64	
13C12-2,3,7,8-TCDF	88	91	89	72	84	77	113	102	92	72	97	99	90	95	95	95	95	90	94	95	95	95	
13C12-1,2,3,7,8-PeCDF	96	99	95	76	83	92	112	94	103	84	110	113	86	104	102	103	100	87	95	95	96	96	
13C12-2,3,4,7,8-PeCDF	97	100	93	66	75	89	100	88	98	77	103	104	75	96	95	95	89	79	85	86	86	86	
13C12-1,2,3,4,7,8-HxCDF	92	94	88	90	88	85	114	111	106	92	111	110	123	119	114	118	108	105	107	107	121	121	
13C12-1,2,3,6,7,8-HxCDF	79	85	80	82	82	80	100	106	94	84	105	101	113	109	105	107	101	96	101	107	107	107	
13C12-2,3,4,6,7,8-HxCDF	82	87	81	76	82	79	99	99	99	82	101	101	106	105	102	102	98	97	98	101	101	101	
13C12-1,2,3,7,8,9-HxCDF	80	85	81	76	80	78	97	92	95	77	100	100	102	104	102	103	99	94	99	99	102	102	
13C12-1,2,3,4,6,7,8-HpCDF	77	79	77	79	77	76	96	78	91	72	97	102	97	99	96	101	93	98	98	98	102	102	
13C12-1,2,3,4,7,8-HpCDF	76	80	78	78	73	73	94	70	88	65	85	102	89	93	90	106	90	93	97	97	102	102	
Cleanup Standard	37Cl4-2,3,7,8-TCDD	76	75	87	79	89	84	105	98	95	104	98	108	94	99	106	102	103	108	94	100	100	

Table A7. Laboratory control sample (LCS) target analyte and extraction standard recoveries (ALS Laboratory Group data) (2009).

Sample Name	LCS			LCS			LCS		
Analysis Method	Mod. 1613B/1668A			Mod. 1613B/1668A			Mod. 1613B/1668A		
Analysis Units	% Rec			% Rec			% Rec		
Instrument - Column	HRMS-1			HRMS-1			HRMS-1		
Target Analytes	Ret. Time	% Rec	Limits	Ret. Time	% Rec	Limits	Ret. Time	% Rec	Limits
2,3,7,8-TCDD	28:01	94	67-158	27:55	107	67-158	27:51	104	67-158
1,2,3,7,8-PeCDD	32:39	104	70-142	32:37	107	70-142	32:36	107	70-142
1,2,3,4,7,8-HxCDD	34:59	104	70-164	34:57	98	70-164	34:55	102	70-164
1,2,3,6,7,8-HxCDD	35:04	118	76-134	35:01	105	76-134	34:59	106	76-134
1,2,3,7,8,9-HxCDD	35:15	107	64-162	35:12	98	64-162	35:10	104	64-162
1,2,3,4,6,7,8-HpCDD	37:08	107	70-140	37:05	108	70-140	37:03	109	70-140
OCDD	39:11	106	78-144	39:08	99	78-144	39:06	101	78-144
2,3,7,8-TCDF	26:43	119	75-158	26:37	111	75-158	26:33	112	75-158
1,2,3,7,8-PeCDF	31:49	95	80-134	31:46	109	80-134	31:45	111	80-134
2,3,4,7,8-PeCDF	32:28	97	68-160	32:25	110	68-160	32:24	111	68-160
1,2,3,4,7,8-HxCDF	34:27	95	72-134	34:24	109	72-134	34:23	109	72-134
1,2,3,6,7,8-HxCDF	34:32	95	84-130	34:29	112	84-130	34:28	112	84-130
2,3,4,6,7,8-HxCDF	34:54	95	78-130	34:52	111	78-130	34:50	107	78-130
1,2,3,7,8,9-HxCDF	35:29	95	70-156	35:27	112	70-156	35:25	109	70-156
1,2,3,4,6,7,8-HpCDF	36:26	102	82-122	36:23	111	82-122	36:22	112	82-122
1,2,3,4,7,8,9-HpCDF	37:32	100	78-138	37:28	104	78-138	37:27	111	78-138
OCDF	39:22	97	63-170	39:18	99	63-170	39:17	99	63-170
Median	107%								
Extraction Standards	% Rec	Limits		% Rec	Limits		% Rec	Limits	
13C12-2,3,7,8-TCDD	27:59	65	20-175	27:53	90	20-175	27:49	69	20-175
13C12-1,2,3,7,8-PeCDD	32:39	70	21-227	32:36	92	21-227	32:35	79	21-227
13C12-1,2,3,4,7,8-HxCDD	34:59	72	21-193	34:56	89	21-193	34:55	75	21-193
13C12-1,2,3,6,7,8-HxCDD	35:03	73	25-163	35:00	92	25-163	34:59	74	25-163
13C12-1,2,3,4,6,7,8-HpCDD	37:07	72	26-166	37:04	72	26-166	37:03	77	26-166
13C12-OCDD	39:11	60	13-138	39:07	50	13-138	39:06	69	13-138
13C12-2,3,7,8-TCDF	26:41	65	22-152	26:35	102	22-152	26:31	68	22-152
13C12-1,2,3,7,8-PeCDF	31:48	76	21-192	31:46	101	21-192	31:44	77	21-192
13C12-2,3,4,7,8-PeCDF	32:27	72	13-328	32:25	94	13-328	32:23	75	13-328
13C12-1,2,3,4,7,8-HxCDF	34:26	82	19-202	34:24	104	19-202	34:22	76	19-202
13C12-1,2,3,6,7,8-HxCDF	34:31	78	21-159	34:29	97	21-159	34:27	70	21-159
13C12-2,3,4,6,7,8-HxCDF	34:53	74	17-205	34:51	91	17-205	34:49	71	17-205
13C12-1,2,3,7,8,9-HxCDF	35:29	72	22-176	35:26	85	22-176	35:24	70	22-176
13C12-1,2,3,4,6,7,8-HpCDF	36:26	82	21-158	36:23	80	21-158	36:21	78	21-158
13C12-1,2,3,4,7,8,9-HpCDF	37:31	78	20-186	37:28	72	20-186	37:26	76	20-186
Median	76%								

Table A8. Detection limits for organic contaminants (ALS Laboratory Group data) (2009).

Sample ID	6974	R1	R4	E4	E5	E6	E8	E1200	E1201	E1202	E14	E15	E16	R700	R701	R702	R8	R9	R10
Date Sampled	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09
Oil and Grease, Total	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Volatile Organic Compounds																			
Benzene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Ethyl Benzene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Toluene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
o-Xylene	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
m+p-Xylenes	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
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	0.15	0.15
Surrogate: 2,5-Dibromotoluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrocarbons																			
F1 (C6-C10)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
F1-BTEX	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
F2 (C10-C16)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
F2-Naphth	-	-	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
F3 (C16-C34)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
F3-PAH	-	-	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
F4 (C34-C50)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
F4G-SG (GHH-Silica)	1000	1000	1000	1500	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	500	500	500	500
Total Hydrocarbons (C6-C50)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Chromatogram to baseline at nC50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surrogate: Octacosane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons																			
Acenaphthene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Acenaphthylene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Acridine	0.80	0.80	0.80	1.6	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	1.6	0.80	1.6	1.6	1.6	1.6
Anthracene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Benz(a)anthracene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Benz(a)pyrene	0.020	0.020	0.020	0.040	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.040	0.020	0.040	0.040	0.040	0.040
Benz(b)fluoranthene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Benz(g,h,i)perylene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Benz(k)fluoranthene	0.020	0.020	0.020	0.040	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.040	0.020	0.040	0.040	0.040	0.040
Chrysene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Dibenzo(ah)anthracene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Fluoranthene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Fluorene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Indeno(1,2,3-cd)pyrene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
1-Methylnaphthalene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
2-Methylnaphthalene	0.050	0.050	0.050	0.10	0.050	0.070	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Naphthalene	0.010	0.010	0.010	0.020	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.020	0.010	0.020	0.020	0.020	0.020
Phenanthrene	0.030	0.030	0.030	0.060	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.060	0.030	0.060	0.060	0.060	0.060
Pyrene	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Quinoline	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Surrogate: 2-Fluorobiphenyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surrogate: p-Terphenyl d14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polychlorinated Biphenyls																			
Aroclor 1242	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Aroclor 1248	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Aroclor 1254	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Aroclor 1260	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Total PCBs	0.050	0.050	0.050	0.10	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.10	0.050	0.10	0.10	0.10	0.10
Surrogate: d14-Terphenyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

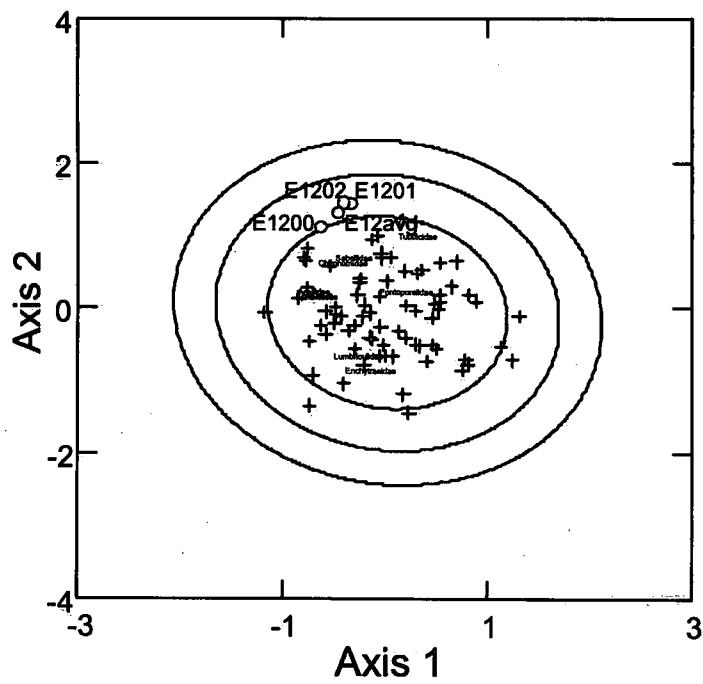


Figure A1. Assessment of field-replicated QA/QC site E12, summarized on Axis 1 and 2. The three separate box cores are indicated by E1200, E1201 and E1202 and the mean by E12avg.
Stress = 0.15.

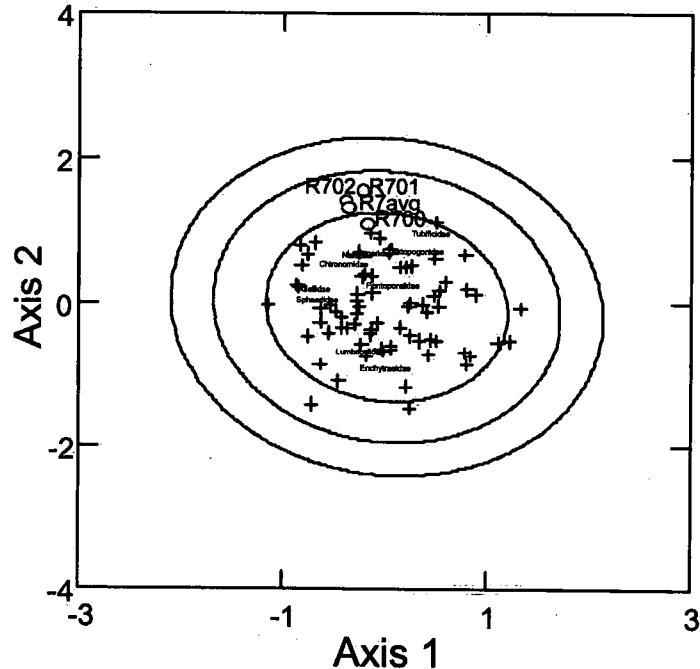


Figure A2. Assessment of field-replicated QA/QC site R7, summarized on Axis 1 and 2. The three separate box cores are indicated by R700, R701 and R702 and the mean by R7avg. Stress = 0.16.

Appendix B - Benthic invertebrate abundances

Table B1. Family level invertebrate abundances (per 33 cm²) (abundances area adjusted for sampling device where necessary) (2009).

Site	6974	R1	R4	E4	E5	E6	E8	E12	E14	E15	E16	R7	R8	R9	R10
Arrenuridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
Asellidae	0.00	0.00	0.00	0.00	0.00	3.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosminidae	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Caenidae	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ceratopogonidae	1.17	0.20	0.00	0.80	1.00	1.23	0.60	0.00	0.00	0.00	0.40	0.87	0.20	0.00	0.00
Chironomidae	33.28	12.00	4.20	7.00	18.20	14.02	13.80	9.67	5.20	48.40	4.80	9.60	4.40	1.40	1.60
Chydoridae	0.10	0.00	0.20	0.00	0.00	0.00	0.20	0.00	0.20	0.40	7.40	0.00	0.00	0.00	0.00
Cyclopidae	0.08	0.20	1.60	0.20	0.00	3.43	1.00	0.47	3.00	3.20	3.60	1.07	0.00	1.80	1.20
Daphniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
Empididae	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Enchytraeidae	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.20	0.00	0.00	5.40	5.00
Ephemeridae	0.10	0.00	0.00	0.80	0.00	0.34	2.20	0.13	0.00	0.00	0.00	0.07	0.00	0.00	0.00
Erpobdellidae	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gammaridae	0.25	0.00	0.00	0.00	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Glossiphoniidae	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Halacaridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00
Hyalellidae	0.00	0.00	0.00	0.00	0.00	9.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydridae	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrobiidae	0.00	0.00	0.00	0.40	0.00	4.95	1.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
Hygrobatidae	0.00	1.00	0.40	0.80	0.20	0.14	0.00	0.13	0.00	0.00	0.00	0.67	0.80	0.00	0.00
Lebertidae	0.00	0.20	0.00	0.00	0.00	0.23	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leptoceridae	0.10	0.00	0.00	0.00	1.00	0.79	0.20	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00
Limnesiidae	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lumbriculidae	1.25	0.00	0.00	0.00	0.00	0.69	0.00	0.07	0.00	0.00	0.00	0.00	0.00	3.80	0.00
Lymnaeidae	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Macrobiotidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.60	2.20	3.00	0.00	0.00	0.00	0.00
Macrothricidae	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.27	4.40	10.20	16.20	0.33	0.20	0.80	0.00
Mideopsidae	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
Naididae	2.09	2.60	1.40	0.20	2.40	5.07	1.40	1.53	9.40	31.40	11.60	11.07	4.60	1.00	0.00
Pionidae	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.13	0.00	0.00	0.20	0.13	0.00	0.00	0.00
Plagiostomidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.20	0.00
Planorbidae	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polycentropodidae	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pontoporeiidae	0.00	0.60	7.00	0.00	0.00	0.68	0.00	2.20	0.20	0.00	0.00	2.73	4.20	11.60	12.20
Sabellidae	0.08	2.60	0.00	1.20	1.40	0.43	65.40	1.13	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Sphaeridae	7.81	2.00	1.40	1.20	1.80	14.19	2.00	4.93	8.20	3.20	5.80	1.47	1.60	0.60	0.00
Spongillidae	75.98	0.20	0.00	0.20	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tubificidae	22.04	9.80	3.20	1.00	41.40	21.77	3.00	22.20	119.00	146.20	183.20	13.73	1.40	3.60	4.20
Unionicolidae	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unionidae	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valvatidae	0.00	0.80	0.00	0.20	0.00	12.77	3.20	0.53	0.00	0.00	0.00	0.27	0.00	0.00	0.00
Total No. Taxa	17	12	8	12	9	29	14	14	10	8	13	17	8	10	6
Total Abundance	69.5	31.8	17.6	13.6	67.6	98.5	93.2	42.7	146.6	231.4	209.4	41.2	17.2	28.4	23.2

Table B2. Lowest level invertebrate abundances (per 33 cm²) (abundances adjusted for sampling device where necessary) (2009).

		Upstream		MidW Bay		South of Mill			Southwest Bay						Kama Point				East Bay			
		6974	R1	R4	E4	E5	E6	E8	E1200	E1201	E1202	E14	E15	E16	R700	R701	R702	R8	R9	R10		
Amphipoda	Pontoporeiidae (Genus) <i>Diporeia</i>		0.6		7.0			0.7		2.8	2.2	1.6	0.2			5.4	0.4	2.4	4.2	11.6	12.2	
	Gammaridae (Genus) <i>Gammarus</i>		0.2							3.6												
	(Species) <i>Gammarus pseudolimna</i>									9.4												
	Hyalellidae (Genus) <i>Hyalella</i>																					
Annelida	Enchytraeidae (Genus) <i>Enchytraeus</i>		0.6													0.2				0.2		
	(Genus) <i>Mesenchytraeus</i>																			5.2	5.0	
	Erpobdellidae (Species) <i>Nephelopsis obscura</i>								0.6													
	Glossiphoniidae (Species) <i>Helobdella stagnalis</i>								0.6													
	Lumbriculidae (Species) <i>Stylodrilus herringi</i>		1.3						0.7			0.2								3.8		
	Naididae (Species) <i>Arcteonais lomondi</i>											0.2				0.8	0.2	0.2				
	(Species) <i>Chaetogaster diaphana</i>								0.2							0.4						
	(Genus) <i>Dero</i>															0.2						
Bivalvia	(Family) Naididae															0.2						
	(Genus) <i>Nais</i>															0.2						
	(Species) <i>Nais bretschieri</i>		0.1																			
	(Species) <i>Ophidona is serpentin</i>								2.1							0.6	2.8	3.8				
	(Species) <i>Piguetiella blanca</i>		0.9						0.4	0.1		0.6				0.2	0.2	0.2		0.2	0.4	
	(Species) <i>Piguetiella michigan</i>								0.9							0.8	0.4					
	(Species) <i>Pristina aquiseta</i>								0.2													
	(Species) <i>Slavina appendiculata</i>															0.2	3.0	11	3.4	0.4	0.4	
	(Species) <i>Specaria joscinae</i>		2.2		0.2				1.7	0.6						0.2	0.6	0.2				
	(Species) <i>Stylaria lacustris</i>											0.2	0.2									
	(Species) <i>Uncinaria uncinata</i>										0.2											
	(Species) <i>Vejdovskyella cornuta</i>																0.8	1.0	0.6			
	(Species) <i>Vejdovskyella interna</i>		0.7	0.2	1.2		1.8	0.3	0.8	0.6	1.4	0.2	4.2	16.2	4.2	2.4	10.8	12.6	3.6	1.0		
	(Genus) <i>Vejdovskyella</i>															2.0						
Diptera	Sabellidae (Species) <i>Manayunkia speciosa</i>		0.1	2.6			1.2	1.4	0.4	65.4	1.6	0.6	1.2				0.2					
	Tubificidae (Genus) <i>Aulodrilus</i>						0.4				0.4	0.2	0.2									
	(Species) <i>Aulodrilus americanus</i>										0.4											
	(Species) <i>Aulodrilus limnobius</i>										0.2											
	(Species) <i>Aulodrilus pigueti</i>										0.6											
	(Species) <i>Aulodrilus plurisetata</i>										0.6											
	(Species) <i>Limnodrilus hoffmeisteri</i>																					
	(Species) <i>Limnodrilus udekemiana</i>		0.2				4		0.6	9.4	16.8	14.2	5.6	6.2	3.2							
	(Species) <i>Potamothrix vejvodskii</i>								1.0	0.6						0.2						
	(Species) <i>Quistadrilus multiseta</i>							0.2	7.4		0.4	0.4					1.0	0.4				
Unionidae	(Species) <i>Spirosperma ferox</i>		2.2				0.2	14.4	2.0	0.4	2.8	2.8	3.6	59.4	104.4	63	0.2	13.2	0.2	3.6	1.8	
	(Genus) Immature with cheatal hairs		0.8	0.2			0.2	16.8	10.9	1.8	3.2	4.0	5.6	46.8	33.8	103.6	11.6	14.6	1.2		2.4	
	(Genus) Immature without cheatal ha		18.9	7.2		3.2	0.6															
	Sphaeriidae (Genus) <i>Musculium</i>		0.9						0.4		1.4		2.2	2.4	0.4	2.6		0.4	0.4			
	(Species) <i>Musculium transversum</i>								0.7													
	(Genus) <i>Pisidium</i>		5.7	1.2		1.4	1.2	1.4	8.2	1.4	2.8	1.4	2.0	5.6	2.6		0.4	1.4	1.8	1.6	0.6	
	(Species) <i>Pisidium casertanum</i>		0.2	0.8			0.2		0.2		1.0											
	(Species) <i>Pisidium compressum</i>		0.1																			
	(Species) <i>Pisidium fallax</i>																					
	(Species) <i>Pisidium henslowanum</i>																					
Diptera	(Species) <i>Pisidium milium</i>																					
	(Species) <i>Pisidium nitidum</i>																					
	(Species) <i>Pisidium suprum</i>																					
	(Species) <i>Pisidium variable</i>																					
	(Species) <i>Pisidium ventricosum</i>																					
	(Species) <i>Sphaerium simile</i>																					
	Unionidae (Family) Unionidae		0.1																			

Table B2. Continued.

		Upstream 6974	MidW Bay R1	South of Mill R4	E4	E5	E6	E8	Southwest Bay					Kama Point			East Bay				
Diptera	Chironomidae	(Genus) Ablabesmyia	0.1	0.2		0.2		0.2								0.4					
	(Species) Ablabesmyia(Asaya)					0.2															
	(Family) Chironomidae		1.0			0.2	0.2	0.1	0.4							0.2					
	(Genus) Chironomus			0.6		0.2			0.4												
	(Genus) Cladotanytarsus		0.5			0.2	1.5	0.2								0.2					
	(Genus) Conchapelopia		1.0																		
	(Genus) Cricotopus								0.2							0.6					
	(Genus) Cryptochironomus					0.6	0.2	2.5	0.4							0.2	0.2	0.8			
	(Genus) Cryptotendipes								0.6							0.4					
	(Genus) Demicryptochironomus		0.2	0.2						0.2	0.4					0.2					
	(Species) Demicryptochironomus cune		0.1					0.1			0.4										
	(Genus) Epolocladius					0.2															
	(Species) Epolocladius flaven					0.4		0.1	1.0												
	(Genus) Hamischia		0.1	0.2	0.2		0.2									1.0					
	(Genus) Heterotanytarsus		0.4			0.2	0.2	2.8													
	(Genus) Heterotriassocladius					0.4	1.0	0.6								0.8	2.6	1.4	2.0		
	(Species) Heterotriassocladius changi					0.2	0.6	2.2								1.4					
	(Species) Heterotriassocladius marcidus gp																				
	(Species) Heterotriassocladius oliveri																				
	(Genus) Hydrobaenus							0.1													
	(Genus) Larsi						0.4	0.3								0.4	0.2	0.6			
	(Species) Larsi canadensis						0.2														
	(Species) Larsi decolorata							0.1													
	(Genus) Microspectra								0.2												
	(Genus) Microtendipes		0.1		0.2											2.2	43.0	1.2	2.2	0.2	
	(Genus) Monodiamesa		0.1					0.1								0.2			0.2	0.2	
	(Species) Monodiamesa depectin		1.6																		
	(Genus) Orthocladius							0.1													
	(Genus) Pagastiella		1.0					0.1									0.2	0.2	0.2		
	(Genus) Parachironomus					0.2	0.2	0.4	0.2												
	(Genus) Paracladopelma		1.3	0.8	0.2	0.2	1.2	0.3	0.2	1.4	0.8	0.6									
	(Species) Paracladopelma undin						1.2	0.2	0.8	0.2											
	(Species) Paracladopelma winne											0.2					1.2				
	(Genus) Paraklefferiella			0.2													0.2			0.2	
	(Species) Paralauterborniella nigrohalta		6.0	0.6		0.2	0.2	1.6	1.4	0.8	0.2	0.2	0.2								
	(Genus) Paramerina							1.2								0.2					
	(Genus) Paratanytarsus							0.2													
	(Genus) Paratendipes								0.2												
	(Genus) Phaenopsectra		0.1				0.4	0.4	0.3												
	(Genus) Polypedilum					0.1	0.2														
	(Species) Polypedilum aviceps						0.4													0.2	
	(Species) Polypedilum scalaenu		16.3	0.6			0.6	2.6	0.1	0.2									0.2	0.2	
	(Species) Pothastia longimana		0.2					0.4	0.3	0.2	0.2										
	(Genus) Prociadius		0.1	5.2	2.8	1.2	3.4	0.8	4.8	1.8	1.6	2.6	0.6	1.6	0.8	4.0	1.8	2.8	1.6	0.4	0.4
	(Genus) Protanytarsus							0.1		0.2						0.2				0.2	
	(Genus) Psectrocladius																				
	(Genus) Rheotanytarsus							0.4													
	(Genus) Stempellina		0.1	0.2	0.2		0.2	0.2	0.4		0.2						0.2				
	(Genus) Stempellinella		0.8																		
	(Genus) Stictochironomus									3.2	4.4	3.0	1.4	2	1.6						
	(Genus) Stilocladius		1.8	1.0	0.2	0.2	0.4	1.1	0.2	0.6	0.8	0.6	0.2	0.2	0.2	1.0	0.6	0.6			
	(Species) Sublettea coffmani		0.1																		
	(Genus) Tanytarsus		1.0	0.6	0.2	1.0	1.6	0.3	1.2	0.8	0.4	0.4	0.2								
	(Species) Tribelos jucundum							0.3	0.2												
	(Genus) Tvetenia		0.1																		
	Empididae (Genus) Hemerodromia		0.3																		

Table B2. Continued.

	Upstream 6974	MidW Bay R1	South of Mill R4	South of Mill				Southwest Bay					Kama Point			East Bay				
				E4	E5	E6	E8	E1200	E1201	E1202	E14	E15	E16	R700	R701	R702	R8	R9	R10	
Ephemeroptera	Caenidae (Genus) Caenis					0.4														
	Ephemeridae (Genus) Ephemeridae (Genus) Hexagenia		0.1		0.8		0.3		2.2	0.2	0.2				0.2					
Gastropoda	Hydrobiidae (Species) Arnicola limosus				0.4		0.1	0.6								0.2				
	(Species) Pyrgulopsis lustrica						4.9	0.4												
	Lymnaeidae (Genus) Fossaria						0.4													
	(Species) Pseudosuccinea columba						1.1													
	(Species) Stagnicola catascopi						0.1													
	Planorbidae (Species) Helisoma anceps					0.4														
	Valvatidae (Species) Valvata lewisi		0.6		0.2				0.2	0.2	0.4				0.2	0.2				
	(Species) Valvata piscinalis						10.8	2.0												
	(Species) Valvata sincera						0.1													
	(Species) Valvata tricarinata		0.2			1.8	1.2	0.2			0.8					0.4				
	(Family) Valvatidae																			
Hydriida	Hydriidae (Genus) Hydra						0.1													
Malacostraca	Isopoda (Genus) Caecidotea							3.0												
	(Genus) Lirceus						0.9													
	Ostracoda (Order) Ostracoda	4.4	4.4	11.4			40.9	30.6			28.6	23.2	14.6	21.6	45.2	44.2	53.2	9.4	5.4	9.8
Nemata	Nemata (Phylum) Nemata	2.7	13.2	5.0	2.0		13.4	61.8			37.8	28.2	31.4	46.2	14	16.4	18.8	9.0	21.8	6.2
Oribatei	Halacaridae (Family) Halacaridae																0.4			
Platyhelminthes	Turbellaria (Genus) Hydrolimax						0.5				0.2							1.0	0.2	
	(Class) Turbellaria		0.2																	
Porifera	(Family) Spongillidae	76.0	0.2		0.2		0.1													
Prostigmata	Arrenuridae (Genus) Arrenurus														0.2		0.4	1.6	0.8	
	Hygrobatidae (Genus) Hygrobates		1.0	0.4	0.8	0.2	0.1		0.2	0.2										
	Lebertidae (Genus) Lebertia		0.2				0.2	0.2												
	Limnesiidae (Genus) Limnesia						0.5													
	Mideopsidae (Genus) Mideopsis						0.2									0.2	0.4			
	Pionidae (Genus) Forelia							0.1		0.2	0.2						0.2			
	Pionidae (Genus) Piona							0.1									0.2			
	(Order) Prostigmata		0.2				3.0			0.2					0.2	0.8	0.6	1		
	Unionicolidae (Genus) Unionicola					0.2														
Tardigrada	Macrobiotidae (Family) Macrobiotidae										4.6	2.2	3							
Trichoptera	Leptoceridae (Genus) Ceraclea		0.1													0.2		0.2		
	(Genus) Mystacides																			
	(Genus) Oecetis							1.0	0.8	0.2										
	Polycentropodidae (Genus) Polycentropus		0.3																	
Branchiopoda	Cladocera (Family) Bosminidae						0.5								0.2					
	(Family) Macrothricidae						0.1								0.2	0.4	10.2	16.2		
	(Family) Chydoridae	0.1		0.2				0.2							0.4		7.4			
Maxillipoda	Daphniidae (Family) Daphniidae														0.2	0.2	0.2			
	Calanoida (Order) Calanoida														0.2	0.2	0.2			
	Cyclopoida (Family) Cyclopoidae	0.1	0.2	1.6	0.2		3.4	1.0			1.4	3	3.2	3.6		1.2	2.0		0.8	
	(Order) Cyclopoida														3.8	8.8	14.8			
	Harpacticoida (Order) Harpacticoida		0.2				6.9	27.2												

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