10-1999

Preliminary Investigation of the Extent of Sediment Contamination in the Lower Grand River

Richard Rediske
R. B. Annis Water Resources Institute

Carissa Bertin
R. B. Annis Water Resources Institute

Jessica Blunt
R. B. Annis Water Resources Institute

Min Qi
R. B. Annis Water Resources Institute

ScholarWorks Citation

Rediske, Richard; Bertin, Carissa; Blunt, Jessica; and Qi, Min, "Preliminary Investigation of the Extent of Sediment Contamination in the Lower Grand River" (1999). *Scientific Technical Reports*. 5.
https://scholarworks.gvsu.edu/scitechreports/5

United States
Environmental Protection
Agency

Great Lakes National Program Office
77 West Jackson Boulevard
Chicago, Illinois 60604

EPA-905-R-99-010
October 1999

EPA Preliminary Investigation of the Extent of Sediment Contamination in the Lower Grand River

PRELIMINARY INVESTIGATION OF THE EXTENT OF SEDIMENT CONTAMINATION IN THE LOWER GRAND RIVER

TM-99-11

BY

Dr. Richard Rediske
Principal Investigator
And
Carissa Bertin
Jessica Blunt
Dr. Min Qi

R. B. Annis Water Resources Institute
Grand Valley State University
One Campus Drive
Allendale MI 49401

GRANT NUMBER GL985555-01-0
U. S. Environmental Protection Agency
Great Lakes National Program Office

PROJECT OFFICER:
Dr. Marc Tuchman
U. S. Environmental Protection Agency
Great Lakes National Program Office
77 West Jackson Blvd
Chicago IL 60604-3590

October 1999

Acknowledgements

This work was supported by Grant Number GL985555-01-0 between the Environmental Protection Agency Great Lakes National Program Office (GLNPO) and Grand Valley State University. Additional funding was provided by the Robert B. Annis Water Resources Institute (WRI).

Project Team

EPA Project Officer

Dr. Marc Tuchman	USEPA GLNPO

Principal Scientists

Dr. Richard Rediske	GVSU	Sediment Chemistry
Dr. Min Qi	GVSU	PCB Congeners
Jeffery Cooper	GVSU	Sediment Toxicity

Project technical assistance was provided by the following individuals at GVSU:

Carissa Bertin
Jessica Blunt
Alexey Stiop
Mike Sweich
Shana McCrumb
Kane Onwuzulike

Ship support was provided by the crews of the following Research Vessels:

R/V *Mudpuppy* (USEPA)	J. Bohnam
R/V *D.J. Angus* (GVSU)	B. Burns

The Gas Chromatograph/Mass Spectrometer used by GVSU for this project was partially funded by a National Science Foundation Grant (DUE-9650183).

Table of Contents

List Of Tables

List Of Figures

Executive Summary

A preliminary investigation of the nature and extent of sediment contamination in the lower Grand River was performed. Three areas in the lower Grand River exceeded sediment quality guidelines for heavy metals and selected organic chemicals. The locations and parameters of concern are listed below:

Harbor Island (G20).	Exceeds sediment PEL values for chromium, lead, nickel, and DDE in the top core section. Deeper core sections were extensively contaminated with heavy metals.
Spring Lake (G6).	Exceeds sediment PEL values for chromium, lead, cadmium, nickel, and DDE.
Grand Haven (G12).	Exceeds sediment PEL values for chromium and nickel. The sediments at this location exhibited a statistically significant level of toxicity to amphipods when compared to the control.

The extent of contaminated sediments in the vicinity of G12 (near the Grand Haven tannery) appears to be localized in a small area. Some additional sampling of this area would be necessary to define the extent of the contaminated sediments. The results for Spring Lake and Harbor Island show these areas to be contaminated with heavy metals and selected organic compounds. Additional sampling and analysis would be necessary to characterize the extent of sediment contamination in the areas around Harbor Island and Spring Lake.

Meander core islands appear to play a significant role in the lower Grand River with respect to the deposition of contaminated sediments. Pockets of contaminated sediments were found at the downstream tip of Harbor Island (G20), and the unnamed islands near G24 and G17. These areas serve as sediment deposition zones and indicate the effects of historical discharges of metals and organic chemicals to the lower Grand River. High water events however can transport contaminated sediments from these deposits and increase the contaminant loading to Lake Michigan. Since metals and organic chemicals are associated with the suspended sediment load, the role of the meander core deposits in contaminant transport needs to be examined in detail. This investigation examined three of the 12 meander core islands that are located in the lower Grand River.

The normalization of heavy metal data with aluminum was examined for chromium and lead. Statistically significant correlations between these elements were determined in background samples ($r = 0.73$ and 0.75 for Cr and Pb respectively). Plots of the project data set demonstrate that anthropogenic enrichment of lead and chromium has occurred in a majority of the top and middle core sections.

Statistically significant (alpha = 0.05) acute toxicity effects were observed in the sediments of samples G6-P and G12-P on the amphipod, H. azteca, by the Dunnett's test. The PEL values for chromium and DDE were exceeded at G12-P. PEL values for arsenic and DDE were exceeded at G6-P. Statistically significant (alpha = 0.05) mortality was not seen on the midge, C. tentans in the Grand River sediments.

1.0 Introduction

The Grand River watershed contains the longest river in the State of Michigan and comprises 13% of the entire Lake Michigan drainage basin (Sommers, 1977). A map of the Lower Grand River is provided in Figure 1.1. Two thirds of this 3.6 million acre watershed is designated as agricultural with 22% of the total pesticide usage in the Lake Michigan basin concentrated within its boundaries (GAO, 1993; Hester, 1995). Approximately 300,000 lbs. of atrazine alone are applied within the Grand River watershed on an annual basis (Hester, 1995). Since the Grand River watershed includes two of the larger population and industrial centers in the State of Michigan, there have been significant anthropogenic activities that have adversely impacted the watershed. Historically, both the Grand Rapids and Lansing areas were known for large-scale metal finishing and plating industries that contributed significant amounts of heavy metals to the environment. A large tannery with a historic discharge to the river is also located in the Grand Haven area. In addition, the lower region of the Grand River supported a large number of wood processing facilities. High levels of the wood preservative compound, pentachlorophenol, was recently found in sediments of Spring Lake and in the navigation channel outside its confluence with the Grand River by the U.S. Army Corps of Engineers (Bowman, 1995). A second sampling of the area was however unable to confirm these results. Additional surveys of the sediments in the Grand River were performed by USACE in 1996 (DLZ, 1996). Elevated levels of heavy metals and PAH compounds were detected in these investigations. The USACE investigations focused on the evaluation of the sediments for dredging and concentrated on samples collected from the navigation channels. The sediments in areas outside of the navigation channel have not been investigated.

Recent studies of the 12 major tributaries of Lake Michigan have found the Grand River to be one of the most significant contributors of contaminant loads to Lake Michigan (Shafer, et al., 1995; Hall and Behrendt, 1995; and Cowell, et al., 1995, and Robertson 1997). For most contaminants, the loading from the Grand River is comparable to that of the Fox River (WI), yet we know little about sites and sources of contamination in the Grand as compared to the Fox. For example, preliminary results of the Lake Michigan Mass Balance Study have found that the Grand River is the largest tributary source to Lake Michigan for lead, DDT compounds and atrazine and the second largest source for mercury (D. Armstrong, J. Hurley, and P. Hughes pers. comm.). There is, however, very little data available concerning the location of contaminant source areas in the Grand River watershed.

1.1 The Geology Of The Grand River Watershed

The geology of the Grand River Watershed was described in a previous report (U.S. Army Corps of Engineers 1972). From its headwaters in northeastern Hillsdale County at elevation 1040 feet, the Grand River flows northward to Lansing, Michigan, where it makes an abrupt bend and meanders westerly to Grand Haven where it discharges into Lake Michigan. The Grand River flows 260 miles through a basin 135 miles long and up to 70 miles in width. With a drainage area of 5572 square miles, the Grand River basin encompasses all or part of nineteen counties. A map of the Grand River watershed is shown in Figure 1.1. The topography of the basin is a result of Pleistocene glaciating with moraines and outwash plains dissected by streams. Kettle holes appear sporadically on out wash plains and usually are filled with water as swamps or lakes. Till plains, moraines, kames, and esker systems of the Port Huron system are the predominant surface feature with relief of 50 to 60 feet. Pasture and crop land comprise approximately 63 percent of the basin and another 15 percent is comprised of forest. The harbor at Grand Haven has a minimum draft of 21 feet, and a channel 100 feet wide and eight feet deep extends 17 miles upstream. Above this point, the river is not suitable for commercial navigation.

The Grand River Basin is underlain by two distinct groups of rocks, the younger glacial tills, and the older bedrock. Glacial deposits are a mixture of rock material from many different sources. This rock material was picked up, transported and deposited by glaciers or by waters flowing from the glaciers. The principal glacial deposits in the Grand River basin are till, moraines, outwash, and glacial lakebeds. The bedrock, that underlies the glacial deposits, was deposited in large inland seas that covered most of the area of the Great Lakes States. Bedrock formations are comprised primarily of sandstone, limestone, dolomite and shale, but include thick beds of salt, gypsum, and anhydrite. After deposition, the bedrock formations in the Great Lakes were warped into geologic structures that resembles a gigantic set of shallow bowls. The Grand River Basin overlies the south and southwestern part of this structure. The bedrock that underlies this basin generally dips gently to the north and east toward the center of the basin structure causing individual formations to be progressively deeper in a northerly and easterly direction.

The Grand River Basin evolved during the retreat of the last of the great continental glaciers. Most of the present surface features of the basin resulted from deposition of the rock materials from glaciers and subsequent erosion. The basin is underlain by sediments deposited from glacial lobes that advanced over the basin from the Saginaw Bay and from Lake Michigan. The two lobes coalesced along a north-south line near the center of Kent County. The area of coalescence is one of rolling topography. The lower part of the Grand River Basin is formed on the sediments of former glacial Lake Chicago.

The major portion of the basin is rather flat and featureless. The maximum local relief in the areas upstream from Maple Rapids, Portland, and Hastings generally ranges from 50 to 75 feet. The areas of minimal relief contain very poorly drained soil. Swamps and marshes make up a significant part of the Maple, Looking Glass, and Cedar River basins. The upper reaches of the Flat and Rogue River basins include extensive and numerous swamps, marshes, and many lakes, as does the middle part of the Thornapple River basin and the upper part of the Grand River Basin. The upper part of the Maple River includes flatlands formed on the sediments of ancient glacial lakes. The total relief between Lake Michigan, which has an altitude of about 580 feet, and the highest point in the basin, which are at altitudes of about 1170 feet in southern Jackson County, is about 700 feet. The maximum local relief within the basin ranges from 200 to 275 feet between the banks of the Grand River and the adjacent highlands. Areas with 200 or more feet of local relief, most of which are along the Grand River, constitute much less than 5 percent of the total basing area.

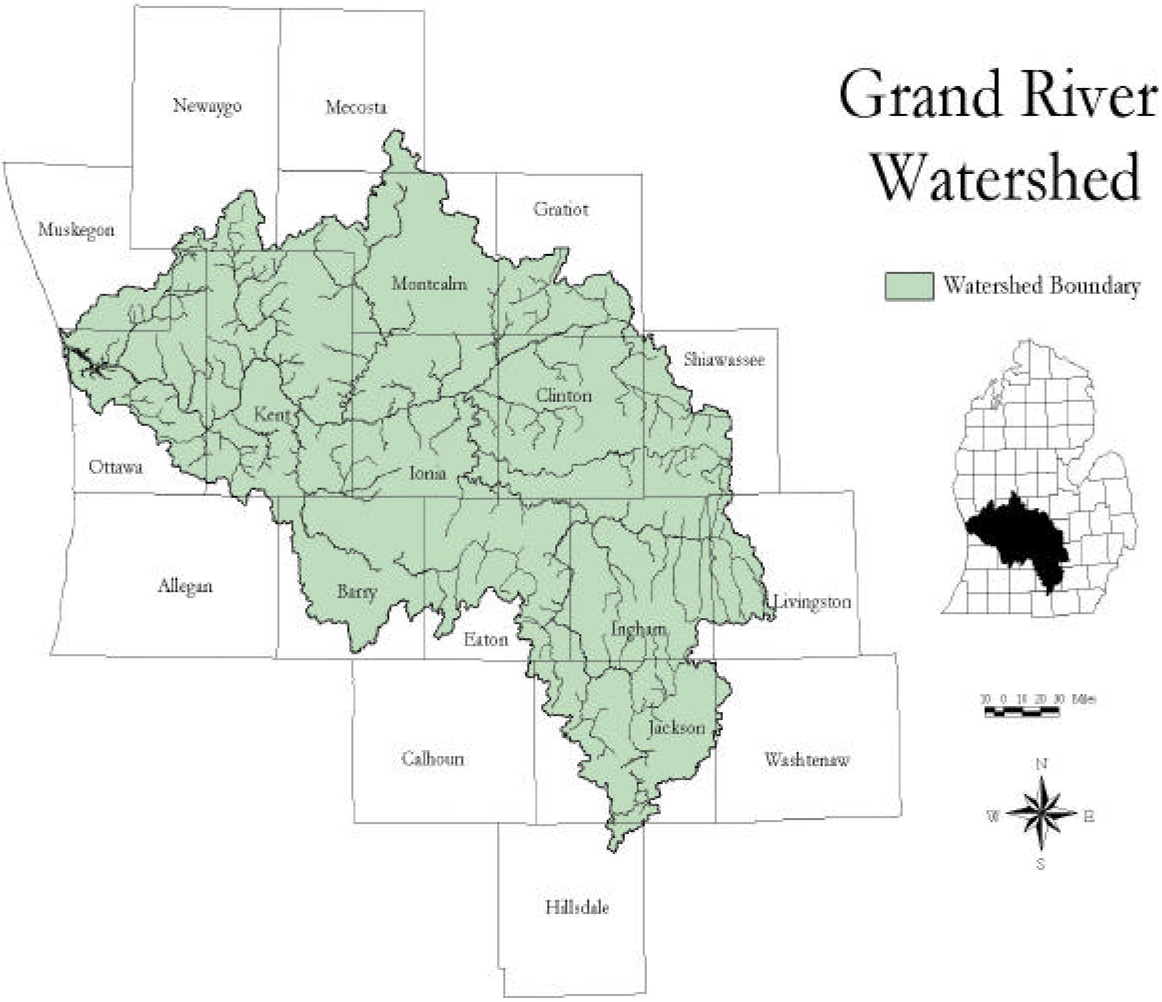


Figure 1.1 The Grand River Watershed

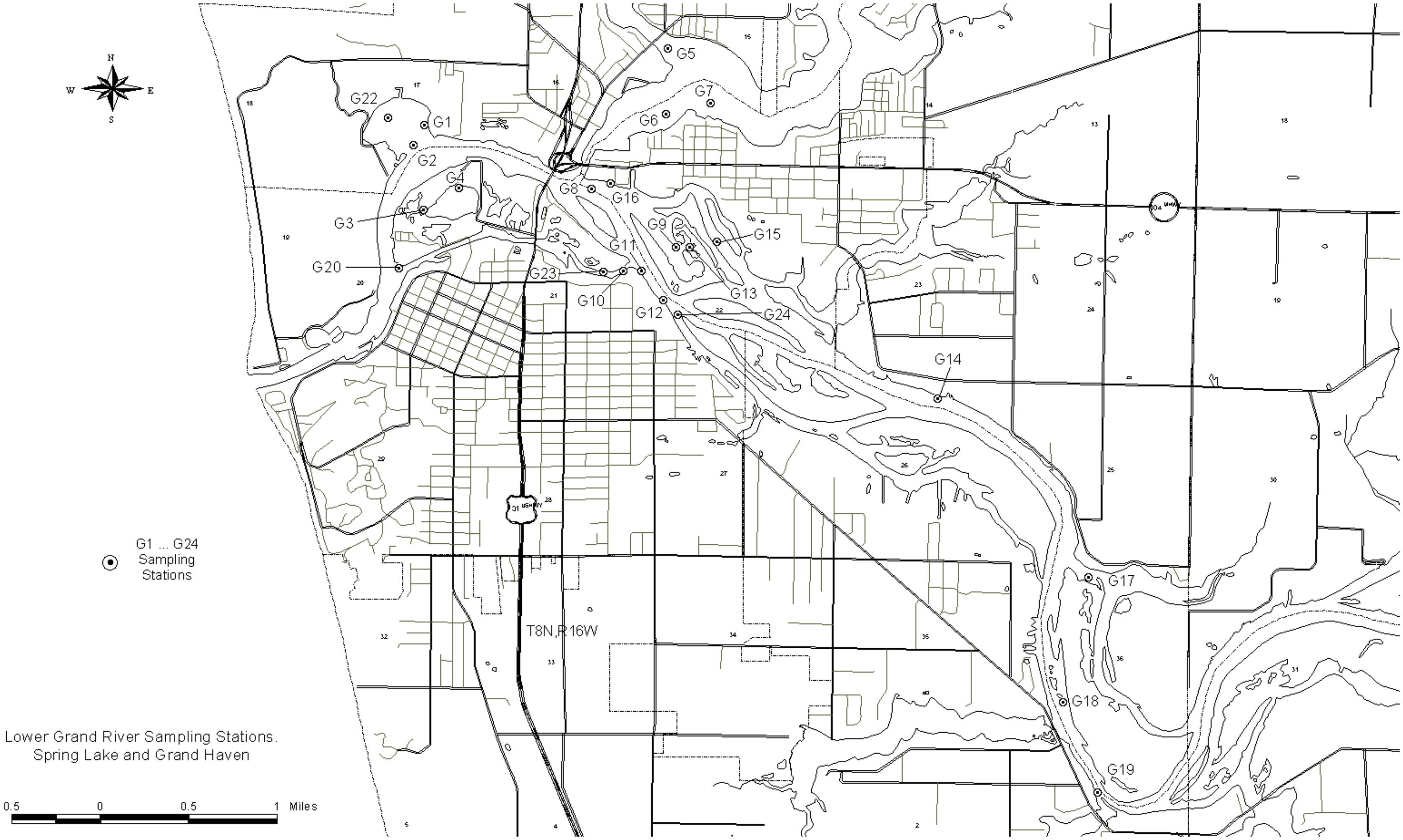


Figure 1.2 The Lower Grand River Watershed

1.2 Project Objectives And Task Elements

The objective of this investigation was to conduct a Phase I assessment of heavy metal and pesticide contamination in the lower Grand River. Selected samples were analyzed for chlorinated phenols, PAH compounds, and PCB congeners in areas where industrial releases may have occurred. In addition, a preliminary assessment of sediment depositional patterns and sediment toxicity were performed to assist in the analysis of the ecological effects and in the evaluation of remediation alternatives. Specific objectives and task elements are summarized below:

- Determine the nature and extent of sediment contamination in the lower Grand River.
  - A Phase I investigation was conducted to expand the sediment core sampling previously performed by the U.S. Army Corps of Engineers. The investigation included additional spatial coverage in the lower river section and targeted areas of suspected contamination from industrial and agricultural sources. Twenty-three core samples were collected in this investigation. Arsenic, barium, cadmium, chromium, copper, lead, nickel, zinc, aluminum, selenium, iron, calcium, magnesium, manganese, mercury, TOC, DDT compounds, PCB congeners, and grain size were analyzed on the sediments in all core samples. Aluminum, iron, magnesium, and calcium were used to normalize the metals data (Loring, 1991). In addition, a subgroup of core samples taken from the Spring Lake and areas adjacent to CERCLA and RCRA sites were analyzed for chlorinated phenols and PAH compounds. Eleven cores were analyzed for these semivolatile organic compounds.
  - Surface sediments were collected in the lower Grand River area with a Ponar dredge to provide heavy metal concentration information for the toxicity evaluations. Four sites were selected for toxicity evaluations based on the results of the core sample analyses.
  - Critical measurements were the concentration of arsenic, barium, cadmium, chromium, copper, lead, nickel, zinc, aluminum, selenium, iron, calcium, magnesium, manganese, mercury, chlorinated phenols, DDT compounds, PCB congeners and PAH compounds in sediment samples. Non-critical measurements were total organic carbon, and grain size.
- Evaluate the toxicity of sediments from sites in the lower Grand River area.
  - Sediment toxicity evaluations were performed with *Hyalella azteca* and *Chironomus tentans* on four sediment samples.
  - Toxicity measurements in Grand River sediments were evaluated and compared to the control location. These measurements determined the presence and degree of toxicity associated with sediments from the Grand River.
  - Critical measurements were the determination of lethality during the toxicity tests and the monitoring of water quality indicators during exposure (ammonia, dissolved oxygen, temperature, conductivity, pH, and alkalinity).

1.3 Experimental Design

This investigation was designed to examine specific sites of possible contamination as well as provide an overall assessment of the nature and extent of sediment contamination in the lower region of the Grand River. This bifurcated approach allowed the investigation to focus on specific sites based on historical information in addition to examining the broad-scale distribution of contamination. To address contamination at specific sites, 16 core samples were collected from locations likely to have been impacted by significant anthropogenic activity. The locations were selected to target current and historical point sources and downstream sites from known industrial and municipal discharges. These sites were determined by the analysis of historical data and industrial site locations. Analysis of river flow patterns and depositional areas were then used to select seven locations that would reflect the general distribution of contaminants.

Sediment samples were collected using the U.S. EPA Research Vessel *Mudpuppy* and the GVSU Research Vessel *D.J. Angus*. The sediment cores were collected with a VibraCore device with core lengths ranging from 6-8 ft. The core samples were then sectioned in three equal lengths for chemical analysis. For each core, the analytical parameters included a general series of inorganic and organic constituents as well as specific chemicals related to a particular source or area. The general chemical series for each core included the following heavy metals; arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc. In addition, DDT, DDE, DDD, and PCB Congeners were analyzed on all cores. A subset of the 11 core samples were analyzed for PAH compounds and chlorinated phenols. Basic sediment chemistry parameters (organic carbon, aluminum, calcium, iron, manganese, magnesium, and grain size) were also analyzed on each core. Aluminum and other sediment chemistry parameters were used to normalize sediment metal data for the differentiation of background levels and anthropogenic sources (Loring 1991, Helmke, et al 1977). The location of the sampling stations are illustrated in Figure 1.2. Analytical methods were performed according to the protocols described in SW-846 3rd edition (EPA 1994a).

Chemistry data were then supplemented by laboratory toxicity studies that utilize standardized exposure regimes to evaluate the effects of contaminated sediment on test organisms. Six Ponar samples were collected in areas that had elevated levels of contaminants in the top core sections. Standard EPA methods (1994b) using *Chironomus tentans* and *Hyalella azteca* were used to determine the acute toxicity of sediments from the Ponar samples.

1.4 References

Bowman, D. W. 1995. Grand River at Grand Haven Michigan: U.S. Army Corps of Engineers Tier II Evaluation. June, 1995.

Cowell, S. E., Hurley, J. P., Schafer, M. M. and P. E. Hurley. 1995. Mercury partitioning and transport in Lake Michigan Tributaries. Presented at 38th Conference. International Association of Great Lakes Research.

DLZ, 1996. Grand Haven Sediment Sampling and Analysis. Delivery Order #0014. Prepared for the U.S. Army Corps of Engineers. Detroit District.

EPA, 1994a. *Test Methods for Evaluating Solid Waste Physical/Chemical Methods. U.S. Environmental Protection Agency*. SW-846, 3rd Edition.

EPA, 1994b. *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates*. U.S. Environmental Protection Agency. EPA/600/R-94/024.

GAO. 1993. *Issues Concerning Pesticide Usage in the Great Lakes Watershed.* GAO-RCED-93-128. 39pp.

Hall, D. W. and T. E. Behrendt. 1995. Polychlorinated byphenyls and pesticides in Lake Michigan tributaries, 1993-95. Presented at 38th Conference. International Association of Great Lakes Research.

Helmke, P. A., Koons, R. D., Schomberg, P. J. and I. K. Iskandar. 1977. Determination of trace element contamination of sediments by multielement analysis of clay-size fraction. Environ. Sci. Technol.10:984-988. 23:200-208.

Hester, M. R. 1995. *Atlas of Pesticide Usage Trends and Environmental Risk Potentials in the Grand River Watershed.* Pub. #MR-95-3. Water Resources Institute. Grand Valley State University.

Loring, D. H. 1991. Normalization of heavy-metal data from estuarine and coastal sediments. ICES J. Mar. Sci. 48:101-115.

Robertson, D. M. 1997. Regionalized loads of suspended sediment and phosphorus to Lakes Michigan and Superior-High flow and long –term average. *Journal of Great Lakes Research.* 23:416-439.

Schropp, S. J., Windom, H. L., Ed. 1988. A Guide to the Interpretation of Metal Concentrations in Estuarine Sediments. Florida Department of Environmental Regulation Coastal Zone Management Section.

Shaffer, M. M., Overdier, J. T., Baldino, R. A., Hurley, J. P. and P. E. Hughes. 1995. Levels, partitioning, and fluxes of six trace elements in Lake Michigan tributaries. Presented at 38th Conference. International Association of Great Lakes Research.

Sommers, L. 1977. *Atlas of Michigan*. Michigan State University Press. East Lansing. 241pp.

U.S. Army Corps of Engineers, 1972. Comprehensive Water Resources Study. The Grand River Basin. Part II. Detroit District. Appendix C.

2.0 Sampling Locations

The lower Grand River region included in this investigation covers the Grand Haven/Spring Lake area in Ottawa County. Samples sites were selected based on proximity to potential point and non point sources of contamination. The locations of these sites were determined by review of historical records and communications with the Michigan Department of Natural Resources and the U.S. Army Corps of Engineers. Samples were collected in areas of fine sediment deposition. Samples from areas containing rubble and sand were excluded. A total of 23 core samples and 6 Ponar samples were collected. Locations of each sample were obtained by differential GPS.

For this project, the lower Grand River was divided into four regions to evaluate potential source locations and deposition areas:

- Harbor Island and the Sag area
- Grand Haven area
- Spring Lake area
- Middle Bayou area

The Harbor Island and the Sag region is shown in Figure 2.1. This region contains a meander core island called Harbor Island that contains an old landfill area to the north and a power generation facility on the southern tip. The main channel of the Grand River flows around the western side of the island. The eastern channel has a limited flow and is primarily used for recreational boating. Stations G3 and G4 were selected to investigate potential sediment contamination from the old landfill and fly ash storage areas. Station G20 was selected as a sediment deposition area. The Sag region consists of a meander lake that has been expanded by sand mining activity on the western shore. Station G1 was selected to examine potential sediment contamination from a large petroleum storage facility located near the northeastern corner. Stations G2 and G22 were selected to monitor historic sediment deposition.

The Grand Haven region is located along the southern shoreline of the lower Grand River (Figure 2.2). Stations G10, G11, G12, and G23 were selected to examine potential sediment contamination from the tannery located on the southern shore. The municipal wastewater treatment plant and a brass foundry are also located in this area. Station G24 was located at the tip of a meander core island in a sediment deposition area. Effects from the tannery discharge were not anticipated due to river flow. Stations G9, G13, and G15 were also selected as sediment deposition zones and were located in shallow channels near meander islands.

The Spring Lake Region is located on the northern shoreline of the lower Grand River (Figure 2.3). Stations G5, G6, and G7 were located in the Village of Spring Lake. Station G5 was selected as a control location with residential development as the only potential impact. Stations G6 and G7 were located near the southern shoreline of Spring Lake in the area where the USACE previously detected pentachlorophenol (Bowman 1995). These

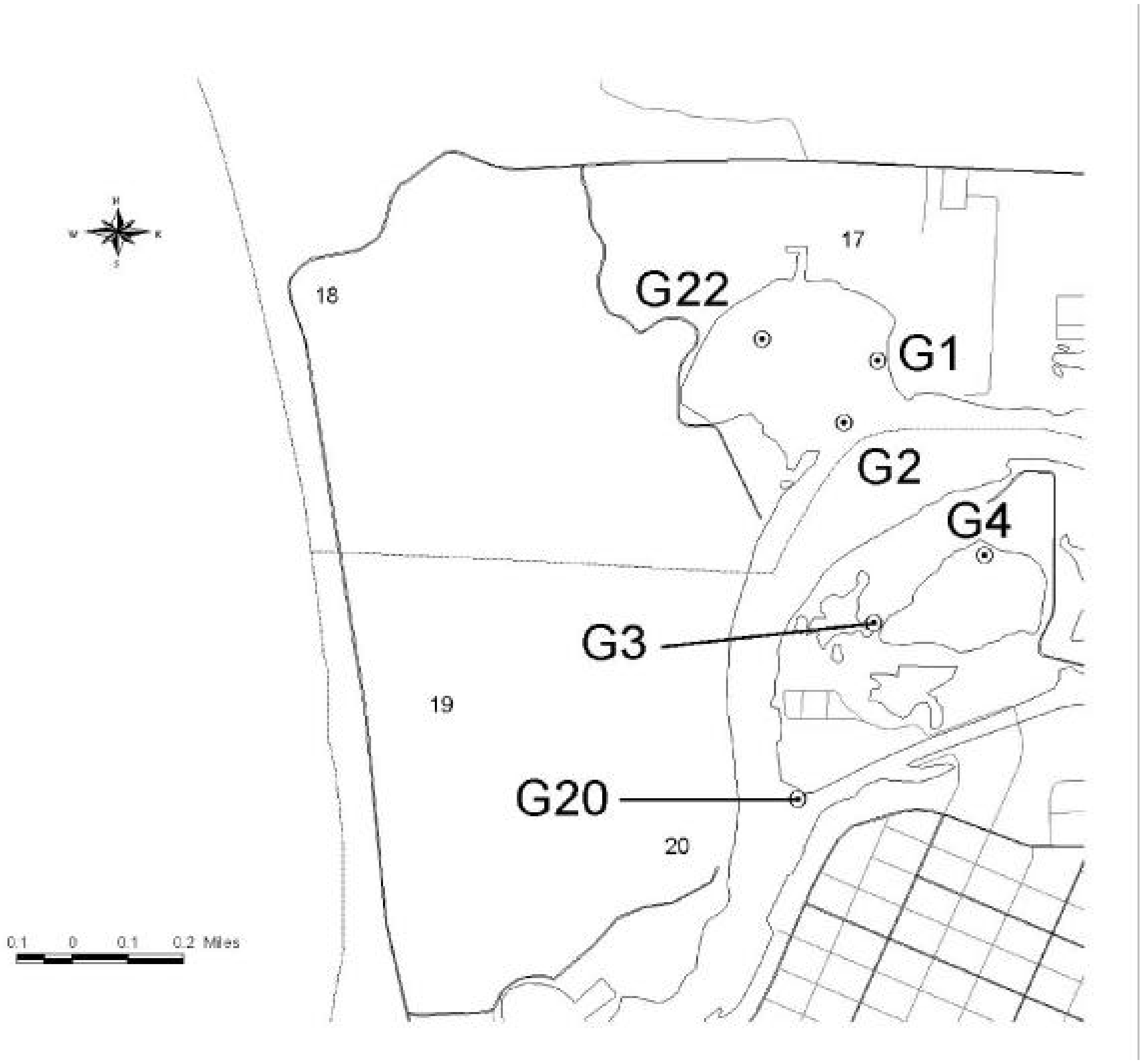


Figure 2.1 **Sampling Stations Located In The Harbor Island And Sag Region Of The Lower Grand River, October 1997.**

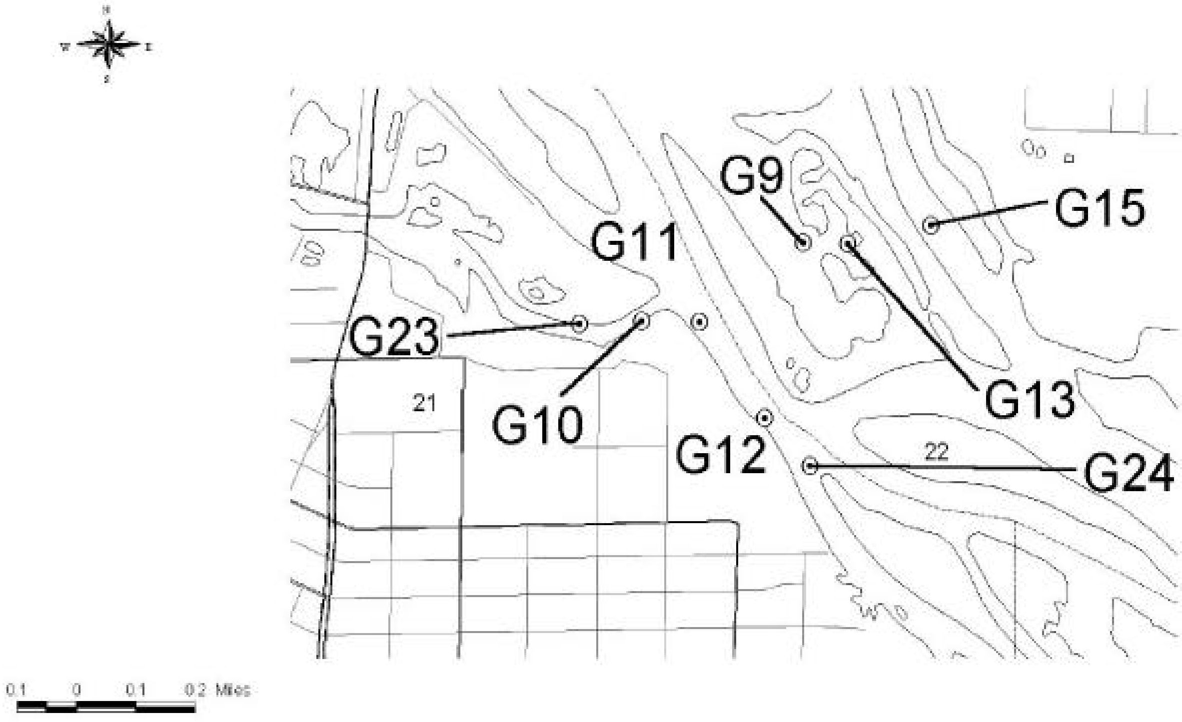


Figure 2.2 **Sampling Stations Located In The Grand Haven Region Of The Lower Grand River, October 1997.**

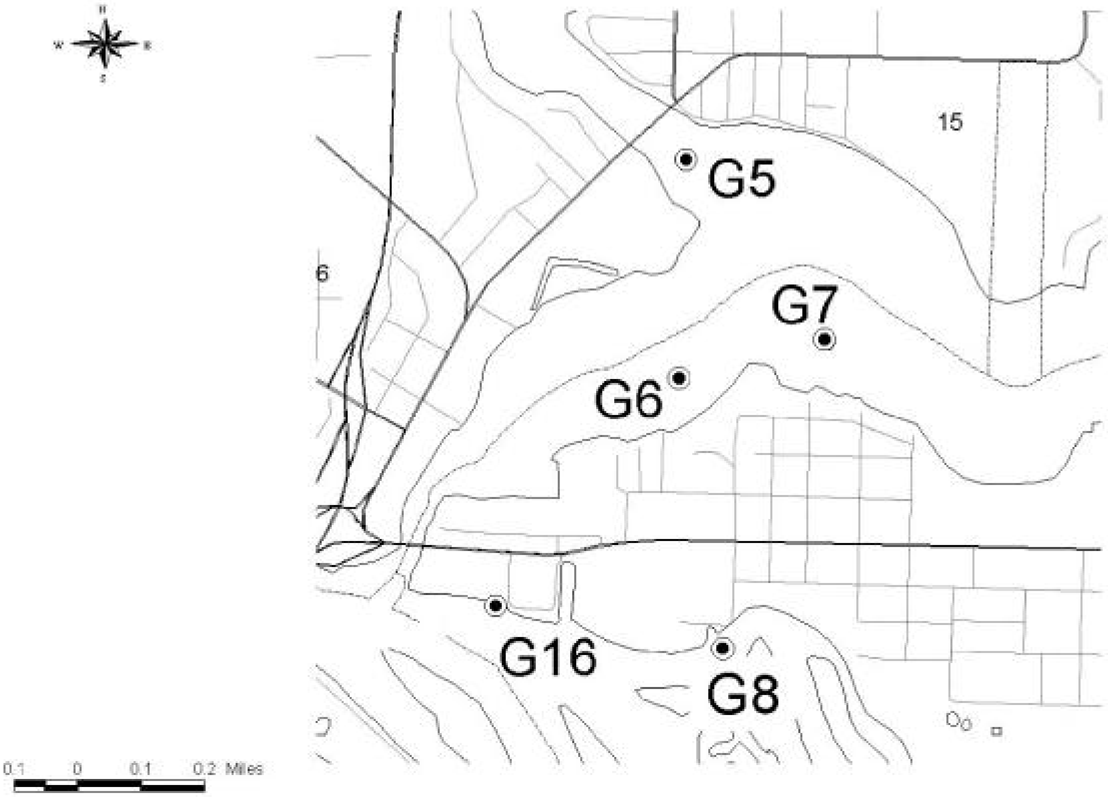


Figure 2.3 Sampling Stations Located In The Spring Lake Region Of The Lower Grand River, October 1997.

locations were in areas that may be influenced by historical discharges from two metal finishing facilities (Miller Smith Plating and Burnside Manufacturing). Both of these facilities are included on the Michigan Department of Environmental Quality's 201 Priority List of hazardous waste sites because of known groundwater and soil contamination. Stations G8 and G16 were located on the southern shore of the Village of Spring Lake in the channel of the Grand River. These stations are also in locations that may be influenced by the 201 Priority sites described above.

The Middle Bayou region of the lower Grand River (Figure 2.4) is located approximately 2 miles east of the Grand Haven area. Sampling stations G14, G17, G18, and G19 were located in deposition areas off the main channel. These stations are not located near any known industrial source and the only anthropogenic impact would be from contaminant deposition from discharges in Grand Rapids.

The coordinates, depths, and visual descriptions of the sediments for the core sampling locations described above are presented in Table 2.1. Descriptions for the Ponar samples are included in Table 2.2. Ponar samples are designated with the letter P (e.g. G12P) to differentiate this group from the core samples. The Ponar samples were collected from the same corresponding locations as the sediment cores.

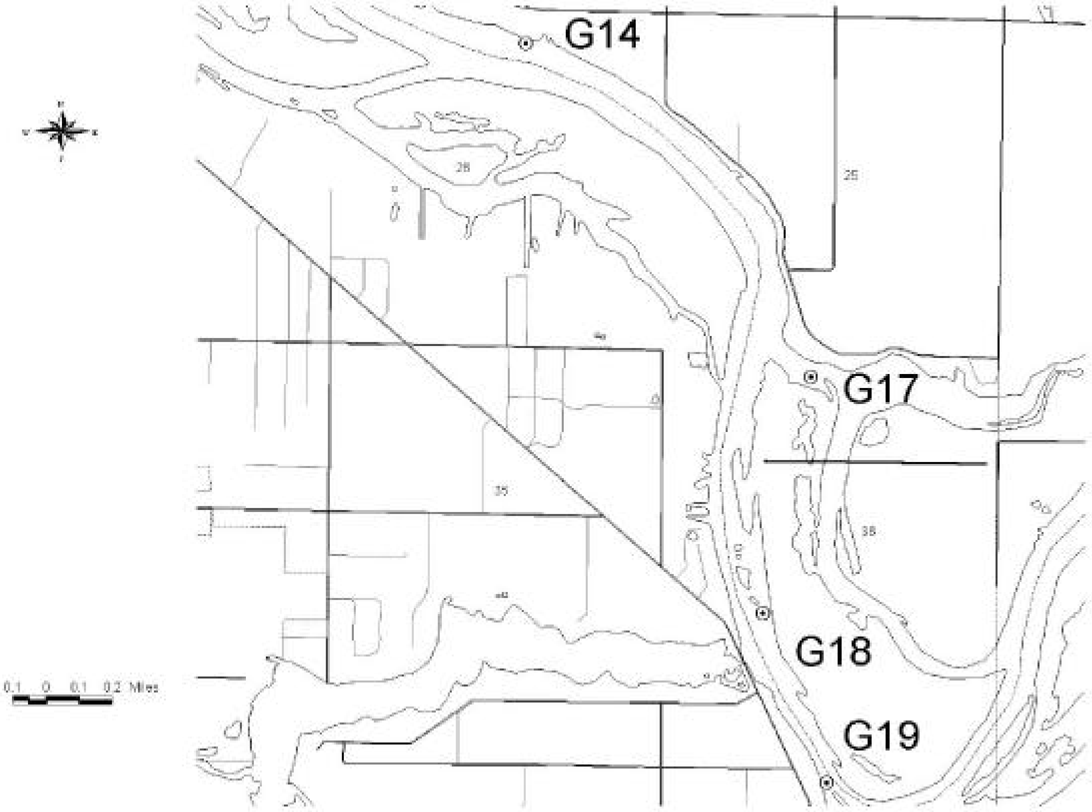


Figure 2.4 **Sampling Stations Located In The Middle Bayou Region Of The Lower Grand River, October 1997.**

Table 2.1 Grand River Core Sampling Stations. (* Field Duplicate Sample).

Station	Date	Depth to Core	Depth of Core	Latitude	Longitude	Description
		ft/inches	inches	N	W	
G1	10/14/97	5'1"	55	43^{o} 04.7619'	86^{o} 13.9171'	
			0-15			black organic
			15-35			brown silts
			35-55			brown silts shell fragments
G2	10/14/97	4'6"	67	43^{o} 04.6611'	86^{o} 13.9862'	
			0-22			sandy silt
			22-44			silt some sand
			44-67			silts, sand plug at 60"
G3	10/15/97	2'3"	30	43^{o} 04.3442'	86^{o} 13.9124'	
			0-15			brown silts
			15-30			brown silts
G4	10/16/97	2'7"	36	43^{o} 04.4557'	86^{o} 13.6795'	
			0-18			black sandy silt
			18-36			black sandy silt
G5	10/16/97	26'8"	70	43^{o} 05.1621'	86^{o} 12.2968'	
			0-25			black organic silts
			25-50			black silts
			50-70			black silts
G5 FD	10/16/97	26'3"	81	43^{o} 05.1621'	86^{o} 12.2968'	
			0-27			black organic silts
			27-54			black silts
			54-81			black silts
G6	10/16/97	27'9"	76	43^{o} 04.8388'	86^{o} 12.3039'	
			0-25			black organic silts
			25-50			black silts
			50-75			black silts
G7	10/16/97	31'2"	62	43^{o} 04.6643'	86^{o} 11.9944'	
			0-20			wood chips, black organic
			20-40			black organic silts
			40-62			black organic silts
G8	10/17/97	3'8"	75	43^{o} 04.4692'	86^{o} 12.4286'	
			0-23			brown silty clay
			25-50			brown silty clay
			50-75			brown silty clay
G9	10/18/97	3'11"	40	43^{o} 04.1913'	$86^{'}$ 12.2186'	
			0-13			clay silt
			13-26			clay silt
			26-40			clay silt sand on bottom

Table 2.1 Grand River Core Sampling Stations (continued)
(* Field Duplicate Sample)

Station	Date	Depth to Core	Depth of Core	Latitude	Longitude	Description
		ft/inches	inches	N	W	
G10	10/15/97	2'0"	27	43° 04.0637'	86° 12.5577'	
			0-13			black organic silts
			13-27			Sandy silt peat
G11	10/15/97	10'11""	23	43° 04.0704'	86° 12.4408'	
			0-11			clay, wood chips
			11-23			wood chips, black organic
G12	10/15/97	12'11"	11	43° 03.9310'	86° 12.2939'	
			0-11			oily organic, hair
G13	10/18/97	2'9"	63	43° 04.1913'	86' 12.1219'	
			0-21			brown silts
			21-42			gray silts
			42-63			gray silts
G14	10/17/97	9'5"	75	43° 03.4801'	86° 10.4487'	
			0-25			black silty clay
			25-50			silty clay
			50-75			white/gray clay
G15	10/18/97	4'8"	54	43° 04.2217'	86° 11.9411'	
			0-18			silty sand
			18-36			silty sand
			36-54			sand and shells
G16	10/17/97	9'2"	10	43° 04.4950'	86° 12.6622'	coarse silt sand
G17	10/17/97	7'10"	37	43° 02.6295'	86° 09.4134'	
			0-12			black organic sand
			12-24			black silt
			24-37			grey silty sand shells
G18	10/17/97	3'9"	48	43° 02.0121'	86° 09.5429'	
			0-16			black silty sand
			16-32			black silty sand
			32-48			black silty sand oil odor
G19	10/17/97	9'10"	29	43° 01.5747'	86° 09.2665'	
			0-15			detritus silt sand
			15-29			black silty sand
G20	10/15/97	9'9"	60	43° 04.0600'	86° 14.0656'	
			0-20			black silts sand
			20-40			brown silts
			40-60			brown silts, sand plug at 50"
G20 FD*	10/15/97	9'9"	61	43° 04.0600'	86° 14.0656'	
			0-20			black silts sand
			20-40			brown silts
			40-61			brown silts, sand plug at 50"

Table 2.1 Grand River Core Sampling Stations (continued)
(* FIELD DUPLICATE SAMPLE)

Station	Date	Depth to Core	Depth of Core	Latitude	Longitude	Description
		ft/inches	inches	N	W	
G22	10/16/97	5'9"	110	43° 04.7919'	86° 14.1640'	
			0-24			black silts
			24-48			black silts
			48-72			black silts
			72-98			black silts
			98-110			black silts
G23	10/15/97	2'6"	61	43° 04.0640'	86°12.6987'	
			0-20			3" sand, brown organic
			20-40			peat, organic silt
			40-61			gray sand
G24	10/15/97	7'0"	55	43° 03.8637'	86° 12.1941'	
			0-17			oily sand
			17-34			sand silt
			34-55			oily sand silt

Table 2.2 Grand River Ponar Sampling Stations

Station	Date	Depth to Sample	Latitude	Longitude	Description
		ft/inches	N	W	
G5P	4/22/98	27'10"	43° 05.1598'	86° 12.2933'	Black/brown organic silts
G6P	4/22/98	28'09"	43° 04.00489'	86°12.2820'	Black/brown organic silts
G7P	4/22/98	29'11"	43° 04.0690'	86°12.0110'	Black/brown organic silts
G12P	4/22/98	13'10”	43° 03.9286'	86° 12.2888'	Oily red/black silts and hair
G20P	4/22/98	10”08”	43° 04.0596'	86° 14.0600'	Black/brown organic silts

3.0 Methods

3.1 Sampling Methods

Sediment and benthos samples were collected using the U.S. EPA Research Vessel *Mudpuppy* and the GVSU Research Vessel *D.J. Angus*. Vibra Core methods were used to collect sediment cores for chemical analysis. A 4 inch lexan core tube was used for collection. A new core tube was used at each location. The core samples were measured and sectioned into three equal segments corresponding to top, middle, and bottom. Each section was then homogenized in a polyethylene pan and split into sub-samples. The visual appearance of each segment was recorded along with the water depth and core depth.

Ponar samples were collected for toxicity testing and sediment chemistry. For sediment chemistry and toxicity testing, a standard Ponar sample was deposited into a polyethylene pan and split into sub-samples. The Ponar was washed with water in between stations.

3.1.2 Sample Containers, Preservatives, And Volume Requirements

Requirements for sample volumes, containers, and holding times are listed in Table 3.1. All sample containers for sediment chemistry and toxicity testing were purchased precleaned and certified as Level II by I-CHEM Inc.

Table 3.1 Sample Containers, Preservatives, And Holding Times

Matrix	***Parameter***	***Container***	***Preservation***	***Extraction***	***Analysis***
Sediment	Metals	250 mL Wide Mouth Plastic	Cool to 4^{o}C	---	6 months, Mercury-28 Days
Sediment	TOC	250 mL Wide Mouth Plastic	Freeze -10^{0}C	---	6 months
Sediment	Semi-Volatile Organics	500 mL Amber Glass	Cool to 4^{o}C	14 days	40 days
Sediment	PCB Congeners DDT Compounds	500 mL Amber Glass	Cool to 4^{o}C	14 days	40 days
Sediment	Grain Size	1 Quart Zip-Lock Plastic Bag	Cool to 4^{o}C	---	6 months
Sediment	Toxicity	4 liter Wide Mouth Glass	Cool to 4^{o}C	---	45 days
Culture Water	Alkalinity Ammonia Hardness Conductivity pH	250 mL Wide Mouth Plastic	Cool to 4^{o}C	---	24 hrs.

3.2 Chemical Analysis Methods For Sediment

A summary of analytical methods is provided in Table 3.2.1. Instrumental conditions and a summary of quality assurance procedures are provided in the following sections.

Table 3.2.1 Analytical Methods And Detection Limits

SEDIMENT MATRIX

Parameter	Method Description	Analytical Method	Detection Limit
USEPA Semivolatiles	Solvent Extraction and GC/MS analysis	8270[1], 3550[1] Extraction	Table 3.2.2
Arsenic, Cadmium, Lead, Selenium	Arsenic-Graphite Furnace Atomic Absorption Spectroscopy	7060[1], 3052[1] Digestion	0.10 mg/kg
Aluminum, Barium, Calcium, Chromium, Copper, Iron, Magnesium, Manganese, Nickel, Zinc	Inductively Coupled Plasma Atomic Emission Spectroscopy	6010[1], 3052[1] Digestion	2.0 mg/kg
Mercury	Mercury Analysis of Soils, Sludges and Wastes by Manual Cold Vapor Technique	7471[1], Prep Method in 7471[1]	0.10 mg/kg
Grain Size	Wet Sieve	WRI Method PHY-010	1 %
Total Organic Carbon	Combustion/IR	9060[1]	0.1%

[1] - SW846 3rd. Ed. EPA 1994.

3.2.1 Sample Preparation For Metals Analysis

For aluminum, arsenic, barium, calcium, cadmium, chromium, copper, iron, magnesium, manganese, nickel, lead, selenium, and zinc analysis, sediment samples were digested according to a modified version of EPA SW-846 method 3052 “Microwave Assisted Acid Digestion of Sediments, Sludges, Soils and Oils”. Samples were air-dried prior to digestion. A Questron (Mercerville, NJ) Q-4000 microwave system was used. The system provided a controled temperature and pressure in each digestion vessel. Approximately 0.25 g of sediment was weighed into a teflon liner. 4 mL Type 1 deionized water, 3 mL of concentrated nitric acid, 6 mL of concentrated hydrochloric acid, and 4 mL of hydrofluoric acid was added to each sample. Vessels then were capped and placed into the microwave cavity. The program was set to raise the temperature inside the vessels to 200°C for 20.0 minutes. After completion of the run, vessels were cooled and vented. Then 15 mL of saturated boric acid was added to each sample in place of using hydrogen peroxide. The vessels were recapped and placed into the microwave cavity. The program was set to raise the temperature inside the vessels to 180°C for 15.0 minutes. After completion of the second run, the vessels were cooled and vented. The contents were transferred into 50 mL centrifuge tubes and brought up to 50 mL with Type I deionized water. Samples were centrifuged for 5 minutes at 3000 rpm before analysis.

For every 10 samples at least one set of the following quality control samples was prepared:

- Method Blank (4 mL of Type 1 deionized water, 3 mL of nitric acid, 6 mL of hydrochloric acid, 4 mL of hydrofluoric acid, and 15 mL of boric acid)
- Laboratory Control Spike (Blank Spike)
- Matrix Spike
- Matrix Duplicate

For determining total mercury the samples were prepared by EPA SW-846 method 7471A “Mercury in Solid and Semisolid Waste”. Approximately 0.2 g of wet sediment was weighed into a 50 mL centrifuge tube. 2.5 mL of Type I deionized water and 2.5 mL of aqua regia were then added to the tube. Samples were heated in a water bath at 95°C for 2 minutes. After cooling, the volume of the samples was brought up to 30 mL with Type I deionized water. Then 7.5 mL of 5% potassium permanganate solution was added to each sample, samples were mixed, and the centrifuge tubes were returned in the water bath for a period of 30 minutes. Three mL of 12% hydroxylamine chloride solution was added to each sample after cooling. Finally, the samples were mixed and centrifuged for 5 minutes at 3,000 rpm.

Calibration standards were digested along with the samples. Quality control samples were prepared as stated previously for every batch of 10 samples or less.

3.2.2 Arsenic Analysis By Furnace

Arsenic was analyzed in accordance with the EPA SW-846 method 7060A utilizing Graphite Furnace technique. The instrument employed was Perkin Elmer 4110ZL atomic absorption spectrophotometer. An arsenic Electrodeless Discharge Lamp (EDL) was used as a light source at wavelength of 193.7 nm. The instrument utilized a Zeeman background correction that reduces the non-specific absorption caused by some matrix components. The temperature program is summarized below:

Step	Temp,°C	Time, sec.		Gas Flow, ml/min	Read
		Ramp	Hold		
1	110	1	35	250	
2	130	15	37	250	
3	1300	10	20	250	
4	2100	0	5	0	X
5	2500	1	3	250	

A Pd/Mg modifier was used to stabilize As during the pyrolysis step. The calibration curve was constructed from four standards and a blank. Validity of calibration was verified with a check standard prepared from a secondary source. This action was taken immediately after calibration and after every 10 samples. At least 1 postdigestion spike was performed for every analytical batch of 20 samples.

3.2.3 Cadmium Analysis By Furnace

Cadmium was analyzed in accordance with the EPA SW-846 method 7060A utilizing Graphite Furnace technique. The instrument employed was Perkin Elmer 4110ZL atomic absorption spectrophotometer. A hollow cathode lamp was used as a light source at wavelength of 228.8 nm. The instrument utilized a Zeeman background correction that reduces the non-specific absorption caused by some matrix components. The temperature program is summarized below:

Step	Temp,°C	Time, sec.		Gas Flow, ml/min	Read
		Ramp	Hold		
1	110	1	40	250	
2	130	15	45	250	
3	500	10	20	250	
4	1550	0	5	0	X
5	2500	1	3	250	

A Pd/Mg modifier was used to stabilize Cd during the pyrolysis step. The calibration curve was constructed from four standards and a blank. Validity of calibration was verified with a check standard prepared from a secondary source. This action was taken immediately after calibration and after every 10 samples. At least 1 postdigestion spike was performed for every analytical batch of 20 samples.

3.2.4 Lead Analysis By Furnace

Lead was analyzed in accordance with the EPA SW-846 method 7060A utilizing Graphite Furnace technique. The instrument employed was Perkin Elmer 4110ZL atomic absorption spectrophotometer. A lead EDL Lamp was used as a light source at wavelength of 283.3 nm. The instrument utilized a Zeeman background correction that reduces the non-specific absorption caused by some matrix components. The temperature program is summarized below:

Step	Temp,°C	Time, sec.		Gas Flow, ml/min	Read
		Ramp	Hold		
1	120	1	20	250	
2	140	5	40	250	
3	200	10	10	250	
4	850	10	20	250	
5	1900	0	5	0	X
6	2500	1	3	250	

A Pd/Mg modifier was used to stabilize Pb during the pyrolysis step. The calibration curve was constructed from four standards and a blank. Validity of calibration was verified with a check standard prepared from a secondary source. This action was taken immediately after calibration and after every 10 samples. At least 1 postdigestion spike was performed for every analytical batch of 20 samples.

3.2.5 Selenium Analysis By Furnace

Selenium was analyzed in accordance with the EPA SW-846 method 7060A utilizing Graphite Furnace technique. The instrument employed was Perkin Elmer 4110ZL atomic absorption spectrophotometer. An arsenic EDL Lamp was used as a light source at wavelength of 196.0 nm. The instrument utilized a Zeeman background correction that reduces the non-specific absorption caused by some matrix components. The temperature program is summarized below:

Step	Temp,°C	Time, sec.		Gas Flow, ml/min	Read
		Ramp	Hold		
1	120	1	22	250	
2	140	5	42	250	
3	200	10	11	250	
4	1300	10	20	250	
5	2100	0	5	0	X
6	2450	1	3	250	

A Pd/Mg modifier was used to stabilize Se during the pyrolysis step. The calibration curve was constructed from four standards and a blank. Validity of calibration was verified with a check standard prepared from a secondary source. This action was taken immediately after calibration and after every 10 samples. At least 1 postdigestion spike was performed for every analytical batch of 20 samples.

3.2.6 Metal Analysis By ICP

Aluminum, barium calcium, chromium, copper, iron, magnesium, manganese, nickel and zinc were analyzed in accordance with EPA SW-846 method 6010A by Inductively Coupled Plasma Atomic Emission Spectroscopy. Samples were analyzed on a Perkin Elmer P-1000 ICP Spectrometer with Ebert monochromator and cross-flow nebulizer. The following settings were used:

Element Analyzed	Wavelength, nm
Al	308.2
Ba	233.5
Ca	315.9
Cr	267.7
Cu	324.8
Fe	259.9
Mg	279.1
Mn	257.6
Ni	231.6
Zn	213.9

RF Power: 1300 W

Matrix interferences were supressed with internal standartization utilizing Myers-Tracy signal compensation. Interelement interference check standards were analyzed in the beginning and at the end of every analytical run, and indicated absence of this type of interference at the given wavelength. The calibration curve was constructed from four standards and a blank and was verified with a check standard prepared from a secondary source.

3.2.7 Mercury

After the digestion procedure outlined in 3.2.1, sediment samples were analyzed for total mercury by cold vapor technique according to SW-846 Method 7471. A Perkin Elmer 5100ZL atomic absorption spectrophotometer with FIAS-200 flow injection accessory was used. Mercury was reduced to an elemental state with stannous chloride solution, and atomic absorption was measured in a quartz cell at an ambient temperature and a wavelength of 253.7 nm. A mercury electrodeless discharge lamp was used as a light source. The calibration curve consisted of four standards and a blank and was verified with a check standard prepared from a secondary source.

3.2.8 Total Organic Carbon

Total Organic Carbon anlysis of sediments was conducted on a Shimadzu TOC-5000 Total Organic Carbon Analyzer equipped with Solid Sample Accessory SSM-5000A.

An air dried sample was first placed in the oven at 900°C, where all the carbon was catalyticly converted to CO_2 (Total Carbon Analysis). A different portion of the sample was treated with phosphoric acid at 250°C to displace CO_2 from carbonates and bicarbonates (Inorganic Carbon Analysis). CO_2 was measured in the infra-red cell. Total Organic Carbon content was determined by difference between results of the two analyses.

Calibration curves for both analyses were constructed from three standards and a blank. Glucose was used as a standard compound for Total Carbon Analysis (44% carbon by weight). For Inorganic Carbon Analysis, sodium carbonate was used (11.11% of carbon by weight)

3.2.9 Grain Size Analysis

Grain size was performed by wet sieving the sediments. The following mesh sizes were used: 2mm (granule), 1 mm (very coarse sand), 0.5 mm (coarse sand), 0.25 mm (medium sand), 0.125 mm (fine sand), 0.063 (very fine sand), and 0.031 (coarse silt).

3.2.10 PCB Congener And DDT Analysis

The sediment samples were extracted for PCB congeners and DDT using SW-846 Method 3050. Sediment samples were air dried for 24 hrs, and then equal amounts of dried soil and anhydrous sodium sulfate were mixed together. The samples were then extracted using 50 mL of methanol and 100 mL of hexane. The samples were sonicated for 3 minutes, and then the hexane layer was removed and filtered through anhydrous sodium sulfate. The process was repeated two more times, adding 50 mL of hexane each time. The hexane extract was concentrated to 1 mL in the Turbovap, and then run through a chromatography column packed with 2% deactivated florisil and anhydrous sodium sulfate. Copper turnings cleaned with 1 M hydrochloric acid were added to remove sulfur. The eluent was concentrated to 1 mL using the Turbovap, and concentrated sulfuric acid was added as a final clean-up step. Solvent transfer to iso-octane was achieved under a flow of nitrogen gas and condensed to a final volume of 1 mL.

Sample extracts were analyzed using gas chromatography with a Ni^{63} electron capture detector and RTX-5 capillary column. Helium and nitrogen were used as the carrier and makeup gas, respectively. Instrumental operating conditions were as follows:

- Column temperature program: 80°C for 2 min., 10°C/min to 160°C, 1.5°C/min to 190°C, 2°C/min to 256°C and hold at 256°C for 6 min.
- Injector temperature: 260°C
- Detector temperature: 330°C
- Sample volume: 1 ul

Table 3.2.3. is a list of PCB congeners and their detection limits. Two surrogate standards, PCB congeners 46 and 142 were used to monitor extraction efficiency. Acceptance limits for the surrogates were ± 50% for precision and accuracy.

Table 3.2.2 Detection Limits For PCB Congeners And DDT Compounds

PCB Congener	Detection Limit (ug/kg)
48	1.0
52	1.0
59	1.0
70	1.0
87	1.0
97	1.0
101	1.0
105	1.0
118	1.0
138	1.0
149	1.0
151	1.0
153	1.0
155	1.0
180	1.0
183	1.0
205	1.0
DDT	1.0
DDD	1.0
DDE	1.0

3.2.11 Semivolatiles Analysis

Sediment samples were extracted for semivolatiles analysis using SW-846 Method 3050. The sediment samples were dried with anhydrous sodium sulfate to form a free flowing powder. The samples were then serially sonicated 3 times with 1:1 methylene chloride/acetone and concentrated to a 1 mL volume.

The sample extracts were analyzed by GC/MS on a Finnigan GCQ Mass Spectrometer according to Method 8270. Instrumental Conditions are itemized below:

MS operating conditions:

- Electron energy:	70 volts (nominal)
- Mass range:	40-450 amu
- Scan time:	820 amu/second, 2 scans/sec
- Source temperature:	190°C
- Transfer line temperature:	250°C

GC operating conditions:

- Column temperature program: 45°C for 6 min., then to 250°C at 10°C/min, then to 300°C at 20°C/min hold 300°C for 15 min.
- Injector temperature program: 250°C
- Sample volume: 1 ul

A list of analytes and detection limits is given in Table 3.2.4. Surrogate standards were utlilized to monitor extraction efficiency. Acceptance criteria for surrogate standards are given in Table 3.2.5. The GC/MS was calibrated using a 5 point curve. Instrument tuning was performed by injecting 5 ng of Decafluorotriphenylphosphine and meeting method acceptance criteria. The MS and MSD samples were analyzed at a 5% frequency.

3.2.12 Hexane Extractable Materials

Hexane extractable Materials (HEM) was analyzed on the Ponar samples by SW-846 Method 6030. The method was modified to use a gravimetric measurement of the hydrocarbon residue. Wet sediment samples were mixed with anhydrous sodium sulfate until the mixture was dry and free flowing. The dried sediment was then placed in cellulose thimble and extracted in a soxhlet apparatus for 24 hours with hexane. After extraction, the hexane was dried with sodium sulfate and evaporated to approximately 2 mLs in a Kuderna Danish concentrator with a three-ball Snyder column. The concentrate was then placed in a preweighed aluminum pan and evaporated on a steam bath to remove the residual hexane. The pan was then cooled in a dessicator for 12 hours and weighed. For quality control purposes, a blank, blank spike, matrix spike and matrix spike duplicate were analyzed with the sample set. Mineral oil was used as the spiking compound. Acceptance limits for precision and accuracy were ± 50%.

3.3 Chemical Analysis Methods for Culture Water

The parameters, methods, and detection limits for the measurements performed on the culture water used in the sediment toxicity tests are listed in Table 3.3.1. All methods were performed according to proceedures outlined in Standard Methods 14th Edition (1996).

3.4 Quality Assurance/Quality Control Program

A detailed description of the Quality Assurance/Quality Control program for this project was described in the Quality Assurance Project Plan.

Table 3.2.3 Organic Parameters And Detection Limits

	Sediment (mg/kg)
Semi-Volatile Organic Compounds (8270)	
Phenol	0.33
Bis(2-chloroethyl)ether	0.33
2-Chlorophenol	0.33
1,3-Dichlorobenzene	0.33
1,4-Dichlorobenzene	0.33
1,2-Dichlorobenzene	0.33
2-Methylphenol	0.33
4-Methylphenol	0.33
Hexachloroethane	0.33
Isophorone	0.33
2,4-Dimethylphenol	0.33
Bis(2-chloroethoxy)methane	0.33
2,4-Dichlorophenol	0.33
1,2,4-Trichlorobenzene	0.33
Naphthalene	0.33
Hexachlorobutadiene	0.33
4-Chloro-3-methylphenol	0.33
2-Methylnaphthalene	0.33
Hexachlorocyclopentadiene	0.33
2,4,6-Trichlorophenol	0.33
2,4,5-Trichlorophenol	0.33
2-Chloronaphthalene	0.33
Dimethylphthalate	0.33
Acenaphthylene	0.33
Acenaphthene	0.33
Diethylphthalate	0.33
4-Chlorophenyl-phenyl ether	0.33
Fluorene	0.33
4,6-Dinitro-2-methylphenol	1.7
4-Bromophenyl-phenyl ether	0.33

Table 3.2.3 Organic Parameters And Detection Limits (continued)

	Sediment (mg/kg)
Semi-Volatile Organic Compounds (8270)	
Hexachlorobenzene	0.33
Pentachlorophenol	1.7
Phenanthrene	0.33
Anthracene	0.33
Di-n-butylphthalate	0.33
Fluoranthene	0.33
Pyrene	0.33
Butylbenzylphthalate	0.33
Benzo(a)anthracene	0.33
Chrysene	0.33
Bis(2-ethylhexyl)phthalate	0.33
Di-n-octylphthalate	0.33
Benzo(b)fluoranthene	0.33
Benzo(k)fluoranthene	0.33
Benzo(a)pyrene	0.33
Indeno(1,2,3-cd)pyrene	0.33
Dibenzo(a,h)anthracene	0.33
Benzo(g,h,i)perylene	0.33
3-Methylphenol	0.33

Table 3.2.4 Data Quality Objectives For Surrogate Standards Control Limits For Percent Recovery

Parameter	Control Limit
Nitrobenzene-d_5	30%-97%
2-Fluorobiphenyl	42%-99%
o-Terphenyl	60%-101%
Phenol-d_6	43%-84%
2-Fluorophenol	33%-76%
2,4,6-Tribromophenol	58%-96%

Table 3.3.1 Analytical Methods And Detection Limits For Culture Water

Parameter	Method	Detection Limit
Specific Conductance	Standard Methods 2510 B.	NA
Alkalinity	Standard Methods 2320	10 mg/l
Temperature	Standard Methods 2550	NA
Dissolved Oxygen	Standard Methods 4500-O G.	0.5 mg/l
Ammonia Electrode	Standard Methods 4500-NH_3 F.	0.05 mg/l
Hardness	Standard Methods 2340 C.	10 mg/l

3.5 Sediment Toxicity

The evaluation of the toxicity of the Grand River sediments was conducted using the ten day survival test for the amphipod *Hyalella azteca* and the dipteran *Chironomus tentans*. The procedures followed are contained in EPA/600/R-94/024, Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Fresh Water Invertebrates. All sediments were stored at 4°C prior to analysis. Toxicity analysis was initiated within 30 days of sample collection.

3.5.1 Laboratory Water Supply

A moderately hard well water for *H. azteca* and *C. tentans* cultures and maintenance was employed.

3.5.2 Test Organisms

The original stock of *H. azteca* was obtained from the Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan. The *H. azteca* culture was maintained in four 20 L glass aquaria using maple leaves as a substrate and food source. The food source was supplemented with a suspension of Tetramin® fish food. The original stock of *C. tentans* was obtained from the University of Michigan Department of Environmental Health in Ann Arbor, Michigan. The culture of *C. tentans* was maintained in 36 L glass aquaria using shredded paper toweling as a substrate and was fed a suspension of Tetrafin® goldfish food.

3.5.3 Experimental Design

Eight replicates per sediment were set up for both *H. azteca* and *C. tentans* exposures, with the sediment from site G-5P designated as the control. In all tests, moderately hard well water was utilized as the overlying water. The experimental conditions outlined in Tables 3.5.1 and 3.5.2 were used for the toxicity evaluations.

One day prior to the start of the test (day -1), the sediment from each site was mixed thoroughly and 100 mLs were transferred to each of the eight test chambers. Additionally, visual observations of the sediments were made. Moderately hard well water was also added at this time. On day 0, the overlying water was renewed once before the test organisms were introduced into each of the glass beakers. Measurement of water quality parameters was also initiated on this day. Ten, 7-14 day old *H. azteca* and 10 third instar *C. tentans* larvae were randomly added to their respective test chambers. At this time the organisms were fed, 1.5 mL YCS for the *H. azteca* and 1.5 mL Tetrafin® for the *C. tentans*. The glass beakers were placed in a rack and transferred to a temperature controlled room ($23 \pm 1^{o}C$). The light cycle was 16 hours on and 8 hours off. Temperature and dissolved oxygen measurements were taken from one randomly selected beaker for each sediment sample every 12 hours, after which the overlying water was renewed in all the beakers. Feeding occurred after the morning renewal. This procedure was repeated daily through day 10, at which point the test was terminated. On day 0, the overlying water from the beakers was composited from each sediment sample and 250 mLs were retained for alkalinity, hardness and ammonia analysis. On the last day the same procedure was carried out. On day 10, the sediments were sieved, and the surviving test organisms were removed and counted. The biological endpoint for these sediment tests was mortality. The validity of the test was based on greater than 80% survival in the control treatment for *H. azteca* and greater than 70% survival in the control treatment for the *C. tentans*. In addition, it was recommended that the hardness, alkalinity, pH, and ammonia in the overlying water within a treatment should not vary by more than 50% over the duration the test.

Table 3.5.1 Test Conditions For Conducting A Ten Day Sediment Toxicity Test With *Hyalella Azteca*

1.	Test Type:	Whole-sediment toxicity test with renewal of overlying water
2.	Temperature (°C):	23 ± 1°C
3.	Light quality:	Wide-spectrum fluorescent lights
4.	Illuminance:	About 500 to 1000 lux
5.	Photoperiod:	16 h light, 8 h darkness
6.	Test chamber size:	300 mL high-form lipless beaker
7.	Sediment volume:	100 mL
8.	Overlying water volume:	175 mL
9.	Renewal of overlying water:	2 volume additions per day (e.g., one volume addition every 12 hours)
10.	Age of test organisms:	7 to 14 days old at the start of the test
11.	Number of organisms per chamber:	10
12.	Number of replicate chambers per treatment:	8
13.	Feeding:	Tetramin® fish food, fed 1.5 mL daily to each test chamber
14.	Aeration:	None, unless dissolved oxygen in overlying water drops below 40% of saturation
15.	Overlying water:	Reconstituted water
16.	Overlying water quality:	Hardness, alkalinity, conductivity, pH, and ammonia measured at the beginning and end of a test. Temperature and dissolved oxygen measured daily.
17.	Test duration:	10 days
18.	End point:	Survival, with greater than 80% in the control.

Test Method 100.1. EPA Publication 600/R-94/024 (July 1994).

Table 3.5.2 Recommended Test Conditions For Conducting A Ten Day Sediment Toxicity Test With *Chironomus Tentans*

1.	Test Type:	Whole-sediment toxicity test with renewal of overlying water
2.	Temperature (°C):	23 ± 1°C
3.	Light quality:	Wide-spectrum fluorescent lights
4.	Illuminance:	About 500 to 1000 lux
5.	Photoperiod:	16 h light, 8 h darkness
6.	Test chamber size:	300 mL high-form lipless beaker
7.	Sediment volume:	100 mL
8.	Overlying water volume:	175 mL
9.	Renewal of overlying water:	2 volume additions per day (e.g., one volume addition every 12 hours)
10.	Age of test organisms:	Third instar larvae (All organisms must be third instar or younger with at least 50% of the organisms at third instar)
11.	Number of organisms per chamber:	10
12.	Number of replicate chambers per treatment:	8
13.	Feeding:	Tetrafin® goldfish food, fed 1.5 mL daily to each test chamber (1.5 mL contains 4.0 mg of dry solids)
14.	Aeration:	None, unless dissolved oxygen in overlying water drops below 40% of saturation
15.	Overlying water:	Reconstituted water
16.	Overlying water quality:	Hardness, alkalinity, conductivity, pH, and ammonia measured at the beginning and end of a test. Temperature and dissolved oxygen measured daily.
17.	Test duration:	10 days
18.	End point:	Survival, with greater than 70% in the control.

Test Method 100.2. EPA Publication 600/R-94/024 (July 1994).

3.5.4 Statistical Analysis

Survival data for the toxicity testing were analyzed first for normality and homogeneity employing Chi Square. The data were then examined using Dunnett's Procedure to determine whether there was a significant difference in survival between the designated control sediment and those sediments containing pollutants. The TOXSTAT® 3.5 Computer Program was used for the statistical evaluations.

3.5.5 Quality Assurance

Sodium chloride was used as a reference toxicant to calibrate the toxicity tests. The results are provided in Appendix E.

3.6 References

EPA. 1994. *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates*. EPA Publication 600/R-94/024.

4.0 Results And Discussion

The results and discussion section is organized according to four regions of the lower Grand River. Sections 4.1.1, 4.1.2., 4.1.3, and 4.1.4 present the results for Harbor Island and the Sag area, Grand Haven area, Spring Lake area, and the Middle Bayou area respectively. These sections are followed by discussions of the sediment chemistry of the entire study area and the toxicity testing. A summary of the complete project data set is also included in Appendices A, B, C, D, and E.

4.1 Sediment Chemistry Of The Harbor Island And The Sag Areas

The results of the sediment analyses for selected inorganic parameters from the Harbor Island and the Sag area are given in Table 4.1.1. The results for selected organic parameters are presented in Table 4.1.2. Congener specific PCB data, grain size distributions, metals data, and semivolatile results are included in Appendices A, B, and C. Results for chromium, mercury, lead, total PCBs and DDE are displayed Figures 4.1.1, 4.1.2, 4.1.3, 4.1.4, and 4.1.5 respectively. Elevated levels of heavy metals, PCB congeners, DDT compounds, and semivolatiles were not detected in the Sag area. We were unable to collect core samples in the area northwest of G1 near the petroleum tank farm because the sediments contained strata that were rich in peat. This peat layer may act as a barrier that prevents the migration of hydrocarbons from the tank farm area. Evidence of an operational hydrocarbon recovery system was visible near the tank farm suggesting a localized area of free product existed on the water table. Sediments from G2 had a coarse particle size (primarily 125-500 *u*m) and low results for total organic carbon. This type of sediment would not accumulate metals or organic contaminants. A deep core of fine grained sediments was collected at station G22. With the exception of slightly elevated lead levels in the top section (24 mg/kg), most parameters were at concentrations similar to the other stations in the Sag. Sediment deposition in the Sag would primarily occur during rain events. The absence of sediment contamination at G22 may indicate that the station was located outside the deposition zone.

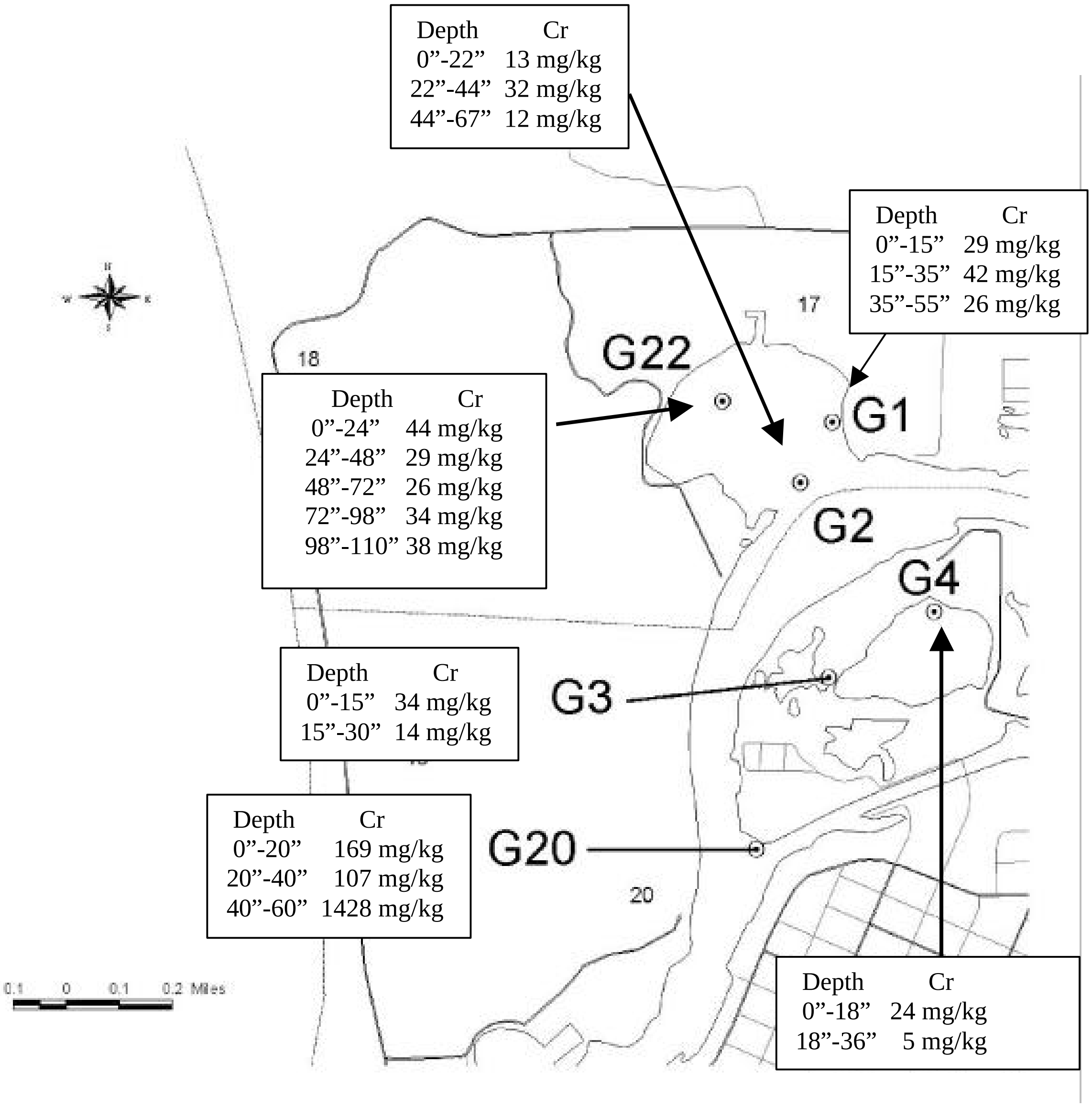
Harbor island stations G3 and G4 were located in an internal pond area between the old landfill and the power plant. Approximately 50% of the particle size distribution was in the 125-500 *u*m fraction. Hard sediments were encountered at 30”-36”. Levels of organic compounds and metals were low at these stations. In contrast, station G20 contained the highest levels of metals and organic compounds reported for this investigation. It is located in a sediment deposition zone at the southern tip of Harbor Island. These sediments were fine grained (50%-70% < 63 *u*m) and had total organic carbon levels of 4%-6%. Fine grained sediments would be deposited in this area due to friction induced velocity losses as the Grand River passes around the meander core island. With the exception of DDE and cadmium, most parameters were higher in the deeper core sections. Chromium levels of 1071 mg/kg and 1428 mg/kg were found in the 20”-40” and 40”-60” core sections respectively. Following a similar trend, Mercury levels of 1.44 mg/kg and 4.33 mg/kg were found at the same core depths. PAH compounds were also elevated in all core sections at this location. Fluoranthene and pyrene were present at the highest concentrations (≈2.0 mg/kg).

Table 4.1.1 Inorganic Results For The Sediment Cores Collected From The Harbor Island And Sag Areas Of The Lower Grand River, October 1997.

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg
G-1 Top	10	0.56	29	14	0.14	42	6.4	<0.5	70
G-1 Mid	12	0.37	42	14	<0.100	23	4.4	<0.5	72
G-1 Bot	10	0.35	26	14	<0.10	18	5.6	0.6	58
G-2 Top	3.3	0.25	13	7.1	<0.10	13	4.8	<0.5	39
G-2 Mid	9.2	0.28	32	12	0.40	15	20	<0.5	49
G-2 Bot	4.2	0.13	12	4.7	<0.10	9.3	2.8	<0.5	18
G-3 Top	5.5	0.69	34	22	0.21	23	14	<0.5	58
G-3 Bot	6.2	0.20	14	6.6	<0.10	11	4.2	<0.5	19
G-4 Top	4.6	0.18	24	6	<0.10	7.5	4.1	<0.5	30
G-4 Bot	1.8	0.03	5	0.9	<0.10	bdl	1.7	<0.5	2.3
G-20 Top	10	2.3	169	98	0.34	67	85	<0.5	262
G-20 Mid	14	0.56	1071	267	1.44	166	184	0.6	855
G-20 Bot	17	1.2	1428	348	4.33	214	172	0.6	894
G-20D Top	12	2.7	209	141	0.41	79	100	<0.5	311
G-20D Mid	13	0.48	768	233	1.27	149	154	0.6	668
G-20D Bot	16	1.0	1426	372	3.84	210	180	0.6	863
G-22 Top	8.9	0.58	44	23	0.22	37	24	<0.5	88
G-22-2	7.6	0.20	29	10	<0.10	15	2.2	<0.5	48
G-22-3	5.2	0.20	26	9	<0.10	15	1.8	<0.5	49
G-22-4	6.3	0.23	34	12	<0.10	19	2.0	<0.5	58
G-22-5	6.4	0.25	38	12	<0.10	18	2.3	<0.5	62

Table 4.1.2 Organic Results For The Sediment Cores Collected From The Harbor Island And Sag Areas Of The Lower Grand River, October 1997.

Station	Total PCBs	DDE	DDD	DDT	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(a) pyrene
	ug/kg	ug/kg	ug/kg	ug/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-1 Top	30	7.6	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-1 Mid	<1.0	<1.0	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-1 Bot	9	0.8	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-2 Top	11	0.5	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-2 Mid	19	<1.0	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-2 Bot	21	<1.0	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-3 Top	2.0	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-3 Bot	2.0	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-4 Top	2.0	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-4 Bot	1.1	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-20 Top	71	8.2	2.8	<1.0	0.62	0.08	1.40	1.38	0.39	0.51	0.35	0.37
G-20 Mid	107	3.9	14	<1.0	0.81	<0.33	2.04	1.60	<0.33	<0.33	<0.33	<0.33
G-20 Bot	108	7.3	6.1	<1.0	0.72	0.11	1.96	1.68	0.48	0.62	<0.33	0.37
G-20D Top	84	12.1	3.2	<1.0	0.90	0.12	2.31	2.10	0.51	0.64	<0.33	0.48
G-20D Mid	124	12	14	<1.0	1.02	0.12	2.20	2.10	0.57	0.78	0.85	0.50
G-20D Bot	137	9.7	13	<1.0	0.66	0.09	1.73	1.73	0.63	0.28	0.71	0.35
G-22 Top	6.2	1.8	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-22-2	2.9	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-22-3	2.6	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-22-4	1.1	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-22-5	1.2	1.3	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA



Depth	Cr
0”-22”	13 mg/kg
22”-44”	32 mg/kg
44”-67”	12 mg/kg

Depth	Cr
0”-15”	29 mg/kg
15”-35”	42 mg/kg
35”-55”	26 mg/kg

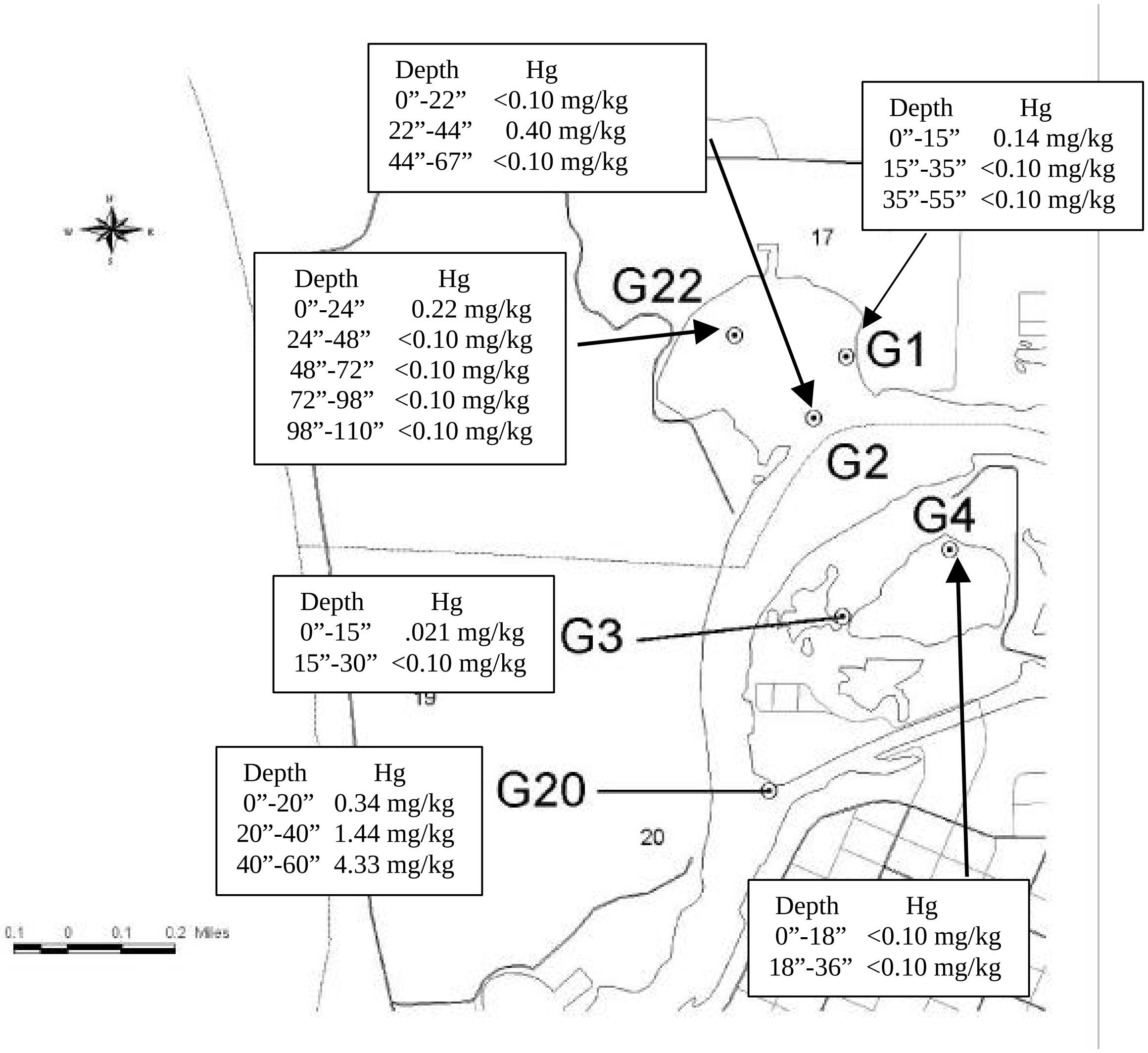
Depth	Cr
0”-24”	44 mg/kg
24”-48”	29 mg/kg
48”-72”	26 mg/kg
72”-98”	34 mg/kg
98”-110”	38 mg/kg

Depth	Cr
0”-15”	34 mg/kg
15”-30”	14 mg/kg

Depth	Cr
0”-20”	169 mg/kg
20”-40”	107 mg/kg
40”-60”	1428 mg/kg

Depth	Cr
0”-18”	24 mg/kg
18”-36”	5 mg/kg

Figure 4.1.1 Total Chromium In Core Samples Collected From The Harbor Island And Sag Areas In The Lower Grand River, October 1997.



Depth	Hg
0”-22”	<0.10 mg/kg
22”-44”	0.40 mg/kg
44”-67”	<0.10 mg/kg

Depth	Hg
0”-15”	0.14 mg/kg
15”-35”	<0.10 mg/kg
35”-55”	<0.10 mg/kg

Depth	Hg
0”-24”	0.22 mg/kg
24”-48”	<0.10 mg/kg
48”-72”	<0.10 mg/kg
72”-98”	<0.10 mg/kg
98”-110”	<0.10 mg/kg

Depth	Hg
0”-15”	.021 mg/kg
15”-30”	<0.10 mg/kg

Depth	Hg
0”-20”	0.34 mg/kg
20”-40”	1.44 mg/kg
40”-60”	4.33 mg/kg

Depth	Hg
0”-18”	<0.10 mg/kg
18”-36”	<0.10 mg/kg

Figure 4.1.2 Total Mercury In Core Samples Collected From The Harbor Island And Sag Areas In The Lower Grand River, October 1997.

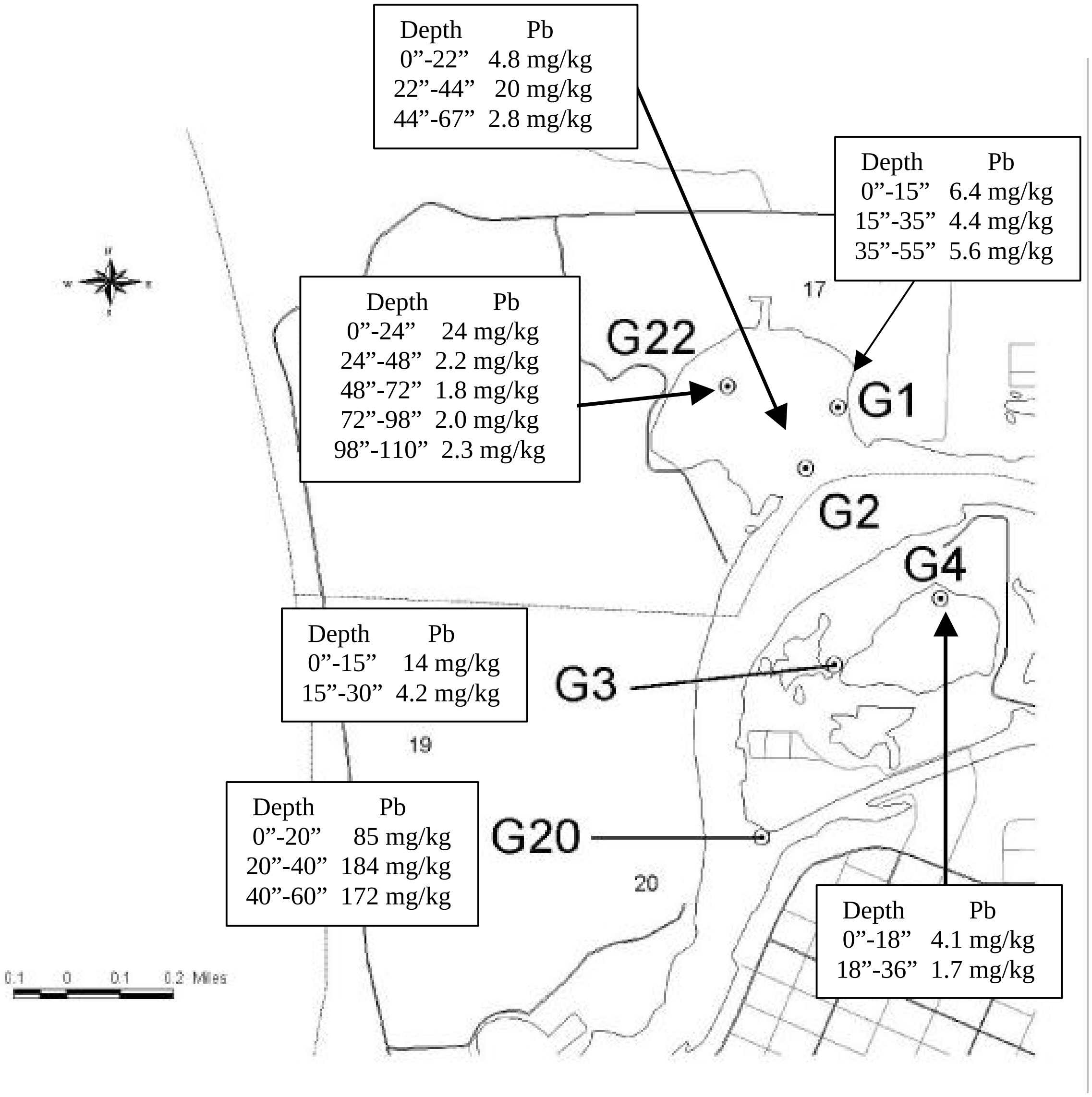
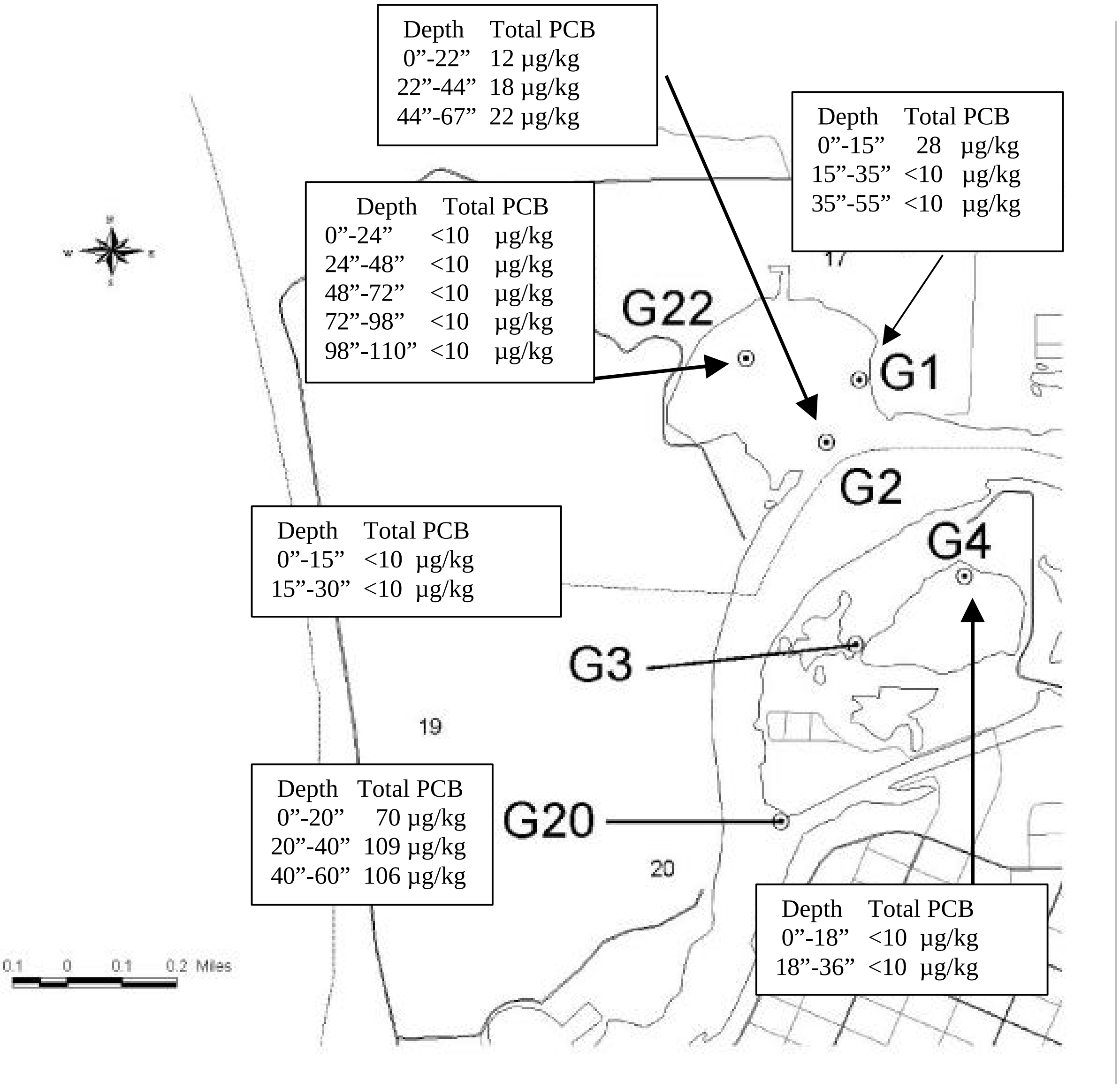


Figure 4.1.3 Total Lead In Core Samples Collected From The Harbor Island And Sag Areas In The Lower Grand River, October 1997.



Depth	Total PCB
0”-22”	12 µg/kg
22”-44”	18 µg/kg
44”-67”	22 µg/kg

Depth	Total PCB
0”-15”	28 µg/kg
15”-35”	<10 µg/kg
35”-55”	<10 µg/kg

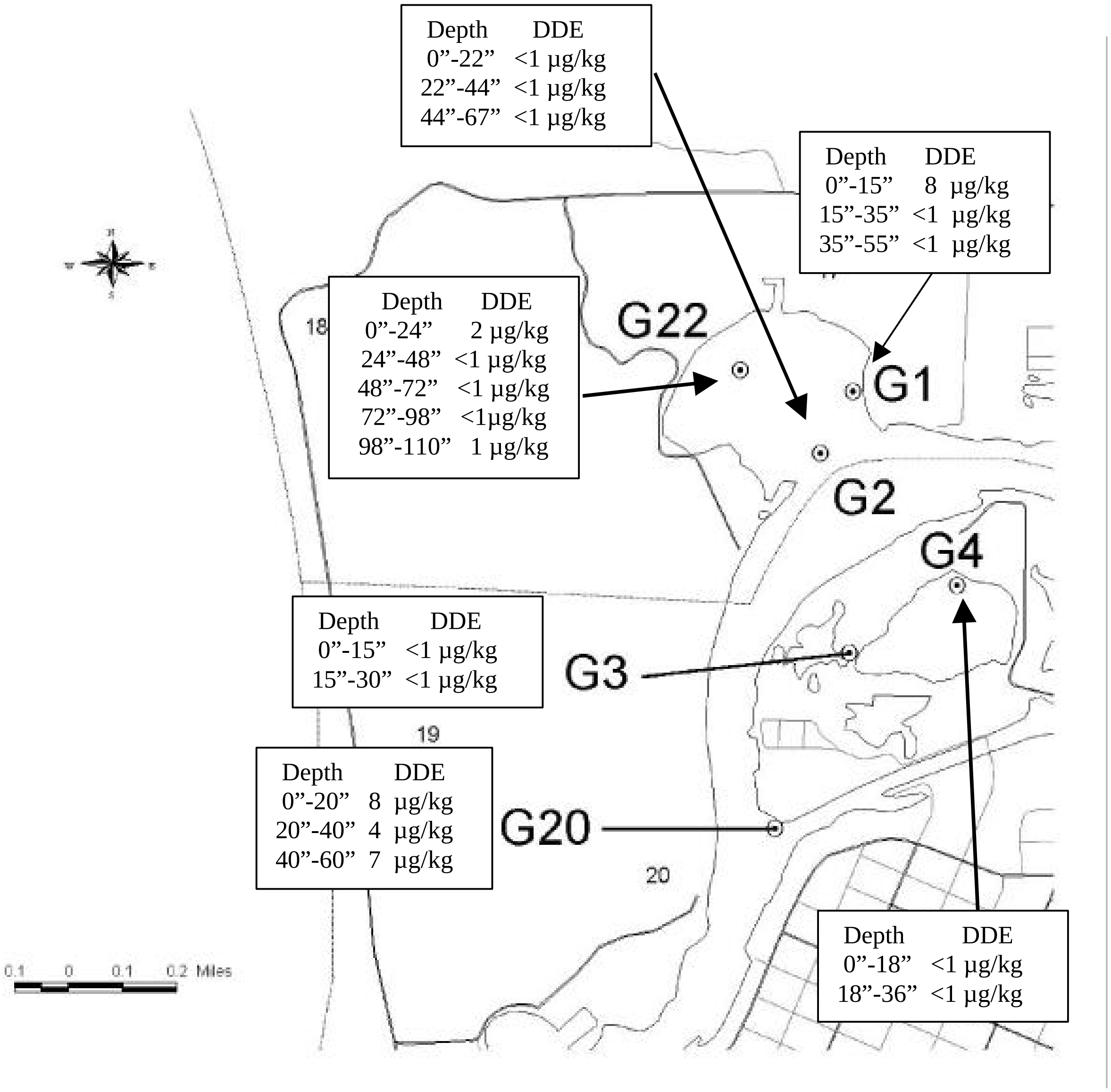
Depth	Total PCB
0”-24”	<10 µg/kg
24”-48”	<10 µg/kg
48”-72”	<10 µg/kg
72”-98”	<10 µg/kg
98”-110”	<10 µg/kg

Depth	Total PCB
0”-15”	<10 µg/kg
15”-30”	<10 µg/kg

Depth	Total PCB
0”-20”	70 µg/kg
20”-40”	109 µg/kg
40”-60”	106 µg/kg

Depth	Total PCB
0”-18”	<10 µg/kg
18”-36”	<10 µg/kg

Figure 4.1.4 Total PCBs In Core Samples Collected From The Harbor Island And Sag Areas In The Lower Grand River, October 1997.



Depth	DDE
0”-22”	<1 µg/kg
22”-44”	<1 µg/kg
44”-67”	<1 µg/kg

Depth	DDE
0”-15”	8 µg/kg
15”-35”	<1 µg/kg
35”-55”	<1 µg/kg

Depth	DDE
0”-24”	2 µg/kg
24”-48”	<1 µg/kg
48”-72”	<1 µg/kg
72”-98”	<1µg/kg
98”-110”	1 µg/kg

Depth	DDE
0”-15”	<1 µg/kg
15”-30”	<1 µg/kg

Depth	DDE
0”-20”	8 µg/kg
20”-40”	4 µg/kg
40”-60”	7 µg/kg

Depth	DDE
0”-18”	<1 µg/kg
18”-36”	<1 µg/kg

Figure 4.1.5 DDE In Core Samples Collected From The Harbor Island And Sag Areas In The Lower Grand River, October 1997.

This pattern indicates that historical deposition of sediments with high levels of heavy metals occurred in this area. It is also possible that contaminated fill materials were deposited in this area. The high levels of metals may be a result of a combination of historical of erosion from the old landfill prior to the construction of the power plant and sediment deposition from sources up stream.

4.2 Sediment Chemistry Of The Grand Haven Area

The results of the sediment analyses for selected inorganic parameters from the Grand Haven area are given in Table 4.2.1. The results for selected organic parameters are presented in Table 4.2.2. Congener specific PCB data, grain size distributions, metals data, and semivolatile results are included in Appendices A, B, and C. Results for chromium, mercury, lead, total PCBs and DDE are displayed in Figures 4.2.1, 4.2.2, 4.2.3, 4.2.4, and 4.2.5 respectively.

Elevated levels of chromium (877 mg/kg), copper (100 mg/kg), and lead (72 mg/kg) were detected at Station G12 near the tannery. Historically, the tannery discharged untreated wastewater into the Grand River. A majority of the sediments in this area consist of coarse rubble and hard clay. We were able to find a small area of soft sediment that yielded this sample. The core depth was limited to 11” at this location due to the hard clay bottom. A slight level of enrichment of metals was noted in the downstream stations G23, G10, and G11. Sediment cores at G10 and G11 were relatively shallow (27” and 23” respectively) and hard sediments were encountered below these depths. Copper was the only element that showed some degree of enrichment in the bottom section of G10 (72 mg/kg). This station was located downstream from a brass foundry and elevated levels of copper would be anticipated from this type of operation. Even though high levels of metals were detected near the tannery, the extent appears to be localized to a small area with limited persistence downstream. The metals that were historically discharged in this area were probably transported downstream and deposited in the area of Harbor Island and ultimately in Lake Michigan.

Station G24 was located on the downstream tip of a meander core island similar to station G20. The deposition pattern for both stations was similar for heavy metals. As shown in Figures 4.2.1, 4.2.2, 4.2.3, and 4.4.4, the deeper core sections at this location are enriched with chromium (134 mg/kg and 226 mg/kg), lead (33 mg/kg and 32 mg/kg) and mercury (0.35 mg/kg 0.19 mg/kg). Copper, cadmium, nickel, and zinc were also elevated in the deeper core sections. Since this location is upgradient from the tannery, any deposition of metals would probably be from sources in the Grand Rapids area. The results from stations G24 and G20 show the importance of the downstream side of meander core islands as an area for contaminant deposition. While these areas serve as deposition zones under normal stream flow, they would tend to be scoured during rain events. The resuspension of sediments in deposition zones behind meander core islands may be a significant source of contaminant loadings to Lake Michigan during rain events.

Table 4.2.1 Inorganic Results For The Sediment Cores Collected From The Grand Haven Area Of The Lower Grand River, October 1997.

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-9 Top	10	0.19	26	7.8	<0.10	14	3.4	<0.5	40
G-9 Mid	6.0	0.14	20	5.6	<0.10	11	2.9	<0.5	30
G-9 Bot	6.4	0.16	24	7.5	<0.10	13	3.1	<0.5	34
G-10 Top	5.7	0.48	42	35	0.16	18	11	<0.5	71
G-10 Bot	6.8	0.33	33	14	<0.10	20	7.9	<0.5	39
G-11 Top	9.3	0.87	27	13	0.36	15	8.9	<0.5	64
G-11 Bot	8.4	0.21	18	72	<0.10	12	3.8	<0.5	38
G-12 Top	6.6	1.6	877	100	0.42	59	72	0.9	183
G-13 Top	8.7	0.49	36	28	0.31	19	27	<0.5	79
G-13 Bot	8.9	0.16	25	7.8	<0.10	15	3.1	<0.5	38
G-13-2	6.6	0.13	20	6.4	0.14	12	5.1	<0.5	29
G-13-3	7.4	0.11	20	5.7	<0.10	14	2.6	<0.5	31
G-15 Top	7.3	0.39	30	30	0.48	20	27	<0.5	72
G-15 Mid	10	0.09	11	4.3	0.13	9.7	3.6	<0.5	26
G-15 Bot	8.6	0.02	7	1	<0.10	6.9	1.5	<0.5	10
G-23 Top	12	0.42	57	23	0.12	26	13	<0.5	59
G-23 Mid	10	0.23	27	9.6	<0.10	19	6.3	<0.5	34
G-23 Bot	3.8	0.04	10	1.7	<0.10	9.3	1.8	<0.5	2.9
G-24 Top	2.3	0.21	31	7.6	< 0.10	18	2.4	<0.5	2.9
G-24 Mid	5.1	1.3	134	58	0.35	58	33	<0.5	110
G-24 Bot	5.2	1.5	226	71	0.19	77	32	<0.5	111

Table 4.2.2 Organic Results For The Sediment Cores Collected From The Grand Haven Area Of The Lower Grand River, October 1997.

Station	Total PCBs	DDE	DDD	DDT	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(a) pyrene
	ug/kg	ug/kg	ug/kg	ug/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-9 Top	2.5	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-9 Mid	14	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-9 Bot	9	3.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-10 Top	12	1.6	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-10 Bot	<1.0	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-11 Top	25	2.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-11 Bot	32	1.4	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-12 Top	2.1	<1.0	<1.0	<1.0	1.40	0.36	2.90	2.79	1.10	0.88	0.54	0.71
G-13 Top	2.1	<1.0	<1.0	<1.0	0.30	0.10	1.04	1.32	0.70	0.53	0.42	0.49
G-13 Bot	10	<1.0	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-13-2	<1.0	<1.0	<1.0	<1.0	<0.33	<0.33	0.41	0.42	0.23	0.15	0.13	<0.33
G-13-3	10	<1.0	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-15 Top	1.7	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-15 Mid	13	1.1	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-15 Bot	3.8	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-23 Top	34	4.7	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-23 Mid	113	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-23 Bot	13	1.3	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-24 Top	5	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-24 Mid	47	2.5	1.2	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-24 Bot	32	1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA

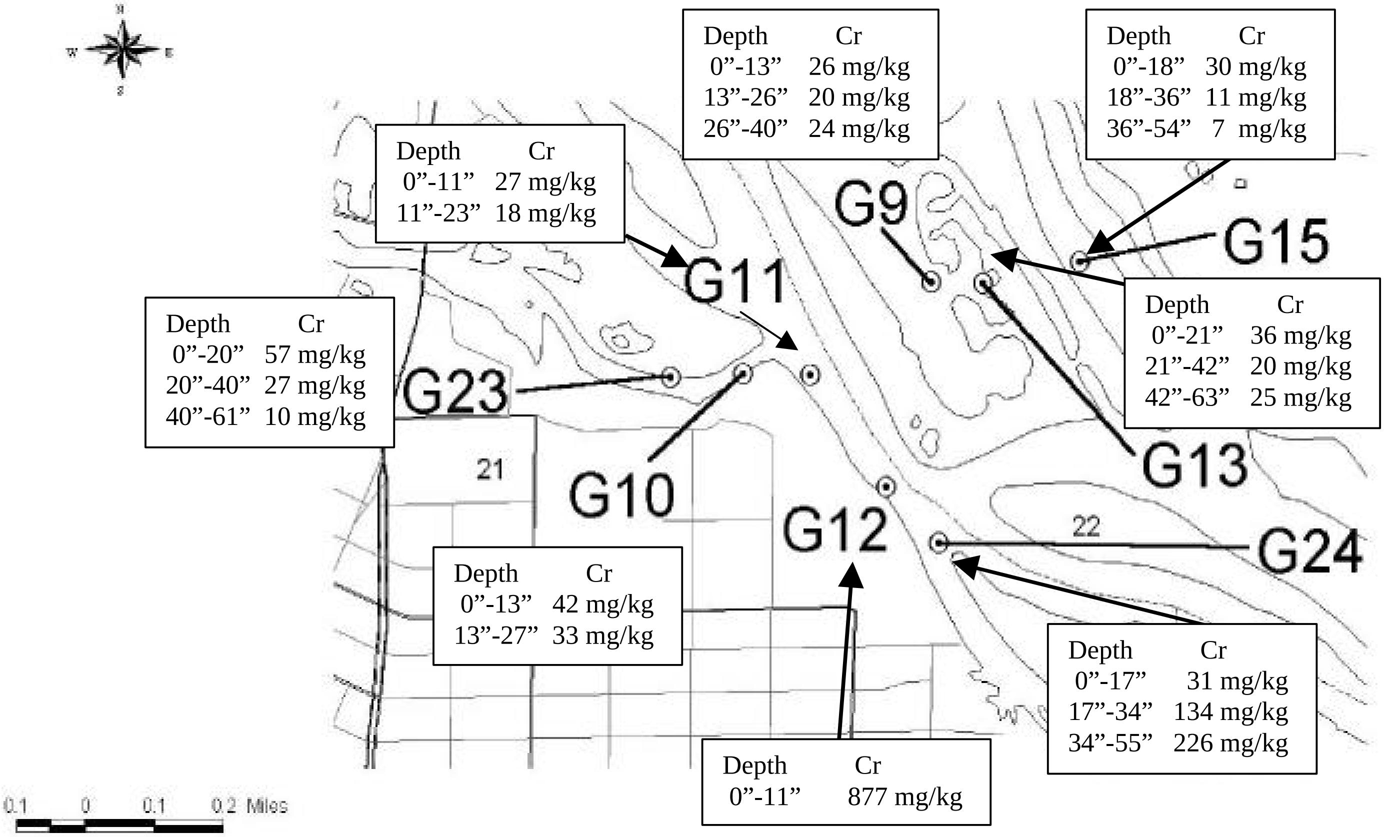
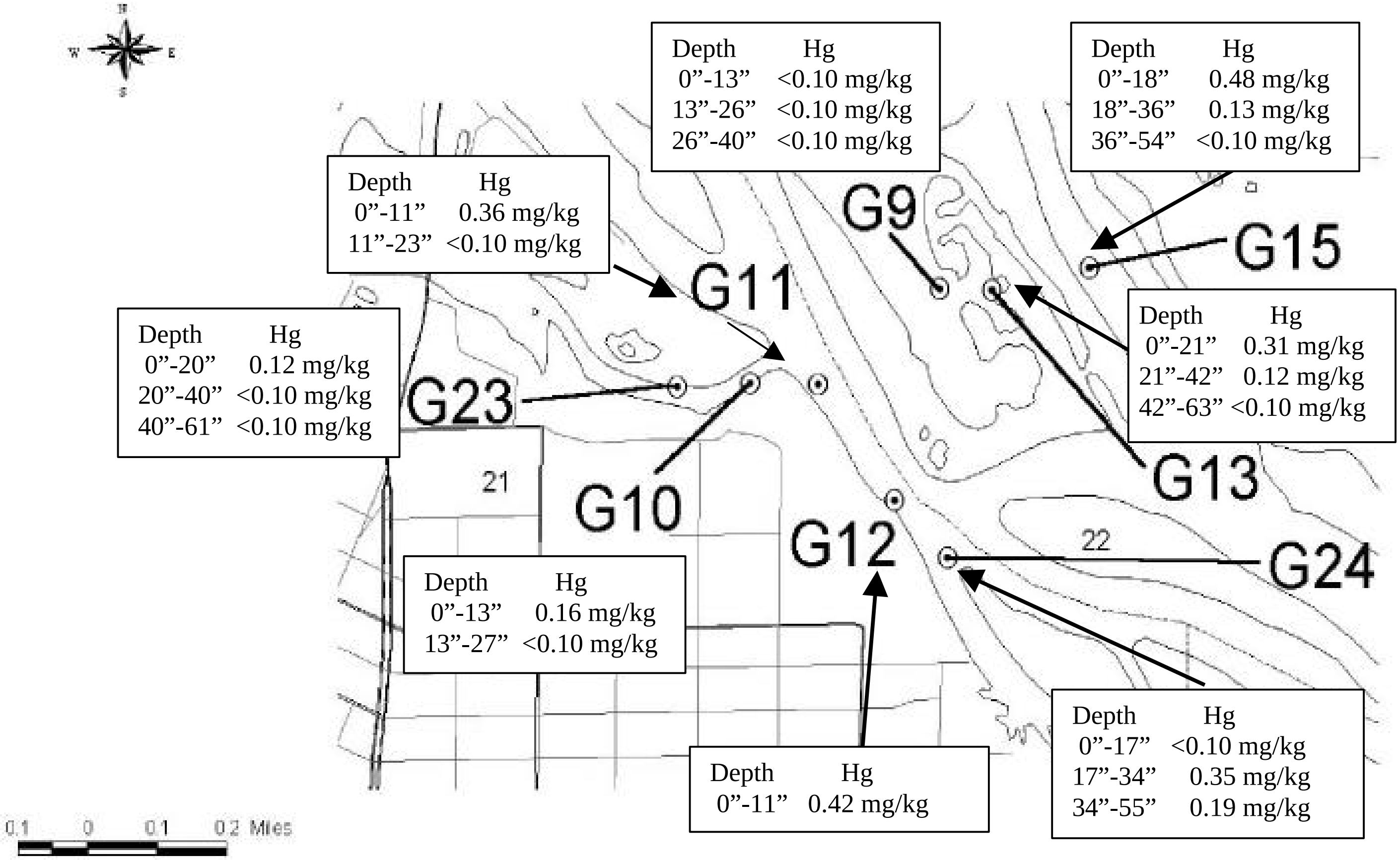


Figure 4.2.1 Total Chromium In The Grand Haven Area Of The Lower Grand River, October 1997.



Depth	Hg
0”-13”	<0.10 mg/kg
13”-26”	<0.10 mg/kg
26”-40”	<0.10 mg/kg

Depth	Hg
0”-18”	0.48 mg/kg
18”-36”	0.13 mg/kg
36”-54”	<0.10 mg/kg

Depth	Hg
0”-11”	0.36 mg/kg
11”-23”	<0.10 mg/kg

Depth	Hg
0”-20”	0.12 mg/kg
20”-40”	<0.10 mg/kg
40”-61”	<0.10 mg/kg

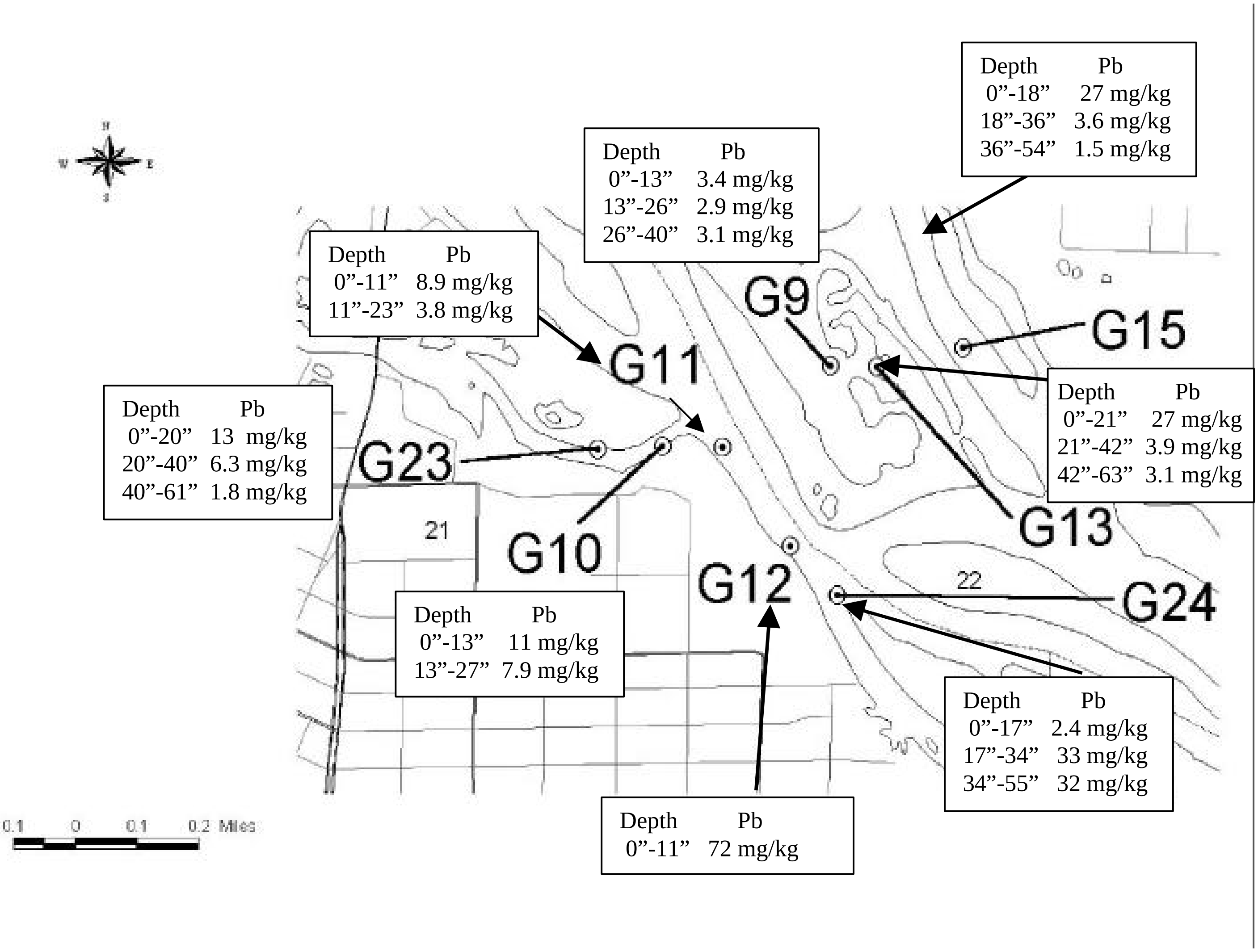
Depth	Hg
0”-21”	0.31 mg/kg
21”-42”	0.12 mg/kg
42”-63”	<0.10 mg/kg

Depth	Hg
0”-13”	0.16 mg/kg
13”-27”	<0.10 mg/kg

Depth	Hg
0”-17”	<0.10 mg/kg
17”-34”	0.35 mg/kg
34”-55”	0.19 mg/kg

Depth	Hg
0”-11”	0.42 mg/kg

Figure 4.2.2 Total Mercury In The Grand Haven Area Of The Lower Grand River, October 1997.



Depth	Pb
0”-18”	27 mg/kg
18”-36”	3.6 mg/kg
36”-54”	1.5 mg/kg

Depth	Pb
0”-13”	3.4 mg/kg
13”-26”	2.9 mg/kg
26”-40”	3.1 mg/kg

Depth	Pb
0”-11”	8.9 mg/kg
11”-23”	3.8 mg/kg

Depth	Pb
0”-21”	27 mg/kg
21”-42”	3.9 mg/kg
42”-63”	3.1 mg/kg

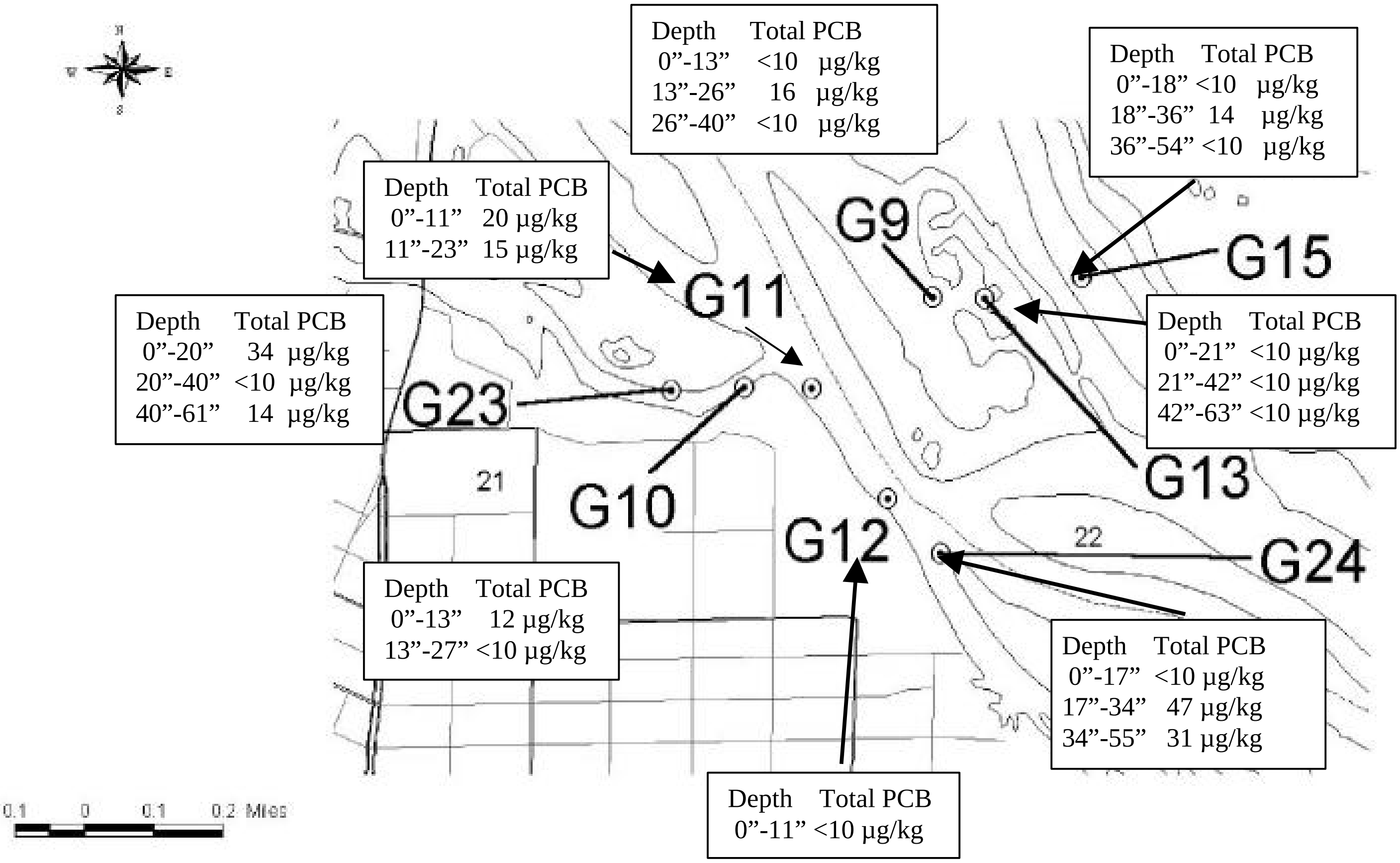
Depth	Pb
0”-20”	13 mg/kg
20”-40”	6.3 mg/kg
40”-61”	1.8 mg/kg

Depth	Pb
0”-13”	11 mg/kg
13”-27”	7.9 mg/kg

Depth	Pb
0”-17”	2.4 mg/kg
17”-34”	33 mg/kg
34”-55”	32 mg/kg

Depth	Pb
0”-11”	72 mg/kg

Figure 4.2.3 Total Lead In The Grand Haven Area Of The Lower Grand River, October 1997.



Depth	Total PCB
0”-13”	<10 µg/kg
13”-26”	16 µg/kg
26”-40”	<10 µg/kg

Depth	Total PCB
0”-18”	<10 µg/kg
18”-36”	14 µg/kg
36”-54”	<10 µg/kg

Depth	Total PCB
0”-11”	20 µg/kg
11”-23”	15 µg/kg

Depth	Total PCB
0”-20”	34 µg/kg
20”-40”	<10 µg/kg
40”-61”	14 µg/kg

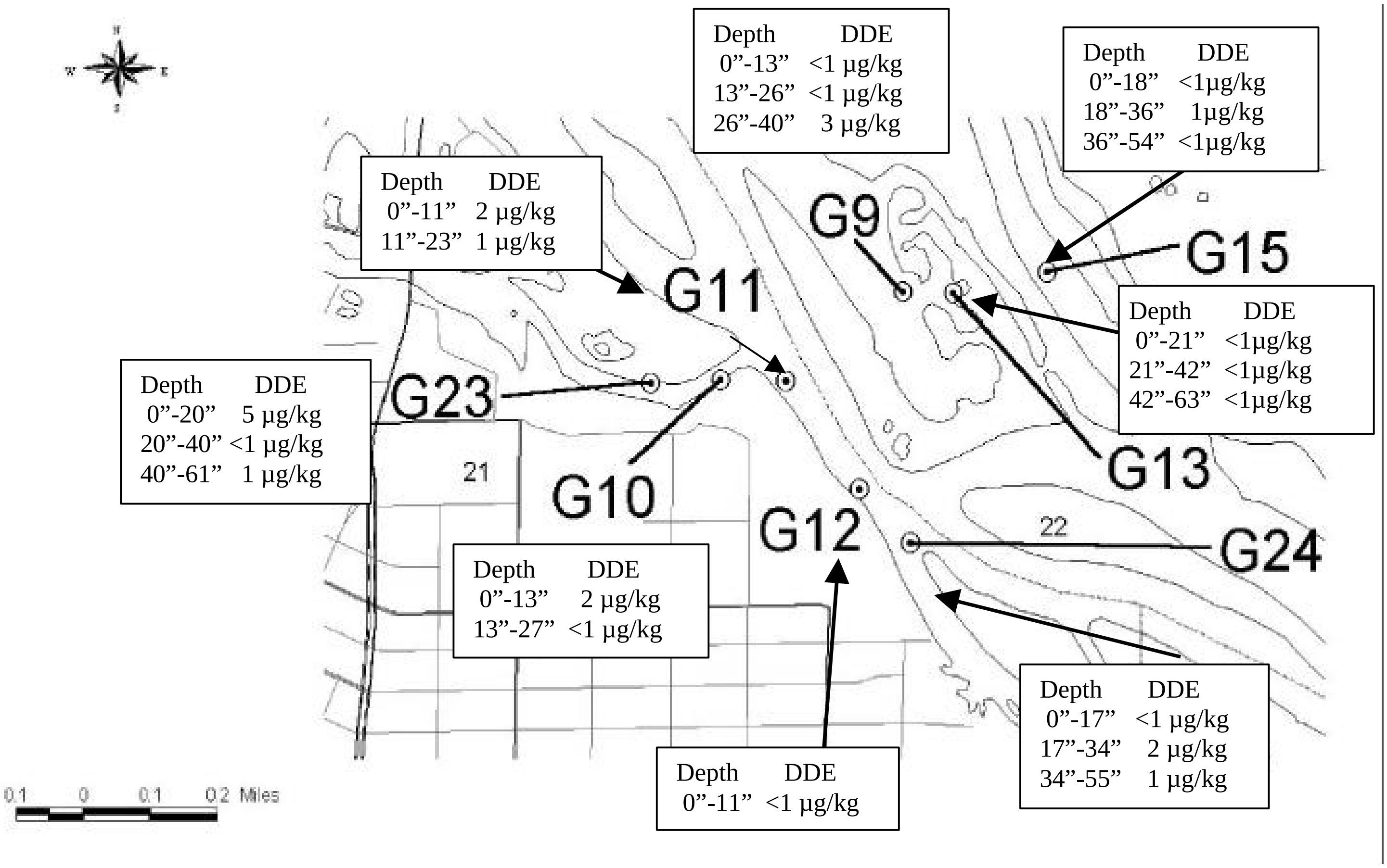
Depth	Total PCB
0”-21”	<10 µg/kg
21”-42”	<10 µg/kg
42”-63”	<10 µg/kg

Depth	Total PCB
0”-13”	12 µg/kg
13”-27”	<10 µg/kg

Depth	Total PCB
0”-17”	<10 µg/kg
17”-34”	47 µg/kg
34”-55”	31 µg/kg

Depth	Total PCB
0”-11”	<10 µg/kg

Figure 4.2.4 Total PCBs In The Grand Haven Area Of The Lower Grand River, October 1997.



Depth	DDE
0”-13”	<1 µg/kg
13”-26”	<1 µg/kg
26”-40”	3 µg/kg

Depth	DDE
0”-18”	<1µg/kg
18”-36”	1µg/kg
36”-54”	<1µg/kg

Depth	DDE
0”-11”	2 µg/kg
11”-23”	1 µg/kg

Depth	DDE
0”-21”	<1µg/kg
21”-42”	<1µg/kg
42”-63”	<1µg/kg

Depth	DDE
0”-20”	5 µg/kg
20”-40”	<1 µg/kg
40”-61”	1 µg/kg

Depth	DDE
0”-13”	2 µg/kg
13”-27”	<1 µg/kg

Depth	DDE
0”-17”	<1 µg/kg
17”-34”	2 µg/kg
34”-55”	1 µg/kg

Depth	DDE
0”-11”	<1 µg/kg

Figure 4.2.5 DDE In The Grand Haven Area Of The Lower Grand River, October 1997.

Stations G9, G13, and G15 were selected as locations of sediment deposition. Station G9 showed no significant enrichment for metals or organic compounds. Stations G13 and G15 showed a small degree of enrichment in the top core sections for lead (27 mg/kg), chromium (36 mg/kg and 30 mg/kg) and mercury (0.21 mg/kg and 0.48 mg/kg).

4.3 Sediment Chemistry Of The Spring Lake Area

The results of the sediment analyses for selected inorganic parameters from the Spring Lake area are shown in Table 4.3.1. The results for selected organic parameters are presented in Table 4.3.2. Congener specific PCB data, grain size distributions, metals data, and semivolatile results are included in Appendices A, B, and C. Results for chromium, mercury, lead, total PCBs and DDE are displayed in Figures 4.3.1, 4.3.2, 4.3.3, 4.3.4, and 4.3.5 respectively.

Station G5 served as a control location. Sediments from this area would only be influenced by residential development and recreational activity. Heavy metals and organic compounds were not found at elevated concentrations at this station. Stations G6 and G7 were located along the northern shoreline of Spring Lake near the commercial/industrial area. Station G6 was directly north of two plating facilities. At this station, chromium (313 mg/kg), copper (100 mg/kg), nickel (99 mg/kg), zinc (268 mg/kg), and lead (100 mg/kg) were all found in high levels in the top core section. PCB congeners (78 ug/kg), DDE (8 ug/kg) and PAH compounds (≈ 3 mg/kg for fluoranthene and pyrene) were also elevated in the top core section. The middle and bottom core sections did not show significant levels of heavy metals and organics. Station G7 was located further to the east and upgradient for G6. Chromium (59 mg/kg), copper (20 mg/kg), and zinc (112 mg/kg) showed a moderate degree of enrichment at this location. Both stations were located in the area where the USACE found high levels of pentachlorophenol during a previous investigation (Bowman 1995). Pentachlorophenol was not detected at either location during this study. These results coupled with the fact that a subsequent set of samples collected by the USACE was unable to confirm the previous detection of this compound suggests that it is localized in a small area or its original detection was an artifact. The sediments near to the shoreline at both locations were covered with wood chips and bark from old sawmills. We were unable to collect core samples at shallower water depths.

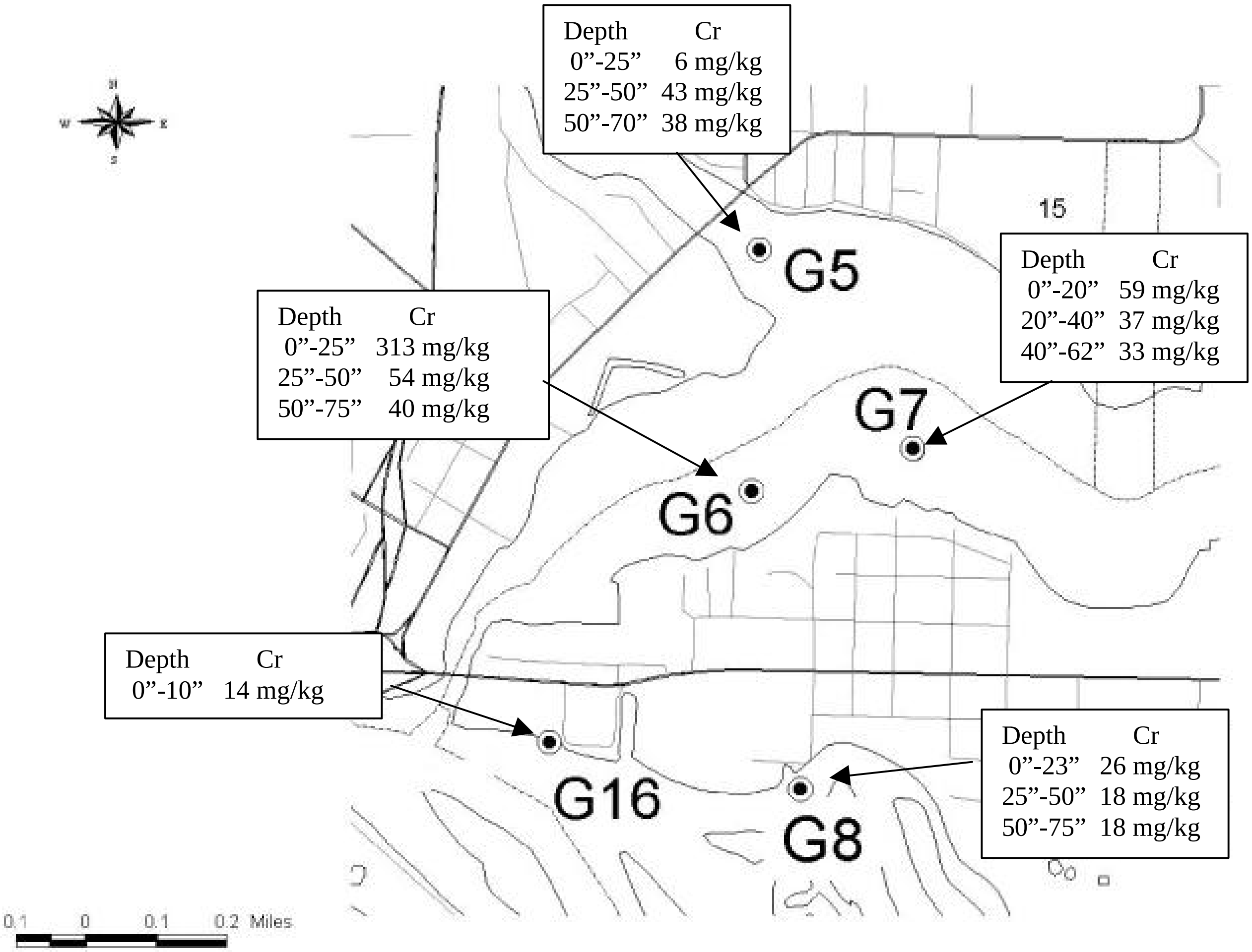
Stations G8 and G16 are located on the northern shoreline of the Grand River directly below the Village of Spring Lake. Limited deposits of soft sediment were found in this area due to dredging and marina development. A shallow core of 10” could be collected at G16. A deeper core was collected at G8 however it was primarily clay. Metals and organic compounds were not elevated at these stations.

Table 4.3.1 Inorganic Results For The Sediment Cores Collected From The Spring Lake Area Of The Lower Grand River, October 1997.

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-5 Top	8.4	0.54	6	39	0.16	29	12	<0.5	89
G-5 Mid	6.5	0.33	43	16	0.11	19	5.4	0.5	67
G-5 Bot	5.1	0.27	38	12	<0.10	17	4.7	<0.5	65
G-5D Top	10	1.0	83	53	0.24	26	10	<0.5	105
G-5D Mid	6.6	0.33	42	17	<0.10	21	4.9	<0.5	81
G-5D Bot	4.4	0.29	40	13	<0.10	20	6.0	<0.5	59
G-6 Top	17	3.6	313	160	0.37	99	100	<0.5	268
G-6 Mid	8.0	0.58	54	22	0.28	23	15	<0.5	85
G-6 Bot	5.3	0.30	40	13	0.11	18	6.5	<0.5	58
G-7 Top	7.8	0.45	59	20	0.11	30	8.7	0.7	112
G-7 Mid	4.5	0.27	37	11	<0.10	21	4.4	<0.5	70
G-7 Bot	5.2	0.26	33	9.3	<0.10	19	3.7	<0.5	71
G-8 Top	8.3	0.16	26	7.7	<0.10	14	3.2	<0.5	40
G-8 Mid	4.9	0.11	18	3.3	<0.10	7.9	3.0	<0.5	21
G-8 Bot	5.6	0.12	18	4.1	<0.10	9.3	2.5	<0.5	26
G-16	4.2	0.06	14	2.2	<0.10	15	2.3	<0.5	17

Table 4.3.2 Organic Results For The Sediment Cores Collected From The Spring Lake Area Of The Lower Grand River, October 1997.

Station	Total PCBs	DDE	DDD	DDT	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(a) pyrene
	ug/kg	ug/kg	ug/kg	ug/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-5 Top	5.1	2.6	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-5 Mid	1.1	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-5 Bot	1.5	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-5dup Top	3.5	2.5	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-5dup Mid	2.6	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-5dup Bot	5.2	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-6 Top	78	8.4	<1.0	<1.0	1.18	<0.33	3.14	3.20	0.88	<0.33	0.97	0.52
G-6 Mid	10	<1.0	<1.0	<1.0	0.27	<0.33	0.63	0.56	0.24	0.35	0.24	<0.33
G-6 Bot	11	<1.0	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-7 Top	6.0	1.9	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-7 Mid	5.5	1.9	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-7 Bot	2.4	<1.0	<1.0	<1.0	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G-8 Top	12	1.4	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-8 Mid	1.7	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-8 Bot	11	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA	NA
G-16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA



Depth	Cr
0”-25”	6 mg/kg
25”-50”	43 mg/kg
50”-70”	38 mg/kg

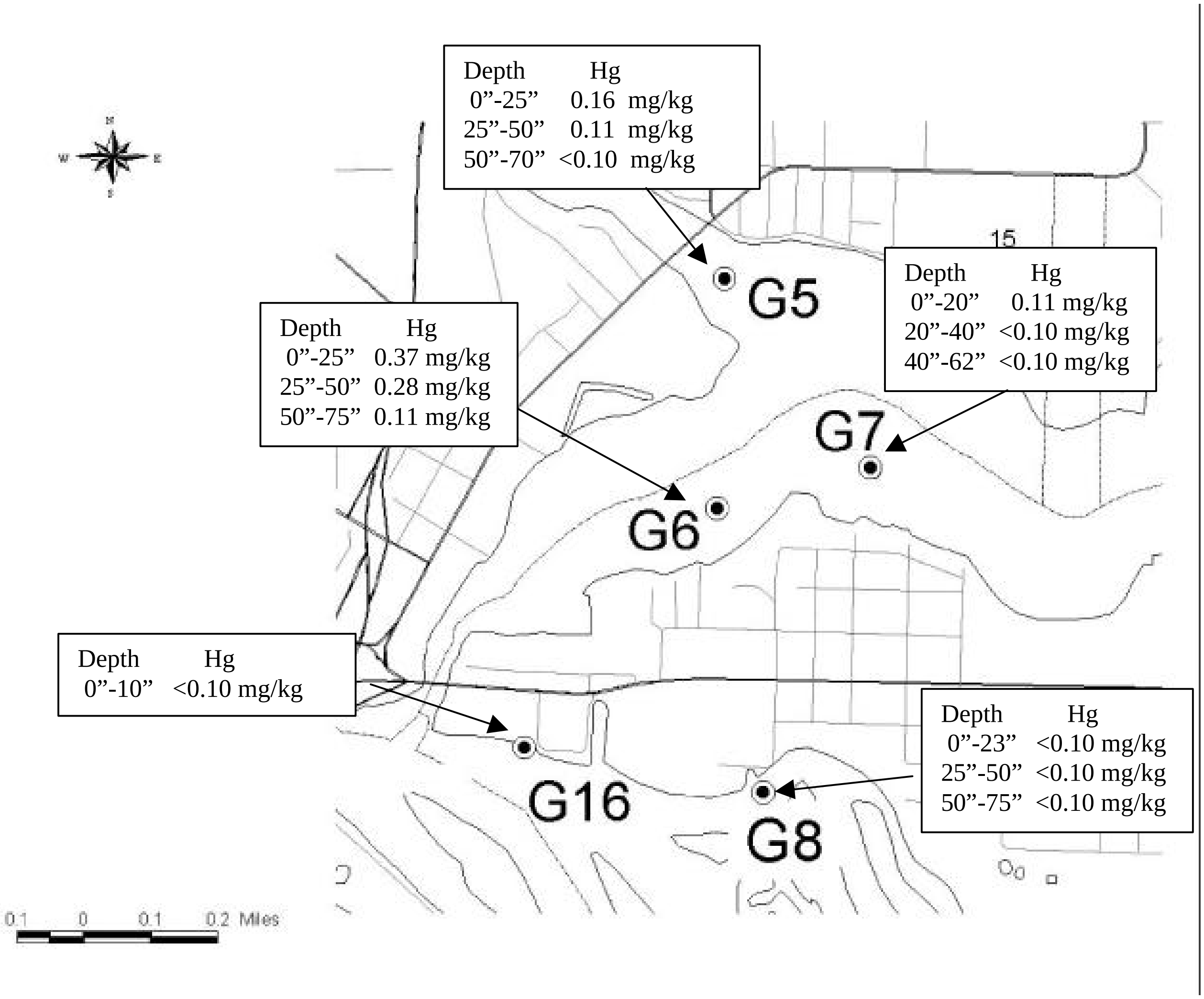
Depth	Cr
0”-25”	313 mg/kg
25”-50”	54 mg/kg
50”-75”	40 mg/kg

Depth	Cr
0”-20”	59 mg/kg
20”-40”	37 mg/kg
40”-62”	33 mg/kg

Depth	Cr
0”-10”	14 mg/kg

Depth	Cr
0”-23”	26 mg/kg
25”-50”	18 mg/kg
50”-75”	18 mg/kg

Figure 4.3.1 Total Chromium In Core Samples Collected From The Spring Lake Area Of The Lower Grand River, October 1997.



Depth	Hg
0”-25”	0.16 mg/kg
25”-50”	0.11 mg/kg
50”-70”	<0.10 mg/kg

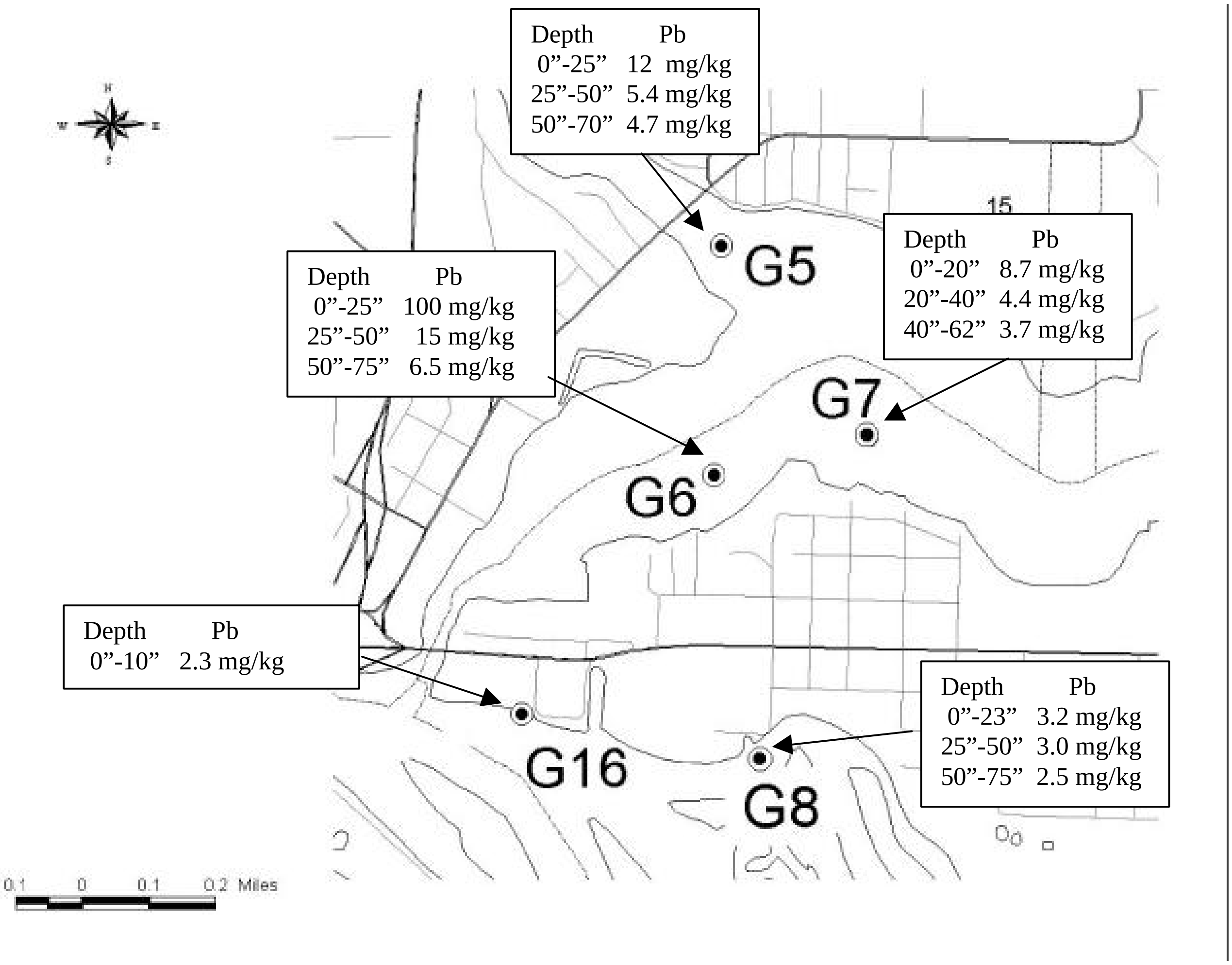
Depth	Hg
0”-25”	0.37 mg/kg
25”-50”	0.28 mg/kg
50”-75”	0.11 mg/kg

Depth	Hg
0”-20”	0.11 mg/kg
20”-40”	<0.10 mg/kg
40”-62”	<0.10 mg/kg

Depth	Hg
0”-10”	<0.10 mg/kg

Depth	Hg
0”-23”	<0.10 mg/kg
25”-50”	<0.10 mg/kg
50”-75”	<0.10 mg/kg

Figure 4.3.2 Total Mercury In Core Samples Collected From The Spring Lake Area Of The Lower Grand River, October 1997.



Depth	Pb
0”-25”	12 mg/kg
25”-50”	5.4 mg/kg
50”-70”	4.7 mg/kg

Depth	Pb
0”-25”	100 mg/kg
25”-50”	15 mg/kg
50”-75”	6.5 mg/kg

Depth	Pb
0”-20”	8.7 mg/kg
20”-40”	4.4 mg/kg
40”-62”	3.7 mg/kg

Depth	Pb
0”-10”	2.3 mg/kg

Depth	Pb
0”-23”	3.2 mg/kg
25”-50”	3.0 mg/kg
50”-75”	2.5 mg/kg

Figure 4.3.3 Total Lead In Core Samples Collected From The Spring Lake Area Of The Lower Grand River, October 1997.

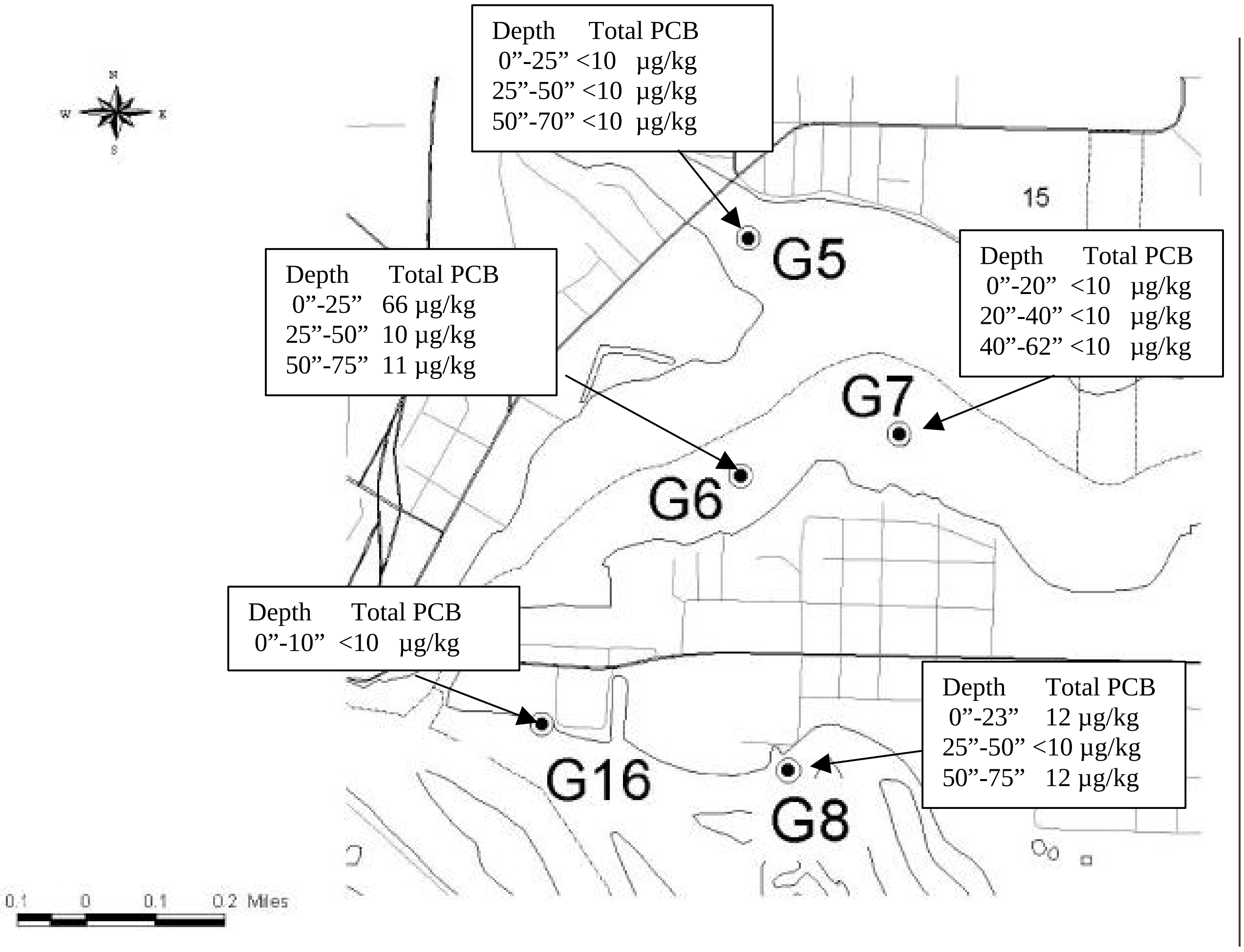
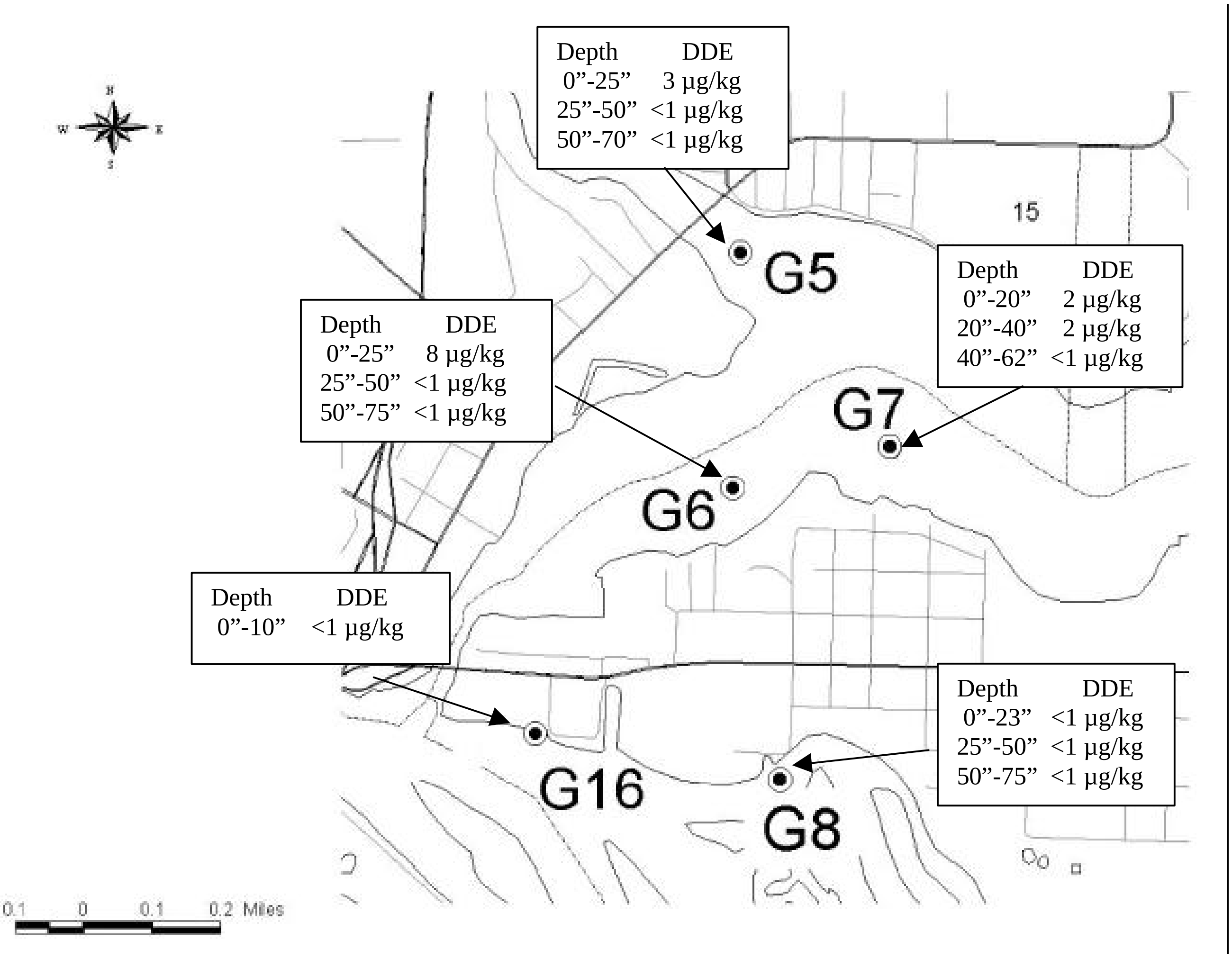


Figure 4.3.4 Total PCBs In Core Samples Collected From The Spring Lake Area Of The Lower Grand River, October 1997.



Depth	DDE
0”-25”	3 µg/kg
25”-50”	<1 µg/kg
50”-70”	<1 µg/kg

Depth	DDE
0”-25”	8 µg/kg
25”-50”	<1 µg/kg
50”-75”	<1 µg/kg

Depth	DDE
0”-20”	2 µg/kg
20”-40”	2 µg/kg
40”-62”	<1 µg/kg

Depth	DDE
0”-10”	<1 µg/kg

Depth	DDE
0”-23”	<1 µg/kg
25”-50”	<1 µg/kg
50”-75”	<1 µg/kg

Figure 4.3.5 DDE In Core Samples Collected From The Spring Lake Area Of The Lower Grand River, October 1997.

4.4 Sediment Chemistry Of The Middle Bayou Area

The results of the sediment analyses for selected inorganic parameters from the Middle Bayou area are given in Table 4.4.1. The results for selected organic parameters are presented in Table 4.4.2. Congener specific PCB data, grain size distributions, metals data, and semivolatile results are included in Appendices A, B, and C. Results for chromium, mercury, lead, total PCBs and DDE are displayed in Figures 4.4.1, 4.4.2, 4.4.3, 4.4.4, and 4.4.5 respectively.

G17 is another station located at the downstream tip of a meander core island. Chromium (92 mg/kg and 110 mg/kg), copper (65 mg/kg and 88 mg/kg), lead (30 mg/kg and 43 mg/kg), and zinc (88 mg/kg and 130 mg/kg) were elevated in the top and middle core sections respectively. The presence of elevated heavy metals in the top core section was not observed at the other locations near meander core islands. G17 is also located near the outlet of Dermo Bayou that may be a source of heavy metals. A previous study by Thorpe (1994) found elevated levels of heavy metals in the sediments of the bayous in this area. The elevated level of metals was attributed to sediment deposition from the back flow of the Grand River during rain events. Over the last 10 years, residential development in the bayou areas has increased overland runoff . This change may be causing movement of contaminated sediments out of the bayous and into the main channel of the Grand River.

Station G18 showed the enrichment of metals only in the middle core section (16"-32"). Chromium (87 mg/kg), copper (55 mg/kg), lead (58 mg/kg), and zinc (210 mg/kg) were elevated in this core region. G18 is located in a channel between two islands that would receive sediment deposition during periods of high flow. Samples collected from G14 and G19 did not show significant levels of metals.

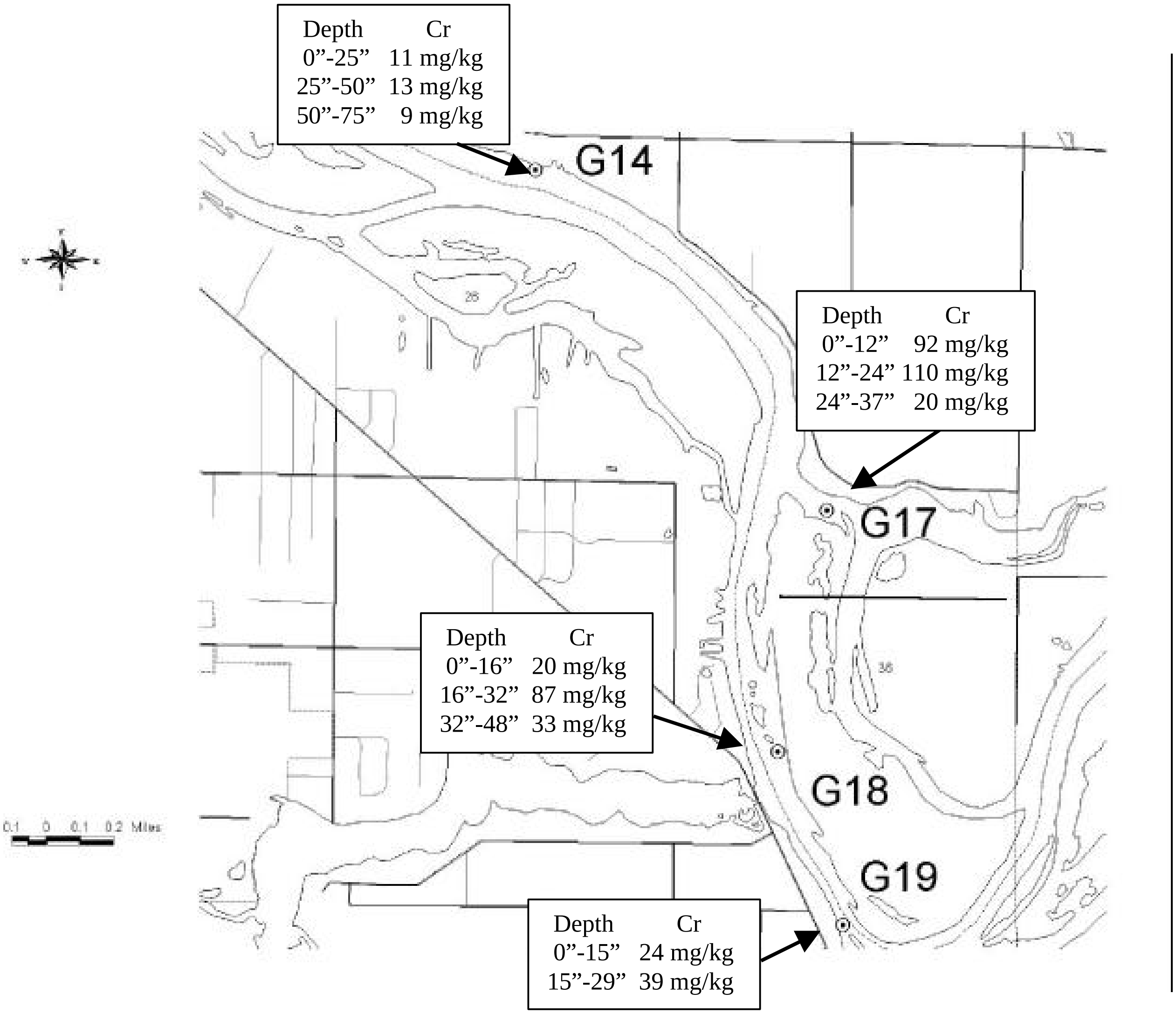
Levels of heavy metals, PCB congeners, and DDT compounds were lower in this region of the Grand River than the downstream locations near Grand Haven and Spring Lake. As mentioned in Section 3, concentrations of metals and organics found at the Middle Bayou locations would have originated from at least 20 miles upstream from point and nonpoint discharges. There is no record of localized industrial discharges in the Middle Bayou area. Potential upstream sources include the metro Grand Rapids area, known industrial sources east of Grand Rapids, and contributions from the cities of Lansing and Jackson.

Table 4.4.1 Inorganic Results For The Sediment Cores Collected From The Middle Bayou Area Of The Lower Grand River, October 1997.

Sample ID	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-14 Top	12	1.0	11	3.9	<0.10	9.9	0.8	<0.5	16
G-14 Mid	16	0.09	13	3.9	<0.10	11	1.0	<0.5	18
G-14 Bot	8.1	0.65	9	3.7	<0.10	8.7	0.6	<0.5	12
G-17 Top	10	1.8	92	65	<0.10	38	30	<0.5	88
G-17 Mid	6.2	2.2	110	88	0.17	37	43	<0.5	130
G-17 Bot	8.0	0.14	20	4.4	<0.10	15	2.0	<0.5	7.1
G-18 Top	2.6	0.14	20	6.5	<0.10	12	4.4	<0.5	4.7
G-18 Mid	6.0	1.0	87	55	1.47	60	58	<0.5	210
G-18 Bot	3.2	0.65	33	15	<0.10	17	5.5	<0.5	14
G-19 Top	4.2	0.23	24	8.2	<0.10	14	6.0	<0.5	26
G-19 Bot	5.3	0.41	39	15	<0.10	20	23	<0.5	69

Table 4.4.2 Organic Results For The Sediment Cores Collected From The Middle Bayou Area Of The Lower Grand River, October 1997.

Station	Total PCBs	DDE	DDD	DDT
	ug/kg	ug/kg	ug/kg	ug/kg
G-14 Top	2.3	1.1	<1.0	<1.0
G-14 Mid	16	<1.0	<1.0	<1.0
G-14 Bot	1.7	<1.0	<1.0	<1.0
G-17 Top	54	2.9	1.5	<1.0
G-17 Mid	35	2.3	2.9	<1.0
G-17 Bot	8	<1.0	<1.0	<1.0
G-18 Top	13	2.4	<1.0	<1.0
G-18 Mid	9	1.2	<1.0	<1.0
G-18 Bot	14	1.4	<1.0	<1.0
G-19 Top	16	2.6	<1.0	<1.0
G-19 Bot	19	2.0	<1.0	<1.0



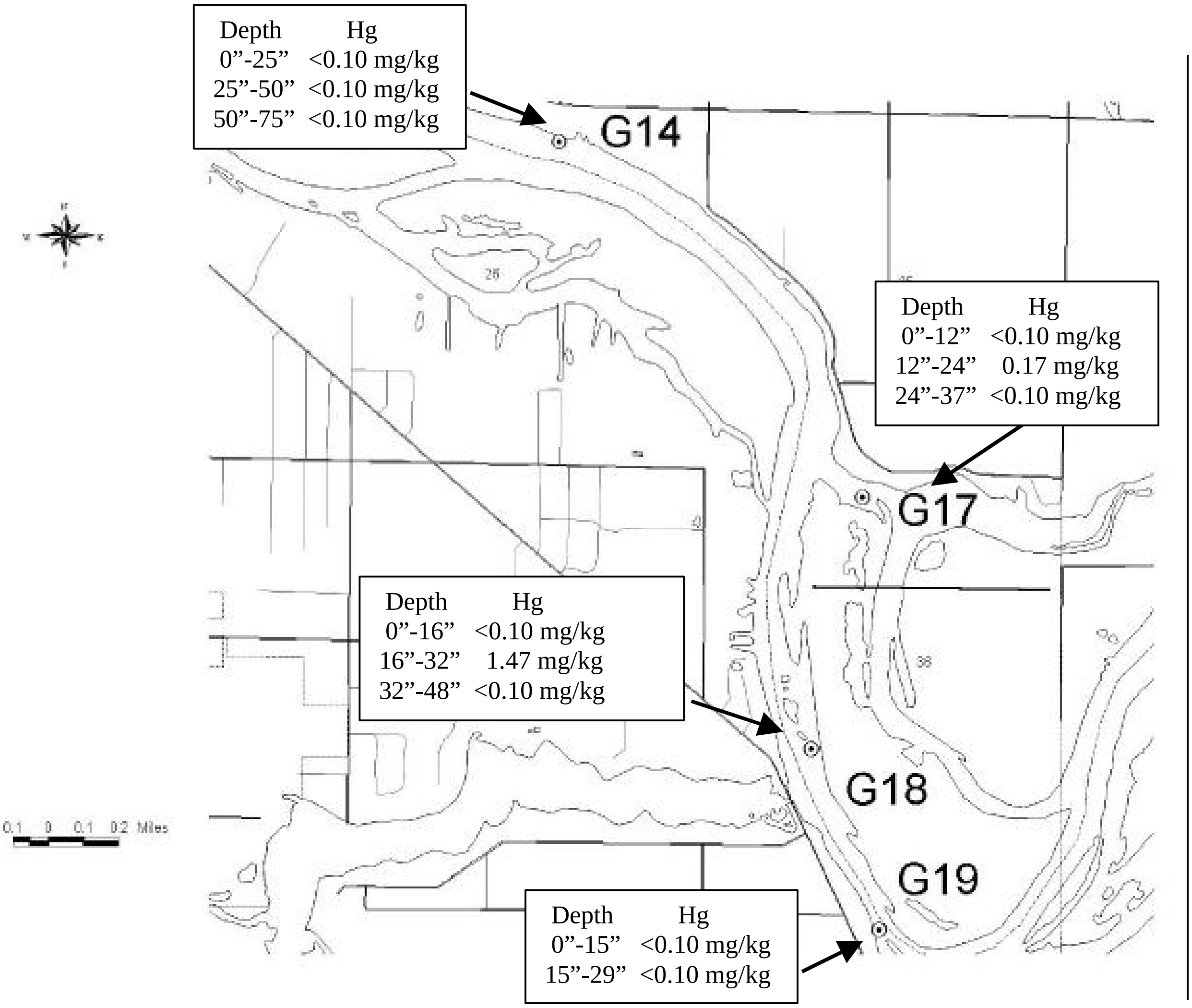
Depth	Cr
0”-25”	11 mg/kg
25”-50”	13 mg/kg
50”-75”	9 mg/kg

Depth	Cr
0”-12”	92 mg/kg
12”-24”	110 mg/kg
24”-37”	20 mg/kg

Depth	Cr
0”-16”	20 mg/kg
16”-32”	87 mg/kg
32”-48”	33 mg/kg

Depth	Cr
0”-15”	24 mg/kg
15”-29”	39 mg/kg

Figure 4.4.1 Total Chromium In Core Samples From The Middle Bayou Area Of The Lower Grand River, October 1997.



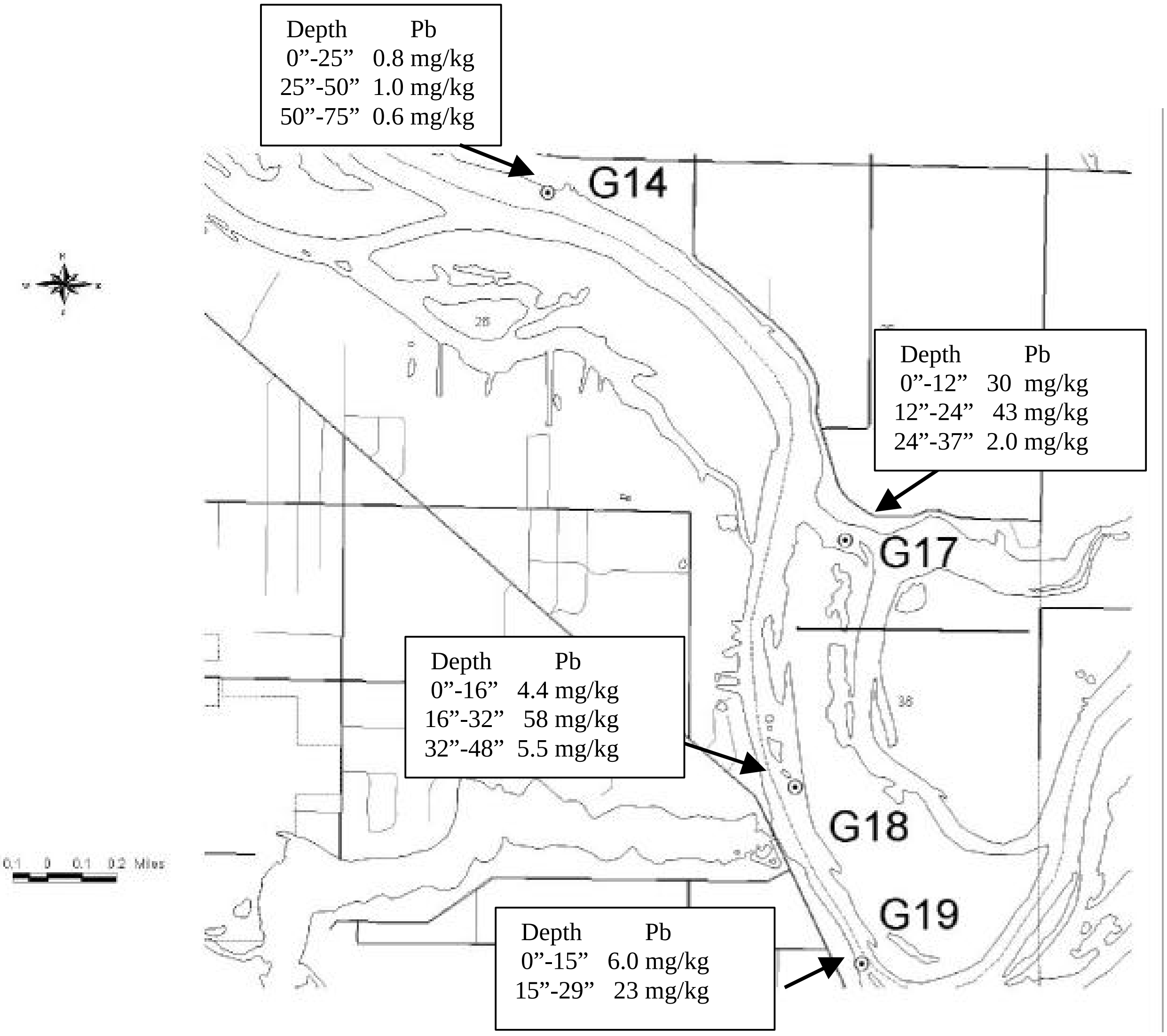
Depth	Hg
0”-25”	<0.10 mg/kg
25”-50”	<0.10 mg/kg
50”-75”	<0.10 mg/kg

Depth	Hg
0”-12”	<0.10 mg/kg
12”-24”	0.17 mg/kg
24”-37”	<0.10 mg/kg

Depth	Hg
0”-16”	<0.10 mg/kg
16”-32”	1.47 mg/kg
32”-48”	<0.10 mg/kg

Depth	Hg
0”-15”	<0.10 mg/kg
15”-29”	<0.10 mg/kg

Figure 4.4.2 Total Mercury In Core Samples Collected From The Middle Bayou Area Of The Lower Grand River, October 1997.



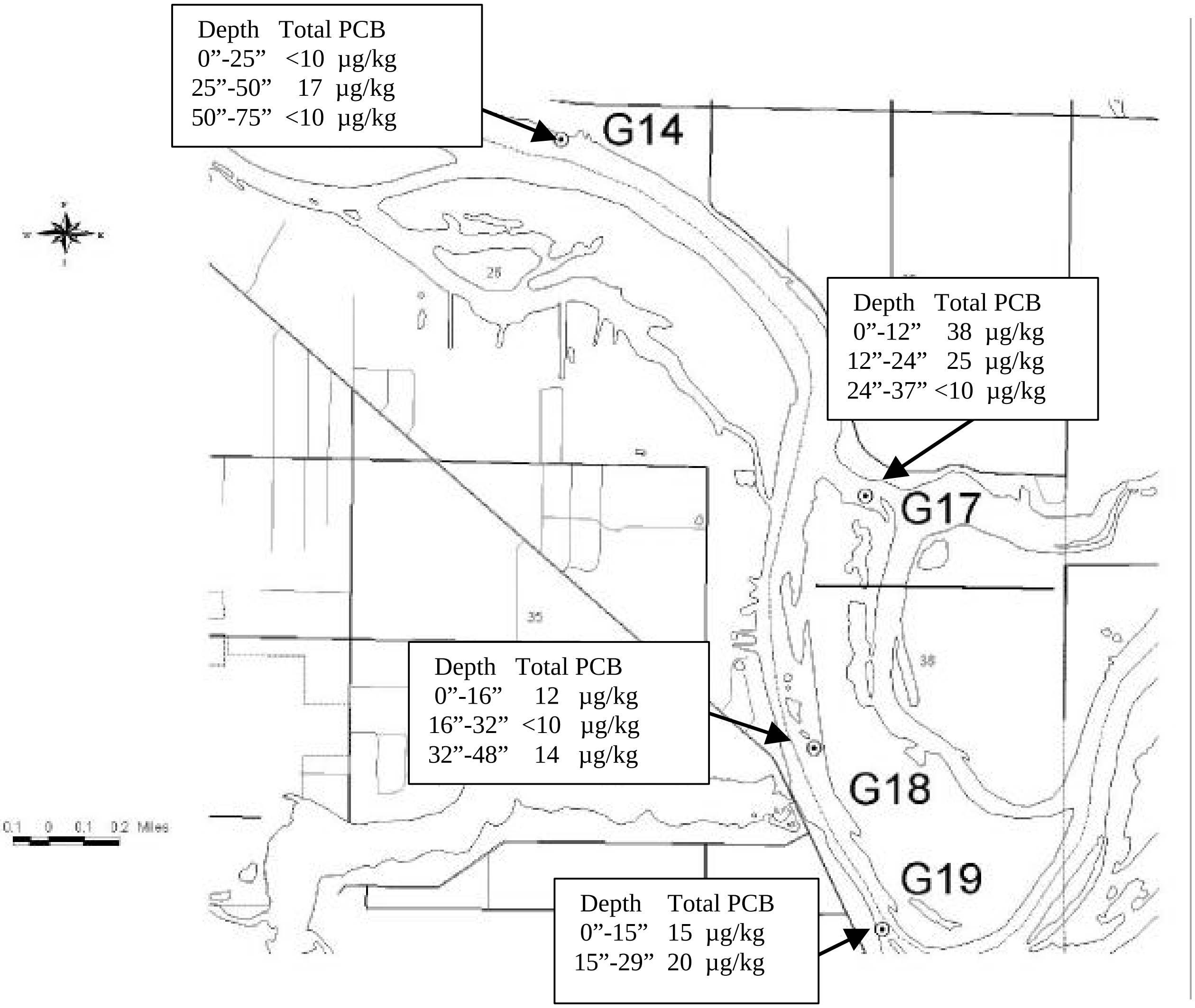
Depth	Pb
0”-25”	0.8 mg/kg
25”-50”	1.0 mg/kg
50”-75”	0.6 mg/kg

Depth	Pb
0”-12”	30 mg/kg
12”-24”	43 mg/kg
24”-37”	2.0 mg/kg

Depth	Pb
0”-16”	4.4 mg/kg
16”-32”	58 mg/kg
32”-48”	5.5 mg/kg

Depth	Pb
0”-15”	6.0 mg/kg
15”-29”	23 mg/kg

Figure 4.4.3 Total Lead In Core Samples Collected From The Middle Bayou Area Of The Lower Grand River, October 1997.



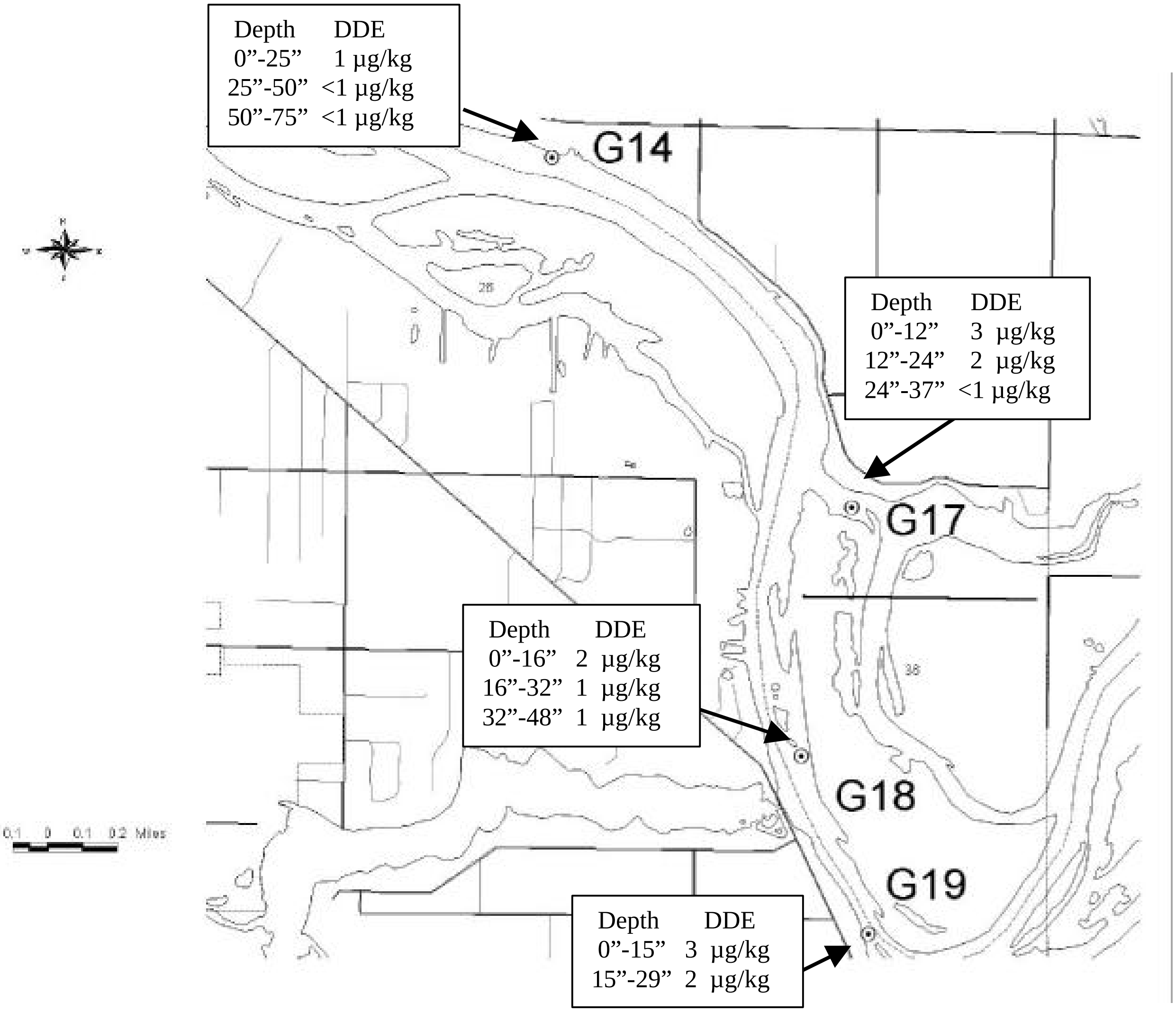
Depth	Total PCB
0”-25”	<10 µg/kg
25”-50”	17 µg/kg
50”-75”	<10 µg/kg

Depth	Total PCB
0”-12”	38 µg/kg
12”-24”	25 µg/kg
24”-37”	<10 µg/kg

Depth	Total PCB
0”-16”	12 µg/kg
16”-32”	<10 µg/kg
32”-48”	14 µg/kg

Depth	Total PCB
0”-15”	15 µg/kg
15”-29”	20 µg/kg

Figure 4.4.5 Total PCBs In Core Samples Collected From The Middle Bayou Area Of The Lower Grand River, October 1997.



Depth	DDE
0”-25”	1 µg/kg
25”-50”	<1 µg/kg
50”-75”	<1 µg/kg

Depth	DDE
0”-12”	3 µg/kg
12”-24”	2 µg/kg
24”-37”	<1 µg/kg

Depth	DDE
0”-16”	2 µg/kg
16”-32”	1 µg/kg
32”-48”	1 µg/kg

Depth	DDE
0”-15”	3 µg/kg
15”-29”	2 µg/kg

Figure 4.4.6 DDE In Core Samples Collected From The Middle Bayou Area Of The Lower Grand River, October 1997.

4.5 Evaluation Of The Sediment Quality Of The Lower Grand River

There is no single set of guidelines established for evaluating sediment quality. A summary of recently proposed sediment quality guidelines is provided in Table 4.5.1. These guidelines are derived by combining the results of laboratory and field studies that include a variety of methodological approaches (background levels, equilibrium-partitioning, spiked sediment bioassays, field surveys, screening level concentrations, apparent effects thresholds, and bioeffects/contamination co-occurrence analyses) for both freshwater and marine sediments. These data are used to estimate the range of no effect, possible effect, and probable effect concentrations of contaminants in sediments. Threshold effect levels estimate the breakpoint between no effect and possible effect concentrations. The Effects Range Low (Long et al. 1995), Lower Effect Level (Persaud et al. 1992), and the Threshold Effect Level (Smith et al. 1996) are all estimates of contaminant concentrations where ecological effects are not anticipated if the level is below the proposed guideline. The Effects Range Median

Table 4.5.1 Summary Of Recent Sediment Quality Guidelines

		Threshold Effect Levels		
	Units	Long and Morgan (1990)	Persaud et al. (1992)	Smith et al. (1996)
Guideline		ERL	LEL	TEL
Arsenic	mg/kg	8.2	6	5.9
Cadmium	mg/kg	1.2	0.6	0.6
Chromium	mg/kg	81	26	37.3
Lead	mg/kg	47	31	35
Mercury	mg/kg	0.15	0.2	0.17
Nickel	mg/kg	21	16	18
Total PCBs	ug/kg	23	70	34
DDE	ug/kg	*	5	1.4
		Probable Effect Levels		
Guideline		ERM	SEL	PEL
Arsenic	mg/kg	70	33	17
Cadmium	mg/kg	9.6	10	3.5
Chromium	mg/kg	370	110	90
Lead	mg/kg	47	170	91.3
Mercury	mg/kg	0.71	1	0.48
Nickel	mg/kg	52	61	36
Total PCBs	ug/kg	180	5300	277
DDE	ug/kg	*	190	6.75

TEL=Threshold Effect Level
ERL=Effects Range Low
LEL=Lower Effects Level
ERM=Effects Range Median
PEL=Probable Effect Level
SEL=Severe Effect Level
* Not Calculated

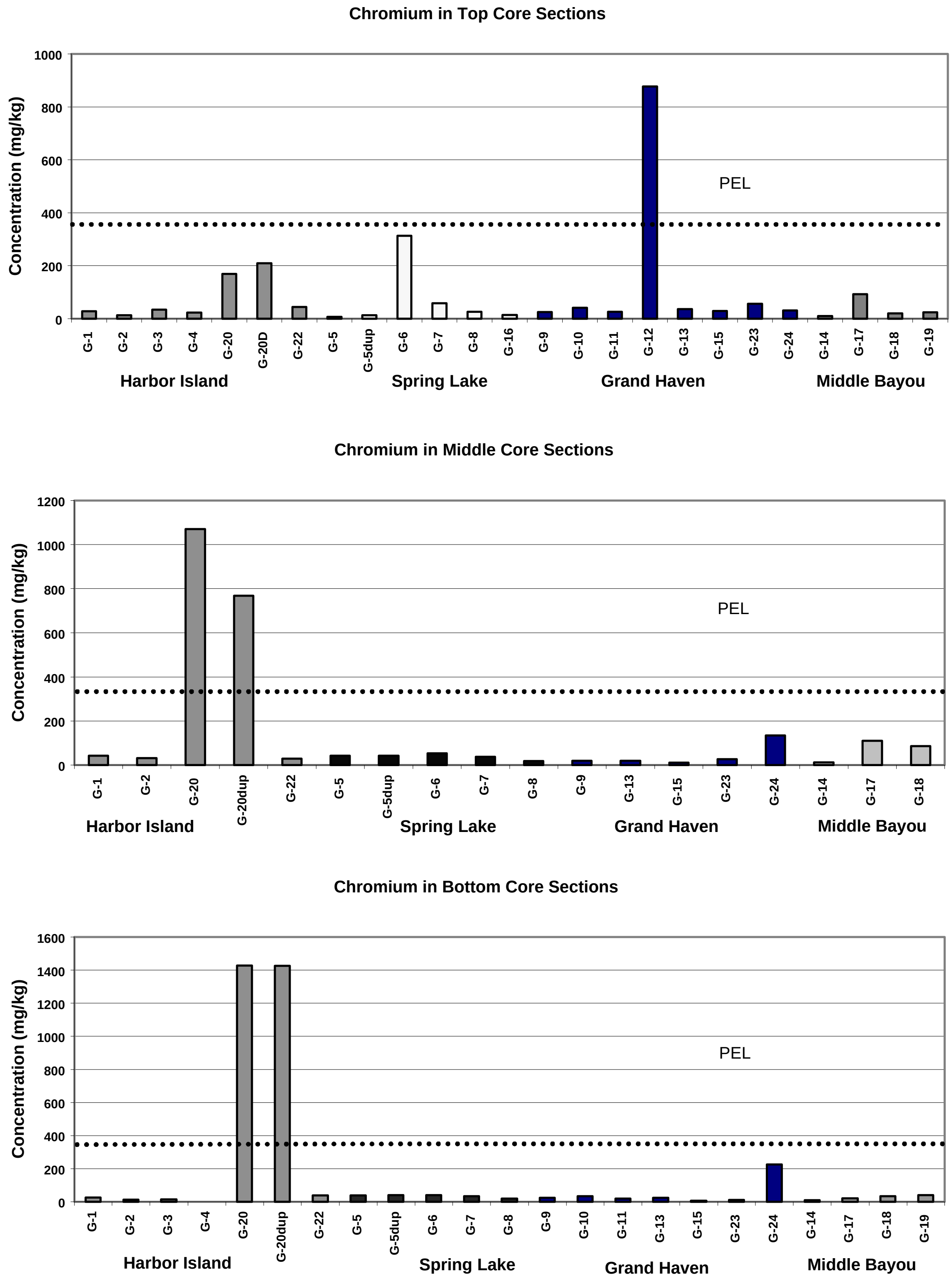
(Long et al. 1995), Severe Effect Level (Persaud et al. 1992), and the Probable Effect Level (Smith et al. 1996) are all estimates of contaminant concentrations at which ecological effects are anticipated if the level is above the proposed guideline. While these guidelines do not address all site specific conditions that may affect the availability of heavy metals, they are useful benchmarks for determining sediment quality (USEPA 1992). For the purpose of this investigation, the Probable Effect Level (PEL) described by Smith et al. (1996) will be used to evaluate the sediment quality of the lower Grand River. The PEL value represents the level of a contaminant at which adverse biological effects frequently occur. These values are based on sediments and organisms found in the Great Lakes and are more indicative of the conditions found in this investigation. Long et al. (1995) and Persaud et al. (1992) included both freshwater and saltwater environments in their evaluations.

For comparative purposes, PELs selected as the most representative guideline to evaluate the potential environmental effects of the Grand River sediments. PELs were derived using sediments and organisms from the Great Lakes region (Smith et al. 1996 and Ingersoll et al. 1996), that were similar to the environments found in the Grand River. The only potential problem associated with applying these guidelines to the Grand River sediments was that the toxicity data for arsenic, cadmium, chromium, copper, lead, nickel, and zinc in the PEL database were derived from samples analyzed for total extractable metals using a nitric acid digestion. The samples for the Grand River project were analyzed by a more rigorous total metals digestion procedure using hydrofluoric acid. The concentration of heavy metals measured in the Grand River would therefore include the anthropogenic fraction (metals attached by sorption to the sediment particle surface) and the intrinsic fraction (metals incorporated in the mineral matrix). The intrinsic metals fraction would have a very limited potential for bioavailability. Samples with metals concentrations near the PEL value may therefore have some degree of high bias associated with the analytical method. The Effect Rang Median (Long and Morgan 1990) data in Table 4.5.1 were derived using a total metals digestion procedure similar to the analytical method for this project . While these guidelines are usually higher than the PELs, the ERM data set was developed from marine and estuarine sediments collected in Florida and the Carolinas. Differences between the two guidelines therefore reflect the inclusion of variables related to analytical methodology and regional differences in the respective aquatic environments. In consideration of the strong potential for regional bias in the ERM data set, the PELs were selected as the benchmark to evaluate the potential for environmental effects. Additional caution should be used when evaluating data near the PEL value because of the potential of the analytical method to include a fraction of metals that are not bioavailable.

The distribution of chromium in the core samples collected in the lower Grand River is shown in Figure 4.5.1. The stations at Harbor Island (G20), Spring Lake (G6), the Grand Haven tannery (G12), and meander core island located in the Middle Bayou area (G17) all exceeded the PEL value of 90 mg/kg for chromium in the top core sections (≈0"-24"). The middle core section for G17 and the middle and bottom core sections for Harbor Island and the meander core island (G24) near Grand Haven also exceeded the PEL value of 90 mg/kg. The spatial distribution of the chromium results suggests that the metal was introduced by several point sources located in Grand Haven, Spring Lake, and Harbor Island. The distribution of chromium also shows the importance of upstream sources. Significant chromium deposition at the downstream tips of meander core islands that are located above potential point sources illustrates the effects of historic upstream discharges.

The distribution of lead in the core samples collected in the lower Grand River is shown in Figure 4.5.2. Lead follows a similar distribution pattern with potential sources located near Harbor Island, the Grand Haven tannery, and Spring Lake. The Harbor Island and Spring Lake stations exceeded the PEL of 91 mg/kg for lead. The middle and bottom core sections at Harbor Island also exceeded the PEL. In addition, anthropogenic enrichment of lead was noted in the Middle Bayou area (G18) and meander core island stations G24 and G17. Since anthropogenic lead can originate from industrial sources and from the release of fuels, its presence in these core samples is indicative of inputs from both types of discharges.

The distribution of mercury in the core samples collected in the lower Grand River (Figure 4.5.3.) follows a different pattern than lead and chromium. Mercury was not detected on the top core sections of the Middle Bayou area. Over the last 10 years, the City of Grand Rapids has initiated an aggressive pollution prevention program to reduce the discharge of mercury. The absence of mercury in the top sections and its presence in the middle at G18 (1.47 mg/kg) suggests that elevated levels were discharged from upstream locations in the past. With the exception of Harbor Island (G20), mercury appears to be dispersed in the top core sections of the remaining study areas. The Grand Haven and Spring Lake areas have detectable mercury concentrations that range from 0.1 mg/kg to 0.48 mg/kg. Only station



Chromium in Top Core Sections

Chromium in Middle Core Sections

Chromium in Bottom Core Sections

Figure 4.5.1 **Chromium Concentrations In Core Samples Taken From The Lower Grand River, October 1997. (PEL = Probable Effect Level).**

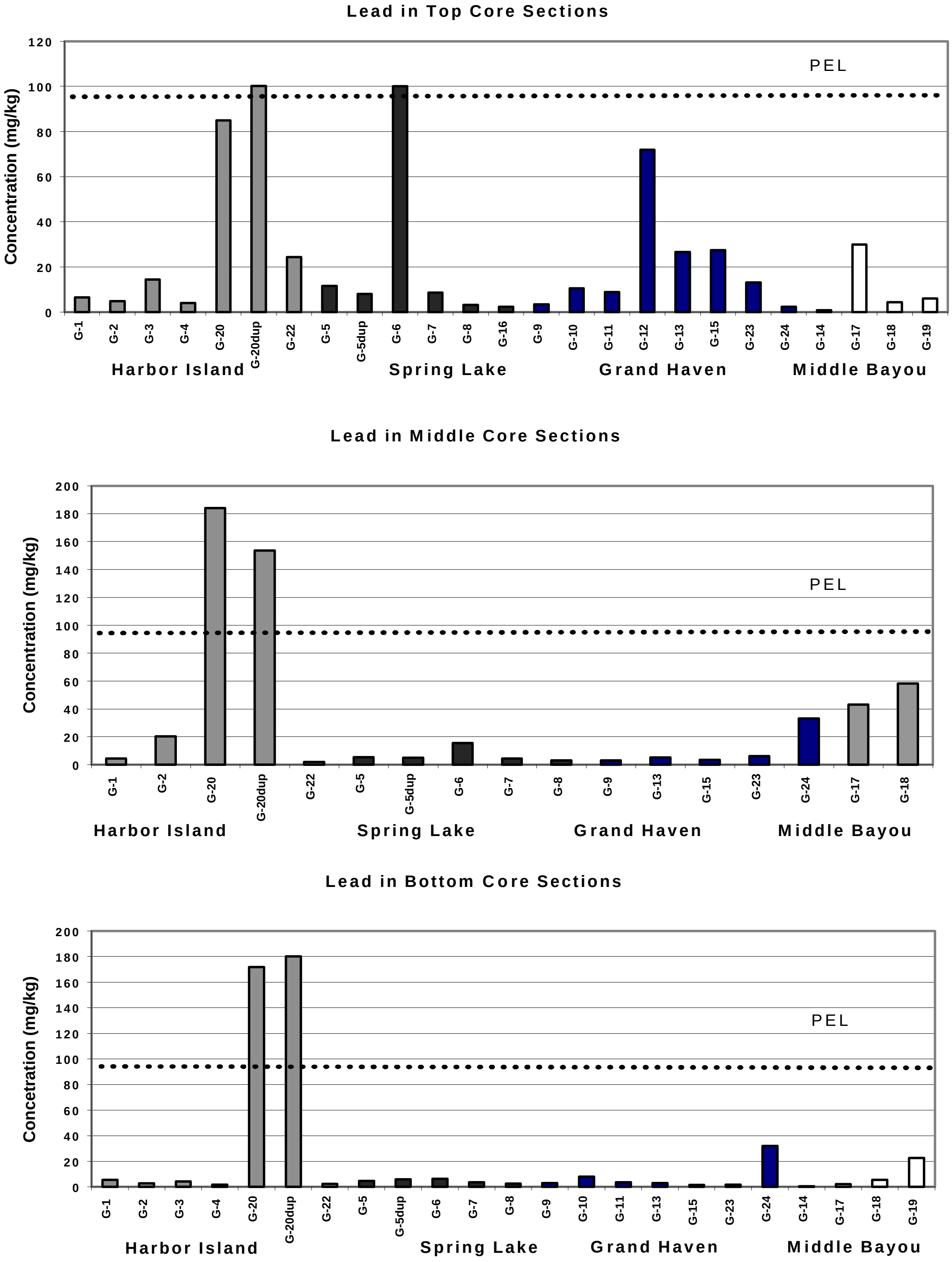
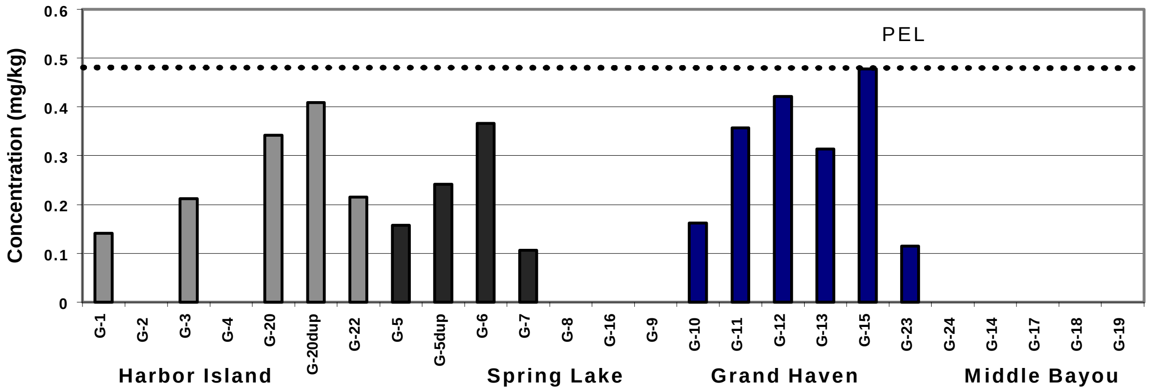
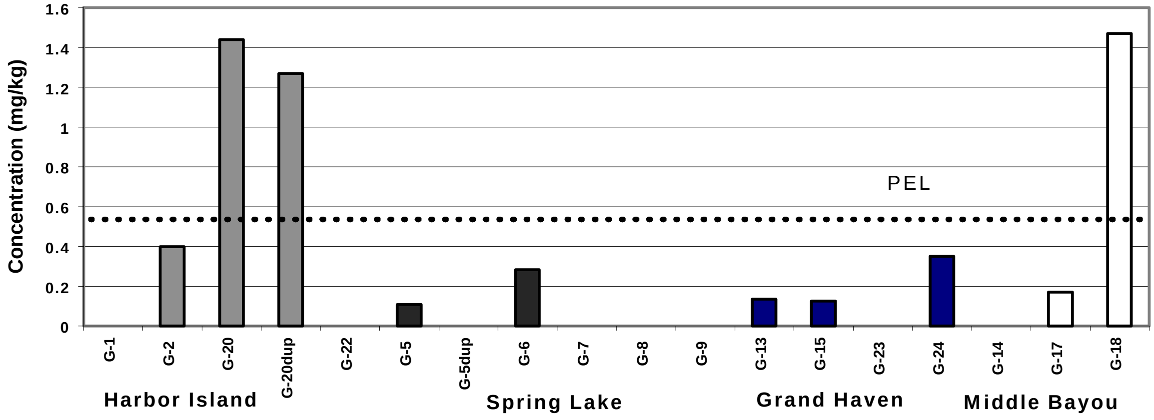


Figure 4.5.2 Lead Concentrations In Core Samples Taken From The Lower Grand River, October 1997. (PEL = Probable Effect Level).

Mercury in Top Core Sections



Mercury in Middle Core Sections



Mercury in Bottom Core Sections

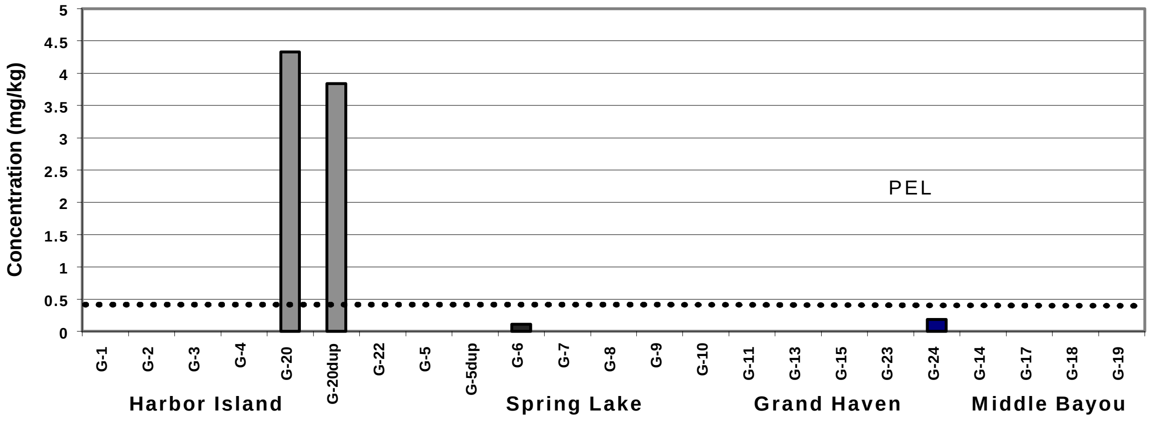


Figure 4.5.3 Mercury Concentrations In Core Samples Taken From The Lower Grand River, October 1997. (PEL = Probable Effect Level).

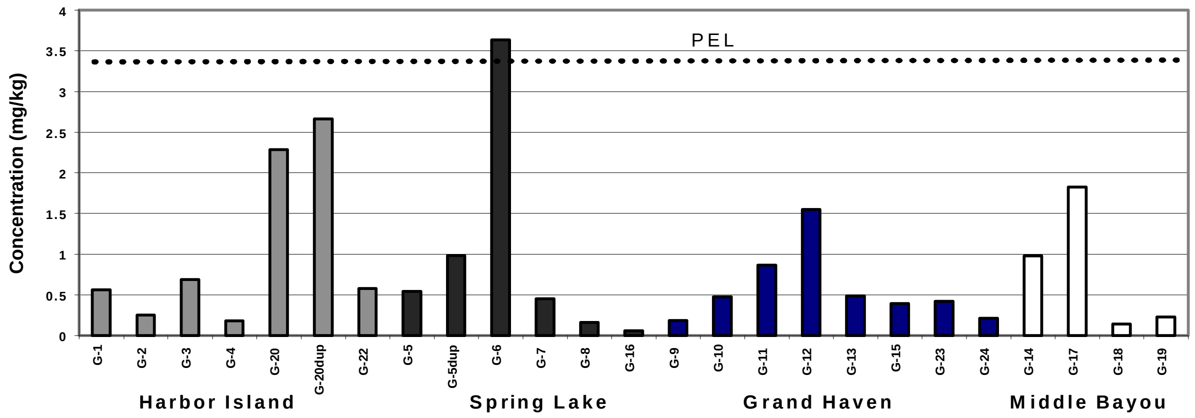
G15 had a surface zone concentration equivalent to the PEL for mercury (0.48 mg/kg). The middle and bottom core sections had either very low or non detectable levels of mercury. In contrast, the bottom section of the Harbor Island station (G20) was heavily contaminated with mercury (4.3 mg/kg). The levels decreased in the top section to 0.4 mg/kg. These results suggest heavy historical deposition of mercury in this area. The high concentrations found in the deeper sections appear to be stable as lower concentrations are found with decreasing depth. The results however suggest that sediments contaminated with mercury from historic discharges are still subject to resuspension and deposition in the lower Grand River. Atmospheric deposition may also contribute to the levels found near the surface.

The distribution of cadmium in the core samples collected in the lower Grand River (Figure 4.5.4.) follows a different pattern than the previous elements. The highest level of cadmium was found at the Spring Lake station G6 (3.6 mg/kg). The sediment from this location was the only station to exceed the PEL of 3.5 mg/kg. The Harbor Island station G20 had 2 mg/kg in the top section and lower levels in the deeper strata. Concentrations of the other heavy metals were highest in the bottom sections at this location. These results illustrate that the concentration of cadmium in the recently deposited sediments is higher than historical levels. While some movement of contaminated sediments can occur from Spring Lake, the sediments with the greatest potential for mobility appear to be located in the Middle Bayou area and at the meander core island station G24. The sediments with the highest cadmium concentrations in the middle and bottom core sections were located at G17 (2.4 mg/kg) and G24 (1.5 mg/kg) respectively. The top core section at G17 was also elevated (1.8 mg/kg). Based on these data, the resuspension and transport of sediments from the upper region of the lower Grand River appears to be the source for observed distribution of cadmium. In addition, the results suggest that upstream locations were the historical source of much of the cadmium found in the lower Grand River.

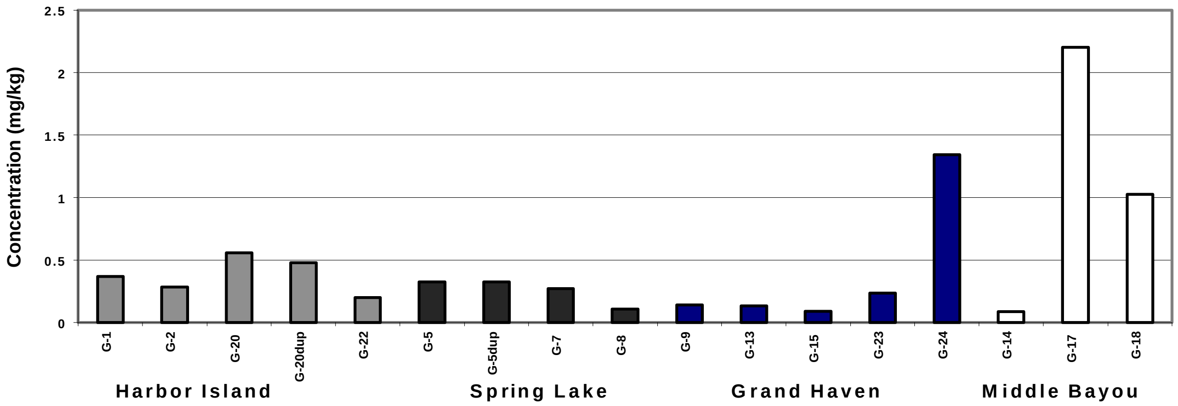
The distribution of nickel in the core samples collected in the lower Grand River (Figure 4.5.5.) follows a pattern similar to chromium. The stations at Harbor Island (G1, G20, and G22), Spring Lake (G6), the Grand Haven tannery (G12), and meander core island located in the Middle Bayou area (G17) all exceeded the PEL value of 36 mg/kg for chromium in the top core sections. The middle core section for G17 (37 mg/kg) and G18 (60 mg/kg) and the middle and bottom core sections for Harbor Island (184 mg/kg and 172 mg/kg respectively) and the meander core island G24 (58 mg/kg and 7 mg/kg respectively) near Grand Haven also exceeded the PEL value. The spatial distribution of the nickel suggests that the metal was introduced by several point sources located in Grand Haven, Spring Lake, and Harbor Island. As observed for chromium, the data suggest that upstream locations contributed significant levels of nickel to the lower Grand River. Nickel deposition at the downstream tips of meander core islands located above the point sources illustrates the effects of historic upstream discharges.

Significant levels of PCBs were not found at the locations that were examined in this investigation (Figure 4.5.6). The highest PCB level in the top core sections was found near Harbor Island at G20 (71 ug/kg). This level is well below the PEL of 277 ug/kg. Concentrations increased with depth at this location to 137 in the bottom core section.

Cadmium in Top Core Sections



Cadmium in Middle Core Sections



Cadmium in Bottom Core Sections

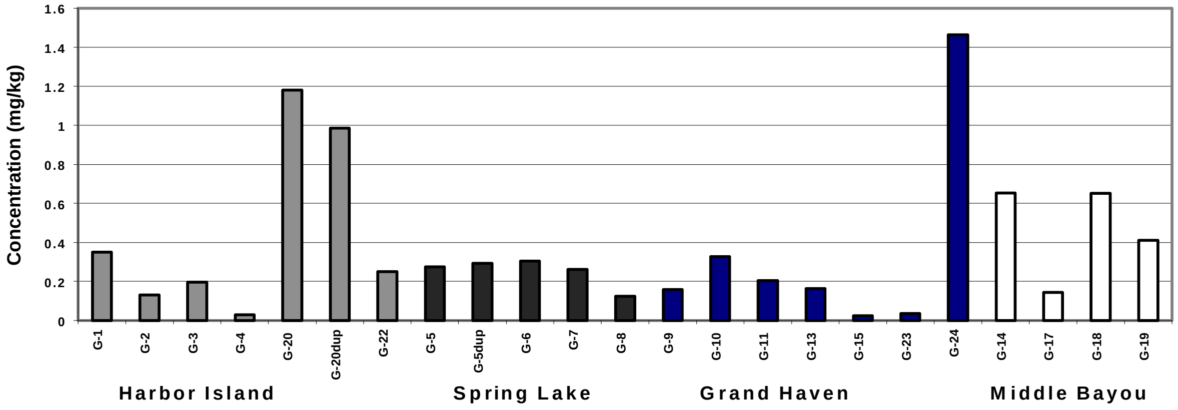
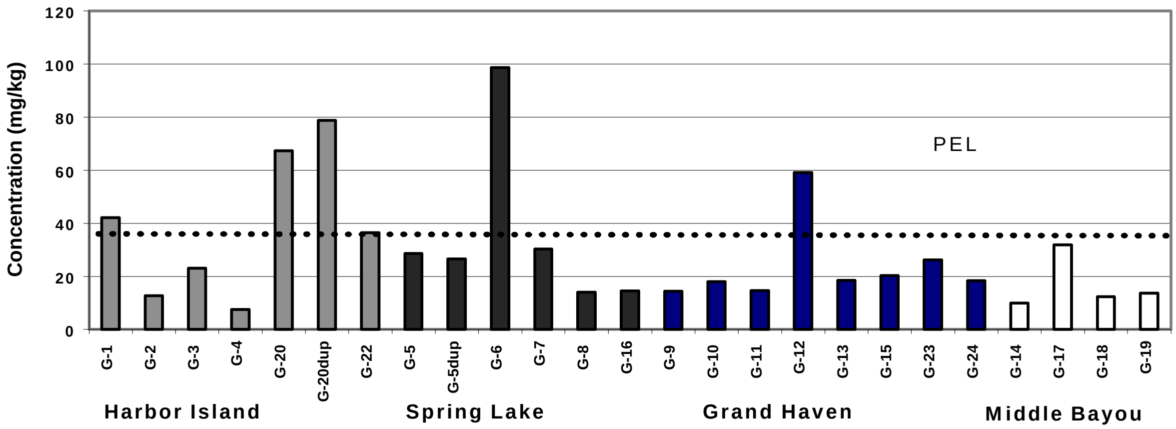
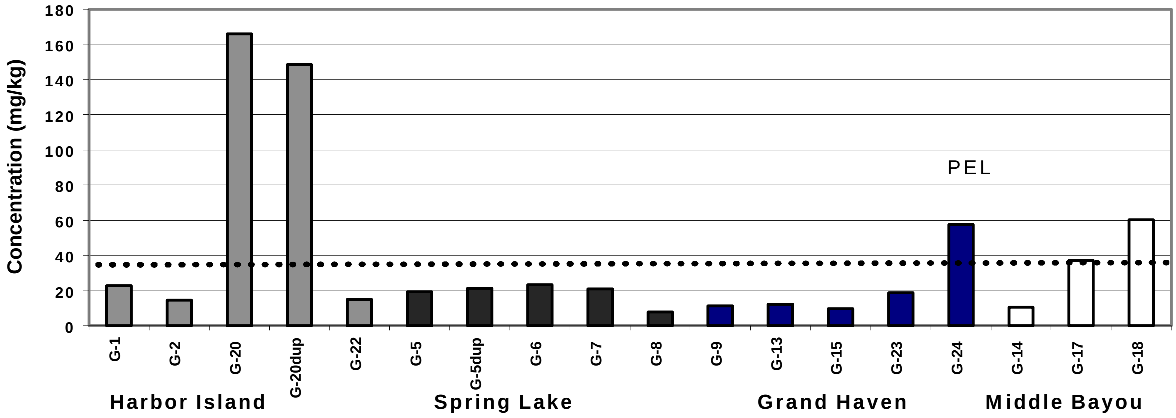


Figure 4.5.4 Cadmium Concentrations In Core Samples Taken From The Lower Grand River, October 1997. (PEL = Probable Effect Level).

Nickel in Top Core Sections



Nickel in Middle Core Sections



Nickel in Bottom Core Sections

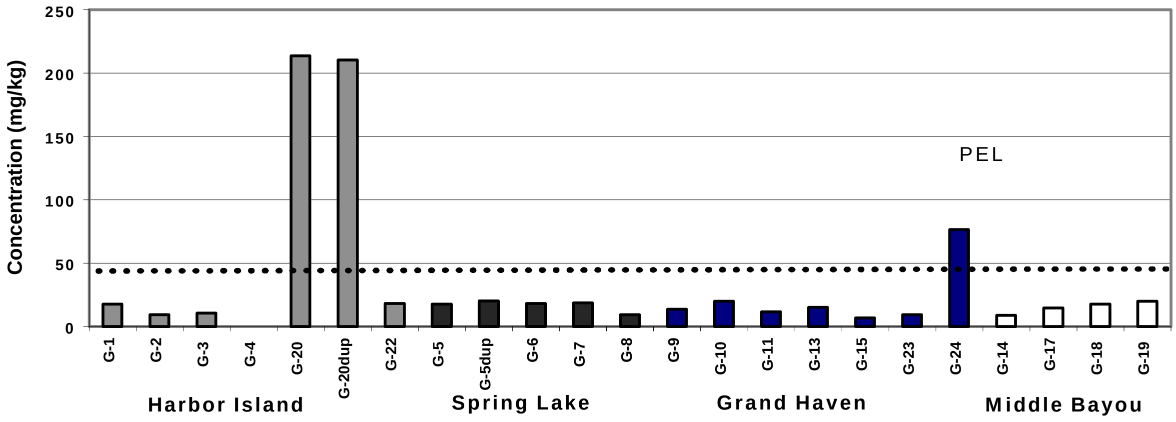
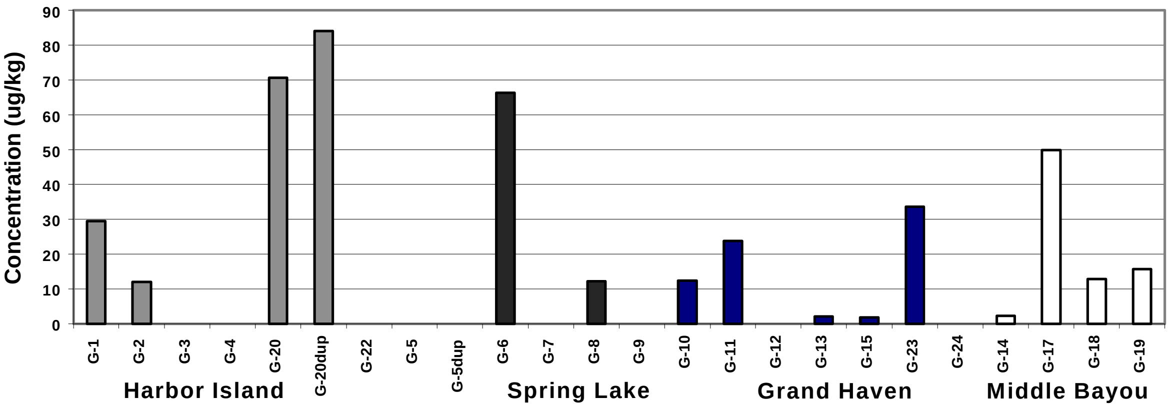
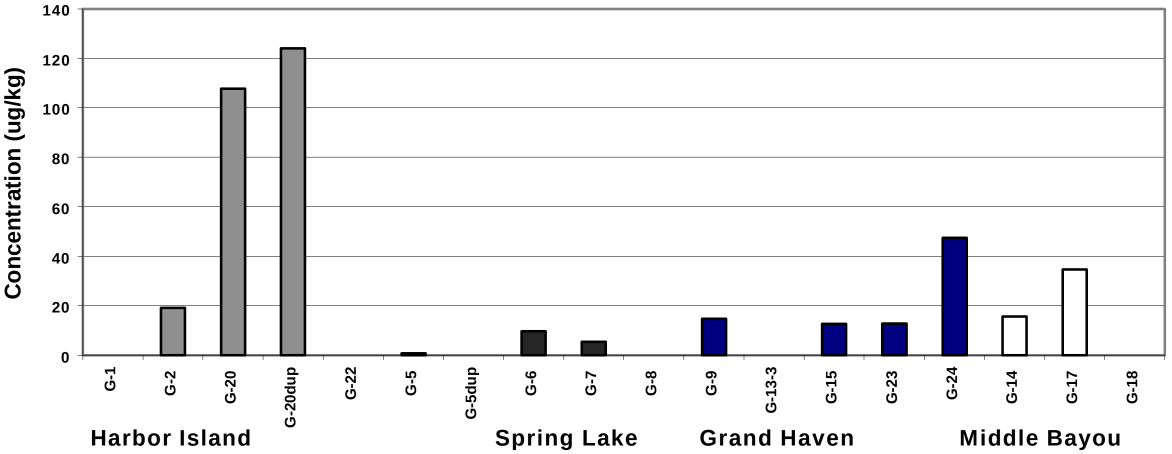


Figure 4.5.5 Nickel Concentrations In Core Samples Taken From The Lower Grand River, October 1997. (PEL = Probable Effect Level).

Total PCBs in Top Core Sections



Total PCBs in Middle Core Sections



Total PCBs in Bottom Core Sections

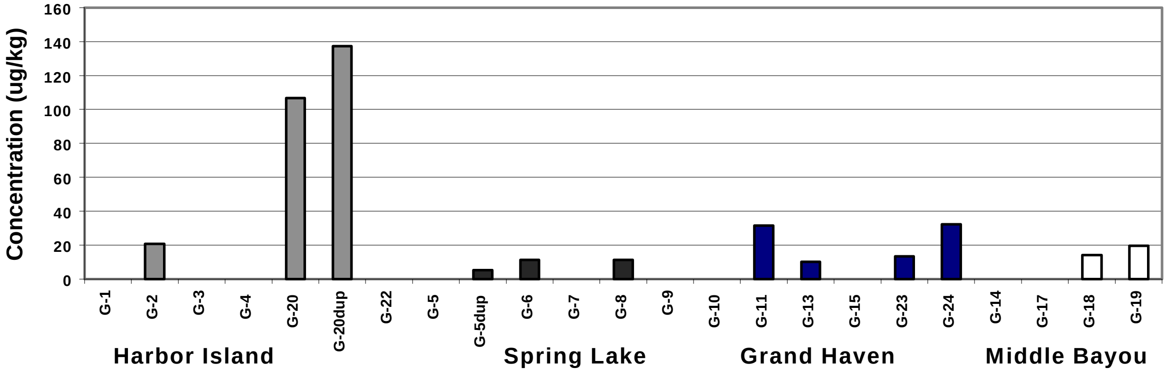


Figure 4.5.6 PCB Concentrations In Core Samples Taken From The Lower Grand River, October 1997.

The distribution of the individual PCB congeners in each study area is shown in Figures 4.5.7 and 4.5.8. For these graphs, the samples containing > 10 ug/kg of total PCBs were split into homolog groups of trichloro, tetrachloro, pentachloro, hexachloro, heptachloro, and octachloro biphenyls. In addition, the area designated as Grand Haven in the previous discussions was split into the middle Grand River area (G9, G13, G14, G15, and G24) and Grand Haven shoreline area (G10, G11, and G23). The Grand Haven Shoreline area would be primarily influenced by discharges and releases from the local industries and the wastewater system. The Middle Grand River area consists of sampling stations that would be influenced by sediment deposition from upstream sources. Figure 4.5.7 shows the PCB congener distribution for the Grand Haven Shoreline, Harbor Island, and the Middle Bayou area. These stations show a similar distribution pattern consisting primarily of tetrachloro, pentachloro and hexachloro congeners. Pentachloro isomers were in the greatest abundance. This pattern is similar to the distribution described by Anderson et al. (1999) for the PCB congeners in the suspended solids found in Lake Michigan. The congener distributions for Spring Lake and the Middle Grand River were different (Figure 4.5.8) showing a greater weighting for tetrachlorobiphenyl and a lower weighting for hexachlorobiphenyl. Pentachlorobiphenyl was still the isomer group in greatest abundance. Biodegredation may have caused the change in congener distribution for the Middle Grand River. The source of PCBs in this area would be the same as the Middle Bayou that was located 1 Km upstream. The difference in congener distribution for Spring Lake may also be from biodegradation; however the possibility of a separate source also exists. Congener distributions for the Middle Bayou, Harbor Island and the Grand Haven Shoreline suggest that similar aroclor mixtures were used in all areas or the material originated from upstream sources.

The distribution of DDE in the core samples collected in the lower Grand River (Figure 4.5.9.) follows a different distribution pattern than PCBs. DDT was heavily used in the lower Grand River Watershed for agricultural and pest control purposes. Extensive DDT usage was associated with mosquito abatement as the surrounding wetland areas were developed for residential and commercial use. The persistent degradation product of DDT, DDE, was found in concentrations in excess of the PEL (6.75 ug/kg) in the Harbor Island area (G1 at 7.6 ug/kg and G20 at 8.2 ug/kg) and Spring Lake (G6 at 8 ug/kg). The highest DDE levels were found in the deeper core sections at G20 (10 ug/kg - 12 ug/kg).

In summary, three areas of contaminated sediment in the lower Grand River exceeded PEL values for heavy metals and selected organic chemicals. The locations and parameters of concern are listed below:

Harbor Island (G20).	Exceeds sediment PEL values for chromium, lead, nickel, and DDE in the top core section. Deeper core sections were heavily contaminated with trace metals.
Spring Lake (G6).	Exceeds sediment PEL values for chromium, lead, cadmium, nickel, and DDE.
Grand Haven (G12).	Exceeds sediment PEL values for chromium and nickel.

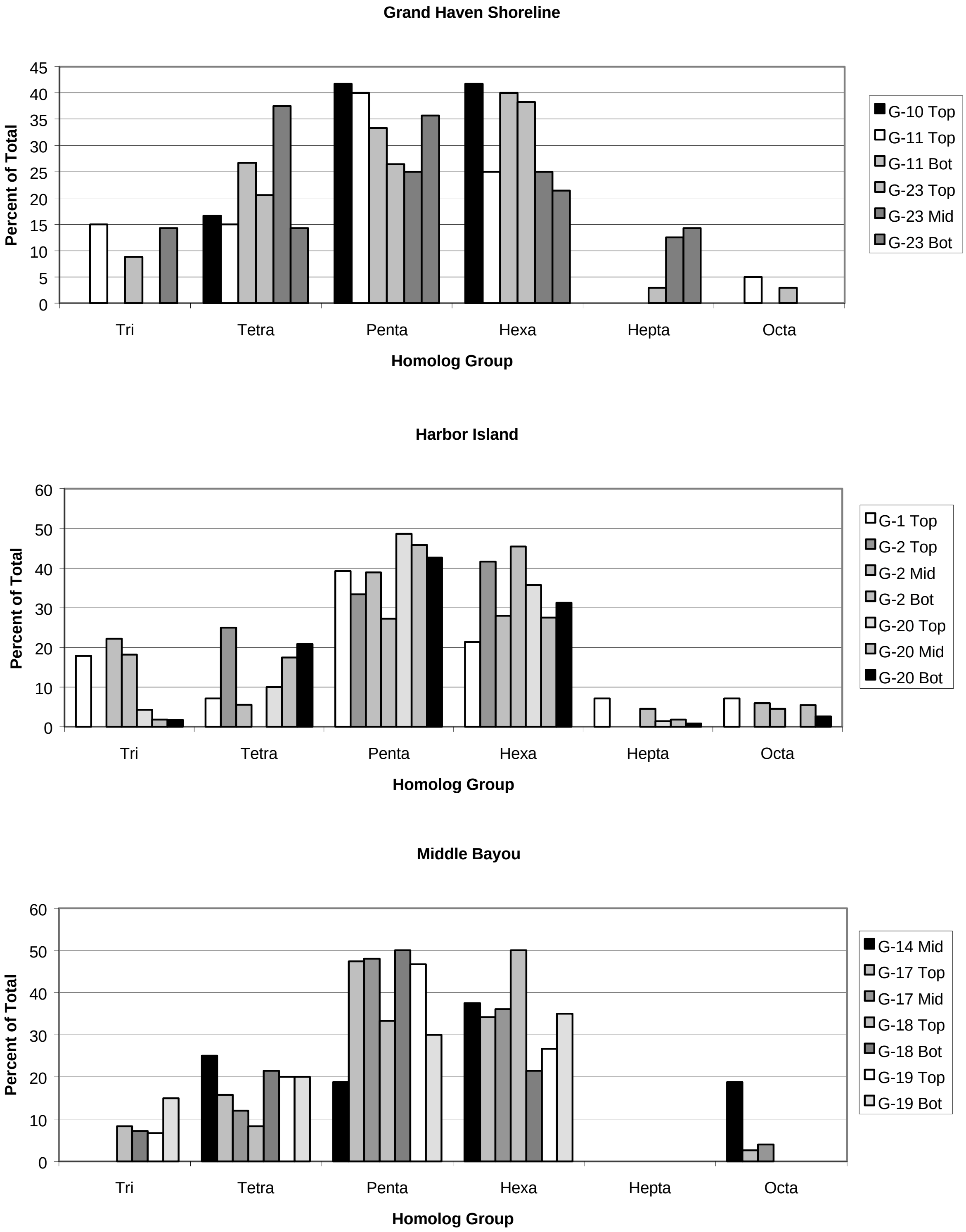
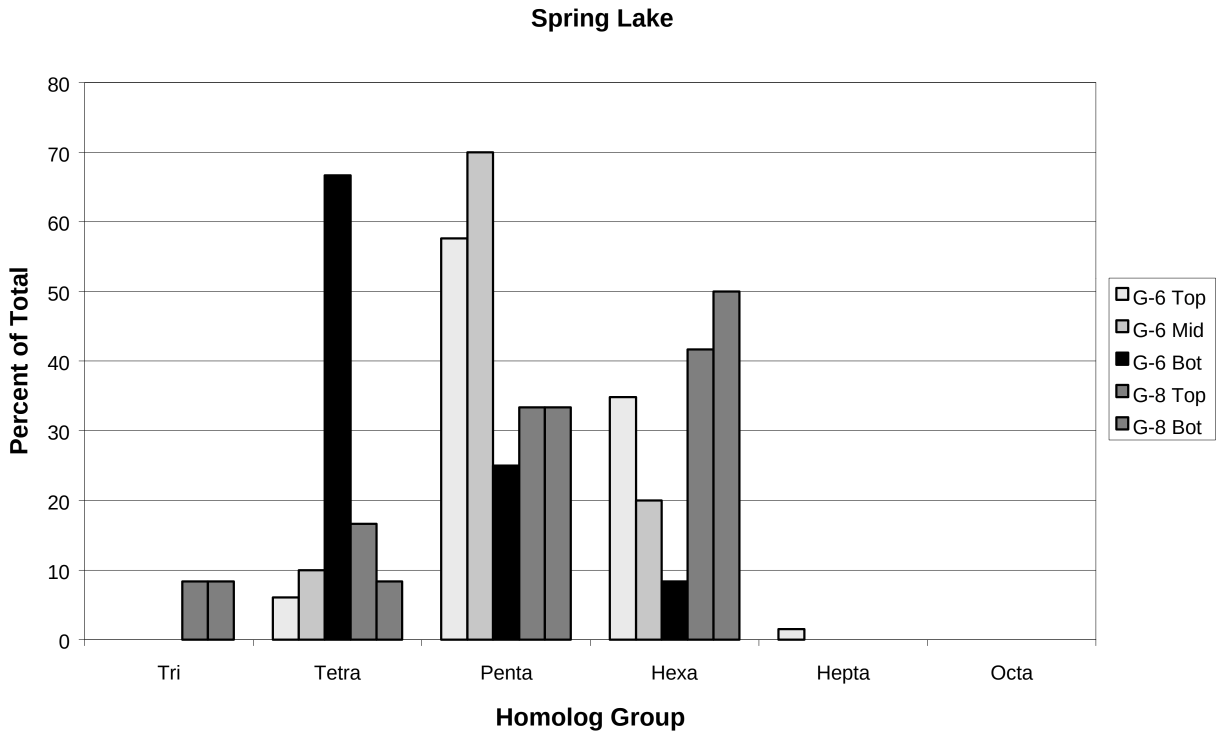


Figure 4.5.7 PCB Congener Distribution For Grand Haven Shoreline, Harbor Island, And Middle Bayou Regions Of The Lower Grand River, October 1997.



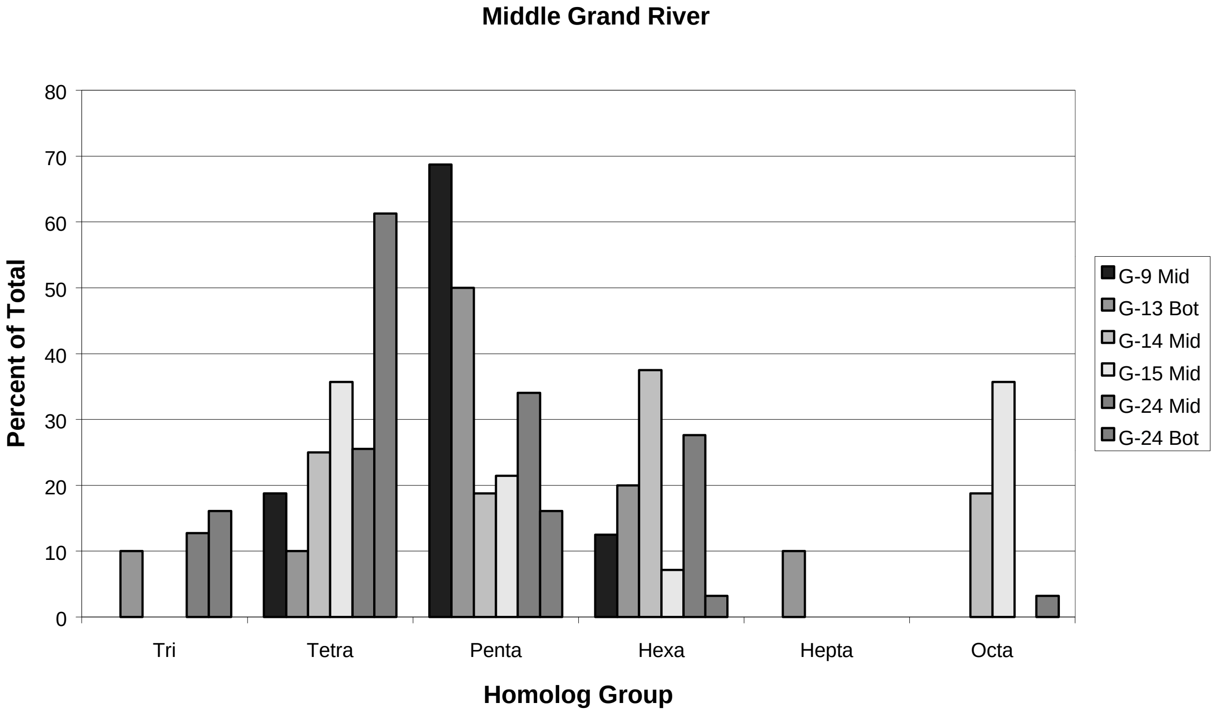
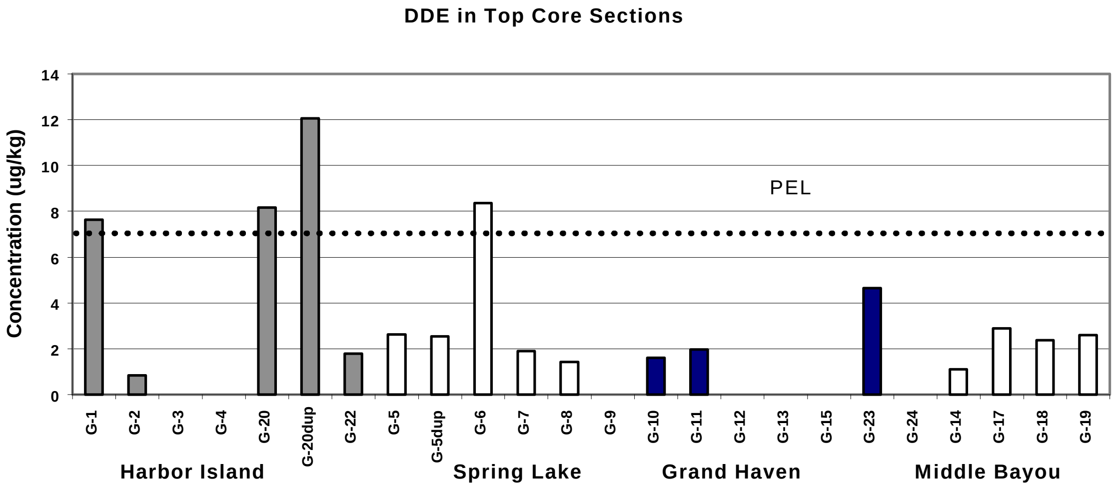
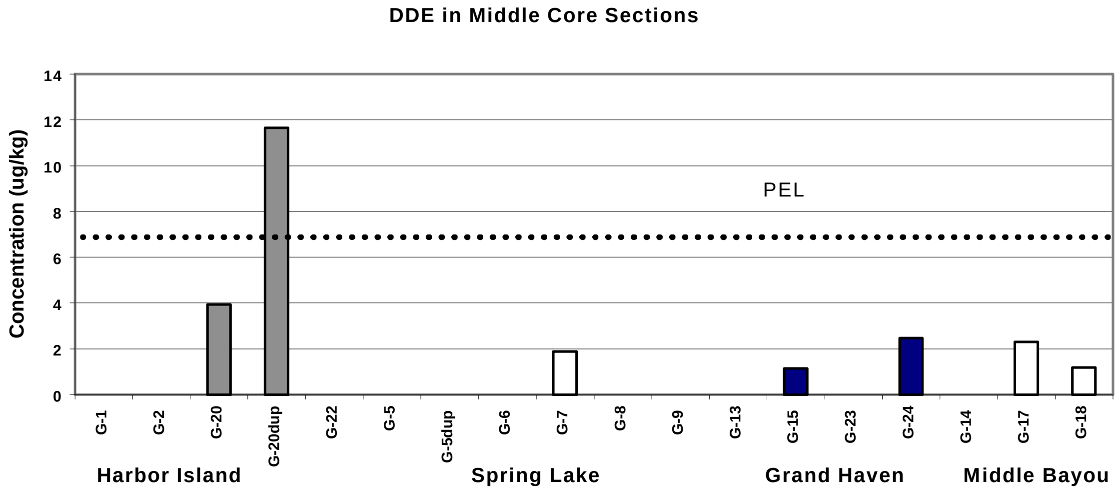


Figure 4.5.8 PCB Congener Distribution For The Spring Lake And Middle Regions Of The Lower Grand River, October 1997.





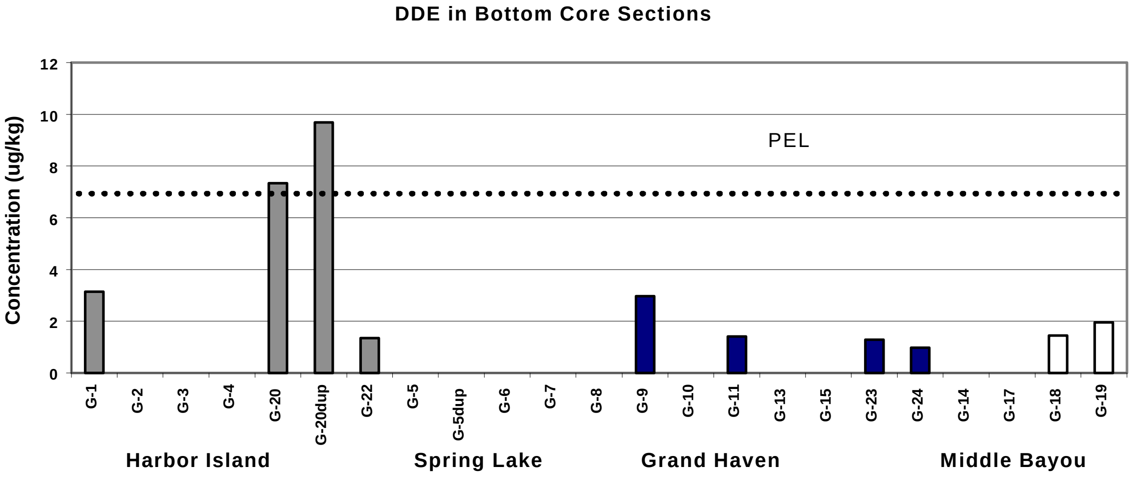


Figure 4.5.9 **DDE Concentrations In Core Samples Taken From The Lower Grand River, October 1997. (PEL = Probable Effect Level).**

The extent of contaminated sediments in the vicinity of G12 (near the Grand Haven tannery) appear to be localized in a small area. Additional sampling and analysis would be necessary to characterize the extent of sediment contamination in the areas around Harbor Island and Spring Lake.

Meander core islands appear to play a significant role in the lower Grand River with respect to the deposition of contaminated sediments. Pockets of contaminated sediments were found at the downstream tip of Harbor Island (G20), and the unnamed islands near G24 and G17. These areas serve as sediment deposition zones and indicate the effects of historical discharges of metals and organic chemicals to the lower Grand River. High water events however can transport contaminated sediments from these deposits and increase the contaminant loading to Lake Michigan. Robertson (1997) itemized suspended sediment loadings from the major tributaries to Lake Michigan and found that the Grand River was the major source of suspended sediment entering the lake. He estimated that the Grand River contributed 20% of Lake Michigan's sediment loading during normal flow and during flood events. Since metals and organic chemicals are associated with the suspended sediment load, the role of the meander core deposits in contaminant transport needs to be examined in detail. The resuspension and transport of sediment deposits at meander core islands may be a significant factor that contributed to the high loading of contaminants from the Grand River during the Lake Michigan Mass Balance Study (Shaffer, et al., 1995; Hall and Behrendt, 1995; and Cowell, et al., 1995).

4.6 Metals Normalization

Loring (1991) and Schropp et al. (1990) used aluminum to normalize estuarine sediments for the assessment of anthropogenic enrichment of heavy metals. The concentration of aluminum in sediments is directly related to clay content. Clay minerals are produced by the weathering of aluminosilicate minerals that contain background concentrations of heavy metals. In contrast, trace metals are not typically associated with carbonate and quartz based minerals. Based on this relationship, the background concentration of trace metals will increase with the amount of clay minerals present. Loring and Schropp both found that levels of heavy metals such as chromium and lead increased as part of the natural background as the sediments contained greater concentrations of clay minerals. Aluminum was used by both authors to indicate the amount of clay minerals present.

The metals analyses were performed using a hydrofluoric acid digestion (total metals) procedure that dissolves the aluminosilicate crystal lattice. To determine the relationship between aluminum heavy metals in the sediments of the lower Grand River, a group of samples from the middle and bottom core sections was examined. Sediments from the meander core islands were removed from the data set because the anthropogenic enrichment discussed in sections 4.4 and 4.5. The remaining data were plotted in Figures 4.6.1 and 4.6.2 for chromium and lead respectively. Significant correlations between aluminum and chromium and aluminum and lead were obtained (r = 0.73 and r = 0.75 respectively). Based on these relationships, the natural background concentration of chromium would increase from 12 mg/kg to 60 mg/kg as the aluminum concentration increased. Lead would follow a similar pattern and increase within a range of 2 mg/kg to 9 mg/kg.

The regression lines for the relationship between aluminum and chromium are plotted along with all of the sample data in Figure 4.6.3. The data for lead and aluminum are plotted in a similar manner in Figure 4.6.4. These figures show that considerable anthropogenic enrichment has occurred for both elements based on the number of samples above the regression line. Two distinct clusters of data are present in the diagrams for each metal. The data for chromium shows a small cluster of data points above 400 mg/kg and a larger group above between 60 mg/kg and 400 mg/kg. The cluster of high level samples come from suspected point source areas such as Spring Lake, the Grand Haven tannery, and Harbor Island. The lower level data group includes the sediment deposition zone near meander core islands and downstream areas from the point sources. Lead follows a similar pattern with a high level cluster between 100 mg/kg and 200 mg/kg and a lower level cluster between 10 mg/kg and 100 mg/kg. The locations for the high level cluster are again associated with potential point sources. Enrichment by lead appears to have occurred to a greater extent than for chromium. This pattern is consistent with the fact that anthropogenic lead can originate from point sources and from non point sources such as urban runoff and fuel releases from boat traffic. The normalization of heavy metal data with aluminum therefore appears to provide a means to determine the extent of anthropogenic enrichment in sediments.

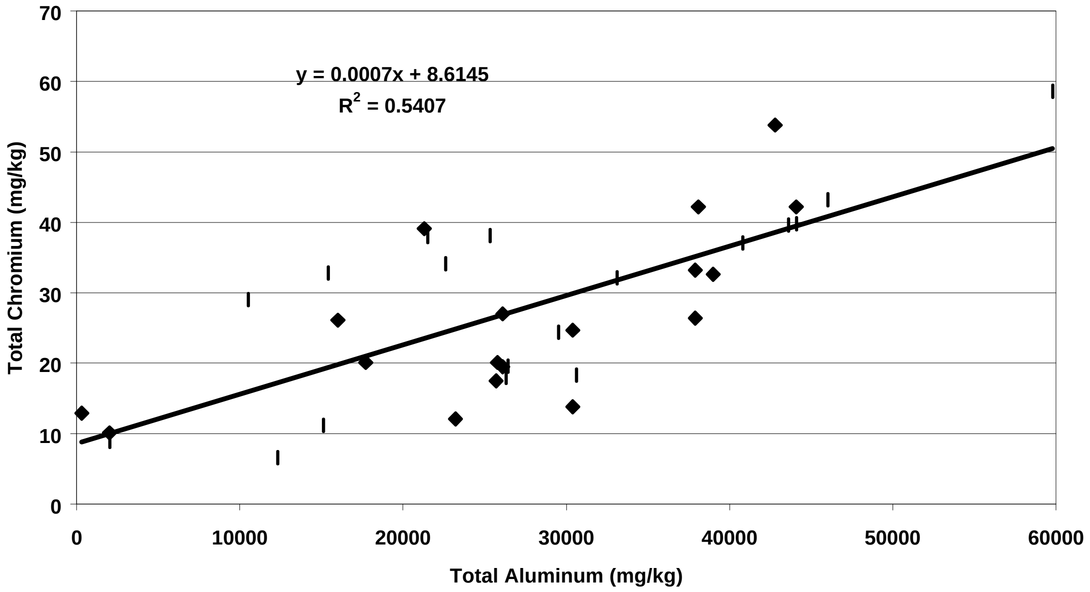


Figure 4.6.1 **The Relationship Between Aluminum And Chromium In Grand River Core Samples (Middle And Bottom Core Sections Without Significant Anthropogenic Enrichment), October 1997.**

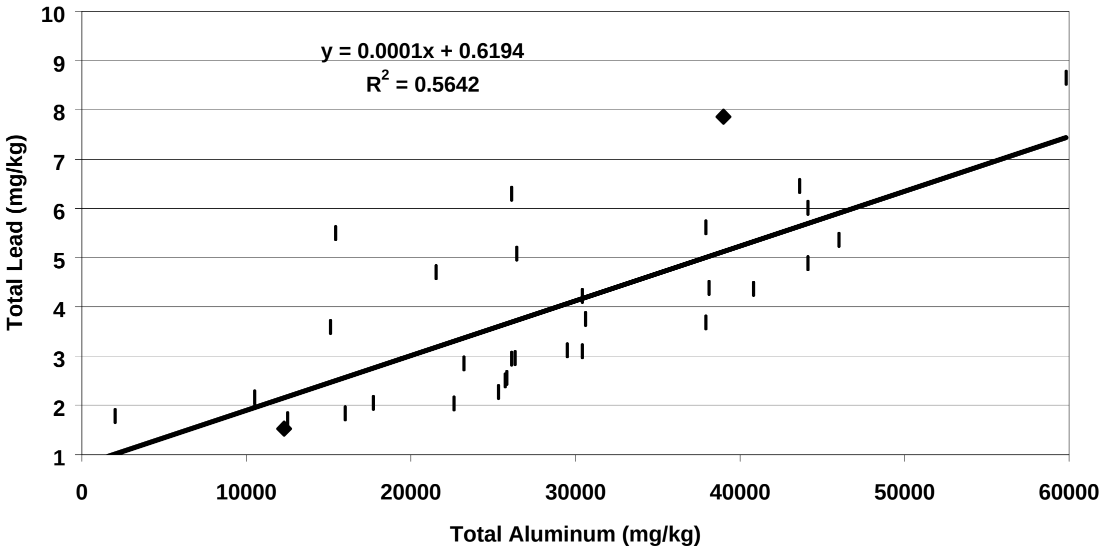


Figure 4.6.2 **The Relationship Between Aluminum And Lead In Grand River Core Samples (Middle And Bottom Core Sections Without Significant Anthropogenic Enrichment), October 1997.**

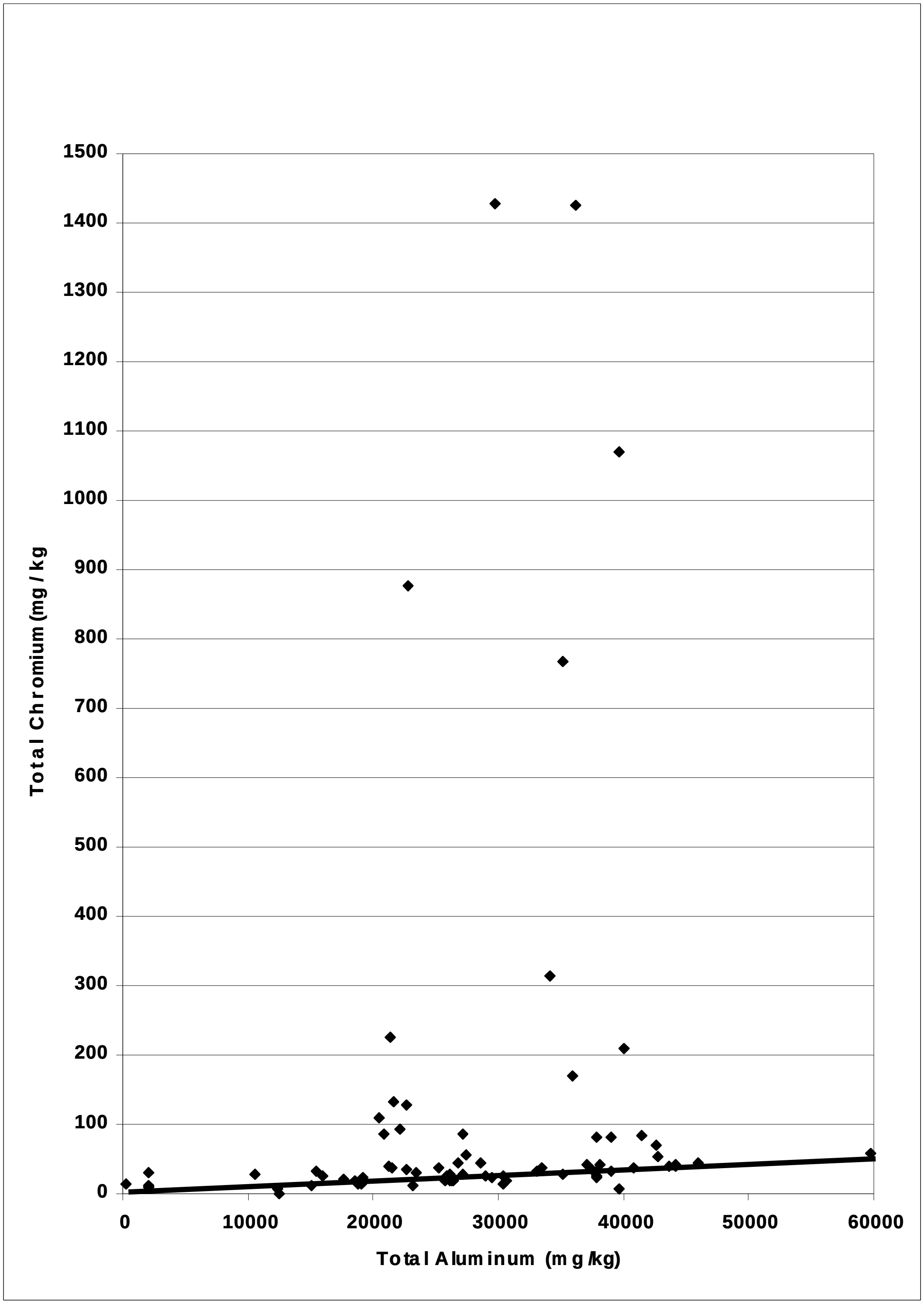


Figure 4.6.3 The Relationship Between Aluminum And Chromium In Grand River Core Samples (Regression Line Is From Figure 4.6.1), October 1997.

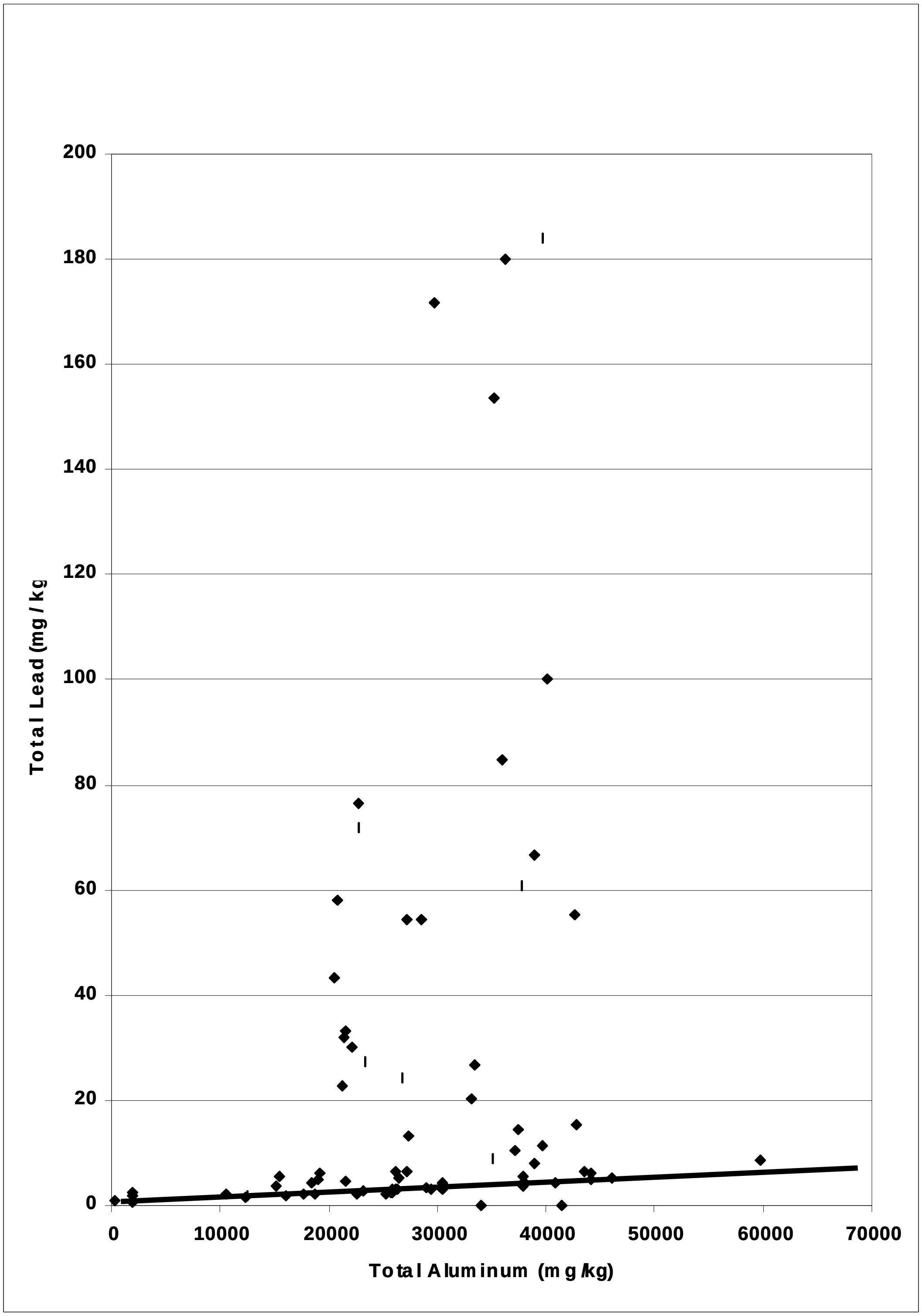


Figure 4.6.4 The Relationship Between Aluminum And Lead In Grand River Core Samples (Regression Line Is From Figure 4.6.2), October 1997.

4.7 Toxicity Testing Results

Toxicity evaluations of the Grand River sediments were initiated on May 12, 1998 and completed on May 23, 1998. Sediment toxicity was evaluated using *Hyalella azteca* and *Chironomus tentans*. Ponar samples were collected at five locations (with one duplicate) on April 22, 1998. These locations were selected based on the sediment chemistry results for the core samples. The results of the inorganic chemical analyses on the sediments selected for toxicity testing are presented in Table 4.7.1. The organic analytical results are given in Table 4.7.2. Composite sediment samples collected on the same day from six different sites were employed in exposing both H. azteca and C. tentans over this period.

Table 4.7.1 Inorganic Results For The Ponar Samples Collected For Sediment Toxicity Evaluation From The Lower Grand River, April 1998.

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G5P (Control)	9	1.6	13	53	0.41	35	77	<0.5	185
G6P	22	1.1	129	62	0.40	34	67	<0.5	191
G7P	21	1.1	82	70	0.35	33	61	<0.5	181
G12P	16	2.8	890	111	0.26	43	54	<0.5	177
G20P	15	2.8	70	352	0.18	29	55	<0.5	192
G20P Dup	15	1.4	87	340	0.24	35	54	<0.5	134

Table 4.7.2 Organic Results For The Ponar Samples Collected For Sediment Toxicity Evaluation From The Lower Grand River, April 1998.

Station	Total PCBs	DDE	DDD	DDT	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(a) pyrene
	ug/kg	ug/kg	ug/kg	ug/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G5P (Control)	38	3	<1.0	4	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
G6P	36	12	<1.0	5	1.45	<0.33	3.55	2.98	0.91	<0.33	0.84	0.69
G7P	43	9	<1.0	4	0.56	<0.33	0.41	<0.33	<0.33	<0.33	<0.33	<0.33
G12P	35	13	<1.0	2	1.65	0.49	3.75	3.11	1.34	0.95	0.73	0.81
G20P	29	3	<1.0	1	0.75	<0.33	1.20	1.10	0.43	0.51	0.35	0.37
G20P Dup	53	5	<1.0	<1.0	0.55	<0.33	1.35	1.22	0.39	0.65	0.42	0.33

Temperature and dissolved oxygen measurements were taken daily throughout the duration of the tests (Appendix D). The test beakers were maintained in a climate controlled room and little variation in temperature was observed. Dissolved oxygen remained above 40% saturation in both the H. azteca and C. tentans test beakers. Conductivity, hardness, ammonia and pH were determined at the beginning and on the tenth day of each test and these data are shown in Appendix D. With the exception of ammonia, these parameters remained relatively constant, with a variation of less than 50%, from initial to final measurements for both test species. Ammonia decreased overtime and was < 50% of the original concentration in all exposures.

4.7.1 Hyalella azteca

The evaluation of Grand River’s sediment began on May 12, 1998 and the resulting survival data are presented in Table 4.7.1.1 The survival in the control treatment exceeded the required 80%. Statistical analyses were performed on the toxicity data and the results are summarized in Tables 4.7.1.2, 4.7.1.3, and 4.7.1.4. Normality of the data was tested using the Chi-Square test for normality. The data passed the tests with an alpha value of 0.01. Dunnett’s Test showed a statistically significant (alpha = 0.05) difference on the survival data, in two out of six sediments when each was compared to the control (G5P). These samples were collected from Spring Lake (G6P) and near the Grand Haven Tannery (G12P). Using Steel’s many-one rank test (Table 4.7.1.4), sample G12P was determined to be more toxic to amphipods than the other samples.

Table 4.7.1.1 Summary Of *Hyalella azteca* Survival Data Obtained During The 10 Day Toxicity Test With Grand River Sediments.

Sample	Number of	Replicate								Survival		
ID	Organisms	A	B	C	D	E	F	G	H	Mean	Std Dev	C.V.%
G5-P	Initial	10	10	10	10	10	10	10	10			
	Final	10	9	8	10	8	10	8	8	8.875	0.9910	11.1665
G6-P	Initial	10	10	10	10	10	10	10	10			
	Final	9	8	9	10	7	9	8	8	8.50	0.92582	10.8920
G7-P	Initial	10	10	10	10	10	10	10	10			
	Final	9	8	8	8	9	6	8	9	8.125	0.99103	12.1973
G12-P	Initial	10	10	10	10	10	10	10	10			
	Final	6	7	7	7	9	7	6	9	7.25	1.1650	16.0685
G20-P	Initial	10	10	10	10	10	10	10	10			
	Final	9	8	7	6	8	7	8	7	7.50	0.92582	12.3443
G20-P DUP	Initial	10	10	10	10	10	10	10	10			
	Final	8	8	7	8	9	8	8	7	7.875	0.6409	8.1380

Table 4.7.1.2 Chi-Square Test For Normality Of *Hyalella azteca* Survival Data.

CHI-SQUARE TEST FOR NORMALITY

	Actual and Expected Frequencies				
INTERVAL	<-1.5	-1.5 to <-0.5	-0.5 to 0.5	>0.5 to 1.5	>1.5
EXPECTED	3.2160	11.6160	18.3360	11.6160	3.2160
OBSERVED	3	14	14	12	5

Chi-Square = 2.5315 (p-value = 0.6390)

Critical Chi-Square = 13.277 (alpha = 0.01, df = 4)
= 9.488 (alpha = 0.05, df = 4)

Data PASS normality test (alpha = 0.01).

Table 4.7.1.3 Dunnett's Test For *Hyalella azteca* Survival Data.

DUNNETT'S TEST - Ho:Control<Treatment

GROUP	IDENTIFICATION	MEAN	T STAT	SIG 0.05
1	G5P (Control)	8.8750		
2	G6P	7.5000	2.8864	*
3	G7P	8.1250	1.5744	
4	G12P	7.2500	3.4112	*
5	G20P	8.5000	0.7872	
6	G20P Dup	7.8750	2.0992	

Dunnett critical value = 2.3100 (1 Tailed, alpha = 0.05, df [used] = 5,40)
(Actual df = 5,42)

Table 4.7.1.4 Steel's Many-One Rank Test For *Hyalella azteca* 10 Day Toxicity Test With Grand River Sediments.

STEEL'S MANY-ONE RANK TEST- Ho: Control<Treatment

GROUP	IDENTIFICATION	MEAN IN ORIGINAL UNITS	RANK SUM	CRIT. VALUE	DF	SIG 0.05
1	G5P (Control)	8.8750				
2	G6P	7.5000	46.50	46.00	8.00	
3	G7P	8.1250	57.50	46.00	8.00	
4	G12P	7.2500	45.00	46.00	8.00	*
5	G20P	8.5000	62.00	46.00	8.00	
6	G20P Dup	7.8750	50.50	46.00	8.00	

Critical values are 1 tailed (k = 5)

4.7.2 *Chironomus tent*ans

The midge survival data are presented in Table 4.7.2.1. The survival in the control treatment exceeded the required 70%. There were no low survival (≤ 50%) noted in the Grand River sediments for C. tentans. Statistical analyses were performed on the toxicity data and the results are summarized in Table 4.7.2.2 and 4.7.2.3. Un-transformed survival data were evaluated for normality with Chi-squares test for normality at alpha = 0.01. These data were then analyzed for effects on survival employing Dunnett's Test. No statistically significant (alpha = 0.05) differences from the control (G5P) were observed in the sediments.

4.7.3 Summary

Statistically significant (alpha = 0.05) acute toxicity effects were observed in the sediments of samples G6-P and G12-P on the amphipod, H. azteca, by the Dunnett's test. Statistical significant (alpha = 0.05) acute toxicity effects were observed in the sediments at G12-P and G6-P for H. azteca. The PEL values for chromium and DDE were exceeded at G12-P. The PEL value for arsenic was exceeded at G7-P however statistically significant mortality was not observed. Statistically significant mortality was also not observed in assays using the midge, C. tentans in the Grand River sediments.

Table 4.7.2.1 Summary Of *Chironomus Tentans* Survival Data Obtained During The 10 Day Toxicity Test With Grand River Sediments.

Sample ID	Number of Organisms	Replicate								Survival		
		A	B	C	D	E	F	G	H	Mean	Std Dev	C.V.%
G5P	Initial	10	10	10	10	10	10	10	10			
	Final	9	10	9	8	9	10	9	10	9.250	0.7071	7.6444
G6	Initial	10	10	10	10	10	10	10	10			
	Final	9	10	9	8	10	9	8	9	9.000	0.7559	8.3992
G7P	Initial	10	10	10	10	10	10	10	10			
	Final	10	9	7	9	9	10	9	8	8.875	0.9910	11.1665
G12P	Initial	10	10	10	10	10	10	10	10			
	Final	9	8	10	9	9	10	9	9	9.125	0.6409	7.0232
G20P	Initial	10	10	10	10	10	10	10	10			
	Final	10	9	10	10	9	9	10	9	9.500	0.5345	5.6266
G20P Dup	Initial	10	10	10	10	10	10	10	10			
	Final	10	10	9	7	9	8	9	10	9.000	1.0690	11.8783

Table 4.7.2.2 Chi-Square Test For Normality Of *Chironomus tentans* Survival Data.

CHI-SQUARE TEST FOR NORMALITY

	Actual and Expected Frequencies				
INTERVAL	<-1.5	-1.5 to <-0.5	-0.5 to 0.5	>0.5 to 1.5	>1.5
EXPECTED	3.2160	11.6160	18.3360	11.6160	3.2160
OBSERVED	4	8	20	16	0

Chi-Square = 6.3383 (p-value = 0.1753)

Critical
Chi-Square= 13.277 (alpha = 0.01, df = 4)
= 9.488 (alpha = 0.05, df = 4)

Data PASS normality test (alpha = 0.01).

Table 4.7.2.3 Dunnett's Test For *Chironomus tentans* Survival Data.

DUNNETT'S TEST - Ho:Control<Treatment

GROUP	IDENTIFICATION	MEAN	T STAT	SIG 0.05
1	G5P (control)	9.2500		
2	G6P	9.0000	0.6207	
3	G7P	8.8750	0.9311	
4	G12P	9.1250	0.3104	
5	G20P	9.5000	-0.6207	
6	G 20P Dup	9.0000	0.6207	

Dunnett critical value = 2.3100 (1 Tailed, alpha = 0.05, df [used] = 5,40)
(Actual df = 5,42)

5.0 Summary

A preliminary investigation of the nature and extent of sediment contamination in the lower Grand River was performed. Three areas in the lower Grand River exceeded sediment quality guidelines for heavy metals and selected organic chemicals. The locations and parameters of concern are listed below:

Harbor Island (G20).	Exceeds sediment PEL values for chromium, lead, nickel, and DDE in the top core section. Deeper core sections were extensively contaminated with heavy metals.
Spring Lake (G6).	Exceeds sediment PEL values for chromium, lead, cadmium, nickel, and DDE.
Grand Haven (G12).	Exceeds sediment PEL values for chromium and nickel. The sediments at this location exhibited a statistically significant level toxicity to amphipods when compared to the control.

The extent of contaminated sediments in the vicinity of G12 (near the Grand Haven tannery) appears to be localized in a small area. Some additional sampling of this area would be necessary to define the extent of the contaminated sediments. The results for Spring Lake and Harbor Island show these areas to be contaminated with heavy metals and selected organic compounds. Additional sampling and analysis would be necessary to characterize the extent of sediment contamination in the areas around Harbor Island and Spring Lake.

Meander core islands appear to play a significant role in the lower Grand River with respect to the deposition of contaminated sediments. Pockets of contaminated sediments were found at the downstream tip of Harbor Island (G20), and the unnamed islands near G24 and G17. These areas serve as sediment deposition zones and indicate the effects of historical discharges of metals and organic chemicals to the lower Grand River. High water events however can transport contaminated sediments from these deposits and increase the contaminant loading to Lake Michigan. Since metals and organic chemicals are associated with the suspended sediment load, the role of the meander core deposits in contaminant transport needs to be examined in detail. This investigation examined three of the 12 meander core islands that are located in the lower Grand River.

The normalization of heavy metal data with aluminum was examined for chromium and lead. Statistically significant correlations between these elements were determined in background samples ($r = 0.73$ and 0.75 for Cr and Pb respectively). Plots of the project data set demonstrate that anthropogenic enrichment of lead and chromium has occurred in a majority of the top and middle core sections.

Statistically significant (alpha = 0.05) acute toxicity effects were observed in the sediments of samples G6-P and G12-P on the amphipod, H. azteca, by the Dunnett's test. The PEL values for chromium and DDE were exceeded at G12-P. PEL values for arsenic and DDE were exceeded at G6-P. Statistically significant (alpha = 0.05) mortality was not seen on the midge, C. tentans in the Grand River sediments.

6.0 References

Anderson, D. J., Bloem, T. B., Blankenbaker, R. K., Stanko, T.A. 1999. Concentrations of polychlorinated biphenyls in the water column of the Laurentian Great Lakes: Spring 1993. *Journal of Great Lakes Research.* 25:160-169.

Bowman, D. W. 1995. Grand River at Grand Haven Michigan: U.S. Army Corps of Engineers Tier II Evaluation. June, 1995.

Cowell, S. E., Hurley, J. P., Schafer, M. M. and P. E. Hurley. 1995. Mercury partitioning and transport in Lake Michigan Tributaries. Presented at 38th Conference. International Association of Great Lakes Research.

Hall, D. W. and T. E. Behrendt. 1995. Polychlorinated byphenyls and pesticides in Lake Michigan tributaries, 1993-95. Presented at 38th Conference. International Association of Great Lakes Research.

Helmke, P. A., Koons, R. D., Schomberg, P. J. and I. K. Iskandar. 1977. Determination of trace element contamination of sediments by multielement analysis of clay-size fraction. Environ. Sci. Technol. 11:10:984-988. 23:200-208.

Long, E. R., and Morgan, L. G. 1990. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.* NOAA Technical Momorandum NOS OMA 52, Seattle, WA.

Loring, D. H. 1991. Normalization of heavy-metal data from estuarine and coastal sediments. ICES J. Mar. Sci. 48:101-115.

Persaud, D., R. Jaagumagi, and A. Hayton. 1992. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.* ISBN 0-7729-9248-7. Ontario Ministry of the Environment, Toronto, Canada, 23 p.

Robertson, D. M. 1997. Regionalized loads of suspended sediment and phosphorus to Lakes Michigan and Superior-High flow and long –term average. *Journal of Great Lakes Research.* 23:416-439.

Schropp, S. J. and H. L. Windom. 1988. A Guide to the Interpretation of Metal Concentrations in Estuarine Sediments. Florida Department of Environmental Regulation Coastal Zone Management Section.

Schropp, S. J., Lewis, F. G., Windom, H. L. Ryan, J. D., Calder, F. D. and L. C. Burney 1990. Interpretation of metal concentrations in estuarine sediments of Florida using aluminum as a reference element. Estuaries 13(3):227-235.

Shaffer, M. M., Overdier, J. T., Baldino, R. A., Hurley, J. P. and P. E. Hughes. 1995. Levels, partitioning, and fluxes of six trace elements in Lake Michigan tributaries. Presented at 38th Conference. International Association of Great Lakes Research.

Smith, S. L., D. D. MacDonald, K. A. Keenleyside, C. G. Ingersoll, and L. J. Field. 1996. A preliminary evaluation of sediment quality assessment values for freshwater sediments. J. Great Lakes Res., 22(3): 624-638.

Thorpe, P. 1994. *The Identification Of Heavy Metals, Their Movement, and their Impact on Life in The Lower Grand River, Michigan.*, 1992 Summary Report (WRI-MR-94-2). 68pp.

USEPA, 1992. *Sediment Classification Methods Compendium.* U.S. Environmental Protection Agency. EPA/823/R-92/006.

Appendix A

Summary Of General Chemistry And Metals Data For Sediments Collected From The Lower Grand River

Table A-1 Grain Size Distribution, Total Organic Carbon (TOC) And % Solids For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

	>2000 *u*m	200-1000 *u*m	100-850 *u*m	850-500 *u*m	500-125 *u*m	125-63 *u*m	<63 *u*m	TOC	Solids
Sample ID	**Weight %**	**Weight%**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**%**	**%**
G-1 Top	1	1	0	2	36	25	35	2.5	41
G-1 Mid	0	0	0	0	17	18	64	8	30
G-1 Bot	0	0	0	1	11	13	75	6.4	33
G-2 Top	3	1	0	2	70	9	14	<1.0	66
G-2 Mid	0	0	0	1	52	19	26	1.5	50
G-2 Bot	2	1	0	4	67	13	13	<1.0	62
G-3 Top	0	0	0	3	52	20	24	5.4	43
G-3 Bot	0	1	0	1	54	19	25	3.5	52
G-10 Top	0	4	2	5	57	18	13	5.2	42
G-10 Bot	0	1	0	2	51	13	32	5.3	46
G-11 Top	1	2	0	2	39	10	47	4.1	45
G-11 Bot	0	3	1	2	29	11	54	5.1	52
G-12 Top	4	2	1	4	45	7	37	2.8	50

Table A-1 (continued). Grain Size Distribution, Total Organic Carbon (TOC) And % Solids For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

	>2000 *u*m	**200-1000 *u*m**	**100-850 *u*m**	**850-500 *u*m**	**500-125 *u*m**	**125-63 *u*m**	**<63 *u*m**	**TOC**	**Solids**
Sample ID	**Weight %**	**Weight%**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**%**	**%**
G-20 Top	1	0	0	1	28	16	53	4.1	37
G-20 Mid	1	1	0	1	16	13	68	5.6	37
G-20 Bot	0	0	0	0	11	16	72	5.9	41
G-20D Top	1	1	0	1	35	14	48	3.8	39
G-20DMid	2	1	0	1	17	13	65	4.9	38
G-20D Bot	0	0	0	0	11	15	73	5.4	40
G-23 Top	0	7	4	8	49	15	16	10	33
G-23 Mid	0	1	1	4	45	14	36	10	37
G-23 Bot	0	1	0	3	84	4	9	<1.0	73
G-24 Top	0	1	0	3	90	3	2	<1.0	73
G-24 Mid	0	0	0	3	87	8	1	<1.0	64
G-24 Bot	1	1	1	5	67	5	21	1.2	72
G-4 Top	0	1	0	2	52	14	30	1.7	64
G-4 Bot	0	0	0	1	50	12	37	<1.0	68

Table A-1 (continued). Grain Size Distribution, Total Organic Carbon (TOC) And % Solids For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

	>2000 *u*m	**200-1000 *u*m**	**100-850 *u*m**	**850-500 *u*m**	**500-125 *u*m**	**125-63 *u*m**	**<63 *u*m**	**TOC**	**Solids**
Sample ID	**Weight %**	**Weight%**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**%**	**%**
G-5 Top	0	0	0	0	16	15	69	9.7	20
G-5 Mid	0	0	0	1	7	13	78	9.3	18
G-5 Bot	0	0	0	0	3	5	91	7.5	27
G-5D Top	0	0	0	0	14	16	69	9.2	20
G-5D Mid	0	0	0	1	10	14	76	10.3	20
G-5D Bot	0	0	0	0	5	9	86	7.4	29
G-6 Top	0	0	0	0	5	8	88	5.7	24
G-6 Mid	0	0	0	0	10	15	75	8.1	25
G-6 Bot	0	0	0	0	10	18	71	6.2	27
G-7 Top	1	0	0	0	12	18	69	8.6	18
G-7 Mid	0	0	0	1	8	12	78	5	28
G-7 Bot	0	0	0	2	5	8	84	3.5	35

Table A-1 (continued). Grain Size Distribution, Total Organic Carbon (TOC) And % Solids For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

	>2000 *u*m	200-1000 *u*m	100-850 *u*m	850-500 *u*m	500-125 *u*m	125-63 *u*m	<63 *u*m	TOC	Solids
Sample ID	**Weight %**	**Weight%**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**%**	**%**
G-8 Top	1	1	1	2	18	27	51	4.1	39
G-8 Mid	0	1	0	0	29	30	40	1.7	61
G-8 Bot	1	0	0	3	29	20	46	<1.0	57
G-9 Top	0	1	0	2	27	23	47	4.1	48
G-9 Mid	0	0	0	1	37	20	42	2.4	57
G-9 Bot	0	0	0	1	18	23	58	1.8	54
G-13 Top	0	1	1	2	51	18	26	2.4	52
G-13 Bot	0	1	0	1	15	24	59	2.6	45
G-13-2	2	1	0	2	41	16	37	1.6	53
G-13-3	0	0	0	2	29	21	47	<1.0	57
G-22 Top	0	1	0	2	34	17	45	5.5	25
G-22-2	0	0	0	2	17	14	67	5	28
G-22-3	0	0	0	2	13	15	69	4.9	24
G-22-4	0	0	1	2	12	13	72	7.6	29
G-22-5	0	0	1	2	11	11	76	8.3	28

Table A-1 (Continued). Grain Size Distribution, Total Organic Carbon (TOC) And % Solids For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

Sample ID	>2000 *u*m Weight %	200-1000 *u*m Weight%	100-850 *u*m Weight %	850-500 *u*m Weight %	500-125 *u*m Weight %	125-63 *u*m Weight %	<63 *u*m Weight %	TOC %	Solids %
G-14 Top	1	3	1	4	27	19	46	<1.0	49
G-14 Mid	4	1	1	3	25	15	51	<1.0	52
G-14 Bot	1	2	1	4	24	18	50	<1.0	45
G-15 Top	1	1	1	4	60	12	21	1	57
G-15 Mid	4	5	2	12	54	2	22	<1.0	74
G-15 Bot	6	7	3	16	65	1	2	<1.0	76
G-16	22	7	2	9	55	4	1	<1.0	73
G-17 Top	2	6	4	13	43	8	24	3.5	45
G-17 Mid	0	1	0	3	81	7	7	1.3	48
G-17 Bot	7	4	1	6	48	9	25	2	46
G-18 Top	0	0	0	1	90	8	0	<1.0	71
G-18 Mid	0	0	0	1	77	9	13	1.2	77
G-18 Bot	0	0	0	0	96	2	1	<1.0	69
G-19 Top	2	1	0	1	73	8	16	<1.0	54
G-19 Bot	2	1	0	1	66	20	10	1.2	52

Table A-2. Grain Size Distribution, Total Organic Carbon (TOC) And % Solids For The Ponar Samples Collected In The Lower Grand River. April 1998.

	>2000 *u*m	**200-1000 *u*m**	**100-850 *u*m**	**850-500 *u*m**	**500-125 *u*m**	**125-63 *u*m**	**<63 *u*m**	**TOC**	**Solids**
Sample ID	**Weight %**	**Weight%**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**%**	**%**
G-5P	0	0	0	0	22	11	67	8.5	22
G-6P	0	0	0	0	6	10	84	4.3	21
G-7P	1	0	0	0	12	22	65	7.3	17
G-12P	4	3	2	5	40	15	31	3.9	45
G-20P	1	0	0	1	28	16	53	5.1	32
G-20P Dup	1	0	1	1	33	13	50	4.7	36

Table A-3. Results Of Laboratory Duplicate Analyses For Grain Size Distribution And % Solids For The Lower Grand River Sediment Samples.

	>2000 *u*m	**200-1000 *u*m**	**100-850 *u*m**	**850-500 *u*m**	**500-125 *u*m**	**125-63 *u*m**	**<63 *u*m**
Sample ID	**Weight %**	**Weight%**	**Weight %**	**Weight %**	**Weight %**	**Weight %**	**Weight %**
G-2 Bot	2	1	0	4	67	13	13
G-2 Bot Dup	1	1	0	3	65	16	14
G-20 Top	1	0	0	1	28	16	53
G-20 Top Dup	0	1	0	1	31	16	51
G-24 Mid	0	0	0	3	87	8	1
G-24 Mid Dup	0	0	0	1	80	11	7
G-6 Top	0	0	0	0	5	8	88
G-6 Top Dup	0	0	0	0	3	12	85
G-7 Top	1	0	0	0	12	18	69
G-7 Top Dup	7	0	0	0	12	18	62
G-8 Bot	1	0	0	3	29	20	46
G-8 Bot Dup	1	0	0	2	29	21	47
G-16	22	7	2	9	55	4	1
G-16 Dup	20	4	1	11	50	9	5
G-19 Bot	2	1	0	1	66	20	10
G-19 Bot Dup	4	3	0	3	59	23	8

Table A-4. Results Of Laboratory Duplicate Analyses For TOC In The Lower Grand River Sediment Samples.

Field ID	TOC % wt.	RPD %
G-3 Bot	3.5	
G-3 Bot Dup	3.9	11%
G-20 Bot	5.9	
G-20 Bot Dup	5.3	11%
G-5 Mid	9.3	
G-5 Mid Dup	9.1	2%
G-5 Bot	7.4	
G-5 Bot Dup	7.5	1%
G-22-2	5.0	
G-22-2 Dup	4.8	4%
G-13 Bot	2.6	
G-13 Bot Dup	2.8	7%
G-15 Top	1.0	
G-15 Top Dup	1.2	18%
G-17 Bot	2.0	
G-17 Bot Dup	1.5	29%
G6-P	7.3	
G6-P Dup	8.0	9%

Table A-5 Metals Results For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

Field	Concentration, mg/kg														
Sample ID	Al	As	Ba	Ca	Cd	Cr	Cu	Hg	Fe	Mg	Mn	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-1 Top	27200	10	315	77800	0.56	29	14	0.14	17029	11700	335	42	6	0.39	70
G-1 Mid	38100	12	327	82500	0.37	42	14	< 0.10	26486	18300	431	23	4	0.34	72
G-1 Bot	37900	10	323	92000	0.35	26	14	< 0.10	26453	18400	464	18	6	0.55	58
G-2 Top	19000	3.3	318	19700	0.25	13	7	< 0.10	5867	4040	126	13	5	0.11	39
G-2 Mid	33100	9.2	389	51400	0.28	32	12	0.40	18009	10300	372	15	20	0.34	49
G-2 Bot	23200	4.2	323	32300	0.13	12	5	< 0.10	11487	6980	298	9	3	0.17	18
G-3 Top	37500	5.5	362	29400	0.69	34	22	0.21	15507	6090	180	23	14	0.47	58
G-3 Bot	30400	6.2	366	29100	0.20	14	7	< 0.10	9119	8760	115	11	4	0.31	19
G-4 Top	37800	4.6	404	19100	0.18	24	6	< 0.10	12700	8180	152	8	4	0.32	30
G-4 Bot	12500	1.8	234	33500	0.03	5	1	< 0.10	2970	1280	97.5	< 5	2	0.03	2
G-5 Top	39700	8.4	328	44400	0.54	6	39	0.16	44400	12800	771	29	12	0.34	89
G-5 Mid	46000	6.5	347	56900	0.33	43	16	0.11	49200	15300	798	19	5	0.52	67
G-5 Bot	21500	5.1	352	37800	0.27	38	12	< 0.10	46100	15500	887	17	5	0.38	65
G-5D Top	41400	10	336	62300	0.98	83	53	0.24	40600	13100	780	37	5	0.49	105
G-5D Mid	44100	6.6	337	38800	0.33	42	17	< 0.10	53000	14600	923	21	5	0.43	81
G-5D Bot	44100	4.4	330	43100	0.29	40	13	< 0.10	46800	16300	888	20	6	0.46	59
G-6 Top	34100	17	355	39600	3.63	313	160	0.37	25900	14500	732	99	100	0.36	268
G-6 Mid	42800	8.0	386	42200	0.58	54	22	0.24	47200	16000	715	23	15	0.48	85
G-6 Bot	43600	5.3	374	45000	0.30	40	13	0.11	55800	17300	580	18	6	0.44	58
G-7 Top	59800	7.8	450	55600	0.45	59	20	0.11	70700	20800	1050	30	9	0.66	112
G-7 Mid	40800	4.5	320	83300	0.27	37	11	< 0.10	41400	16300	800	21	4	0.49	70
G-7 Bot	37900	5.2	327	96700	0.26	33	9	< 0.10	39800	16800	932	19	4	0.37	71
G-8 Top	25900	8.3	296	85900	0.16	26	8	< 0.10	18300	12800	373	14	3	0.21	40
G-8 Mid	26300	4.9	350	71400	0.11	18	3	< 0.10	10700	9810	242	8	3	0.18	21
G-8 Bot	25700	5.6	316	67900	0.12	18	4	< 0.10	12900	9970	265	9	3	0.24	26
G-9 Top	29000	9.8	291	78700	0.19	26	8	< 0.10	16700	12800	308	14	3	0.19	40
G-9 Mid	26100	6.0	303	70800	0.14	20	6	< 0.10	13100	10400	300	11	3	0.21	30
G-9 Bot	29500	6.4	334	81400	0.16	24	8	< 0.10	15900	12300	392	13	3	0.22	34

Table A-5 (continued) Metals Results For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

Field	Concentration, mg/kg													
Sample ID	Al	As	Ba	Ca	Cd	Cr	Cu	Hg	Fe	Mg	Mn	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-10 Top	37100	5.7	394	22000	0.48	42	35	0.16	13281	5900	232	18	11	0.27	71
G-10 Bot	39000	6.8	405	10600	0.33	33	14	< 0.10	15069	5800	155	20	8	0.25	39
G-11 Top	35100	9.3	420	38200	0.87	27	13	0.36	20695	12200	676	15	9	0.36	64
G-11 Bot	30600	8.4	363	41000	0.21	18	72	< 0.10	17400	10500	710	12	4	0.33	38
G-12 Top	22800	6.6	353	85000	1.55	877	100	0.42	12900	6950	357	59	72	0.88	183
G-13 Top	33500	8.7	354	31000	0.49	36	28	0.31	14800	6610	167	19	27	<0.5	79
G-13-2	26400	6.6	328	39900	0.13	20	6	< 0.10	11800	7490	235	12	5	<0.5	29
G-13-3	25800	7.4	297	62600	0.11	20	6	0.14	16500	11300	536	14	3	<0.5	31
G-13 Bot	30400	8.9	334	79400	0.16	25	8	< 0.10	19400	13800	718	15	3	<0.5	38
G-14 Top	500	12	184	257000	0.98	11	4	< 0.10	12700	8220	588	10	1	<0.5	16
G-14 Mid	319	16	201	231000	0.09	13	4	< 0.10	13100	7710	682	11	1	<0.5	18
G-14 Bot	450	8.1	155	226000	0.65	9	4	< 0.10	7910	6770	568	9	1	<0.5	12
G-15 Top	23400	7.3	283	44600	0.39	30	30	0.48	11000	5550	226	20	27	<0.5	72
G-15 Mid	15100	10	210	29500	0.09	11	4	0.13	12700	5410	264	10	4	<0.5	26
G-15 Bot	12300	8.6	211	28600	0.02	7	1	< 0.10	8860	4260	164	7	2	<0.5	10
G-16	18800	4.2	225	17900	0.06	14	2	< 0.10	9100	4860	176	15	2	<0.5	17
G-17 Top	22200	9.7	291	38900	1.83	92	65	< 0.10	15800	7880	56	32	30	<0.5	88
G-17 Mid	20500	6.2	344	26600	2.20	110	88	0.17	11900	5240	37	37	43	<0.5	130
G-17 Bot	17700	8.0	279	72200	0.14	20	4	< 0.10	19000	7820	104	15	2	<0.5	7
G-18 Top	18500	2.6	385	17700	0.14	20	7	< 0.10	5630	3630	20	12	4	<0.5	5
G-18 Mid	20800	6.0	406	27600	1.03	87	55	1.47	10300	6010	33	60	58	<0.5	210
G-18 Bot	15400	3.2	338	12800	0.65	33	15	< 0.10	5490	2780	22	17	6	<0.5	14
G-19 Top	19200	4.2	387	22400	0.23	24	8	< 0.10	9740	4510	37	14	6	<0.5	26
G-19 Bot	21300	5.3	412	31700	0.41	39	15	< 0.10	9910	5120	40	20	23	<0.5	69
G-20 Top	35900	10	391	61800	2.29	169	98	0.34	20100	11200	545	67	85	0.5	262
G-20 Mid	39700	14	437	72100	0.56	1071	267	1.44	24900	13500	586	166	184	0.56	855
G-20 Bot	29700	17	462	45500	1.18	1428	348	4.33	26900	15200	554	214	172	0.61	894
G-20D Top	40100	12	412	62400	2.66	209	141	0.41	21200	11600	585	79	100	0.4	311
G-20D Mid	35200	13	429	55400	0.48	768	233	1.27	24000	13200	590	149	154	0.55	668
G-20D Bot	36200	16	486	57700	0.99	1426	372	3.84	26100	15000	520	210	180	0.58	863

Table A-5 (Continued) Metals Results For The Sediment Core Samples Collected In The Lower Grand River. October 1997.

Field	**Concentration, mg/kg**														
Sample ID	Al	As	Ba	Ca	Cd	Cr	Cu	Hg	Fe	Mg	Mn	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-22 Top	26800	8.9	260	107000	0.58	44	23	0.22	19900	9940	403	37	24	0.27	88
G-22-2	10500	7.6	258	85700	0.20	29	10	< 0.10	22500	11700	502	15	2	0.24	48
G-22-3	16000	5.2	265	93300	0.20	26	9	< 0.10	24600	12600	570	15	2	0.22	49
G-22-4	22600	6.3	281	69800	0.23	34	12	< 0.10	31800	13400	648	19	2	0.4	58
G-22-5	25300	6.4	282	66300	0.25	38	12	< 0.10	34100	13500	590	18	2	0.26	62
G-23 Top	27400	12	336	25100	0.42	57	23	0.12	16100	5480	256	26	13	0.44	59
G-23 Mid	26100	9.9	306	22500	0.23	27	10	< 0.10	15700	5970	170	19	6	0.29	34
G-23 Bot	2000	3.8	277	<2000	0.04	10	2	< 0.10	3300	1490	129	9	2	BDL	3
G-24 Top	2000	2.3	286	<2000	0.21	31	8	< 0.10	3330	2760	79.8	18	2	0.04	3
G-24 Mid	21600	5.1	373	19400	1.34	134	58	0.35	8930	5190	203	58	33	0.41	110
G-24 Bot	21400	5.2	330	22900	1.47	226	71	0.19	9450	4790	214	77	32	0.18	111

Table A-6 Metals Results For The Ponar Samples Collected In The Lower Grand River. April 1998.

Field	**Concentration, mg/kg**														
Sample ID	Al	As	Ba	Ca	Cd	Cr	Cu	Hg	Fe	Mg	Mn	Ni	Pb	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
G-5P	22700	9	315	112000	1.6	13	53	0.41	21100	10500	773	35	77	<0.5	185
G-6P	39000	22	350	113000	1.1	129	62	0.40	24000	13000	1040	34	67	<0.5	191
G-7P	37800	21	355	126600	1.1	82	70	0.35	23800	12100	892	33	61	<0.5	181
G-12P	28600	16	300	61000	2.8	890	111	0.26	16100	8070	408	43	54	<0.5	177
G-20P	42600	15	373	95000	2.8	70	352	0.18	27000	13900	629	29	55	<0.5	192
G-20PD	27200	15	289	52800	1.4	87	340	0.24	15700	7660	200	35	54	<0.5	134

Table A-7. Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Aluminum Quality Control Data					Arsenic Quality Control Data			
Sample Location	Concentration mg/kg				Sample Location	Concentration mg/kg		
		% RPD	%R				% RPD	%R
G-1 Mid	38100				G-1 Top	10		
G-1 Mid Dup	36000	6%			G-1 Top Spk	12		64%
G-2 Bot	23200				G-1 Mid Dup	13	10%	
G-2 Bot Spk	59300		90%		G-2 Bot Spk	6.0		91%
G-3 Top	37500				G-3 Top	5.5		
G-3 Top Dup	35100	7%			G-3 Top Dup	5.8	6%	
G-11 Top	35100				G-11 Bot	8.4		
G-11 Top Spk	64900		75%		G-11 Bot Spk	9.8		69%
G-11 Bot	30600				G-12 Top	6.6		
G-11 Bot Spk	68100		94%		G-12 Top Dup	5.8	13%	
G-12 Top	22800				G-4 Top	4.6		
G-12 Top Dup	20900	9%			G-4 Top Spk	5.1		23%
G-20 Bot	29700				G-4 Bot	1.8		
G-20 Bot Spk	76400		117%		G-4 Bot Dup	2.7	44%	
G-20D Mid	35200				G-5D Mid	6.6		
G-20D Mid Spk	73300		95%		G-5D Mid Spk	8.0		70%
G-4 Top	37800				G-5D Bot	4.4		
G-4 Top Dup	31700	18%			G-5D Bot Dup	4.6	5%	
G-4 Bot	12500				G-7 Top	7.8		
G-4 Bot Dup	11600	7%			G-7 Top Spk	10.1		116%
G-5 Bot	21500				G-7 Mid	4.5		
G-5 Bot Spk	74100		132%		G-7 Mid Dup	3.9	14%	
G-5D Bot	44100				G-13 Top	8.7		
G-5D Bot Dup	30500	36%			G-13 Top Spk	10		84%
G-6 Top	34100				G-13 Bot	8.9		
G-6 Top Spk	77800		109%		G-13 Bot Dup	9.0	1%	
G-7 Mid	40800				G-14 Top	12		
G-7 Mid Dup	41800	2%			G-14 Top Spk	15		114%
G-7 Top	59800				G-14 Mid	16		
G-7 Top Dup	42700	33%			G-14 Mid Dup	14	13%	
G-13-2	26400				G-17 Top	9.7		
G-13-3 Spk	66200		100%		G-17 Top Spk	11		85%
G-15 Top	23400				G-17 Mid	6.2		
G-15 Top Spk	71600		120%		G-17 Mid Dup	5.0	21%	
G-17 Top	22200				G-6P	22		
G-17 Top Spk	67400		113%		G-6P Dup	20	12%	
G-5P	22700							
G-5P Dup	23600	4%						

Table A-7 (Continued). Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Barium Quality Control Data					Calcium Quality Control Data			
Sample	Concentration	% RPD	%R		Sample	Concentration	% RPD	%R
Location	mg/kg				Location	mg/kg		
G-1 Top	315				G-1 Mid	82500		
G-1 Top Spk	511		98%		G-1 Mid Dup	79500	4%	
G-1 Mid	327				G-2 Bot	32300		
G-1 Mid Dup	324	1%			G-2 Bot Spk	84600		131%
G-2 Bot	323				G-3 Top	29400		
G-2 Bot Spk	529		103%		G-3 Top Dup	28300	4%	
G-3 Top	362				G-11 Top	38200		
G-3 Top Dup	352	3%			G-11 Top Spk	81600		109%
G-11 Bot	363				G-11 Bot	41000		
G-11 Bot Spk	559		98%		G-11 Bot Spk	87400		116%
G-12 Top	353				G-12 Top	85000		
G-12 Top Dup	333	6%			G-12 Top Dup	74900	13%	
G-4 Top	404				G-20 Bot	45500		
G-4 Top Spk	539		68%		G-20 Bot Spk	96500		128%
G-4 Bot	234				G-20D Mid	55400		
G-4 Bot Dup	223	5%			G-20D Mid Spk	107800		131%
G-5D Mid	337				G-4 Bot	33500		
G-5D Mid Spk	541		102%		G-4 Bot Dup	60700	58%	
G-5D Bot	330				G-5 Bot	37800		
G-5D Bot Dup	363	10%			G-5 Bot Spk	91500		134%
G-7 Top	450				G-5D Bot	43100		
G-7 Top Spk	497	10%			G-5D Bot Dup	43500	1%	
G-7 Mid	320				G-6 Top	39600		
G-7 Mid Dup	316	1%			G-6 Top Spk	100200		152%
G-13 Top	354				G-7 Top	55600		
G-13 Top Spk	515		81%		G-7 Top Spk	42000	28%	
G-13 Bot	334				G-7 Mid	83300		
G-13 Bot Dup	348	4%			G-7 Mid Dup	85600	3%	
G-14 Top	184				G-13 Bot	79400		
G-14 Top Spk	255		36%		G-13 Bot Dup	81200	2%	
G-14 Mid	201				G-13-3	62600		
G-14 Mid Dup	148	30%			G-13-3 Spk	85200		57%
G-17 Top	291				G-14 Mid	231000		
G-17 Top Spk	555		132%		G-14 Mid Dup	169000	31%	
G-17 Mid	344				G-15 Top	44600		
G-17 Mid Dup	342	1%			G-15 Top Spk	84700		100%
G-5P	315				G-17 Top	38900		
G-5P Spk	508		97%		G-17 Top Spk	42200		
G-6P	350				G-17 Top Spk	85500		108%
G-6P Dup	283	21%			G-17 Mid	26600		
G-20P	373				G-17 Mid Dup	23000	15%	
G-20P Spk	549		88%		G-5P	112000		
					G-5P Dup	105000	6%	

Table A-7 (continued). Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Cadmium Quality Control Data					Chromium Quality Control Data			
Sample Location	Concentration mg/kg	% RPD	%R		Sample Location	Concentration mg/kg	% RPD	%R
G-1 Top	0.56				G-1 Top	29		
G-1 Top Spk	0.59	5%			G-1 Top Spk	199		85%
G-1 Mid	0.37				G-1 Mid	42		
G-1 Mid Dup	0.37	1%			G-1 Mid Dup	29	36%	
G-2 Bot	0.13				G-2 Bot	12		
G-2 Bot Spk	0.21		80%		G-2 Bot Spk	197		92%
G-3 Top	0.69				G-3 Top	34		
G-3 Top Dup	0.76	10%			G-3 Top Dup	37	8%	
G-11 Bot	0.21				G-11 Bot	18		
G-11 Bot Spk	0.29		82%		G-11 Bot Spk	198		90%
G-12 Top	1.55				G-12 Top	877		
G-12 Top Dup	1.06	37%			G-12 Top Dup	765	14%	
G-4 Top	0.18				G-4 Top	24		
G-4 Top Spk	0.24		69%		G-4 Top Spk	196		86%
G-4 Bot	0.03				G-4 Bot	0.2		
G-4 Bot Dup	0.03	16%			G-4 Bot Dup	0.8	102%	
G-5D Mid	0.33				G-5D Mid	42		
G-5D Mid Spk	0.40		74%		G-5D Mid Spk	274		116%
G-5D Bot	0.29				G-5D Bot	40		
G-5D Bot Dup	0.30	3%			G-5D Bot Dup	37	6%	
G-7 Top	0.45				G-7 Top	59		
G-7 Top Spk	0.51		58%		G-7 Top Spk	207		74%
G-7 Mid	0.27				G-7 Mid	37		
G-7 Mid Dup	0.28	4%			G-7 Mid Dup	37	0%	
G-13 Top	0.49				G-13 Top	36		
G-13 Top Spk	0.62		128%		G-13 Top Spk	210		87%
G-13 Bot	0.16				G-13 Bot	25		
G-13 Bot Dup	0.18	10%			G-13 Bot Dup	26	5%	
G-14 Top	0.98				G-14 Top	11		
G-14 Top Spk	1.06		79%		G-14 Top Spk	350		170%
G-14 Mid	0.09				G-14 Mid	13		
G-14 Mid Dup	0.10	15%			G-14 Mid Dup	12	4%	
G-17 Top	1.83				G-17 Top	92		
G-17 Top Spk	1.91		87%		G-17 Top Spk	246		77%
G-17 Mid	2.20				G-17 Mid	110		
G-17 Mid Dup	1.64	29%			G-17 Mid Dup	85	26%	
G-5P	1.69				G-6P	82		
G-5P Spk	1.76		74%		G-6P Dup	82	1%	
G-6P	1.13				G-20P	70		
G-6P Dup	1.19	5%			G-20P Spk	275		102%

Table A-7 (continued). Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Copper Quality Control Data					Iron Quality Control Data			
Sample	Concentration	% RPD	%R		Sample	Concentration	% RPD	%R
Location	mg/kg				Location	mg/kg		
G-1 Top	13.8				G-1 Mid	26486		
G-1 Top Spk	199.3		93%		G-1 Mid Dup	26635	1%	
G-1 Mid	14.1				G-2 Bot	11487		
G-1 Mid Dup	14.5	3%			G-2 Bot Spk	10150	12%	
G-2 Bot	4.7				G-3 Top	15507		
G-2 Bot Spk	185.3		90%		G-3 Top Dup	15693	1%	
G-3 Top	22.4				G-11 Top	20695		
G-3 Top Dup	24.0	7%			G-11 Top Spk	55000		86%
G-11 Bot	71.6				G-11 Bot	17400		
G-11 Bot Spk	184.5		56%		G-11 Bot Spk	58900		104%
G-12 Top	99.7				G-12 Top	12900		
G-12 Top Dup	87.4	13%			G-12 Top Dup	10600	20%	
G-4 Top	6.0				G-20 Bot	26900		
G-4 Top Spk	166.1		80%		G-20 Bot Spk	63000		90%
G-4 Bot	0.9				G-20D Mid	24000		
G-4 Bot Dup	1.2	29%			G-20D Mid Spk	60300		91%
G-5D Mid	17.3				G-4 Bot	2970		
G-5D Mid Spk	231.5		107%		G-4 Bot Dup	4070	31%	
G-5D Bot	13.2				G-5 Bot	46100		
G-5D Bot Dup	11.2	16%			G-5 Bot Spk	82800		92%
G-7 Top	20.2				G-5D Bot	46800		
G-7 Top Spk	182.3		81%		G-5D Bot Dup	46400	1%	
G-7 Mid	11.4				G-6 Top	25900		
G-7 Mid Dup	10.8	5%			G-6 Top Spk	64800		97%
G-13 Top	28.1				G-7 Top	70700		
G-13 Top Spk	211.1		92%		G-7 Top Spk	52100	30%	
G-13 Bot	7.8				G-7 Mid	41400		
G-13 Bot Dup	8.2	5%			G-7 Mid Dup	42500	3%	
G-14 Top	3.9				G-13 Bot	19400		
G-14 Top Spk	188.1		92%		G-13 Bot Dup	19900	3%	
G-14 Mid	3.9				G-13-3	16500		
G-14 Mid Dup	3.5	11%			G-13-3 Spk	50700		86%
G-17 Top	65.0				G-14 Mid	13100		
G-17 Top Spk	236.4		86%		G-14 Mid Dup	11700	11%	
G-17 Mid	88.4				G-15 Top	11000		
G-17 Mid Dup	63.1	33%			G-15 Top Spk	51900		102%
G-5P	53.0				G-17 Top	15800		
G-5P Spk	314.0		131%		G-17 Top Spk	52600		92%
G-6P	62.0				G-17 Mid	11900		
G-6P Dup	61.0	2%			G-17 Mid Dup	10800	10%	
G-20P	352.0				G-6P	24000		
G-20P Spk	530.0		89%		G-6P Dup	23600	2%	

Table A-7 (continued). Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Mercury Quality Control Data					Magnesium Quality Control Data			
Sample	Concentration	% RPD	%R		Sample	Concentration	% RPD	%R
Location	mg/kg				Location	mg/kg		
G-1 Top	0.14				G-1 Mid	18300		
G-1 Top Spk	0.44		106%		G-1 Mid Dup	18100	1%	
G-1 Mid	<0.1	*			G-2 Bot	6980		
G-1 Mid Dup	<0.1	*			G-2 Bot Spk	27900		105%
G-10 Bot	<0.1				G-3 Top	6090		
G-10 Bot Spk	0.46		118%		G-3 Top Dup	6340	4%	
G-11 Top	0.36				G-11 Top	12200		
G-11 Top Dup	0.14	87%			G-11 Top Spk	32200		100%
G-23 Top	0.12				G-11 Bot	10500		
G-23 Top Dup	0.34	64%			G-11 Bot Spk	33200		114%
G-23 Mid	<0.1	*			G-12 Top	6950		
G-23 Mid Dup	<0.1	*			G-12 Top Dup	5890	17%	
G-5 Bot	<0.1				G-20 Bot	15200		
G-5 Bot Spk	0.69		91%		G-20 Bot Spk	35100		100%
G-5D Top	0.24				G-20D Mid	13200		
G-5D Top Dup	0.29	18%			G-20D Mid Spk	32400		96%
G-22 Top	0.22				G-4 Bot	1280		
G-22 Top Spk	0.75		106%		G-4 Bot Dup	1750	31%	
G-22-2	<0.1	*			G-5 Bot	15500		
G-22-2 Dup	<0.1	*			G-5 Bot Spk	33700		91%
G-9 Bot	<0.1				G-5D Bot	16300		
G-9 Bot Spk	0.26		117%		G-5D Bot Dup	15400	6%	
G-13 Top	0.31				G-6 Top	14500		
G-13 Top Dup	0.31	0.00%			G-6 Top Spk	33500		95%
G-15 Mid	0.13				G-7 Mid	16300		
G-15 Mid Spk	0.32		113%		G-7 Mid Dup	16100	1%	
G-15 Bot	<0.1	*			G-13 Bot	13800		
G-15 Bot Dup	<0.1	*			G-13 Bot Dup	13900	1%	
G-18 Top	<0.1				G-13-3	11300		
G-18 Top Spk	0.23		105%		G-13-3 Spk	29500		91%
G-18 Bot	<0.1	*			G-14 Top	8220		
G-18 Bot Dup	<0.1	*			G-14 Top Spk	7180	14%	
					G-14 Mid	7710		
* RPD Not Calculated. Sample BDL					G-14 Mid Dup	6810	12%	
					G-15 Top	5550		
					G-15 Top Spk	27400		109%
					G-17 Top	7880		
					G-17 Top Spk	34000		131%
					G-17 Mid	5240		
					G-17 Mid Dup	4910	7%	
					G-6P	13000		
					G-6P Dup	11400	13%	

Table A-7 (continued). Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Manganese Quality Control Data					Nickel Quality Control Data			
Sample Location	Concentration mg/kg	% RPD	%R		Sample Location	Concentration mg/kg	% RPD	%R
G-1 Top	335				G-1 Top	42.1		
G-1 Top Spk	478		72%		G-1 Top Spk	210.8		84%
G-1 Mid	431				G-1 Mid	22.9		
G-1 Mid Dup	435	1%			G-1 Mid Dup	19.9	14%	
G-2 Bot	298				G-2 Bot	9.3		
G-2 Bot Spk	448		75%		G-2 Bot Spk	176.2		83%
G-3 Top	180				G-3 Top	23		
G-3 Top Dup	192	6%			G-3 Top Dup	25.1	9%	
G-11 Bot	710				G-11 Bot	11.7		
G-11 Bot Spk	951		121%		G-11 Bot Spk	178.3		83%
G-12 Top	357				G-12 Top	59.2		
G-12 Top Dup	288	21%			G-12 Top Dup	51.7	14%	
G-4 Top	152				G-4 Top	7.53		
G-4 Top Spk	312		80%		G-4 Top Spk	184		88%
G-4 Bot	97.5				G-5D Mid	21.3		
G-4 Bot Dup	164	51%			G-5D Mid Spk	264		121%
G-5D Mid	923				G-5D Bot	20.1		
G-5D Mid Spk	1210		144%		G-5D Bot Dup	19.6	3%	
G-5D Bot	888				G-7 Top	30.3		
G-5D Bot Dup	897	1%			G-7 Top Spk	183.4		77%
G-7 Top	1050				G-7 Mid	21		
G-7 Top Spk	1223		87%		G-7 Mid Dup	22.2	6%	
G-7 Mid	800				G-13 Top	18.5		
G-7 Mid Dup	818	2%			G-13 Top Spk	189.4		85%
G-13 Top	167				G-13 Bot	15.2		
G-13 Top Spk	339		86%		G-13 Bot Dup	16.3	7%	
G-13 Bot	718				G-14 Top	9.9		
G-13 Bot Dup	743	3%			G-14 Top Spk	257		124%
G-14 Top	588				G-14 Mid	10.5		
G-14 Top Spk	795		104%		G-14 Mid Dup	11	5%	
G-14 Mid	682				G-17 Top	31.8		
G-14 Mid Dup	672	1%			G-17 Top Spk	194		81%
G-17 Top	55.7				G-17 Mid	37.2		
G-17 Top Spk	266.1		105%		G-17 Mid Dup	31.7	16%	
G-17 Mid	36.9				G-5P	35		
G-17 Mid Dup	35.9	3%			G-5P Spk	277		121%
G-5P	773				G-6P	34.4		
G-5P Spk	912		70%		G-6P Dup	36.3	5%	
G-6P	1040				G-20P	28.7		
G-6P Dup	1110	7%			G-20P Spk	248		110%
G-20P	629							
G-20P Spk	873		122%					

Table A-7 (continued). Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Lead Quality Control Data					Zinc Quality Control Data			
Sample Location	Concentration mg/kg	% RPD	%R		Sample Location	Concentration mg/kg	% RPD	%R
G-1 Top	6.428				G-1 Top	70		
G-1 Top Spk	9.06		132%		G-1 Top Spk	229		79%
G-1 Mid	4.384				G-1 Mid	72		
G-1 Mid Dup	6.743	42%			G-1 Mid Dup	70	2%	
G-2 Bot	2.849				G-2 Bot	18		
G-2 Bot Spk	3.382		27%		G-2 Bot Spk	193		88%
G-3 Top	14.4				G-3 Top	58		
G-3 Top Dup	17.53	20%			G-3 Top Dup	69	18%	
G-11 Bot	3.755				G-11 Bot	38		
G-11 Bot Spk	6.674		146%		G-11 Bot Spk	239		100%
G-12 Top	72				G-12 Top	183		
G-12 Top Dup	63.9	12%			G-12 Top Dup	148	21%	
G-4 Top	4.1				G-4 Top	30		
G-4 Top Spk	5.509		70%		G-4 Top Spk	182		76%
G-4 Bot	1.719				G-4 Bot	2		
G-4 Bot Dup	1.533	11%			G-4 Bot Dup	3	12%	
G-5D Mid	4.885				G-5D Mid	81		
G-5D Mid Spk	7.575		135%		G-5D Mid Spk	301		110%
G-5D Bot	6.012				G-5D Bot	59		
G-5D Bot Dup	4.531	28%			G-5D Bot Dup	64	8%	
G-7 Top	8.652				G-7 Top	112		
G-7 Top Spk	11.43		139%		G-7 Top Spk	260		74%
G-7 Mid	4.368				G-7 Mid	70		
G-7 Mid Dup	4.55	4%			G-7 Mid Dup	72	2%	
G-13 Top	26.6				G-13 Top	79		
G-13 Top Spk	203.3		88%		G-13 Top Spk	254		87%
G-13 Bot	3.098				G-13 Bot	38		
G-13 Bot Dup	3.474	11%			G-13 Bot Dup	39	4%	
G-14 Mid	0.975				G-14 Top	16		
G-14 Mid Dup	1.054	8%			G-14 Top Spk	189		86%
G-17 Top	30				G-14 Mid	18		
G-17 Top Spk	198.5		84%		G-14 Mid Dup	17	8%	
G-17 Mid	43.2				G-17 Top	88		
G-17 Mid Dup	33.4	26%			G-17 Top Spk	257		84%
G-5P	76.6				G-17 Mid	130		
G-5P Spk	276		100%		G-17 Mid Dup	85	41%	
G-6P	66.7				G-5P	185		
G-6P Dup	63	6%			G-5P Spk	393		104%
G-20P	55.4				G-6P	191		
G-20P Spk	243		94%		G-6P Dup	189	1%	
					G-20P	192		
					G-20P Spk	423		116%

Table A-7 (continued). Results Of Laboratory Duplicate And Matrix Spike Analyses For Metals In The Lower Grand River Sediment Samples.

Selenium Quality Control Data			
Sample Location	Concentration mg/kg	% RPD	%R
G-1 Top	0.39		
G-1 Top Spk	0.9		102%
G-1 Mid	0.34		
G-1 Mid Dup	0.43	23%	
G-2 Bot	0.17		
G-2 Bot Spk	0.59		84%
G-3 Top	0.47		
G-3 Top Dup	0.33	35%	
G-11 Bot	0.33		
G-11 Bot Spk	0.87		108%
G-12 Top	0.88		
G-12 Top Dup	0.55	46%	
G-4 Top	0.32		
G-4 Top Spk	0.86		108%
G-4 Bot	0.03		
G-4 Bot Dup	0.03	0%	
G-5D Mid	0.43		
G-5D Mid Spk	1.03		120%
G-5D Bot	0.46		
G-5D Bot Dup	0.42	9%	
G-7 Top	0.66		
G-7 Top Spk	1.02		72%
G-7 Mid	0.49		
G-7 Mid Dup	0.37	28%	
G-13 Bot	<0.5		
G-13 Bot Dup	<0.5	*	
G-14 Top	<0.5		
G-14 Top Spk	5.4		108%
G-14 Mid	<0.5		
G-14 Mid Dup	<0.5	*	
G-17 Top	<0.5		
G-17 Top Spk	4		80%
G-17 Mid	<0.5		
G-17 Mid Dup	<0.5	*	
G-5P	<0.5		
G-5P Dup	<0.5	*	

*** RPD not calculated. Sample BDL.**

Appendix B

Summary Of PCB Congener And DDT Compound Data For Sediments Collected From The Lower Grand River

Table B-1 Distribution Of Tri, Tetra, And Penta Chlorinated PCB Congeners In The Sediment Core Samples Collected From The Lower Grand River. October 1997.

Field Sample	Congener Number																	
ID	17	18	22	28	31	32	33	44	46	48	52	59	70	87	97	101	105	118
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	% R	(ng/g)	(ng/g)	(mg/g)	(mg/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G-1 Top	<1	<1	3	<1	<1	<1	2	<1	76	<1	1	<1	1	<1	<1	2	<1	9
G-1 Mid	<1	<1	<1	<1	<1	<1	<1	<1	136	<1	<1	<1	<1	<1	<1	1	<1	<1
G-1 Bot	<1	<1	<1	<1	<1	<1	<1	<1	114	<1	<1	<1	1	<1	<1	1	<1	7
G-2 Top	<1	<1	<1	<1	<1	<1	<1	<1	63	<1	2	<1	1	<1	<1	1	<1	3
G-2 Mid	<1	<1	<1	<1	<1	<1	4	<1	62	<1	1	<1	<1	<1	1	1	<1	5
G-2 Bot	<1	<1	<1	<1	<1	<1	4	<1	74	<1	<1	<1	<1	<1	<1	2	1	3
G-3 Top	<1	<1	<1	<1	<1	<1	<1	<1	63	<1	<1	<1	<1	1	<1	1	<1	<1
G-3 Bot	<1	<1	<1	<1	<1	<1	<1	<1	64	<1	<1	<1	<1	2	<1	1	<1	<1
G-4 Top	<1	<1	<1	<1	<1	<1	<1	<1	**	<1	<1	<1	<1	<1	<1	1	<1	1
G-4 Bot	<1	<1	<1	<1	<1	<1	<1	<1	70	<1	<1	<1	<1	<1	<1	1	<1	<1
G-5 Top	<1	<1	<1	<1	<1	<1	<1	<1	63	<1	1	<1	<1	<1	1	1	<1	1
G-5 Mid	<1	<1	<1	<1	<1	<1	<1	<1	127	<1	1	<1	<1	<1	<1	<1	<1	<1
G-5 Bot	<1	<1	<1	<1	<1	<1	<1	<1	46	<1	1	<1	<1	<1	<1	<1	<1	<1
G-5dup Top	<1	<1	<1	<1	<1	<1	<1	<1	81	<1	1	<1	<1	<1	<1	1	<1	<1
G-5dup Mid	<1	<1	<1	<1	<1	<1	<1	<1	81	<1	2	<1	<1	<1	<1	1	<1	<1
G-5dup Bot	<1	<1	<1	<1	<1	<1	<1	<1	54	<1	1	<1	<1	<1	<1	2	<1	<1
G-6 Top	<1	<1	<1	<1	<1	<1	<1	<1	89	<1	4	<1	<1	2	2	8	9	17
G-6 Mid	<1	<1	<1	<1	<1	<1	<1	<1	79	<1	1	<1	<1	1	1	3	<1	2
G-6 Bot	<1	<1	<1	<1	<1	<1	<1	<1	80	<1	8	<1	<1	<1	1	2	<1	<1
G-7 Top	<1	<1	<1	<1	<1	<1	<1	<1	92	<1	<1	<1	<1	<1	1	2	<1	2
G-7 Mid	<1	<1	<1	<1	<1	<1	<1	<1	63	<1	1	<1	<1	<1	<1	3	<1	1
G-7 Bot	<1	<1	<1	<1	<1	<1	<1	<1	55	<1	<1	<1	<1	<1	<1	1	<1	<1
G-8 Top	<1	1	<1	<1	<1	<1	<1	<1	50	1	1	<1	<1	<1	<1	0	1	3
G-8 Mid	<1	<1	<1	<1	<1	<1	<1	<1	64	<1	1	<1	<1	<1	<1	1	<1	<1
G-8 Bot	<1	1	<1	<1	<1	<1	<1	<1	57	<1	1	<1	<1	<1	<1	0	1	3

** Surrogate recovery not available due to matrix interference.

Table B-1 (continued). Distribution Of Tri, Tetra, And Penta Chlorinated PCB Congeners In The Sediment Core Samples Collected From The Lower Grand River. October 1997.

Field Sample	Congener Number																	
ID	17	18	22	28	31	32	33	44	46	48	52	59	70	87	97	101	105	118
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	% R	(ng/g)	(ng/g)	(mg/g)	(mg/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G-9 Top	<1	<1	<1	<1	<1	<1	<1	<1	**48**	<1	**1**	<1	<1	<1	**1**	**1**	<1	<1
G-9 Mid	<1	<1	<1	<1	<1	<1	<1	<1	**95**	<1	**3**	<1	<1	**2**	<1	**6**	<1	**3**
G-9 Bot	<1	**1**	<1	<1	<1	<1	<1	<1	**93**	<1	**2**	<1	<1	<1	<1	**1**	<1	**3**
G-10 Top	<1	<1	<1	<1	<1	<1	<1	<1	**62**	<1	**2**	<1	<1	<1	<1	**2**	**2**	**1**
G-10 Bot	<1	<1	<1	<1	<1	<1	<1	<1	**52**	<1	<1	<1	<1	<1	<1	**1**	<1	<1
G-11 Top	<1	<1	**3**	<1	<1	<1	<1	<1	**77**	<1	**1**	<1	**2**	<1	**1**	**3**	**3**	**1**
G-11 Bot	<1	<1	<1	<1	<1	<1	<1	<1	**48**	<1	**3**	<1	**1**	<1	<1	**1**	**1**	**3**
G-12 Top	<1	<1	<1	<1	<1	<1	<1	<1	**89**	<1	<1	<1	<1	**1**	<1	**1**	<1	<1
G-13 Top	<1	<1	<1	<1	<1	<1	<1	<1	**93**	<1	**1**	<1	<1	<1	<1	**1**	<1	<1
G-13-2	<1	<1	<1	<1	<1	<1	<1	<1	**	<1	<1	<1	<1	<1	<1	<1	<1	<1
G-13-3	<1	**1**	<1	<1	<1	<1	<1	<1	**68**	<1	**1**	<1	<1	<1	<1	**1**	<1	**3**
G-13 Bot	<1	**1**	<1	<1	<1	<1	<1	<1	**79**	<1	**1**	<1	<1	<1	<1	**1**	<1	**4**
G-14 Top	<1	<1	<1	<1	<1	<1	<1	<1	**91**	<1	**1**	<1	<1	<1	<1	<1	<1	<1
G-14 Mid	<1	<1	<1	<1	<1	<1	<1	**3**	**81**	<1	**1**	<1	<1	<1	**1**	**2**	<1	<1
G-14 Bot	<1	<1	<1	<1	<1	<1	<1	<1	**61**	<1	**1**	<1	<1	<1	<1	**1**	<1	<1
G-15 Top	<1	<1	<1	<1	<1	<1	<1	<1	**83**	<1	**1**	<1	<1	<1	<1	**1**	<1	<1
G-15 Mid	<1	<1	<1	<1	<1	<1	<1	**5**	**84**	<1	<1	<1	<1	<1	<1	**1**	<1	**2**
G-15 Bot	<1	<1	<1	<1	<1	<1	<1	**1**	**95**	<1	**1**	<1	<1	<1	<1	**1**	<1	<1
G-17 Top	<1	<1	<1	<1	<1	<1	<1	<1	**141**	<1	**3**	<1	**3**	**2**	**2**	**5**	**5**	**4**
G-17 Mid	<1	<1	<1	<1	<1	<1	<1	<1	**54**	<1	**1**	<1	**2**	**1**	**2**	**3**	**3**	**3**
G-17 Bot	<1	<1	<1	<1	<1	<1	<1	**2**	**	<1	<1	<1	<1	<1	<1	**1**	<1	**1**
G-18 Top	<1	**1**	0	<1	<1	<1	<1	0	**74**	<1	**1**	<1	<1	<1	<1	**1**	**1**	**2**
G-18 Mid	<1	<1	**1**	<1	<1	<1	<1	<1	**73**	<1	**2**	<1	**1**	<1	<1	**1**	**1**	**1**
G-18 Bot	<1	<1	**1**	<1	<1	<1	<1	<1	**64**	<1	**2**	<1	**1**	**1**	<1	**2**	**2**	**2**
G-19 Top	<1	<1	**1**	<1	<1	<1	<1	<1	**75**	<1	**2**	<1	**1**	**3**	<1	**1**	**2**	**1**
G-19 Bot	<1	<1	**3**	<1	<1	<1	<1	<1	**127**	<1	**3**	<1	**1**	**1**	<1	**2**	**2**	**1**

** Surrogate recovery not available due to matrix interference

Table B-1 (Continued). Distribution Of Tri, Tetra, And Penta Chlorinated PCB Congeners In The Sediment Core Samples Collected From The Lower Grand River. October 1997.

Field Sample	Congener Number																	
ID	17	18	22	28	31	32	33	44	46	48	52	59	70	87	97	101	105	118
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	% R	(ng/g)	(ng/g)	(mg/g)	(mg/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G-20 Top	**3**	<1	<1	<1	<1	<1	<1	**2**	51	<1	**5**	<1	<1	**3**	**5**	**12**	<1	**14**
G-20 Mid	<1	<1	<1	<1	**2**	<1	<1	**6**	120	<1	**12**	**1**	<1	**7**	**7**	**13**	<1	**23**
G-20 Bot	<1	<1	<1	<1	<1	**2**	<1	**9**	50	<1	**15**	<1	<1	**8**	**7**	**14**	<1	**20**
G-20D Top	<1	<1	<1	**2**	<1	<1	<1	**3**	78	<1	**4**	<1	<1	**14**	**5**	**12**	<1	**17**
G-20D Mid	<1	<1	<1	<1	<1	<1	<1	**9**	133	<1	**15**	**1**	<1	**7**	**6**	**16**	<1	**35**
G-20D Bot	<1	<1	<1	<1	<1	<1	<1	**9**	126	<1	**22**	<1	<1	**8**	**7**	**15**	<1	**29**
G-22 Top	<1	<1	<1	<1	<1	<1	<1	<1	68	<1	<1	<1	<1	<1	<1	**2**	<1	<1
G-22-2	<1	<1	<1	<1	<1	<1	<1	<1	57	<1	**1**	<1	<1	<1	<1	**1**	<1	**1**
G-22-3	<1	<1	<1	<1	<1	<1	<1	<1	99	<1	**1**	<1	<1	<1	<1	**1**	<1	**1**
G-22-4	<1	<1	<1	<1	<1	<1	<1	<1	58	<1	<1	<1	<1	<1	<1	**1**	<1	<1
G-22-5	<1	<1	<1	<1	<1	<1	<1	<1	56	<1	**1**	<1	<1	<1	<1	**1**	<1	<1
G-23 Top	<1	**3**	<1	<1	<1	<1	<1	<1	54	**2**	**5**	<1	<1	<1	<1	**2**	**1**	**6**
G-23 Mid	<1	<1	<1	<1	<1	<1	<1	<1	67	**2**	**1**	<1	<1	<1	<1	<1	<1	**2**
G-23 Bot	<1	**2**	<1	<1	<1	<1	<1	<1	75	<1	**2**	<1	<1	<1	<1	<1	**1**	**4**
G-24 Top	<1	<1	<1	<1	<1	<1	<1	<1	54	<1	**1**	<1	<1	<1	<1	**1**	<1	**1**
G-24 Mid	<1	**1**	**2**	<1	**2**	**1**	<1	**2**	84	**1**	**5**	<1	**4**	**2**	**2**	**4**	**4**	**4**
G-24 Bot	<1	<1	<1	<1	**3**	**2**	<1	**8**	115	<1	**10**	<1	**1**	<1	**1**	**1**	**1**	**2**

** Surrogate recovery not available due to matrix interference

Table B-2. Distribution Of Hexa, Hepta, And Octa Chlorinated PCB Congeners, Total PCBs, And DDT Compounds In The Sediment Core Samples Collected From The Lower Grand River. October 1997.

Field Sample			Congener Number							Total	DDT Compounds		
ID	138	142	149	151	153	155	180	183	205	PCBs	DDD	DDT	DDE
	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	% R	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G-1 Top	0	**57**	**2**	<1	**4**	<1	0	**2**	**2**	**28**	<1	<1	**8**
G-1 Mid	<1	**111**	<1	<1	<1	<1	<1	<1	<1	**1**	<1	<1	<1
G-1 Bot	<1	**105**	<1	<1	<1	<1	<1	<1	<1	**9**	<1	<1	**3**
G-2 Top	<1	**108**	**1**	<1	**4**	<1	<1	<1	<1	**12**	<1	<1	<1
G-2 Mid	<1	**67**	**1**	<1	**4**	<1	<1	<1	**1**	**18**	<1	<1	<1
G-2 Bot	<1	**129**	**1**	**5**	**4**	<1	<1	**1**	**1**	**22**	<1	<1	<1
G-3 Top	<1	**45**	<1	<1	<1	<1	<1	<1	<1	**2**	<1	<1	<1
G-3 Bot	<1	**62**	<1	<1	<1	<1	<1	<1	<1	**3**	<1	<1	<1
G-4 Top	<1	**56**	<1	<1	<1	<1	<1	<1	**1**	**2**	<1	<1	<1
G-4 Bot	<1	**150**	<1	<1	<1	<1	<1	<1	<1	**1**	<1	<1	<1
G-5 Top	**1**	**56**	**1**	<1	<1	<1	<1	<1	<1	**6**	<1	<1	**3**
G-5 Mid	<1	**79**	<1	<1	<1	<1	<1	<1	<1	**1**	<1	<1	<1
G-5 Bot	<1	**89**	<1	<1	<1	<1	<1	<1	<1	**1**	<1	<1	<1
G-5dup Top	**1**	**47**	**1**	<1	<1	<1	<1	<1	<1	**4**	<1	<1	**3**
G-5dup Mid	<1	**64**	<1	<1	<1	<1	<1	<1	<1	**3**	<1	<1	<1
G-5dup Bot	**1**	**92**	**1**	<1	<1	<1	<1	<1	<1	**5**	<1	<1	<1
G-6 Top	**7**	**97**	**5**	**2**	**5**	**1**	**3**	**1**	<1	**66**	<1	<1	**8**
G-6 Mid	**1**	**87**	**1**	<1	<1	<1	<1	<1	<1	**10**	<1	<1	<1
G-6 Bot	**1**	**91**	<1	<1	<1	<1	<1	<1	<1	**11**	<1	<1	<1
G-7 Top	**1**	**83**	<1	<1	<1	<1	<1	<1	**1**	**7**	<1	<1	**2**
G-7 Mid	**1**	**97**	<1	<1	<1	<1	<1	<1	<1	**6**	<1	<1	**2**
G-7 Bot	**1**	**109**	<1	<1	<1	<1	<1	<1	<1	**2**	<1	<1	<1

** Surrogate recovery not available due to matrix interference

Table B-2 (Continued). Distribution Of Hexa, Hepta, And Octa Chlorinated PCB Congeners, Total PCBs, And DDT Compounds In The Sediment Core Samples Collected From The Lower Grand River. October 1997.

Field Sample			Congener Number							Total	DDT Compounds		
ID	138	142	149	151	153	155	180	183	205	PCBs	DDD	DDT	DDE
	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	% R	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G-8 Top	<1	**108**	**2**	**1**	**2**	<1	<1	<1	<1	**12**	<1	<1	**1**
G-8 Mid	<1	**78**	<1	<1	<1	<1	<1	<1	<1	**2**	<1	<1	<1
G-8 Bot	<1	**72**	**2**	**1**	**3**	<1	<1	<1	<1	**12**	<1	<1	<1
G-9 Top	<1	**73**	<1	<1	<1	<1	<1	<1	<1	**3**	<1	<1	<1
G-9 Mid	**1**	**67**	**1**	<1	<1	<1	<1	<1	<1	**16**	<1	<1	<1
G-9 Bot	<1	**75**	**1**	<1	**1**	<1	<1	<1	<1	**9**	<1	<1	**3**
G-10 Top	**3**	**120**	**1**	<1	<1	**1**	0	<1	<1	**12**	<1	<1	**2**
G-10 Bot	<1	**69**	<1	<1	<1	<1	<1	<1	<1	**1**	<1	<1	<1
G-11 Top	**2**	**65**	<1	**1**	<1	**1**	**1**	<1	**1**	**20**	<1	<1	**2**
G-11 Bot	<1	**123**	<1	**2**	**4**	<1	<1	<1	<1	**15**	<1	<1	**1**
G-12 Top	<1	**54**	<1	<1	<1	<1	<1	<1	0	**2**	<1	<1	<1
G-13 Top	**1**	**81**	<1	<1	<1	<1	<1	<1	<1	**3**	<1	<1	<1
G-13-2	<1	**64**	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
G-13-3	<1	**81**	**1**	**1**	**1**	<1	<1	<1	<1	**9**	<1	<1	<1
G-13 Bot	<1	**103**	**1**	<1	**1**	<1	<1	**1**	<1	**10**	<1	<1	<1
G-14 Top	<1	**81**	**1**	<1	<1	<1	<1	<1	<1	**2**	<1	<1	**1**
G-14 Mid	**1**	**85**	**2**	<1	<1	<1	**4**	<1	**3**	**17**	<1	<1	<1
G-14 Bot	<1	**84**	<1	<1	<1	<1	<1	<1	<1	**2**	<1	<1	<1
G-15 Top	<1	**88**	<1	<1	<1	<1	<1	<1	0	**2**	<1	<1	<1
G-15 Mid	**1**	**120**	<1	<1	<1	<1	<1	<1	**5**	**14**	<1	<1	**1**
G-15 Bot	**1**	**64**	<1	<1	<1	<1	<1	<1	<1	**4**	<1	<1	<1
G-17 Top	**3**	**103**	**4**	**1**	**3**	**1**	**1**	<1	**1**	**38**	**2**	<1	**3**
G-17 Mid	**2**	**50**	**3**	**1**	**2**	<1	**1**	<1	**1**	**25**	**3**	<1	**2**
G-17 Bot	**1**	**84**	<1	<1	<1	<1	<1	**1**	**3**	**9**	<1	<1	<1

** Surrogate recovery not available due to matrix interference

Table B-2 (Continued). Distribution Of Hexa, Hepta, And Octa Chlorinated PCB Congeners, Total PCBs, And DDT Compounds In The Sediment Core Samples Collected From The Lower Grand River. October 1997.

Field Sample			Congener Number							Total	DDT Compounds		
ID	138	142	149	151	153	155	180	183	205	PCBs	DDD	DDT	DDE
	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	% R	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G-18 Top	0	87	1	1	4	<1	0	<1	<1	12	<1	<1	2
G-18 Mid	1	68	1	<1	<1	<1	0	<1	<1	9	<1	<1	1
G-18 Bot	1	50	1	<1	<1	<1	1	<1	<1	14	<1	<1	1
G-19 Top	1	55	1	2	<1	<1	<1	<1	<1	15	<1	<1	3
G-19 Bot	2	84	1	1	<1	2	1	<1	<1	20	<1	<1	2
G-20 Top	8	76	4	<1	6	3	4	1	<1	70	3	<1	8
G-20 Mid	6	63	9	2	7	<1	6	2	6	109	14	<1	4
G-20 Bot	2	103	13	2	5	<1	5	1	3	106	6	<1	7
G-20D Top	8	122	5	2	5	4	4	1	<1	86	3	<1	12
G-20D Mid	2	82	6	3	15	<1	1	9	1	126	14	<1	12
G-20D Bot	2	97	12	3	13	<1	6	5	6	137	13	<1	10
G-22 Top	2	109	2	<1	<1	<1	1	<1	<1	7	<1	<1	2
G-22-2	<1	113	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	<1
G-22-3	<1	68	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	<1
G-22-4	<1	74	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1
G-22-5	<1	100	<1	<1	<1	<1	<1	<1	<1	2	<1	<1	1
G-23 Top	1	97	3	<1	9	<1	<1	1	1	34	<1	<1	5
G-23 Mid	<1	78	1	<1	1	<1	<1	1	<1	8	<1	<1	<1
G-23 Bot	<1	**	<1	<1	3	<1	<1	2	<1	14	<1	<1	1
G-24 Top	1	69	1	<1	1	<1	<1	<1	<1	6	<1	<1	<1
G-24 Mid	3	62	4	1	3	1	1	<1	<1	47	1	<1	2
G-24 Bot	<1	92	1	<1	<1	<1	<1	<1	1	31	1	<1	1

** Surrogate recovery not available due to matrix interference

Table B-3. Distribution Of PCB Congeners, Total PCBs, And DDT Compounds In The Ponar Samples Collected From The Lower Grand River. April 1998.

Field Sample	Congener Number																
ID	17	18	22	28	31	32	33	44	46	48	52	59	70	87	97	101	105
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	% R	(ng/g)	(ng/g)	(mg/g)	(mg/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G5-P	<1	<1	<1	<1	**3**	**2**	<1	**8**	89	<1	**10**	<1	**1**	<1	**1**	**1**	**1**
G6-P	<1	<1	<1	<1	<1	<1	<1	**2**	97	<1	**1**	<1	<1	**14**	**2**	**4**	<1
G7-P	<1	<1	<1	<1	<1	<1	<1	**5**	82	<1	**1**	<1	<1	**1**	**2**	**4**	<1
G12-P	<1	<1	<1	<1	<1	<1	<1	**13**	105	<1	**1**	<1	<1	**1**	**2**	**4**	<1
G20-P	<1	<1	<1	<1	<1	<1	<1	**1**	82	<1	**2**	<1	<1	**11**	**3**	**3**	<1
G20-P Dup	<1	<1	<1	<1	<1	<1	<1	**10**	78	<1	**2**	<1	<1	**1**	**2**	**3**	<1

Table B-3. Distribution Of PCB Congeners, Total PCBs, And DDT Compounds In The Ponar Samples Collected From The Lower Grand River. April 1998.

Field Sample			Congener Number							Total	DDT Compounds		
ID	138	**142**	149	151	153	155	180	183	205	PCBs	DDD	DDT	DDE
	Amount	Surrogate	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	% R	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G5-P	**3**	**89**	**2**	<1	**2**	<1	**11**	**1**	**5**	**53**	**4**	<1	**3**
G6-P	**4**	**57**	**2**	<1	**2**	<1	**8**	**1**	<1	**36**	**5**	<1	**12**
G7-P	**3**	**140**	**2**	<1	**3**	<1	**8**	**1**	<1	**43**	**4**	<1	**9**
G12-P	**3**	**134**	**2**	<1	**2**	<1	**1**	**1**	<1	**35**	**2**	<1	**13**
G20-P	**2**	**62**	**2**	<1	**2**	<1	**1**	<1	<1	**29**	**1**	<1	**3**
G20-P Dup	<1	**77**	**2**	<1	**2**	<1	**1**	<1	<1	**29**	**1**	<1	**3**

Table B-4. Results Of Matrix Spiked Sample Analyses For The Grand River Sediments

Initial Concentration								
	52	44	101	DDE	153	138	180	205
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G2 Bot	<1	<1	1	<1	4	<1	<1	1
G3-Bot	<1	<1	1	<1	<1	<1	<1	<1
G4-Top	<1	<1	<1	<1	<1	<1	<1	<1
G7-Mid	1	<1	3	2	<1	1	<1	<1
G10-Bot	<1	<1	<1	<1	<1	<1	<1	<1
G15-Top	<1	<1	<1	<1	<1	<1	<1	<1

Concentration After Spike Addition								
	52	44	101	DDE	153	138	180	205
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
Sample ID	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G2 Bot	2.35	2.05	1.47	1.62	-	0.93	0.91	0.88
G3-Bot	1.85	2.33	1.42	2.4	1.14	1.48	1.28	0.88
G4-Top	2.56	1.93	0.50	1.18	1.60	0.97	0.81	0.85
G7-Mid	2.06	3.09	1.24	2.1	1.48	1.75	1.48	1.3
G10-Bot	2.08	2.31	1.42	2.6	1.05	1.44	1.13	0.75
G15-Top	1.45	2.00	1.17	1.72	1.73	1.04	0.90	0.65

Amount Spiked								
52	44	101	DDE	153	138	180	205	
Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	
(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	
2.2	2.2	1.0	1.5	1.0	1.0	1.1	1.1	

Spiked Recovery								
Sample	Congener Number							
Location	52	44	101	DDE	153	138	180	205
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery
G2 Bot	107	93	147	108	0	93	83	0
G3-Bot	84	106	142	160	1	148	116	1
G4-Top	116	88	50	79	160	97	74	77
G7-Mid	64	140	31	60	148	88	135	118
G10-Bot	65	105	142	173	105	144	103	68
G15-Top	66	91	117	115	173	104	82	59

Table B-4. Results Of Matrix Duplicate Sample Analyses For The Grand River Sediments

Field	Congener Number							
Sample	52	44	101	153	138	180	205	DDE
ID	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
G4-Top	<1	<1	1	<1	<1	<1	1	<1
G4-Top Dup	<1	<1	1	<1	<1	<1	2	<1
G4-Bot	<1	<1	1	<1	<1	<1	<1	<1
G4-Bot Dup	<1	<1	1	<1	<1	<1	<1	<1
G22-4	<1	<1	1	<1	<1	<1	<1	<1
G22-4 Dup	<1	<1	1	<1	<1	<1	<1	<1
G8-Mid	1	<1	1	<1	<1	<1	<1	<1
G8-Mid Dup	<1	1	1	<1	<1	<1	2	<1
G9-Top	1	<1	1	<1	1	<1	<1	<1
G9-Top Dup	1	1	1	<1	<1	<1	1	<1
G13-Top	1	<1	1	<1	1	<1	<1	<1
G13-Top Dup	<1	1	1	<1	1	<1	4	<1
G15-Top	1	<1	1	<1	<1	<1	<1	<1
G15-Top Dup	<1	1	1	<1	<1	<1	<1	<1

Table B-5. Results Of Method Blanks And Laboratory Control Sample Analyses For The Grand River Sediments.

Method Blanks								
	52	44	101	DDE	153	138	180	205
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
Sample ID	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
BK1	1	1	1	1	<1	<1	<1	<1
BK2	<1	1	<1	<1	<1	<1	<1	<1
BK3	<1	<1	1	<1	<1	<1	<1	<1
BK4	1	<1	<1	<1	<1	<1	<1	<1
BK5	<1	1	<1	<1	<1	<1	<1	<1
BK6	<1	<1	<1	<1	<1	<1	<1	<1
BK7	1	1	1	1	<1	<1	<1	<1

Laboratory Control Samples								
	52	44	101	DDE	153	138	180	205
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
Sample ID	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
LCS1	2.6	2.4	1.6	1.6	1.7	1.1	1.0	1.0
LCS2	2.6	2.5	1.6	1.9	2.0	1.1	1.0	1.0
LCS3	2.5	1.7	1.2	1.2	1.3	0.8	0.7	0.7
LCS4	2.1	1.9	1.3	1.7	1.5	0.9	0.8	0.8
LCS5	2.1	2.3	1.3	1.3	1.5	0.9	0.8	0.8
LCS6	2.3	1.9	1.4	1.4	1.6	0.9	0.8	0.9
LCS7	2.3	2.0	1.5	1.9	1.5	0.9	0.9	0.8

Amount Spiked								
	52	44	101	DDE	153	138	180	205
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
	2.2	2.2	1.0	1.6	1.1	1.0	1.1	1.1

Laboratory Control Sample Spiked Recovery								
Sample	Congener Number							
Location	52	44	101	DDE	153	138	180	205
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery	% Recovery
LCS1	118	109	160	100	155	110	91	91
LCS2	118	114	160	119	182	110	91	91
LCS3	114	77	120	75	118	80	64	64
LCS4	95	86	130	106	136	90	73	73
LCS5	95	105	130	81	136	90	73	73
LCS6	105	86	140	88	145	90	73	82
LCS7	105	91	150	119	136	90	82	73

Appendix C

Summary Of Semivolatile Organic And TPH Data For Sediments Collected From The Lower Grand River

Table C-1. Semivolatile Organics Results for Sediment Cores Collected from the Lower Grand River

Station	G-1	G-1	G-1	G-2	G-2	G-2	G-12	G-4	G-4
Core Section	Top	Mid	Bottom	Top	Mid	Bottom	Top	Top	Bottom
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Hexane Extractable Materials	900			60			2000	400	
Phenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethyl)ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,3-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,4-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachloroethane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Isophorone	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dimethylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethoxy)methane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2,4-Trichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Naphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobutadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chloro-3-methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylnaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorocyclopentadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,6-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,5-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chloronaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dimethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Diethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chlorophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluorene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4,6-Dinitro-2-methylphenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
4-Bromophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Pentachlorophenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Phenanthrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	1.4	<0.33	<0.33
Anthracene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	0.36	<0.33	<0.33
Di-n-butylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluoranthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	2.9	<0.33	<0.33
Pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	2.8	<0.33	<0.33
Butylbenzylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)anthracene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	1.1	<0.33	<0.33
Chrysene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	0.88	<0.33	<0.33
Bis(2-ethylhexyl)phthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Di-n-octylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(b)fluoranthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	0.54	<0.33	<0.33
Benzo(k)fluoranthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	0.71	<0.33	<0.33
Indeno(1,2,3-cd)pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dibenzo(a,h)anthracene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(g,h,i)perylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
3-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33

Surrogate Standards	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery
Nitrobenzene-d5	78	60	62	78	71	78	62	72	75
2-Fluorobiphenyl	85	79	84	77	81	77	84	68	81
o-Terphenyl	77	88	74	70	88	70	74	66	73
Phenol-d6	70	70	68	77	63	77	68	77	69
2-Fluorophenol	69	74	74	69	67	69	74	68	72
2,4,6-Tribromophenol	72	68	75	88	78	88	75	68	83

Table C-1 (continued). Semivolatile Organics Results for Sediment Cores Collected from the Lower Grand River

Station Core Section	G-20 Top mg/kg	G-20 Mid mg/kg	G-20 Bottom mg/kg	G-20 Dup Top mg/kg	G-20 Dup Mid mg/kg	G-20 Dup Bottom mg/kg	G-8 Top mg/kg	G-8 Mid mg/kg	G-8 Bottom mg/kg
Hexane Extractable Materials	4000	6000	2000	3500	3500	2000	400		
Phenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethyl)ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,3-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,4-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachloroethane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Isophorone	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dimethylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethoxy)methane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2,4-Trichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Naphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobutadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chloro-3-methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylnaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorocyclopentadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,6-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,5-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chloronaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dimethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Diethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chlorophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluorene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4,6-Dinitro-2-methylphenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
4-Bromophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Pentachlorophenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Phenanthrene	0.62	0.81	0.72	0.90	1.02	0.66	<0.33	<0.33	<0.33
Anthracene	0.08	< 0.33	0.11	0.12	0.12	0.09	<0.33	<0.33	<0.33
Di-n-butylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluoranthene	1.40	2.04	1.96	2.31	2.20	1.73	<0.33	<0.33	<0.33
Pyrene	1.38	1.60	1.68	2.10	2.10	1.73	0.41	<0.33	<0.33
Butylbenzylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)anthracene	0.39	< 0.33	0.48	0.51	0.57	0.63	<0.33	<0.33	<0.33
Chrysene	0.51	< 0.33	0.62	0.64	0.78	0.28	<0.33	<0.33	<0.33
Bis(2-ethylhexyl)phthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Di-n-octylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(b)fluoranthene	0.35	< 0.33	< 0.33	< 0.33	0.85	0.71	<0.33	<0.33	<0.33
Benzo(k)fluoranthene	< 0.33	< 0.33	< 0.33	< 0.33	0.12	< 0.33	<0.33	<0.33	<0.33
Benzo(a)pyrene	0.37	< 0.33	0.37	0.48	0.50	0.35	<0.33	<0.33	<0.33
Indeno(1,2,3-cd)pyrene	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	<0.33	<0.33	<0.33
Dibenzo(a,h)anthracene	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	<0.33	<0.33	<0.33
Benzo(g,h,i)perylene	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	<0.33	<0.33	<0.33
3-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Surrogate Standards	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery
Nitrobenzene-d5	78	64	90	75	84	71	82	71	90
2-Fluorobiphenyl	84	87	81	73	87	90	83	67	66
o-Terphenyl	78	66	79	71	79	67	62	58	80
Phenol-d6	53	58	69	58	55	64	55	54	52
2-Fluorophenol	77	83	89	73	82	76	61	85	85
2,4,6-Tribromophenol	70	57	71	50	50	54	58	57	66

Table C-1(continued). Semivolatile Organics Results for Sediment Cores Collected from the Lower Grand River

Station	G-9	G-9	G-9	G-22	G-22	G-22	G-22	G-22
Core Section	Top	Mid	Bottom	Top	2	3	4	5
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Hexane Extractable Materials	200			780				
Phenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethyl)ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,3-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,4-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachloroethane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Isophorone	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dimethylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethoxy)methane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2,4-Trichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Naphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobutadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chloro-3-methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylnaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorocyclopentadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,6-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,5-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chloronaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dimethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Diethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chlorophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluorene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4,6-Dinitro-2-methylphenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
4-Bromophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Pentachlorophenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Phenanthrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Anthracene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Di-n-butylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluoranthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Butylbenzylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)anthracene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Chrysene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-ethylhexyl)phthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Di-n-octylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(b)fluoranthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(k)fluoranthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Indeno(1,2,3-cd)pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dibenzo(a,h)anthracene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(g,h,i)perylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
3-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33

Surrogate Standards	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery
Nitrobenzene-d5	74	62	78	89	62	87	74	75
2-Fluorobiphenyl	82	77	74	65	80	61	74	67
o-Terphenyl	78	69	73	55	78	61	78	59
Phenol-d6	61	54	67	65	63	58	64	51
2-Fluorophenol	64	78	61	73	61	72	88	80
2,4,6-Tribromophenol	62	53	59	51	53	64	59	59

Table C-1(continued). Semivolatile Organics Results for Sediment Cores Collected from the Lower Grand River

Station	G-13	G-13	G-13	G-13	G-6	G-6	G-6	G-7	G-7	G-7
Core Section	Top	2	3	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Hexane Extractable Materials	900				1100			800		
Phenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethyl)ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,3-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,4-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachloroethane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Isophorone	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dimethylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethoxy)methane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2,4-Trichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Naphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobutadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chloro-3-methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylnaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorocyclopentadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,6-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,5-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chloronaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dimethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Diethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chlorophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluorene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4,6-Dinitro-2-methylphenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
4-Bromophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Pentachlorophenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Phenanthrene	0.30	< 0.33	< 0.33	< 0.33	1.18	0.27	< 0.33	< 0.33	< 0.33	< 0.33
Anthracene	0.10	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33
Di-n-butylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluoranthene	1.04	0.41	< 0.33	< 0.33	3.14	0.63	< 0.33	< 0.33	< 0.33	< 0.33
Pyrene	1.32	0.42	< 0.33	< 0.33	3.20	0.56	< 0.33	< 0.33	< 0.33	< 0.33
Butylbenzylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)anthracene	0.70	<0.33	< 0.33	< 0.33	0.88	<0.33	< 0.33	< 0.33	< 0.33	< 0.33
Chrysene	0.53	<0.33	< 0.33	< 0.33	< 0.33	0.35	< 0.33	< 0.33	< 0.33	< 0.33
Bis(2-ethylhexyl)phthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Di-n-octylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(b)fluoranthene	0.42	<0.33	< 0.33	< 0.33	0.97	0.24	< 0.33	< 0.33	< 0.33	< 0.33
Benzo(k)fluoranthene	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33
Benzo(a)pyrene	0.49	< 0.33	< 0.33	< 0.33	0.52	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33
Indeno(1,2,3-cd)pyrene	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33
Dibenzo(a,h)anthracene	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33
Benzo(g,h,i)perylene	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33	< 0.33
3-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33

Surrogate Standards	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery	Recovery
Nitrobenzene-d5	81	81	79	73	64	87	67	86	81	78
2-Fluorobiphenyl	89	85	60	80	86	70	69	67	76	85
o-Terphenyl	59	70	80	58	80	76	77	62	77	77
Phenol-d6	53	63	54	76	58	66	59	66	65	70
2-Fluorophenol	73	65	64	84	73	62	69	65	83	69
2,4,6-Tribromophenol	74	58	61	76	56	78	63	69	69	72

Table C-2. Semivolatile Organics Results for Ponar Samples Collected from the Lower Grand River

Station	G5-P mg/kg	G6-P mg/kg	G7-P mg/kg	G12-P mg/kg	G20-P mg/kg	G20-P Dup mg/kg
Phenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethyl)ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,3-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	0.33
1,4-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	0.33
1,2-Dichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachloroethane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Isophorone	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dimethylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Bis(2-chloroethoxy)methane	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4-Dichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,2,4-Trichlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Naphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobutadiene	<0.33	<0.33	<0.33	<0.33	<0.33	0.33
4-Chloro-3-methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Methylnaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorocyclopentadiene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,6-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2,4,5-Trichlorophenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
2-Chloronaphthalene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dimethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Acenaphthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Diethylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4-Chlorophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluorene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
4,6-Dinitro-2-methylphenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
4-Bromophenyl-phenyl ether	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Hexachlorobenzene	<0.33	<0.33	<0.33	<0.33	<0.33	0.33
Pentachlorophenol	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Phenanthrene	<0.33	1.5	0.56	1.6	0.75	0.55
Anthracene	<0.33	<0.33	<0.33	0.49	<0.33	<0.33
Di-n-butylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Fluoranthene	<0.33	3.5	0.41	3.7	1.2	1.3
Pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Butylbenzylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)anthracene	<0.33	0.91	<0.33	1.34	0.43	0.39
Chrysene	<0.33	<0.33	<0.33	0.95	0.51	0.65
Bis(2-ethylhexyl)phthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Di-n-octylphthalate	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(b)fluoranthene	<0.33	0.84	<0.33	0.73	0.35	0.42
Benzo(k)fluoranthene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(a)pyrene	<0.33	0.69	<0.33	0.81	0.37	0.33
Indeno(1,2,3-cd)pyrene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Dibenzo(a,h)anthracene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Benzo(g,h,i)perylene	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
3-Methylphenol	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Surrogate Standards	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery	**%** Recovery
Nitrobenzene-d5	71	84	89	85	60	87
2-Fluorobiphenyl	74	75	62	60	89	71
o-Terphenyl	67	69	57	78	77	79
Phenol-d6	67	74	80	56	62	67
2-Fluorophenol	66	83	68	88	89	68
2,4,6-Tribromophenol	64	76	68	51	55	67

Table C-3. Semivolatile Organics Matrix Spike and Matrix Spike Duplicate Results.

	G-1 Top Initial mg/kg	G-1MS Top Spiked Amount (mg/kg)	G-1MS Top Measured mg/kg	G-1MS Top % Recovery	G-1MSD Top Spiked Amount (mg/kg)	G-1MSD Top Measured mg/kg	G-1MSD Top % Recovery	% RPD
1,2,4-Trichlorobenzene	0.33	5.6	4.3	77	5.6	5.1	91	17
Acenaphthene	0.33	5.6	4.1	73	5.6	5.4	96	27
Pyrene	0.33	5.6	4.6	82	5.6	4.9	88	6
1,4-Dichlorobenzene	0.33	5.6	4.8	86	5.6	4.7	84	2
Pentachlorophenol	<1.7	22.4	9.7	43	22.4	9.5	42	2
Phenol	0.33	11.2	7.1	63	11.2	7.5	67	5
2-Chlorophenol	0.33	11.2	8.8	79	11.2	7.8	70	12
4-Chloro-3-methylphenol	0.33	11.2	7.5	67	11.2	7.1	63	5

	G-8 Top Initial mg/kg	G-8MS Top Spiked Amount (mg/kg)	G-8MS Top Measured mg/kg	G-8MS Top % Recovery	G-8MSD Top Spiked Amount (mg/kg)	G-8MSD Top Measured mg/kg	G-8MSD Top % Recovery	% RPD
1,2,4-Trichlorobenzene	0.33	6.7	3.9	59	6.7	4.3	65	10
Acenaphthene	0.33	6.7	4.6	69	6.7	6.1	92	28
Pyrene	0.33	6.7	5.1	77	6.7	5.4	81	6
1,4-Dichlorobenzene	0.33	6.7	4.2	63	6.7	5.0	75	17
Pentachlorophenol	<1.7	26.6	13	49	26.6	15	56	14
Phenol	0.33	13.3	9.3	70	13.3	10	75	7
2-Chlorophenol	0.33	13.3	8.7	65	13.3	9.8	74	12
4-Chloro-3-methylphenol	0.33	13.3	8.8	66	13.3	9.6	72	9

	G5-P Top Initial mg/kg	G5-P MS Top Spiked Amount (mg/kg)	G5-P MS Top Measured mg/kg	G5-P MS Top % Recovery	G5-P MSD Top Spiked Amount (mg/kg)	G5-P MSD Top Measured mg/kg	G5-P MSD Top % Recovery	% RPD
1,2,4-Trichlorobenzene	0.33	6.3	4.5	71	6.3	4.6	73	2
Acenaphthene	0.33	6.3	5.2	83	6.3	5.6	89	7
Pyrene	0.33	6.3	5.8	92	6.3	5.0	79	15
1,4-Dichlorobenzene	0.33	6.3	4.9	78	6.3	5.8	92	17
Pentachlorophenol	<1.7	25.2	15	60	25.2	18	71	18
Phenol	0.33	12.6	8.8	70	12.6	9.1	72	3
2-Chlorophenol	0.33	12.6	9.3	74	12.6	8.7	69	7
4-Chloro-3-methylphenol	0.33	12.6	8.4	67	12.6	7.5	60	11

Appendix D

Summary Of Chemical Measurements For The Toxicity Test With Sediments From The Lower Grand River

Test No: HA-980526
Toxicant: Grand River Sediment
Organism: *Hyalella azteca*

Analyst: sm, jb,rr
Test Start: 05/12/98 1500
Test Stop: 05/23/98 1500

Table D-1. Summary of Initial and Final Chemical Measurements for the *Hyalella azteca* Sediment Toxicity Tests

		Day		Difference
Sample	**Parameter**	**0**	**10**	(%)
G5-P	pH	7.8	7.5	0
	Conductivity (umhos/cm)	380	350	8
	Alkalinity (mg/l CaCO3)	120	100	17
	Hardness (mg/l CaCO3)	160	136	15
	Ammonia (mg/l NH3)	1.1	0.6	45
G6-P	pH	7.6	7.4	3
	Conductivity (umhos/cm)	350	340	3
	Alkalinity (mg/l CaCO3)	130	99	24
	Hardness (mg/l CaCO3)	146	132	10
	Ammonia (mg/l NH3)	1.4	0.83	41
G7-P	pH	7.5	7.3	3
	Conductivity (umhos/cm)	370	350	5
	Alkalinity (mg/l CaCO3)	130	122	6
	Hardness (mg/l CaCO3)	167	146	13
	Ammonia (mg/l NH3)	1.8	0.65	64
G12-P	pH	7.7	7.4	4
	Conductivity (umhos/cm)	390	340	13
	Alkalinity (mg/l CaCO3)	130	110	15
	Hardness (mg/l CaCO3)	155	144	7
	Ammonia (mg/l NH3)	1.6	0.78	51
G20-P	pH	7.8	7.5	4
	Conductivity (umhos/cm)	350	350	0
	Alkalinity (mg/l CaCO3)	130	120	8
	Hardness (mg/l CaCO3)	152	144	5
	Ammonia (mg/l NH3)	1.2	0.78	35
G20-P Dup	pH	7.7	7.6	1
	Conductivity (umhos/cm)	360	330	8
	Alkalinity (mg/l CaCO3)	143	134	6
	Hardness (mg/l CaCO3)	163	156	4
	Ammonia (mg/l NH3)	1.1	0.74	33

Test No:	HA-98052601	Analyst:	sm, jb. rr
Toxicant:	Grand River Sediment	Test Start:	05/12/98 1500
Organism:	*Hyalella azteca*	Test Stop:	05/23/98 1500

Table D-2. Summary of the Daily Chemical Measurements for the Hyalella azteca Sediment Toxicity Tests.

Sample:	Day (AM)										
G5-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^{o}C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	8.4	8.4	8.4	8.3	8.4	8.4	8.4	8.0	8.2	8.3	8.4

Sample:	Day (AM)										
G6-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^{o}C)	23.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0
D.O. mg/l	6.6	6.8	6.3	3.7	6.4	6.6	6.8	6.3	6.9	7.0	7.6

Sample:	Day (AM)										
G7-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^{o}C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	6.8	6.0	6.3	6.7	5.9	6.1	5.3	5.4	6.6	7.2	7.8

Sample:	Day (AM)										
G12-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^{o}C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	6.2	6.3	6.4	6.2	5.8	6.3	5.8	6.9	5.4	7.0	7.6

Sample:	Day (AM)										
G20-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^{o}C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	6.5	6.1	6.1	6.3	6.0	5.9	5.7	6.2	6.5	7.4	7.3

Sample:	Day (AM)										
G20-P Dup	0	1	2	3	4	5	6	7	8	9	10
Temp (^{o}C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	5.9	5.8	5.7	5.9	6.3	6.2	6.3	7.0	7.5	7.4	7.5

Test No: HA-980526
Toxicant: Grand River Sediment
Organism: *Chironomus tentans*

Analyst: sm, jb,rr
Test Start: 05/12/98 1500
Test Stop: 05/23/98 1500

Table D-3. Summary of Initial and Final Chemical Measurements for the *Chironomus tentans* Sediment Toxicity Tests

		Day		Difference
Sample	**Parameter**	**0**	**10**	**(%)**
G5-P	pH	7.8	7.6	0
	Conductivity (umhos/cm)	380	360	5
	Alkalinity (mg/l CaCO3)	120	100	17
	Hardness (mg/l CaCO3)	155	140	10
	Ammonia (mg/l NH3)	1	0.6	40
G6-P	pH	7.6	7.4	3
	Conductivity (umhos/cm)	365	350	4
	Alkalinity (mg/l CaCO3)	140	110	21
	Hardness (mg/l CaCO3)	150	138	8
	Ammonia (mg/l NH3)	1.3	0.8	38
G7-P	pH	7.5	7.4	1
	Conductivity (umhos/cm)	370	360	3
	Alkalinity (mg/l CaCO3)	140	134	4
	Hardness (mg/l CaCO3)	174	158	9
	Ammonia (mg/l NH3)	1.5	0.8	47
G12-P	pH	7.6	7.4	3
	Conductivity (umhos/cm)	380	350	8
	Alkalinity (mg/l CaCO3)	145	115	21
	Hardness (mg/l CaCO3)	155	140	10
	Ammonia (mg/l NH3)	1.7	0.68	60
G20-P	pH	7.8	7.6	3
	Conductivity (umhos/cm)	360	350	3
	Alkalinity (mg/l CaCO3)	145	130	10
	Hardness (mg/l CaCO3)	150	145	3
	Ammonia (mg/l NH3)	1.1	0.8	27
G20-P Dup	pH	7.7	7.6	1
	Conductivity (umhos/cm)	370	340	8
	Alkalinity (mg/l CaCO3)	155	140	10
	Hardness (mg/l CaCO3)	159	142	11
	Ammonia (mg/l NH3)	1.1	0.7	36

Test No:	HA-98052601	Analyst:	sm, jb. rr
Toxicant:	Grand River Sediment	Test Start:	05/12/98 1500
Organism:	*Chironomus tentans*	Test Stop:	05/23/98 1500

Table D-4. Summary of the Daily Chemical Measurements for the *Chironomus tentans* Sediment Toxicity Tests

Sample:	Day (AM)										
G5-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^oC)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	8.4	8.4	8.4	8.3	8.4	8.4	8.4	8.0	8.2	8.3	8.4

Sample:	Day (AM)										
G6-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^oC)	23.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0
D.O. mg/l	6.6	6.8	6.3	3.7	6.4	6.6	6.8	6.3	6.9	7.0	7.6

Sample:	Day (AM)										
G7-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^oC)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	6.8	6.0	6.3	6.7	5.9	6.1	5.3	5.4	6.6	7.2	7.8

Sample:	Day (AM)										
G12-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^oC)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	6.2	6.3	6.4	6.2	5.8	6.3	5.8	6.9	5.4	7.0	7.6

Sample:	Day (AM)										
G20-P	0	1	2	3	4	5	6	7	8	9	10
Temp (^oC)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	6.5	6.1	6.1	6.3	6.0	5.9	5.7	6.2	6.5	7.4	7.3

Sample:	Day (AM)										
G20-P Dup	0	1	2	3	4	5	6	7	8	9	10
Temp (^oC)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	23.0	23.0	23.0	23.0
D.O. mg/l	5.9	5.8	5.7	5.9	6.3	6.2	6.3	7.0	7.5	7.4	7.5

Appendix E

Summary Of Reference Toxicity Test For The Sediments From The Lower Grand River

1.0 INTRODUCTION

This report contains the reference toxicity methods and data interpretation for the 96 hour acute tests for *Hyalella azteca* and *Chironomus tentans* when exposed to various concentrations of sodium chloride (NaCl).

2.0 PROCEDURES AND METHODS

Two 96 hour acute static renewal survival tests were performed with both *Hyalella azteca* and *Chironomus tentans*. Methods as outlined in EPA-600/R-94/002 were followed. The toxicity tests were initiated on June 1, 1998 and completed on June 5, 1998.

2.1 Laboratory Water Supply

A moderately hard well water was employed for *H. azteca* and *C. tentans* cultures. The moderately hard well water was used to make up the various concentrations of sodium chloride for exposures of *H. azteca* and *C. tentans*.

2.2 Test Organisms

H. azteca and *C. tentans* used in these reference experiments were from the same stock as those organisms employed in the sediment toxicity tests. The *H. azteca* used were 7-14 days old and *C. tentans* were third instar larvae and 12 to 14 days old.

2.3 Experimental Design

The purpose of this series of tests was to evaluate the "relative sensitivity" of both organisms to our reference toxicant, sodium chloride. *H. azteca* were exposed to five different concentrations of NaCl and one control with 10 replicates, one organism per replicate, for each treatment. The organisms were fed 0.1ml of YCS at the beginning of the test and after 48 hours. Renewal of the exposure solutions occurred after 48 hours. The *C. tentans* tests followed the same procedure as described above, except the concentrations of NaCl were different and the organisms were fed 0.25ml of Tetrafin® (4 g/L suspension) on day 0 and 2. Routine parameters were measured prior to the transfer of organisms to their respective exposure vessels and at the end of the test.

2.4 Statistical Analysis

Survival data for all tests were normally distributed according to Chi-square analysis, as a result, estimated EC_{50} values were calculated using the Probit model.

3.0 RESULTS AND DISCUSSION

Reference toxicity evaluations with both organisms began on June 1, 1998. The results of the reference toxicity tests are given in Tables E-1–E-4. Statistical analyses are presented in Tables E-5–E-8. All tests satisfied the validity requirement of 90% survival in the control. The routine physical-chemical parameters varied little over the test periods, the data are presented in

Tables E-1 and E-2. Fo H. azteca and Tables E-3 and E-4 for *C. tentans*. Dissolved oxygen for *H. azteca* increased over the test period. As expected, conductivity increased with increasing NaCl concentrations.

3.1 *Hyalella azteca*

Survival data for this organism are presented in test numbers Tables E-1 and E-2. The Probit model calculated a 96 hour EC_{50} values of 3.72 g/L NaCl with a 95% confidence interval ranging from 3.20 g/L - 4.31 g/l NaCl for the first test. An EC_{50} value of 4.04g/L with a 95% confidence interval of 3.76 to 4.34g/L NaCl was obtained for the second test. Statistical analyses are presented in Tables E-5 and E-6.

3.2 *Chironomus tentans*

Survival and chemistry results are presented in Tables E-3 and E-4 for this organism. The resulting 96 hour EC_{50} values and 95% confidence intervals were calculated using the Probit model and are 7.84g/L NaCl, [7.43, 8.28] for the first test and 7.51 g/L NaCl, [6.78, 8.31] for the second test. Statistical analyses are presented in Tables E-7 and E-8.

4.0 SUMMARY

Separate reference toxicity tests with *Hyalella azteca* and *Chironomus tentans* were carried out with sodium chloride. Both sets of tests proved valid since 90% or greater survival in the controls was achieved after the four day period. In addition, it was determined that the amphipod, *H. azteca* is more sensitive to sodium chloride than the dipteran, *C. tentans* based on the EC_{50}.

Test No.	HA-RT-60198-1	Analyst:	SM, JB, RR
Toxicant:	Sodium Chloride	Test Start - Date/Time:	6/01/98 1400
Test Species:	*Hyalella azteca*	Test Stop - Date/Time:	6/05/98 1400
EC Calculation Method:	Probit		

Table E-1. Summary Of Results Of Reference Toxicity Test #1 For *Hyalella Azteca.*

0 hr

Concentration (g/l)	Control	2.0	2.8	3.6	4.4	5.2
No. of Individuals	10	10	10	10	10	10
Temperature (oC)	24	24	24	24	24	24
Dissolved Oxygen (mg/l)	7.9	8.1	8.2	7.8	8.1	8.2
pH	8.1	8.0	8.0	7.9	8.0	7.9
Conductivity (umhos/cm)	280	3200	4700	6000	7200	8500
Alkalinity (mg/l as CaCO3)	190					
Hardness (mg/l as CaCO3)	216					

48 hr

Concentration (g/l)	Control	2.0	2.8	3.6	4.4	5.2
No. of Individuals Surviving	10	10	10	10	8	7
Temperature (oC)	23	23	23	23	23	23
Dissolved Oxygen (mg/l)	8.4	8.4	8.4	8.4	8.3	8.3
pH	8.1	8.0	8.2	8.1	8.0	8.0
Conductivity (umhos/cm)	280	3300	4900	6100	7300	8800

96 hr

Concentration (g/l)	Control	2.0	2.8	3.6	4.4	5.2
No. of Individuals Surviving	10	9	8	7	3	0
Temperature (oC)	23	23	23	23	23	23
Dissolved Oxygen (mg/l)	8.6	8.4	8.4	8.4	8.4	8.5
pH	8.1	7.9	7.9	7.9	7.9	7.9
Conductivity (umhos/cm)	310	3400	5000	7100	7400	8900

Test No.	HA-RT-60198-2	Analyst:	SM, JB, RR
Toxicant:	Sodium Chloride	Test Start - Date/Time:	6/01/98 1400
Test Species:	*Hyalella azteca*	Test Stop - Date/Time:	6/05/98 1400
EC Calculation Method:	Probit		

Table E-2. Summary Of Results Of Reference Toxicity Test #2 For *Hyalella Azteca.*

0 hr

Concentration (g/l)	Control	2.0	2.8	3.6	4.4	5.2
No. of Individuals	10	10	10	10	10	10
Temperature (oC)	24	24	24	24	24	24
Dissolved Oxygen (mg/l)	7.9	7.9	7.7	7.8	7.9	8.0
pH	8.1	8.0	7.9	7.9	7.9	7.9
Conductivity (umhos/cm)	280	3200	4700	5900	7200	8500
Alkalinity (mg/l as CaCO3)	190					
Hardness (mg/l as CaCO3)	216					

48 hr

Concentration (g/l)	Control	2.0	2.8	3.6	4.4	5.2
No. of Individuals Surviving	10	10	10	10	9	6
Temperature (oC)	23	23	23	23	23	23
Dissolved Oxygen (mg/l)	8.1	8.2	8.1	8.2	8.3	8.1
pH	8.1	8.0	8	7.9	7.9	7.9
Conductivity (umhos/cm)	260	3300	4920	6100	7450	9090

96 hr

Concentration (g/l)	Control	2.0	2.8	3.6	4.4	5.2
No. of Individuals Surviving	10	10	10	8	3	0
Temperature (oC)	24	24	24	24	24	24
Dissolved Oxygen (mg/l)	8.4	8.4	8.1	8.5	8.3	8.5
pH	8.2	8.1	8.1	8.1	8.0	8.0
Conductivity (umhos/cm)	320	3500	5200	6500	7600	9070

Test No. CT-RT-60198-1
Toxicant: Sodium Chloride
Test Species: *Chironomus tentans*
EC Calculation Method: Probit

Analyst: SM, JB, RR
Test Start - Date/Time: 6/01/98 1400
Test Stop - Date/Time: 6/05/98 1400

Table E-3. Summary Of Results Of Reference Toxicity Test #1 For *Chironomus Tentans.*

0 hr

Concentration (g/l)	Control	6.0	7.0	8.0	9.0	10.0
No. of Individuals	10	10	10	10	10	10
Temperature (oC)	24	24	24	24	24	24
Dissolved Oxygen (mg/l)	7.9	8.2	8.0	8.2	7.8	8.1
pH	8.1	7.7	7.7	7.7	7.7	7.7
Conductivity (umhos/cm)	280	8900	9400	12000	1300	1400
Alkalinity (mg/l as CaCO3)	190					
Hardness (mg/l as CaCO3)	216					

48 hr

Concentration (g/l)	Control	6.0	7.0	8.0	9.0	10.0
No. of Individuals Surviving	10	10	10	10	10	6
Temperature (oC)	24	24	24	24	24	24
Dissolved Oxygen (mg/l)	7.8	7.8	7.4	7.4	75	7.4
pH	8.1	8.0	7.9	7.9	7.9	7.9
Conductivity (umhos/cm)	290	9100	9600	12100	13000	14100

96 hr

Concentration (g/l)	Control	6.0	7.0	8.0	9.0	10.0
No. of Individuals Surviving	10	10	8	5	1	0
Temperature (oC)	23	23	23	23	23	23
Dissolved Oxygen (mg/l)	7.6	7.7	7.5	7.4	7.7	7.6
pH	8.0	7.9	7.9	7.7	7.7	7.6
Conductivity (umhos/cm)	210	9200	9600	12700	13200	15000

Test No.	CT-RT-60198-2	Analyst:	SM, JB, RR
Toxicant:	Sodium Chloride	Test Start - Date/Time:	6/01/98 1400
Test Species:	*Chironomus tentans*	Test Stop - Date/Time:	6/05/98 1400
EC Calculation Method:	Probit		

Table E-4. Summary Of Results Of Reference Toxicity Test #2 For *Chironomus Tentans.*

0 hr

Concentration (g/l)	Control	6.0	7.0	8.0	9.0	10.0
No. of Individuals	10	10	10	10	10	10
Temperature (oC)	24	23	23	23	24	23
Dissolved Oxygen (mg/l)	7.9	8.4	8.4	8.4	8.3	8.4
pH	8.1	7.7	7.7	7.7	7.7	7.7
Conductivity (umhos/cm)	280	8900	9400	12000	13000	14000
Alkalinity (mg/l as CaCO3)	190					
Hardness (mg/l as CaCO3)	216					

48 hr

Concentration (g/l)	Control	6.0	7.0	8.0	9.0	10.0
No. of Individuals Surviving	10	10	10	10	9	4
Temperature (oC)	23	23	23	23	23	23
Dissolved Oxygen (mg/l)	7.8	7.8	7.4	7.4	7.5	7.4
pH	8.1	8.0	7.9	8.1	8.0	7.9
Conductivity (umhos/cm)	290	9000	9500	12000	13000	14000

96 hr

Concentration (g/l)	Control	6.0	7.0	8.0	9.0	10.0
No. of Individuals Surviving	10	10	10	4	2	1
Temperature (oC)	23	23	23	23	23	23
Dissolved Oxygen (mg/l)	7.8	7.6	7.7	7.6	7.8	7.8
pH	7.8	7.8	7.8	7.7	7.7	7.6
Conductivity (umhos/cm)	300	9700	10000	12200	13100	14800

Table E-5
HA-RT-60198-1 SODIUM CHLORIDE REFERENCE TEST
96-Hour EC_{50} for *Hyalella azteca*

SUMMARY STATISTICS ON DATA -- Transform: NO TRANSFORMATION

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	0.0 (control)	10	1.0000	1.0000	1.0000
2	2.0 g/L	10	1.0000	1.0000	1.0000
3	2.8 g/L	10	1.0000	1.0000	1.0000
4	3.6 g/L	10	0.0000	1.0000	0.9000
5	4.4 g/L	10	0.0000	1.0000	0.3000
6	5.2 g/L	10	0.0000	0.0000	0.0000

GRP	IDENTIFICATION	VARIANCE	SD	SEM	C.V. %
1	0.0 (control)	0.0000	0.0000	0.0000	0.0000
2	2.0 g/L	0.0000	0.0000	0.0000	0.0000
3	2.8 g/L	0.0000	0.0000	0.0000	0.0000
4	3.6 g/L	0.1000	0.3162	0.1000	35.1364
5	4.4 g/L	0.2333	0.4830	0.1528	161.0153
6	5.2 g/L	0.0000	0.0000	0.0000	N/A

PROBIT ANALYSIS - USING SMOOTHED PROPORTIONS -- Transform: LOG 10 DOSE

DOSE (g/L)	NUMBER SUBJECTS	NUMBER OBSERVED	OBSERVED PROPORTION	SMOOTHED PROPORTION	PREDICTED PROPORTION
2.00	10	9	0.9000	0.9000	0.9538
2.80	10	8	0.8000	0.8000	0.7792
3.60	10	7	0.7000	0.7000	0.5345
4.40	10	3	0.3000	0.3000	0.3233
5.20	10	0	0.0000	0.0000	0.1808

Est. Mu = 0.5782 Est. Sigma = 0.1599
sd = 0.0320 sd = 0.0416

Chi-Square lack of fit = 2.2500 Likelihood lack of fit = 2.2006
Table Chi-square = 11.3449 (alpha = 0.01, df = 3)
Table Chi-square = 7.8147 (alpha = 0.05, df = 3)

PROBIT EC ESTIMATES -- WITHOUT CONTROL DATA

POINT	EST. END POINT	95% CONFIDENCE LIMITS	
EC10	2.3188	1.7721	3.0342
EC20	2.7265	2.2214	3.3464
EC30	3.0642	2.5878	3.6383
EC40	3.3858	2.9123	3.9363
EC50	3.7168	3.2055	4.3096
EC60	4.0801	3.4766	4.7884
EC70	4.5083	3.7430	5.4300
EC80	5.0667	4.0364	6.3602
EC90	5.9575	4.4350	8.0028

Table E-6
HA-RT-60198-2 SODIUM CHLORIDE REFERENCE TEST
96-Hour EC_{50} for *Hyalella azteca*

SUMMARY STATISTICS ON DATA -- Transform: NO TRANSFORMATION

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	0.0 (control)	10	1.0000	1.0000	1.0000
2	2.0 g/L	10	1.0000	1.0000	1.0000
3	2.8 g/L	10	1.0000	1.0000	1.0000
4	3.6 g/L	10	0.0000	1.0000	0.8000
5	4.4 g/L	10	0.0000	1.0000	0.3000
6	5.2 g/L	10	0.0000	0.0000	0.0000

GRP	IDENTIFICATION	VARIANCE	SD	SEM	C.V. %
1	0.0 (control)	0.0000	0.0000	0.0000	0.0000
2	2.0 g/L	0.0000	0.0000	0.0000	0.0000
3	2.8 g/L	0.0000	0.0000	0.0000	0.0000
4	3.6 g/L	0.1778	0.4216	0.1333	52.7046
5	4.4 g/L	0.2333	0.4830	0.1528	161.0153
6	5.2 g/L	0.0000	0.0000	0.0000	N/A

PROBIT ANALYSIS - USING SMOOTHED PROPORTIONS -- Transform: LOG 10 DOSE

DOSE (g/L)	NUMBER SUBJECTS	NUMBER OBSERVED	OBSERVED PROPORTION	SMOOTHED PROPORTION	PREDICTED PROPORTION
2.00	10	10	1.0000	1.0000	1.0000
2.80	10	10	1.0000	1.0000	0.9987
3.60	10	8	0.8000	0.8000	0.8283
4.40	10	3	0.3000	0.3000	0.2441
5.20	10	0	0.0000	0.0000	0.0197

Est. Mu = 0.6066 Est. Sigma = 0.0531
sd = 0.0158 sd = 0.0151

Chi-Square lack of fit = 0.4405 Likelihood lack of fit = 0.6414
Table Chi-square = 11.3449 (alpha = 0.01, df = 3)
Table Chi-square = 7.8147 (alpha = 0.05, df = 3)

PROBIT EC ESTIMATES -- WITHOUT CONTROL DATA

POINT	EST. END POINT	95% CONFIDENCE LIMITS	
EC10	3.4558	3.0707	3.8892
EC20	3.6469	3.3135	4.0138
EC30	3.7911	3.4894	4.1189
EC40	3.9189	3.6353	4.2247
EC50	4.0423	3.7634	4.3419
EC60	4.1695	3.8799	4.4807
EC70	4.3101	3.9909	4.6548
EC80	4.4806	4.1052	4.8903
EC90	4.7283	4.2451	5.2665

Table E-7
CT-RT-60198-1 SODIUM CHLORIDE REFERENCE TEST
96-Hour EC_{50} for *Chironomus tentans*

SUMMARY STATISTICS ON DATA -- Transform: NO TRANSFORMATION

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	0.0 (control)	10	1.0000	1.0000	1.0000
2	6.0 g/L	10	1.0000	1.0000	1.0000
3	7.0 g/L	10	0.0000	1.0000	0.8000
4	8.0 g/L	10	0.0000	1.0000	0.5000
5	9.0 g/L	10	0.0000	1.0000	0.1000
6	10.0 g/L	10	0.0000	0.0000	0.0000

GRP	IDENTIFICATION	VARIANCE	SD	SEM	C.V. %
1	0.0 (control)	0.0000	0.0000	0.0000	0.0000
2	6.0 g/L	0.0000	0.0000	0.0000	0.0000
3	7.0 g/L	0.1778	0.4216	0.1333	52.7046
4	8.0 g/L	0.2778	0.5270	0.1667	105.4093
5	9.0 g/L	0.1000	0.3162	0.1000	316.2278
6	10.0 g/L	0.0000	0.0000	0.0000	N/A

PROBIT ANALYSIS - USING SMOOTHED PROPORTIONS -- Transform: LOG 10 DOSE

DOSE (g/L)	NUMBER SUBJECTS	NUMBER OBSERVED	OBSERVED PROPORTION	SMOOTHED PROPORTION	PREDICTED PROPORTION
6.00	10	10	1.0000	1.0000	0.9934
7.00	10	8	0.8000	0.8000	0.8535
8.00	10	5	0.5000	0.5000	0.4277
9.00	10	1	0.1000	0.1000	0.1020
10.00	10	0	0.0000	0.0000	0.0124

Est. Mu = 0.8945 Est. Sigma = 0.0470
sd = 0.0120 sd = 0.0113

Chi-Square lack of fit = 0.6354 Likelihood lack of fit = 0.8044
Table Chi-square = 11.3449 (alpha = 0.01, df = 3)
Table Chi-square = 7.8147 (alpha = 0.05, df = 3)

PROBIT EC ESTIMATES -- WITHOUT CONTROL DATA

POINT	EST. END POINT	95% CONFIDENCE LIMITS	
EC10	6.8279	6.2499	7.4594
EC20	7.1609	6.6639	7.6950
EC30	7.4110	6.9627	7.8882
EC40	7.6316	7.2109	8.0769
EC50	7.8438	7.4304	8.2802
EC60	8.0619	7.6334	8.5144
EC70	8.3019	7.8310	8.8010
EC80	8.5919	8.0406	9.1809
EC90	9.0108	8.3057	9.7759

Table E-8
CT-RT-60198-2 SODIUM CHLORIDE REFERENCE TEST
96-Hour EC_{50} for *Chironomus tentans*

SUMMARY STATISTICS ON DATA -- Transform: NO TRANSFORMATION

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	0.0 (control)	10	1.0000	1.0000	0.9000
2	6.0 g/L	10	1.0000	1.0000	0.8000
3	7.0 g/L	10	0.0000	1.0000	0.6000
4	8.0 g/L	10	0.0000	1.0000	0.4000
5	9.0 g/L	10	0.0000	1.0000	0.3000
6	10.0 g/L	10	0.0000	1.0000	0.1000

GRP	IDENTIFICATION	VARIANCE	SD	SEM	C.V. %
1	0.0 (control)	0.1000	0.3.162	0.1000	35.1364
2	6.0 g/L	0.1778	0.4216	0.1333	52.7046
3	7.0 g/L	0.2667	0.5164	0.1633	86.8663
4	8.0 g/L	0.2667	0.5164	0.1633	129.0994
5	9.0 g/L	0.2333	0.4838	0.1528	161.0153
6	10.0 g/L	0.1000	0.3162	0.1000	316.2278

PROBIT ANALYSIS - USING SMOOTHED PROPORTIONS -- Transform: LOG 10 DOSE

DOSE (g/L)	NUMBER SUBJECTS	NUMBER OBSERVED	OBSERVED PROPORTION	SMOOTHED PROPORTION	PREDICTED PROPORTION
6.00	10	8	0.8000	0.8000	0.8053
7.00	10	6	0.6000	0.6000	0.6064
8.00	10	4	0.4000	0.4000	0.4046
9.00	10	3	0.3000	0.3000	0.2443
10.00	10	1	0.1000	0.1000	0.1366

Est. Mu = 0.8757 Est. Sigma = 0.1134
sd = 0.0225 sd = 0.0339

Chi-Square lack of fit = 0.2855 Likelihood lack of fit = 0.2878
Table Chi-square = 11.3449 (alpha = 0.01, df = 3)
Table Chi-square = 7.8147 (alpha = 0.05, df = 3)

PROBIT EC ESTIMATES -- WITHOUT CONTROL DATA

POINT	EST. END POINT	95% CONFIDENCE LIMITS	
EC10	5.3749	4.2331	6.8247
EC20	6.0292	5.0372	7.2167
EC30	6.5500	5.6838	7.5482
EC40	7.0304	6.2613	7.8940
EC50	7.5112	6.7873	8.3123
EC60	8.0250	7.2570	8.8742
EC70	8.6136	7.6760	9.6657
EC80	9.3575	8.0855	10.8295
EC90	10.4967	8.5872	12.8308