RE-DESIGNATION REPORT

Assessment of Benthos (BUI #6) in the Detroit River Canadian Area of Concern

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CONTENTS

LIST OF ACRONYMS

Acronym	Definition
AOC	Area of Concern
BSAF	Biota-Sediment Accumulation Factor
BUI	Beneficial Use Impairment
CODMF	Canada-Ontario Decision Making Framework
COPC	Contaminant of Possible Concern
DCA	Detrended Correspondence Analysis
DDE	Dichlorodiphenyldichloroethylene
DRCC	Detroit River Canadian Cleanup
ECCC	Environment and Climate Change Canada
GLIER	Great Lakes Institute for Environmental Research
HCB	Hexachlorobenzene
HEC	Huron-Erie Corridor
HZD	Sediment Hazard Score
IBI	Index of Biological Integrity
IJC	International Joint Commission
LEL	Lowest Effect Level
LOE	Line of Evidence
MeHg	Methyl Mercury
QCB	Pentachlorobenzene
OCs	Organochlorides
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyl
RAP	Remedial Action Plan
RCA	Reference Condition Approach
RDA	Redundancy Analysis
SEL	Severe Effect Level
TCB	Tetrachlorobenzene
THg	Total Mercury
TOC	Total Organic Carbon
WOE	Weight of Evidence

EXECUTIVE SUMMARY

The Detroit River is an important ecological corridor and waterway for commercial activities, bridging Lake St. Clair and Lake Erie. Bordering the Detroit River, the waterfronts of the cities of Detroit and Windsor are extensively urbanized and industrialized. Historically, pollutant discharges from several point and non-point sources along both shorelines have contributed to significant ecological degradation. Included in the list of discharged pollutants are nutrients (phosphorus, nitrogen) and organic contaminants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), metals (cadmium, arsenic, chromium, mercury) and pesticides. Although provincial/state and Canada/US legislation has restricted the continued discharge of many of these pollutants, legacy contaminants persist throughout surface sediments of the Detroit River Area of Concern (AOC).

The overall purpose of this report is to provide recommendations on the state of the *Degradation of Benthos* Beneficial Use Impairment (BUI), within the Canadian waters of the Detroit River AOC.

The delisting criteria for the Degradation of Benthos Beneficial Use Impairment are:

a) "When the benthic community composition is temporally and spatially identified as non-impaired based on an objective and quantitative community analysis and/or a comparison to appropriate reference sites within the river,
   and
b) When benthic organisms analyzed for persistent, bioaccumulative substances (e.g., PCBs and mercury) are below thresholds to protect fish and wildlife."

A weight of evidence approach was employed to examine the state of the Degradation of Benthos BUI. This report examined four key lines of evidence: sediment chemistry, biomagnification potential, sediment toxicity, and impairment of benthic community composition. Data quality corresponding with each line of evidence was variable, as reliable sediment chemistry data was available from as recently as 2013, while biomagnification potential and sediment toxicity data was only as recent as 2008, and benthic community composition was only available from 1999 and 2001. Two key assumptions were made relating sediment chemistry and benthos impairment: 1) sediment contaminants are the primary driver of biological impairment, and 2) through a combination of a reduction in Contaminants of Potential Concern (COPC) discharge and natural remediation processes (e.g., sedimentation), the quality of surface sediments have improved over time. Based on these assumptions, impairment thresholds observed for each line of evidence were related back to sediment chemistry, which was then applied to the 2013 sediment chemistry dataset, to predict contemporary conditions.

Based on this approach and summation of multiple lines of evidence, the following can be stated with a reasonable level of confidence:

- Surface sediment COPC concentrations reached a maximum on both the Canadian and US sides of the river in the early 1990s.
- Surface sediment COPCs have declined steadily from 1999 to 2013, with only a single Canadian site (DR10) exceeding SEL guidelines of the 82 Canadian sites examined between 2008 and 2013.
- Based on the surface sediment COPC concentration trends, it is likely that COPC concentrations have continued to decrease from 2013 to present. There has also been no known source of contaminants on the Canadian side of the river since 2013.

- The highest concentration of surface sediment COPCs is observed on the US side (downstream of Belle Isle to the outflow of the Trenton Channel). Generally, lower surface sediment COPC concentrations exist on the Canadian side, and are focused around the Amherstburg waterfront.
- Due to relatively low amounts of total PCB concentrations on the Canadian side, it is unlikely that sediment PCBs pose a great risk to bioaccumulation potential.
- Site hazard scores (HZD), an index approach to summarizing the cumulative effects of COPCs, can be used to determine community composition impairment. The lowest sediment COPC concentration where evidence exists of community composition impairment was HZD = 44. In 2013, only one Canadian site, DR10 (CA), was found to exceed this HZD threshold (HZD = 333). Based on the sediment chemistry, as well as the sediment toxicity thresholds and community composition thresholds, it is possible that in 2013, DR10 (CA) would have demonstrated biological impairment.
- The remaining 36 Canadian sites from the 2013 survey are likely unimpaired.

Additionally, it was found that sites DR10 (CA), DR11 (CA), DR16 (CA), DR34 (CA), DR44 (CA) and DR49 (CA) all had sediment total mercury concentrations greater than the minimum value observed in a site where benthos tissue methylmercury concentration exceeded Canadian Council of Ministers of the Environment (CCME) guidelines. As a result, although there is no direct evidence to demonstrate bioaccumulation, these sites are at an increased risk of impairment due to bioaccumulation. More broadly, sediment COPCs throughout the Canadian portion of the AOC, remain above background concentrations, and will likely continue to remain elevated for the foreseeable future. With the exception of those sites list above, these elevated COPC concentrations are not expected to demonstrate any observable impairment on the biological processes and systems occurring at these sites.

The Detroit River Stage 2 Remedial Action Plan (RAP) report prescribes the conditions which must be met in order to consider a BUI for delisting as well as the contextual framework with which decisions are to be made. Within this framework, it is acknowledged that the delisting of BUIs should be based on the degree of impairment across the whole of the Canadian portion of the AOC, rather than reliance on eliminating all potential local hotspots within the AOC (Green et al. 2010). It is clear, from the findings of this report, potential benthos impairment, is highly localized, with the vast majority of the Canadian portion of the AOC demonstrating no evidence of biological impairment, and that sediment COPCs are below provincial severe effects levels (SELs). In addition to the in-river dynamics, it is acknowledged that the Detroit River AOC is located with a highly urbanized area, and as a result it is not expected that a recovered benthos community would be comparable to a pristine or unimpacted community. Viewing the results of this report through this lens, the overall benthos community of the Canadian waters of the Detroit River AOC meets the conditions for BUI delisting.

The Detroit River is a dynamic and changing system. Regulation of COPC inputs into the Detroit River has led to a recovery in sediment quality throughout the AOC over that past 20 years. However, given the cultural, ecological, and functional importance of the Detroit River, continued monitoring is important to ensure the continued recovery of ecology integrity. Specifically, it is recommended that baseline monitoring and assessment of benthic community composition and contaminant concentration be conducted in at least 10-year intervals, in parallel with AOC-wide sediment chemistry surveys.

1.0 INTRODUCTION

The Detroit River, connecting Lake St. Clair and Lake Erie, is part of the Huron-Erie Corridor (HEC). The Detroit River is a 51 km binational channel, between the State of Michigan (United States) and the Province of Ontario (Canada). Approximately 95% of the total Detroit River flow is supplied from the outflow of Lake St. Clair, with the remainder draining eight tributaries (UGLCCS 1988). The average velocity of the river ranges between 0.3 and 0.6 m/s with a 21 h residency time (UGLCCS 1988).

The Detroit River is used for commercial and industrial activities, including a heavily used shipping channel. The river is a drinking water source for the cities of Windsor and Detroit and receives both industrial and municipal wastewater. The shorelines of the Detroit River are heavily urbanized and industrialized along the waterfronts of Detroit (west shoreline) and Windsor (east shoreline; McPhedran and Drouillard 2013).

Historically, pollution discharges from point and non-point sources including industrial sites and wastewater treatment facilities along both Canadian and American shorelines contributed to significant ecological degradation (McPhedran and Drouillard 2013). Included in the list of discharged pollutants are nutrients (phosphorus, nitrogen) and contaminants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), metals (cadmium, arsenic, chromium, mercury) and pesticides. Although provincial/state and Canada/United States legislation has restricted the continued discharge of many of these pollutants, legacy contaminants persist throughout sediments of the Detroit River AOC.

Acknowledging environmental and ecological degradation caused by these pollutants, in 1987, the Great Lakes Water Quality Agreement was amended by Protocol to include Great Lakes Areas of Concern (AOC). AOCs are areas that have undergone changes to their chemical, physical, or biological integrity due to human activities (IJC 1991). These changes are characterized by 14 beneficial use impairments (BUIs) which include, but are not limited to, beach closings, fish and wildlife consumption restrictions and degradation of benthos – the subject of this report. To facilitate the remediation of the Detroit River AOC, a remedial action plan (RAP; facilitated by the Detroit River Canadian Cleanup (DRCC)) was developed to address the BUIs. Within the RAP for each AOC, “delisting criteria” and guidance principles were established to identify when BUIs can be re-designated to “not impaired”. Once all BUIs are listed as “not impaired”, an AOC can be considered for delisting from the AOC designation.

The delisting criteria for the Degradation of Benthos Beneficial Use Impairment are (DRCC 2013):

“When the benthic community composition is temporally and spatially identified as non-impaired based on an objective and quantitative community analysis and/or a comparison to appropriate reference sites within the river.

and

When benthic organisms analyzed for persistent, bioaccumulative substances (e.g., PCBs and mercury) are below thresholds to protect fish and wildlife.”

Several benthos related studies have been conducted within the Detroit River AOC. McPhedran and Drouillard (2013) provide a full review of studies examining the relationship between sediment contaminant concentration and Detroit River benthos dating from 1984-2013. This report focuses on data from four extensive monitoring events conducted by the Great Lakes Institute for Environmental

Research (GLIER) in 1999, 2008, and 2013 as well as an additional study conducted by Environment and Climate Change Canada (ECCC) in 2001. During these sampling events, information regarding sediment contaminant concentration, benthic invertebrate contaminant concentration, and benthic community composition were collected. Additionally, supporting information was provided by Thornley and Hamdy's 1980 assessment of the Detroit River. Although data provided by Thornley and Hamdy's assessment provides a strong historical record of benthic conditions, benthic community data collected from before 1988 does not include the impact of *Dreissena* on the ecosystem, which was first detected in 1988. As a result, data from the Thornely and Hamdy's 1980 assessment will only be used to provide limited support in the analysis.

The present report builds off the most recent state of knowledge report (McPhedran and Drouillard 2013) and provides an assessment of contemporary benthic and sediment monitoring data to update the status of the BUI. This report focuses on data from three extensive monitoring events conducted by the Great Lakes Institute for Environmental Research (GLIER; 1999, 2008, 2013), in which information regarding sediment and benthos contaminant concentration and benthic community composition were collected (GLIER 2002; Drouillard 2010; GLIER unpublished). Data analyzed in this report was collected and processed following the methodology outlined in Farara and Burt (1993), GLIER (2002), Milani and Grapentine (2008), Drouillard (2010), and Drouillard et al. (2015).

The first section of this report provides a historical context of the Detroit River AOC, focusing on previous studies detailing the status of benthos conditions. The second section of this report provides a contemporary assessment of the *Biomagnification Potential*, *Assessment of Sediment Toxicity*, and *Assessment of Benthic Community Structure*. For each Line of Evidence (LOE), impairment thresholds linked to sediment contamination are developed and applied to the 2013 dataset as a method of assessing contemporary conditions. Finally, the findings of each LOE, represented by the measure of various benthos integrity, are synthesized and used to provide overall recommendations to Environment and Climate Change Canada on the status and re-designation potential for the *Degradation of Benthos* BUI in accordance with the delisting criteria.

1.1 Historical Context

Thornley and Hamdy (1984) – An Assessment of the Bottom Fauna and Sediments of the Detroit River

1980 AOC-wide assessment of sediment quality and benthos community composition with comparisons to the 1968 river-wide assessment

Thornley and Hamdy (1984) performed a comparison of benthos surveys of the Detroit River from 1968 and 1980, respectively. Their key finding was the observation of significant dissimilarities in benthic community composition between the Canadian and American shorelines. Benthos community structure along the Canadian shoreline was found to be indicative of satisfactory conditions. Furthermore, in a comparison between 1968 and 1980 samples, the increased presence of *Hexagenia* mayflies suggest a recovery in surface sediment quality and habitat. Benthos community structure observed along the American shoreline demonstrated characteristics of serious impairment, with the community being dominated by tolerant taxa. The marginal increase in mayflies between 1968 and 1980 along the American shoreline, suggest that while sediment quality may have improved, sediments remain largely impaired.

Farara and Burt (1993) – Environmental Assessment of Detroit River Sediments and Benthic Macroinvertebrate Communities -1991

1991 AOC-wide assessment of sediment quality and benthos community composition, with comparisons to 1980 AOC-wide assessment

Farara and Burt (1993) were commissioned to conduct a detailed analysis of benthos community composition and sediment quality throughout the Detroit River AOC. This assessment was intended to provide an update on the overall status of the benthos BUI within the Detroit River AOC, following up on the work conducted by Thornley and Hamdy (1984) in 1980. Within Canadian waters, only 3 of 37 sites sampled were found to have contaminant exceedances of Ontario Severe Effect Levels (SELs; Ontario, 2016). Conversely, 24 of 40 sites sampled along the American shoreline had one or more contaminants greater than SELs. Benthos within Canadian waters demonstrated no apparent evidence of severe impairment, while a few moderately impaired areas along the Windsor and Amherstburg waterfronts were observed. Within American waters, an area of severe benthos impairment was observed extending downstream from the outlet of the Rouge River to the outlet of the Trenton Channel. Additionally, an area of moderate benthos impairment was observed extending from upstream of Belle Isle downstream to the outlet of the Rouge River. Overall, it was found that in comparison to the 1980 Thornley and Hamdy (1984) assessment, the extent of impairment within the Detroit River AOC had not declined, with evidence from both sediment quality and benthos community structure suggesting that overall environmental quality within the AOC did not improve markedly between 1980 and 1991.

GLIER (2002) – 1999 AOC-wide assessment of sediment quality and benthos community composition

GLIER (2002) conducted an AOC-wide assessment of sediment quality and benthos community composition as part of the larger Detroit River Modelling and Management Framework Interpretive Report. Similar to previous work conducted by Thornley and Hamdy (1984) and Farara and Burt (1993), it was found that a greater number of sites within American waters exceeded Ontario SEL guidelines (14/76), compared to Canadian sites (9/74). Assessment of benthos community composition suggested that communities can be divided into three groups: Type 1 – Chironomidae, nematode, mayfly and Oligochaete – dominated; Type 2 – Oligochaete; Type 3 – Bivalvia and amphipod – dominated. Community Type 2 comprised of mostly tolerant taxa, was found throughout the highly contaminated Trenton Channel, suggesting evidence of impairment. However, this study also found the much more sensitive Community Type 1 downstream of the Trenton Channel, where concentrations of mercury and PCBs exceed those found in the Trenton Channel. As a result, no clear stressor trends could be observed, as a driver of benthos community composition.

Milani and Grapentine (2008) – 2001 Assessment of sediment quality, bioaccumulation, benthos community composition and sediment toxicity.

Milani and Grapentine (2008) employed the Canada-Ontario Decision-Making Framework for Contaminated Sediment to assess the state of the AOC using a weight of evidence approach combining sediment chemistry, sediment toxicity, bioaccumulation, and benthos community structure. Using samples from 16 sites in both Canadian and American waters, eight sites (5/11 Canadian Sites; 2/5 American Sites) were found to demonstrate a risk of mercury and/or PCB bioaccumulation, warranting further assessment. Additionally, one American site was found to have bioaccumulation, degraded benthic community, and sediment toxicity, warranting direct management action. The benthic community, assessed using the BEAST model (Reynoldson et al. 1995), was found to be mildly degraded at one American site downstream of Belle Isle, however the authors caution that due to the unique habitat characteristics observed at 10 of the 16 sites, comparisons to Great Lakes reference condition established by the BEAST approach may not be appropriate.

Drouillard (2010) – AOC-wide assessment of sediment quality, bioaccumulation, sediment toxicity and low resolution benthos community composition

Drouillard (2010) examined 65 stations through both the Canadian and American sides of the Detroit River AOC. The focus of this assessment was to update the spatial patterns of COPCs, determine the relative change in COPCs extent compared to the 1999 GLIER sediment quality survey results, assess the bioavailability of sediment-associated pollutants to benthic invertebrates (Hg and PCBs), and assess relations between sediment chemistry and sediment toxicity. Similar to previous studies, Drouillard (2010) found high levels of PCBs at a large number of American sites. Only six sites were found to exceed Ontario SELs for all COPCs, of which all were found in U.S. waters. None of the sites examined were found to demonstrate sediment toxicity during Chironomidae survival or growth bioassay. Benthic invertebrates from four of 22 American sites were found in excess of the CCME Tissue Residue Quality Guidelines for the Protection of Aquatic Biota for PCBs. None of the 17 Canadian samples were found in excess of this threshold. One of the five Canadian samples and three of nine American samples examined for methylmercury were found to exceed the CCME guideline. Overall the number of SEL exceedances in Canadian waters decreased from 1999 to 2008.

Drouillard et al. (2014) – 2013 AOC-wide assessment of sediment quality and benthos community composition

Drouillard et al. (2014) examined 73 stations throughout the AOC in 2013, updating sediment chemistry maps as well as collecting limited benthos community composition samples. Sediment contaminant assessment revealed a reduced number of SEL exceedances compared to 1999 and 2008, with only one site in Canadian waters exceeding SEL for any COPC. Benthos data failed to indicate significant differences in community composition between sites categorized by sediment contaminant levels. Overall sediment contaminants were found to be spatially limited and focused on locations along the U.S. shoreline. At the time of publication, the full sediment and habitat summary were not available, as a result, it was recommended that conclusions drawn from this report be treated as preliminary.

1.2 Synthesis Reports

McPhedran and Drouillard 2013 – Review of the Degradation of Benthos Beneficial Use Impairment in the Detroit River and St. Clair River Areas of Concern

The purpose of this report was to provide recommendations on future research needs to achieve re-designation for the Degradation of Benthos BUI in the Detroit River and St. Clair River AOCs. This report provided a comprehensive overview of all of the known previous studies within the Huron-Erie Corridor (HEC). Additionally, based on a meta-survey of the studies from each AOC, the BUI status was evaluated following the CODMF for the assessment of contaminated sediments. McPhedran et al. (2013) found that the St. Clair River AOC should remain listed as impaired due to a lack of suitable reference sites, restricting the ability to adequately assess the state of impairment. Similarly, it was found that the Detroit River AOC should also remain listed as impaired as no specific attempt has been made to determine ‘reference’ sites within the Detroit River and as a result, potentially impaired sites cannot be adequately assessed. Based on these findings it was recommended that further monitoring be conducted throughout the HEC.

1.3 Knowledge Gaps

The McPhedran and Drouillard (2013) report captured the growing knowledge base demonstrating improvements in sediment quality on both sides of the Detroit River. Two locations along the American shoreline (Area 1: Upstream of Belle Isle, downstream to the outlet of Rouge River; Area 2: Outlet of Rouge River downstream past the outlet of the Trenton Channel), remain as important areas of high sediment COPC concentrations. Previous studies, however, have faced several challenges, limiting their ability to compare benthos impairment to the BUI delisting criteria. Chief among the concerns, is that due to widespread historical impacts of COPCs, there has been great difficulty defining a suitable reference condition to compare potential impairment against. Additionally, AOC-wide assessment of sediment toxicity has been limited by the number and sensitivity of endpoints. While assessment of sediment toxicity is not directly referenced in the Detroit River Degradation of Benthos BUI delisting criteria, it is generally viewed as an important line of evidence for the assessment of benthos impairments within AOCs. As a result, the assessment of more sensitive endpoints is an important line of evidence in the evaluation of benthos impairment. Finally, it is recognized that the analysis of bioaccumulation potential is challenged by examining only benthos, rather than including high trophic orders. The CCME Tissue Residue Guidelines for the Protection of Wildlife Consumers and Aquatic Biota (CCME 1999), presents a suitable threshold for evaluating the risk bioaccumulation presents to higher tropic organisms. As a result, it is important that this line of evidence be explored in the evaluation of benthos impairment.

The following key factors are incorporated into this report, to address the identified knowledge gaps and assess the Degradation of Benthos BUI for the Detroit River AOC:

Sediment Toxicity

- Additional endpoints, including those deemed more sensitive, should be included in the analysis of sediment toxicity.

Bioaccumulation Risk

- Benthos tissue residues should be compared to a more practical guideline for assessing risk, such as the CCME Tissue Residue Guidelines for the Protection of Wildlife Consumers and Aquatic Biota.

Benthos Community Composition

- Individual sites should be compared to a reference condition or range which has demonstrated no biological impairment as a result of COPCs.
- Analysis of sites and definition of reference condition should be stratified based on physical habitat conditions, which may impact community composition, but are independent of COPCs.

Synthesis

- Recommendations should be based on a weight of evidence approach which incorporates contemporary data (where available) and is supported by long term trends.

1.4 Project Scope

The objective of this report is to build upon the previous synthesis conducted by McPhedran et al. (2013) and address identified knowledge gaps. Specifically, this report will use available data to further evaluate that state of the Degradation of Benthos BUI within Canadian waters of the Detroit River AOC.

This report will evaluate impairment within the Canadian waters of the Detroit River AOC, based on the BUI delisting criteria. As a result, the evaluation of the state of the BUI will focus on examining:

- Impairment of community composition, on temporal and spatial scales, with a comparison to suitable non-impaired reference sites.
- Evaluation of the risk which persistent, bioaccumulative substances (e.g., PCBs and mercury) in benthos tissue residues, present to fish and wildlife.

Given that there is limited confidence in the strength of the 2013 benthos community composition results, the understanding of contemporary conditions will be based on data collected from 1980, 1999, 2001, and 2008 (Appendix A). Data from these older studies will develop baseline understandings of the relationship between sediment chemistry and biological response. This relationship will then be used to estimate more contemporary biological conditions using the more reliable sediment chemistry from 2013.

Additionally, sites within US waters will not be included as part of the final evaluation, however, where appropriate US sites will be used to provide context and develop historic trends. Sediment chemistry and toxicity although not currently listed in the BUI delisting criteria, will also be discussed to provide additional context.

A weight of evidence will be used to re-evaluate the state of the BUI based on the historical trends and contemporary data. Based on the weight of evidence, recommendations will be made whether the BUI should remain listed as impaired, changed to unimpaired, or whether insufficient evidence exists to fully evaluate the BUI with respect to the BUI criteria.

Two key assumptions were made relating sediment chemistry and benthos impairment: 1) sediment contaminants are the primary driver of biological impairment, and 2) through a combination of a reduction in COPC discharge and natural remediation processes (e.g., sedimentation), the quality of surface sediments have improved over time. Based on these assumptions, impairment thresholds observed for each line of evidence will be related back to sediment chemistry, which can then be applied to the 2013 sediment chemistry dataset, to predict contemporary conditions.

2.0 SPATIAL AND TEMPORAL ASSESSMENT OF SEDIMENT CONTAMINANTS

Elevated levels of several sediment contaminants have been observed throughout the Detroit River AOC as a result of historic pollutant discharges along both the Canadian and American shorelines. These legacy contaminants have been identified as the primary driver of a number of historic and contemporary ecological impairments within the Detroit River AOC. Thirteen priority contaminants: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, hexachlorobenzene (HCB), dichlorodiphenyldichloroethylene (DDE), polychlorinated biphenyl (PCB), and polycyclic aromatic hydrocarbons (PAHs), represent the key contaminants of primary concern (COPCs). Many of these 13

COPCs exist naturally in the environment in trace amounts, however, observations of elevated concentrations are principally a result of anthropogenic discharges. Furthermore, each of these 13 COPCs has demonstrated toxic effects, resulting in biological impairment at high levels. Table 1, outlines the Lowest Effects Level (LEL) where the most sensitive taxa may experience adverse effects, and Severe Effect Level (SEL), the point where broad ecological detriment may begin to be observed, as described by the Ontario Provincial Sediment Quality Guidelines (Fletcher et al. 2008).

Table 1. Overview of the Ontario Provincial Sediment Quality Guidelines for each of the 13 COPC examined

	COPCs (μg/g)												
	As	**Cd**	**Cr**	**Cu**	**Fe %**	**Pb**	**Hg**	**Ni**	**Zn**	**HCB**	**DDE**	**PCB**	**PAH**
LEL	6	0.60	26	16	2	31	0.20	16	120	0.02	0.01	0.07	4.00
SEL	33	10	110	110	4	250	2	75	820	0.24	0.19	5.3	100

Beginning in 1999 and continuing until the 2013 sampling period, there has been a general decline in SEL exceedances in both the Canadian and American waters. Furthermore, since the 1999 sampling event, only one of 81 sites (DR10 (CA)) has exceeded SEL on the Canadian side (Table 2). There have been no known sources of contaminants on the Canadian side of the Detroit River since 2013.

Table 2. Summary of SEL exceedances observed in samples collected from 1999-2013 within the Detroit River AOC

	1999		2001		2009		2013	
	SEL Exceedances	**Sites Surveyed**	**SEL Exceedances**	**Sites Surveyed**	**SEL Exceedances**	**Sites Surveyed**	**SEL Exceedances**	**Sites Surveyed**
Canada	9	74	0	10	0	34	1	37
United States	14	73	2	6	6	39	3	37

Examination of all SEL exceedances observed between 1999 and 2013 agree with the previous findings of Thornley and Hamdy (1984), which note the most significant zones of contaminant accumulation along the American shoreline upstream of Belle Isle downstream past the outlet of Trenton Channel. Furthermore, the SEL exceedance observed in 2013, falls just within the Canadian border downstream of Belle Isle (Appendix A).

Individually, COPCs represent important drivers of stress, however, it is possible that the COPCs may have synergistic or additive effects when co-occurring, resulting in detrimental effects below the SEL for any single COPC. McPhedran et al. (2016) recommend the use of the Hazard Score Approach (HZD) as an index approach to summarizing the cumulative effects of COPCs at a given site. The HZD approach assigns an effect value for each contaminant observed based on the relationship between the observed sediment chemistry concentration and the theoretical toxicity curve. These effect values are then summed to produce the overall hazard score for each site (Equation 1).

Equation 1 - Method of summarizing COPCs into a single comparable score representing overall sediment contaminant concentration.

$$HZD = \sum Effect\ (\%) = \frac{100}{1 + (A \cdot e^{-kC})} - \sum E_c$$

Where *Effect* (%) is the anticipated benthic community response associated with the loss of sensitive species, *A* is a constant that determines the curvature of the dose-response curve, *k* is the chemical-specific toxicity coefficient and *C* is the measured sediment chemical concentration. E_c is the residual effect predicted when a contaminant concentration is 0. In this report, *A*, *k*¸ and E_c, were generated for each priority chemical as part of the Ontario sediment quality guidelines (Fletcher et al. 2008).

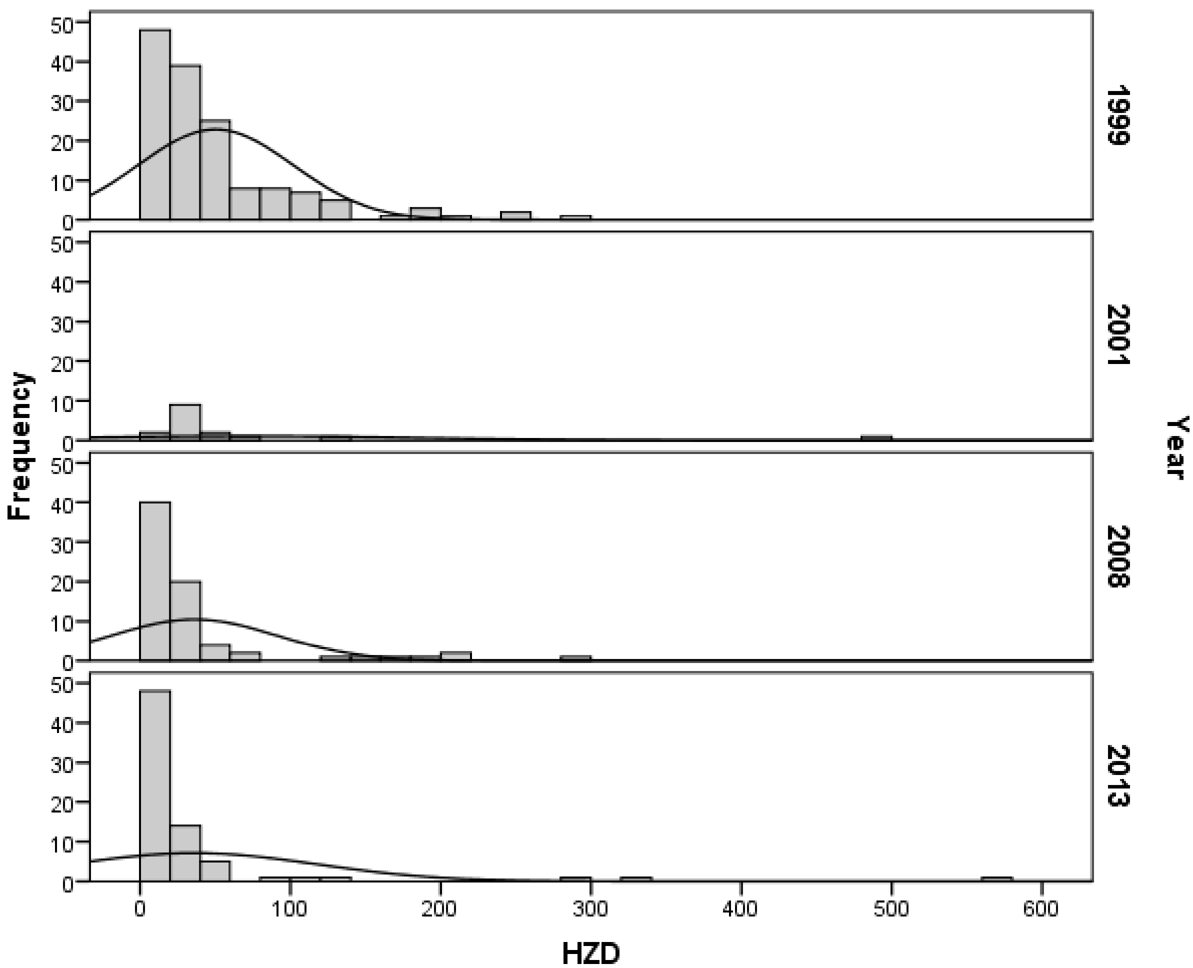

Figure 1. Distribution of HZD scores from 1999-2013 sampling events

The HZD score provides a single dimensional stressor value which is used in the assessment of detriment with respect to overall contaminant concentrations. The distribution of HZD scores has demonstrated continual decrease from 1999 until 2013, suggesting an overall decrease in COPC abundance within the Detroit River AOC (Figure 1).

3.0 ASSESSMENT OF BIOACCUMULATION POTENTIAL

Biomagnification potential refers to the likelihood that contaminants found in benthos will be transferred to its predators and further up the food web, resulting in contaminant concentrations that exceed acceptable fish tissue criteria for the protection of aquatic life or fish consumption criteria for human consumers. Typically, contaminants of concern are those that are retained within an organism, either in lipids (e.g., hydrophobics such as PCBs) or proteins (e.g., methylmercury) and can persist within the environment and individuals.

Mixed benthos tissue residue samples collected in 2008 and 2013, following methods outlined in Drouillard (2010), examined the relationship between benthos contaminant body burdens and sediment quality. In 2008, 57 samples were collected to examine PCB bioaccumulation. A t-test comparing the ratio between benthos tissue residue concentration and sediment concentration (Biota-Sediment Accumulation Factor - BSAF) of PCBs showed that values are not significantly different between American waters (2.4) and Canadian waters (2.2) (p-value = 0.889). Similarly, a t-test comparing the 14 mercury and methylmercury samples collected in 2013, also demonstrated no significant difference between Canadian sites (THg: 1.22; MeHg: 86.7) and American sites (THg: 2.06; MeHg: 123.0) (THg p-value = 0.169; MeHg p-value = 0.289). As the BSAFs for PCBs, mercury and methylmercury were found to be greater than 1, these contaminants have the ability to accumulate within high trophic organisms.

Mercury in the form of methylmercury is much more bioaccumulative and bioavailable compared to total mercury. As a result, methylmercury poses a much greater direct risk to food webs. Both methylmercury and PCB concentrations observed in benthos tissue residues were compared to the CCME Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota. Table 3 illustrates the CCME guidelines for methylmercury and PCBs. CCME guidelines for PCBs are reported in dioxin-like equivalents calculated by multiplying congener specific toxic equivalency factors (TEFs) by the concentration of the same PCB congener present in the sample and summing the quotient across all dioxin-like compounds. There are 12 dioxin-like PCB congeners recognized in the CCME PCB guidelines. Unfortunately, not all of the dioxin-like congeners were measured in the benthic invertebrate samples as dioxin-like compounds require specialized analytical methods. In order to convert the CCMR TEF equivalent guideline to a sum PCB concentration, the conversion factor reported by Bhavsar et al. (2007) was used. This conversion factor was generated to estimate dioxin like TEQs from total PCB concentrations measured in Great Lakes fish based on Ontario's Ministry of Environment, Conservation and Park's fish contaminant surveillance program. The relationship is given by:

$$TEQ_{(\text{dioxin-like PCB})} = 2.56 \times 10^{-5}\, C_{(\text{sum PCBs})}$$

Where $TEQ_{(\text{dioxin-like PCB})}$ and $C_{(\text{sum PCBs})}$ are given in concentration units of ng TEQ/kg and ng sum PCB/kg, respectively. The unit of ng sum PCB/kg was further converted to conventional concentration units of µg/g wet weight by dividing by a value of 1,000,000.

Table 3. Canadian Council of Ministers of the Environment (CCME) Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota for PCBs and methylmercury.

	PCBs (ng · TEQ/kg)	PCBs (µg sum PCB/g)[1]	MeHg (µg/g)
Mammalian	0.79	0.031	0.033
Avian	2.4	0.094	0.033

[1] PCBs in ng TEQ/kg converted to µg/g sum PCB according to Bhavsar et al. (2007)

The concentration of PCBs within sediments on the Canadian side is lower than that of the American side. This is largely due to a lower amount of PCBs historically discharged from industry along Canadian shoreline, compared to the industrialized Detroit waterfront, where PCBs were heavily utilized. As a result, tissue residues of PCBs in benthos collected in Canadian sites were all found below the CCME guideline (Table 4). The exceptions were 2 samples (8% of Canadian samples measured) collected from the same location (DR 3) in the upper Canadian waters where a sample of mayfly and mixed benthic composition had PCB concentrations exceeding the mammalian CCME guideline but below the Avian guideline. All other benthic samples collected in Canadian waters were below the PCB CCME guideline.

Table 4. Summary of exceedances of CCME guidelines for US and Canadian sites, for PCBs (2008) and methylmercury (2013).

	PCB		MeHg	
	Exceedances	Total Sites (Samples)	Exceedances	Total Sites
Canada	2	12 (25)	1	7
United States	13	12 (32)	3	7

A significant correlation between PCBs observed in sediments and tissue residues was observed (R = 0.85; p-value <0.001; Figure 1). Based on the linear relationship between sum PCB in sediment and benthos from Figure 2, a threshold sediment concentration of 0.074 ug/g dry weight has a likelihood of generating benthos PCB bioaccumulation above CCME guidelines. For the 2013 sediment survey, only 1 of 33 Canadian survey stations exceeded this threshold (DR 49) while 20/40 (50%) of US survey stations exceeded the threshold.

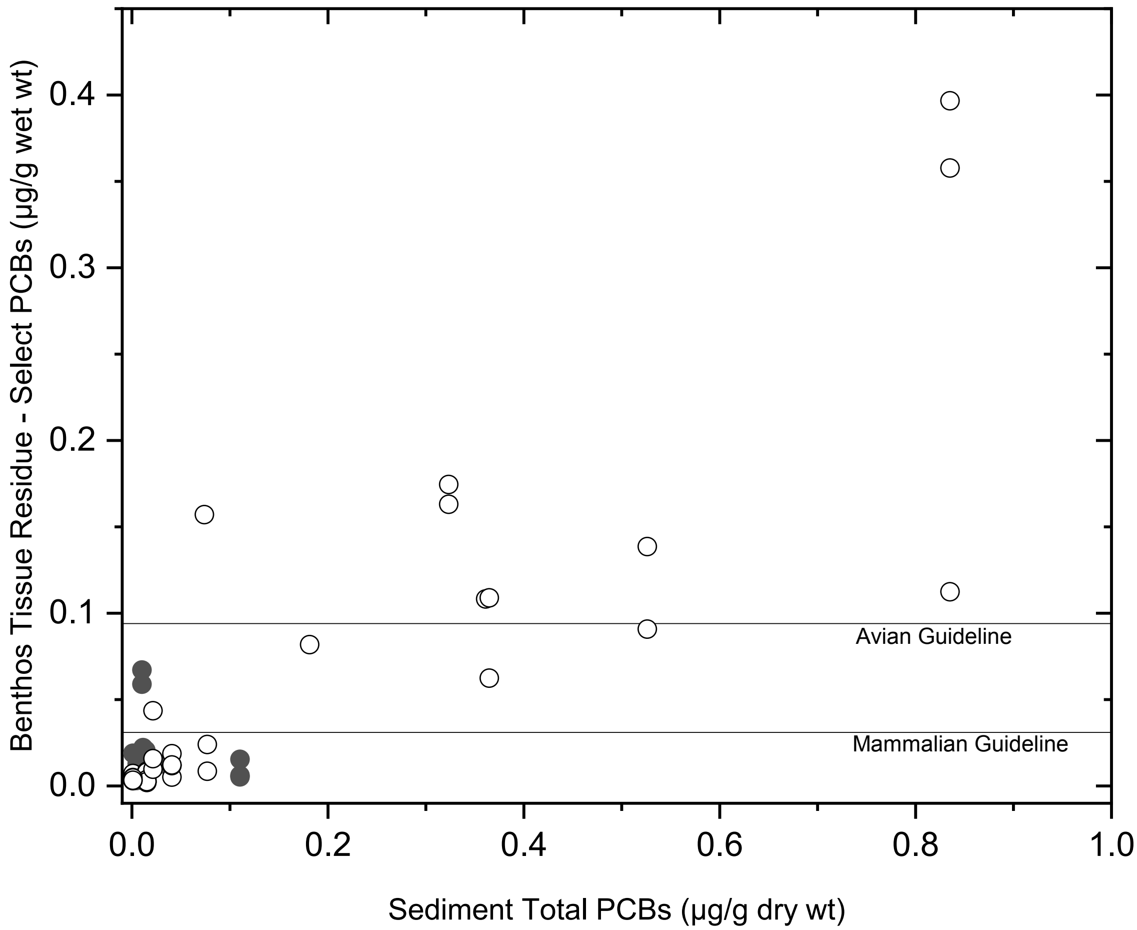

Figure 2. The relationship between total PCBs observed in sediments and select PCBs (based on CCME guidelines), observed in benthos tissue residues for Canadian sites (solid circles) and US sites (open circles)

Methylmercury is the most relevant form of mercury for assessing bioaccumulation in aquatic systems. Methylmercury strongly binds to proteins allowing for easy accumulation and retention within organisms. One of the seven sites examined within the Canadian portion of the AOC (DR47 (CA)) was found to exceed the CCME guideline for methylmercury. Site, DR47 (CA), has a low overall toxicity HZD score (16.27) and does not exceed SELs for any of the COPCs. However, the site does exceed the LEL for total mercury, with a sediment concentration of 0.24 µg/g. This represents the site with the fourth highest total mercury in the sediment, of the sites examined for tissue residue in 2013. Sites DR62(US), DR23(US), DR60(US), and DR47(CA) have benthos methylmercury tissue values above CCME guideline (0.033 µg/g). The remaining ten sites were found to have benthos methylmercury tissue values below CCME guideline. Of the samples collected in 2013, six Canadian sites have sediment mercury concentrations higher than DR47 (CA) (0.24 µg/g), with the highest observed site DR10 (CA) having a sediment total mercury concentration of 0.85 µg/g (Figure 3).

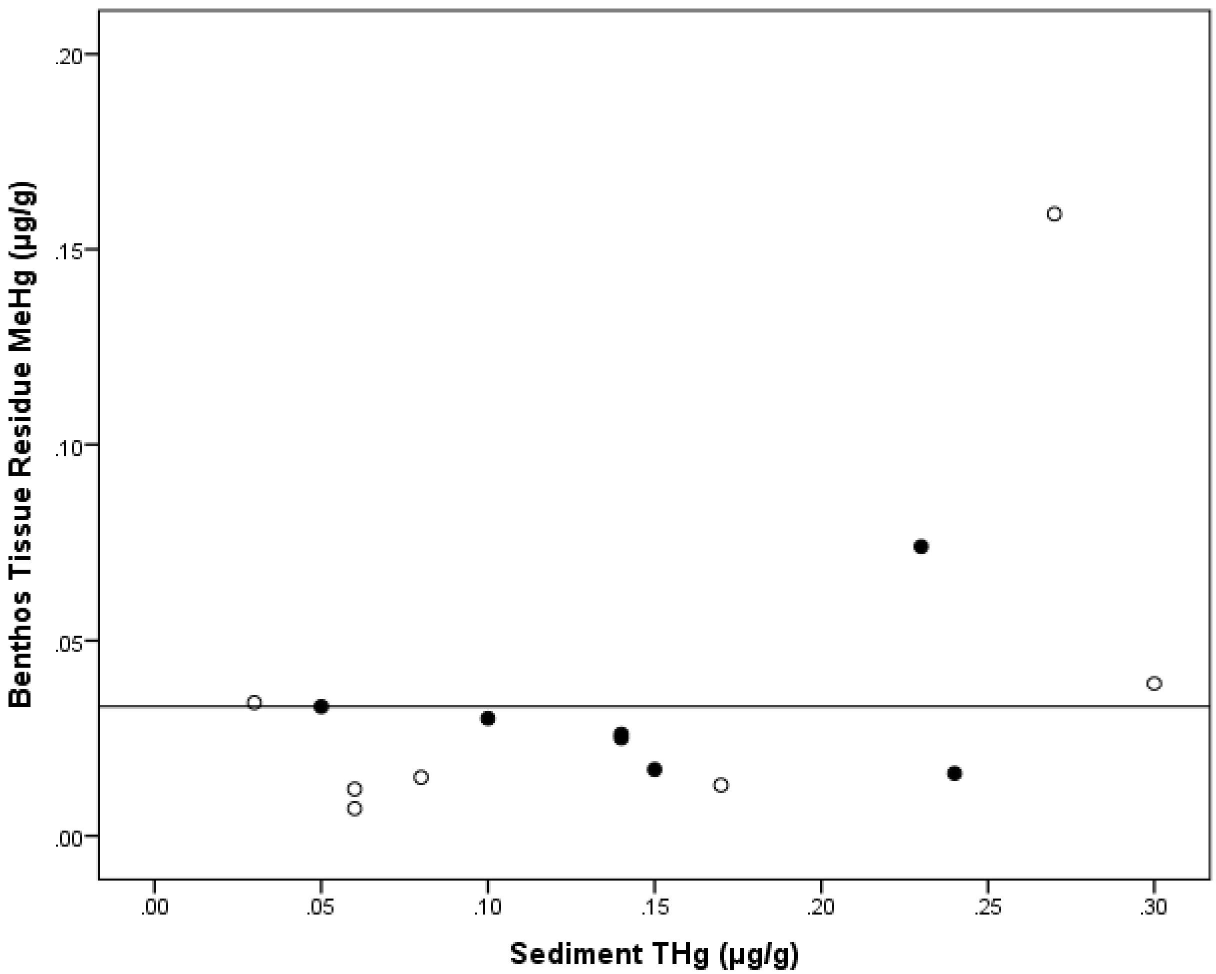

Figure 3. The relationship between 2013 sediment total mercury and 2013 benthos tissue residue methylmercury, for Canadian sites (solid circles) and US sites (open circles)

3.1 Sediment Toxicity

Sediment toxicity although not directly referenced in the Detroit River Benthos BUI criteria, is an important line of evidence in understanding the impacts of sediment contamination, as it is an underlying driver of ecosystem function. Furthermore, sediment toxicity is an important pillar of evaluation in the CODMF which is used widely to assess other Canadian AOC sites within the Great Lakes basin.

Bioassays were conducted in 2001 and 2008 examining a range of endpoints. In 2001, ECCC examined 17 sites within the Detroit River AOC, assessing: *Chironomus riparius* growth, *Chironomus riparius* survival, *Hyallela azteca* growth, *Hyallela azteca* survival, Hexagenia *sp.* growth, Hexagenia *sp.* survival, *Tubifex tubifex* reproduction (number of cocoons per adult), *Tubifex tubifex* reproduction (percentage of cocoons hatched), *Tubifex tubifex* reproduction (number of young per adult), and *Tubifex tubifex* survival. Only site 6678 (US) was found to have endpoints which deviated from the established reference condition. For this site, *Hexagenia sp.* growth and survival were observed to demonstrate a toxic response, and *Tubifex tubifex* reproduction (number of young per adult) and survival demonstrated potential toxicity. Site 6678 (US) has a HZD score of 469 and was observed to have SEL exceedances for cadmium, chromium, copper, lead, nickel and zinc. The remaining sites which had HZD scores ranging as high as 131 were not observed to demonstrate evidence of sediment toxicity.

In 2008, GLIER examined 48 sites for *Chironomus riparius* survivorship and 20 sites for *Chironomus riparius* growth, with sites HZD scores ranging as high as 131. None of the sites examined, including sites containing the highest observed contaminant levels were found to have toxic responses. This finding agrees with the 2001 bioassay, which also failed to observe a toxic response with *Chironomus riparius* endpoints with the sediment conditions observed within the Detroit River AOC.

Overall, only site DR24 (US), observed as part of the 2013 sampling event, was found to have a higher HZD score than that of site 6678 (US), which demonstrated toxicity. Although it is uncertain at what HZD score threshold sediment becomes consistently toxic to various invertebrate endpoints, it is expected that the threshold is greater than 131 for sensitive endpoints and greater than 214 for *Chironomus riparius*, as bioassays run at these levels failed to demonstrate a toxic response. Based on these thresholds, sites DR10 (CA), DR21 (US), DR23 (US) and DR24 (US) from the 2013 survey, may experience toxic effects for the most sensitive endpoints, with DR10 (CA) (HZD = 333) and DR24 (US) (HZD = 561), potentially experiencing toxic effects for more tolerant endpoints.

3.2 Community Composition

With respect to the Detroit River Benthos BUI delisting criteria, benthos community composition from all test sites must not differ significantly compared to appropriate reference sites. The Detroit River AOC is relatively unique among the Great Lakes AOCs, as only the St. Mary's River AOC, St. Clair River AOC, Detroit River AOC, and St. Lawrence River AOC serve as connecting channels. As a result, its natural environmental conditions differ significantly from most other AOCs as well as potential reference sites within the Great Lakes themselves. Furthermore, the St. Clair River located approximately 50 km upstream of the Detroit River within the Huron-Eric Corridor, which does feature similar geographic conditions, is unsuitable as a reference for the Detroit River, as it too has faced a long history of sediment contamination. Therefore, to test potentially contaminated sites within the Detroit River, comparisons had to be made to reference sites within the river. This poses a challenge, as arguably the entirety of the Detroit River has experienced some level of contamination over the past 250 years. For many locations within the Detroit River, the persistence of legacy contaminants is basically negligible, but as the legacy effects are somewhat unknown, reference sites within the Detroit River can only be defined as 'best available'.

Benthos community composition data from the 1999 AOC survey was used to evaluate benthos community structure. The 1999 dataset represents the most recent reliable and comprehensive data available. Data collected in subsequent surveys (e.g., 2008 and 2013) did not target the collection of benthos community composition data and did not provide sufficient resolution to be meaningful for this analysis. Additionally, sites from 1980 Thornley and Hamdy (1984) and ECCC 2001 surveys were used to provide temporal comparisons as well as strategic positive and negative controls.

Prior to the assessment of sites based on community composition, all of the potential sites were subdivided based on habitat conditions. Depth, total organic carbon (TOC) and sediment composition (% gravel, % sand, % silt, and % clay) were used to classify sites based on k-means cluster analysis. Using within group sum of squares, four cluster groups were found to be optimal. Table 5 outlines the centroid characteristics of each of the four groups. Appendix E lists the cluster assignment for each site.

Table 5. Summary of mean habitat characteristics for each of the four defined clusters

	Depth (m)	Gravel	Sand	Silt	Clay	TOC
Cluster 1	9.25	23.87	61.82	12.49	2.63	5.14
Cluster 2	11.40	29.24	58.54	10.74	1.58	1.88
Cluster 3	7.48	16.92	51.10	24.99	6.88	3.86
Cluster 4	1.87	2.02	34.27	39.35	24.35	3.44

Community composition for each cluster was also examined with respect to sediment chemistry using Canonical Correspondence Analysis (CCA). This analysis provides insight into community structure as it is driven by the presence of legacy contaminants. Figure 4a-d outline the observed relationship between community composition and sediment contaminants for each of the four clusters.

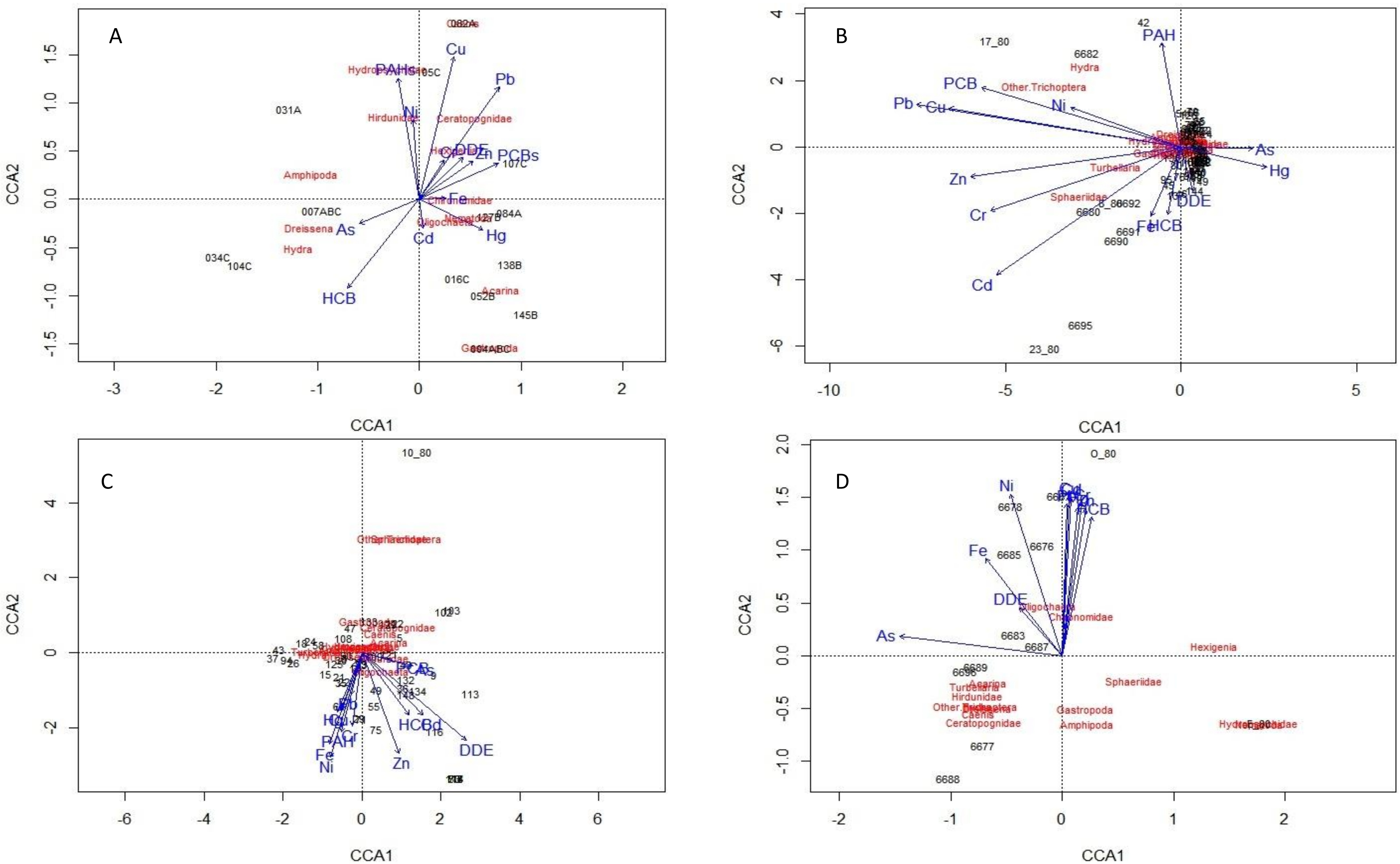

Figure 4. Conical Correspondence Analysis (CCA) showing the relationship between the 13 COPCs and benthic community structure, for Cluster 1 (A), Cluster 2 (B), Cluster 3 (C) and Cluster 4 (D)

15

Generally, for each the four clusters, contaminants are found to be co-occurring. For Clusters 1, 3, and 4, tolerant Oligochaeta are found in greater abundance in sites where contaminant levels (specifically metals like lead, chromium, and copper) are greater (Figure 4). Taxa generally regarded as more sensitive, such as Ephemeroptera demonstrated greater relative abundance in sites where contaminant levels were lower (Cluster 3 and 4). Bivalvia, dominated by the presence of Dreissena in the 1999 and 2001 sample set, as well as Amphipoda, did not show a strong relationship to the observed sediment chemistry, possibly as a result of the importance of localized environmental factors not accounted for in this dataset. Chironomidae, which can serve as either a tolerant or sensitive taxa depending on the species observed, was generally found to occur in greater relative abundance in the presence of moderate or low sediment contaminants.

To further examine the relationship between total sediment contaminant concentration (represented by the HZD score) and individual taxa abundance, non-parametric Spearman correlation analysis was performed. Relationships between sediment contaminants and biological response were evaluated as being: possible (p-value < 0.10), significant (p-value <0.05) or highly significant (p-value <0.01). For Clusters 1, 2 and 3, Chironomidae represented the strongest gradient response to sediment contaminants (Table 6). In each of the clusters, Chironomidae abundance demonstrated a significant negative correlation with an increase in HZD score. Sphaeriidae, was found to demonstrate a significant negative correlation with an increase in HZD score for Cluster 4, however, this trend was driven largely by two sites at opposing ends of the HZD gradient. While this relationship with Sphaeriidae may represent a broader community response, the limited number of sites in Cluster 4 greatly limit the strength of conclusions which can be drawn from this observation.

Table 6. Summary of Spearman's rank correlation analysis, comparing HZD to most responsive taxa for each cluster

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Chironomidae	r_s = -0.541 p – value = 0.046	r_s = -0.320 p – value = 0.023	r_s = -0.294 p – value = 0.012	-
Sphaeriidae	-	-	-	r_s = -0.718 p – value = 0.009

For each cluster, breakpoint analysis using a regression tree (Caskey et al. 2010; Dodds et al. 2010) was used to identify potential biological thresholds in each of the identified taxa as a result of sediment contaminants. For each parameter (e.g., Chironomidae or Sphaeriidae abundances), thresholds were set at the HZD score where the median regression tree decision point was made, provided at least 25 of the cluster sites had a HZD score less than the breakpoint. This analysis identifies the most significant threshold (or step) between values among a distribution. Biological threshold points were identified for each of the significant or potentially significant community parameters.

Using the reference groups established for each habitat cluster and each respective threshold point (Table 7), test sites were evaluated through two methods: 1) Multivariate Community Assessment and 2) Unidimensional Species Assessment. Multivariate Community Assessment was performed using a reference condition approach.

Table 7. Summary of breakpoints identified for each cluster using Regression Tree Breakpoint Analysis. Breakpoints were identified based on the median breakpoint

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Breakpoint	HZD = 55.6	HZD = 35.1	HZD = 34.0	HZD = 28.9

3.3 Multivariate Reference Condition Approach

Multivariate reference condition was established by actively plotting reference sites using a Detrended Correspondence Analysis (DCA). Confidence ellipses were plotted around the reference sites to identify the extent of the reference condition. Three confidence ellipses based on the 90th, 95th and 99th confidence intervals were used to establish progressive deviation from reference condition. Test sites were then passively plotted to eliminate their influence on the orientation of the reference sites. Potential impairment of test sites was evaluated based on the positioning of sites along the first three DCA axes, relative to the three confidence ellipses. Test sites falling within the 90th confidence ellipse are deemed equivalent to a reference condition, sites falling between the 90th and 95th confidence ellipses are potentially impaired, sites falling between the 95th and 99th confidence ellipses are likely impaired and sites falling outside the 99th confidence ellipse are likely severely impaired.

3.3.1 Cluster 1

Cluster 1 had a reference threshold of HZD = 55.6 based on a possible correlation between DCA Axis 2 score and HZD score. Site 31 demonstrated potential impairment and Site 34 demonstrated impairment (Figure 5).

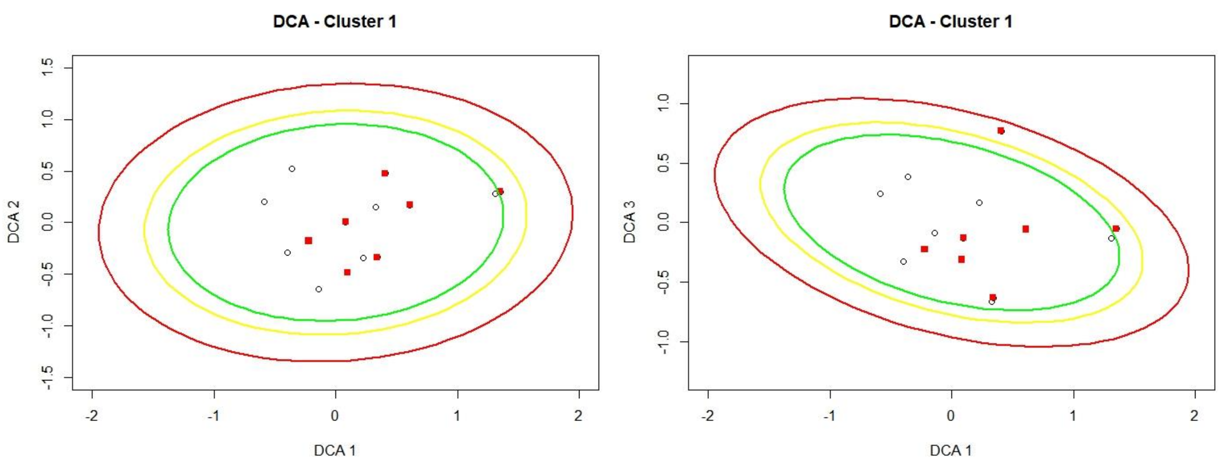

Figure 5. Multivariate illustration of reference sites (open circles) and test sites (closed squares) for Cluster 1. Confidence ellipses are defined around the test sites (test sites are plotted passively), illustrating the location of 90%, 95% and 99% confidence for the reference condition.

3.3.2 Cluster 2

Cluster 2 had a reference threshold of HZD = 35.1 based on a highly significant correlation between DCA Axis 2 score and HZD score. Only two sites demonstrated signs of impairment, based on reference condition: Site 83 demonstrated potential impairment and Site 48 severe impairment. HZD scores for impaired sites ranged between 43.8 and 57.9 (Figure 6).

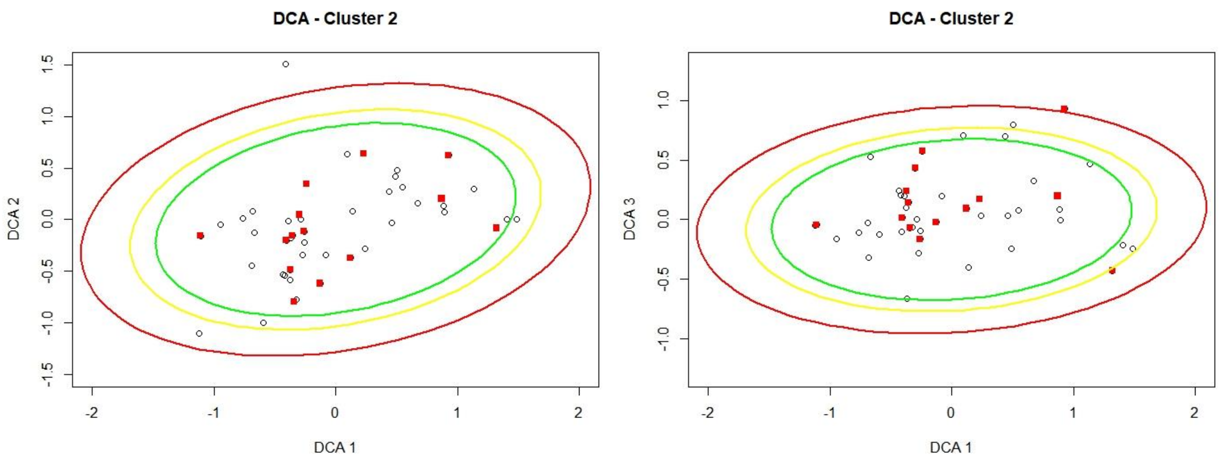

Figure 6. Multivariate illustration of reference sites (open circles) and test sites (closed squares) for Cluster 2. Confidence ellipses are defined around the test sites (test sites are plotted passively), illustrating the location of 90%, 95% and 99% confidence for the reference condition.

3.3.3 Cluster 3

Cluster 3 had a reference threshold of HZD = 34.0 based on highly significant correlation of Chironomidae and HZD score. A total of five sites were found to demonstrate potentially some level of impairment (Figure 7). Site 80 was found to be potentially impaired (HZD = 98.3), Site 6692 was found to demonstrate impairment, Site 23 (1980), 17 (1980) and 6680 were all found to demonstrate severe impairment. Site 23 (1980) Site 17 (1980) were used as positive controls as they are representative of sediment conditions which are historically recognized as impaired due to their high COPC concentrations.

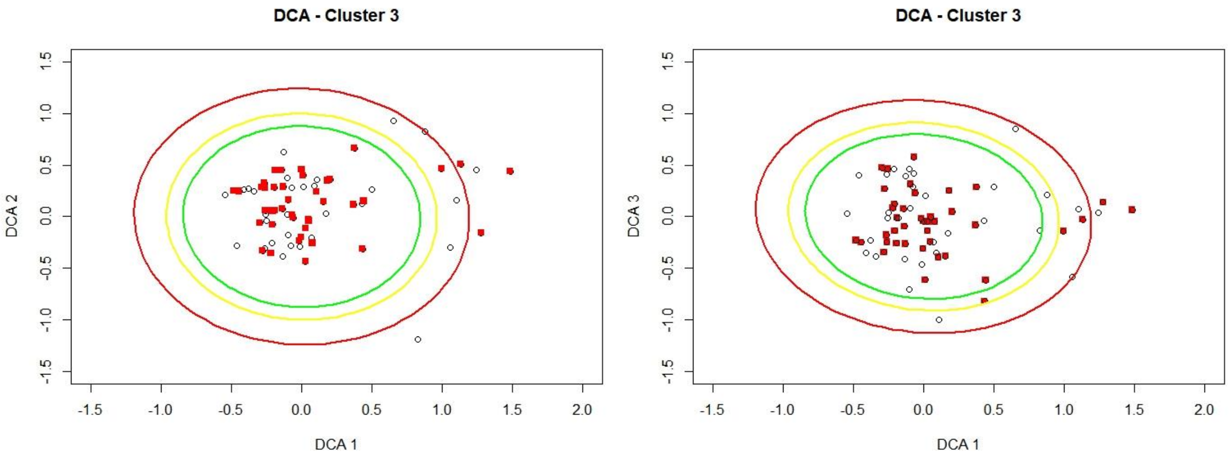

Figure 7. Multivariate illustration of reference sites (open circles) and test sites (closed squares) for Cluster 3. Confidence ellipses are defined around the test sites (test sites are plotted passively), illustrating the location of 90%, 95% and 99% confidence for the reference condition

3.3.3 Cluster 4

Cluster 4 had a reference threshold of HZD = 24.9 based on a significant correlation between DCA Axis 2 score and HZD score. None of the sites tested were found to be impaired, including the positive control Site O (1980), a Trenton Channel site selected due to its extremely high concentration of sediment contaminants (Figure 8).

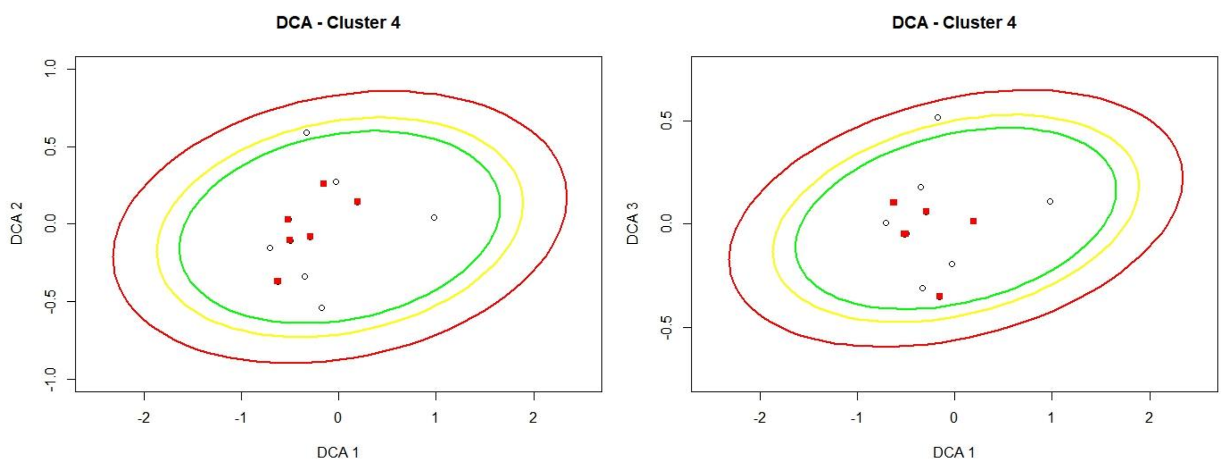

Figure 8. Multivariate illustration of reference sites (open circles) and test sites (closed squares) for Cluster 4. Confidence ellipses are defined around the test sites (test sites are plotted passively), illustrating the location of 90%, 95% and 99% confidence for the reference condition

3.4 Unidimensional Species Assessment

Unidimensional Species Assessment similar to Multivariate Community Assessment, establishes reference condition for each taxon demonstrating significant correlation with HZD scores. Confidence intervals were established to identify reference condition (10th < site < 90th confidence interval), possibly impaired (5^{th} < site < 10^{th} or 90^{th} < site < 95^{th} confidence interval), likely impaired (1^{st} < site < 5^{th} or 95^{th} < site < 99^{th} confidence interval), or likely severely impaired (site < 1^{st} or 99^{th} < site confidence interval).

3.4.1 Cluster 1

Based on the Unidimensional assessment of Chironomidae density, five sites were found to demonstrate possible impairment. Sites 145 (US) and 138 (US) were found to demonstrate impaired Chironomidae density (Figure 9). Sites 31 (CA), 52 (US) and 34 (US) were found to demonstrate severe impairment. Reference condition in Cluster 1 was defined using only seven sites. This limits the ability to draw strong conclusions from these test sites, however, the impaired test sites follow the broader trend that in general Chironomidae density declines with an increase in HZD score. This finding agrees with McPhedran et al. (2016), who observed a significant dose-response relationship between Chironomidae abundances and toxicity scores.

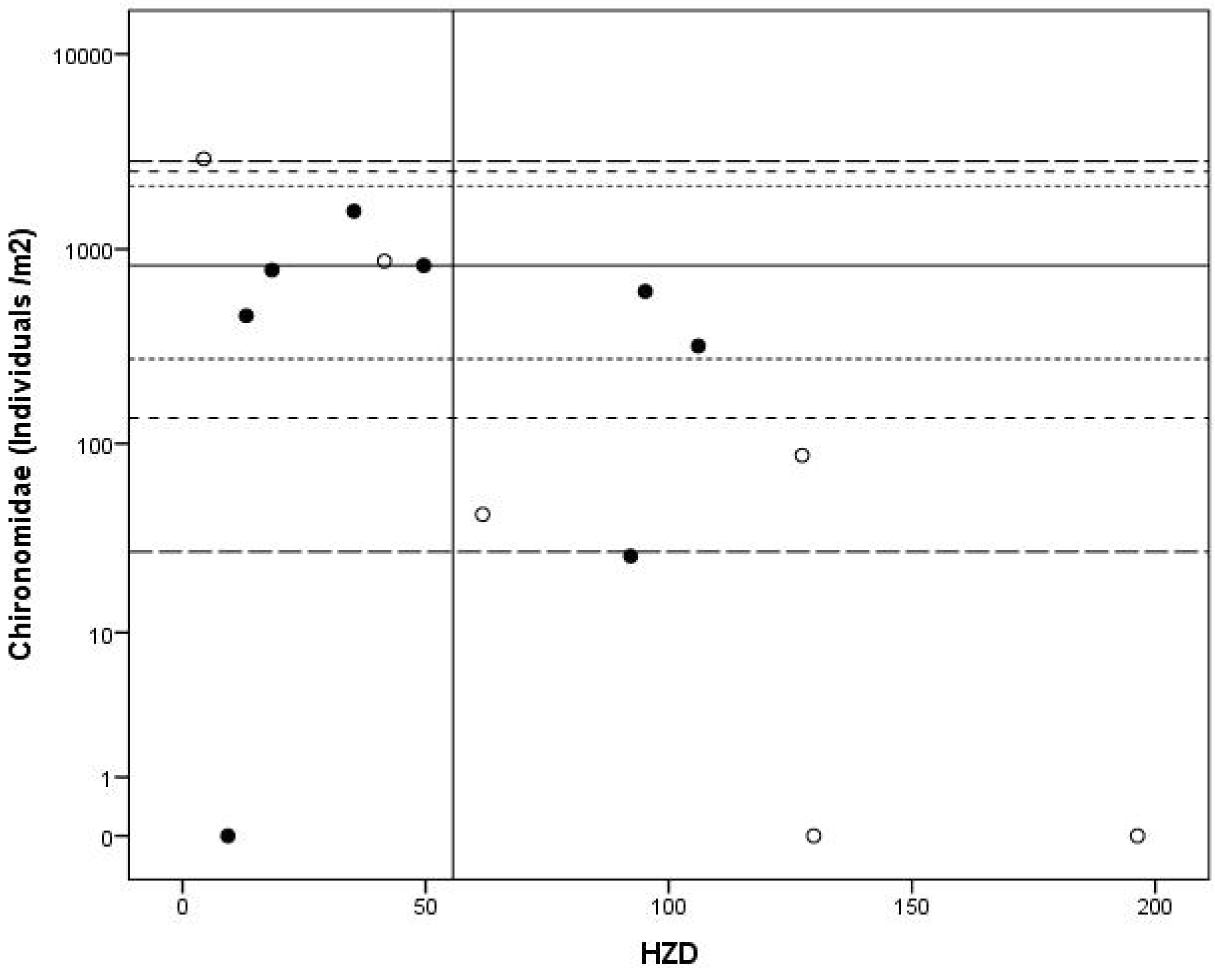

Figure 9. The relationship between Chironomidae density and HZD score for Canadian (solid circles) and US (empty circles) sites for Cluster 1. The vertical solid line represents the breakpoint identified at HZD = 55.6. The solid horizontal line represents the median density for reference sites. The small dashed lines represent the 10^{th} and 90^{th} percentiles; the medium dashed lines represent the 5^{th} and 95^{th} percentiles and the large dashed lines represent the 1^{st} and 99^{th} percentiles respectfully.

3.4.2 Cluster 2

Based on the Unidimensional assessment of Chironomidae density, none of the sites exceeded the 90th percentile (Figure 10). However, it is important to note that the 1st, 5th and 10th percentiles were all equal to zero. This limits the ability of the model to discern impaired sites with low Chironomidae density. Several of the test sites were found to have a Chironomidae density of zero or near zero. Although this appears to support a larger trend that sites with higher HZD scores have lower Chironomidae densities, several reference sites were also found to have low Chironomidae densities. As a result, caution should be applied when interpreting this relationship.

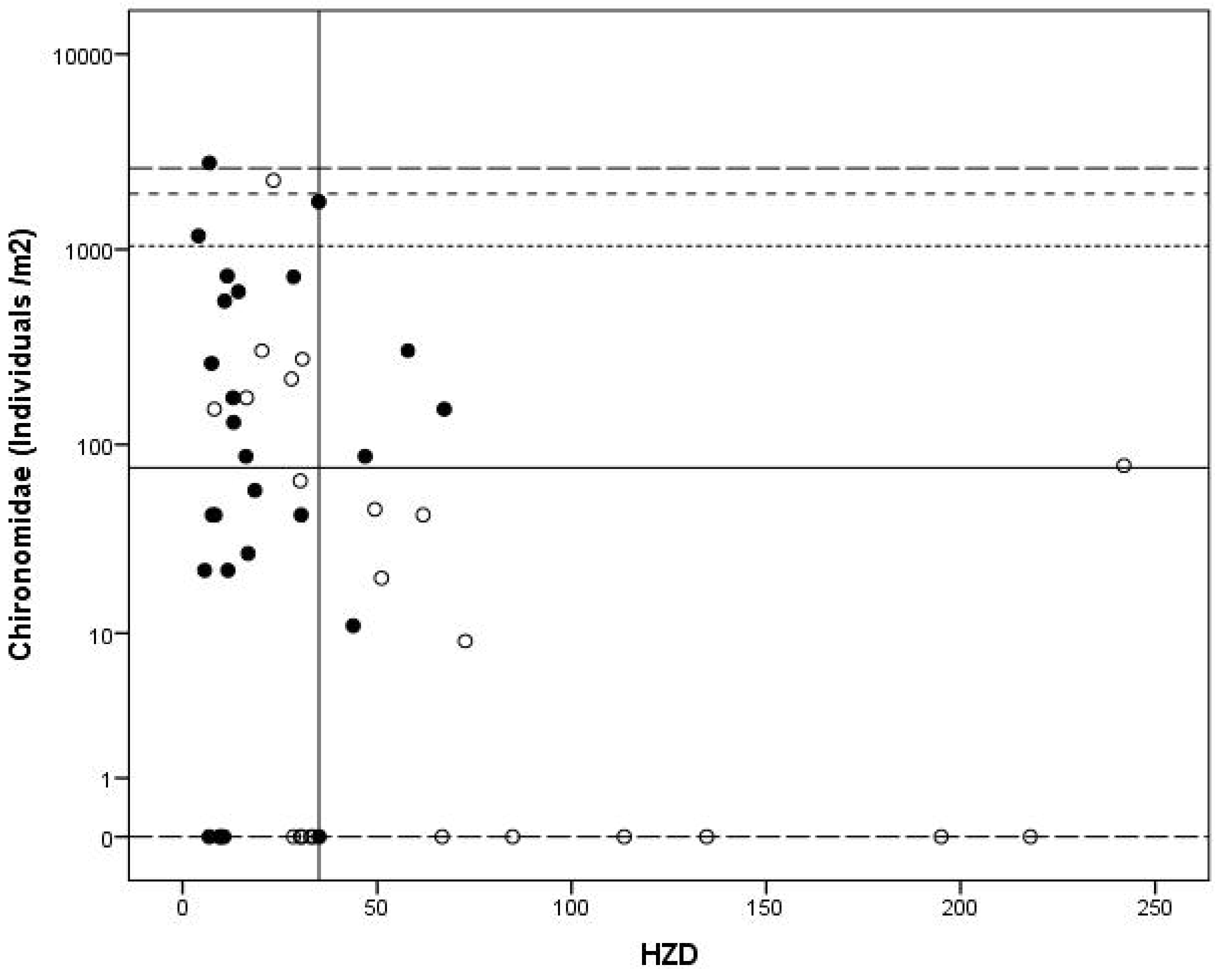

Figure 10. The relationship between Chironomidae density and HZD score for Canadian (solid circles) and US (empty circles) sites for Cluster 2. The vertical solid line represents the breakpoint identified at HZD = 35.1. The solid horizontal line represents the median density for reference sites. The small dashed lines represent the 10th and 90th percentiles; the medium dashed lines represent the 5th and 95th percentiles and the large dashed lines represent the 1st and 99th percentiles respectfully.

3.4.3 Cluster 3

Similar to what was observed in Cluster 2, Cluster 3 test sites demonstrated a generally lower Chironomidae abundance relative to reference sites (Figure 11). However, like Cluster 2, several Cluster 3 reference sites had a density of zero individuals/m^2. As a result, the 1st, 5th and 10th percentiles all included zero. As a result, while the overall trend suggests that a reduction in Chironomidae density coincides with an increase in sediment contaminant concentration, caution must be applied in the interpretation of this result.

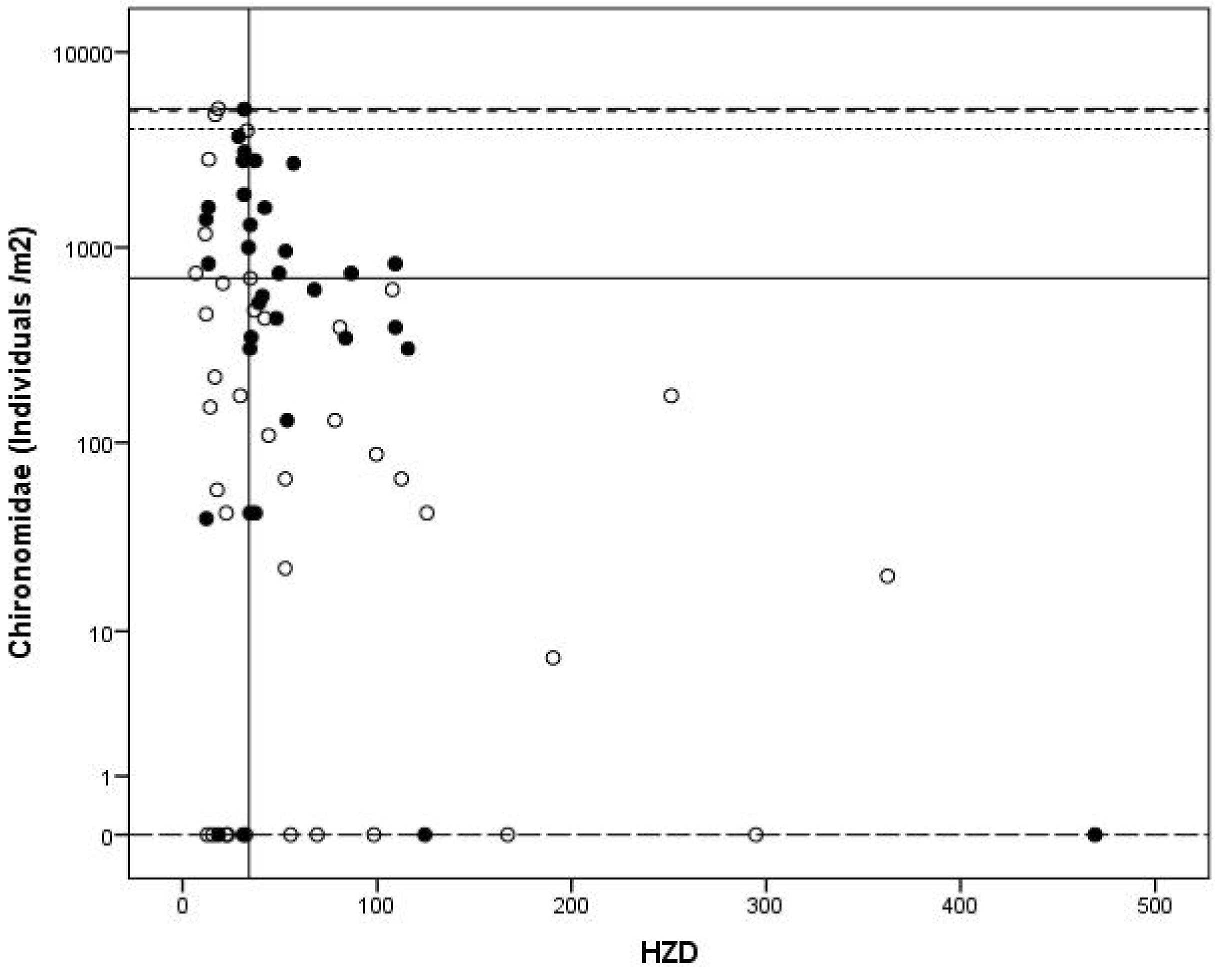

Figure 11. A relationship between Chironomidae density and HZD score for Canadian (solid circles) and US (empty circles) sites for Cluster 3. The vertical solid line represents the breakpoint identified at HZD = 34. The solid horizontal line represents the median density for reference sites. The small dashed lines represent the 10th and 90th percentiles; the medium dashed lines represent the 5th and 95th percentiles and the large dashed lines represent the 1st and 99th percentiles respectfully.

3.4.4 Cluster 4

Cluster 4 is comprised of 11 sites with a HZD score less than 34, and one site (Site O (US) 1980) with a HZD score of 642. Site O (US) was included in the dataset as a positive control from Trenton Channel, with multiple SEL exceedances. Site O (US) was found to be severely impaired, however, it should be cautioned that several reference sites were also found to have similarly low Sphaeriidae abundance (Figure 12).

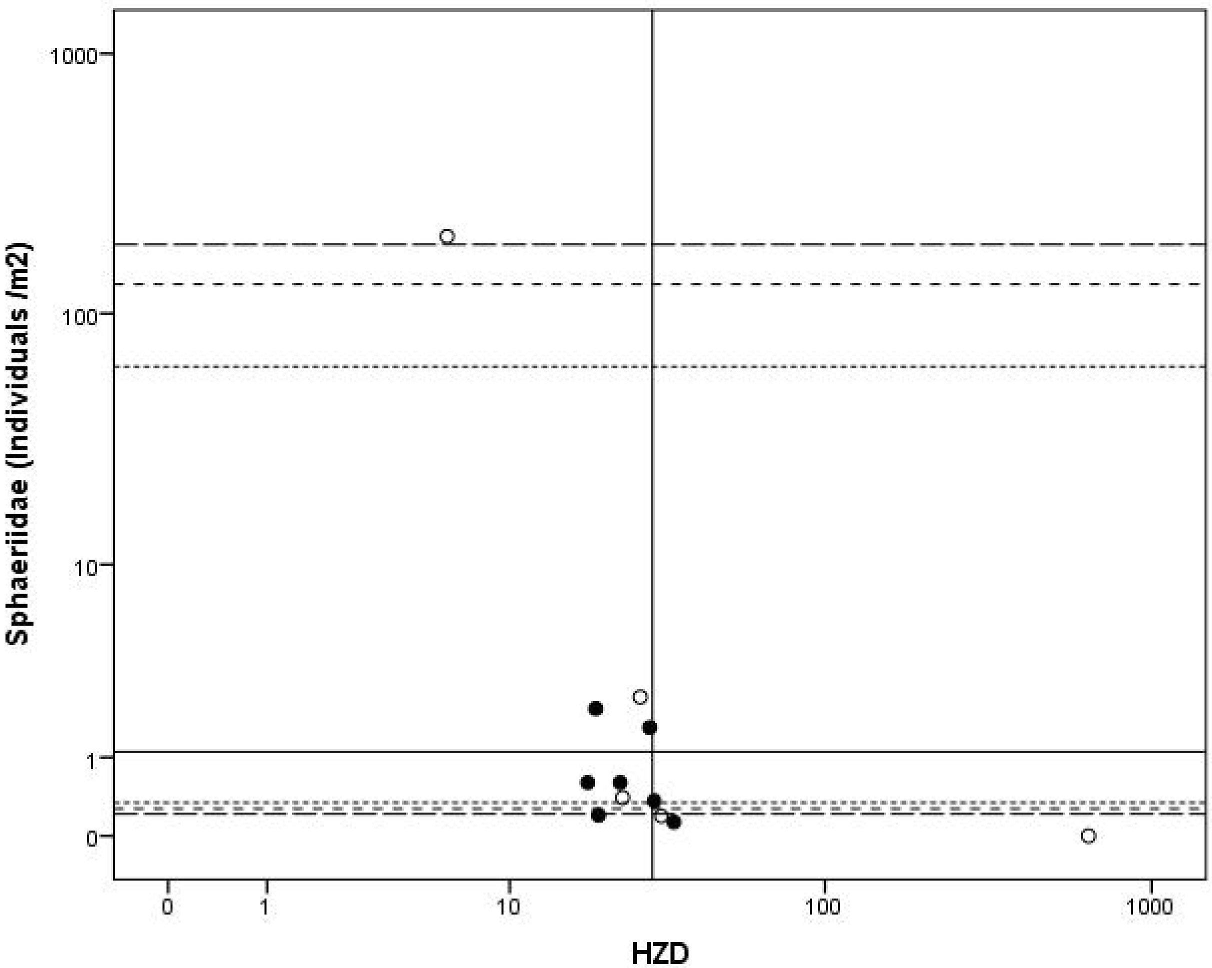

Figure 12. The relationship between Sphaeriidae density and HZD score for Canadian (solid circles) and US (empty circles) sites for Cluster 4. The vertical solid line represents the breakpoint identified at HZD = 29. The solid horizontal line represents the median density for reference sites. The small dashed lines represent the 10th and 90th percentiles; the medium dashed lines represent the 5th and 95th percentiles and the large dashed lines represent the 1st and 99th percentiles respectfully.

3.5 Combined Assessment of Community Composition

The multivariate and unidimensional analysis demonstrated differing abilities to distinguish potentially impaired test sites from reference condition (i.e., those which fall outside of the 10th and 90th confidence ellipses (multivariate assessment) or 10th and 90th percentiles (univariate assessment)), for each of the four clusters. For Cluster 1 & 4, the univariate approach demonstrated greater sensitivity in identifying test sites as impaired. For Clusters 2 and 3, the multivariate approach demonstrated greater sensitivity, as the univariate approach failed to distinguish any sites from the reference condition. The proportions of test sites identified as demonstrating possible impairment are illustrated in Table 8.

Table 8. Summary of Test sites determined to be impaired based on Multivariate Assessment (MVA) and Univariate Assessment (UVA). Sites are counted as Impaired if they demonstrate potential impairment, impairment or severe impairment.

Test	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	Test Sites	Impaired	Test Sites	Impaired	Test Sites	Impaired	Test Sites	Impaired
MVA	7	2 (29)	16	2 (13)	42	5 (12)	4	1 (17)
UVA	7	5 (71)	28	0 (0)	42	0 (0)	4	1 (17)

Sites found to demonstrate impairment were found to vary greatly for each cluster. In part, this is a result of the HZD gradient, which is skewed by the abundance of sites with low or moderate HZD scores (HZD = 0 – 50). This leads to a reliance on a handful of individual test sites demonstrating impairment to provide a proxy understanding of impairment at all points along the gradient. Similarly, because natural variation from environmental factors and other non-accounted for factors play an important role in defining a reference condition, reference condition (especially in Cluster 1 and 4 where the sample size is small) can vary greater than the impacts of contaminants. It is difficult to identify precise instances along the HZD gradient where community composition become impaired, however, for Clusters 1, 2 and 3, HZD score appears to be a limiting factor, with consistently lower Chironomidae abundances observed at the highest end of the HZD gradient. Figure 13, illustrates the relationship between HZD score and instances of biological impairment and non-impairment.

The site with the highest HZD score found to be non-impaired was Site 101 which had a HZD score of 251. A total of three sites with HZD scores greater than 200 were observed be non-impaired. Given that all sites observed with HZD scores greater than 251 were found to be severely impaired by at least one method of community analysis, it would suggest that a HZD score of 250 is close to the maximum amount of sediment contamination probable, in which an unimpaired community may exist.

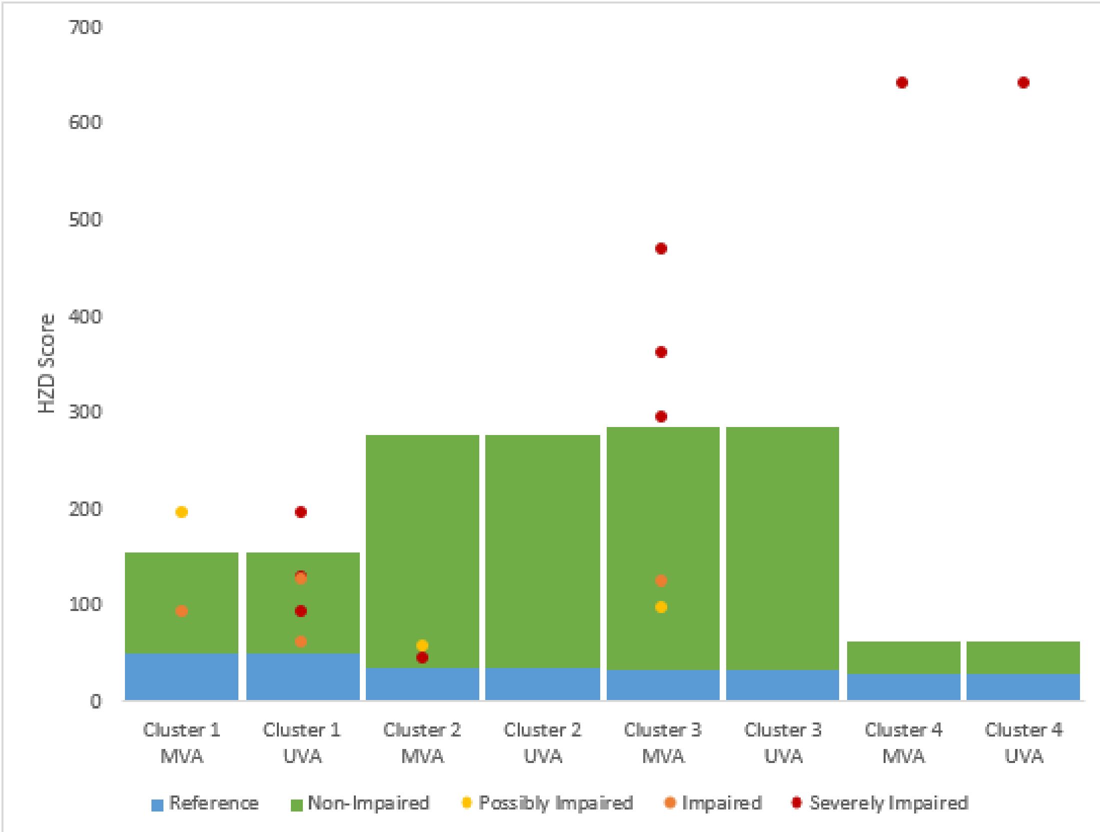

Figure 13. Summary of findings from the Multivariate Assessment (MVA) and the Univariate Assessment (UVA) for each of the four habitat clusters. Blue bars represent the maximum ZD score for reference sites, green bars represent the maximum HZD score for non-impacted sites. Yellow circles represent possibly impaired sites, orange circle represent impaired sites and red sites represent severely impaired sites.

The site with the lowest HZD score found to be impaired was Site 48, which had a HZD score of 43.8. A total of four sites were found to demonstrate either impairment or severe impairment with HZD scores less than 100. These sites represent four of 45 test sites with HZD scores less than 100, with the remaining 41 sites demonstrating non-impaired communities. Examination of the minimum and maximum HZD scores where impairment is observed provides a wide range in sediment contamination (HZD = 48 – 251).

Reference condition by definition is difficult to define as it attempts to capture all of the factors which influence a *natural* environment in isolation of anthropogenic influence. Establishing reference condition with the Detroit River presents further challenges, as it is a dynamic and varied system, and there isn't anywhere within the Detroit River which hasn't at least been historically, if not also contemporarily, impacted to some degree by anthropogenic influence. As a result, while natural environmental factors such as sediment composition, depth, oxygen availability and flow characteristics, are important in defining benthic community structure (Poff & Ward, 1989; Vinson & Hawkins, 1998), unmeasured environmental factors and legacy impacts may also play an important, yet unknown role. Sites were clustered into four groups as a method of stratifying data based on *natural* sediment characteristics (e.g. grain size and TOC), in order to limit their influence on defining community composition. However, even when taking into account these factors to limit *natural* variation, the reference condition demonstrated high variability in community composition. As a result of this variation, it was difficult to distinguish test sites from reference condition.

3.5.1 Variation in Test Site Sediment Contaminant Composition

The HZD method was established to account for the cumulative effects of multiple stressors. Specifically, it aggregates the estimated impact on benthos of sediment contaminants based on laboratory mortality response curves. This is thought to be an improvement upon the simple summation of sediment contaminants or quantification of SEL exceedances. This method does have its limitations, as it assumes that contaminants have no interactive effects other than additive. For practical considerations, the HZD method also is limited in scope to focusing on 13 priority COPCs. Although these COPCs are often cited as playing important roles in benthos community impairment (e.g., Canfield et al. 1996), individual constituents of these COPCs as well as other potential chemicals may play differing roles. For example, individual PCBs represented as total PCBs by the HZD method, have dramatically different impacts on benthos depending on the congeners present (CCME 2001).

The HZD score assigned to each site is an important method of assessing the aggregate or total sediment contamination, however, some caution must be used when developing impairment predictions and evaluating the relationship between HZD score and observed community composition.

4.0 SYNTHESIS

This report employed a range of sediment chemistry, toxicological, and biological data as a method of developing multiple lines of evidence for the evaluation of the Detroit River AOC (Table 9). Each line of evidence demonstrated differing responses to sediment contaminant composition. Specifically, it was found that from 1999 until 2013, sediment SEL exceedances decreased, with only a single SEL exceedance observed in Canadian waters between 2001 and 2013. This decrease in SEL exceedances follows surveys in 1980 and 1991 which suggested that while PCBs and complex organic contaminants (e.g. DDE and HCB) were declining, metals contamination were still increasing on both the Canadian and US sides of the river. As a result, while the Canadian waters of the Detroit River maintain legacy contaminants above background levels, the total area where COPCs are in excess of SEL guidelines as of 2018 is limited. Bioaccumulation potential within Canadian sites of the Detroit River was found to be minimal, with only one site exceeding the CCME Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota for MeHg and another site exceeding the CCME tissue residue guidelines for PCBs. At this site, the overall HZD score remained low, however sediment THg concentration was in excess of LEL guidelines. Similar to bioaccumulation potential, sediment toxicity was found to be limited within the Detroit River. Only one US site was found to demonstrate toxic effects, and only to the most sensitive endpoints. No Canadian sites were found to demonstrate any observable toxicity. Analysis of community composition found possible impairment for sites on both the Canadian and US sides of the river. Impairment was observed at a range of HZD scores (HZD = 43.8 - 642.3).

Table 9. Summary of the findings from each line of evidence (LOE), as well as the minimum value at which impairment was observed

Line of Evidence	Key Findings	Minimum Impairment Threshold
Sediment Chemistry and Contaminant Distribution	• From 1968 to 1980, significant improvement in sediment mercury composition was observed, however other metals (Cd, Cr, Cu, Pb, Ni and Zn) demonstrated significant increases. A similar increase in metals was observed between 1980 and 1991, however PCBs, DDE and HCB were found to decline. 1991 represents a peak in metals contamination. • From 1999 until 2013, the number of SEL exceedances for all 13 COPCs declined in both Canadian and US waters • From 2001 until 2013 only one SEL exceedance was observed (2013) in Canadian waters. • Primary reaches of contamination along American shoreline upstream of Belle Isle, to downstream past the outlet of Trenton Channel. • Primary reaches of contamination along Canadian shoreline downstream of Belle Isle, to the Ambassador Bridge.	N/A
Bioaccumulation Potential	• None of the 17 sites examined demonstrated exceedances of CCME guideline for PCB in Canadian Water; 4 of 22 US sites exceeded this guideline • One of the seven Canadian sites examined in 2013 for MeHg exceeded the CCME guideline; three of seven US sites exceeded this guideline • Canadian site in excess of CCME MeHg guideline had HZD = 16.3 and was found to exceed LEL for Hg • Minimum sediment THg for sites exceeding MeHg guideline = 0.24 μg/g • The relationship between PCBs in sediment and benthos permitted use of a liner relationship to estimate the threshold sediment concentration likely to exceed PCB bioaccumulation above CCME guideline. This value was 0.074 μg/g. Only one station in 2013 exceeded the threshold (PCB concentration was 0.075 μg/g)	ΣPCB = 0.36 μg/g THg = 0.24 μg/g
Sediment Toxicity	• Multiple endpoints examined in 2001 bioassay revealed toxicity only in sensitive taxa (*Hexagenia*) at HZD = 469 • No toxicity was observed in *Hexagenia* bioassay with maximum HZD = 131 • No toxicity was observed in *Chironomus* bioassay with maximum HZD = 215	HZD > 131

Line of Evidence	Key Findings	Minimum Impairment Threshold
Community Composition	• Reference was established based on the response to sediment contamination (HZD score). High variation in community composition of reference sites. Cluster 1 • Impairment observed at HZD = 61.8 Cluster 2 • Impairment observed at HZD = 43.8 Cluster 3 • Impairment observed at HZD = 98.3 Cluster 4 • Impairment observed at HZD = 642.3	44<HZD<251

Using the thresholds developed through each line of evidence the most conservative threshold for impairment would be a HZD score of 44, ΣPCB = 0.36 μg/g and THg = 0.24 μg/g. These thresholds correspond with intermediate levels of sediment contamination. Of all the data examined (Appendix B), sites with HZD score of 44 or less, and were found to have on average 3.3 LEL exceedances and no observed SEL exceedances. Furthermore, the thresholds for total sediment PCB and THg are far below the provincial sediment quality guidelines. As a result, these thresholds likely represent a highly conservative impairment limit for these lines of evidence

5.0 APPLICATION OF RESULTS

The 2013 GLIER dataset represent the most recent available data set. Unfortunately, this dataset lacked reliable benthos composition and toxicity data, which could be used to directly examine benthos impairment due to bioaccumulation potential, sediment toxicity or community composition. However, based on sediment chemistry alone, biological impairment at each site can be predicted. One of the Canadian sites DR 10 was found to exceed the SEL for chromium, copper and lead, this site was found to have an HZD score of 333. Bioaccumulation potential for methylmercury was observed at two sites with a sediment total mercury concentration of 0.24 μg/g and a low sediment PCB of 0.01 ug/g at the other but nonetheless exhibited higher bioaccumulation in benthos. Six Canadian sites were found to have sediment mercury concentrations greater than this threshold (Figure 14); however, as discussed previously, the relationship between sediment total mercury and tissue residue methylmercury is not consistent at all sites. The distribution of sites exceeding this threshold is mapped out in Figure 14. PCBs had a stronger relationship between benthic bioaccumulation and sediment concentration, but this relationship was variable at very low sediment PCB concentrations (<0.2 ug/g). The threshold relationship for PCB bioaccumulation potential generated from linear regression was 0.074 ug/g. Only 1 Canadian station from the 2013 survey contained PCBs above the threshold (the measured sediment value at this location was 0.075 ug/g). It is not anticipated that Canadian sites are at significant risk of impairment due to PCBs. Sediment toxicity in the form of growth inhibition or mortality was only demonstrated at a site with a HZD score of 469, in which the sensitive *Hexagenia* growth and mortality endpoints were found to be toxic, while the more tolerant *Tubifex* endpoints were found to be potentially toxic. Conversely, Chironomidae growth and mortality endpoints failed to demonstrate impairment even at a HZD score 215. As a result, it is assumed that the impairment of benthos endpoints is due to sediment toxicity occurs when the HZD score is between 131 and 469. Only one Canadian site DR10 exceeds the HZD score of 215, however, given the large range in endpoint responses, it is difficult to know whether this site is truly impaired. Finally, examination of community composition demonstrated that impairment may be observed at HZD scores as low as 44, while sites with HZD as high as 251 may remain unimpaired. Only one Canadian site DR10 was found to exceed this minimum HZD threshold of 44 for community composition impairment. As this site has a HZD score which is also greater than the maximum observed unimpaired site (HZD = 251), it is possible that this site demonstrates some level of impairment.

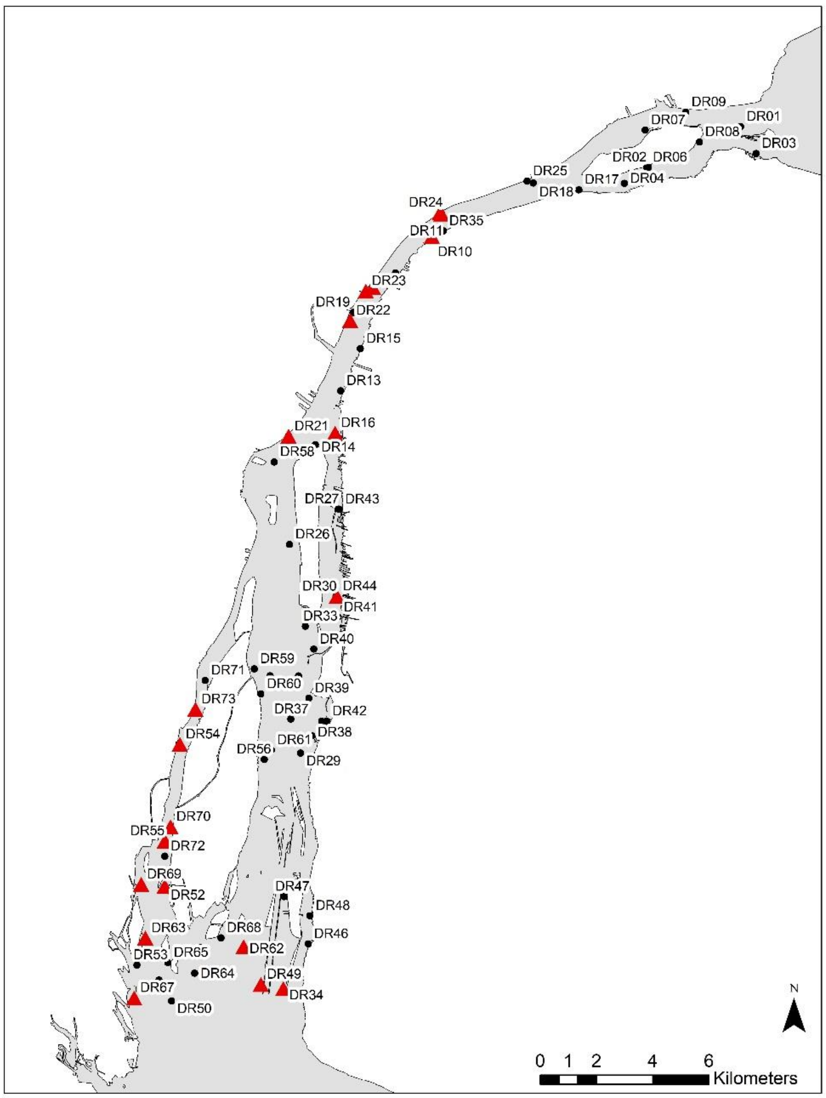

Figure 14. Distribution of 2013 sites in excess of the 0.24 ug/g sediment THg threshold. Six of the 37 Canadian sites examined are in excess of this threshold

6.0 CONCLUSIONS AND RECOMMENDATIONS

The Detroit River presents a unique challenge for understanding ecological impairment, as there is a necessary assumption that at least historically, the entire river has experienced some level of anthropogenic influence. This is challenged furthered by trying to use historical data to infer current trends. This report made use of data from a wide variety of sources in an attempt to understand the contemporary conditions of the Detroit River. Based on this approach and summation of multiple lines of evidence, the following can be stated with a reasonable level of confidence:

- Surface sediment Contaminants of Potential Concern (COPC) concentrations reached a maximum on both the Canadian and US sides of the river in the early 1990s.
- Surface sediment COPCs have declined steadily from 1999 to 2013, with only a single Canadian site DR10 (CA) exceeding SEL guidelines of the 82 Canadian sites examined between 2008 and 2013.
- Based on the surface sediment COPC concentration trends, it is likely that COPC concentrations have continued to decrease from 2013 to present.
- The highest concentration of surface sediment COPCs is observed on the US side (downstream of Belle Isle to the outflow of the Trenton Channel). Generally, lower surface sediment COPC concentrations exist on the Canadian side, and are focused around the Amherstburg waterfront.
- Due to relatively low amounts of total PCB concentrations on the Canadian side, it is unlikely that sediment PCBs pose a great risk to bioaccumulation potential.
- The lowest sediment COPC concentration as described by site hazard scores (HZD), where evidence exists of community composition impairment was HZD = 44. In 2013, only one Canadian site DR10 (CA) was found to exceed this threshold (HZD = 333). Based on the sediment chemistry, as well as the sediment toxicity and community composition thresholds, it is possible that in 2013, DR10 (CA) would have demonstrated biological impairment.
- The remaining 36 Canadian sites from the 2013 survey are likely unimpaired.

Additionally, it was found that Sites DR10 (CA), DR11 (CA), DR16 (CA), DR34 (CA), DR44 (CA) and DR49 (CA) all have sediment total mercury concentrations greater than the minimum value observed in a site where benthos tissue methylmercury concentration exceeded CCME guidelines and DR49 had a sediment PCB concentration at the threshold concentration that could potentially drive benthic concentrations above the CCME guideline value. As a result, although there is limited direct evidence to demonstrate bioaccumulation, these sites are at an increased risk of impairment due to bioaccumulation. More broadly, sediment COPCs throughout the Canadian portion of the AOC remain above background concentrations and will likely continue to remain elevated for the foreseeable future. With the exception of those sites list above, these elevated COPC concentrations are not expected to demonstrate any observable impairment on the biological processes and systems occurring at these sites.

The Detroit River Stage 2 Remedial Action Plan (RAP) report prescribes the conditions which must be met in order to consider a BUI for delisting as well as the contextual framework on which decisions are to be made. Within this framework, it is acknowledged that the delisting of BUIs should be based on the degree of impairment across the whole of the Canadian portion of the AOC, rather than reliance on eliminating all potential local hotspots within the AOC (Green et al. 2010). It is clear, from the findings of this report that potential benthos impairment is highly localized, with the vast majority of the Canadian portion of the AOC demonstrating no evidence of biological impairment, and sediment COPCs below provincial severe effects levels (SELs). In addition to the in-river dynamics, it is acknowledged that the Detroit River AOC is located with a highly urbanized area, as a result it is not expected that a recovered benthos community would be comparable to a pristine nor unimpacted community. Viewing the results of this report through this lens, the overall benthos community of the Canadian waters of the Detroit River AOC meet the conditions for BUI delisting.

The Detroit River is a dynamic and changing system. Regulation of COPC inputs into the Detroit River, has led to a recovery in sediment quality throughout the AOC over that past 20 years. However, given the cultural, ecological and functional importance of the Detroit River, continued monitoring is important to ensure the continued recovery of ecology integrity. Specifically, it is recommended that baseline monitoring and assessment of benthic community composition and contaminant concentration be conducted in at least 10-year intervals, in parallel with AOC-wide sediment chemistry surveys.

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APPENDIX A. Distribution of Severe Effects Level (SEL) exceedances

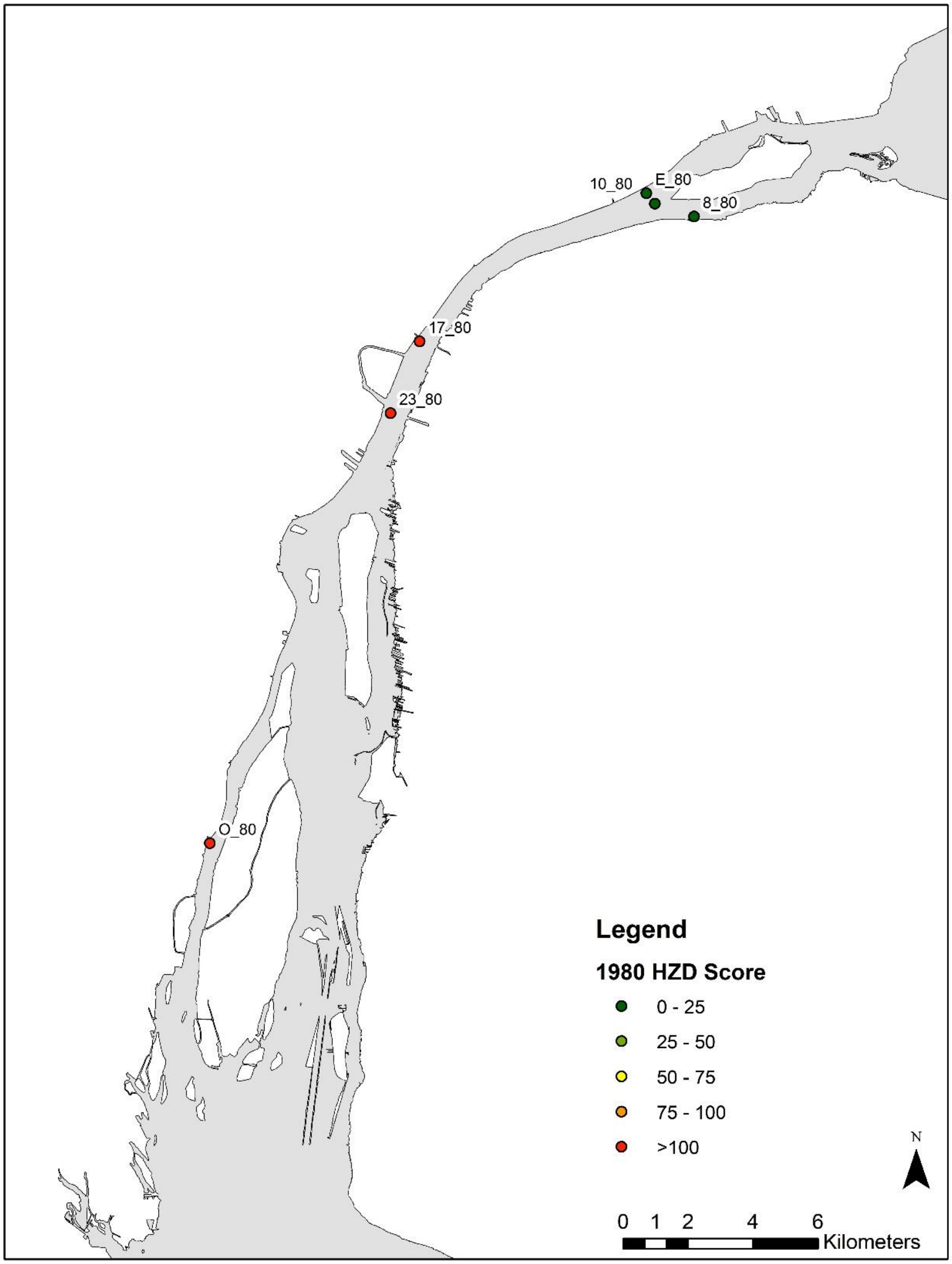

Figure 15. Distribution of select 1980 sites. Symbols for sites are represented by their sediment chemistry HZD score. Sites represented in dark green HZD < 25, sites represented in light green HZD 25 – 50, sites represented in yellow HZD 50 -75, sites represented in orange HZD 75 – 100 and sites represented in red HZD >100.

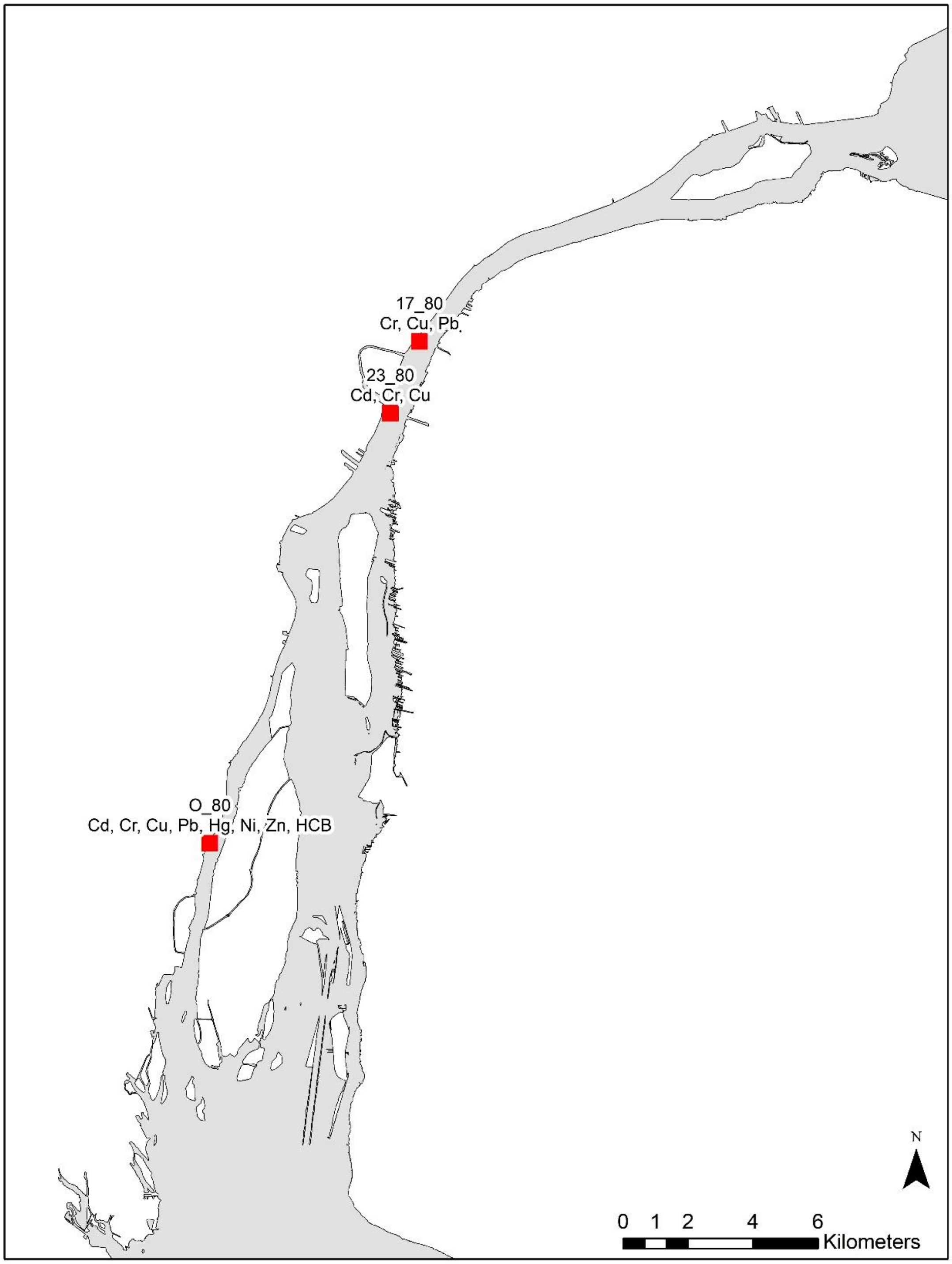

Figure 16. Distribution of SEL exceedances from select 1980 sampling event sites. Sites, where SEL exceedances were observed, are represented by a red square and are labelled using the Site ID and COPC parameter where the sediment concentration is in excess of the Ontario SEL guideline.

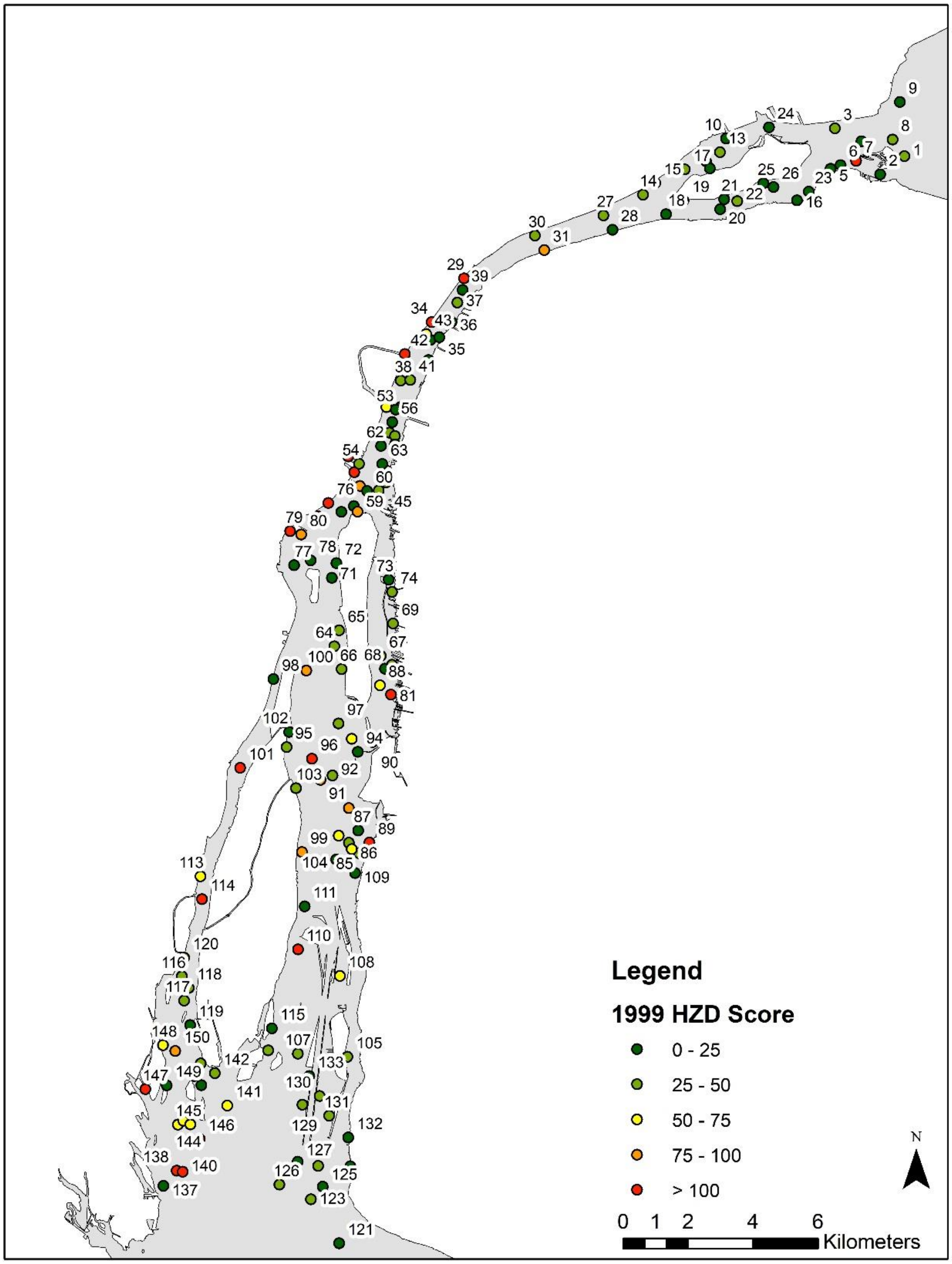

Figure 17. Distribution of SEL exceedances from the 1999 sampling event. Symbols for sites are represented by their sediment chemistry HZD score. Sites represented in dark green HZD < 25, sites represented in light green HZD 25 – 50, sites represented in yellow HZD 50 -75, sites represented in orange HZD 75 – 100 and sites represented in red HZD >100.

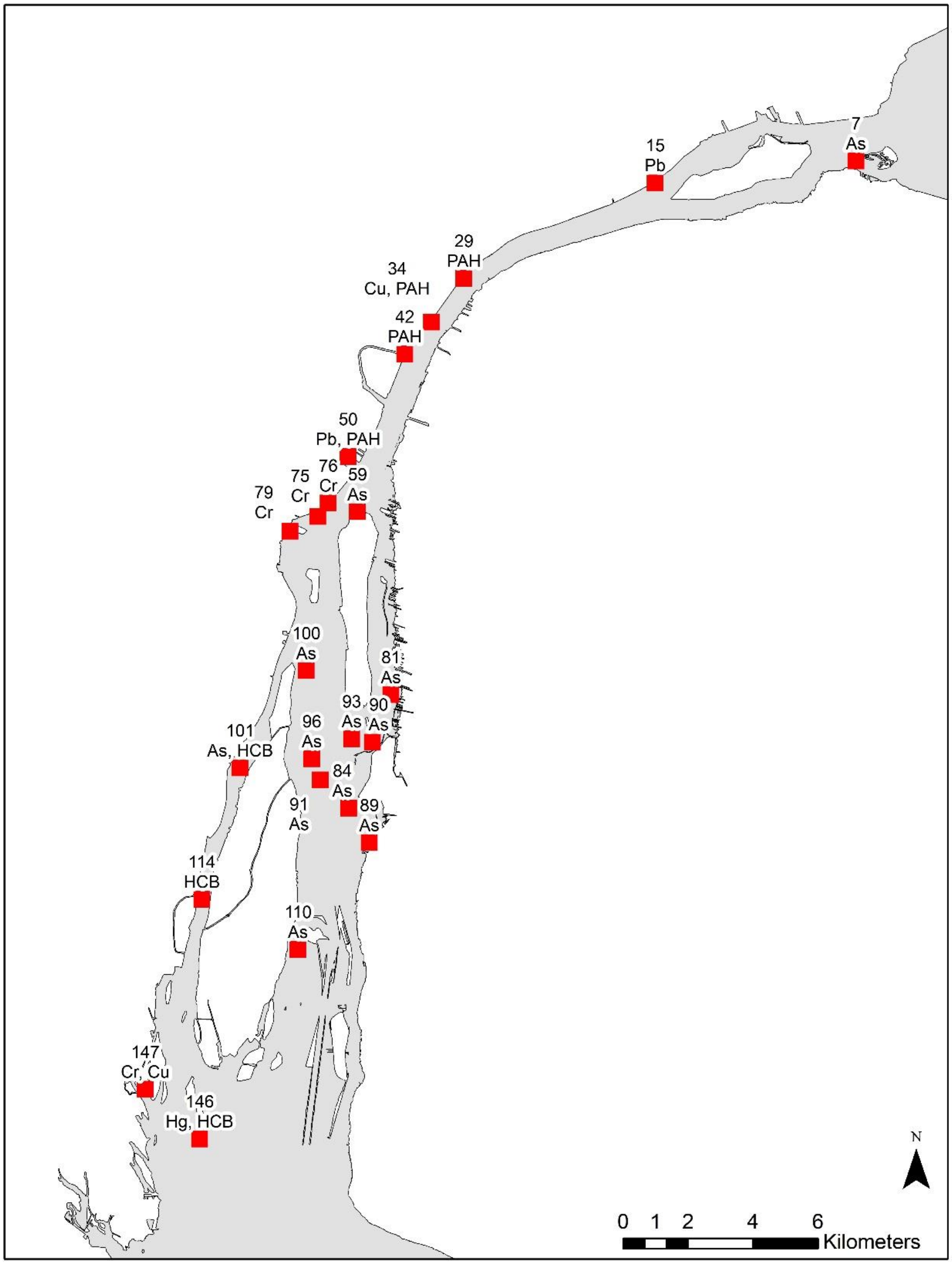

Figure 18. Distribution of SEL exceedances from the 1999 sampling event sites. Sites, where SEL exceedances were observed, are represented by a red square and are labelled using the Site ID and COPC parameter where the sediment concentration is in excess of the Ontario SEL guideline.

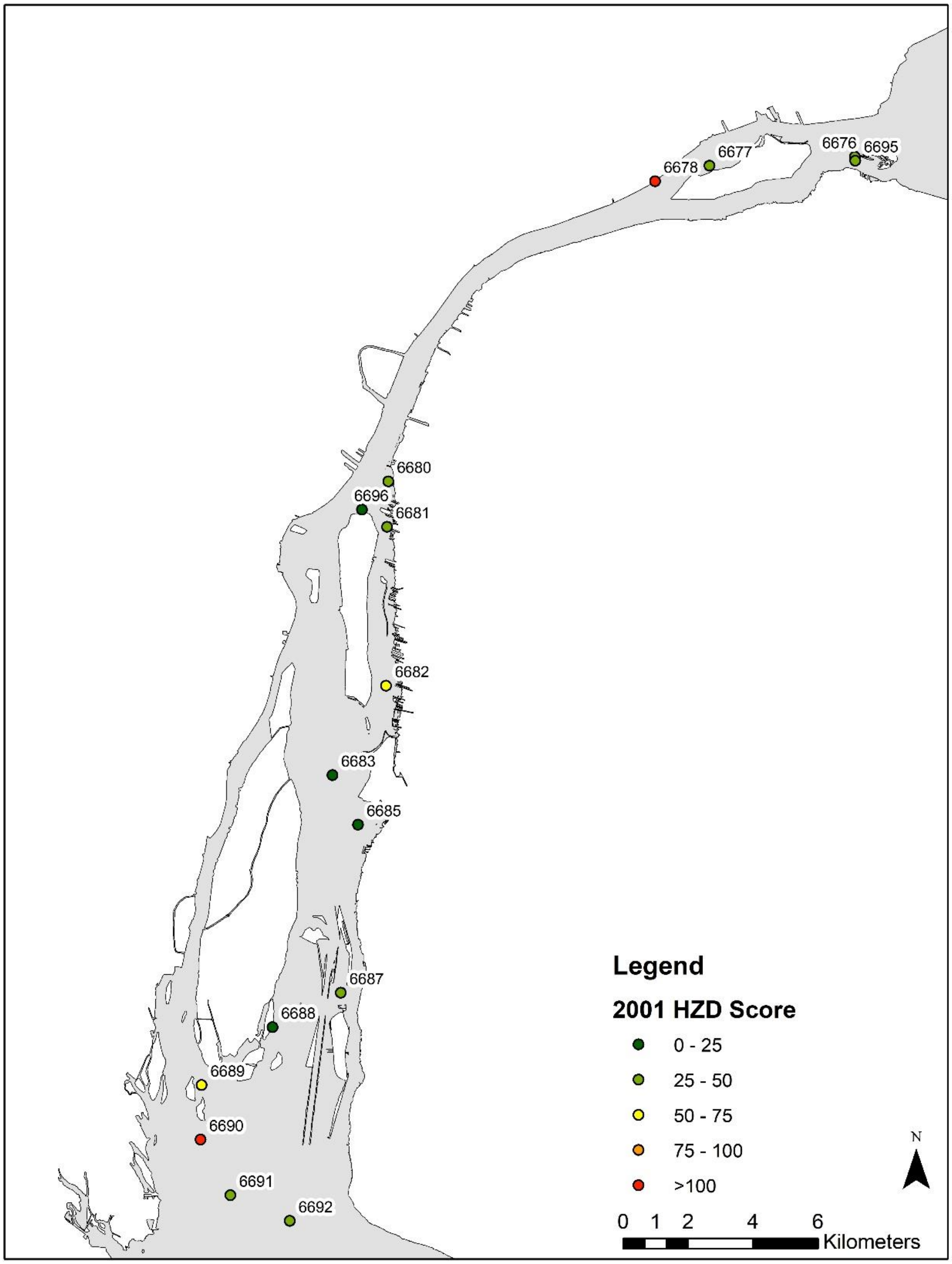

Figure 19. Distribution of SEL exceedances from the 2001 sampling event. Symbols for sites are represented by their sediment chemistry HZD score. Sites represented in dark green HZD < 25, sites represented in light green HZD 25 – 50, sites represented in yellow HZD 50 -75, sites represented in orange HZD 75 – 100 and sites represented in red HZD >100.

Figure 20. Distribution of SEL exceedances from the 2001 sampling event sites. Sites, where SEL exceedances were observed, are represented by a red square and are labelled using the Site ID and COPC parameter where the sediment concentration is in excess of the Ontario SEL guideline.

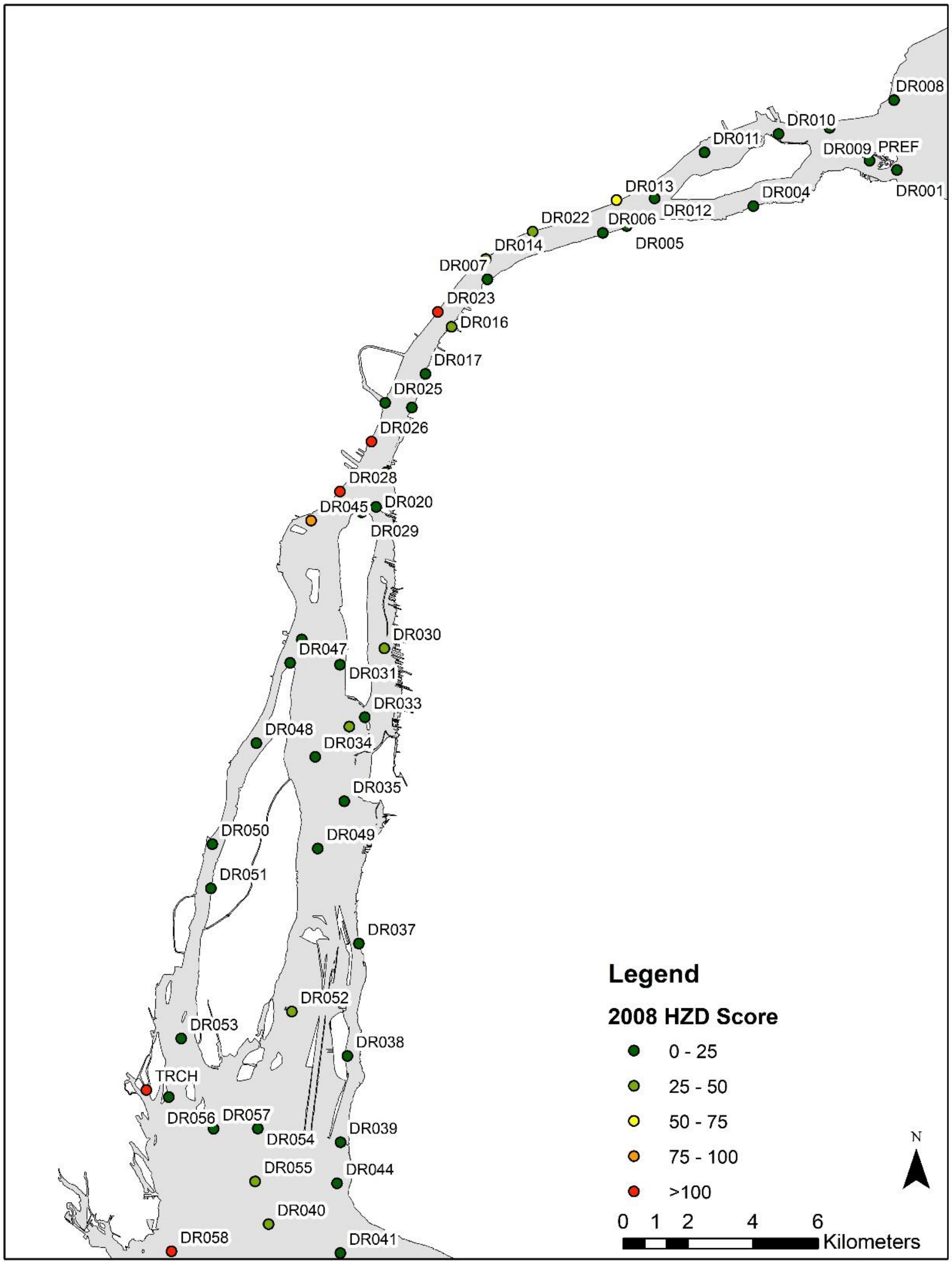

Figure 21. Distribution of SEL exceedances from the 2008 sampling event. Symbols for sites are represented by their sediment chemistry HZD score. Sites represented in dark green HZD < 25, sites represented in light green HZD 25 – 50, sites represented in yellow HZD 50 -75, sites represented in orange HZD 75 – 100 and sites represented in red HZD >100.

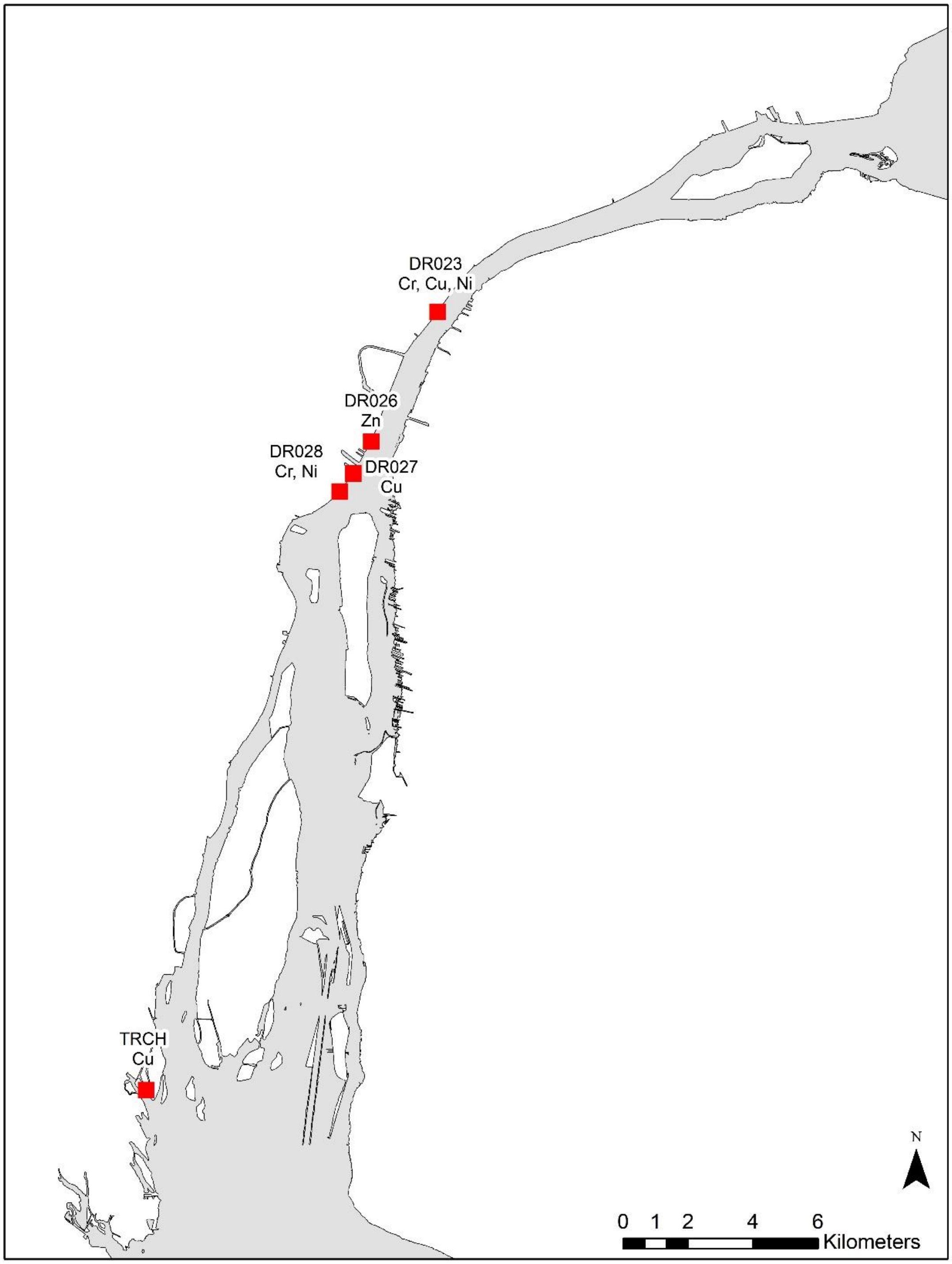

Figure 22. Distribution of SEL exceedances from the 2008 sampling event sites. Sites, where SEL exceedances were observed, are represented by a red square and are labelled using the Site ID and COPC parameter where the sediment concentration is in excess of the Ontario SEL guideline.

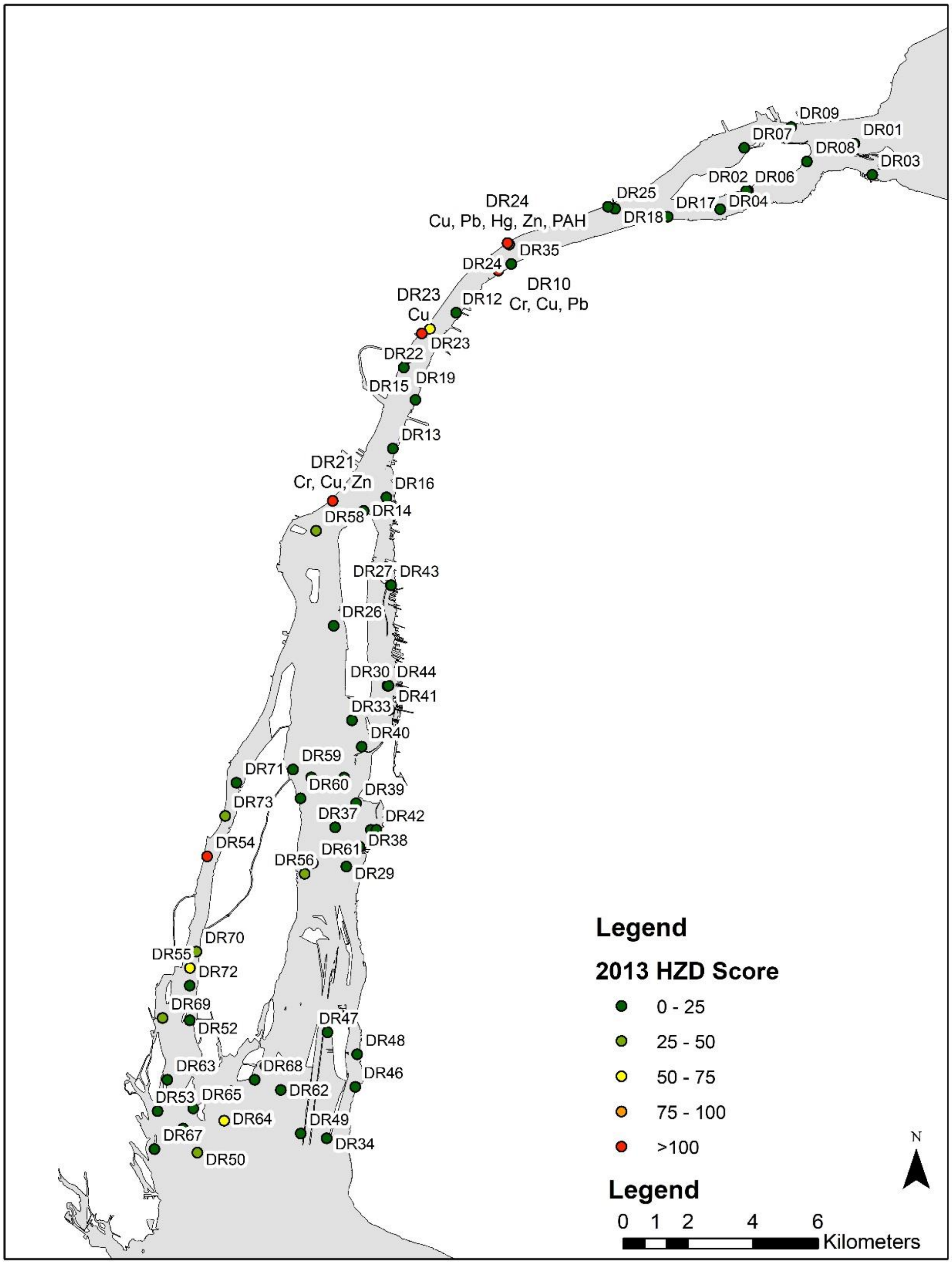

Figure 23. Distribution of SEL exceedances from the 2013 sampling event. Symbols for sites are represented by their sediment chemistry HZD score. Sites represented in dark green HZD < 25, sites represented in light green HZD 25 – 50, sites represented in yellow HZD 50 -75, sites represented in orange HZD 75 – 100 and sites represented in red HZD >100.

Figure 24. Distribution of SEL exceedances from the 2013 sampling event sites. Sites, where SEL exceedances were observed, are represented by a red square and are labelled using the Site ID and COPC parameter where the sediment concentration is in excess of the Ontario SEL guideline.

APPENDIX B. Site habitat characteristics

Table 10. Summary of the physical site characteristics for all of the sites examined 1980-2013. (Adapted from Thornley and Hamdy 1984, GLIER 2002, Milani and Grapentine 2008, Drouillard 2010, and GLIER unpublished)

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
1	CA	GLIER	1999	42.34647	-82.9181	6.55	27.12	54.05	15.26	3.57	0.95
2	CA	GLIER	1999	42.34123	-82.927	10.30	18.93	52.19	22.26	6.62	1.21
3	US	GLIER	1999	42.35371	-82.9443	11.39	36.84	55.93	6.88	0.35	1.14
4	US	GLIER	1999	42.35033	-82.9343	9.41	0.00	0.00	0.00	0.00	0.78
5	CA	GLIER	1999	42.34246	-82.9456	8.50	24.27	64.51	10.69	0.52	0.53
6	CA	GLIER	1999	42.34358	-82.9419	8.69	0.00	0.00	0.00	0.00	0.75
7	CA	GLIER	1999	42.34481	-82.9361	11.41	0.00	0.00	0.00	0.00	4.17
8	CA	GLIER	1999	42.35097	-82.9227	7.30	27.03	63.35	8.95	0.67	0.82
9	US	GLIER	1999	42.36144	-82.9202	8.78	22.97	64.49	11.87	0.66	0.96
10	US	GLIER	1999	42.35023	-82.9849	9.30	25.32	56.92	14.58	3.19	1.43
11	US	GLIER	1999	42.34376	-82.9922	8.79	18.12	53.80	25.19	2.90	1.57
12	US	GLIER	1999	42.34184	-82.9907	6.81	19.38	55.43	21.91	3.29	1.13
13	US	GLIER	1999	42.34636	-82.9871	7.92	17.85	53.15	23.63	5.37	1.99
14	US	GLIER	1999	42.33405	-83.0154	13.29	22.99	58.76	16.51	1.74	1.47
15	US	GLIER	1999	42.33746	-83.011	8.53	23.43	59.22	15.73	1.62	1.27
16	CA	GLIER	1999	42.33353	-82.9579	4.50	0.00	0.00	0.00	0.00	0.87
17	US	GLIER	1999	42.34138	-83.0001	10.93	18.70	54.62	22.21	4.47	1.69
18	CA	GLIER	1999	42.32879	-83.0067	15.03	24.04	55.50	16.92	3.54	2.55
19	US	GLIER	1999	42.33272	-83.0003	9.69	20.07	52.24	22.56	5.13	2.19
20	CA	GLIER	1999	42.33054	-82.9865	16.48	22.68	53.78	19.48	4.06	2.76
21	CA	GLIER	1999	42.33335	-82.9851	13.04	34.03	60.00	5.95	0.01	0.97
22	CA	GLIER	1999	42.3329	-82.9802	16.29	59.42	39.68	0.90	0.00	1.67
23	CA	GLIER	1999	42.33599	-82.9535	4.70	22.59	60.31	15.37	1.72	0.97
24	US	GLIER	1999	42.3536	-82.969	12.43	32.81	49.91	14.16	3.12	4.89
25	US	GLIER	1999	42.33799	-82.9706	9.09	15.47	45.68	29.13	9.73	2.76
26	CA	GLIER	1999	42.33704	-82.9668	13.44	40.78	56.49	2.50	0.24	1.80
27	US	GLIER	1999	42.32806	-83.03	15.63	23.80	53.79	17.64	4.77	1.70
28	CA	GLIER	1999	42.32415	-83.0265	9.05	0.00	0.00	0.00	0.00	1.37

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
29	US	GLIER	1999	42.30971	-83.0816	12.73	34.07	57.40	7.82	0.70	1.39
30	US	GLIER	1999	42.32201	-83.0554	15.51	26.73	63.49	9.46	0.32	1.81
31	CA	GLIER	1999	42.31804	-83.0519	12.60	0.00	0.00	0.00	0.00	6.67
32	CA	GLIER	1999	42.29238	-83.0935	17.13	64.08	33.22	2.70	0.00	5.21
33	CA	GLIER	1999	42.2868	-83.0941	12.05	22.50	61.25	15.10	1.15	1.45
34	US	GLIER	1999	42.29734	-83.0933	14.02	0.00	0.00	0.00	0.00	19.15
35	CA	GLIER	1999	42.2932	-83.0902	12.87	45.34	52.46	2.20	0.00	3.99
36	CA	GLIER	1999	42.29755	-83.0859	13.55	19.23	51.98	22.58	6.21	2.18
37	CA	GLIER	1999	42.30293	-83.0838	18.09	27.42	50.94	18.15	3.50	3.91
38	US	GLIER	1999	42.2809	-83.1042	15.35	56.07	43.35	0.57	0.00	9.88
39	US	GLIER	1999	42.30645	-83.082	19.32	0.00	0.00	0.00	0.00	1.83
40	CA	GLIER	1999	42.27357	-83.1041	15.42	22.00	52.90	19.60	5.49	1.54
41	CA	GLIER	1999	42.28117	-83.1007	15.72	31.64	51.60	13.96	2.80	1.75
42	US	GLIER	1999	42.28833	-83.103	9.73	35.01	54.58	8.71	1.71	16.28
43	US	GLIER	1999	42.29398	-83.0952	17.78	85.69	12.65	1.50	0.17	5.31
44	CA	GLIER	1999	42.25031	-83.1115	7.11	20.54	58.74	18.78	1.94	1.67
45	CA	GLIER	1999	42.25257	-83.1088	6.44	16.05	48.06	27.39	8.51	5.72
46	CA	GLIER	1999	42.2664	-83.1081	15.45	0.00	0.00	0.00	0.00	1.54
47	CA	GLIER	1999	42.26551	-83.1059	16.26	36.75	58.44	4.55	0.26	1.23
48	CA	GLIER	1999	42.26316	-83.1059	13.09	27.08	64.88	7.67	0.36	0.65
49	US	GLIER	1999	42.27344	-83.1094	17.12	31.62	62.32	5.92	0.14	6.02
50	US	GLIER	1999	42.25952	-83.1231	-	19.23	55.89	19.77	5.11	5.48
51	US	GLIER	1999	42.25141	-83.1221	16.15	61.20	36.61	2.19	0.00	1.67
52	US	GLIER	1999	42.25515	-83.1208	10.95	23.06	61.82	12.49	2.63	10.06
53	US	GLIER	1999	42.27281	-83.1059	15.96	0.00	0.00	0.00	0.00	1.88
54	US	GLIER	1999	42.25758	-83.1191	11.83	19.02	52.62	22.00	6.36	2.00
55	US	GLIER	1999	42.2514	-83.1186	15.27	33.08	62.37	4.54	0.00	0.87
56		GLIER	1999	42.26938	-83.107	15.31	25.63	55.24	15.48	3.65	-
57	US	GLIER	1999	42.24409	-83.1252	15.44	0.00	0.00	0.00	0.00	1.82
58	CA	GLIER	1999	42.24583	-83.1206	12.08	33.60	56.65	8.95	0.80	0.94
59	CA	GLIER	1999	42.24429	-83.1192	6.32	20.41	52.28	20.77	6.54	3.08
60	CA	GLIER	1999	42.25012	-83.1158	13.77	36.11	60.82	2.76	0.31	0.88

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
62	US	GLIER	1999	42.26269	-83.111	15.68	0.00	0.00	0.00	0.00	1.21
63	CA	GLIER	1999	42.25767	-83.1104	16.62	47.52	49.85	2.63	0.00	0.62
64	CA	GLIER	1999	42.2068	-83.1265	6.50	17.57	50.61	24.33	7.50	7.11
65	CA	GLIER	1999	42.21127	-83.1249	6.61	17.01	49.89	25.35	7.75	2.06
66	CA	GLIER	1999	42.2005	-83.1236	6.53	17.66	50.39	24.95	6.99	3.61
67	CA	GLIER	1999	42.20446	-83.1091	7.16	16.00	48.00	27.47	8.54	5.54
68	CA	GLIER	1999	42.20092	-83.1075	8.75	19.27	56.58	22.11	2.05	2.13
69	CA	GLIER	1999	42.2135	-83.1049	6.37	15.56	46.67	27.98	9.79	6.25
70	CA	GLIER	1999	42.20206	-83.1049	7.24	15.99	47.86	26.80	9.35	5.65
71	CA	GLIER	1999	42.22573	-83.1281	15.17	32.85	63.94	3.08	0.14	1.25
72	CA	GLIER	1999	42.22988	-83.1266	7.22	21.87	55.54	19.34	3.25	2.44
73	CA	GLIER	1999	42.2256	-83.1069	9.23	25.73	65.41	8.42	0.45	1.12
74	CA	GLIER	1999	42.22223	-83.1055	7.05	17.89	51.59	23.14	7.38	6.88
75	US	GLIER	1999	42.24269	-83.1339	10.46	22.48	60.18	16.79	0.56	2.81
76	US	GLIER	1999	42.24647	-83.1301	12.22	16.58	48.80	26.57	8.05	8.22
77	US	GLIER	1999	42.22901	-83.1423	7.27	20.25	57.65	20.01	2.09	4.48
78	US	GLIER	1999	42.23044	-83.1362	6.50	18.85	55.31	22.09	3.75	2.35
79	US	GLIER	1999	42.23838	-83.1442	8.00	15.92	47.57	28.54	7.97	7.43
80	US	GLIER	1999	42.23754	-83.14	8.59	17.99	53.44	26.26	2.30	2.43
81	CA	GLIER	1999	42.19378	-83.105	6.22	16.28	48.58	26.25	8.89	6.35
82	CA	GLIER	1999	42.14962	-83.1155	7.04	0.00	0.00	0.00	0.00	5.93
83	CA	GLIER	1999	42.15431	-83.1232	14.49	27.60	58.03	13.53	0.84	1.97
84	CA	GLIER	1999	42.16206	-83.1197	6.67	0.00	0.00	0.00	0.00	4.07
85	CA	GLIER	1999	42.15245	-83.1193	8.64	17.43	51.59	26.99	4.00	2.74
86	CA	GLIER	1999	42.15067	-83.1182	7.99	17.75	52.68	26.39	3.17	2.73
87	CA	GLIER	1999	42.15591	-83.1159	6.58	15.74	47.04	27.66	9.56	3.04
88	CA	GLIER	1999	42.19628	-83.1092	11.23	16.93	49.90	25.55	7.61	6.81
89	CA	GLIER	1999	42.15262	-83.1117	6.43	17.89	49.42	26.09	6.60	6.08
90	CA	GLIER	1999	42.18051	-83.1114	9.39	26.17	54.28	16.15	3.40	2.09
91	CA	GLIER	1999	42.16964	-83.1305	6.91	18.36	52.73	23.29	5.62	9.25
92	CA	GLIER	1999	42.17093	-83.126	10.31	18.84	53.49	23.96	3.71	2.62
93	CA	GLIER	1999	42.18128	-83.1192	8.96	17.52	51.85	26.75	3.88	3.16

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
94	CA	GLIER	1999	42.1777	-83.1169	8.72	32.30	57.40	8.87	1.43	1.53
95	US	GLIER	1999	42.17854	-83.1434	6.83	21.36	59.64	18.09	0.91	1.12
96	CA	GLIER	1999	42.17545	-83.1339	10.26	17.53	50.39	25.15	6.94	3.56
97	CA	GLIER	1999	42.18541	-83.1243	6.38	16.81	50.38	24.96	7.85	6.67
98	US	GLIER	1999	42.19728	-83.149	11.96	18.26	50.42	24.18	7.15	3.21
99	US	GLIER	1999	42.14952	-83.1367	6.44	17.97	52.15	26.07	3.80	5.42
100	US	GLIER	1999	42.19985	-83.1368	7.93	17.93	53.16	24.79	4.12	2.44
101	US	GLIER	1999	42.17243	-83.1606	8.32	15.70	46.95	28.44	8.91	8.03
102	US	GLIER	1999	42.1827	-83.1426	6.76	25.04	62.38	11.25	1.33	1.18
103	US	GLIER	1999	42.16717	-83.1396	12.59	19.46	55.91	22.84	1.78	1.44
104	CA	GLIER	1999	42.14769	-83.1239	12.02	0.00	0.00	0.00	0.00	2.01
105	CA	GLIER	1999	42.09308	-83.1179	7.98	0.00	0.00	0.00	0.00	4.88
106	US	GLIER	1999	42.09429	-83.1475	8.19	15.49	46.15	27.10	11.26	2.51
107	US	GLIER	1999	42.09359	-83.1364	7.42	0.00	0.00	0.00	0.00	5.17
108	CA	GLIER	1999	42.11545	-83.1214	7.24	16.72	48.79	25.96	8.53	6.91
109	CA	GLIER	1999	42.14405	-83.1167	8.97	25.86	56.48	16.71	0.95	1.10
110	US	GLIER	1999	42.12251	-83.1373	7.01	0.00	0.00	0.00	0.00	8.71
111	US	GLIER	1999	42.13444	-83.1352	7.51	17.62	52.40	24.36	5.62	1.91
113	US	GLIER	1999	42.14206	-83.1742	9.99	27.93	53.27	16.56	2.24	1.32
114	US	GLIER	1999	42.13576	-83.1735	11.94	21.84	62.52	14.70	0.94	2.27
115	US	GLIER	1999	42.10045	-83.1463	6.97	18.24	52.41	24.49	4.86	3.20
116	US	GLIER	1999	42.11424	-83.1803	8.45	26.20	65.48	7.86	0.46	1.13
117	US	GLIER	1999	42.1075	-83.1792	10.25	25.48	67.33	6.73	0.46	2.14
118	US	GLIER	1999	42.11107	-83.1776	10.33	27.54	68.14	4.16	0.15	3.76
119	US	GLIER	1999	42.10076	-83.1767	7.62	18.02	49.44	26.51	6.03	2.34
120	US	GLIER	1999	42.11943	-83.1796	8.56	44.48	51.63	3.73	0.16	2.14
121	CA	GLIER	1999	42.04129	-83.1192	9.84	22.86	59.83	14.21	3.10	2.47
122	CA	GLIER	1999	42.06271	-83.1158	6.69	25.05	72.77	2.10	0.08	0.56
123	CA	GLIER	1999	42.0533	-83.1302	12.84	16.51	49.17	25.98	8.35	7.14
124	CA	GLIER	1999	42.06264	-83.1278	11.31	16.01	47.99	26.74	9.26	6.30
125	CA	GLIER	1999	42.05688	-83.1259	12.90	32.47	55.68	11.07	0.78	1.16
126	CA	GLIER	1999	42.05717	-83.1421	8.71	15.94	46.49	27.76	9.82	3.2

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
127	CA	GLIER	1999	42.06364	-83.1354	9.46	0.00	0.00	0.00	0.00	3.03
128	US	GLIER	1999	42.08313	-83.1518	8.86	20.00	53.80	21.97	4.23	1.79
129	CA	GLIER	1999	42.07946	-83.1342	8.21	24.19	61.04	12.69	2.08	1.05
130	CA	GLIER	1999	42.08199	-83.1279	8.61	17.40	51.25	22.89	8.46	4.99
131	CA	GLIER	1999	42.0766	-83.1241	8.68	17.01	50.25	23.71	9.03	5.77
132	CA	GLIER	1999	42.07071	-83.1169	6.01	24.47	72.12	3.36	0.05	0.60
133	CA	GLIER	1999	42.08744	-83.1319	7.80	22.90	60.98	15.01	1.10	1.55
134	US	GLIER	1999	42.08667	-83.1749	7.30	33.83	61.77	3.87	0.53	0.57
135	US	GLIER	1999	42.09019	-83.1724	7.21	17.74	52.22	26.90	3.15	3.89
136	US	GLIER	1999	42.06407	-83.186	6.72	21.71	61.53	16.25	0.51	2.80
137	US	GLIER	1999	42.05603	-83.1852	6.68	18.34	54.95	26.38	0.33	0.56
138	US	GLIER	1999	42.06033	-83.1804	7.97	0.00	0.00	0.00	0.00	2.45
139	US	GLIER	1999	42.08418	-83.172	7.26	21.03	59.35	18.21	1.41	1.82
140	US	GLIER	1999	42.06004	-83.1781	8.23	17.42	52.15	29.05	1.38	1.29
141	US	GLIER	1999	42.07873	-83.1621	8.06	18.96	55.34	23.57	2.13	4.14
142	US	GLIER	1999	42.08758	-83.1671	6.95	19.57	52.75	23.74	3.94	3.14
143	US	GLIER	1999	42.07307	-83.1803	8.70	19.56	57.81	22.05	0.59	1.69
144	US	GLIER	1999	42.07424	-83.1784	8.66	20.02	58.37	21.04	0.57	3.61
145	US	GLIER	1999	42.07322	-83.1757	8.08	0.00	0.00	0.00	0.00	2.65
146	US	GLIER	1999	42.0693	-83.1721	7.81	18.93	54.55	24.52	2.00	6.32
147	US	GLIER	1999	42.0827	-83.1928	-	15.10	45.23	28.48	11.19	12.71
148	US	GLIER	1999	42.09503	-83.1867	8.07	23.73	63.55	12.11	0.60	1.75
149	US	GLIER	1999	42.08385	-83.1849	5.99	22.26	50.76	21.34	5.64	2.59
150	US	GLIER	1999	42.09348	-83.182	8.83	19.95	57.44	21.81	0.80	5.62
DR 001	CA	GLIER	2008	42.34256	-82.9208	9.33	-	-	-	-	1.00
DR 002	CA	GLIER	2007	42.3482	-82.9328	6.10	-	-	-	-	0.83
DR 002	CA	GLIER	2009	42.3482	-82.9328	6.10	-	-	-	-	1.32
DR 003	CA	GLIER	2008	42.33498	-82.9571	9.79	-	-	-	-	2.90
DR 004	CA	GLIER	2009	42.3316	-82.9741	10.09	-	-	-	-	1.46
DR 005	CA	GLIER	2008	42.32528	-83.0213	9.69	-	-	-	-	1.80
DR 006	CA	GLIER	2009	42.32322	-83.0302	10.66	-	-	-	-	3.42
DR 008	US	GLIER	2007	42.36192	-82.9225	7.96	-	-	-	-	0.47

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
DR 008	US	GLIER	2009	42.36192	-82.9225	7.96	-	-	-	-	1.70
DR 009	US	GLIER	2008	42.35377	-82.9464	10.94	-	-	-	-	3.40
DR 009 Alt	US	GLIER	2008	42.35377	-82.9464	10.94	-	-	-	-	2.20
DR 010	US	GLIER	2009	42.35179	-82.9654	9.69	-	-	-	-	4.60
DR 011	US	GLIER	2008	42.34624	-82.9929	8.95	-	-	-	-	4.20
DR 012	US	GLIER	2009	42.33314	-83.0111	11.03	-	-	-	-	3.70
DR 013 Alt	US	GLIER	2009	42.33241	-83.0253	9.07	-	-	-	-	8.30
DR 013	US	GLIER	2008	42.33151	-83.0263	10.35	-	-	-	-	6.60
DR 022	US	GLIER	2008	42.3231	-83.0564	7.58	-	-	-	-	5.60
DR 014	US	GLIER	2009	42.31521	-83.0736	11.53	-	-	-	-	2.40
DR 007	CA	GLIER	2008	42.3096	-83.0728	7.88	-	-	-	-	2.70
DR 015	CA	GLIER	2009	42.3039	-83.0798	11.29	-	-	-	-	2.20
DR 016	CA	GLIER	2008	42.29617	-83.0858	4.34	-	-	-	-	5.60
DR 017	CA	GLIER	2009	42.28294	-83.0951	6.84	-	-	-	-	4.60
DR 018	CA	GLIER	2008	42.27352	-83.0998	8.59	-	-	-	-	3.40
DR 019	CA	GLIER	2009	42.2554	-83.1087	7.26	-	-	-	-	2.20
DR 023	US	GLIER	2009	42.30022	-83.091	11.74	-	-	-	-	3.00
DR 023	US	GLIER	2008	42.30022	-83.091	11.74	-	-	-	-	5.60
DR 025	US	GLIER	2009	42.27467	-83.1099	12.85	-	-	-	-	3.40
DR 026	US	GLIER	2008	42.26383	-83.1146	9.43	-	-	-	-	7.60
DR 027	US	GLIER	2009	42.25483	-83.121	9.43	-	-	-	-	3.90
DR 020	CA	GLIER	2008	42.24573	-83.1123	8.38	-	-	-	-	1.60
DR 020 Alt	CA	GLIER	2009	42.24422	-83.1164	7.40	-	-	-	-	3.90
DR 021	CA	GLIER	2009	42.24635	-83.1185	9.05	-	-	-	-	2.20
DR 029	CA	GLIER	2008	42.24414	-83.1176	6.53	-	-	-	-	2.30
DR 030	CA	GLIER	2007	42.20655	-83.1079	7.25	-	-	-	-	6.40
DR 030	CA	GLIER	2009	42.20655	-83.1079	7.25	-	-	-	-	6.65
DR 031	CA	GLIER	2008	42.20173	-83.1243	6.49	-	-	-	-	12.30
DR 032	CA	GLIER	2009	42.18466	-83.1203	9.65	-	-	-	-	6.70
DR 033	CA	GLIER	2008	42.18735	-83.1146	7.75	-	-	-	-	0.60
DR 034	CA	GLIER	2009	42.17599	-83.1327	7.38	-	-	-	-	2.70
DR 035	CA	GLIER	2008	42.16391	-83.1214	9.08	-	-	-	-	3.20

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
DR 037	CA	GLIER	2008	42.12455	-83.1147	7.91	-	-	-	-	2.60
DR 038	CA	GLIER	2009	42.09328	-83.1179	7.98	-	-	-	-	3.00
DR 039	CA	GLIER	2008	42.0693	-83.1197	9.51	-	-	-	-	1.80
DR 040	CA	GLIER	2009	42.0461	-83.1457	9.73	-	-	-	-	4.40
DR 041	CA	GLIER	2008	42.0386	-83.1187	10.16	-	-	-	-	4.70
DR 042	CA	GLIER	2009	42.03516	-83.1166	10.64	-	-	-	-	5.80
DR 044	CA	GLIER	2009	42.05791	-83.1206	8.56	-	-	-	-	1.40
DR 028	US	GLIER	2008	42.24972	-83.1259	11.24	-	-	-	-	3.70
DR 045	US	GLIER	2009	42.24148	-83.1364	8.41	-	-	-	-	3.30
DR 046	US	GLIER	2008	42.20847	-83.1388	8.87	-	-	-	-	3.60
DR 047	US	GLIER	2009	42.20188	-83.1429	7.80	-	-	-	-	1.63
DR 048a	US	GLIER	2007	42.1794	-83.1547	7.79	-	-	-	-	3.03
DR 048b	US	GLIER	2008	42.1794	-83.1547	7.79	-	-	-	-	3.40
DR 049	US	GLIER	2009	42.15062	-83.1308	9.36	-	-	-	-	1.71
DR 050	US	GLIER	2008	42.15105	-83.1702	10.36	-	-	-	-	2.60
DR 050 Alt	US	GLIER	2009	42.14876	-83.1728	7.78	-	-	-	-	2.26
DR 051 Alt	US	GLIER	2009	42.13885	-83.1703	8.64	-	-	-	-	0.92
DR 051	US	GLIER	2009	42.12157	-83.1359	6.69	-	-	-	-	5.30
DR 052	US	GLIER	2008	42.10524	-83.139	8.73	-	-	-	-	4.30
DR 053	US	GLIER	2009	42.09699	-83.1799	9.00	-	-	-	-	2.90
DR 054	US	GLIER	2008	42.07258	-83.1506	8.87	-	-	-	-	3.60
DR 055	US	GLIER	2009	42.05789	-83.1511	9.84	-	-	-	-	4.70
DR 056	US	GLIER	2008	42.08064	-83.184	7.51	-	-	-	-	6.10
DR 057	US	GLIER	2009	42.07216	-83.167	6.74	-	-	-	-	5.10
DR 058	US	GLIER	2008	42.03792	-83.1815	8.21	-	-	-	-	5.30
DR 059	US	GLIER	2009	41.99729	-83.1655	10.23	-	-	-	-	0.80
DR 060	US	GLIER	2008	42.02681	-83.1556	10.50	-	-	-	-	2.50
PREF	CA	GLIER	2007	42.34496	-82.9311	4.80	-	-	-	-	2.59
PREF	CA	GLIER	2008	42.34496	-82.9311	4.80	-	-	-	-	2.70
PREF	CA	GLIER	2009	42.34506	-82.9309	4.80	-	-	-	-	1.90
TRCH	US	GLIER	2007	42.08263	-83.1928	-	-	-	-	-	8.98
TRCH	US	GLIER	2008	42.08263	-83.1928	-	-	-	-	-	11.10

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
DR_01	CA	GLIER	2013	42.3496	-82.9369	9.21	17.73	33.62	44.64	4.02	1.65
DR_02	CA	GLIER	2013	42.33584	-82.9763	11.28	5.06	16.35	74.96	3.63	1.56
DR_03	CA	GLIER	2013	42.34109	-82.93	8.42	0.08	12.04	38.79	49.09	3.19
DR_04	CA	GLIER	2013	42.33054	-82.9865	16.48	1.22	6.24	83.89	8.65	6.13
DR_05	CA	GLIER	2013	42.31804	-83.0519	12.60	17.07	46.48	30.48	5.96	-
DR_06	US	GLIER	2013	42.33583	-82.9769	11.72	41.82	47.96	6.66	3.55	5.82
DR_07	US	GLIER	2013	42.34773	-82.978	7.08	3.65	24.75	44.99	26.60	3.09
DR_08	US	GLIER	2013	42.34433	-82.9545	8.98	0.55	47.45	26.34	25.66	5.38
DR_09	US	GLIER	2013	42.35381	-82.9607	11.18	6.73	45.78	34.93	12.57	-
DR_10	CA	GLIER	2013	42.31209	-83.0689	12.12	50.11	32.19	15.14	2.56	10.96
DR_11	CA	GLIER	2013	42.31939	-83.065	13.47	0.88	41.88	35.14	22.10	5.67
DR_12	CA	GLIER	2013	42.3001	-83.0842	16.20	34.84	38.26	23.39	3.51	5.52
DR_13	CA	GLIER	2013	42.262	-83.1066	15.19	2.05	30.47	30.35	37.14	2.63
DR_14	CA	GLIER	2013	42.24457	-83.1169	6.93	0.80	39.32	35.57	24.32	5.23
DR_15	CA	GLIER	2013	42.27565	-83.0986	4.65	0.58	22.91	56.73	19.79	-
DR_16	CA	GLIER	2013	42.24845	-83.1086	6.21	0.43	46.90	23.20	29.47	9.80
DR_17	CA	GLIER	2013	42.32817	-83.0061	12.95	14.65	38.14	43.62	3.59	-
DR_18	US	GLIER	2013	42.32998	-83.0257	14.55	79.20	16.17	3.88	0.75	1.14
DR_19	US	GLIER	2013	42.28718	-83.102	16.61	2.56	43.55	34.21	19.68	12.46
DR_20	US	GLIER	2013	42.29543	-83.0938	18.05	15.66	25.60	53.91	4.83	13.46
DR_21	US	GLIER	2013	42.24709	-83.1286	13.97	2.03	27.92	43.43	26.62	8.57
DR_22	US	GLIER	2013	42.28457	-83.1032	15.47	1.04	49.36	25.76	23.84	5.11
DR_23	US	GLIER	2013	42.29414	-83.0968	12.27	2.41	20.63	64.35	12.61	6.02
DR_24	US	GLIER	2013	42.31977	-83.0656	9.40	1.28	28.10	42.33	28.28	15.25
DR_25	US	GLIER	2013	42.33052	-83.0285	12.15	2.04	31.53	54.13	12.30	2.50
DR_26	CA	GLIER	2013	42.21247	-83.127	6.71	3.64	35.52	35.40	25.45	4.36
DR_27	CA	GLIER	2013	42.22418	-83.1061	9.26	3.64	62.52	17.22	16.61	7.94
DR_28	CA	GLIER	2013	42.15031	-83.1226	12.27	18.52	59.09	19.93	2.46	7.15
DR_29	CA	GLIER	2013	42.14583	-83.1201	10.00	20.76	42.26	33.51	3.47	3.43
DR_30	CA	GLIER	2013	42.19621	-83.1064	6.48	0.13	51.61	26.19	22.07	8.30
DR_31	CA	GLIER	2013	42.17046	-83.1217	8.32	7.86	32.01	29.53	30.60	3.73
DR_32	CA	GLIER	2013	42.15612	-83.1113	6.36	0.20	8.97	70.97	19.85	4.56

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
DR_33	CA	GLIER	2013	42.1864	-83.1193	9.08	2.69	11.43	74.32	11.56	2.37
DR_34	CA	GLIER	2013	42.07034	-83.1249	9.90	2.29	43.04	29.27	25.40	7.47
DR_35	CA	GLIER	2013	42.31398	-83.0641	13.24	1.07	23.89	37.10	37.93	5.26
DR_36	CA	GLIER	2013	42.18268	-83.1097	10.69	29.55	48.17	18.97	3.30	3.23
DR_37	CA	GLIER	2013	42.15658	-83.1246	14.19	1.06	29.37	41.23	28.34	4.81
DR_38	CA	GLIER	2013	42.1514	-83.1153	6.69	8.00	32.30	44.84	14.85	5.44
DR_39	CA	GLIER	2013	42.16338	-83.117	6.43	8.14	25.65	46.50	19.71	1.45
DR_40	CA	GLIER	2013	42.17912	-83.1154	8.92	0.24	3.32	90.93	5.51	2.34
DR_41	CA	GLIER	2013	42.18957	-83.1054	6.22	0.09	11.95	60.47	27.48	3.13
DR_42	CA	GLIER	2013	42.15618	-83.1092	6.39	10.24	55.51	27.39	6.87	4.98
DR_43	CA	GLIER	2013	42.22409	-83.106	8.45	23.48	44.14	26.62	5.76	1.69
DR_44	CA	GLIER	2013	42.19626	-83.106	6.48	0.00	55.45	22.15	22.40	5.22
DR_45	CA	GLIER	2013	42.17027	-83.1339	12.05	0.22	6.07	87.23	6.48	1.38
DR_46	CA	GLIER	2013	42.0848	-83.1147	10.03	2.58	36.55	39.66	21.22	5.38
DR_47	CA	GLIER	2013	42.09973	-83.1255	7.66	0.00	31.00	33.66	35.34	5.99
DR_48	CA	GLIER	2013	42.09384	-83.1143	11.07	2.42	33.45	47.04	17.08	4.29
DR_49	CA	GLIER	2013	42.0715	-83.1345	8.25	0.47	34.65	40.98	23.89	6.73
DR_50	US	GLIER	2013	42.06544	-83.1729	8.70	0.62	25.03	66.17	8.17	5.71
DR_51	US	GLIER	2013	42.08279	-83.1612	7.59	3.44	23.77	58.87	13.92	6.25
DR_52	US	GLIER	2013	42.10211	-83.177	7.85	1.39	42.29	47.10	9.22	2.99
DR_53	US	GLIER	2013	42.07669	-83.1881	6.61	0.37	7.37	85.66	6.61	1.93
DR_54	US	GLIER	2013	42.14762	-83.172	11.38	3.72	31.17	61.77	3.34	5.74
DR_55	US	GLIER	2013	42.11659	-83.1773	9.08	21.43	41.88	35.89	0.80	18.32
DR_56	US	GLIER	2013	42.14353	-83.1355	6.82	1.08	22.84	32.99	43.10	7.89
DR_57	US	GLIER	2013	42.09	-83.1483	8.90	14.29	24.93	36.62	24.17	5.81
DR_58	US	GLIER	2013	42.23873	-83.1344	12.24	8.57	13.57	58.92	18.94	6.71
DR_59	US	GLIER	2013	42.17236	-83.1408	12.81	0.10	1.53	92.24	6.14	2.19
DR_60	US	GLIER	2013	42.16438	-83.1377	12.27	6.52	20.43	61.86	11.19	0.97
DR_61	US	GLIER	2013	42.14654	-83.1326	7.34	0.12	4.19	82.07	13.63	3.42
DR_62	US	GLIER	2013	42.08342	-83.1424	8.62	0.00	32.43	36.68	30.89	4.76
DR_63	US	GLIER	2013	42.08541	-83.1847	7.60	2.00	8.82	68.79	20.39	5.06
DR_64	US	GLIER	2013	42.07448	-83.1632	7.68	0.24	4.71	75.83	19.22	9.92

Site	Country	Author	Year	Latitude	Longitude	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
DR_65	US	GLIER	2013	42.0777	-83.1747	6.85	0.25	1.97	93.99	3.79	3.77
DR_66	US	GLIER	2013	42.07202	-83.1784	8.62	0.04	10.98	76.46	12.53	3.38
DR_67	US	GLIER	2013	42.06615	-83.1888	6.58	0.00	7.30	79.37	13.32	-
DR_68	US	GLIER	2013	42.08606	-83.1522	8.43	2.82	34.38	25.43	37.37	3.13
DR_69	US	GLIER	2013	42.10254	-83.1871	7.98	0.00	33.40	32.28	34.32	10.80
DR_70	US	GLIER	2013	42.12117	-83.1751	9.15	9.28	39.81	48.68	2.24	14.44
DR_71	US	GLIER	2013	42.16828	-83.1618	8.10	38.41	24.20	36.01	1.38	2.30
DR_72	US	GLIER	2013	42.1117	-83.1772	10.05	8.13	11.50	73.41	6.96	4.29
DR_73	US	GLIER	2013	42.15902	-83.1657	14.09	2.22	31.35	62.37	4.06	3.97
6676	CA	ECCC	2001	42.3459	-82.9365	3.30	0.00	2.00	53.82	44.18	2.60
6695	CA	ECCC	2001	42.3449	-82.9364	8.90	0.00	2.99	53.65	43.36	2.10
6677	US	ECCC	2001	42.3426	-82.9909	1.10	0.00	4.43	62.95	32.62	2.00
6678	US	ECCC	2001	42.3379	-83.0111	1.50	0.00	57.08	28.03	14.90	4.90
6680	CA	ECCC	2001	42.2529	-83.1080	0.60	0.00	26.18	41.79	32.03	2.80
6696	CA	ECCC	2001	42.2449	-83.1175	0.70	6.19	44.88	30.81	18.11	1.00
6681	CA	ECCC	2001	42.2403	-83.1080	0.70	0.00	2.50	53.21	44.29	2.50
6682	CA	ECCC	2001	42.1962	-83.1069	0.60	0.00	30.09	37.96	31.95	1.70
6683	CA	ECCC	2001	42.1711	-83.1261	1.20	0.00	27.65	41.17	31.19	2.00
6685	CA	ECCC	2001	42.1575	-83.1161	0.70	0.00	46.58	31.85	21.56	2.10
6687	CA	ECCC	2001	42.1108	-83.1210	3.00	0.00	0.96	49.68	49.60	2.00
6688	US	ECCC	2001	42.1008	-83.1460	0.70	3.46	54.65	27.49	14.40	2.20
6689	US	ECCC	2001	42.0842	-83.1719	0.50	1.50	90.37	0.00	8.13	1.90
6690	US	ECCC	2001	42.0691	-83.1718	1.50	0.47	97.60	0.00	1.92	9.20
6691	US	ECCC	2001	42.0539	-83.1602	3.30	0.00	57.61	25.67	16.72	1.30
6692	CA	ECCC	2001	42.0472	-83.1378	3.80	0.00	1.58	59.28	39.14	1.90
E_80	US	H&T	1980	42.33452	-83.0142	0.00	55.75	42.02	2.23	2.00	0.00
10_80	US	H&T	1980	42.33166	-83.011	46.75	50.48	2.77	0.00	1.43	46.75
8_80	CA	H&T	1980	42.32837	-82.9962	9.76	58.58	20.49	11.17	2.13	9.76
17_80	US	H&T	1980	42.29189	-83.0976	0.00	87.51	9.99	2.50	1.69	0.00
23_80	US	H&T	1980	42.27183	-83.1078	3.69	21.50	64.07	2.24	0.97	3.69
O_80	US	H&T	1980	42.15138	-83.1711	0.00	13.40	62.00	24.10	6.86	0.00

APPENDIX C. Sediment chemistry

Table 11. Summary of sediment chemistry COPCs. All values except HZD are presented as µg/g. Values highlighted and italicized represent SEL exceedances relative to provincial sediment quality guidelines. (Adapted from Thornley and Hamdy 1984, GLIER 2002, Milani and Grapentine 2008, Drouillard 2010, and GLIER unpublished)

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
1	29.560	1.726	18.202	18.022	0.157	21.233	0.039	17.406	35.857	0.001	BDL	BDL	0.086	49.82
2	6.209	0.502	20.821	21.883	0.191	4.406	0.011	23.829	44.565	-	-	-	0.195	14.01
3	23.452	1.271	12.129	11.124	0.112	4.307	0.018	11.281	26.445	0.003	0.001	0.004	0.175	30.27
4	0.833	0.225	9.579	8.718	0.089	3.394	0.057	8.748	17.887	0.001	BDL	0.001	0.120	4.34
5	12.979	0.674	9.045	4.488	0.065	2.253	0.023	8.842	15.219	0.002	BDL	0.002	0.095	11.45
6	20.026	1.011	11.992	6.770	0.085	4.571	0.032	9.621	20.480	BDL	BDL	0.006	0.145	22.25
7	45.730	3.067	32.900	31.174	0.242	17.585	0.309	33.565	87.632	0.003	0.001	0.007	0.322	106.08
8	23.180	1.103	9.367	12.490	0.093	2.097	0.034	8.570	15.933	0.001	BDL	0.001	0.073	28.50
9	20.243	1.048	9.704	7.343	0.088	6.606	0.011	9.333	27.458	0.003	0.006	0.064	0.190	23.26
10	2.636	0.293	15.678	16.752	0.138	4.505	0.031	14.674	34.653	0.001	BDL	0.004	0.210	8.13
11	0.239	0.262	12.345	15.253	0.100	8.776	0.085	10.900	34.695	0.002	0.001	0.028	1.474	6.83
12	18.361	0.933	8.999	13.471	0.070	4.261	0.092	10.411	23.511	0.002	0.001	0.005	0.344	20.65
13	23.859	1.281	13.017	14.243	0.093	6.931	0.112	13.165	37.948	0.002	0.001	0.009	0.766	32.99
14	20.206	1.305	18.145	11.376	0.101	18.595	0.328	11.063	33.763	0.001	0.003	0.026	16.932	30.79
15	8.838	2.543	65.442	101.843	0.178	686.121	1.901	29.305	218.197	0.002	-	1.125	69.162	241.97
16	14.180	0.762	7.061	6.688	0.056	2.993	0.065	8.121	17.874	0.001	0.001	0.002	0.164	13.06
17	25.236	1.450	13.078	18.743	0.109	8.756	0.102	13.609	40.470	0.002	0.001	0.010	0.595	37.13
18	3.985	0.590	27.586	30.342	0.215	3.067	0.022	30.293	55.828	BDL	BDL	BDL	0.227	18.51
19	1.650	0.411	19.465	24.137	0.149	15.900	0.182	18.550	62.713	0.003	0.001	0.010	4.568	13.42
20	0.460	0.597	27.580	29.363	0.225	4.690	0.026	30.273	55.787	BDL	BDL	-	0.214	17.14
21	17.045	0.749	5.059	8.758	0.068	3.166	0.011	7.647	17.722	0.001	BDL	0.001	0.099	16.24
22	29.424	1.660	15.853	13.209	0.141	2.387	0.031	16.482	22.410	0.001	BDL	BDL	0.160	46.88
23	14.496	0.739	7.498	7.563	0.061	2.227	0.059	7.331	15.315	0.001	BDL	0.003	0.126	13.27
24	4.246	0.747	24.871	27.068	0.186	15.275	0.134	22.539	64.303	0.001	0.001	0.008	0.218	16.38
25	3.862	0.713	17.577	26.659	0.155	13.214	0.347	20.740	64.555	0.006	0.002	0.015	1.847	16.73
26	2.593	0.338	12.684	21.336	0.136	3.322	0.023	13.715	41.146	0.001	BDL	0.001	0.130	8.31
27	23.276	1.318	12.107	12.861	0.112	3.434	0.050	12.481	29.041	0.001	BDL	0.003	15.306	32.97

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
28	6.367	0.842	15.219	32.752	0.188	20.330	0.097	14.548	132.087	BDL	BDL	0.007	2.167	16.79
29	2.945	0.841	31.321	73.113	0.210	173.812	0.225	18.080	109.134	0.001	0.004	0.166	114.121	113.49
30	0.966	0.406	18.198	27.564	0.100	34.826	0.349	10.586	53.022	0.001	0.007	0.546	84.341	49.38
31	27.553	1.806	18.088	17.243	0.153	67.362	1.748	14.153	53.685	0.001	-	1.782	8.201	92.10
32	1.017	0.310	9.329	14.135	0.117	4.922	0.021	10.442	21.347	BDL	BDL	0.001	0.719	5.45
33	1.615	0.320	15.554	21.983	0.137	22.645	0.130	11.823	58.695	0.002	0.001	0.033	4.724	10.77
34	3.293	0.808	37.997	161.052	0.167	124.205	0.359	42.954	166.999	0.001	0.005	0.674	141.526	196.36
35	3.186	0.278	15.546	27.250	0.140	15.509	0.012	16.056	67.440	0.001	0.001	0.016	1.255	11.60
36	4.048	0.347	15.911	29.948	0.179	4.363	0.018	21.661	43.195	0.001	-	0.001	0.197	13.07
37	6.037	1.021	30.558	40.428	0.261	19.720	0.405	35.163	99.504	0.003	0.001	0.004	0.605	30.50
38	5.339	1.032	8.823	90.239	0.298	33.164	-	12.350	137.959	0.001	BDL	0.006	13.134	44.42
39	1.257	0.617	16.086	52.706	0.358	11.340	0.020	14.390	27.190	0.001	0.001	0.003	0.877	17.62
40	5.189	0.584	22.770	28.194	0.189	4.548	0.020	28.398	50.128	0.001	-	-	0.317	16.98
41	26.070	0.738	17.455	37.515	0.391	6.874	0.030	20.353	28.453	BDL	BDL	0.004	0.464	43.28
42	2.585	0.854	11.953	28.654	0.151	21.232	0.374	13.906	58.757	0.001	0.004	0.138	214.771	107.75
43	4.738	0.511	21.729	20.910	0.154	4.962	0.031	21.044	38.867	BDL	BDL	0.006	90.908	51.07
44	23.029	1.428	14.473	12.774	0.113	8.103	0.543	10.564	39.805	0.001	0.001	0.024	0.713	35.09
45	3.243	1.160	39.037	44.293	0.247	23.261	0.398	35.820	131.444	0.006	0.002	0.099	2.876	34.45
46	24.583	1.397	9.169	13.104	0.115	5.757	-	13.947	25.952	0.001	BDL	BDL	0.290	33.27
47	25.363	1.473	8.787	12.469	0.118	6.121	0.016	11.659	34.058	0.002	BDL	0.012	1.645	35.11
48	28.624	1.592	13.111	12.867	0.134	8.094	0.018	12.800	26.746	0.001	BDL	0.020	0.339	43.83
49	9.551	3.044	44.436	67.644	0.617	53.682	0.403	28.297	349.026	0.001	-	1.541	38.593	72.65
50	7.126	3.124	74.970	96.753	0.426	254.039	0.416	50.124	372.390	0.001	0.023	0.592	128.210	217.90
51	5.362	0.803	14.583	26.596	0.197	177.667	0.045	17.530	87.582	BDL	BDL	0.011	22.075	41.06
52	6.284	3.043	70.258	100.184	0.433	123.636	0.478	51.969	373.272	0.003	0.023	0.522	47.868	129.83
53	7.298	0.588	10.481	21.383	0.168	7.482	-	18.017	35.726	0.001	BDL	0.002	0.368	11.72
54	8.883	0.922	31.093	38.567	0.284	13.105	0.022	38.742	73.964	-	-	0.821	1.574	32.33
55	28.860	1.879	14.297	15.873	0.162	226.325	0.019	11.795	39.690	0.009	0.002	0.017	2.251	84.77
56	6.870	0.655	20.584	25.149	0.206	5.218	0.009	28.050	49.980	-	-	-	-	16.80
57	1.359	0.531	16.898	50.162	0.169	6.980	0.035	13.535	42.042	0.001	BDL	0.005	4.268	16.96
58	2.743	0.372	11.408	14.226	0.129	6.053	0.047	12.833	33.153	0.001	BDL	0.003	2.954	7.56
59	39.142	2.442	25.312	24.979	0.201	13.231	0.282	25.607	66.664	0.004	0.001	0.009	0.598	83.71

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
60	3.411	0.500	13.632	18.027	0.153	8.583	0.041	15.685	43.478	0.003	BDL	0.016	8.030	10.59
62	10.257	0.748	21.245	25.741	0.229	5.282	0.033	26.896	57.533	BDL	-	-	0.276	19.27
63	4.391	0.593	10.063	20.687	0.187	7.841	0.016	14.623	31.982	0.002	BDL	0.008	0.589	9.46
64	3.066	0.767	33.902	45.279	0.255	6.829	0.091	37.780	87.284	0.001	BDL	0.005	0.563	28.71
65	5.220	0.723	43.233	49.613	0.347	7.704	0.062	43.943	89.766	0.002	BDL	0.009	0.286	37.29
66	0.946	0.644	44.259	38.313	0.279	7.542	0.100	42.221	77.062	0.002	BDL	0.005	0.326	31.05
67	2.146	1.060	29.364	42.619	0.222	21.979	0.595	32.946	127.123	0.005	0.002	0.026	1.289	31.48
68	1.867	0.554	17.969	20.023	0.138	18.827	0.220	15.302	64.806	0.004	0.001	0.031	1.169	12.08
69	3.148	1.349	38.925	51.631	0.274	26.934	0.599	40.373	161.371	0.006	0.005	0.026	1.674	43.04
70	2.031	1.105	33.148	44.467	0.241	23.020	0.545	35.616	131.773	0.006	0.003	0.026	1.380	33.77
71	7.152	0.395	11.144	15.346	0.129	7.426	BDL	12.864	30.629	0.003	0.001	0.005	3.639	9.76
72	2.047	0.396	17.706	23.199	0.146	19.259	0.289	16.573	58.389	0.002	0.001	0.022	1.513	13.19
73	3.243	0.289	8.989	9.472	0.092	13.872	0.072	9.773	44.469	0.003	0.001	0.031	0.929	6.80
74	4.476	1.388	43.897	58.511	0.294	26.435	0.485	42.476	170.118	0.005	0.007	0.036	1.627	48.02
75	4.860	3.363	101.272	192.642	-	86.859	0.189	56.756	414.507	0.001	0.004	0.199	38.170	195.05
76	5.495	3.965	98.449	134.092	0.568	102.528	0.568	59.598	548.524	0.004	0.025	0.694	34.831	190.56
77	1.855	2.246	16.357	28.415	0.139	30.899	0.153	14.135	60.722	0.002	0.004	0.092	0.029	16.60
78	3.500	1.107	21.343	37.376	0.185	17.837	0.243	20.453	81.866	0.002	0.002	0.053	17.991	22.40
79	3.921	3.227	77.778	111.060	0.542	85.977	0.425	44.633	369.810	0.004	0.015	0.574	38.000	125.67
80	4.499	3.304	63.394	98.861	0.498	81.087	0.410	45.092	384.567	0.002	0.003	0.070	3.931	98.26
81	44.519	3.148	35.534	38.223	0.229	24.688	0.392	34.259	137.074	0.004	0.002	0.027	1.101	109.26
82	28.365	1.777	18.953	28.479	0.138	6.811	0.068	21.994	44.472	BDL	BDL	0.001	0.152	49.62
83	32.398	1.989	13.311	16.887	0.157	14.267	0.113	14.839	60.870	0.003	0.001	0.012	4.549	57.88
84	40.987	3.005	30.274	31.357	0.213	20.221	0.346	29.338	103.801	0.005	0.002	0.033	1.626	95.10
85	27.709	1.918	20.155	20.966	0.142	16.677	0.299	18.818	74.459	0.003	0.002	0.051	2.134	49.45
86	27.814	1.806	18.562	18.649	0.132	14.486	0.281	17.621	68.787	0.037	0.013	0.480	4.375	52.84
87	3.733	0.634	27.371	24.341	0.199	8.191	0.054	28.162	76.782	BDL	-	BDL	0.059	17.05
88	7.238	1.308	42.508	50.978	0.343	28.332	0.492	47.485	135.128	0.045	0.025	0.156	0.985	53.66
89	50.248	3.341	38.544	34.690	0.267	15.871	0.104	35.338	113.902	0.001	0.005	0.011	1.596	115.81
90	35.168	2.062	18.713	19.792	0.171	10.871	0.133	18.800	58.043	0.003	0.001	0.017	2.133	67.28
91	38.659	2.653	28.390	38.623	0.205	7.935	0.077	30.678	66.484	0.001	BDL	0.001	0.289	86.64
92	26.244	1.609	15.613	18.310	0.125	9.915	0.202	18.092	44.926	0.003	0.001	0.018	1.159	42.12

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
93	33.456	2.245	22.441	24.559	0.165	19.114	0.274	22.663	79.725	0.004	0.001	0.036	3.820	67.79
94	6.308	0.228	9.906	17.806	0.130	6.712	0.071	11.583	63.700	0.002	0.001	0.009	0.327	9.46
95	25.207	1.776	17.018	12.825	0.145	6.989	0.057	12.037	33.634	0.001	0.003	0.069	0.418	36.75
96	45.232	2.739	29.045	31.492	0.224	14.167	0.359	30.928	79.656	0.080	0.001	0.018	1.835	109.19
97	3.884	0.851	38.266	47.458	0.267	9.590	0.080	39.253	84.219	BDL	BDL	BDL	0.117	31.66
98	3.165	0.852	18.567	28.226	0.182	9.779	0.039	24.360	180.260	0.001	0.001	0.015	2.121	17.74
99	31.160	2.536	25.158	26.812	0.168	15.198	0.178	20.734	82.298	0.002	0.009	0.420	54.858	78.25
100	36.694	2.438	21.182	32.128	0.183	14.594	0.219	21.449	72.882	0.003	0.003	0.070	22.184	80.80
101	56.135	4.961	54.940	57.496	0.287	44.406	0.439	42.562	204.182	0.842	0.010	0.248	17.134	251.33
102	17.265	1.130	12.270	11.213	0.080	5.216	0.059	14.599	34.878	0.001	0.001	0.033	0.507	20.31
103	20.455	1.503	15.988	15.676	0.100	14.541	0.075	11.727	53.436	0.001	0.006	0.089	1.665	27.96
104	4.960	0.344	8.527	12.863	0.102	7.492	0.097	10.473	33.527	0.005	0.001	0.021	9.927	9.29
105	4.444	1.032	32.974	43.085	0.246	25.928	0.464	37.158	105.537	0.006	0.002	0.022	11.325	35.22
106	26.827	1.692	17.722	17.286	0.149	4.091	0.038	18.606	40.983	BDL	BDL	0.003	0.144	42.07
107	2.664	0.958	40.917	52.582	0.265	23.208	0.574	40.330	110.545	0.005	0.003	0.043	3.428	41.45
108	1.677	1.137	48.445	66.071	0.338	26.358	0.643	48.407	140.100	0.006	0.004	0.024	1.287	57.04
109	1.948	0.268	10.906	9.678	0.088	6.620	0.288	9.470	31.465	0.002	BDL	0.014	0.904	7.42
110	57.485	3.565	38.195	50.541	0.229	18.843	0.262	31.549	113.249	0.002	0.003	0.044	1.462	127.44
111	2.684	0.530	15.997	20.293	0.115	8.723	0.248	15.563	51.489	0.002	0.002	0.043	1.024	11.66
113	4.384	2.538	62.334	51.195	0.431	40.656	0.482	49.616	320.113	0.012	0.003	0.141	6.325	66.73
114	2.939	1.150	35.874	44.065	0.343	35.095	0.528	34.109	171.451	1.017	0.006	0.407	14.937	134.76
115	2.197	0.900	23.377	29.575	0.141	14.423	0.161	23.998	77.569	0.002	0.008	0.123	3.530	18.28
116	5.864	1.163	26.965	23.417	0.258	22.920	0.350	31.888	184.514	0.014	0.004	0.151	31.992	33.64
117	7.173	0.874	20.115	23.011	0.186	25.838	0.266	38.037	152.827	0.021	0.005	0.215	12.736	30.68
118	5.655	0.748	17.759	22.416	0.170	20.850	0.199	33.422	132.172	0.029	0.005	0.274	30.297	30.34
119	2.345	0.285	12.668	14.426	0.108	3.649	0.014	13.174	31.703	0.027	0.017	0.442	8.107	12.07
120	6.704	1.340	28.596	37.774	0.253	39.286	0.604	38.468	257.825	0.008	0.003	0.145	23.278	44.72
121	2.253	0.623	18.411	21.044	0.151	12.537	0.330	19.645	72.868	0.004	0.001	0.014	0.647	14.28
122	3.280	0.168	5.256	7.792	0.086	3.448	0.029	5.969	20.916	0.001	BDL	0.003	0.111	4.05
123	3.170	1.178	38.244	47.437	0.286	21.750	0.515	41.198	121.979	0.007	0.002	0.018	1.174	39.16
124	5.691	1.164	36.900	49.737	0.280	22.895	0.532	40.973	121.562	0.008	0.002	0.018	1.191	40.90
125	0.566	0.194	10.039	13.924	0.113	6.381	0.060	9.841	35.091	0.001	BDL	0.004	0.759	5.67

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
126	2.070	1.986	40.030	47.666	0.188	29.333	0.485	24.664	122.353	0.004	0.006	0.168	9.305	34.51
127	3.239	0.738	18.542	27.503	0.160	14.370	0.277	18.988	68.658	0.005	0.003	0.086	15.974	18.33
128	30.370	1.674	15.763	22.290	0.124	9.251	0.127	14.848	50.692	0.003	0.002	0.031	4.640	52.70
129	24.510	1.394	16.403	15.820	0.098	4.673	0.105	12.316	36.003	0.001	0.001	0.015	2.231	35.01
130	1.455	0.759	33.636	50.779	0.270	18.826	0.543	35.663	105.048	0.008	0.002	0.021	1.575	34.66
131	4.476	1.059	27.785	41.234	0.237	21.028	0.597	33.193	100.494	0.009	0.002	0.020	1.936	31.61
132	14.722	0.586	5.362	6.495	0.057	4.813	0.043	6.126	20.265	0.001	BDL	0.006	0.317	12.92
133	0.725	0.338	13.467	13.389	0.105	4.742	0.098	10.939	33.855	0.002	0.001	0.026	2.256	6.88
134	22.144	1.367	13.775	10.367	0.114	7.119	0.047	11.602	43.639	BDL	0.001	0.028	0.507	28.48
135	3.753	1.163	26.598	28.546	0.167	17.739	0.260	20.350	97.797	0.019	0.048	1.431	26.859	34.72
136	25.809	1.870	20.641	18.203	0.107	11.284	0.365	13.557	99.441	0.001	0.001	0.046	4.641	44.07
137	17.863	1.421	13.483	12.640	0.066	8.371	0.248	9.098	70.527	0.002	0.001	0.024	0.461	23.03
138	1.991	4.825	78.401	73.016	0.480	54.348	1.560	49.934	458.281	0.019	0.005	0.195	9.546	127.45
139	0.226	0.943	23.963	21.245	0.162	12.215	0.135	18.480	79.892	0.001	0.002	0.122	5.785	14.16
140	3.764	4.240	73.929	72.958	0.474	47.867	1.534	47.002	380.703	0.003	0.003	0.100	3.171	112.30
141	2.909	1.314	26.686	38.591	0.252	23.114	0.565	21.523	138.354	0.014	0.005	0.186	72.606	52.71
142	4.738	1.255	26.162	52.690	0.209	15.971	0.281	23.840	93.988	0.001	0.004	0.101	12.703	29.55
143	1.718	1.113	31.591	36.926	0.241	30.853	0.354	24.385	155.716	0.229	0.003	0.186	11.066	69.20
144	3.840	1.763	37.149	37.680	0.237	30.405	0.816	35.156	205.067	0.036	0.008	0.582	44.384	55.54
145	21.379	1.582	19.099	12.903	0.119	11.991	0.215	19.688	82.279	0.008	0.006	0.211	76.309	61.69
146	1.937	1.702	33.369	36.612	0.244	30.215	2.031	27.835	186.010	0.409	0.008	0.515	28.048	167.05
147	1.511	7.408	121.653	156.519	0.396	108.020	1.432	66.442	741.067	0.009	0.029	0.751	22.096	282.72
148	2.963	1.458	31.765	25.689	0.243	27.771	0.628	34.613	227.552	0.179	0.004	0.113	14.128	61.85
149	2.360	1.221	26.063	32.982	0.223	15.475	0.317	23.869	122.985	0.002	0.001	0.042	8.016	22.21
150	2.233	1.244	32.952	35.525	0.219	37.021	1.766	28.980	185.735	0.117	0.005	0.845	67.308	99.57
DR 001	-	-	9.555	5.582	0.081	3.341	0.036	8.144	18.487	BDL	BDL	0.003	0.059	3.17
DR 002	-	-	-	-	-	-	0.029	-	-	0.002	BDL	0.001	0.019	0.27
DR 002	-	1.766	6.051	10.659	0.050	3.234	0.025	7.174	13.052	BDL	BDL	0.002	-	5.98
DR 003	-	0.754	18.164	7.870	0.166	7.053	0.145	19.603	56.893	0.001	0.001	0.010	0.419	9.59
DR 004	-	-	-	-	-	-	0.063	-	-	BDL	BDL	0.006	0.007	0.42
DR 005	-	0.536	14.760	16.555	0.127	13.357	0.120	12.765	63.970	BDL	0.003	0.011	3.063	9.09
DR 006	1.655	1.721	12.792	33.164	0.108	35.035	0.245	11.335	67.540	BDL	0.001	0.031	15.423	18.62

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
DR 008	-	-	-	-	-	-	0.010	-	-	BDL	BDL	0.004	0.044	0.11
DR 008	1.281	1.102	8.673	13.957	0.074	3.755	0.012	7.747	19.287	BDL	BDL	0.010	-	5.95
DR 009		0.749	17.828	6.977	0.172	8.181	0.091	20.573	60.732	0.001	0.001	0.015	0.650	9.49
DR009Alt	1.834	5.278	10.352	19.763	0.089	9.026	0.063	11.415	31.652	BDL	BDL	0.001	0.036	21.33
DR 010	3.187	2.480	18.216	36.758	0.201	13.345	0.162	23.669	63.672	0.001	BDL	0.016	0.443	21.14
DR 011	3.689	1.026	20.734	14.369	0.194	12.439	0.172	24.908	75.076	0.002	0.001	0.022	0.854	15.11
DR 012	3.136	2.321	16.489	34.217	0.169	12.420	0.127	20.746	55.986	0.001	BDL	0.011	0.884	18.55
DR013Alt	7.506	2.362	40.643	67.250	0.302	43.431	0.183	39.677	165.767	0.001	0.003	0.191	2.188	51.21
DR 013	4.460	1.714	40.341	39.352	0.317	42.353	0.187	40.575	182.127	0.001	0.007	0.128	12.032	39.89
DR 022	4.412	3.187	37.074	54.885	0.238	71.239	0.243	33.706	199.191	0.002	0.005	0.361	14.377	48.40
DR 014	3.044	2.277	26.119	76.505	0.141	74.969	0.161	15.699	120.443	BDL	0.002	1.101	12.784	47.70
DR 007	2.280	0.925	21.229	13.719	0.180	21.649	0.218	19.507	94.464	0.001	0.001	0.110	1.469	14.14
DR 015	5.184	1.351	10.619	24.263	0.092	14.470	0.107	9.875	39.398	0.001	0.001	0.034	5.678	12.52
DR 016	3.319	1.019	39.504	16.282	0.347	9.776	0.279	39.355	125.096	0.003	0.002	0.015	1.269	27.55
DR 017	1.918	1.364	9.914	18.986	0.092	15.681	0.099	10.042	42.536	BDL	0.001	0.055	1.460	9.73
DR 018	2.712	0.928	24.843	15.121	0.180	13.283	0.217	20.925	92.165	0.002	0.001	0.028	2.575	14.92
DR 019	3.322	1.657	15.501	23.337	0.128	12.028	0.108	13.761	44.235	0.001	0.001	0.090	1.546	12.94
DR 023	2.524	2.415	114.942	178.988	0.209	211.066	0.165	133.992	217.958	BDL	0.004	2.217	27.727	291.79
DR 023	3.308	2.114	60.696	599.259	0.325	182.475	0.187	38.393	-	0.001	0.011	1.479	35.891	167.33
DR 025	4.610	1.141	24.947	37.791	0.179	5.667	0.017	27.538	55.191	-	BDL	0.004	0.298	19.98
DR 026	-	2.326	88.903	58.019	BDL	191.624	0.193	59.574	1013.353	0.001	0.009	0.365	46.552	186.05
DR 027	1.770	2.940	23.962	110.973	0.481	87.658	0.115	24.635	221.712	BDL	0.003	0.188	15.689	77.15
DR 020	-	0.504	13.076	2.241	0.096	3.674	0.069	11.816	33.277	0.001	BDL	0.005	0.579	5.07
DR020Alt	8.349	1.317	20.094	42.557	0.196	17.580	0.164	26.014	67.915	0.001	0.001	0.021	0.874	24.35
DR 021	2.380	1.719	10.282	24.308	0.133	10.676	0.831	13.021	37.112	0.001	BDL	0.016	2.683	20.49
DR 029	9.235	0.943	20.747	9.900	0.353	11.914	0.121	26.311	64.030	0.002	0.001	0.010	0.463	17.30
DR 030	-	-	-	-	-	-	0.332	-	-	0.007	0.003	0.020	0.885	3.20
DR 030	3.234	3.585	34.370	51.279	0.294	16.908	0.311	35.694	103.993	0.001	0.001	0.019	0.575	38.97
DR 031	-	0.588	29.187	25.194	0.249	4.164	0.088	34.034	75.583	0.001	BDL	0.006	0.218	18.96
DR 032	4.901	3.160	27.541	47.718	0.237	16.718	0.266	32.190	87.691	0.001	0.001	0.014	5.712	33.98
DR 033	1.928	BDL	8.108	1.902	0.056	2.340	0.018	6.526	13.687	BDL	BDL	0.001	0.017	2.74
DR 034	4.279	0.866	14.228	25.117	0.172	9.597	0.131	16.443	40.154	0.002	0.001	0.013	0.890	12.48

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
DR 035	3.077	0.825	18.702	11.338	0.150	10.790	0.151	18.004	65.291	0.002	0.001	0.014	1.440	11.37
DR 037	2.323	0.586	13.692	9.433	0.128	9.914	0.096	14.330	42.432	0.001	0.002	0.011	1.178	8.16
DR 038	3.432	1.291	28.870	38.058	0.252	18.638	0.205	24.268	77.025	0.001	0.001	0.016	5.320	22.47
DR 039	1.843	0.504	11.826	3.766	0.107	8.818	0.089	11.430	40.490	0.001	0.001	0.010	1.782	6.33
DR 040	2.586	1.624	24.478	45.664	0.237	19.496	0.252	24.418	92.434	0.003	0.003	0.118	13.150	26.84
DR 041	3.178	1.094	29.645	18.538	0.276	14.377	0.167	33.478	105.786	0.003	0.002	0.013	11.318	23.02
DR 042	4.865	1.514	29.998	46.413	0.317	29.677	0.229	29.503	91.714	0.002	0.001	0.026	1.119	28.79
DR 044	2.917	1.211	7.764	15.071	0.096	7.025	0.052	9.365	31.348	BDL	BDL	0.007	0.335	7.70
DR 028	-	-	188.672	42.133	-	97.310	0.179	115.804	435.808	0.001	0.022	0.526	17.981	214.83
DR 045	3.355	3.106	33.684	104.955	0.506	52.997	0.197	28.712	248.051	BDL	0.003	0.111	23.084	76.11
DR 046	BDL	0.914	1.166	10.442	BDL	1.796	0.197	16.612	74.404	0.002	0.006	0.074	19.102	11.88
DR 047	1.842	2.043	13.697	47.295	0.153	14.498	0.061	15.016	57.163	0.003	0.004	0.053	6.353	20.36
DR 048a	-	-	-	-	-	-	0.180	-	-	0.003	0.008	0.085	11.804	3.97
DR 048b	1.699	0.938	19.046	11.612	0.176	15.464	0.219	16.352	86.198	0.001	0.005	0.077	9.524	13.46
DR 049	4.206	1.981	13.886	28.620	0.159	9.896	0.080	15.640	58.890	0.003	0.005	0.065	2.810	15.79
DR 050	-	0.948	34.225	18.220	BDL	26.489	0.169	26.182	146.578	0.004	0.007	0.181	13.636	22.13
DR050Alt	3.372	1.897	34.476	45.226	0.212	28.465	0.235	23.637	185.882	0.020	0.031	0.182	9.914	34.63
DR051Alt	2.159	1.690	13.455	21.037	0.105	6.986	0.074	13.316	39.445	0.001	0.002	0.028	0.825	11.12
DR 051	-	-	-	-	-	-	0.198	-	-	0.005	0.017	0.198	17.085	6.32
DR 052	3.878	1.384	30.124	29.529	0.266	22.133	0.327	30.953	118.057	0.002	0.004	0.060	3.419	25.72
DR 053	2.357	1.723	11.638	21.918	0.137	13.632	0.090	17.685	67.855	0.029	0.008	0.163	14.742	17.91
DR 054	4.380	1.198	29.390	21.147	0.248	16.487	0.267	29.280	99.651	0.003	0.003	0.041	2.654	21.74
DR 055	3.820	3.247	28.074	46.980	0.227	20.450	0.222	25.059	96.912	0.006	0.009	0.070	11.412	32.67
DR 056		1.164	38.325	16.338	0.355	20.638	0.282	29.985	165.709	0.005	0.006	0.151	5.359	24.33
DR 057	2.221	2.531	14.670	16.972	0.073	27.257	0.159	12.311	49.305	0.021	0.009	0.308	27.337	21.78
DR 058		4.892	102.910	34.778	-	74.424	1.842	55.260	467.309	0.007	0.013	0.835	15.287	151.90
DR 059	1.203	1.790	14.116	22.808	0.135	10.152	0.140	12.120	57.146	0.001	0.002	0.027	1.234	12.06
DR 060	3.780	4.929	52.088	50.004	-	52.541	0.514	28.005	253.242	0.012	0.011	0.117	11.351	56.71
PREF07	-	-	-	-	-	-	0.178	-	-	0.006	0.002	0.009	0.330	1.68
PREF08		0.649	13.753	6.371	0.111	8.418	0.221	15.994	40.710	0.002	BDL	0.004	0.193	8.13
PREF09	2.143	2.746	10.021	19.438	0.084	7.843	0.124	13.029	31.258	0.001	BDL	0.013	0.007	12.84
TRCH07	-	-	-	-	-	-	0.646	-	-	0.005	0.023	0.429	10.791	11.24

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
TRCH08	-	4.970	84.761	82.566	0.414	72.526	1.039	49.236	470.756	0.001	0.001	0.324	5.590	122.41
TRCH09	2.741	7.687	82.324	149.347	0.348	91.090	0.996	58.668	564.527	0.010	0.035	0.598	8.800	206.64
DR_01	1.706	0.488	10.012	4.177	0.089	3.084	0.030	5.791	16.263	-	BDL	0.023	0.084	3.83
DR_02	1.216	0.250	5.520	1.860	0.041	2.611	0.020	3.335	10.762	-	BDL	0.003	0.279	2.17
DR_03	2.942	0.586	14.751	9.166	0.121	6.979	0.240	10.697	38.421	BDL	BDL	0.010	1.221	8.46
DR_04	3.243	0.879	21.575	13.129	0.173	15.373	0.050	15.067	61.562	BDL	0.001	0.030	5.379	11.43
DR_05	3.234	0.606	13.096	26.106	0.135	32.282	0.140	8.671	43.315	-	-	-	-	11.22
DR_06	4.891	1.534	29.366	20.051	0.237	13.644	0.180	21.742	70.254	0.001	BDL	0.017	0.968	17.74
DR_07	2.809	0.674	14.762	11.404	0.129	8.501	0.170	11.317	39.167	0.001	0.001	0.012	1.474	8.57
DR_08	3.707	0.952	24.294	14.876	0.190	10.832	0.170	17.816	56.161	0.001	BDL	0.011	0.784	12.86
DR_09	3.726	1.029	22.980	14.089	0.181	13.277	0.060	16.115	69.797	-	-	-	1.246	11.83
DR_10	5.483	5.466	217.671	519.376	0.196	555.571	0.850	25.810	437.168	-	-	-	-	333.83
DR_11	9.584	2.389	47.460	35.250	0.332	35.510	0.260	32.733	136.153	BDL	0.002	0.073	3.872	38.04
DR_12	5.238	1.676	34.728	20.974	0.256	19.334	0.160	22.157	82.262	BDL	0.001	0.024	2.361	20.11
DR_13	3.081	0.935	20.008	10.948	0.193	8.574	0.130	11.493	40.910	BDL	BDL	0.008	1.147	9.40
DR_14	5.149	1.093	26.251	16.226	0.218	12.375	0.040	19.573	73.997	0.001	0.001	0.018	3.684	14.68
DR_15	-	-	-	-	-	-	0.190	-	-	-	-	-	-	1.27
DR_16	5.672	1.315	34.618	20.901	0.262	17.827	0.300	23.528	90.887	BDL	0.001	0.021	2.239	21.27
DR_17	-	-	-	-	-	-	0.100	-	-	-	-	-	-	0.62
DR_18	2.791	0.675	14.970	10.680	0.094	30.846	0.040	7.627	38.527	BDL	0.001	0.103	24.413	12.75
DR_19	8.527	7.361	65.013	64.267	0.784	64.011	0.170	24.786	387.373	BDL	0.002	0.261	39.388	93.24
DR_20	3.134	1.351	37.757	87.014	0.162	65.938	0.320	17.052	136.413	-	-	-	-	50.10
DR_21	9.751	7.714	164.626	132.563	0.921	105.150	0.320	45.849	1035.145	BDL	0.003	0.122	20.769	283.49
DR_22	5.978	1.466	31.773	34.071	0.246	25.175	0.270	22.607	109.098	BDL	0.001	0.033	8.543	24.95
DR_23	3.150	8.143	44.805	125.092	0.166	83.595	0.300	22.860	201.845	0.001	0.040	0.200	32.314	126.44
DR_24	14.496	7.016	83.305	427.764	0.189	769.448	9.140	54.556	1731.617	BDL	BDL	0.018	228.453	561.81
DR_25	2.983	1.749	22.739	23.791	0.118	34.316	0.130	9.542	140.163	-	0.001	0.148	6.982	17.36
DR_26	7.960	1.474	28.684	14.295	0.220	10.902	0.090	21.752	61.891	BDL	BDL	0.004	0.310	17.17
DR_27	7.254	1.875	37.695	25.017	0.288	18.339	0.230	27.298	99.603	BDL	0.001	0.008	1.444	25.41
DR_28	4.560	0.574	9.994	5.127	0.091	6.668	0.050	6.730	27.230	-	-	-	-	5.68
DR_29	-	-	-	-	-	-	0.090	-	-	-	0.001	0.032	3.366	1.14
DR_30	4.926	1.672	35.385	24.653	0.250	17.097	0.240	25.131	98.209	0.001	0.001	0.031	1.212	22.40

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
DR_31	2.788	0.787	15.873	9.430	0.125	6.668	0.090	10.968	41.483	BDL	BDL	0.015	0.665	7.78
DR_32	3.491	0.826	17.340	10.811	0.111	7.976	0.060	11.825	37.733	BDL	0.002	0.007	3.366	8.92
DR_33	2.393	0.547	11.472	5.925	0.087	6.226	0.100	7.255	27.655		BDL	0.005	0.386	5.49
DR_34	5.014	1.767	33.908	26.866	0.258	19.150	0.420	25.372	89.834	BDL	0.001	0.021	2.310	24.63
DR_35	5.360	1.151	22.154	14.125	0.165	10.772	0.150	16.314	51.607		0.001	0.042	0.750	12.96
DR_36	6.051	0.693	13.163	6.043	0.123	6.176	0.130	7.281	32.555	-	-	-	-	7.70
DR_37	5.116	1.213	23.048	14.392	0.185	11.124	0.180	16.796	55.072	BDL	0.001	0.025	1.224	13.58
DR_38	3.813	0.745	20.651	12.818	0.132	6.086	0.050	13.283	37.567	BDL	BDL	0.004	0.099	9.19
DR_39	1.524	0.315	8.525	4.367	0.064	3.092	0.030	5.724	16.264	BDL	BDL	0.003	0.109	3.35
DR_40	3.121	0.642	16.629	8.239	0.108	11.765	0.230	8.735	38.869	-	BDL	0.031	2.622	8.78
DR_41	2.426	0.577	13.297	8.883	0.101	6.355	0.080	10.369	31.852	BDL	BDL	0.009	0.218	6.54
DR_42	3.569	1.058	25.189	13.616	0.169	9.884	0.050	15.871	58.801	-	0.003	0.007	0.281	11.72
DR_43	2.624	0.389	8.784	4.130	0.082	3.616	0.060	5.677	20.522	BDL	BDL	0.039	0.735	4.29
DR_44	4.558	1.271	31.101	21.681	0.222	14.958	0.270	22.296	84.863	BDL	0.001	0.022	0.787	18.92
DR_45	1.839	0.337	6.606	2.916	0.050	2.934	0.050	4.296	13.451	BDL	BDL	0.005	0.245	3.05
DR_46	4.600	1.306	29.807	19.493	0.221	13.266	0.150	20.864	77.642	0.001	0.001	0.028	1.355	16.86
DR_47	4.614	1.156	27.548	17.874	0.218	12.512	0.240	20.968	67.828	BDL	BDL	0.004	0.771	16.27
DR_48	4.007	0.925	20.102	14.060	0.162	10.029	0.140	13.762	57.769	0.001	BDL	0.031	2.420	11.29
DR_49	3.809	0.943	27.316	15.838	0.195	10.915	0.280	19.897	65.816	0.001	0.002	0.075	3.645	15.81
DR_50	4.963	1.876	32.495	21.526	0.224	19.515	0.230	19.354	123.980	0.017	0.004	0.143	19.702	25.08
DR_51	4.063	2.096	34.309	24.860	0.251	18.462	0.180	16.816	114.855	0.001	0.003	0.132	29.764	26.41
DR_52	4.513	1.986	33.402	23.193	0.238	18.988	0.270	18.085	119.417	BDL	0.001	0.103	9.063	22.16
DR_53	2.948	1.685	28.150	14.994	0.213	14.073	0.170	15.558	100.955	0.001	0.002	0.097	10.756	16.80
DR_54	7.132	6.951	98.197	29.119	0.860	62.991	0.670	52.385	334.108	0.003	0.012	0.276	17.074	115.11
DR_55	4.614	1.758	29.016	20.123	0.215	20.095	0.620	22.191	140.688	0.001	0.074	0.842	69.016	59.26
DR_56	5.435	2.024	37.269	33.252	0.264	21.713	0.200	26.806	115.463	BDL	0.001	0.066	5.980	27.34
DR_57	4.532	1.384	25.617	19.817	0.196	13.089	0.120	18.596	70.807	-	0.002	0.049	1.453	15.42
DR_58	4.378	2.430	42.150	33.736	0.340	27.004	0.170	19.383	145.456	-	0.001	0.076	9.362	28.03
DR_59	2.439	0.662	14.515	9.080	0.092	11.752	0.110	8.386	44.789	BDL	0.002	0.071	5.100	8.10
DR_60	3.289	0.508	9.498	6.065	0.091	8.540	0.030	6.317	22.621	BDL	BDL	0.013	0.449	5.07
DR_61	2.506	0.804	14.704	9.602	0.106	6.624	0.120	9.895	49.637	BDL	0.001	0.051	3.393	8.22
DR_62	5.135	1.151	24.981	18.219	0.198	12.317	0.270	19.295	66.898	0.002	0.001	0.141	8.226	17.45

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
DR_63	3.429	1.191	27.634	18.350	0.203	15.556	0.510	14.587	94.357	0.002	0.001	0.241	17.941	21.33
DR_64	3.051	1.811	34.464	24.158	0.295	17.750	0.170	16.233	112.742	0.003	0.001	0.173	82.016	51.28
DR_65	2.409	0.527	11.079	6.292	0.083	5.177	0.080	7.829	35.738	BDL	0.002	0.074	5.009	6.42
DR_66	3.071	1.535	29.664	21.633	0.221	16.197	0.160	17.047	107.842	0.001	0.002	0.074	6.957	17.76
DR_67	-	-	-	-	-	-	0.720	-	-	-	-	-	-	7.32
DR_68	3.173	0.733	16.315	8.738	0.154	5.787	0.060	11.260	36.848	BDL	BDL	0.010	0.586	7.56
DR_69	5.903	2.371	49.286	48.436	0.329	33.741	0.580	26.228	197.466	0.001	0.004	0.205	8.820	43.60
DR_70	7.728	2.419	35.342	37.399	0.326	36.383	0.830	25.854	183.824	BDL	0.006	0.077	16.673	42.36
DR_71	2.259	0.363	9.084	7.229	0.085	2.982	0.040	6.012	21.821	BDL	BDL	0.032	1.657	4.53
DR_72	3.352	1.038	19.471	15.363	0.169	14.067	0.120	12.356	72.050	BDL	0.002	0.097	13.846	13.43
DR_73	2.500	1.000	24.610	35.580	0.238	33.190	0.480	41.840	99.470	0.007	0.001	0.012	-	32.70
6676	2.500	1.000	24.610	35.580	0.238	33.190	0.480	41.840	99.470	0.007	0.001	0.012		32.44
6695	2.500	1.000	25.480	29.770	0.229	40.550	0.480	40.390	92.700	0.006	0.001	0.009	-	30.55
6677	2.500	1.000	19.780	32.280	0.200	35.140	0.270	36.360	88.040	0.005	0.001	0.015	-	25.23
6678	2.500	10.070	128.200	197.260	0.159	963.170	1.150	144.050	962.190	0.005	0.061	1.907	-	485.40
6680	2.500	1.000	21.580	28.750	0.179	42.710	1.230	34.010	122.040	0.004	0.002	0.091	-	41.36
6696	2.500	1.000	12.760	12.940	0.135	27.530	0.140	23.860	49.500	0.003	0.001	0.009	-	13.09
6681	2.500	2.000	27.890	37.440	0.223	47.140	0.420	42.800	141.700	0.004	0.003	0.069	-	37.29
6682	2.500	1.000	18.370	24.340	0.150	39.200	1.910	31.850	96.930	0.004	0.001	0.021	-	62.20
6683	2.500	1.000	16.980	26.040	0.165	36.110	0.450	32.230	74.750	0.003	0.001	0.009	-	22.84
6685	7.000	0.830	15.900	24.670	0.133	31.720	0.420	27.140	70.940	0.003	0.001	0.015	-	21.41
6687	2.500	1.000	25.470	35.590	0.248	46.240	0.400	43.890	108.330	0.006	0.001	0.011	-	34.11
6688	2.500	1.000	16.780	20.340	0.103	27.650	0.110	26.250	75.910	0.001	0.005	0.060	-	16.11
6689	2.500	1.000	17.920	12.410	0.130	22.790	1.840	22.950	75.160	0.001	0.002	0.057	-	52.50
6690	2.500	1.000	33.720	23.360	0.290	51.880	0.690	35.840	181.510	0.797	0.007	0.534	-	131.46
6691	2.500	1.000	22.330	57.840	0.172	58.900	0.730	23.440	170.880	0.002	0.017	0.064	-	38.57
6692	2.500	1.000	28.260	34.500	0.228	44.650	0.420	40.930	115.630	0.005	0.003	0.048	-	32.73
E_80	BDL	0.400	14.000	12.000	0.110	17.000	0.160	8.000	46.000	0.005	BDL	0.033	-	7.14
10_80	BDL	0.730	21.000	39.800	0.086	44.000	0.100	12.000	64.000	BDL	BDL	0.480	-	17.41
8_80	BDL	0.500	38.000	25.000	0.150	46.000	0.490	23.000	81.000	0.005	BDL	0.036	-	22.54
17_80	BDL	6.900	120.00	370.00	0.220	470.00	1.200	66.000	760.00	0.003	BDL	2.960	-	379.96
23_80	BDL	14.000	140.00	190.00	0.460	180.00	0.530	40.00	550.00	BDL	BDL	0.330	-	299.31

Site	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn	HCB	DDE	ΣPCB	ΣPAHs	HZD
O_80	BDL	17.000	330.00	300.00	0.180	760.00	8.100	110.00	4600.00	0.360	BDL	1.580	-	738.57

APPENDIX D. Bioassay – 2001 multi-endpoint assessment

Table 12. Results of the 2001 Environment Canada multi-endpoint bioassay. (Adapted from Milani and Grapentine 2008).

	C. riparius Growth	C. riparius % Survival	H. azteca Growth	H. azteca % Survival	Hexagenia Growth	Hexagenia % Survival	T. tubifex (No. cocoons /adult)	T. tubifex (% cocoons hatched)	T. tubifex % Survival	T. tubifex (No. young / adult)
Reference Mean	0.35	87.10	0.5	85.6	3.03	96	9.9	0.57	98	29
Ref. 6676	0.447	94.67	0.55	94.67	3.359	96	9.05	0.7	100	21.5
Ref. 6695	0.481	98.67	0.673	97.33	3.747	98	10.35	0.66	100	22.6
Ref. 6677 (US)	0.519	93.33	0.652	98.67	4.205	100	10.05	0.65	100	20.95
6678 (US)	0.37	70.67	0.418	74.67	-0.072	38	8.31	0.44	85	8.56
6680	0.543	78.67	0.562	92	2.809	100	9.6	0.69	100	16.55
6696	0.561	82.67	0.598	98.67	4.233	100	10.85	0.62	100	19.25
6681	0.491	97.33	0.794	92	4.723	98	11.45	0.64	100	19.5
6682	0.461	97.33	0.549	90.67	3.84	94	10.25	0.66	100	16.4
6683	0.375	97.33	0.75	92	4.543	100	11.55	0.65	100	25.25
6685	0.38	96.00	0.543	92	3.832	100	11	0.63	100	25.7
6687	0.34	94.67	0.54	94.67	3.172	100	10.3	0.71	100	24.45
6688 (US)	0.381	89.33	0.564	96	6.198	100	10.6	0.55	100	26.2
6689 (US)	0.374	97.33	0.699	94.67	4.603	100	11.3	0.48	100	18.95
6690 (US)	0.473	100.00	0.675	85.33	4.428	100	11.5	0.65	100	25.5
6691 (US)	0.417	97.33	0.462	84	1.904	96	9.05	0.79	100	24.35
6692	0.435	88.00	0.618	94.67	2.88	100	9.7	0.74	100	22.05
Non-Toxic	0.49-0.21	67.70	.75-.23	67	5.00-0.90	85.5	12.4-7.2	0.78-38	88.9	46.3-9.9
Potentially Toxic	0.20-0.14	67.6-58.8	0.22-0.10	66.9-57.1	0.80-0	85.4-80.3	7.1-5.9	0.38-0.28	88.8-84.2	9.8-0.8
Toxic	<0.14	<58.8	<.10	<57.1	<0.00	<80.3	<5.9	<.28	<84.2	<0.8

APPENDIX E. Bioassay – adapted from Drouillard 2010

Table 13. Results of the 2008 Chironomus riparius bioassay examination (adapted from Drouillard, 2010)

	C. riparius Growth	% Difference from Control	C. riparius % Survival	P-value (Survival)
Control	0.1646		84.33333333	N/A
DR 002 '07	0.286437	74.0200486	78.66666667	0.307313529
DR002	0.233332	41.7569866	97.33333333	0.093324004
DR 003 #1			100	0.02619983
DR 003 #2			77.33333333	0.240851404
DR004	0.175279	6.4878493	100	0.056929115
DR 005 '08	0.239364	45.4216282	86.66666667	0.405686998
DR007			75	0.202447366
DR 008 '07	0.237843	44.4975699	86.66666667	0.405686998
DR008	0.208103	26.4295261	100	0.056929115
DR 009 '08	0.195256	18.6245443	78.66666667	0.307313529
DR010	0.157047	-4.5886999	94.66666667	0.149487094
DR011			76.66666667	0.235311556
DR012	0.149054	-9.4447145	97.33333333	0.093324004
DR013	0.166156	0.945322	96	0.118525184
DR 013			94.66666667	0.147823138
DR015	0.207137	25.8426488	92	0.215678908
DR 016			92	0.218909627
DR018			70	0.084850817
DR019	0.210587	27.9386391	73.33333333	0.135893271
DR020	0.140366	-14.7229648	92	0.223559248
DR 020			89.33333333	0.307033848
DR022			85.41666667	0.126981893
DR 026			90.66666667	0.257556679
DR028			81.66666667	0.391941753
DR 030 '07	0.177764	7.9975699	74.66666667	0.171622707
DR030	0.18685	13.5176185	88	0.353391113
DR031			81.66666667	0.395314184
DR032	0.192112	16.7144593	77.33333333	0.236236129
DR034	0.194489	18.1585662	89.33333333	0.304546876
DR035			95	0.137952518
DR039			100	0.056929115
DR046			81.66666667	0.394225356
DR 048 '07	0.178616	8.5151883	74.66666667	0.171622707
DR048			81.66666667	0.391941753
DR049	0.181413	10.2144593	92	0.218909627

DR 049			90.66666667	0.256040333
DR050			90	0.280742704
DR052			90	0.280742704
DR 053 '07	0.133418	18.9441069	74.66666667	0.171622707
DR054			91.66666667	0.230825884
DR056			95	0.137952518
DR058			61.66666667	0.062512305
DR 060			74.66666667	0.161794894
DR PREF			94.66666667	0.146137018
PREF			89.33333333	0.309428515
DR TRCH #1			84	0.486725178
DR TRCH #2			93.33333333	0.181295987
TRCH			91.66666667	0.225922258

APPENDIX F. Benthos community composition

Table 14. Summary of benthos community composition data. The 16 most prevalent taxa are included here. Taxa are reported as density (individual/m^2). (Adapted from Thornley and Hamdy 1984, GLIER 2002, and Milani and Grapentine 2008.)

Site	Cluster	Oligochaeta	Nematoda	Chironomidae	Ceratopogonidae	Ephemeridae	Caenidae	Hydropsychidae
3	2	116	14	65	0	7	0	134
4	1	507	406	2913	0	0	0	0
5	2	779	1283	732	0	22	0	0
7	1	145	11	320	0	74	0	0
8	2	174	29	725	0	14	2	14
9	2	609	0	2261	0	0	0	0
10	2	11	0	152	0	0	43	22
11	3	174	435	739	43	0	0	0
12	3	188	29	656	14	0	0	0
13	3	1304	522	3957	0	0	29	0
14	2	333	174	275	0	0	0	0
15	2	183	35	78	0	0	0	0
16	1	674	565	457	0	0	0	0
17	3	261	913	2783	0	87	0	0
18	2	0	14	58	0	72	0	0
19	3	1000	652	2826	0	0	0	174
21	2	43	0	87	0	0	0	0
22	2	130	0	87	0	0	0	0
23	3	739	43	826	0	43	43	0
24	2	196	43	174	0	0	0	22
25	3	2565	696	4783	0	0	0	0
26	2	87	22	43	0	0	0	22
27	2	87	0	0	0	0	0	43
29	2	43	0	0	0	0	0	0
30	2	58	27	46	0	0	0	72
31	1	9	0	26	0	0	0	83
33	2	452	5	546	0	65	0	14
34	1	87	0	0	0	0	0	0

68

Site	Cluster	Oligochaeta	Nematoda	Chironomidae	Ceratopogonidae	Ephemeridae	Caenidae	Hydropsychidae
35	2	54	0	22	0	0	0	0
36	2	22	0	130	0	0	0	0
37	2	87	174	43	0	0	0	43
42	3	2783	43	609	0	0	0	0
43	2	0	0	20	0	0	0	67
44	3	565	22	348	0	0	0	0
45	3	609	0	43	0	0	0	0
47	2	7	3	0	0	0	0	6
48	2	22	33	11	0	11	0	0
49	2	191	26	9	0	0	0	0
50	2	40957	0	0	0	0	0	0
52	1	1826	0	0	0	0	0	0
54	3	130	0	0	0	0	0	0
55	2	232	0	0	0	0	0	14
58	2	0	22	43	0	0		43
59	3	243	21	345	0	0	17	0
60	2	22	0	0	0	0	0	0
64	3	130	87	3696	0	0	2000	130
65	3	43	304	43	0	0	348	0
66	3	0	217	2783	0	0	435	43
67	3	2217	652	1870	0	87	0	0
68	3	739	0	1391	0	0	0	0
70	3	2522	174	1000	174	43	391	87
71	2	43	0	0	0	0	0	0
72	3	304	130	1609	130	43	565	0
73	2	130	0	0	0	0	0	0
74	3	1391	217	435	43	0	217	217
75	2	522	0	0	0	0	0	0
76	3	4065	29	7	0	0	0	7
77	3	957	1261	217	0	0	0	0
78	3	942	101	43	14	0	0	0
79	3	2696	87	43	0	0	0	0

69

Site	Cluster	Oligochaeta	Nematoda	Chironomidae	Ceratopogonidae	Ephemeridae	Caenidae	Hydropsychidae
80	3	3043	43	0	0	0	0	87
81	3	652	0	391	43	43	0	0
82	1	348	130	826	43	130	43	43
83	2	304	0	304	0	174	0	87
84	1	1043	348	609	0	43	0	0
85	3	87	130	739	0	0	0	0
86	3	435	0	957	0	0	0	0
88	3	696	87	130	0	0	0	0
89	3	261	174	304	43	87	0	0
90	2	65	22	152	0	65	0	22
91	3	87	43	739	0	43	87	0
92	3	94	80	1601	7	87	0	7
93	3	696	87	609	0	87	0	0
94	2	0	0	0	0	0	0	0
95	3	1261	87	478	217	0	43	0
96	3	435	130	826	0	87	0	43
97	3	87	14	3087	14	58	29	0
98	3	19	0	57	0	0	0	0
99	3	783	130	130	0	43	0	0
100	3	2217	43	391	0	0	0	0
101	3	1348	0	174	0	0	0	0
102	2	1043	4043	304	391	0	43	0
103	2	1261	435	217	826	0	43	0
104	1	87	22	0	0	0	0	0
105	1	913	652	1565	43	43	0	43
106	3	913	1391	435	0	0	0	0
107	1	1000	304	870	43	43	0	0
108	3	1870	652	2696	478	0	43	43
109	2	478	826	261	0	0	0	0
111	3	2783	1696	1174	0	0	43	29
113	2	65	0	0	0	0	0	0
114	2	957	0	0	0	0	0	0

70

Site	Cluster	Oligochaeta	Nematoda	Chironomidae	Ceratopogonidae	Ephemeridae	Caenidae	Hydropsychidae
115	3	1696	159	5130	43	0	0	0
116	2	2935	22	0	0	0	0	0
117	2	1783	0	0	0	0	0	0
118	2	326	0	0	0	0	0	0
119	3	5935	261	457	0	0	0	0
121	2	217	1217	609	0	87	0	0
122	2	109	4500	1174	0	0	0	0
123	3	543	65	522	22	87	0	0
124	3	130	304	565	0	261	43	0
125	2	22	43	22	0	0	0	0
126	3	391	22	304	0	0	0	0
127	1	1739	1348	783	43	304	0	0
128	3	1022	54	22	0	0	11	0
129	2	543	1217	1761	130	22	174	43
130	3	304	435	1304	0	0	0	0
131	3	87	3348	5087	739	43	87	0
132	2	565	217	174	0	0	0	0
133	2	2893	1054	2778	38	0	38	115
134	2	77	115	0	0	0	0	0
135	3	1935	935	696	43	0	0	22
136	3	522	109	109	22	0	0	0
137	3	3478	174	0	0	0	0	0
138	1	1826	957	87	0	0	0	0
139	3	739	43	152	0	0	87	0
140	3	1239	87	65	0	0	0	0
141	3	5283	761	65	0	0	22	0
142	3	783	1739	174	43	0	0	0
143	3	182	1696	0	0	0	0	0
144	3	1565	87	0	0	0	0	0
145	1	1391	413	43	0	0	0	0
146	3	5913	478	0	0	0	0	0
147		3087	391	130	0	0	0	0

71

Site	Cluster	Oligochaeta	Nematoda	Chironomidae	Ceratopogonidae	Ephemeridae	Caenidae	Hydropsychidae
148	2	783	0	43	0	0	0	43
149	3	54	174	0	0	0	0	0
150	3	5261	217	87	0	0	0	0
6676	4	68.6	0	8.4	0	0	0.2	0
6677	4	184	0	94.2	2.6	0	24.2	0
6678	4	78.2	0	0.4	0	0	0	0
6680	3	145.6	0	0	0.4	0	1	0
6681	4	76.4	0	10.6	0	0	0	0
6682	3	112.8	0	40.2	0.6	0	3.2	0
6683	4	50.75	0	12.8	0.13	0	0.07	0
6685	4	71	0	17.2	0	0	0.6	0
6687	4	42	0	0	0.73	0	0.2	0
6688	4	106.52	0	0	1	0	2.6	0
6689	4	114.69	0	0	0	0	1.25	0
6690	3	68.79	0	0	0	0	0.09	0
6691	3	82.66	0	0	0.03	0	0.03	0
6692	3	66.28	0	0	0.03	0	0	0
6695	3	54.2	0	0	0.2	0	0	0
6696	4	51.55	0	0	0.33	0	0.71	0
10_80	2	138	0	27	0	26	0	617
17_80	3	20	0	20	0	0	0	46
23_80	3	5280	0	0	0	0	0	0
8_80	3	125	7	0	0	171	7	440
E_80	4	577	13	195	0	182	0	13
O_80	4	52167	0	27	0	7	0	0

72

Site	Other Trichoptera	Amphipoda	Dreissena	Acarina	Hydra	Hirunidae	Turbellaria	Gastropoda	Sphaeriidae
3	0	670	2025	0	0	0	0	0	0
4	0	0	29	29	0	0	0	14	0
5	0	0	4	29	0	0	0	11	0
7	0	216	7370	0	212	14	0	0	0
8	0	2754	11826	0	0	0	0	29	0
9	0	0	0	43	0	43	0	0	0
10	0	1076	1120	11	11	0	0	0	0
11	0	0	0	43	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	43	304	0	0	87	0	0	0
14	0	275	449	0	0	0	0	0	0
15	0	35	113	0	43	0	0	0	0
16	0	0	0	0	22	0	0	0	0
17	0	0	0	43	0	0	0	0	0
18	0	391	1899	0	14	0	0	0	0
19	0	87	0	0	0	0	0	0	0
21	0	87	696	0	0	0	0	0	0
22	0	130	652	0	0	0	0	0	0
23	0	0	43	0	0	0	0	0	0
24	0	13413	14630	0	2478	0	0	174	0
25	0	0	0	0	0	0	0	0	0
26	0	130	761	0	87	0	65	0	0
27	0	348	1696	43	0	0	0	0	0
29	0	0	217	0	0	0	0	0	0
30	0	507	2560	0	0	0	0	0	0
31	0	117	587	0	0	0	0	0	0
33	0	22	0	0	10	7	0	0	0
34	0	1739	1130	0	43	0	0	0	0
35	0	65	315	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0
37	0	31043	51652	0	5522	0	2609	0	0

73

Site	Other Trichoptera	Amphipoda	Dreissena	Acarina	Hydra	Hirunidae	Turbellaria	Gastropoda	Sphaeriidae
42	0	87	130	0	43	0	0	0	0
43	0	2341	2797	0	110	0	0	0	0
44	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	43	0
47	0	83	674	7	0	0	0	18	0
48	0	0	0	0	0	11	0	0	0
49	0	0	157	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0
54	0	0	87	0	0	0	0	0	0
55	0	0	130	0	0	0	0	0	0
58	0	565	64130	0	0	0	0	0	0
59	0	196	0	32	0	0	0	0	0
60	0	0	2065	0	0	0	0	0	0
64	0	130	0	130	0	43	0	0	0
65	0	43	0	0	0	0	0	0	0
66	0	43	0	43	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0
70	0	43	130	0	0	0	0	0	0
71	0	0	174	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0
74	0	0	261	0	0	43	0	0	0
75	0	0	348	0	0	0	0	0	0
76	0	0	0	29	0	0	0	7	0
77	0	0	0	130	0	0	0	0	0
78	0	14	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0	0

Site	Other Trichoptera	Amphipoda	Dreissena	Acarina	Hydra	Hirunidae	Turbellaria	Gastropoda	Sphaeriidae
82	0	43	0	0	0	0	0	0	0
83	0	0	1217	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0
89	0	0	43	0	0	0	0	43	0
90	0	130	1870	0	0	0	0	0	0
91	0	87	0	43	0	0	0	0	0
92	0	116	0	29	0	0	0	14	0
93	0	0	0	0	0	0	0	0	0
94	0	130	739	0	0	0	0	0	0
95	0	0	0	43	0	43	43	87	0
96	0	43	0	0	0	0	0	0	0
97	0	188	0	0	0	14	0	0	0
98	0	0	0	0	0	19	0	0	0
99	0	0	0	0	0	174	0	0	0
100	0	0	0	0	0	43	0	0	0
101	0	0	0	0	0	0	0	0	0
102	0	0	0	174	0	0	0	0	0
103	0	0	0	217	0	0	0	0	0
104	0	5283	9609	0	217	0	0	0	0
105	0	696	0	0	0	304	0	0	0
106	0	87	0	0	0	0	0	43	0
107	0	0	0	0	0	0	0	0	0
108	0	565	0	174	0	43	0	43	0
109	0	609	87	43	0	0	0	0	0
111	0	0	0	43	0	43	0	174	0
113	0	0	0	22	0	0	0	0	0
114	0	0	0	0	0	0	0	0	0
115	0	87	58	43	0	29	0	14	0

75

Site	Other Trichoptera	Amphipoda	Dreissena	Acarina	Hydra	Hirunidae	Turbellaria	Gastropoda	Sphaeriidae
116	0	0	0	0	0	0	0	0	0
117	0	0	0	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0
119	0	65	0	174	0	22	0	0	0
121	0	0	0	0	0	0	0	0	0
122	0	0	0	0	0	0	0	43	0
123	0	0	22	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0
125	0	391	3087	0	0	0	0	0	0
126	0	239	304	43	0	0	0	0	0
127	0	0	43	43	0	0	0	0	0
128	0	0	0	0	0	0	0	0	0
129	0	348	2739	22	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0
131	0	43	0	0	0	0	0	130	0
132	0	0	0	0	0	0	0	0	0
133	0	2490	2356	38	0	0	57	153	0
134	0	0	0	0	0	0	0	0	0
135	0	109	0	174	0	0	22	0	0
136	0	0	0	22	0	0	0	0	0
137	0	0	0	0	0	0	0	43	0
138	0	0	0	0	0	0	0	0	0
139	0	43	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	0
142	0	0	0	43	0	0	0	0	0
143	0	87	0	0	0	0	0	0	0
144	0	0	0	0	0	0	0	0	0
145	0	0	0	22	0	0	0	0	0
146	0	0	0	0	0	0	0	43	0
147	0	0	0	0	0	0	0	0	0

76

Site	Other Trichoptera	Amphipoda	Dreissena	Acarina	Hydra	Hirunidae	Turbellaria	Gastropoda	Sphaeriidae
148	0	0	0	0	0	0	0	0	0
149	0	0	0	33	0	0	0	0	0
150	0	0	0	43	0	0	0	0	0
6676	0.6	0	0	1.2	0	0	0	0.2	1.6
6677	1.6	18.8	4.2	16.6	6.12	0.4	0.2	9.6	2.4
6678	0	0	0	0.2	0.6	0.2	0	0	0.4
6680	0.8	0	0.2	2.2	0	0	3	1.4	1.4
6681	0	0	0	0.6	0	0	0	0.4	0.6
6682	6.4	5.4	4.4	12.8	6.4	1.6	3.6	4.8	0.8
6683	0.14	0.34	1.6	1.1	1.47	0	0.07	3.87	0.13
6685	0.4	0.4	0	0.4	0	0	2	0	0.2
6687	0.2	0	0.4	0.14	0	0.07	0	2.01	2.07
6688	7	4	0.8	4.6	3.8	0.4	4.2	15.4	0.6
6689	0.77	0.89	0	2.97	0	0.15	0.89	2.56	0.19
6690	0	0.18	0	2.12	0	0.09	2.44	8.59	0.49
6691	0.09	0	0	0.72	0	0.03	0.09	8.11	0.66
6692	0.3	0.03	0.03	0.84	0	0.15	0.15	1.07	0.36
6695	0	0	0	1.6	0	0	0	0	5.2
6696	0.6	0.59	0.39	1.19	1.07	0.12	0.03	0.6	0.36
10_80	13	7	0	0	0	0	0	59	119
17_80	66	53	0	0	26	0	20	78	20
23_80	0	0	0	0	0	39	7	7	381
8_80	0	236	0	0	0	0	0	13	165
E_80	0	60	0	0	0	0	0	348	198
O_80	0	0	0	0	0	0	0	0	0

APPENDIX G. Results of Multivariate Assessment

Table 15. Summary of Multivariate Reference Condition Approach for Cluster 1. Sites used as 'reference' sites to train the model are listed as Reference, while test sites are denoted as Not Impaired, Possibly Impaired, Impaired or Severely Impaired based on the RCA evaluation.

Site	HZD Score	Result
4	4.3	Reference
104	9.3	Reference
16	13.1	Reference
127	18.3	Reference
62	19.3	Reference
6	22.3	Reference
105	35.2	Reference
107	41.4	Reference
82	49.6	Reference
145	61.7	Not Impaired
31	92.1	Potentially Impaired
84	95.1	Not Impaired
7	106.1	Not Impaired
138	127.5	Not Impaired
52	129.8	Not Impaired
34	196.4	Impaired

Table 16. Summary of Multivariate Reference Condition Approach for Cluster 2. Sites used as 'reference' sites to train the model are listed as Reference, while test sites are denoted as Not Impaired, Possibly Impaired, Impaired or Severely Impaired based on the RCA evaluation.

Site	HZD Score	Result
122	4.1	Reference
32	5.4	Reference
125	5.7	Reference
73	6.8	Reference
133	6.9	Reference
109	7.4	Reference
58	7.6	Reference
10	8.1	Reference
26	8.3	Reference
63	9.5	Reference
94	9.5	Reference
71	9.8	Reference
60	10.6	Reference
33	10.8	Reference
5	11.5	Reference
35	11.6	Reference
132	12.9	Reference
36	13.1	Reference
121	14.3	Reference
21	16.2	Reference
24	16.4	Reference
40	17.0	Reference
20	17.1	Reference
18	18.5	Reference
102	20.3	Reference
9	23.3	Reference
103	28.0	Reference
134	28.5	Reference
8	28.5	Reference
3	30.3	Reference
118	30.3	Reference
37	30.5	Reference
117	30.7	Reference
14	30.8	Reference
27	33.0	Reference
116	33.6	Reference
129	35.0	Reference
47	35.1	Reference
10_80 (Negative Control)	16.8	Not Impaired
41	43.3	Not Impaired
48	43.8	Severely Impaired

Site	HZD Score	Result
38	44.4	Not Impaired
120	44.7	Not Impaired
22	46.9	Not Impaired
30	49.4	Not Impaired
1	49.8	Not Impaired
43	51.1	Not Impaired
83	57.9	Potentially Impaired
148	61.8	Not Impaired
113	66.7	Not Impaired
90	67.3	Not Impaired
49	72.7	Not Impaired
55	84.8	Not Impaired
29	113.5	Not Impaired
114	134.8	Not Impaired
75	195.0	Not Impaired
50	217.9	Not Impaired
15	242.0	Not Impaired

Table 17. Summary of Multivariate Reference Condition Approach for Cluster 3. Sites used as 'reference' sites to train the model are listed as Reference, while test sites are denoted as Not Impaired, Possibly Impaired, Impaired or Severely Impaired based on the RCA evaluation.

Site	HZD Score	Result
11	6.8	Reference
111	11.7	Reference
119	12.1	Reference
68	12.1	Reference
6682	12.2	Reference
6691	12.7	Reference
72	13.2	Reference
23	13.3	Reference
19	13.4	Reference
2	14.0	Reference
139	14.2	Reference
6690	15.4	Reference
77	16.6	Reference
25	16.7	Reference
87	17.1	Reference
98	17.7	Reference
115	18.3	Reference
12	20.7	Reference
149	22.2	Reference
78	22.4	Reference
137	23.0	Reference
64	28.7	Reference
142	29.6	Reference
66	31.0	Reference
6695	31.1	Reference
67	31.5	Reference
131	31.6	Reference
97	31.7	Reference
54	32.3	Reference
13	33.0	Reference
70	33.8	Reference
8_80 (Negative Control)	18.4	Not Impaired
45	34.4	Not Impaired
126	34.5	Not Impaired
130	34.7	Not Impaired
135	34.7	Not Impaired
44	35.1	Not Impaired
95	36.7	Not Impaired
17	37.1	Not Impaired
65	37.3	Not Impaired
123	39.2	Not Impaired

Site	HZD Score	Result
124	40.9	Not Impaired
51	41.1	Not Impaired
106	42.1	Not Impaired
92	42.1	Not Impaired
136	44.1	Not Impaired
74	48.0	Not Impaired
85	49.5	Not Impaired
128	52.7	Not Impaired
141	52.7	Not Impaired
86	52.8	Not Impaired
88	53.7	Not Impaired
144	55.5	Not Impaired
108	57.0	Not Impaired
93	67.8	Not Impaired
143	69.2	Not Impaired
99	78.2	Not Impaired
100	80.8	Not Impaired
59	83.7	Not Impaired
91	86.6	Not Impaired
80	98.3	Potentially Impaired
150	99.6	Not Impaired
42	107.8	Not Impaired
96	109.2	Not Impaired
81	109.3	Not Impaired
140	112.3	Not Impaired
89	115.8	Not Impaired
6692	124.6	Impaired
79	125.7	Not Impaired
146	167.0	Not Impaired
76	190.6	Not Impaired
101	251.3	Not Impaired
23_80 (Positive Control)	294.7	Severely Impaired
17_80 (Positive Control)	362.3	Severely Impaired
6680	469.1	Severely Impaired

Table 18. Summary of Multivariate Reference Condition Approach for Cluster 4. Sites used as 'reference' sites to train the model are listed as Reference, while test sites are denoted as Not Impaired, Possibly Impaired, Impaired or Severely Impaired based on the RCA evaluation.

Site	HZD	Result
6688	18.0	Reference
6687	19.2	Reference
6685	19.6	Reference
6681	22.9	Reference
6678	23.3	Reference
E_80 (Negative Control)	6.1	Not Impaired
6677	26.5	Not Impaired
6676	28.4	Not Impaired
6696	29.4	Not Impaired
6689	31.0	Not Impaired
6683	33.9	Not Impaired
O_80 (Positive Control)	642.3	Not Impaired

APPENDIX H. Review comments from the U.S. Fish and Wildlife Service and Michigan Department of Environment, Great Lakes, and Energy (EGLE) on the Beneficial Use Assessment for BUI #6: Degradation of Benthos in the Detroit River Area of Concern

Public

Comment: Thank you for all the info. I really feel that the 2BUIs should be removed from the impaired list. It is unfortunate that more Benthos could not be collected, however, as indicated, all signs point to a healthy ecosystem. I think it would be wise to continue to monitor Benthos to see if our changing climate has any effect on their health. The health of the river and the fish in it has improved greatly. When I worked on Fighting Island, the men would take guests fishing almost every day. The fish would be cleaned that day and there was never any mention of tumours. All the fish caught were healthy. I think that it would be wise to monitor the sediment at least yearly to make sure that there are no sudden changes, again, because of climate change. Chemicals react differently in higher temps.

It is a feather in the cap of the DRCC that the Detroit River has improved this much on the Canadian side and is improving on the USA side.

Response (Report Author: Ken Drouillard, University of Windsor): We thank the above Public author for their comments on the two BUI Reports. We agree that continued monitoring of Benthos and sediment quality should take place in the Detroit River and anticipate that this will be incorporated into future post-delisting monitoring exercises. Regarding timing of sediment monitoring, sediment contamination generally reflects a long period of time integration and does not change dramatically from year to year. For example, there have been no significant regional changes in sediment contamination for chemicals of potential concern (COPCs) in Canadian waters of the Detroit River between 1999 and 2013, although the number of exceedances of severe effect level contamination at individual sites has decreased. Other published reports and governmental guidance documents have recommended that sediment chemistry surveys used for baseline condition monitoring be completed at approximately 10-year intervals. Given the lack of major change in contamination observed in the Detroit River, we agree with the recommended 10-year interval for sediment chemistry assessments and would suggest that the next survey match the sampling resolution and geographic scope of the original 1999 sediment chemistry and benthos survey design. There would be benefits to complete a benthos assessment timed with the next comprehensive sediment chemistry survey.

United States Environmental Protection Agency

Comment: I have reviewed the report and have no major comments or concerns. The report summarizes existing studies to present data that support the assessment that potential benthos impairment is highly localized; the majority of sites sampled in the Canadian portion of the AOC demonstrate no evidence of biological impairment, and sediment COPCs are below provincial severe effects levels. The data as presented are supportive of the report's recommendation that the Degradation of Benthos BUI removal criteria have been met.

A few minor comments/questions:

I could not follow the results for Fig 2 (highlighted below) when I looked at Fig. 2. If there is indeed an error with the Figure, it should be corrected in the final version.

A significant correlation between PCBs observed in sediments and tissue residues was observed (p-value = 3.00 x 10-5; Figure 2). Site DR22 (US) was observed to have the lowest total sediment PCB concentration (0.36 µg/g) while exceeding the CCME tissue residue guideline for benthos. Only one site, DR55 (US), from the 2013 sampling was observed to have sediment total PCB concentrations greater than 0.36 µg/g.

Response (Report Author: Ken Drouillard, University of Windsor): We thank the US EPA for their comments. The question pertaining to Figure 2 indeed appears to be an error of unit conversion. Referring to Table 3, the CCME Canadian Tissue Residue Guideline for the Protection of Wildlife Consumers of Aquatic Biota for PCBs is listed in units of ng TEQ/kg equivalent. However, the concentration of PCBs measured in benthos are in units of µg/g sum PCBs for selected PCB congeners. It was therefore an error to directly compare the measured PCB concentration in benthos in sum PCBs with the CCME guidelines as was done in Figure 2. TEQ equivalents are generated by multiplying a congener specific toxic equivalent factor (TEFs) by the concentration of each PCB congener measured in the sample. TEF values are only available for 12 PCB congeners commonly referred to as dioxin-like PCBs that are non-ortho or have only a mono-ortho chlorine substitution patterns. Unfortunately, the most toxic dioxin-like PCBs with the highest TEF factors require specialized analytical procedures to measure them and thus only a small subset of the dioxin-like PCB congeners (mainly less toxic mono-ortho PCBs) were measured in the benthic invertebrate samples from the 2013 survey. To correct this error, we applied the correction factor reported by Bhavsar et al. (2007; Environmental Toxicol. Chem. 26:1622-1628) who calibrated the relationship between total PCBs and dioxin like TEQ values based on the Ministry of Environment, Conservation and Parks' Great Lakes fish monitoring database. The relationship is given as follows:

$$\text{TEQ (dioxin-like PCBs)} = 2.56 \times 10^{-5} \text{ Concentration of total PCBs}$$

The above relationship was used to convert the CCME PCB avian and mammalian guidelines into a total PCB equivalent. Using this conversion factor the comparable CCME PCB guideline values of 0.79 ng TEQ/kg protective of mammals and 2.4 ng TEQ/kg protective of avians becomes 0.031 and 0.094 µg total PCBs/g, respectively. We regenerated Figure 2 and placed the converted CCME guidelines on the new figure. This changes the interpretation somewhat. There are now 2 Canadian samples from one location that exceeded the CCME mammalian guideline. There are 13 US samples from 8 sample locations that exceeded the same guideline and 9 U.S. samples from 6 locations that exceeded the Avian guideline. The text of the revised report has been corrected to reflect these measurements. We also removed the confusing sentence that was highlighted by the EPA reviewer from the report.

Comment: There seems to be a lot of emphasis on the US station results in this report. I presume the US EPA had no concerns with sample design or data interpretation in the studies that are cited (*see below)?

**This report focuses on data from three extensive monitoring events conducted by the Great Lakes Institute for Environmental Research (GLIER; 1999, 2008, 2013), in which information regarding sediment and benthos contaminant concentration and benthic community composition were collected (GLIER 2002; Drouillard 2010; GLIER unpublished).*

Response (Report Author: Ken Drouillard, University of Windsor): Much of the data included in this report has been published in various forms in the peer-review literature. However, the study objectives and methods to interpret the data as were published literature differed from the objectives and study goals in this report. For example, sediment chemistry survey data for the 1999 data set are published in Szalinska et al. 2006 and Drouillard et al. 2006. The sediment chemistry data for 2008/2009 was described by Szalinska et al. 2013. The calculation metric for Hazard Scores and its validation based on chironomidae composition in field samples was published in McPhedran et al. 2017. The most recent survey data for sediment chemistry from 2013 has not yet been published but has been submitted in late 2019 as a book chapter and is currently under review. The data on 2008 benthic invertebrate PCB concentrations and its relationship to sediments PCB levels are described in Li et al. 2019. The 1999 benthic invertebrate composition data was published as an MSc thesis by Woods (2004). The toxicity bioassays by Environment Canada were made available to the report authors as unpublished government reports. The GLIER chironomidae toxicity bioassay data and 2013 benthic invertebrate composition have not been published.

Drouillard, K.G., M. Tomczak, S. Reitsma, G.D. Haffner. 2006. A river-wide survey of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and selected organochlorine pesticide residues in sediments of the Detroit River – 1999. J. Great Lakes Res. 32:209-226.

Li, J., K. McPhedran, E Szalinska, A.M. McLeod, S.P. Bhavsar, J. Bohr, A. Grgicak-Mannion, K. Drouillard. 2019. Characterizing polychlorinated biphenyl exposure pathways from sediment and water in aquatic life using a food web bioaccumulation model. Int. Environ. Assess. Manag. 15:398-411.

McPhedran, K.N., A. Grgicak-Mannion, G. Paterson, T. Briggs, J.J.H Ciborowski, G.D. Haffner, K.G. Drouillard. 2017. Assessment of hazard metrics for predicting field benthic invertebrate toxicity in the Detroit River, Ontario, Canada. Int. Environ. Assess. Manag. 13:410-422.

Szalinska, E., A. Grgicak-Mannion, G.D. Haffner, K.G. Drouillard. 2013. Assessment of decadal changes in sediment contamination in a large connecting channel (Detroit River, North America). Chemosphere 93:1773-1781.

Szalinska, E., K.G. Drouillard, B. Fryer, G.D. Haffner. 2006. Distribution of heavy metals in sediments of the Detroit River. J. Great Lakes Res. 32:442-454.

Wood, S. 2004. The use of benthic macroinvertbrate community composition as a measure of contaminant induced stress in the sediments of the Detroit River. MSc thesis submitted to the Faculty of Graduate Studies and Research, University of Windsor, Windsor, Ont. Canada, 194 pp.

Michigan Department of Environment, Great Lakes, and Energy

Comment: Thank you for the opportunity to review the removal recommendation for the Degradation of Benthos BUI for the Detroit River AOC. We have no objections to the removal of the BUI; however, a few comments are below.

HZD Scores: The scale for the HZD scores is unclear. The report mentions that a HZD score of 50-100 indicates contamination approaching the SEL and that an exceedance of 100 represents high sediment contamination of the 13 Contaminants of Potential Concern (COPC). The report goes on to state that scores at high as 251 were found and this indicates a severe impairment; however, it is also mentioned that a HZD score of 44 also suggests impairment.

Response (Report Author: Ken Drouillard, University of Windsor): The theoretical basis and calculation metrics of the Hazard Score metric is described in: McPhedran, K.N., A. Grgicak-Mannion, G. Paterson, T. Briggs, J.J.H Ciborowski, G.D. Haffner, K.G. Drouillard. 2017. Assessment of hazard metrics for predicting field benthic invertebrate toxicity in the Detroit River, Ontario, Canada. Int. Environ. Assess. Manag. 13:410-422.

The basis of the hazard score metric is that it uses a two point calibration curve based on sediment quality guidelines and differs from the conventional hazard index (e.g. sum PEC quotient) used in other studies. The conventional PEC quotient is calculated as the sum of PECx/Cx, where PECx is the chemical specific probable effect (or severe effect) concentration obtained from a specific jurisdiction sediment quality guideline and C_x is the concentration of chemical in sediment in equivalent concentration units. Here we are using Ontario's Sediment Quality guidelines for reference. In the conventional metric, when any measured contaminant exceeds the probable effect level guideline a hazard index > 1 will be generated. The problem with this metric is that it scales directly with the number of pollutants used in its computation. As a result, sum PEC quotients frequently overestimate toxicity of sediments when sediments contain a many of pollutants for which sediment guidelines values are available.

The hazard score used in this report indexes the measured sediment concentration to both the low effect concentration and the severe effect concentration giving it two points of calibration. Here the LEL provides a lower bound for toxicity reference. For a given pollutant, if its concentration in sediment is less than LEL it is given a value of 0 hazard score for that pollutant. If the pollutant exceeds the LEL but is less than PEL it is scaled nearly linearly to achieve a score between >0 and 49.9. If the concentration equals PEL it is given a hazard score of 50 and if it exceeds the PEL it is given a score between 50.1 and 100. The mathematical relationship for scaling is provided in McPhedran et al. (2017). A hazard score of 100 is the maximum score a single pollutant can generate and equates to a sediment concentration that is approximately 2.2 x PEL.

However, like PEC quotients, hazard scores are added across all chemicals being measured. As such it is possible to achieve hazard scores > 100 because multiple chemicals had high hazard scores. However, because all chemicals with sediment concentration less than LEL are omitted from the summation (having HZD = 0), this index is a little bit less sensitive to the number of chemical parameters considered in the metric. From the perspective of understanding the scale, if the sum of HZD > 50 we know that multiple chemicals are both above LEL and or exceed approach SEL. In order to generate HZD > 100, these means that several chemicals had high HZD's with more than one likely exceeding the SEL.

In the McPhedran et al. (2017) publication, the investigators attempted to compare toxicity predictions across various hazard metrics. The toxicity end point evaluated was equated to the abundance of chironomidae in Detroit River sediments when samples were taken from sediments with appropriate chironomidae habitat characteristics. There were strong negative correlations observed between chemicals of potential concern concentrations in sediments and chironomidae abundance for the Detroit River. Various hazard metrics were then computed based on sediment chemistry measures and contrasted against field toxicity as described above. The metrics included: sum PEC quotient, average PEC quotient and HZD among others. The study of McPhedran et al. (2017) revealed that the HZD metric provided the most accurate prediction of sediment toxicity (relative chironomidae abundance) across the hazard metrics evaluated. This is why the HZD was chosen in this report because it was both calibrated for Detroit River benthos and shown to be superior to other commonly used hazard score indexes.

However, direct interpretation of the HZD value in reference to actual toxicity instead of its reference to sediment quality guidelines is more difficult and depends on the benthic species being evaluated. The reference values for HZD = 50 or HZD > 100 described previously are based on sediment concentrations relative to sediment quality guidelines. In order to translate a HZD into actual toxicity the metric needs to be calibrated to actual toxicity data. In McPhedran et al. (2017), the metric was calibrated to relative chironomidae abundance and the authors observed that different HZD score thresholds occurred for different chironomidae habitat types. A HZD score of 32 was established as a threshold toxicity for chironomidae abundance in low velocity sandy habitats while scores as high as 54 were necessary to observe changes in chironomidae abundance in silt habitats. These observations provide some justification for interpreting HZD scores between 30-50 as being indicative of probable toxicity of one family of benthos.

However, BUI #6 does not just correspond to ‘degradation of chironomidae’ it corresponds to degradation of benthos in general. Therefore, Pages 14-30 of the report was dedicated to trying to calibrate a new set of HZD scores that are predictive of alteration of benthic community composition. In addition, single taxa sensitivity was evaluated for candidate benthic taxa as described in McPhedran. The inferred protective HZD values varied between the 4 benthos habitat types. However, the site with the lowest HZD that was associated with an altered benthic composition had a HZD of 44. This was observed in the Cluster 3 habitat type. However, one site which had a hazard score as high as 251 did not show impairment of the benthic community. These issues and the data presented in Figure 14 illustrate how difficult it is to estimate a protective hazard metric value given how variable the toxicity data are.

As a conservative measure, the report chose the lowest HZD score that was shown to generate an impaired benthic community composition (value = 44). The argument is that if no sediments in the Detroit River exceed a HZD of 44 then there is likely to be no alteration of benthic community composition. When HZD scores were compared across the 2013 Canadian data set, there was only 1 station that exceeded this reference value suggestive that it is probably toxic. The HZD score at this 1 CDN station was 642 suggesting toxicity is likely at this site. Indeed, when sediment bioassay tests were placed in a HZD framework, the test site with a HZD greater than 480 generated reduced survival in Hexagenia and Oligochaetes.

Overall, while it is recognized that neither sediment quality guidelines nor HZD are highly accurate descriptions of actual sediment toxicity they are shown across weight of metrics to be broadly correlated with different toxicity metrics. The problem is that the most recent survey data (2013) had sediment contamination measurements but did not have associated toxicity bioassays or benthic invertebrate composition data. As such, the best estimates of likely toxicity from 2013 had to be generated from sediment chemistry data. Both direct comparison with severe effect level concentrations and the multi-pollutant HZD scores suggest that with the exception of 1 location, the majority of Canadian waters are unlikely to cause toxic stress to benthos.

Comment: Reference Locations: In the report, the difficulty of finding appropriate reference areas for the Detroit River is discussed. However, the reference areas are not clearly defined but only referred to as sites within the river and analyzed based on habitat conditions. These conditions then, appear to be statistically divided into four cluster groups. It is mentioned that there are reference groups which are established for each cluster, indicated as breakpoints. The analysis that follows is unclear. It is mentioned that the reference conditions demonstrated high variability in community composition and as a result it became difficult to distinguish test sites from reference conditions.

The BUI removal criteria requires that sample sites need to be compared to an appropriate reference site; however, it is unclear if this has been accomplished. A greater explanation of the development of the references sites may be helpful showing that this criteria has been met.

Congratulations on the expected restoration of this impairment.

Response: (Report Author: Ken Drouillard, University of Windsor): The report authors (and many others) recognize the difficulty of defining reference sites particularly for Great Lakes Connecting Channels. There are three issues that make this difficult. 1) no matter what approach is utilized the designation of a reference site is and will always be subjective. In many cases what is called 'pristine', is arbitrarily designated so based on lack of perceived influence by anthropogenic activity that may or may not reflect a full site characterization. In Environment Canada's BEAST approach used to evaluate BUI's in many Canadian areas of concern, a concerted effort over many years was developed to sample Great Lakes reference sites across the basin to generate a reference database. These sites were largely chosen to reflect diverse habitat characteristics at locations far from perceived human influence. 2) previous attempts to assess the degraded benthos BUI in Great Lakes Connecting channels attempted to use Environment Canada's BEAST reference database but failed in these attempts to complete an assessment. The problem identified was that all of the Environment Canada reference sites were located in lakes and the report authors argued that lake reference sites are not appropriate for use to evaluate connecting channel benthic communities. These conclusions were drawn because the cleanest sites within the connecting channels could not be matched to the benthic community composition with the most representative habitat types in the reference database, i.e. almost all sites regardless of sediment contamination were designated impaired in the BEAST model because of differing communities relative to lake reference. Second there are major differences in environmental conditions between small streams and tributaries compared to connecting channels that preclude using CABIN or other national/regional benthic invertebrate rapid assessment approaches to the BUI evaluation. It was therefore recommended that a new set of reference sites be defined for connecting channels and that the locations of these sites would most likely have to occur within the connecting channels themselves. 3) each of the connecting channels are themselves designated as AOCs. This precludes using St. Clair River or St. Mary's river as references. St. Mary's river is arguably geographically isolated and potentially unsuitable as a reference site. St. Clair River tends to have different flow velocities and sediment characteristics over much of its length compared to the Detroit River which is more strongly impacted by its many islands, small channels and much larger width at its downstream end.

In this report the COPC concentrations measured in sediments was used to evaluate and subsequently define reference sites. This was done by defining a minimum HZD value for each habitat cluster considered protective of benthic invertebrate composition. Various methods were tried prior to selecting the procedure utilized and described on Page 17 of the report. At first, we tried using an arbitrary very low value of HZD score at 20 for each habitat. The problem was that when using such a stringent reference criteria, this removed too many sites that could be allocated as reference sites excessively decreasing the power of statistical inferences.

The subsequent approach was to try and let the taxonomic data tell us which threshold HZD score could be used. The process is described on Page 17. For each habitat cluster, the relationship between the dominant taxa and sediment HZD scores was determined. Where significant correlation existed between numerically abundant and HZD occurred, a breakpoint analysis by regression tree was used to estimate the HZD score at the breakpoint. This generated four breakpoint HZD scores, one for each cluster as outlined in Table 7 that were used to define reference sites within each habitat. Thus, for cluster 1, all sites with HZD < 56 are defined as reference while critical HZD used to define reference for Clusters 2, 3 and for were 35.1, 34.0 and 28.9, respectively. Thus all sediment samples having HZD below the breakpoint for a given habitat cluster were designated as reference. All sediment samples having HZD above the breakpoint were designated as unknown samples. The multivariate community condition approach then compared benthos composition in each unknown sample against the 90, 95 and 99% confidence intervals of community composition of reference samples in ordinated space on a habitat-by-habitat basis.

Figure 14 juxtaposed different critical HZD values derived from the community composition and break-point analysis. In the best scenario, (i.e. HZD perfectly predicts toxicity of benthic community composition) we would expect that all the impaired data points would be above the maximum HZD score values observed for reference and unknown samples. We might also anticipate that severely impaired sites would have higher HZD scores compared to possibly impaired categorized sites. The latter was only observed for Cluster 3. Apart from Cluster 3, there was considerable overlap between HZD scores for sites with similar benthic community composition as the reference compared to sites with different biological communities. For habitat cluster's 1 and 2 the impaired community locations with the lowest HZD values approached but were still higher than the initial breakpoint reference values used to define reference. For cluster 1 the breakpoint was 56 while the lowest altered community composition occurred at HZD of 92; for cluster 2 the breakpoint was 35 and lowest altered community composition sample had a HZD of 44. These data were then contrasted against the HZD of sediments used in toxicity bioassays shown to produce toxicity in laboratory specimens. Only sediment sample across toxicity assays demonstrated reduced survival in mayflies and oligochaetes. This sample had a very hazard score of 485. However, based on the analysis conducted, a HZD of 44 was chosen as the most conservative estimate of the lowest sediment COPC concentrations with the potential to cause toxicity (altered benthic community composition) against suitable habitat reference. This HZD was then examined relative to the most recent sediment chemistry survey data to determine the number of stations in Canadian waters are likely to generate toxicity.

There is a weakness to the approach. It is possible that sediment samples with HZD less than the critical HZD score used to define reference samples indeed had benthic compositions that were actually perturbed owing to causal factors (e.g. ammonia or other chemical substances) not considered in the sediment chemistry survey and which have no associated LEL or SEL sediment guideline values. However, we cannot think of an alternative method of defining reference sites that are within the AOC and correctly habitat matched to other samples with high HZD scores. Indeed, the same criticisms can just as easily be levied against the Great Lakes Reference Database sample used in the Environment Canada BEAST model since the criteria of geographic isolation from human disturbance (within the Great Lakes basin) does not necessarily mean a lack of disturbance history having occurred in the samples collected as reference. Ultimately, we must accept the limitations to our inferences from this work that benthic community composition is not affected by the concentration of the 16 priority COPCs considered when HZD > 44.

An improvement to the study design over that used in this report would have been to randomly allocate sediment samples with HZD less than the critical value (i.e., Breakpoint analysis used to define reference) as Unknowns. This would generate a population of unknown samples that had HZD scores both above and below the HZD used for reference. The advantage of such an approach would be that it would enable us to verify that benthic communities in unknown samples with very low HZD were indeed indistinguishable in all cases against the reference community. Unfortunately, the small replicate size precluded this type of random sample allocation procedure. It is possible however to use this information generated by this work to inform and improve on future assessments of benthic community structure.

APPENDIX I. Degradation of Benthos BUI Assessment Report Tracking

DRCC Monitoring and Research Work Group	Draft assessment presented on May 14, 2019; comments addressed. Decision to move assessment forward to DRCC Steering and Implementation Committee.
DRCC Steering and Implementation Committee (SIC)	Draft assessment presented to SIC June 19, 2019; comments addressed. Decision to move forward with re-designation to ‘not impaired’.
Public Review	Presented to DR PAC at June 26, 2019 meeting, comments requested; one comment received. Assessment and associated fact sheets posted on DRCC website for public comment period July 5, 2019 – August 31, 2019 (Facebook reminders to comment on July 4, 10, 22, 31 and August 21, 29; periodic Twitter reminders; notice in July and August newsletter). No comments received.
Indigenous Review	Reports and fact sheets were sent to Aamjiwnaang and Caldwell First Nations on September 3, 2019. No comments were received.
Four Agency Management Committee	Comments received from Michigan Department of Environment, Great Lakes, and Energy on September 27, 2019; comments addressed. Comments received from US EPA and US EPA GLNPO on August 23, 2019; comments addressed.
COA AOC Annex Leads	Submitted for formal re-designation April 2020.