Chapter IV

AMBIENT RIVER MONITORING

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4.1 Introduction

The overall objective of the Ambient River Monitoring component of the Niagara River Toxics Project was to "assess the extent of toxic contamination in the Niagara River and locate areas in the Niagara River where significant inputs of toxic chemicals are occurring" (NRTC, 1983).

Twenty-eight sub-projects were undertaken to address this objective. They varied widely in their scope, their purpose, and in the media and stations sampled. To clarify the situation, this chapter begins with a general overview of each sub-project, including the rationale, the benefits, and the potential drawbacks of sampling specific parts of the ecosystem. It also includes a brief summary of the various sub-projects for which data were available, indicating how they were conducted (sampling locations or stations, sampling frequency, numbers of chemicals analyzed). Illustrations of sampling stations of studies discussed in this chapter are contained in the appropriate sections, i.e. water, sediment, and biota. The classes of chemical substances analyzed are summarized in Table 4.1. Space limitations did not permit presentation of detailed information regarding field and analytical methodologies of individual sub-projects. This is available from the study leader indicated in the Niagara River Toxics Committee Status Report (NRTC, 1983). Where evaluation of the Data Quality Subcommittee precluded use of specific data sets, this is noted in the appropriate location of the Ambient Projects Overview (section 4.2).

In the previous chapters, point and non-point source data were given without reference to the relationship between the input of pollutants and the dynamics of the Niagara River. In this chapter, this relationship will be explored. Background information on physical, chemical, and biological processes which occur in the river will be provided to make this discussion more meaningful to the reader.

The results of the various sub-projects will be presented in summary form in the text, and detailed discussions along with data tabulations will be given in Appendix C.

TABLE 4.1

CONTAMINANT ANALYSES PERFORMED ON NIAGARA RIVER AMBIENT MONITORING SUB-PROJECT SAMPLES

CHEMICAL CLASS	MEDIA	WATER AND SUSPENDED SEDIMENT												BOTTOM SEDIMENT						BIOTA										
	SUB-PROJECT #	3	7	9	10	11	21	22	23	24	25	26	32	1	8	12&12a	13+14	23	27&27a	2	3	4	5	6	15	28	29	30	31	33
Metals				*	*	*		*	*	*	*	*		*	*	*	*	*	*	*			*				*	*		*
PCBs				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*			*	*	*	*	*
Pesticides			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*			*		*	*	*
Aliphatic hydrocarbons													*	*		*	*													
Aromatic hydrocarbons				*									*	*		*	*													
Polynuclear aromatic Hydrocarbons		*		*	*	*		*						*		*	*	*		*										
Halogenated aliphatics				*									*	*		*	*													
Halogenated aromatics				*	*	*	*	*	*				*	*		*	*	*			*						*			
Alcohols, Organic acids, Ethers, Esters				*									*	*		*	*													
Nitro-and Amino aromatics				*										*		*	*													
Aldehydes and Ketones													*	*		*	*													
Organo-sulphides													*				*													
Phenol				*							*	*					*													
Halogenated phenols				*										*		*	*													
Phthalates				*	*	*		*	*					*		*	*													
Dioxin													*				*				*				(*)		*	*	*	
Total Number of Analyses: 105,747		see	66	804	1758	649	290	1934	2392	3454	15418	7788	13965	9383	3142	1684	20951	2292	3729	845	90	1429		--	--	7043	5040	1320	8	
Total Number of Detections: 27,167		biota	66	25	311	98	193	1073	1118	1827	3293	1674	2097	1983	681	265	1668	1118	1540	53	85	488			--	1838	4708	957		8

(*) Samples collected but not yet analyzed.

Identification of sub-projects is as follows:

Sub-Project Number	Title	Agency	Sub-Project	Title	Agency
1	Buffalo Harbour & Niagara River Sediment Survey	USEPA V	21	Survey of Contaminants at Niagara-on-the-Lake	IWD-OR
2	Ambient Feasibility Study	NYSDEC	22	Niagara River Suspended Sediments	IWD-OR
3	Polycyclic Aromatic Hydrocarbon Trackdown	NYSDEC/USEPA V	23	Toxic Contaminants Sources Survey	IWD-OR
4	Nearshore Ambient Trackdown	NYSDEC	24	Niagara-on-the-Lake Daily Water Monitoring	IWD-OR
5	Fish Studies	NYSDEC	25	Lower Niagara River Water Quality Survey	MOE
6	Macroinvertebrate Survey	NYSDEC/NYSDOH	26	Upper Niagara River Water Quality Survey	MOE
7	Lake Erie and Lake Ontario Water Sampling	USEPA/ERL	27a	Niagara River Sediment Survey (1979)	MOE
8	Sediment Testing in Buffalo River and Harbour	USACOE	27	Lower Niagara River Sediment Survey (1981)	MOE
9	Water Quality Surveillance Network Sampling	NYSDEC	28	Freshwater Clam Studies	MOE
10	Lake Erie Input to Niagara River	NYSDEC	29	Cladophora Surveys	MOE
11	Buffalo River Toxics Loading	NYSDEC	30	Fish Studies - Toxic Contaminants	MOE
12	Open Lake (Erie) Dredge Spoil Site Sampling	USEPA II	31	Trends in Contaminants in Herring Gulls	CWS
12a	Niagara River Sediment Sampling	USEPA II	32	Drinking Water Monitoring	MOE
13	Scajaquada Creek Sediment Sampling	NYSDEC	33	Sport Fish Testing - Angler Advisory Program	MOE
14	Two Mile Creek Sediment Sampling	NYSDEC			
15	Cayuga Creek Dioxin Trackdown	NYSDEC			

In addition, supporting data tables, referenced within the text and text tables, are found in Appendix C.

4.2 Ambient Projects Overview

4.2.1 General

The various sub-projects fall into three broad groups, depending on the media monitored: water and associated particulates (suspended sediments), bottom sediments, and biota.

For brevity, a number of abbreviations are used in this report. These are explained at the end of the report in the GLOSSARY (Appendix E).

4.2.2 Data Quality

Of the approximately 105,000 chemical analyses conducted as part of the ambient studies of the Niagara River Toxics Project, about 77,000 could not be quantified because the concentration of the chemical looked for was less than the detection capability of the analytical procedure. More than 75% of the results were less than the detection limit for the water measurements.

From the recommendations made in the report of the Data Quality Subcommittee *(DQS), a further 4000 data points were deemed unusable for quantitative purposes; however, they were used qualitatively to indicate the presence or absence of a chemical in a particular sample.

Thus, only about 19,000 chemical analyses could be used in a quantitative fashion. The total data base available was about 10,000 organic

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* Available as a separate publication. "Final Report to the Niagara River Toxics Committee by The Data Quality Sub-committee, 1984".

contaminant numbers and about 9,000 trace metal numbers. When the DQS recommended that data not be included in this report, the data were not used.

4.2.3 Water and Suspended Sediments

The complex hydrology of the river, coupled with the variable nature of contaminant inputs from both point and non-point sources, requires frequent water sampling to determine both temporal and spatial trends in water quality. Thus, water and suspended sediment samples accounted for approximately fifty percent of the total number of ambient river samples collected during the two-year study period (see Table 4.1).

Unless a water sample is filtered prior to analysis, it will contain some particulate matter (suspended sediment). Hence, contaminant concentrations in the sample will reflect the sum of chemicals in the aqueous phase and that portion associated with suspended sediment. Suspended sediment in water can come from a number of sources: shoreline erosion (primarily inorganic), biological material such as plankton (organic), industrial or municipal discharges, resuspension of bottom sediments (inorganic and organic), or atmospheric deposition (inorganic and organic). Contaminants, particularly those organics and metals with a very low solubility in water, have a tendency to adsorb or "partition out" onto the surface of particulate matter in the water column. This tendency becomes greater as the mean size (diameter) of the particles decreases or the proportion of organic to inorganic matter increases. Because of this concentration effect, the ability to detect contaminants in suspended or bottom sediments is usually greater than in an equal volume or weight of water. Indeed, Kuntz and Warry (1983) found that, depending on the compound, the concentration of organochlorine contaminants associated with suspended sediments in the lower Niagara River was 400 to 500,000 times greater than in the aqueous phase.

Mean suspended sediment concentration in lower Niagara River waters is relatively low**, but, coupled with the high flow of the river, constitutes 50% of the fine-grained sediment input to Lake Ontario (Kemp & Harper, 1976). It was, therefore, important to measure contaminants in suspended sediments, the aqueous phase (water with suspended sediments removed) as well as in whole water (unfiltered) samples to determine the relative proportions and importance of contaminants in the aqueous and particulate phases.

Ambient river water and suspended sediment samples were collected by two basic types of sampling: fixed station monitoring and river surveys. The locations of these sampling points are shown in Fig. 4.1.

4.2.3.1 Fixed Station Monitoring

Fixed water quality monitoring stations, particularly those which use an in-place intake structure such as that of a water treatment plant (WTP) permit year-round monitoring, even during storms or periods of ice cover.

Suspended sediments have been collected using a continuous-flow centrifuge at Niagara-on-the-Lake (NOTL) since 1979 to determine temporal trends in contaminant concentrations in the lower river and in loadings to Lake Ontario. Beginning in 1980, IWD-OR also initiated the collection and analysis of whole water samples at this site. These collections were continued during 1981 and 1982 (sub-projects 21, 22, and 24). During 1982, a concurrent study was conducted by NYSDEC (sub-project 10) at the Buffalo WTP which draws water from Lake Erie (outside the project area). Whole water samples collected on 14 occasions at the Buffalo WTP and 48 times at NOTL were each analyzed for an average of 10 metals and 40 organics (Table 4.1). Suspended sediments collected at Buffalo (19 samples) and at NOTL (22 samples) were analyzed for a similar group and number of contaminants. By comparing the data gathered at the inlet and outlet of the Niagara River, it

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** 8.6 mg/L from 1981 to 1982 inclusive, Kuntz and Warry, 1983.

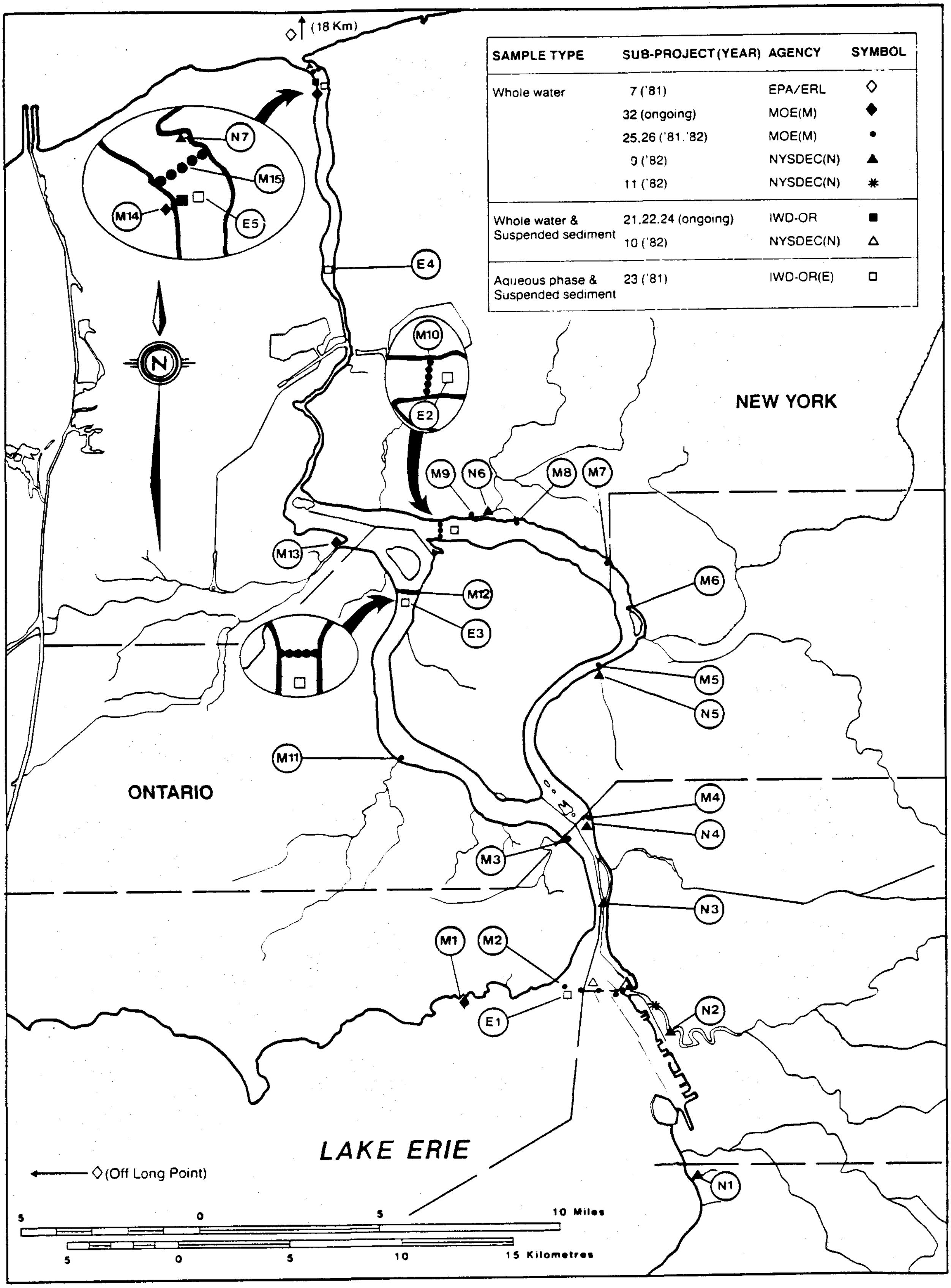

FIGURE 4.1 AMBIENT WATER QUALITY STATIONS. (Data for Stations Identified by by Letter and Number are Available in Appendix C.)

was hoped that the relative contributions of Lake Erie and inputs within the Niagara River watershed to contaminant loadings to Lake Ontario could be determined. However, the higher detection limits for most organic parameters and questionable qualitative identifications of PCBs and pesticides (DQS, 1983) for the NYSDEC sub-project precluded this. Although metals data from both sub-projects were comparable, the large temporal variability in concentrations, particularly at the Buffalo WTP, resulted in differences which were difficult to interpret.

Whole (raw) water samples* have been collected by MOE at Ontario WTP intakes on the river since 1978 at the water treatment plants at Niagara Falls, Niagara-on-the-Lake** (drawing from the Niagara River), and Rosehill*** (drawing from Bertie Bay, Lake Erie). An average of 11 samples were collected from each plant during 1981 and 19 during 1982 (sub-project 32). Each sample was analyzed for 69 organic contaminants. About eight samples from each year were also analyzed for total tetrachlorodibenzo-p-dioxins.

Fixed station monitoring was also carried out from June to October 1982 by NYSDEC (sub-project 9) at seven stations along the U.S. shoreline of the Niagara River. This included sampling of Smoke Creek, Buffalo River, Two Mile Creek, and Cayuga Creek to determine inputs to the river. Whole water samples were also collected at the Tonawanda WTP and in the Niagara River at Buffalo and Fort Niagara (lower river). Five to eight samples per station were analyzed for 13 metals and 115 organics. NYSDEC had planned to determine the loading of the Buffalo River to the Niagara River (sub-project 11); however, because of the absence of high flow events, the project could not be carried out.

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* The quality of drinking (treated) water is not discussed in this chapter since it has been addressed by U.S. reports and will be addressed by a Canadian report.

** As of mid-1982, drinking water for Niagara-on-the-Lake is obtained from nearby St. Catharines, Ont. However, the raw water sampling program at Niagara-on-the-Lake was continued.

*** Sampled since January 1981.

4.2.3.2 River Surveys

In sub-projects 25 and 26, whole water samples were collected by MOE at a number of stations in the river. In 1981, 21 stations were distributed from shore to shore along four strategic transects (see Figure 4.1). Based on results of this sampling and other previous studies (Kauss, 1983; Kuntz, 1983), the 1982 sampling was restricted to 15 stations close to the mainland shore, where contaminant concentrations were expected to be highest. This included six stations from transects M2, M10, M12 and M15 used in 1981. During each of the survey years, samples were taken on twelve days from May to October and analyzed for a total of 12 metals and 21 organics.

River sampling was also conducted by IWD-OR during 1981 (sub-project 23). At each of five stations situated in mid-channel (Figure 4.1), suspended sediments were separated from river water by continuous-flow centrifuge and collected. A large subsample (200 litres) of the effluent stream from the centrifuge (the aqueous phase, containing mainly dissolved contaminants) was also collected and solvent-extracted on-board. Each of the aqueous phase and suspended sediment samples was analyzed for a total of 22 organics to determine the relative contribution of aqueous- and particulate-associated contaminants to spatial differences in contaminants concentrations in the river. Owing to the time-consuming nature of these collections (about 20 hours per suspended sediment sample), samples to address temporal variability were only collected three times in 1981-during the months of May, July, and November.

4.2.4 Bottom Sediments

Particulate matter (suspended sediments) tends to settle out of the water column in depositional areas, ultimately becoming incorporated in the bottom sediments. Therefore, analysis of bottom sediment cores can provide valuable information about the existence of contaminants inputs, both recent and historic. In a river, the exact location of a source may be difficult to determine. Contaminated sediment resulting from a current or historical source can be carried some distance downstream, either as result of normal river flow or resuspension of sediment due to storm events or ice scour, before being deposited.

In the Niagara River, the higher current velocity in the centre of channels prevents the formation of extensive sediment deposits in these areas. Consequently, as is shown by Figures 4.2, 4.3, and 4.4, bottom sediment sampling was largely confined to nearshore areas where current velocity is reduced, causing increased sedimentation.

Sediment studies were undertaken for a variety of purposes, and hence they vary in geographical coverage, sampling site selection criteria, and the contaminants analyzed (see Table 4.1). For example, the 13 sites sampled by the USACOE in 1981 and the 16 sites sampled by USEPA II in 1982 (sub-projects 8 and 12, respectively) were designed to determine the chemical quality of sediments in areas most likely to have high contaminants concentrations (the Buffalo River/Buffalo Harbor area and the former Lake Erie open dredge spoil dumping site, respectively). The USACOE samples were analyzed for 11 metals and 31 organics. However, since qualitative identifications of PCBs and pesticides from the USACOE study were considered to be incomplete (DQS, 1983)* only the metals data from sub-project 8 were utilized in this chapter. The USEPA II samples were analyzed for 13 metals and 129 organics. Sub-project 1 (USEPA V) sampled sediments in the upper river (U.S. side) and its main tributaries in suspected source areas. Sixty-nine samples were each analyzed for 25 metals and 129 organics. Sub-project 3 (NYSDEC) involved the collection of sediments from thirty sites in the upper river to identify areas of polycyclic aromatic hydrocarbon (PAH) input to the Niagara River. Samples were each analyzed for 14 PAHs. Sub-project 27, conducted in 1981 (MOE) was designed to determine sediment quality in the lower river in areas of sediment accumulation (embayments)

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* The original objective (to determine chemical quality of sediments in the Buffalo Harbor navigation channel) of the U.S. Army Corps of Engineers study was not intended to address the objectives of the NRTC study.

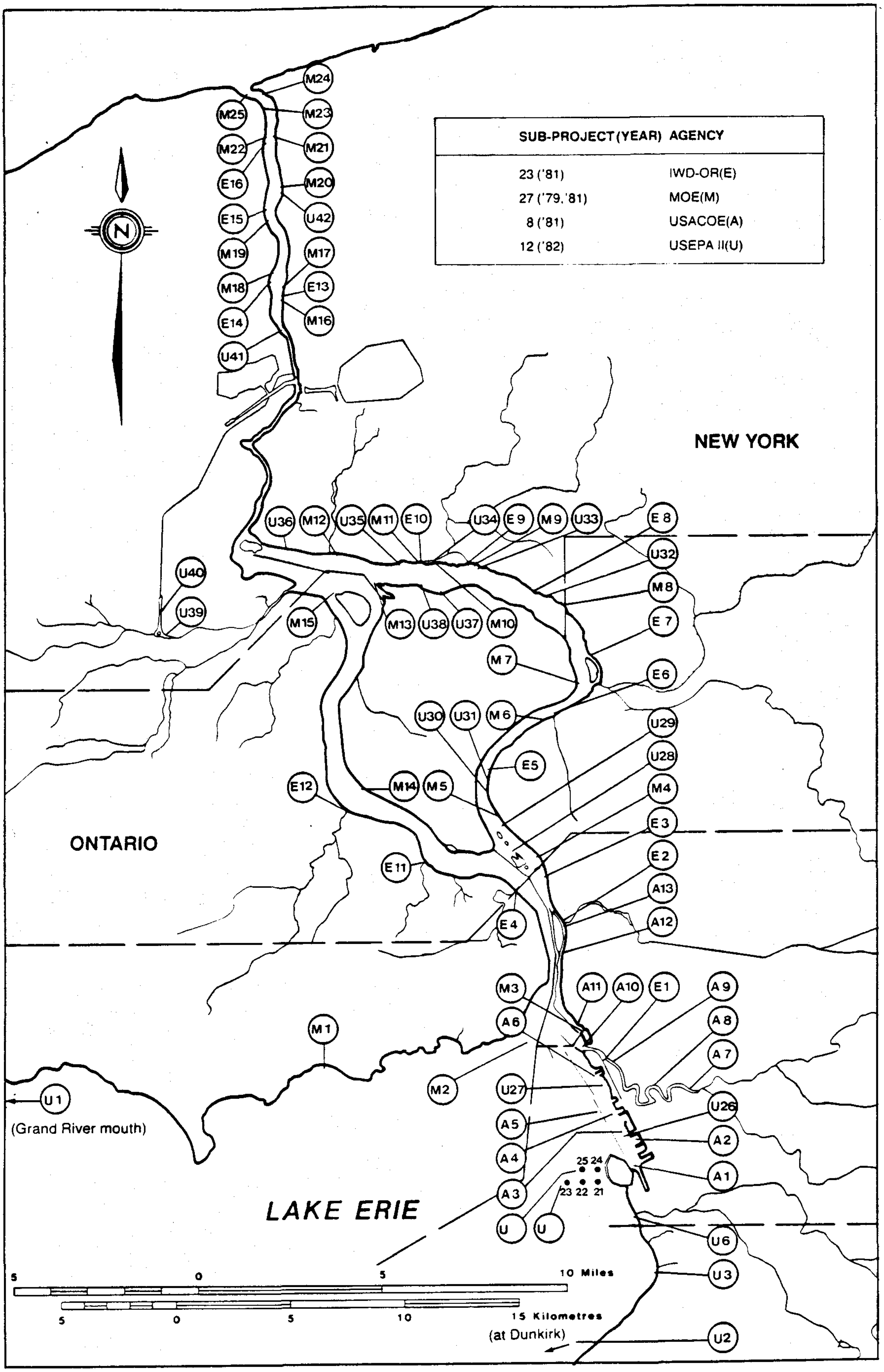


FIGURE 4.2 SEDIMENT SAMPLING STATIONS. (Data for Stations Identified by Letter and Number are Available in Appendix C.)

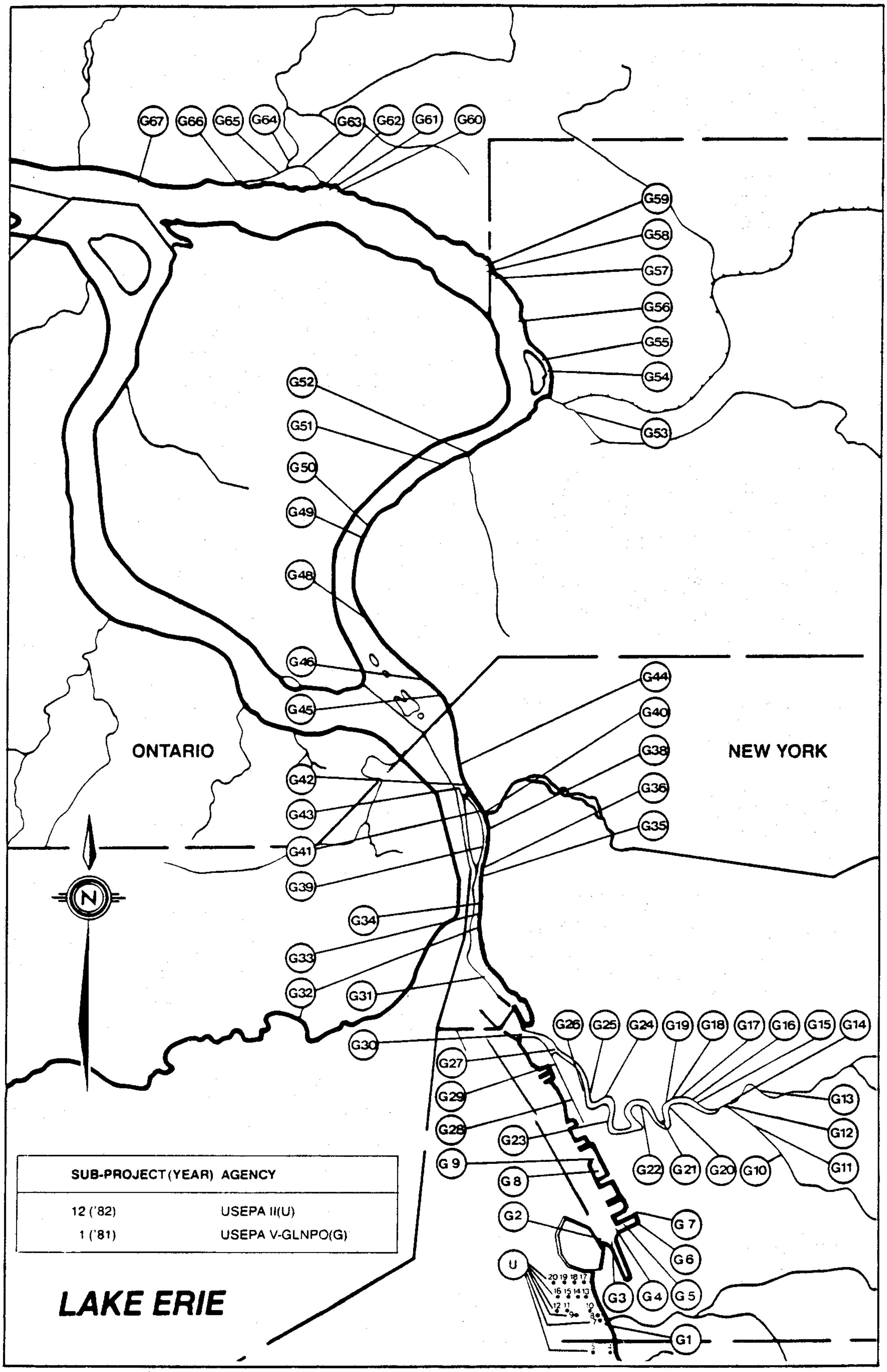
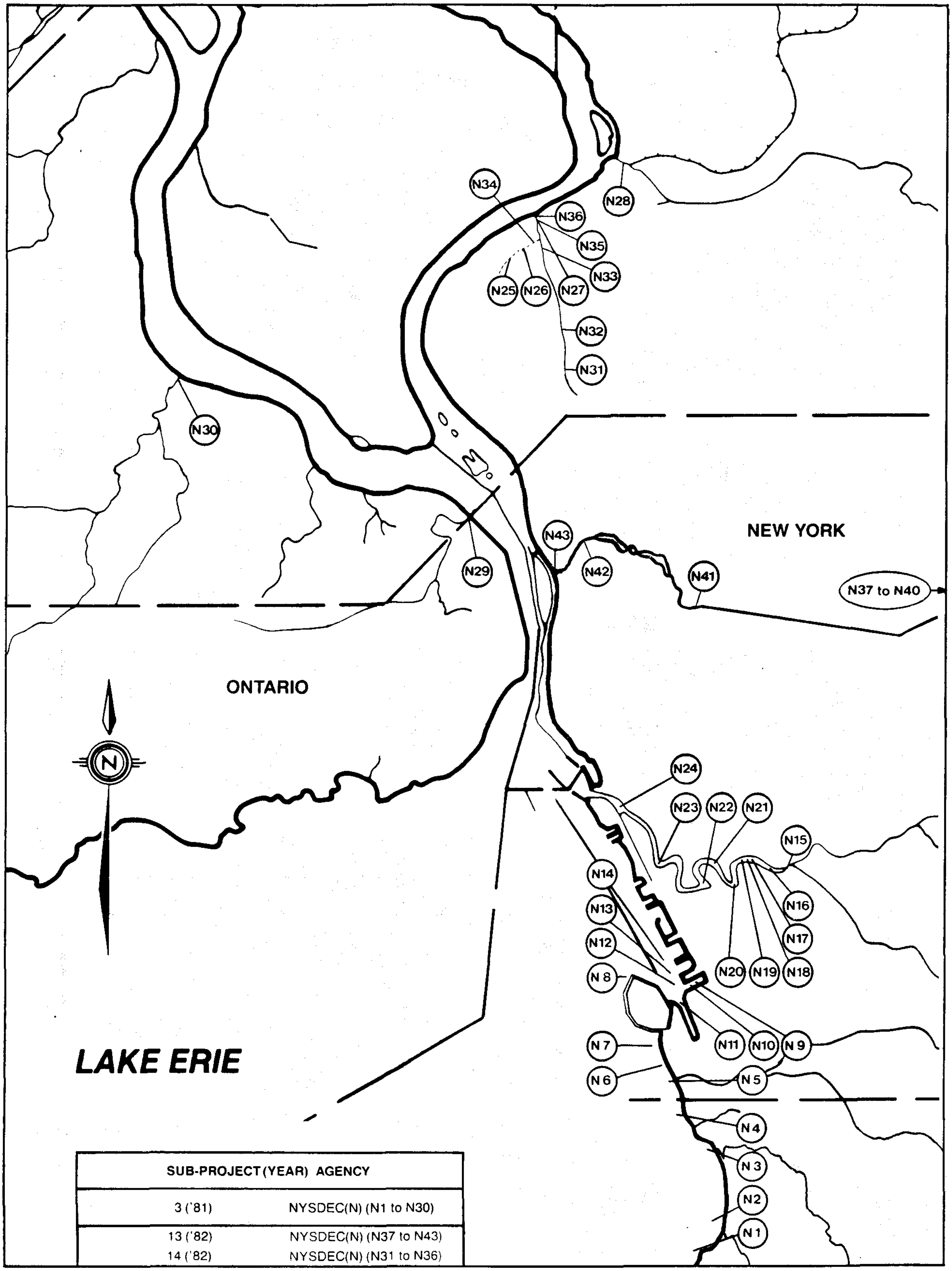


FIGURE 4.3 SEDIMENT SAMPLING STATIONS. (Data for Stations Identified by Letter "U" and Number are Available in Appendix C. Data for "G" Designated Stations are Available in a USEPA Report by Rockwell <u>et al</u>. (1984); See Page 4-109.)



SUB-PROJECT(YEAR)	AGENCY
3 ('81)	NYSDEC(N) (N1 to N30)
13 ('82)	NYSDEC(N) (N37 to N43)
14 ('82)	NYSDEC(N) (N31 to N36)

FIGURE 4.4 SEDIMENT SAMPLING STATIONS. (Data for Stations Identified by Letter and Number are Available in Appendix C.)

that contained elevated contaminant levels identified in a previous 1979 study (Kauss, 1983). A number of samples were collected from each area and composited prior to analysis to yield information on overall sediment quality in each area. In all, 21 samples were each analyzed for 10 metals and 21 organics.

The remaining studies were oriented to provide a more general idea of sediment quality in the whole (upper and lower) river and also to sample suspected source areas. In a 1979 MOE study (sub-project 27a) samples were obtained from 24 sites in the river, and these were each analyzed for 8 inorganics and 20 organics. Sub-project 23 (IWD-OR) involved the collection of bottom sediments at 16 sites in 1981 and these were analyzed for 10 metals and 30 organics. A 1982 survey by USEPA Region II (sub-project 12a) sampled 26 sites and each sample was analyzed for 21 metals and 111 organics. Two NYSDEC studies in 1982 involved sediment sampling of Scajaquada Creek (sub-project 13) and Two-mile Creek (sub-project 14). In total, samples from thirteen stations were each analyzed for 13 metals and 112 organics.

Bottom sediments were obtained by boat or helicopter, using Ponar, Shipek, or modified Shipek dredge samplers which collected the upper, most recently deposited layers of sediment. The concentrations in the uppermost layers reflect the more recent contaminant inputs to the river. However, the actual depth of sediment analyzed varied somewhat, ranging from a top 3 centimeter subsample of Shipek dredge samples (sub-project 27) to the complete Ponar dredge sample (sub-project 12). In addition, sub-project 1 included some short (5 to 25 cm in length) core samples which were composited for analysis.

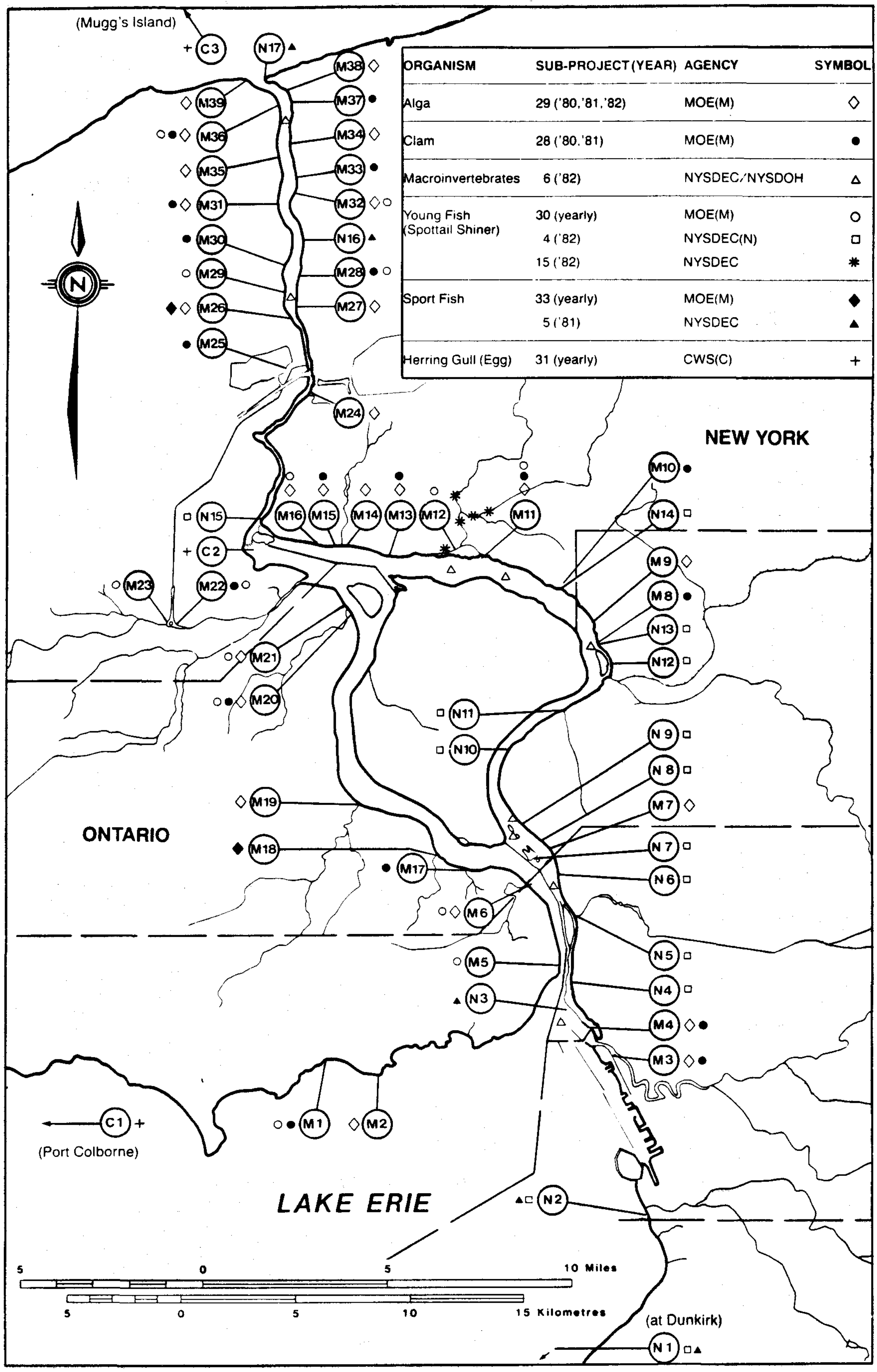
4.2.5 Biota

Aquatic organisms are in continuous contact with their environment. Hence, they are the primary indicators of the individual, synergistic, or antagonistic effects of water-borne contaminants, and can reflect the effects of even sporadic, short term contaminant inputs which may not be detected by routine water sampling. More importantly, the presence of potential human health hazards from persistent bioaccumulative chemicals may be more readily detected by analysis of aquatic organisms than by analysis of water samples. This is particularly true when the chemicals of concern exist in water at concentrations near or below analytical detection limits or are introduced too sporadically to be detected by routine water quality sampling. Biological monitoring, then, provides an important tool for evaluating the impact of chemical loadings on living organisms, due either to their acute toxicity to or accumulation in organisms.

A wide variety of biota, both plants and animals, were sampled (Figure 4.5) as part of the Niagara River Toxics Project. The use of a variety of species has been necessary, since each has its particular strengths and weaknesses, depending upon the specific purpose(s) of the study (long-term trend evaluation or source area identification) and the chemicals of interest (metals or organics). Consequently, based on the life history and hence, the application of a particular species, the various sub-projects can be subdivided into two groups as discussed below.

4.2.5.1 Identification of Contaminant Source Areas

Spottail shiners (*Notropis hudsonius*) are found throughout the Great Lakes and are an important food source of many game fish. When young, these fish feed on minute plants and animals (plankton) over sandy shoals (Scott, 1978). Due to their low mobility and restriction to nearshore waters during early life, young-of-the-year spottails have proven to be useful integrators and indicators of localized water column contamination during their three to four month exposure period (Suns *et al*, 1981). Fish have been collected in the Niagara River by MOE at NOTL since 1975. Additional collection sites were added, so that there were seven in 1981. In 1982, a joint NYSDEC/MOE study (sub-projects 4 and 30, respectively) collected fish from 23 sites in the river as well as sites in Lake Erie and the Welland River (see Figure 4.5). Spottail shiner collections are made yearly in the fall by seining and



ORGANISM	SUB-PROJECT(YEAR)	AGENCY	SYMBOL
Alga	29 ('80,'81,'82)	MOE(M)	◇
Clam	28 ('80,'81)	MOE(M)	●
Macroinvertebrates	6 ('82)	NYSDEC/NYSDOH	△
Young Fish (Spottail Shiner)	30 (yearly)	MOE(M)	○
	4 ('82)	NYSDEC(N)	□
	15 ('82)	NYSDEC	✱
Sport Fish	33 (yearly)	MOE(M)	◆
	5 ('81)	NYSDEC	▲
Herring Gull (Egg)	31 (yearly)	CWS(C)	+

FIGURE 4.5 BIOTA SAMPLING STATIONS. (Data for Stations Identified by Letter and Number are Available in Appendix C.)

fish kept frozen until analyzed. Analysis for about 30 organics was carried out on whole (homogenized) fish. Results were reported on a wet weight basis.

During 1982, NYSDEC collected spottail shiners in the Cayuga Creek system as part of a dioxin trackdown (sub-project 15). Results are pending.

The proliferation of the green filamentous alga Cladophora glomerata has been a problem in the lower Great Lakes nearshore for several years. However, as a result of its yearly regrowth on rocky substrates, Cladophora is useful for the identification of contaminant source areas and the monitoring of individual point source discharges for metals and PCBs. Cladophora was collected from 18 sites in the Niagara River in 1980, 16 in 1981 and 19 sites in 1982 (Figure 4.5). Samples were collected by hand from 0 to 0.5 m below water level, rinsed, and then dried prior to analysis (sub-project 30). Three collections were made during 1981 in mid-June, late July, and mid-August. On the basis of analytical results and algal growth characteristics, the optimal collection time was found to be late July (ie. at maximum standing crop); this collection date was therefore used in 1982. Analysis on a dry weight basis has been shown to give more useful data because of increased resolution and minimized within-sample variability.* Unfortunately, the drying process precludes analysis for the more volatile organochlorine pesticides, so samples could only be analyzed for one organic compound: PCBs.

Introduced biological monitors may be necessary where the habitat is unsuitable for the preferred resident biota or where monitoring at a greater frequency than once a year is desirable. Mature clams are normally relatively sedentary, and are filter-feeders, removing suspended particles (zooplankton, phytoplankton and organic detritus) from the water column (Pennak, 1978). Previous studies (Curry, 1978; Kauss et al, 1981) have shown

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* M. Jackson (MOE), personal communication, February, 1984.

that clams (Elliptio complanatus) can quickly accumulate elevated levels of organochlorine contaminants, but require a longer period of exposure for most metals. Clams of this species were collected by MOE (sub-project 28) from a healthy population containing low background levels of contaminants. They were placed in cages (in groups of 5 to 10) and anchored on the river bottom at the desired locations (see Figure 4.5). In 1980, individuals were retrieved at selected intervals, ranging from 1 to 101 days after immersion. In 1981, the clams were exposed for 3 weeks (21 days). Upon completion of the exposure period, the clams (shell length about 7 cm) were retrieved, and the soft tissue removed and frozen. Analysis for 21 organics was carried out on a whole (homogenized) clam. Results were reported on a wet weight basis.

In 1981, NYSDEC conducted a study to determine the feasibility of using freshwater clams (Elliptio complanatus) and adsorptive polypropylene substrates to identify contaminant inputs (sub-project 2). In contrast to the foregoing sub-project, the results of the NYSDEC study indicated that, using their methodology, neither clams nor substrates demonstrated any significant accumulation of metals or organic contaminants. No further work was carried out on this sub-project.

4.2.5.2 Temporal Trends Analysis of Contaminants

Young-of-the-year spottail shiners (Notropis hudsonius) have been collected annually at NOTL since 1975 and, due to their restricted geographic range of movement, have proven to be indicative of contaminant trends in Niagara River waters entering Lake Ontario. Cladophora have been collected from a number of locations in the river since 1980, with a view to providing a data base for temporal as well as spatial trends in contaminants.

Although species which are not continually resident in one localized area cannot be used for source identification, their contaminant levels are indicative of the degree to which a whole water body has been contaminated. This is the case for game fish and predaceous aquatic birds which, because of their trophic levels, integrate contaminants through the water and their food sources. Hence, tissue contaminant analysis at regular intervals can provide valuable information on the status of the aquatic ecosystem. In the Niagara River, the American and Canadian falls geographically isolate the lower and upper river game fish populations.

Over the years, game fish have been collected from numerous locations in the Great Lakes and their interconnecting rivers. Available species were collected in 1980, 1981, and 1982 by MOE/MNR at two locations in the Niagara River: near Miller Creek, Ont. in the upper river and at Queenston, Ont. in the lower river (sub-project 33). Samples of boneless, skinless fillets (dorsal muscle) of these fish were analyzed for mercury and thirteen organics, including 2,3,7,8-TCDD. Fish were also collected in 1981 by NYSDEC (sub-project 5) as part of a cyclic three-year sampling program. The five sampling locations included two in Lake Erie (Dunkirk and Lackawanna) and three in the Niagara River. Samples of dorsal muscle fillets (with skin) were analyzed for the same chemicals as the MOE collections, excluding dioxin.

Breeding populations of herring gulls (Larus argentatus) are considered as non-migratory (Moore, 1976). As such, their eggs may reflect contaminants accumulated by the female bird, either during the nesting period or over the previous year. They may travel up to 30 km or more to feed on a daily basis (Weseloh, 1983). Herring gull eggs have been collected yearly by CWS from an isolated colony in the upper river since 1979 (sub-project 31). The site, located just above the Horseshoe Falls, is accessed by helicopter. Egg homogenates were analyzed for a variety of organic contaminants, including dioxin, PCBs, DDT, and mirex.

The 1982 NYSDEC/NYSDOH macroinvertebrate survey (sub-project 6) involved the use of artificial substrates suspended in the water column at nine sites. Three exposures were used, each of five weeks duration. At the end of each exposure period, the multiple plate samplers were disassembled and cleaned, and the colonizing organisms (mainly insect larvae) identified and enumerated. Results were compared to a similar 1976 study to determine changes in water quality in different sections of the river. Organisms were not analyzed for contaminants.

4.3 Results of Niagara River Ambient Sub-Projects

4.3.1 Water and Suspended Sediment

Five studies were undertaken to provide data on the status of toxic contaminants in waters of the Niagara River and its tributaries. These were sub-projects 9, 11, 23, 25 and 26. Data evaluation resulted in all or part of three of these studies (sub-projects 23, 25 and 26) being used for the determination of quantitative differences with regard to metals and organic contaminants. Where possible, data from the remaining studies were used in a qualitative sense only (i.e., indicative of the presence of contaminants, but not their concentrations).

4.3.1.1 Frequencies of Detection and Comparison of Contaminant Levels with Minimum Agency Criteria

Table 4.2 summarizes data on frequencies of detection for inorganics, phenols and pesticides in whole water samples obtained in sub-projects 25 and 26 during 1981 and 1982. Selenium and cyanide were not detected in any samples at the analytical detection limit used. Arsenic was only detected (in 3 to 13% of samples) at the mouth of the Buffalo River. Detection of other inorganics ranged from 4% for mercury in the lower river segment in 1982 to 100% for aluminum and copper in all segments/sub-areas in 1982. The higher frequency of detection of phenols throughout the river in 1982 is a result of a change in the method of reporting of analytical results and not due to changes in the methods of analysis. PCBs and organochlorine pesticides were detected in 0 to 92% of samples, depending on the segment or sub-area sampled. Those pesticides detected, particularly the BHC isomers, were found more frequently in samples taken in 1982, perhaps as a result of these being taken only along the mainland shores. While no clear differences were evident for frequencies of detection of inorganics between any of the segments, BHC isomers were generally detected more often in the Wheatfield-Upper River segment than in other river segments or in Lake Erie waters (Fort Erie sub-area). A number of organochlorine pesticides were never detected. These included: aldrin, gamma-chlordane, oxychlordane, o,p'-DDT, p,p'-DDT, p,p'-DDD (TDE), beta-endosulfan, endosulfan sulphate, endrin, heptachlor, methoxychlor, and mirex.

TABLE 4.2

SUMMARY OF FREQUENCY (%) OF TRACE CONTAMINANTS DETECTIONS IN NIAGARA RIVER WATER SAMPLES DURING 1981 AND 1982

CHEMICAL CLASS & PARAMETER	RIVER SEGMENT/SUB-AREA Fort Erie '81	Fort Erie '82	Chippawa '81	Chippawa '82	Lake Erie '81	Lake Erie '82	Buffalo R. '81	Buffalo R. '82	Bird Is.-Riverside '81	Bird Is.-Riverside '82	Ton-N. Ton '81	Ton-N. Ton '82	Wheatfield-Upper R. '81	Wheatfield-Upper R. '82	Lower River '81	Lower River '82
Inorganics:																
Aluminum	92	100	100	100	91	100	94	100	---	100	---	100	97	100	100	100
Arsenic	0	0	0	0	0	0	3	13	---	0	---	0	0	0	0	0
Cadmium	58	40	64	30	61	27	59	27	---	27	---	31	60	56	82	50
Chromium	0	80	84	91	77	64	76	87	---	91	---	86	72	94	100	92
Copper	92	100	81	100	74	100	88	100	---	100	---	100	90	100	96	100
Cyanide	0	---	0	---	0	---	0	---	---	---	---	---	0	---	0	---
Lead	25	24	36	30	36	18	36	7	---	9	---	26	34	22	51	33
Mercury	(75)	18	80	24	(71)	15	85	27	---	18	---	25	71	24	100	4
Nickel	75	60	74	91	74	45	76	87	---	100	---	74	76	86	100	75
Selenium	0	0	0	0	0	0	0	0	---	0	---	0	0	0	---	0
Silver	---	12	---	13	(0)	18	(83)	7	---	27	---	6	(57)	8	---	17
Zinc	75	52	79	83	76	64	90	93	---	100	---	100	92	100	100	100
Phenols (4 AAP)	0	40	12	50	13	40	28	51	---	53	---	62	22	58	20	47
PCBs, Total	0	0	0	0	0	0	0	0	---	0	---	0	5	3	0	4
Pesticides																
Dieldrin	8	0	0	4	0	0	0	0	---	0	---	0	2	0	0	0
alpha-BHC	58	84	75	91	54	80	64	87	---	92	---	79	75	92	73	83
beta-BHC	0	4	0	0	0	10	3	7	---	0	---	6	5	22	0	4
gamma-BHC	8	36	5	39	8	10	11	27	---	25	---	29	15	53	27	33
alpha-Chlordane	0	0	0	0	0	0	0	0	---	0	---	3	2	3	0	0
p,p'-DDE	0	4	0	0	0	0	3	0	---	0	---	0	2	0	4	0
alpha-Endosulfan	0	0	0	0	4	0	0	0	---	0	---	0	0	0	0	0
HCB	0	0	0	0	0	0	3	7	---	0	---	6	12	3	3	0
Heptachlor epoxide	0	8	0	4	0	0	0	0	---	0	---	3	2	3	0	4

NOTES: Data sources: sub-projects 25 and 26 (see Appendix Tables C.10 and C.11).
A dash "-" indicates no samples collected (Black Rock Canal segment also not sampled).
Bracketed "()" values represent questionable frequencies owing to small sample size.
Reporting methods for Phenols changed between 1981 and 1982 resulting in increased frequency of detection in 1982.

The percentages in Table 4.2 illustrate a problem common to many ambient water studies: namely, that low detection levels in combination with conventional sampling methods (small volumes) can yield analytical results for organics which are in most cases, inadequate for the purposes of quantitation and the determination of concentration differences. This is because many organics, due to their low solubility, are generally present in ambient waters at levels at least one thousand times lower than are most metals (ng/L vs. ug/L).

The individual contaminants with a 50% or greater average frequency of detection in water samples were, in order of decreasing frequency: aluminum, copper, zinc, chromium, alpha-BHC, and nickel in all segments sampled in both years, and cadmium, mercury, phenols, lead, and gamma-BHC in only certain segments or in all segments of only one of the two survey years. Except aluminum, all of these are contaminants listed in Group I (Chapter VI), and are chemicals which require immediate action. Aluminum is considered to be of natural origin and minimal toxicological concern.

The detection limits for these sub-projects were, in most cases, at or below existing water quality criteria for the protection of aquatic life (1978 Canada-U.S. Great Lakes Water Quality Agreement (GLWQA)). Therefore, a consideration of the frequency of exceedances* of these criteria can provide insight into the relative severity of problems with a given contaminant in different river segments (Table 4.3). Water sample data from sub-projects 25 and 26 were compared to the most stringent available criteria (see Table C.10 for listing). For some contaminants, these were below the 1978 GLWQA objectives and the analytical detection limits used. Consequently, for a number of inorganics (cadmium, lead, silver,) and organics (PCBs and aldrin/dieldrin), the frequencies with which measured concentrations exceed criteria are only approximate (prefixed by "$\geq$", Table 4.3) and cannot be used, for an examination of differences between segments. However, the most stringent criteria for aluminum, cadmium, chromium, copper, lead, silver and zinc were exceeded in at least one sample from most segments or sub-areas of

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* Percent of samples with concentrations above criterion.

TABLE 4.3

SUMMARY OF FREQUENCY (%) WITH WHICH TRACE CONTAMINANT WATER QUALITY CRITERIA* WERE EXCEEDED IN THE NIAGARA RIVER DURING 1981 AND 1982

	RIVER SEGMENT/SUB-AREA															
CHEMICAL CLASS	Fort Erie		Chippawa		Lake Erie		Buffalo R.		Bird Is.-Riverside		Ton-N. Ton		Wheatfield-Upper R.		Lower River	
& PARAMETER	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82
Inorganics:																
Aluminum	25	12	43	61	17	0	44	60	---	36	---	37	53	36	73	42
Arsenic	0	0	0	0	0	0	0	0	---	0	---	0	0	0	0	0
Cadmium	≥58	≥40	≥64	≥30	≥61	≥27	≥59	≥27	---	≥27	---	≥31	≥60	≥56	≥82	≥50
Chromium	0	4	0	13	0	18	0	7	---	0	---	14	0	11	0	0
Copper	66	100	67	100	74	91	79	100	---	100	---	91	76	86	80	100
Cyanide	0	---	0	---	0	---	0	---	---	---	---	---	0	---	0	---
Lead	≥33	≥24	≥36	≥30	≥36	≥18	≥36	≥ 7	---	≥ 9	---	≥26	≥34	≥22	≥51	≥33
Mercury	0	0	0	10	0	0	15	9	---	0	---	0	4	0	0	0
Nickel	0	0	0	0	0	0	0	0	---	0	---	0	2	0	0	0
Selenium	(0)	0	0	0	(0)	0	(0)	0	---	0	---	0	0	0	---	0
Silver	---	≥12	---	≥13	(0)	≥18	(≥83)	≥7	-	≥27	---	≥6	(≥57)	≥8	---	≥17
Zinc	0	0	0	0	0	0	0	0	---	0	---	3	5	8	0	0
Phenols (4 AAP)	0	26	0	27	0	20	0	22	---	11	---	38	3	29	0	34
PCBs, Total	≥0	≥0	≥0	≥0	≥0	≥0	≥0	≥0	---	≥0	---	≥0	≥5	≥3	0	≥4
Pesticides																
Aldrin + Dieldrin	≥8	≥0	≥0	≥4	≥0	≥0	≥0	≥0	---	≥0	--	≥0	≥2	≥0	≥0	≥0
alpha-BHC	0	0	0	4	0	0	0	0	---	0	---	6	5	28	0	4
beta-BHC	0	0	0	0	0	0	0	0	---	0	---	0	0	0	0	0
gamma-BHC	0	0	0	0	0	0	0	7	---	0	---	0	0	3	0	0
Chlordane (alpha gamma)	0	0	0	0	0	0	0	0	---	0	---	3	2	0	0	0

NOTES: * Water quality criteria are for the protection of aquatic life and are the most stringent available (as listed in Appendix Tables C.10 and C.11).

- Data Sources: sub-projects 25 and 26 (see Appendix C, Tables C.10 and C.11).
- A dash "-" indicates no samples collected (Black Rock Canal segment also not sampled).
- Bracketed "()" values represent questionable frequencies owing to small sample size.
- Numbers prefixed by "≥" represent instances where the detection limit is greater than the minimum criterion. Consequently, frequency with which criteria were exceeded is a minimum in these instances.

the river. The criteria for nickel and zinc were only exceeded in the Tonawanda-North Tonawanda and Wheatfield-Upper River segments. A criterion for mercury was only exceeded in the Buffalo River segment (1981 and 1982), the Chippawa sub-area (1982) and the Wheatfield-Upper River segment (1981). Levels of arsenic, cyanide and selenium did not exceed their respective criteria. With the exception of somewhat higher frequencies of exceedances for aluminum and chromium in the river than in Lake Erie water samples (Fort Erie sub-area), the frequencies of criteria exceedances for inorganics did not differ appreciably between the various segments or sub-areas of the river. Of the pesticides analyzed, four (dieldrin, alpha-BHC, gamma-BHC and chlordane) exceeded criteria in some of the water samples. The highest frequency (28% for alpha-BHC in 1982) was observed in water samples from the Wheatfield-Upper River segment. This higher frequency in 1982 is probably a result of sampling only in the nearshore (as opposed to across the channel in 1981) and was also observed for phenols, chromium, and copper (see Table 4.3). Owing to a higher analytical detection limit than criterion for PCBs, the frequencies of exceedance are likely to be underestimates, since 64% of water samples collected at NOTL (using larger volumes and a lower detection limit) exceeded this PCB criterion (Kuntz, 1983).

The 1978 GLWQA (Article IV(b)) specifies that statistically valid sampling data be used to gauge achievement of objectives. Following this recommendation, statistical methods were used to determine if minimum aquatic criteria were or were not exceeded. The concept behind a statistical sampling program is that samples come from a population whose mean (or median) exceeds or does not exceed a criterion. Occasional exceedances are not necessarily an indication of a problem.

MOE's raw drinking water monitoring (sub-project 32) had the largest number of observations and therefore data from this study were used in the statistical evaluation. Because of the high frequency of not-detected concentrations, the non-parametric Sign Test (Steel and Torrie, 1960), was used to analyze the data. This test was applied to the data set to determine for which chemicals a significant exceedance of the minimum agency ambient water quality criteria occurred at the 0.05 confidence level (Table 4.4).

TABLE 4.4

COMPARISON OF CONTAMINANTS IN MOE RAW DRINKING WATER SAMPLES WITH MINIMUM AGENCY CRITERIA BY SIGN TEST

MINIMUM AGENCY CRITERION (ug/l)	SUBSTANCE	NOTL			FT. ERIE			INTERPRETATION
		Exceedances	Ties*	#Obs	Exceedances	Ties*	#Obs	
970	Total trichlorophenols	0	0	48	0	0	31	Median less than criterion at both sites
970	2,4,6-Trichlorophenol	0	0	59	0	0	38	"
11600	Dichloroethylene	0	0	65	0	0	41	"
763	Dichlorobenzene	0	0	65	0	0	41	"
244	Dichloropropylene	0	0	65	0	0	41	"
10	Methylene chloride	3	0	67	1	0	41	"
50	1,1-Dichloroethane	0	0	67	0	0	41	"
0.2	Chloroform	27	17	67	13	9	41	Median equal to criterion at both sites
1.0	1,2-Dichloroethane	0	0	67	0	0	41	Median less than criterion at both sites
20	1,1,1-Trichloroethane	0	0	67	0	0	41	"
0.3	Carbon tetrachloride	1	0	67	0	0	41	"
50	Dichlorobromomethane	0	0	67	0	0	41	"
50	1,2-Dichloropropane	0	0	67	0	0	41	"
5.0	Trichloroethylene	0	0	67	0	0	41	"
50	Chlorodibromomethane	0	0	67	0	0	41	"
1.5	Benzene	0	0	67	0	0	41	"
50	Bromoform	0	0	67	0	0	41	"
2.0	Tetrachloroethylene	0	0	67	0	0	41	"
10	Toluene	0	0	67	0	0	41	"
50	Chlorobenzene	0	0	67	0	0	41	"
50	Ethyl benzene	0	0	67	0	0	41	"
50	m-Xylene	0	0	67	0	0	41	"
50	o-or p-Xylene	0	0	67	0	0	41	"
50	Tetrahydrofuran	0	0	67	0	0	41	"
0.001	Aldrin	0	0	67	0	0	40	"
0.01	alpha-BHC	1	1	67	0	0	40	"
0.01	beta-BHC	0	0	67	0	0	40	"
0.01	gamma-BHC	0	0	67	0	0	40	"
0.004	alpha-Chlordane	0	0	67	0	0	40	"
0.004	gamma-Chlordane	0	0	67	0	0	40	"

TABLE 4.4 (Continued)

MINIMUM AGENCY CRITERION (ug/l)	SUBSTANCE	NOTL			FT. ERIE			INTERPRETATION
		Exceedances	Ties	#Obs	Exceedances	Ties	#Obs	
0.001	Dieldrin			67			40	Detection limit greater than criterion
0.03	Methoxychlor	0	0	67	0	0	40	Median less than criterion at both sites
0.003	Endosulfan I (alpha-)	0	0	67	0	0	40	"
0.003	Endosulfan II (beta-)			67			40	Detection limit greater than criterion
0.002	Endrin			67			40	"
0.001	Heptachlor epoxide	0	0	67	0	0	40	Detection limit= criterion
0.001	Heptachlor	0	0	67	0	0	40	Median less than criterion at both sites
0.001	Mirex			67			40	Detection limit greater than criterion
0.001	o,p-DDT			67			40	"
0.001	Total PCB			67			40	"
0.001	p,p'-DDD			67			40	"
0.001	p,p'-DDE	0	0	67	0	0	40	Detection limit= criterion
0.001	p,p'-DDT			67			40	Detection limit greater than criterion
0.040	Hexachlorobenzene	0	0	67	0	0	40	Median less than criterion at both sites
0.000001	Tetrachlorodioxins	0	0	31	0	0	26	"

*"Ties" refers to samples with contaminant concentrations that equal the criterion. Such observations are excluded from the analysis.

There are aquatic criteria from one or more of the participating agencies for 45 substances reported by MOE's program. The minimum agency criteria were lower than the detection limits of nine of these contaminants. None of the medians of the remaining 36 exceeded the criteria. Chloroform was found, at both ends of the river, to have a median indistinguishable from the minimum agency criterion.

Other data sets, could not be used to draw statistically valid conclusions with respect to criteria exceedances.

4.3.1.2 Locations of Numerically High Contaminant Concentrations

Five sub-projects examined contaminant concentrations in water and suspended sediment in the Niagara River. While it is recognized that sampling methodology and detection limits vary between sub-projects, the data remain useful for identifying sites within the river where mean contaminant concentrations are higher than in Lake Erie. These locations are shown in Figure 4.6. No statistical** analysis or consideration of standard deviations has been applied in this comparison of means. In the determination of mean values for each station sampled, ND (not detected) values were assigned zero for sub-project 23, and one-half the detection limit for sub-projects 25 and 26 (this is not consistent with the recommendation of the DQS; for further explanation see the DQS report).

Trends in cross-channel and longitudinal (along-river) water quality, as well as the distribution of organic contaminants between the aqueous and particulate phases are discussed in detail in Appendix C.

** Data from sub-projects 23, 25, 26 and 32 have undergone some statistical testing for other purposes and contaminants marked with an asterisk (*) in Fig. 4.6 show a significant increase between Fort Erie and Niagara-on-the-Lake (see section 4.3.1.3).

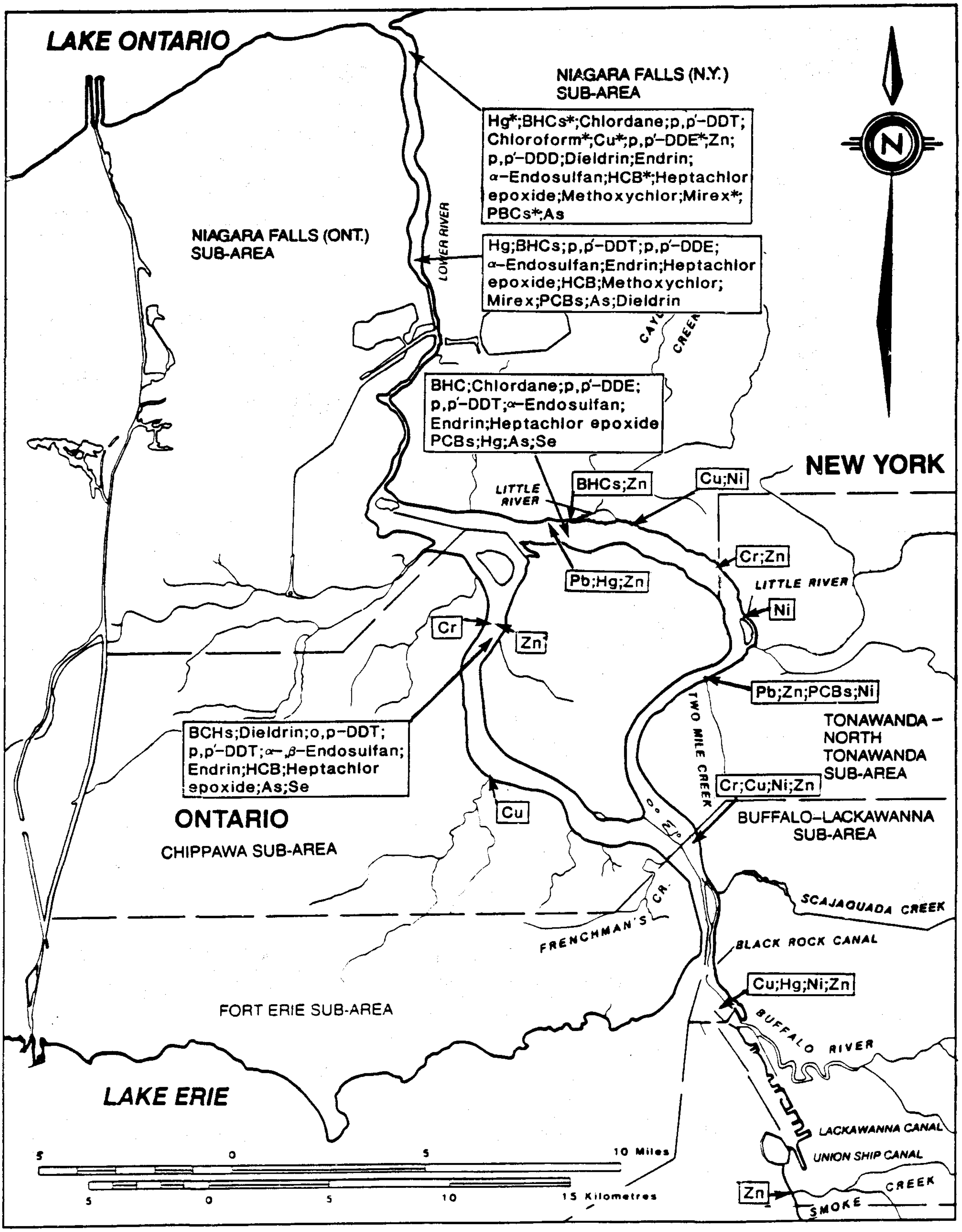

FIGURE 4.6 LOCATIONS IN THE NIAGARA RIVER WHERE MEANS LEVELS OF GROUP I CHEMICALS IN WATER AND SUSPENDED SEDIMENTS WERE NUMERICALLY HIGHER THAN AT LAKE ERIE STATIONS. *Contaminants Evaluated for Statistical Significance; See 4.3.1.3. (Ref: See C.2, Tables C.10 to C.14.)

4.3.1.3 Differences Between the Source and the Mouth of the Niagara River

Data from four studies (sub-projects 23, 25, 26 and 32) were analyzed by various statistical methods to determine whether or not there were significant concentration differences between the source and the mouth of the Niagara River (El-Shaarawi and Esterby, 1984). The MOE transect studies (sub-projects 25 and 26) were used to evaluate differences in 10 trace metals. Raw water samples from the MOE drinking water study (project 32) were used to evaluate 69 organic contaminants, and the IWD-OR study (sub-project 23), which analyzed large volume water and suspended sediment samples, was used to evaluate differences for 29 organics and 3 metals.

The rationale for the statistical methods used was based on obtaining the maximum amount of information possible from the data while not pushing the data or the methods beyond acceptable levels of scientific credibility. The tests were used to determine if the substances at Niagara-on-the-Lake had higher concentrations than at Fort Erie. Specifically, the Sign Test was used for the drinking water data (sub-project 32), the t-test for testing the equality of means in two samples with modification for unequal variances was used for metal data (sub-projects 25 and 26), while two different non parametric tests (see below) were applied to the large volume data (sub-project 23). Details are documented by El-Shaarawi and Esterby (1984).

As in the application of any statistical analysis, certain assumptions are necessary about the data and the nature of the systems, i.e., the validity of the sample as a representative of the total population. Some of the more significant assumptions in the present analysis are discussed briefly below. It was assumed that:

- The chemical composition of the river varies the same way during the time of sampling as it does between sampling times. At present, time series data for contaminants are insufficient to determine the validity of this assumption. In this regard, it was felt that comparing samples collected at or about the same time, while not entirely eliminating this possible source of variation, would tend to minimize it to the extent possible within the constraints of data presently available.

- The contaminants analyzed act conservatively and do not interact within the river ecosystem (i.e., they are not removed by biological uptake, volatilization, loss to sediment, etc.), from one end of the river to the other. Obviously this is not a valid assumption, but the objective of the statistical analyses was to document increases. This suggests that where such increases occur the statistical estimates may be conservative.

- The parcel of water that was sampled at Niagara-on-the-Lake was the same parcel of water that was sampled at Fort Erie, so that any changes are a true reflection of within-system changes. Admittedly, this is an unreasonable assumption even under the best of sampling conditions for duplicate sampling, especially in a river environment. It is assumed, however, that variations from this source of error would be small.

Table 4.5 summarizes the results of the applied statistical analyses. Briefly, the results indicate that: (1) 38 of the 90 substances in the data sets were not detected often enough to permit any valid statistical interpretation; (2) 24 of the remaining substances exhibited a statistically significant increase (either in the number of times detected or in concentrations) at NOTL as compared to Fort Erie; and (3) 26 substances exhibited no statistically significant increase at NOTL as compared to Fort Erie.

TABLE 4.5

STATISTICAL SUMMARY FOR 79 ORGANICS AND 11 TRACE METALS TESTED AT FORT ERIE AND NIAGARA-ON-THE-LAKE

Substances that could not be tested (values < D.L.)	Substances Showing Significant Increases (P=0.05) at NOTL as compared to Ft. Erie	Substances for which there was no significant increase at NOTL as to Ft. Erie (P=0.05)
Dichloroiodomethane	alpha-BHC	Methylene chloride
1,1,4-Trichlorobutadiene	gamma-BHC	1,1,1-Trichloroethane
Bromoform	p,p'-DDE	Dichlorobromomethane
1,1-Dichloroethane	Chloroform	Chlorodibromomethane
1,2-Dichloroethane	Heptachlor epoxide	Toluene
1,2-Dichloropropane	Mirex	m-Xlyene
Chlorobenzene	Trichloroethylene	o,p-Xlyene
Ethyl benzene	1,2-Dichlorobenzene	Hexane
Carbon tetrachloride	1,4-Dichlorobenzene	Hexanal
Trichlorophenols, total	1,2,3-Trichlorobenzene	Diethyl ether
2,3,4,5-Trichlorophenol	1,2,4-Trichlorobenzene	Butanol
3,4,6-Trichlorophenol	1,2,5-Trichlorobenzene	Carbon disulphide
Dichloropropylene	1,2,3,4-Tetrachlorobenzene	Methyl ethyl ketone
2,3,5-Trichlorophenol	1,2,3,5- & 1,2,4,5-Tetrachlorobenzene	Acetone
2,4,6-Trichlorophenol	Pentachlorobenzene	Hydrocarbons
2,3,6-Trichlorophenol	Hexachlorobenzene	Dieldrin
Chlorotoluene	p-Chlorotrifluorotoluene	alpha-Chlordane
Dichloroethylene	Tetrahydrofuran	p,p'-DDD(TDE)
Dichlorobenzene	Fe	alpha-Endosulfan
Oxychlordane	Al	beta-Endosulfan
Styrene	Zn	Endrin
Tetrachlorodioxins	Cu	Methoxychlor
Heptanone	total PCBs	1,3-Dichlorbenzene
Endosulphan sulphate	Hg	Benzene
Benzaldehyde		Tetrachlorethylene
Methyl furan		Chlorotoluene
Trichlorotrifluoroethane		
Aldrin		
G-Chlordane		
o,p-DDT		
p,p'-DDT		
heptachlor		
Ni		
Cr		
Cd		
Pb		
Se		
As		

NOTE: Dimethyl disulphide in the inverse test showed a significantly (P=0.05) higher level at Fort Erie as compared to NOTL.

The large volume water and suspended sediment data from sub-project 23 were used in an attempt to determine source areas of chemicals to the river. Using the Euclidean distance of ranks technique, El-Shaarawi and Esterby were able to show distinct statistical differences between two groups of stations. Specifically, while the Erie, Chippawa, and Wheatfield stations (Upper River) showed similar chemical characteristics, this group was significantly different from the group consisting of the Queenston and NOTL stations (Lower River). These two groups were consistently different from one another no matter what time of year sampling took place. In addition, the Lower River stations consistently had higher concentrations of contaminants than the group in the Upper River.

The above analysis indicates that the major contaminant input occurs above the Queenston/Lewiston area of the lower river; it is probable that virtually all the toxic chemical contamination entering the Niagara River along its course comes from sources upstream of Queenston/Lewiston.

For the 24 chemicals which significantly increase as one moves downstream in the Niagara River, 11 are found in Group I (Chapter VI, chemicals requiring immediate action) and a further 11 are found in Group II (chemicals requiring more study as to their possible health effects) and two are considered not to pose a potential health hazard.

4.3.2 Bottom Sediments

To facilitate the following discussion, the bottom sediment data were subdivided into general classes of chemicals as follows:

Heavy metals
Polychlorinated Biphenyls (PCBs)
Pesticides
Naphthalenes and Polynuclear Aromatic Hydrocarbons (PAHs)
Chlorinated Aliphatic and Aromatic Hydrocarbons
Unsubstituted Aliphatic and Aromatic Hydrocarbons
Alcohols, organic acids, ethers, and esters
Nitro and amino aromatics
Aldehydes and ketones

Bottom sediment pollutant levels were compared to screening levels (Table 4.6) for chemicals based on published guidelines, standards, or criteria when available. Note that screening levels were only available for PCBs and some metals.

Exceedance of a screening level by any chemical in a chemical class in a segment of the river is noted in the summary table (Table 4.7). For chemical classes with no available screening levels, the discussions of pollutant levels are based solely on the relative degree of contamination between segments.

In considering the interpretation of the data, it should be noted that many of the studies involved analysis of samples for metals, PCBs, pesticides, PAHs, alcohols, esters, and chlorinated aromatics. Much less data (i.e., fewer studies and more limited in geographical coverage) were available for the remaining chemical classes. The studies were undertaken for different purposes; as a result, they vary in geographical coverage as well as sampling site selection criteria. For example, the 1981 USEPA study (sub-project 1) was designed to sample in areas most likely to have high sediment contamination (outfall zones, inside enclosed slips, etc.). Other studies were oriented to give a more general idea of ambient concentrations. Concentration levels found in the studies will, therefore, vary accordingly. Additionally, some segments were sampled in as many as five studies; whereas, some segments were only sampled in one or two studies.

Based on this screening analysis, sediments in the Bird Island-Riverside, Fort Erie, and Chippawa segments/sub areas were relatively uncontaminated, showing only some metals contamination and no PCB levels in excess of the screening levels.

There were no screening levels available for sediments for the remaining chemical classes. Therefore, the discussion is based only on relative pollutant levels between segments.

TABLE 4.6

BOTTOM SEDIMENT SCREENING CRITERIA
(ug/g)

PARAMETER	X	Y	Z
PCBs	10	0.05	.08
Mercury	1	0.3	0.65
Lead	60.	50.	106.
Arsenic	8.	8.	3.3
Cadmium	6.	1.	2.5
Copper	50.	25.	50.
Zinc	200.	100.	192.
Chromium	75.	25.	48.
Nickel	50.	25.	52.
Manganese	500.		
Cyanide	0.25	0.1	

NOTE:
USEPA Dredging Guidelines
MOE Dredging Guidelines
IJC Dredging Guidelines (Lake Ontario)

TABLE 4.7

SUMMARY OF BOTTOM SEDIMENT CONTAMINATION

	RIVER SEGMENT/SUB-AREA								
CHEMICAL CLASS	Lake Erie	Buffalo River	Black Rock Canal	Bird Island-Riverside	Fort Erie	Tonawanda-North Tonawanda	Chippawa Channel	Wheatfield-Upper River	Lower River
Metals and Cyanides	XYZ(1,8,12,27a) Y(12a)	XYZ(1,8,23)	XYZ(1,8,23)	U(27a)	U(27a) Z(23)	XYZ(1,23,27a) Y(12a)	U(27a) XYZ(23)	XYZ(1,23,27a) YZ(12a)	U(12a) XYZ(23,27a,27)
PCBs	U(12a) YZ(1,27a)	YZ(1,23)	XYZ(1,23)	U(27a)	U(23,27a)	XYZ(1,23) YZ(27a,12a)	U(23,27a)	YZ(1,23,27a,12a)	U(12a) YZ(23,27a,27)

NOTE ON HOW TO USE THIS TABLE:

This table summarizes the exceedances of the Ambient Sediment Screening Criteria by chemical class and by river segment. The letters X,Y,Z refer to the specific agency criteria exceeded (see Table 4.6) and the numbers identify the sub-project in which the measurement was made. If one letter appears, it means only one agency criteria was exceeded, if all three letters appear; it indicates all agency criteria were exceeded. All project numbers do not appear in all segments because not all studies sampled in every segment or the data quality precluded its' use (See DQS. 1984). Project numbers and agencies involved in sediment sampling are listed in Table 4.1. "U" denotes all concentrations are below the applicable screening levels.

Pesticides in sediments were most consistently elevated in the Black Rock Canal segment and the Wheatfield-Upper River segment, but also occurred in the Buffalo River, Tonawanda-North Tonawanda and Lower River segments. The Lake Erie, Fort Erie and Chippawa segments were less contaminated with respect to pesticides.

Sediment concentrations of PAHs were consistently highest in the Lake Erie segment, but were also high in the Buffalo River and Tonawanda-North Tonawanda segments.

Hexachlorobenzene and other chlorinated aromatics were found at elevated levels in the Buffalo River, Black Rock Canal, Tonawanda-North Tonawanda, Wheatfield-Upper River, and Lower River segments.

Unsubstituted aliphatic and aromatic hydrocarbons (miscellaneous hydrocarbons, toluene, etc.) were found at elevated levels in sediments in the Lake Erie, Buffalo River and Tonawanda-North Tonawanda segments.

Alcohols, organic acids, ethers, and esters (including phthalates, hexadecanoic acid, etc.) were only elevated in sediments in the Buffalo River segment. Only one study (sub-project 1) however, looked for these compounds.

Nitro and amino aromatic hydrocarbons were found at elevated levels in the Lake Erie, Buffalo River, Tonawanda-North Tonawanda and Wheatfield-Upper River segments. Nelson and Hites (1980) detected several aromatic amines in 1979 samples of Buffalo River bottom sediments and 1978 soil samples obtained in the vicinity of a dye manufacturing plant.

Aldehydes and ketones were elevated in sediments in the Buffalo River and Wheatfield-Upper River segments. However, only one study (sub-project 1) looked for these compounds in the sediments.

In addition to the above chemical classes, three of the sediment samples collected by USEPA V in 1981 (sub-project 1) were analyzed for polychlorinated planar aromatic compounds by EPA-ERL in Duluth. These compounds are similar in structure to 2, 3, 7, 8-TCDD and TCDF. Although no TCDD was found, a large number of polychlorinated planar chemicals were detected. The highest concentrations (up to 25 ug/kg of 1, 3, 6, 8-tetrachloro-9-H-carbazole) were found in a sample from the vicinity of Buffalo Color (Kuehl *et al*., 1984).

In summary, although there is some variation depending upon the chemical being examined, the overall pattern of bottom sediment pollutant concentrations is as follows:

- Low pollutant levels in the Bird Island-Riverside, Fort Erie, and Chippawa segments.
- Intermediate levels of pollutants in the Lake Erie, Black Rock Canal, and Lower River segments.
- High pollutant levels in the Buffalo River, Tonawanda-North Tonawanda, and Wheatfield-Upper River segments.

Most of the pollutant-specific variation from the overall pattern consists of shifts between the last two categories (intermediate and high).

4.3.2.1 Areas of Elevated Sediment Contamination

As a step in locating active sources of the Group I chemicals analyzed under this project, areas of elevated sediment contamination of these chemicals were mapped out in Figure 4.7. An area of sediment contamination for a particular chemical was defined by the following process:

In each study, for each Group I chemical analyzed, the locations of the highest concentrations of that chemical within each segment were noted. If the concentrations of those chemicals exceeded the average Lake Ontario

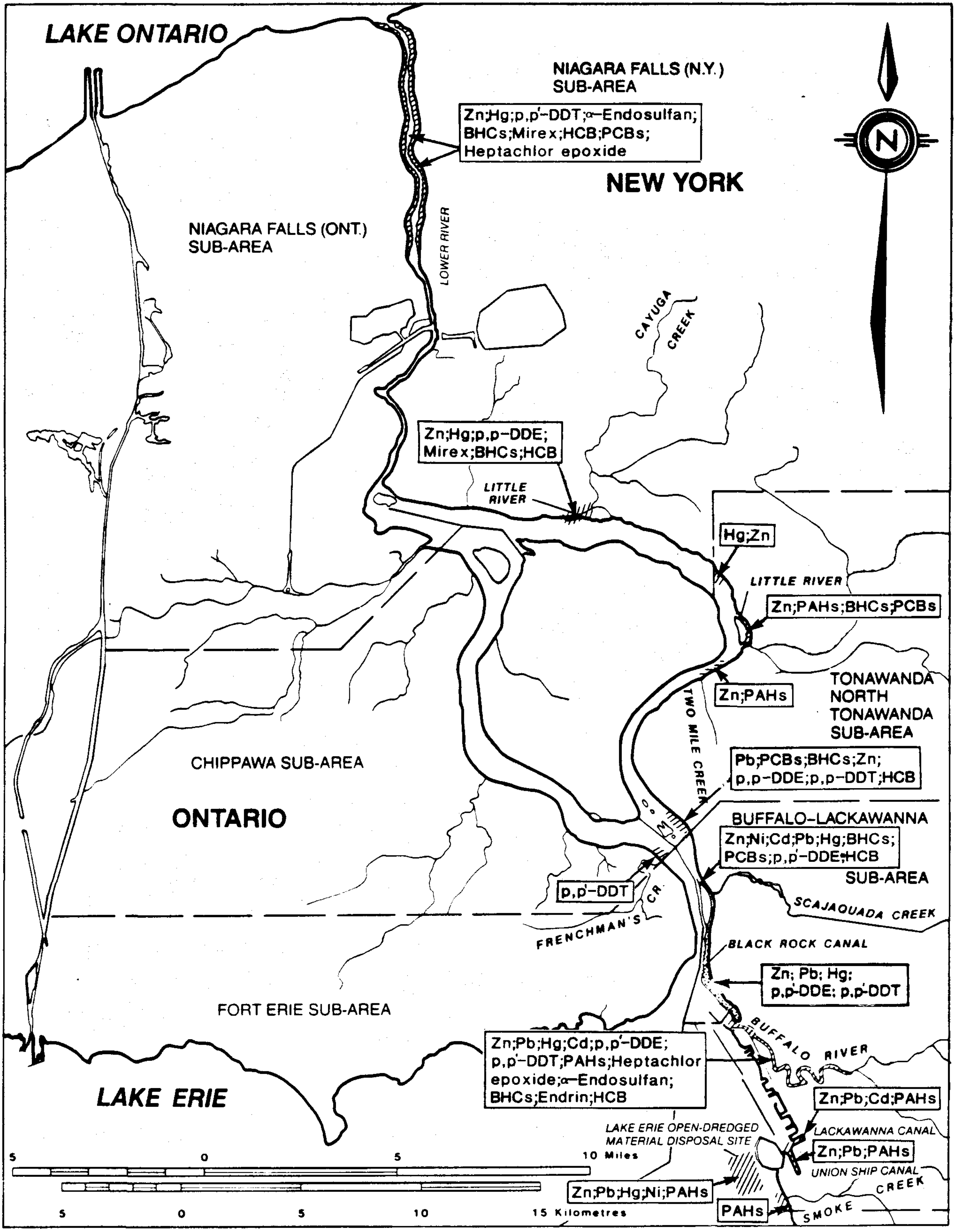

FIGURE 4.7 LOCATIONS IN THE NIAGARA RIVER WHERE LEVELS OF GROUP I CHEMICALS IN BOTTOM SEDIMENTS NUMERICALLY EXCEEDED AVERAGE LAKE ONTARIO LEVELS

surficial sediment concentration* (indicative of an active source), that location remained a candidate for further consideration. Finally, if the presence of the chemical could be verified by its occurrence in another sample taken in close proximity in either the same or another study, the location was designated as an area of elevated sediment contamination for that chemical.

PAHs (specifically, benzo(a)pyrene and fluoranthene) were also included in this analysis because of their suspected carcinogenic link as well as the high levels found in some sediments. Black (1983) reported a correlation between sediment PAH levels and the incidence of skin neoplasms in native freshwater drum. Also, independent confirmation was not required for areas of elevated sediment contamination identified by the PAH Trackdown Study (sub-project 3), since that specialized study used a more specific technique than the other studies for PAH determinations.

For a more detailed discussion of elevated sediment contaminants levels, see Appendix C.

4.3.3 Biota

Biota provide a useful tool for the detection of contaminant source areas, and the determination of contaminant residue trends. However, fewer categories of contaminants were analyzed in biota than in sediments. These categories were heavy metals, PCBs, pesticides, chlorinated phenols, chlorinated aromatic hydrocarbons, and dioxin.

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* For those chemicals for which such data are available, i.e., metals and PCBs (IJC, 1982) and organochlorine pesticides (Frank et al., 1977; Frank et al., 1979; Holdrinet et al., 1978; IJC, 1982).

A number of factors may determine whether residues are detected in biota. Aside from the possibility that a contaminant may not be present in a given area, contaminants may not accumulate to detectable levels, certain areas may not provide a suitable habitat or yield sufficient biomass for analysis and biota with higher levels of contaminants may not survive in sufficient quantities for analysis. These factors account for the lack of sample collections in certain areas or the absence of contaminants found in biota. For example, dredging in the Buffalo River has produced a channel without shoals, an important physical prerequisite for spottail shiner reproduction. No spottails were found in this segment, likely due to this physical interference.

Station-to-station differences in biota contaminant levels are not exclusively related to differences in the magnitude of contaminant inputs (loadings). Factors such as physiological state, metabolic rate, frequency of exposure and most importantly the contaminant concentrations, interact to yield a given body burden.

As with bottom sediments, contaminant levels were compared with available guidelines, standards, and criteria (Table 4.8). For chemicals for which these were not available, the discussions of pollutant levels are based solely on the relative degree of contamination between segments. In the absence of criteria for other biota, contaminant levels in clams and herring gull eggs were also compared to the fish criteria. The data are summarized in Table 4.9.

Of the segments in which biota were collected, the biota in the Wheatfield-Upper River Segment contained the largest number of contaminants. Relatively high levels of heavy metals, low to high levels of PCBs, low to high levels of pesticides, and low levels of chlorinated aromatic hydrocarbons were found in tissues.

TABLE 4.8

BIOTA SCREENING CRITERIA
(ppm)

PARAMETER	A	B	C	D
PCBs	--	0.1^b	2.0^a	--
Aldrin/Dieldrin	0.3^a	0.3^a	0.1^a	0.3^a
alpha-BHC	--	--	--	0.1^a
beta-BHC	--	--	--	0.1^a
Heptachlor Epoxide	0.3^a	0.3^a	0.3^a	0.3^a
Heptachlor	0.3^a	0.3^a	0.1^a	0.3^a
Endrin	0.3^a	0.3^a	0.02^a	0.3^a
Endosulfan	--	--	0.1^a	--
Total DDT	1^b	1^b	5^a	5^a
Mirex	--	DL^b	0.1^a	0.1^a
Lindane	0.3^a	0.3^a	0.2^a	0.1^a
Mercury	0.5^b	0.5^b	0.5^a	1^a
Arsenic	--	--	0.1^a	--
Copper	--	--	0.5^a	--
2,3,7,8-TCDD	--	--	0.00002^a	0.0005^a

NOTE:
A = MOE Fish Criteria
B = 1978 Canada/U.S. Agreement Fish Criteria
C = Canadian Health & Welfare (Fish)
D = U.S. Dept. of Agriculture (Fish)

DL	less than, analytical detection level
a	edible portion (for protection of human consumers of fish)
b	whole fish (for the protection of fish consuming birds)

TABLE 4.9

SUMMARY OF BIOTA CONTAMINATION

CHEMICAL CLASS	RIVER SEGMENT/SUB-AREA Lake Erie	Buffalo River	Black Rock Canal	Bird Island-Riverside	Fort Erie	Tonawanda-North Tonawanda	Chippawa Channel	Wheatfield-Upper River	Lower River
Heavy Metals	C(5)			U(5)	U(30) C(33)		U(28) C(33)		C(5) U(30,33)
PCBs	U(4,5,30)	B(28)	B(4)	U(5) B(4)	U(28,33) B(30) AB(31)	B(4,28)	U(28,33) B(30)	B(31,30,4,28)	U(28) B(30,4,31) C(5,33)
Pesticides	U(4,30)		U(4)	B(4) U(28)	U(30,28,33) AB(31)	B(4)	U(30,28,33)	U(28) B(30,4) AB(31)	B(30,4,28) AB(31)
2,3,7,8-TCDD	U(33)						U(33)		C(33)

NOTE ON HOW TO USE THIS TABLE:

This table summarizes the exceedances of the Ambient Biota Screening Criteria by chemical class and by river segment. The letters A, B, C, and D refer to the specific agency criteria exceeded (Table 4.8) and the numbers identify the sub-project in which the measurement was made. If one letter appears, it means only one agency criteria was exceeded, if all four letters appear, it indicates all agency criteria were exceeded. All project numbers do not appear in all segments because not all studies sampled in every segment or the data quality precluded its' use (See DQS, 1984). All project numbers and agencies involved in biota sampling are listed in Table 4.1. "U" denotes all measured concentrations are below the applicable screening levels.

Biota from the Lake Erie segment were below the screening levels in Table 4.8.

Biota in the remaining segments had low to moderate levels of PCB contamination and exceeded screening levels for PCBs, with lower levels found more frequently in the Fort Erie and Chippawa segments.

The Niagara River macroinvertebrate survey of 1982 did not employ analysis of biota tissues for contaminants. Rather, the study involved the collection, identification, and enumeration of macroinvertebrates from several locations in the river. Comparison of the results on community structure (numbers and diversity of organisms) and cross-channel differences with a prior 1976 study (Simpson, 1980) suggested that water quality improved since 1976 and when the effects of acutely toxic inputs were still prevalent. This was supported by increased numbers of organisms, increased abundance of clean water forms, and lessening of cross-channel differences in the upper river in 1982 (Simpson, 1983).

4.3.3.1 Locations of Higher Contaminant Levels in Different Biota

As noted in the Ambient Projects Overview (Section 4.2), monitoring with many biota species spans a number of years, usually with the largest data set (ie., greatest number of stations) being available for the most recent time period. For this reason, as well as for the sake of brevity, the remainder of this section will, in most instances, be devoted to a species-by-species presentation of contaminant distributions in the Niagara River during 1981 or 1982. Site-to-site differences in concentrations of Group I chemicals, as well as levels of other contaminants detected are discussed and summarized in Appendix C.

To determine locations of elevated Group I chemicals and their possible sources, mean concentrations of contaminants in each species were compared to the average levels in samples from Lake Erie. No statistical analysis or consideration of standard deviations has been applied in this comparison of means. With one exception, not detected (ND) levels in biota samples were assigned a value of zero for the calculation of means. In sub-project 29, ND values were assigned the DL value in the determination of means for both Lake Erie and the river. This is not consistent with the recommendations of the DQS; for further explanation, the reader should refer to the DQS report of March 1984.

As shown by elevated contaminant concentrations in the biological monitors used most extensively (Cladophora, clams, and spottail shiners) there are sources of a number of contaminants, particularly in the upper Niagara River. The high degree of dilution and mixing that occurs in the Falls, whirlpool, rapids and power plant tailraces results in relatively homogeneous contaminant concentrations in biota from the lower river. In a number of instances, biota contaminant levels from this segment reflect the impacts of inputs from the upper river or the Falls area.

(a) Cladophora

Samples of Cladophora were collected from 19 sites in the Niagara River and one in Lake Erie in the early summer of 1982.

Figure 4.8 depicts the locations in the Niagara River where mean concentrations of Group I contaminants in Cladophora were numerically higher than in Lake Erie. Chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), selenium (Se), zinc (Zn) and PCBs were higher at most locations in the Niagara River. Arsenic (As), cadmium (Cd) and mercury (Hg) were, however, only higher at specific sites within the Buffalo, Bird Island-Riverside, Tonawanda-North Tonawanda, Wheatfield-Upper River and the Lower River sections of the river.

The significance of contaminant concentration differences has not been statistically tested. However, obvious differences between sites were evident, as depicted for four contaminants in Figure 4.9. Higher concentrations at specific locations indicate localized inputs at or near the collection sites. For example, the highest mean PCB levels in Cladophora

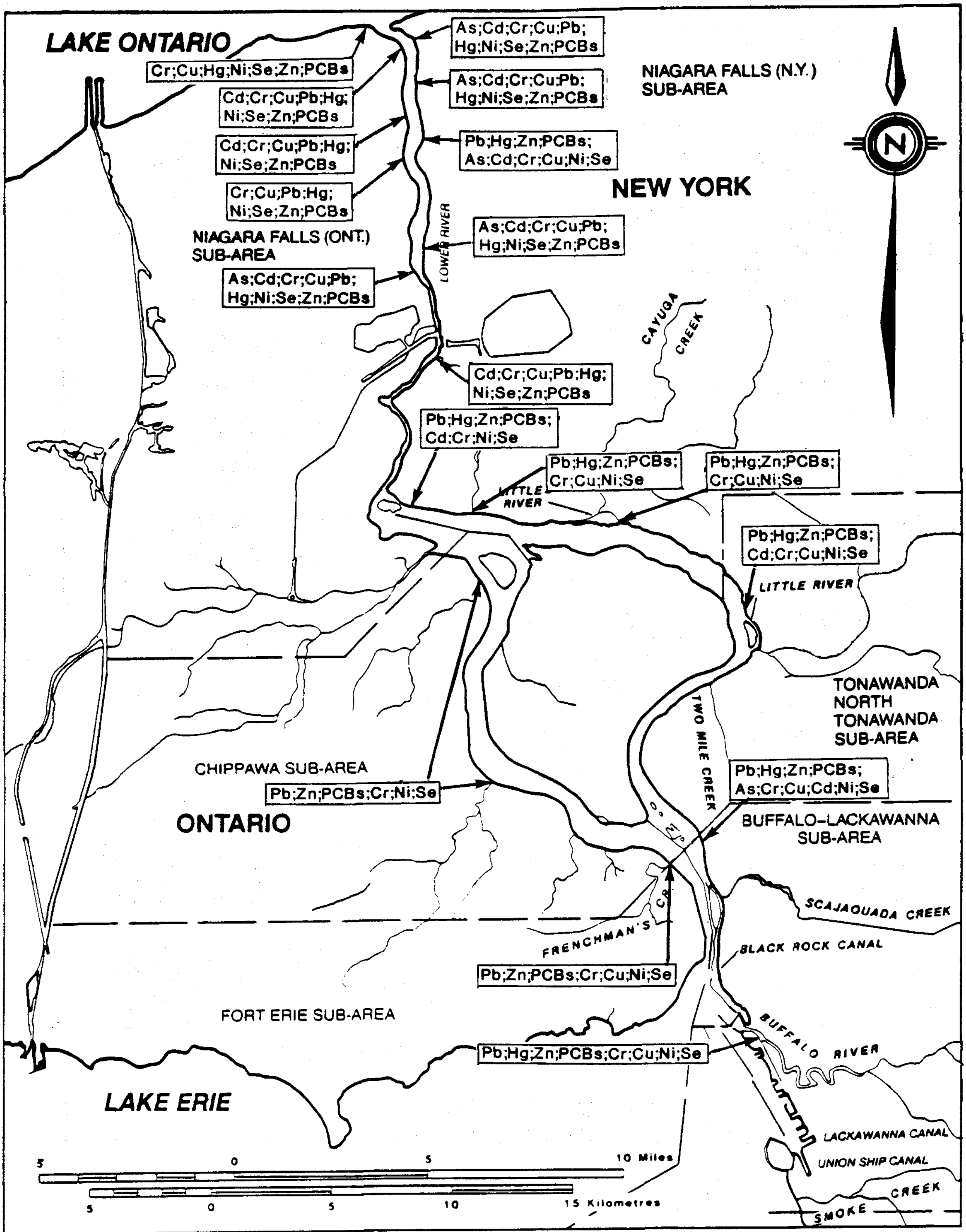

FIGURE 4.8 LOCATIONS IN THE NIAGARA RIVER WHERE MEAN LEVELS OF GROUP I CHEMICALS IN ALGAE (Cladophora glomerata) WERE NUMERICALLY HIGHER THAN AT THE LAKE ERIE STATION. (Ref: See C.4.2., Table C.28.)

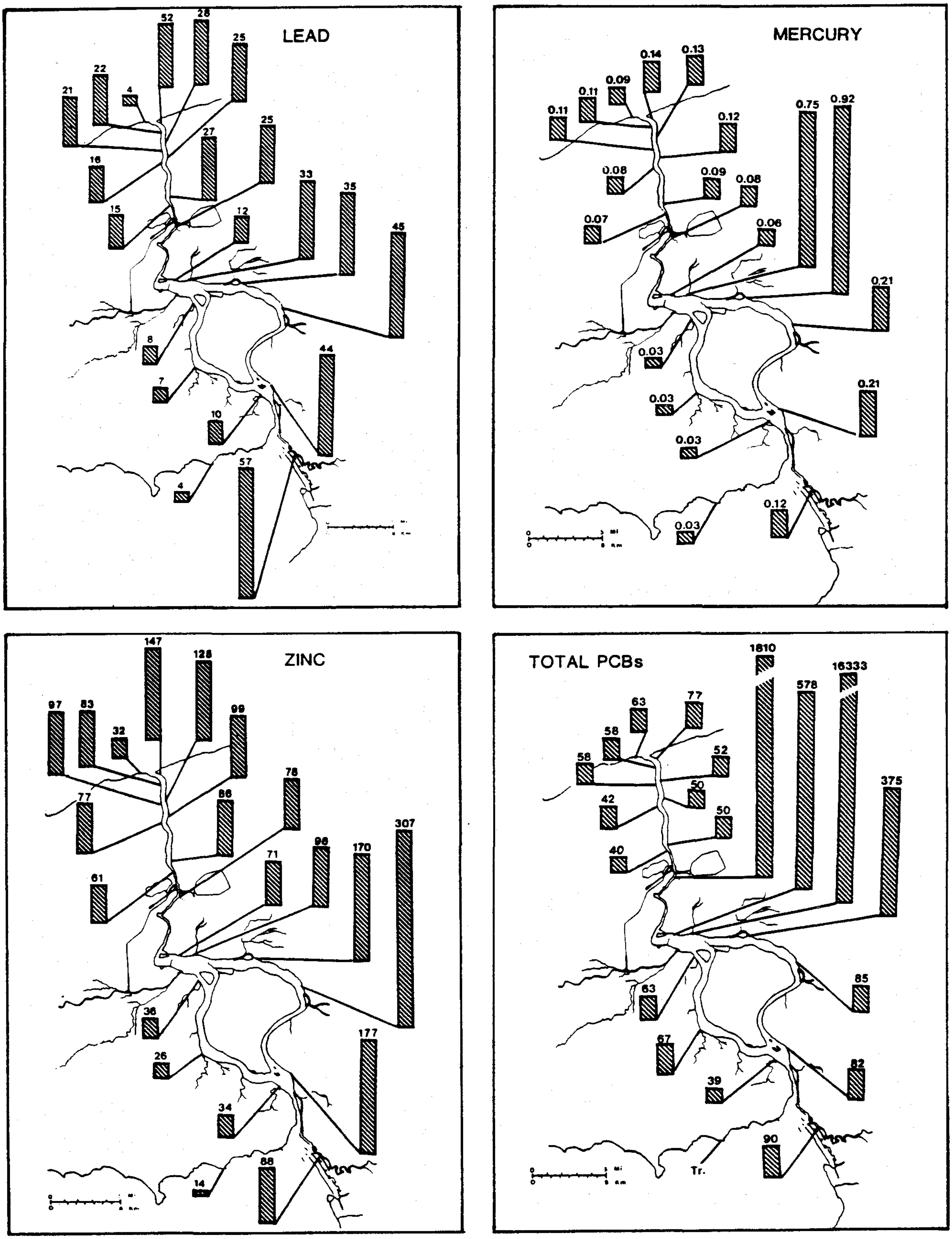

FIGURE 4.9 MEAN CONCENTRATIONS OF LEAD, MERCURY, ZINC (ug/g) AND TOTAL PCBs (ng/g) IN CLADOPHORA, 1982. (Ref: Table C.28.)

were found at the mouth of Gill Creek (16,333 ng/g) and drainage from Bloody Run Creek (1810 ng/g), suggesting sources in these areas. The highest concentrations of mercury in Cladophora were found near the Griffon Park-102nd Street (0.92 ug/g), and Gill Creek sites (0.75 ug/g). Zinc levels were highest downstream of the Pettit Flume input to the Tonawanda Channel in the Tonawanda-North Tonawanda segment (307 ug/g). Lead in Cladophora was highest at the mouth of the Buffalo River (57 ug/g). Numerically higher levels of mercury and zinc were also found in Cladophora in the Buffalo River, and at the east shore opposite Strawberry Island. Lead was also found in this alga from areas downstream of the Pettit Flume, and at the 102nd Street and Gill Creek sites.

Site-to-site differences for all contaminants analyzed in samples from 1980, 1981 and 1982 are detailed in Appendix C.

(b) Clams

Clean clams (Elliptio complanatus) were exposed to water for three weeks (August 18 to September 8) at 14 sites in the Niagara River and one in Lake Erie during 1981.

As shown by Figure 4.10, mean tissue concentrations of the Group I contaminants hexachlorocyclohexane (BHC), p,p-DDE and hexachlorobenzene (HCB) were numerically higher at most locations within the Niagara River than in Lake Erie. In contrast, chlordane, heptachlor epoxide, DDT (o,p- or p,p-) and PCBs were only higher at specific sites in the Buffalo, Tonawanda-North Tonawanda, Wheatfield-Upper River and/or Lower River sections of the river. Higher levels of dieldrin were only found in the Queenston-Lewiston area of the Lower river.

As with Cladophora, site-to-site concentration differences were found in clams. Examples of these are shown in Figure 4.11 for five Group I

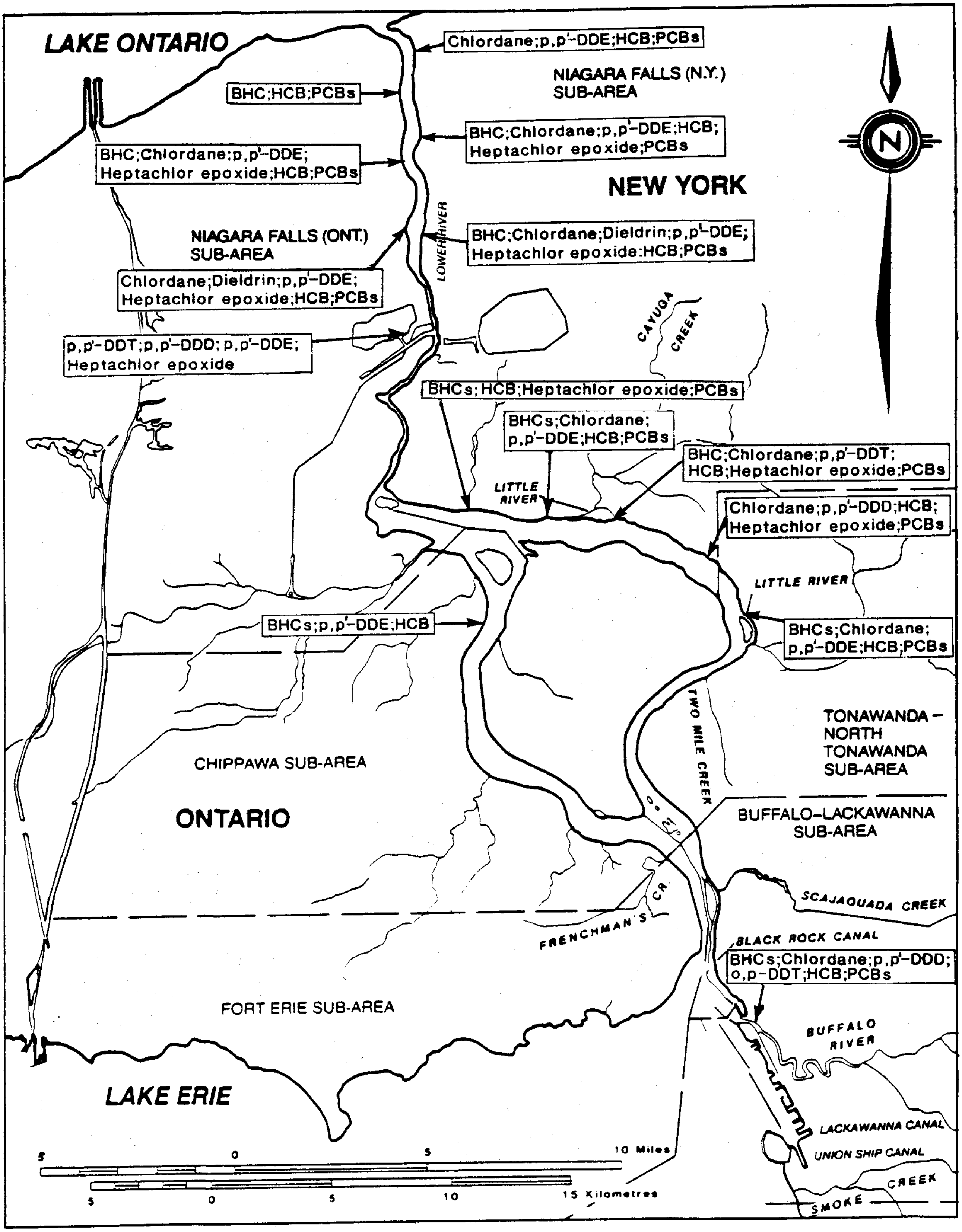

FIGURE 4.10 LOCATIONS IN THE NIAGARA RIVER WHERE MEAN CONCENTRATIONS OF GROUP I CHEMICALS IN CLAMS (Elliptio complantus) WERE NUMERICALLY HIGHER THAN AT THE LAKE ERIE STATION. (Ref: See C.4.3, Table C.34.)

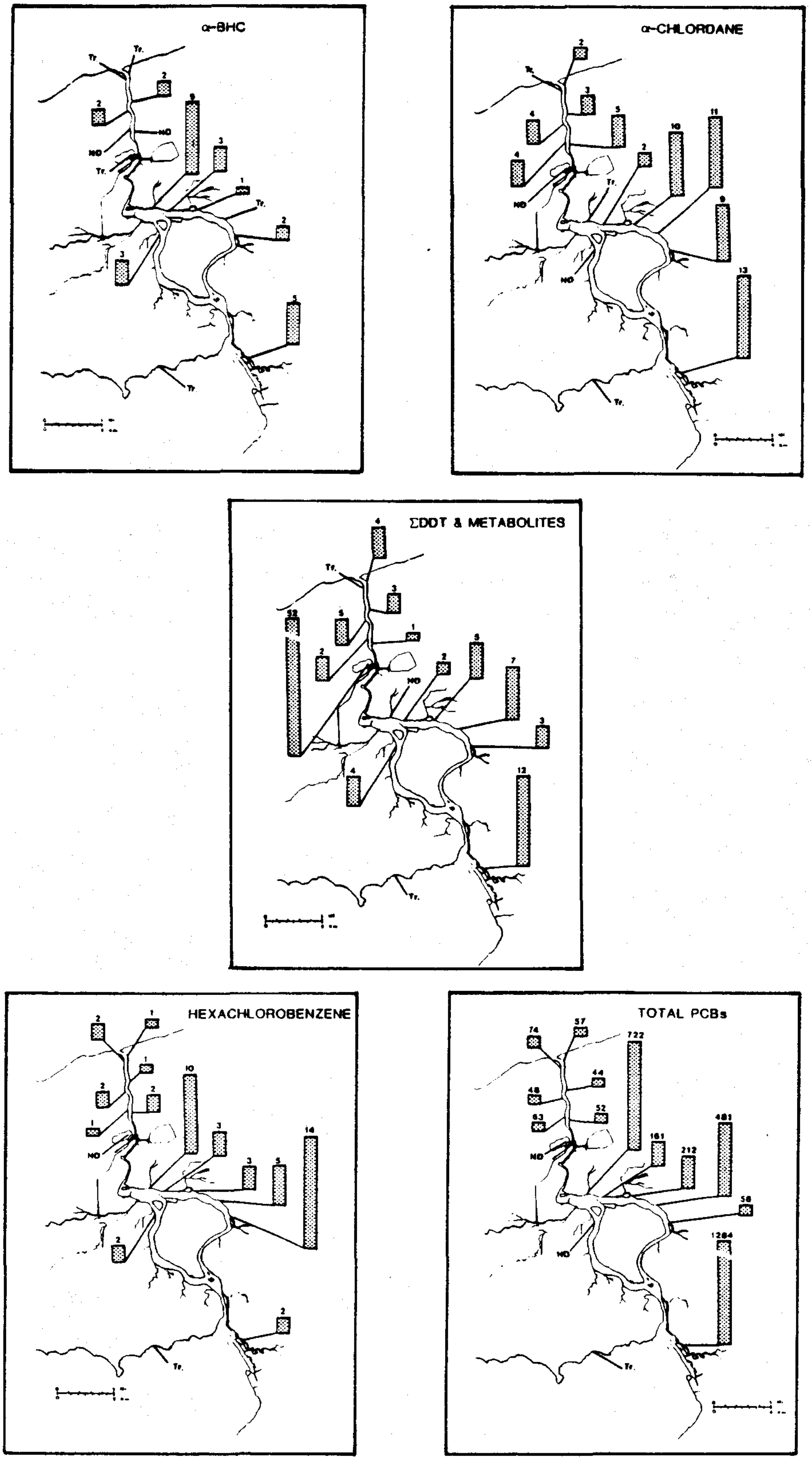

FIGURE 4.11 MEAN CONCENTRATIONS OF alpha-BHC, alpha-CHLORDANE, total DDT & METABOLITES HEXACHLOROBENZENE AND TOTAL PCBs (ng/g) IN CLAMS, 1981. (Ref: Table C.34.)

contaminants. The highest mean PCB levels in clams were found in the Buffalo River (1284 ng/g), with high levels also detected in the Wheatfield-Upper River segment at Niagara County Refuse Disposal Site drain/Gratwick-Riverside Park (481 ng/g), Griffon Park-102nd Street (212 ng/g), Niagara Falls upstream of the Occidental Chemical S area (161 ng/g), and the mouth of Gill Creek (722 ng/g). The highest mean levels of alpha-BHC in clams occurred at the mouth of Gill Creek (9 ng/g) and in the Buffalo River (5 ng/g). The highest mean concentrations of alpha-chlordane in clams occurred at the Buffalo River site (13 ng/g), the Niagara County Refuse Disposal Site drain/Gratwick Riverside Park (11 ng/g), Griffon Park-102nd Street (10 ng/g) and the Pettit Flume sites (9 ng/g). The highest level of DDT and metabolites was found in the Sir Adam Beck Reservoir (52 ng/g). This was composed mainly of p,p-DDD (33 ng/g), with lesser amounts of p,p'-DDE (14 ng/g) and p,p'-DDT (5 ng/g). The highest levels of hexachlorobenzene in clams occurred at the Pettit Flume (14 ng/g) and Gill Creek (10 ng/g).

The levels of contaminants found in clams in both 1980 and 1981 are described in greater detail in Appendix C.

(c) Young-of-the-Year Spottail Shiners

Cooperative sampling of spottail shiners (Notropis hudsonius) was done in 1982 by the Ontario MOE and the NYSDEC in Lake Erie and the Niagara River to ascertain spatial distribution of contaminants in these areas. Twenty-seven locations were sampled (Figure 4.5). Spottail shiners were collected from all sites except at one station (station N15) below Niagara Falls where rock bass were substituted for spottail shiners which could not be collected at this location.

Figure 4.12 depicts the locations in the Niagara River where mean concentrations of Group I contaminants in spottail shiners were higher than in Lake Erie collections. Chlordane, dieldrin, hexachlorobenzene (HCB), DDT, PCBs and pentachlorophenol (PCP) were higher at most locations in the river. PCP was also found at a higher level at one of the three locations in Lake Erie.

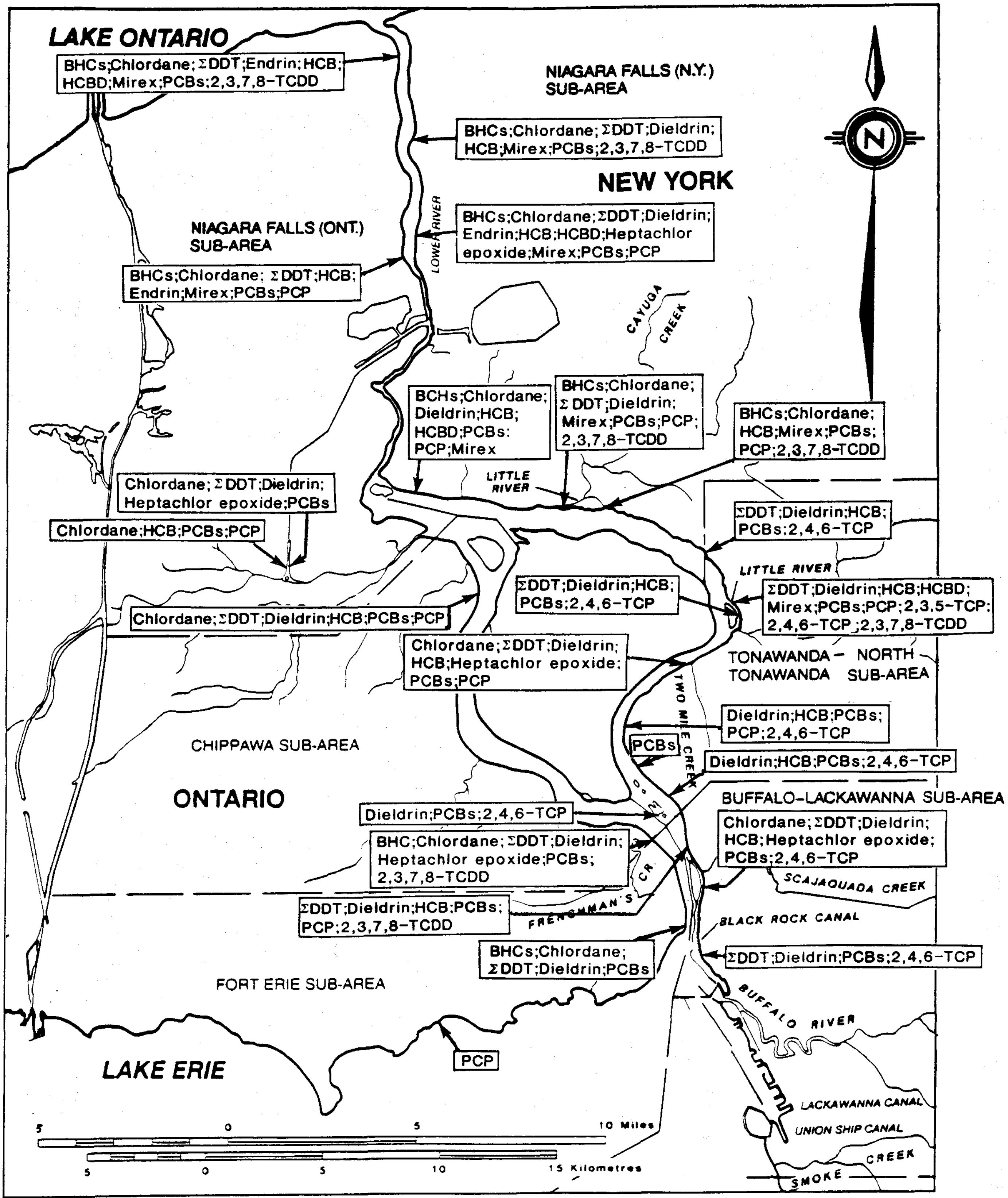

FIGURE 4.12 LOCATIONS IN THE NIAGARA RIVER WHERE MEAN CONCENTRATIONS OF GROUP I CHEMICALS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS (Notropis hudsonius) WERE NUMERICALLY HIGHER THAN AT THE LAKE ERIE STATIONS. (Ref: See C.4.1, Tables C.26 and C.27.)

However, higher concentrations of hexachlorocyclohexanes (BHC), mirex, trichlorophenols (TCP), hexachlorobutadiene (HCBD), endrin and 2,3,7,8-TCDD were specific to the Black Rock Canal, Bird Island-Riverside, Tonawanda-North Tonawanda, Wheatfield-Upper River and/or the Lower River segments or sub-areas.

Although the significance of contaminant concentration differences has not been statistically tested, there were certain obvious differences between sites as depicted for six contaminants in Figure 4.13. For example, the highest mean concentrations of total PCBs were found along the eastern shore of the upper river. Alpha-BHC was highest at the Love Canal-Cayuga Creek area and mirex was only detected in samples from three locations in the upper river and all four sites in the lower river. Although analysis for samples from all sites is not yet complete, 2,3,7,8-TCDD was also identified at only certain locations in the upper river. These higher concentrations at specific locations indicate localized inputs at or near the collection sites.

Appendix C provides more information on all contaminants analyzed in spottail shiners collected in 1981 and 1982.

Criteria (for the protection of fish-eating birds, GLWQA, 1978) exist for a limited number of contaminants. The objective for PCBs (100 ng/g) was exceeded in spottail shiners collected from 22 of 24 (92%) sites in the Niagara River in 1982. Mirex residues exceeded the objective (not detectable by best analytical methods) at 3 out of 9 sites in the Tonawanda Channel and all 4 sites in the lower river. Trace levels were also found in fish from Cornelius Creek in the Bird Island-Riverside segment. The total DDT (1000 ng/g) and mercury (500 ng/g) objectives were not exceeded in any fish, nor was the PCBs objective at the three Lake Erie collection sites.

(d) Sport Fish

Extensive sport fishery data exist for a wide variety of sport fishes. These data are reported annually by the MOE in its "Guide to Eating

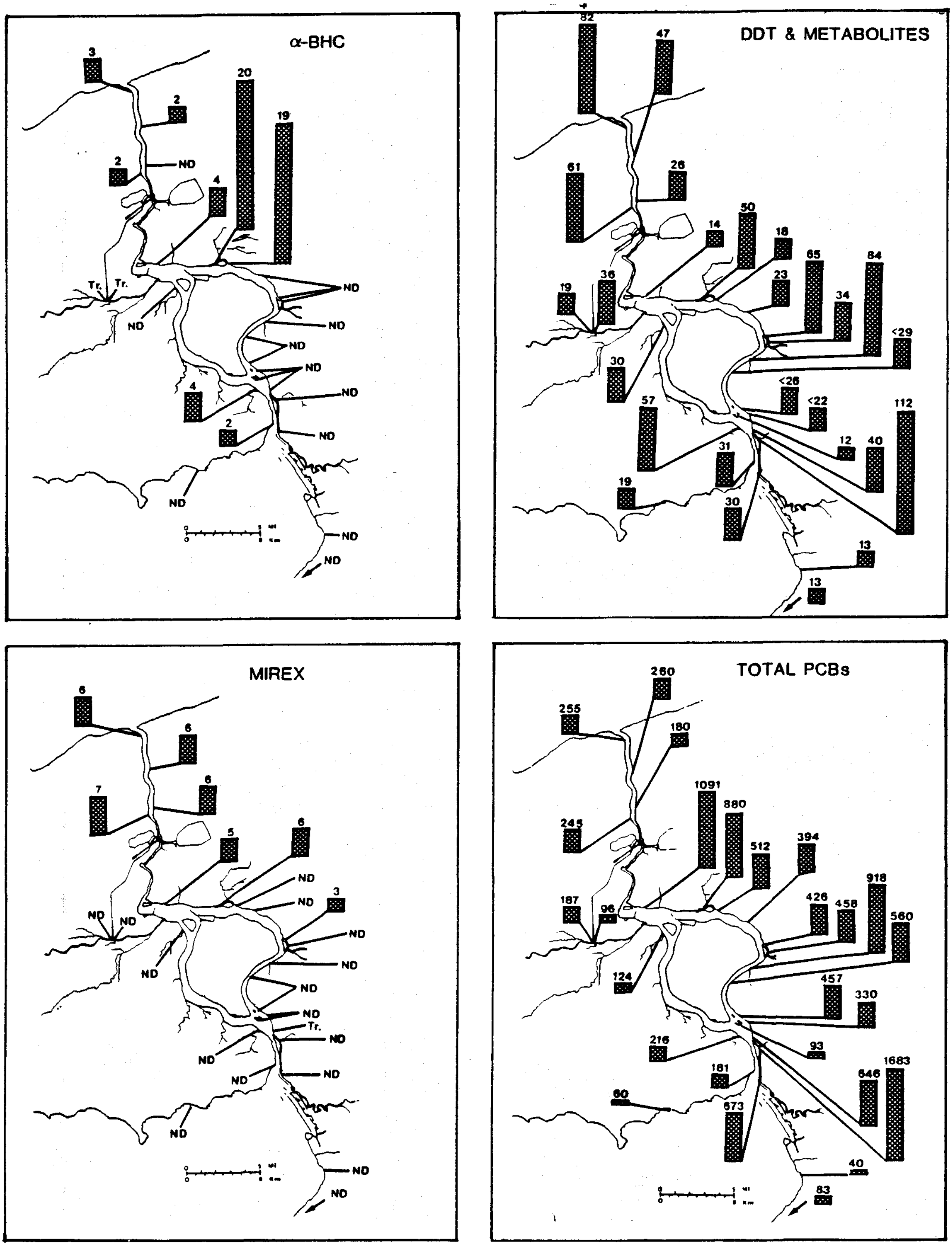

FIGURE 4.13 MEAN CONCENTRATIONS OF α-BHC, DDT, MIREX, AND TOTAL PCBs (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS, 1982. (Ref: Table C.27.)

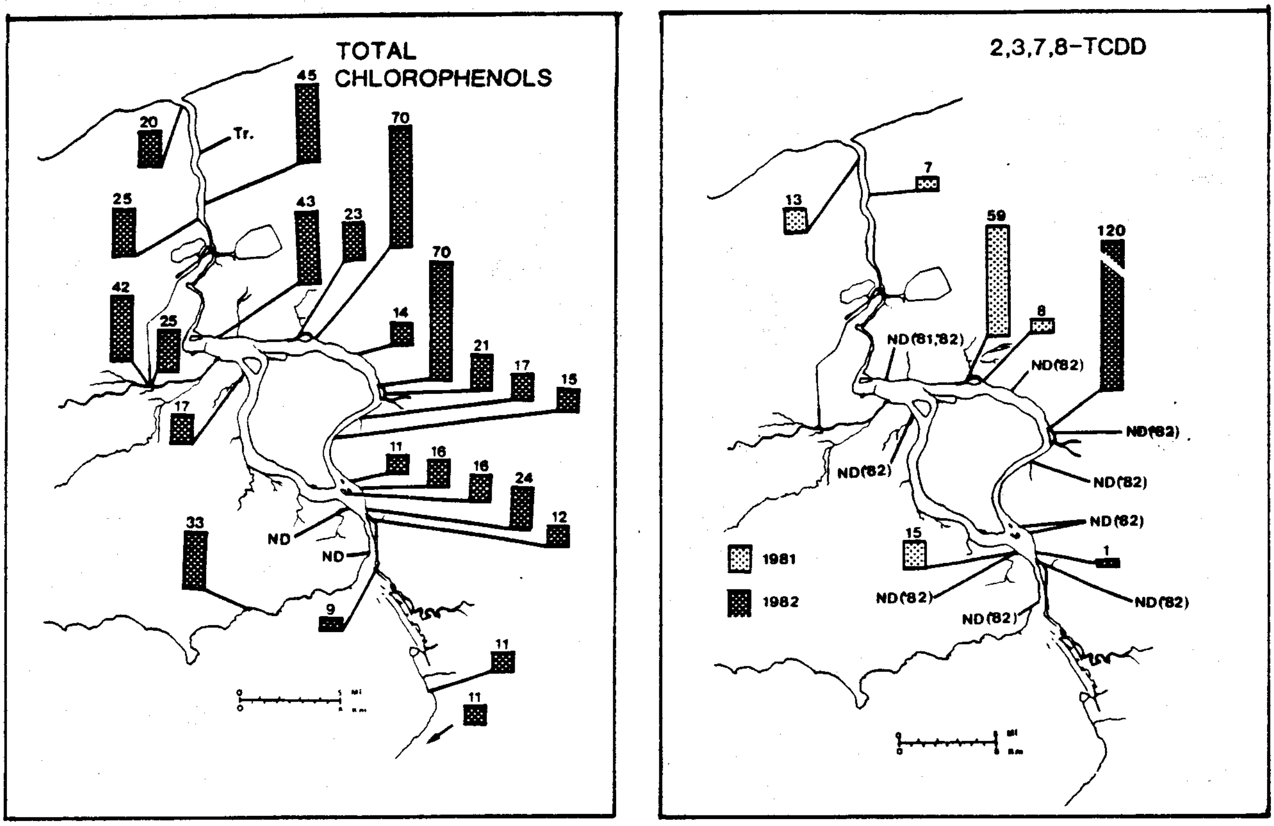

FIGURE 4.13 (CONT'D) MEAN CONCENTRATIONS OF TOTAL CHLOROPHENOLS (ng/g) AND 2,3,7,8-TCDD (pg/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS, 1981 and 1982. (Ref: Table C.27.)

Ontario Sport Fish". Direct comparison of these sport fishes by length were made for mercury, and for PCBs, Mirex and 2,3,7,8-TCDD (Dioxin) as a class of organic contaminants.

Generally, the levels of PCBs in edible portions of sport fish are higher in samples from the Lower Niagara River compared to samples from the Chippawa Channel of the Upper River. Mirex and the chlorinated dioxin 2,3,7,8-TCDD were only detected in samples from the Lower Niagara River. Detailed data are found in Appendix C.

Most sizes and species of sport fish from the Niagara River are suitable for unrestricted consumption according to Canadian Guidelines. However, concentrations of PCBs and mirex above Canadian consumption guidelines (2.0 ppm and 0.1 ppm, respectively) have led to restricted consumption advisories by Ontario for larger sizes of American eel and coho salmon in the lower river (between Queenston and the whirlpool). In addition, a restricted consumption advisory is in effect on large lake trout from western Lake Ontario due to 2,3,7,8-TCDD levels above the 20 ppt Canadian guideline (MOE, 1983). For New York, fish in the upper Niagara River fall under the New York State Department of Health recommendation that the consumption of fish from all New York State waters be restricted. Fish in the lower river are similar to those in Lake Ontario and are included in the consumption guidelines and health advisories by the State.

4.3.4 Temporal Trends of Contaminants at the Outlet of the Niagara River and in Western Lake Ontario

To overcome the complexity of problems associated with commenting on a large number of individual chemicals, all of which interact uniquely with the Niagara River ecosystem in terms of both time and space, the approach adopted here will be to comment on the observed changes only in general terms. To overcome time complications, three well-defined time periods will be discussed: the early 1930s to 1972, from 1972 to 1980, and from 1980 to the present.

A detailed literature review was conducted, and it was found that, as of this writing, fifteen different studies had addressed the topic of contaminant changes in the Niagara River in time frames ranging from three to fifty years. The studies involved an evaluation of organic and trace metal contamination in all components of the Niagara River ecosystem, including wildlife (Weseloh _et_ _al_., 1983), fish (Armstrong and Sloan, 1980; IJC, 1983), bottom sediments (Durham and Oliver, 1983; Onuska _et_ _al_., 1983; Mudroch, 1983; Frank _et_ _al_., Holdrinet _et_ _al_., 1978), suspended sediments (Warry and Chan, 1981; Kuntz, 1983) and water (El-Shaarawi _et_ _al_., 1983; Kuntz, 1983; Kuntz and Warry, 1983; Kauss, 1983; Oliver and Nicol, 1983).

Although the details changed slightly for each chemical studied, in each media examined there was, perhaps surprisingly, a consensus from all of these studies with respect to the general changes which have occurred.

4.3.4.1 Bottom Sediments

The Niagara River experienced gradually accelerating deterioration from the 1930's to the mid 1950's, at which time a great increase in the rate of deterioration occurred as the concentrations of some organics and metals doubled and tripled over the previous levels. As shown in Figure 4.14 for mercury, PCBs, mirex and chlorinated benzenes in bottom sediments of western Lake Ontario, concentrations of these contaminants peaked in the mid to late 1960's and early 1970's. Since then, a marked improvement in contaminant burdens has been observed across all media sampled, until about 1980, when there was a levelling off in the decrease of some substances and an increase in some others. This is also evident from contaminants data for fish.

4.3.4.2 Spottail Shiners

Temporal trends in contaminant levels in the Niagara River are documented by the annual MOE spottail shiner sampling program at NOTL.

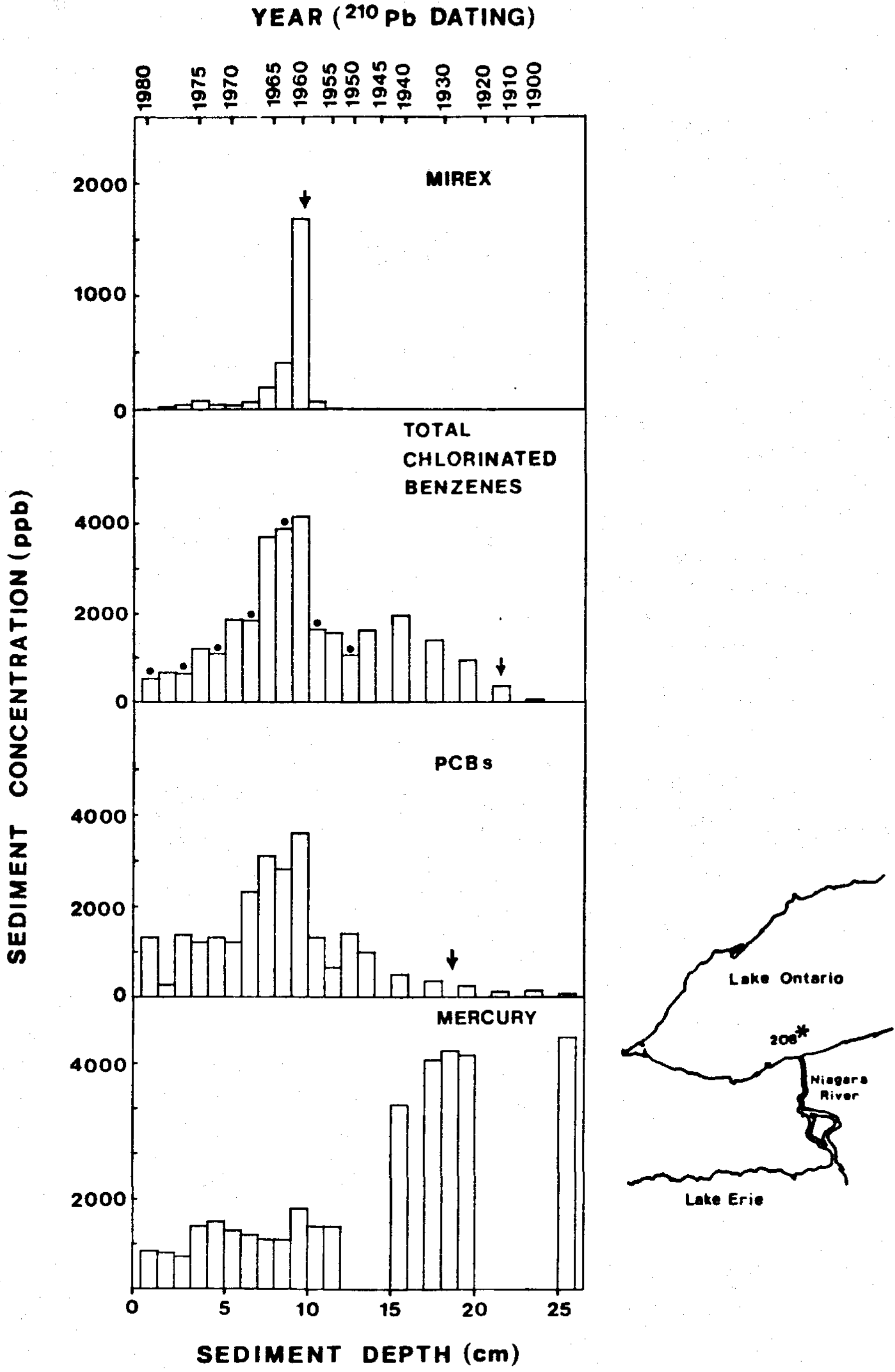

FIGURE 4.14 Concentration profiles of Mercury (from Mudroch, 1983), total PCBs, total Chlorinated Benzenes and Mirex (from Durham & Oliver, 1983) in sediment cores from western Lake Ontario (station 208 indicated on map). Horizontal axis indicates depth from sediment surface and approximate years of deposition (dated by lead-210 isotope). Arrows indicate start of production. Dotted section of total Chlorinated Benzenes graph indicates where samples were freeze-dried prior to analysis, so that concentrations represent minimum values due to possible losses by volatilization.

PCB and DDT residues in spottail shiners have declined significantly in the lower Niagara River since the mid '70's. From 1980 to 1982, PCB concentrations fluctuated, rising in 1980 and 1981 and declining in 1982. Trends with time appear to be absent for chlordane and BHCs (hexachlorocyclohexane). Mirex residues have also declined since 1978 in the lower river (see Figure 4.15 and Appendix-C Table C.25).

Concentrations of mercury declined from mean levels of 77 ng/g in 1977, to 50 ng/g in 1978 and 1979. Mean levels ranged between 23 and 43 ng/g in 1980 and 1982, respectively.

Information on other contaminants, such as chlorinated benzenes and phenols, octachlorostyrene, and dioxin (2,3,7,8-TCDD) is less amenable to a discussion of trends, since the capability to analyze for them is relatively recent and therefore data are not available for as far back in time as for PCBs. However, declines in the mean concentrations of total chlorinated benzenes (from 11 to 3 ng/g) and octachlorostyrene (from 9 to 4 ng/g) have been observed in NOTL fish between 1980 and 1982. The rise in levels of total chlorinated phenols from not detected to 20 ng/g over this same time period cannot at present be explained, although inputs from Lake Erie may be partly responsible.

Analysis for 2,3,7,8-TCDD was begun in 1981 and detectable levels (average=13 pg/g) were found in NOTL fish. At present, analysis of the 1982 NOTL collection has not been completed.

4.3.4.3 Sports Fish

New York State data for Lake Ontario small mouth bass, white perch and yellow perch (Armstrong and Sloan, 1980) indicate significant declines (90%) in levels of DDT and its metabolites in these fish between 1970 and 1977. Over the same period, concentrations of mercury in small mouth bass from the upper Niagara River and in Lake Ontario coho salmon declined by 30% and 22%, respectively. Between 1975/76 and 1978, Lake Ontario salmonids

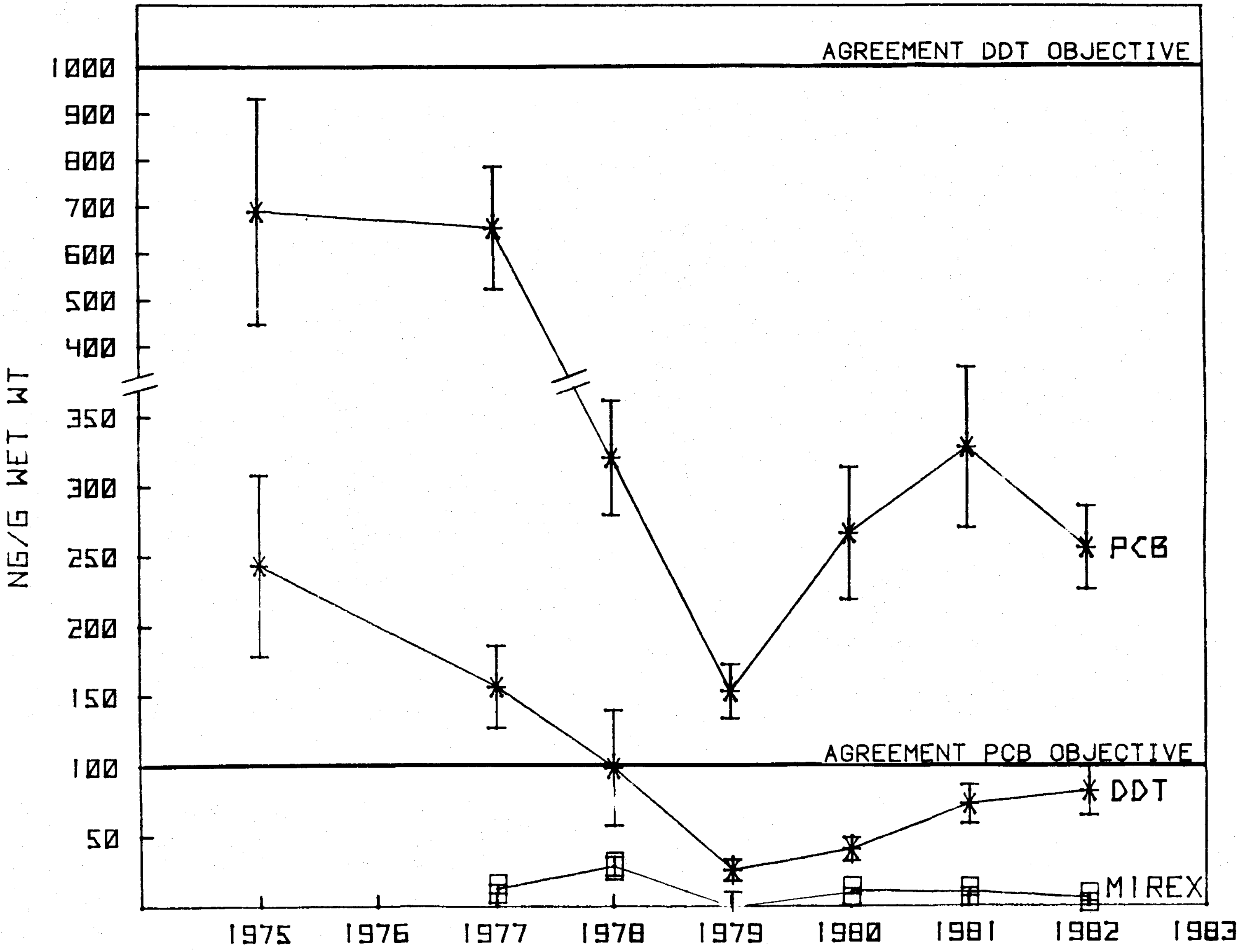

FIGURE 4.15 TOTAL PCBs, TOTAL DDT, PLUS METABOLITES AND MIREX RESIDUE TRENDS IN NIAGARA-ON-THE-LAKE YOUNG-OF-THE-YEAR SPOTTAIL SHINERS, 1975 TO 1982. (Ref: Table C.25)

(chinook and coho salmon, rainbow and brown trout) exhibited an average decline of 46% in their PCB levels. However, mirex levels in most species of game fish from Lake Ontario remained relatively unchanged between 1976 and 1978. More recently, analysis of several salmonid species caught in Lake Ontario in 1979 and 1980 (NYSDEC, 1982) indicated levels of DDT, PCBs and mirex similar to those in 1978 fish.

4.3.4.4 General Trends Since 1980

Since 1980, it has become more difficult to describe the general situation of contaminant trends. Divergences have appeared, in that some chemical concentrations in some media have not changed (eg. PCBs in spottail shiners; DDE and PCBs in Niagara River herring gull eggs), some have increased (eg. DDT in spottail shiners; PCBs and mirex in open Lake Ontario sport fish; and mirex in Niagara River herring gull eggs), while others have continued to decline (eg. alpha-BHC loadings to Lake Ontario from the Niagara River) and although the general decline in contaminant concentrations has slowed, it is not so clear whether conditions are staying the same or getting a little worse. As illustrated by Figure 4.15, some contaminant concentrations, notably PCBs and mirex have recently undergone fluctuations which are difficult to interpret in NOTL spottail shiner tissues. Furthermore, although the total load of alpha-BHC, as measured at NOTL by 2 litre unfiltered water samples, has declined from 2282 kg yr^{-1} in 1980 to 988 kg yr^{-1} in 1982, the suspended sediment portion of that load, while small, has increased from 4 kg yr^{-1} in 1980 to 11 kg yr^{-1} in 1982 (Kuntz, 1983).

4.4 Comparison of Contaminants in Different Media

The problems of contamination are found in all parts of the ecosystem studied (Table 4.10), both the living and non-living portions. The water, the suspended sediments, and the bottom sediments all show evidence of chemical contamination, as do all levels of the food chain sampled including plants, (algae, clams, young-of-the-year fish, sport fish, and herring gull

TABLE 4.10

SUMMARY OF CONTAMINANT DIFFERENCES BETWEEN INLET AND OUTLET OF NIAGARA RIVER - 1981 and 1982

	MEDIUM					
			BIOTA			
CHEMICAL CLASS AND SUBSTANCE	WATER (INCLUDING SUSPENDED SEDIMENT)*	BOTTOM SEDIMENT	ALGAE (CLADOPHORA)	CLAMS (ELLIPTIO)	YOUNG FISH SPOTTAIL SHINERS	SPORT FISH (SMALL MOUTH BASS)
Inorganics						
Aluminum	>		<>			
Arsenic		>	>			
Cadmium		>	>			
Chromium		>	>			
Cobalt			<>			
Copper	>	>	<>			
Iron	>					
Lead		>	>			
Manganese		>	<>			
Mercury	>	>	>		=	<>
Nickel		>	<>			
Selenium			<>			
Zinc	>	>	>			
Organics						
PCBs, total	>	>	>	>	>	>
Dioxin (2,3,7,8-TCDD)					>	>
alpha-BHC	>					
beta-BHC					>	
gamma-BHC	>					>
alpha-Chlordane	=					
gamma-Chlordane					>	>
Dieldrin	=					>
o,p-DDT		>				
p,p-DDT						
p,p-DDD (TDE)	=	<			>	>
p,p-DDE	>	>				
alpha-Endosulfan	=					
beta-Endosulfan	=					
Endrin	=					=
Heptachlor epoxide	>					
Methoxychlor (DMDT)	=					
Mirex	>	>			>	>
1,2-Dichlorobenzene	>					
1,3-Dichlorobenzene	=					
1,4-Dichlorobenzene	>					
1,2,3-Trichlorbenzene	>					
1,2,4-Trichlorobenzene	>					
1,2,5-Trichlorobenzene	>					
1,2,3,4-Tetrachlorobenzene	>					
1,2,3,5 & 1,2,4,5-Tetrachlorobenzene	>					

TABLE 4.10 (Continued)

	MEDIUM					
			BIOTA			
CHEMICAL CLASS AND SUBSTANCE	WATER (INCLUDING SUSPENDED SEDIMENT)*	BOTTOM SEDIMENT	ALGAE (CLADOPHORA)	CLAMS (ELLIPTIO)	YOUNG FISH SPOTTAIL SHINERS	SPORT FISH (SMALL MOUTH BASS)
Pentachlorobenzenes	>					
Hexachlorobenzene	>					
Octachlorostyrene					>	
Acetone	=					
Chloroform	>					
Chlorodibromomethane	=					
Dichlorobromomethane	=					
Methylene chloride	=					
1,4-Dichloroethane	=					
Tetrachloroethylene	=					
Benzene	=					
Toluene	=					
m-Xylene	=					
o- p-Xylene	=					
Chlorotoluene	=					
p-Chlorotrifluorotoluene	>					
Trichloroethylene	>					
Diethyl ether	=					
Hexane	=					
Hexanal	=					
Tetrahydrofuran	>					
Carbon disulphide	=					
Dimethyl disulphide	<					
Methylethylketone	=					
Butanol	=					
2,4,6-Trichlorophenol	=				=	
Hexachlorobutadiene					>	
Hexachloroethane					>	

Sources:
- Water and Suspended Sediments: sub-projects 23, 25, 26, 32 (Appendix C, Tables C.9, C.10, C.11 and C.12).
- Bottom Sediment: Appendix C, Table C.2.
- Algae: sub-project 29 (Appendix C, Table C.33).
- Clams: sub-project 28 (Appendix C, Table C.36).
- Young Fish: sub-projects 4, 30 (Appendix C, Tables C.25 and C.27).
- Sport Fish: sub-projects 5, 33 (Appendix C, Tables C.3 and C.4).

Notes:
- ">" indicates concentration and/or frequency of detection greater at outlet of river (NOTL) than at Lake Erie (Fort Erie) inlet.
- "<" indicates concentration and/or frequency of detection less at outlet of river than at inlet.
- "<>" indicates concentration less than or greater at outlet than at inlet, depending on year sampled (i.e., Cladophora).
- "=" indicates concentration and/or frequency of detection equal at outlet and inlet.
- A space indicates no data available to permit comparison.

* These differences have been tested for statistical significance and were found to be significant at the 0.05 level. (See Sec. 4.3.1.3)

eggs). The problems are magnified as one travels up the food chain because many of the chemicals in question cannot be rapidly metabolized and, therefore, are passed along and accumulated in the higher levels of the food chain.

Six representative contaminants were chosen to examine their distribution within the Niagara River: mercury, zinc, PCBs, mirex, alpha-BHC, and total DDT. As shown by Figures 4.16 to 4.19*, there was a rather consistent segment-to-segment distribution pattern: excluding the Fort Erie and Chippawa segments, most components had higher relative contaminant levels in the upper river segments, while concentrations were intermediate in media of the Lower River segment. With respect to mirex, levels were higher in the Wheatfield-Upper and the Lower River segments. Also, it is evident that the components most affected (or with highest concentrations) were the biota and bottom sediments. This is not to say, however, that there is a direct link between contaminants in sediments and in biota. Addressing the interactions between the various ecosystem components was not within the scope of these projects. Segment-to-segment fluctuations were generally much lower in suspended sediments and water, where data were available. This largely reflects the fact that these two components are not "stationary" as are sediments and biota, and their contaminants burdens are more subject to dilution.

4.5 Relationship of Ambient Data to Source Data

4.5.1 Introduction and Data Limitations

The preceding portions of this report examined the occurrences of various substances in ambient (river water, sediments, spottail shiners, clams, and *Cladophora* and other biota) and source (discharges from industrial

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* Average (median in the case of sediments) concentrations for each sub-area or segment expressed as a multiple of average levels in the Fort Erie or Chippawa reaches.

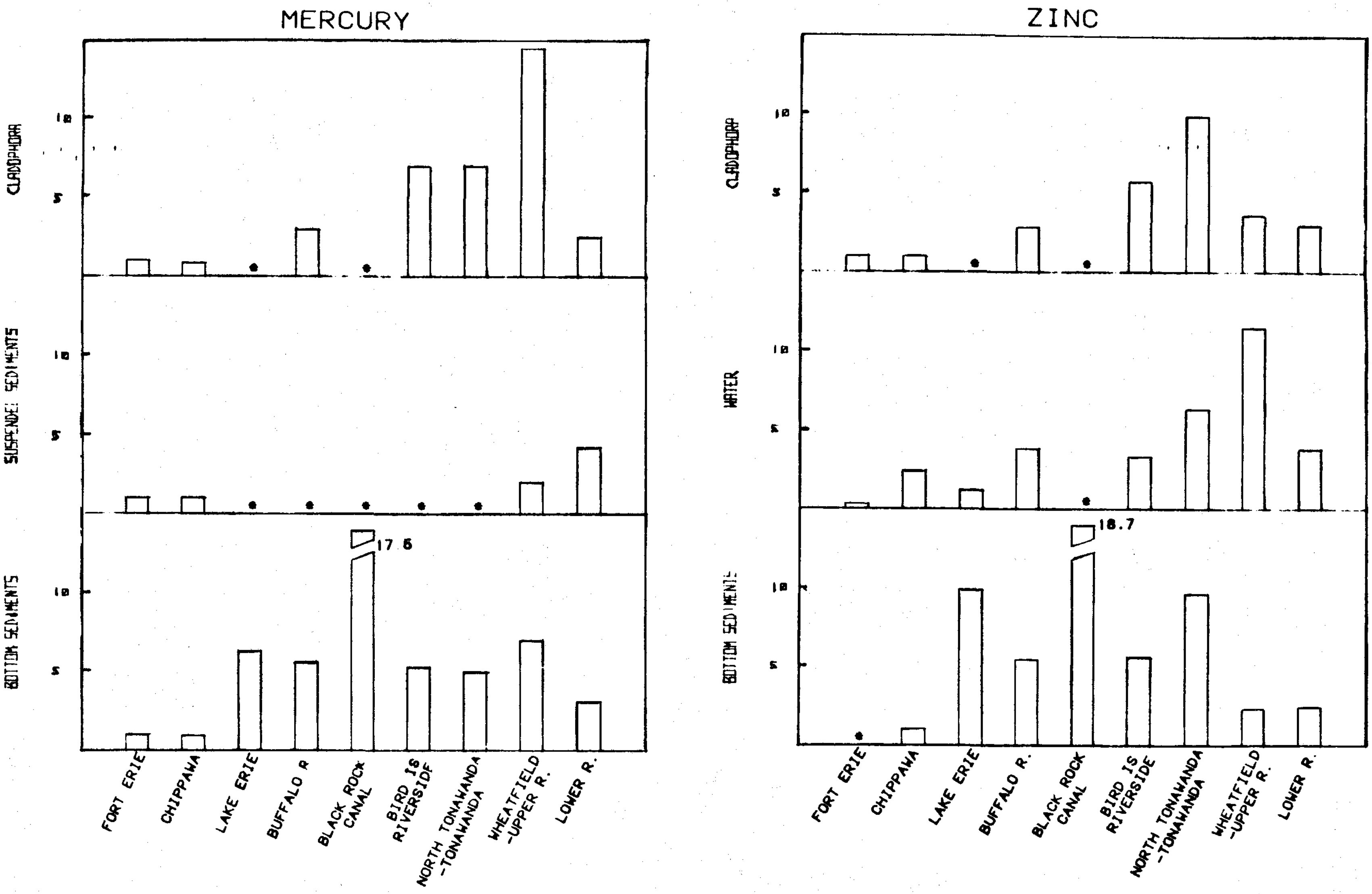
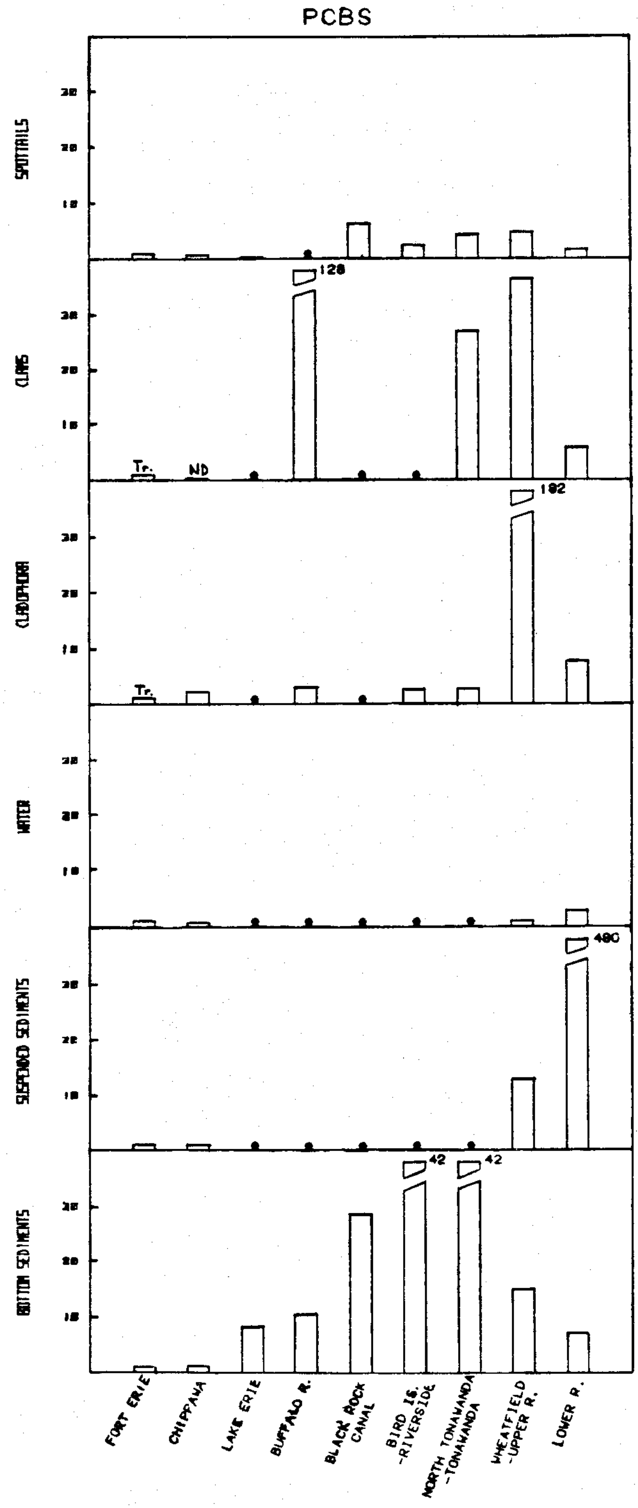


FIGURE 4.16 RELATIVE LEVELS OF MERCURY AND ZINC IN VARIOUS COMPONENTS OF THE NIAGARA RIVER ECOSYSTEM. MEAN CONCENTRATIONS (MEDIAN IN THE CASE OF BOTTOM SEDIMENTS) FOR EACH SEGMENT ARE EXPRESSED AS A MULTIPLE OF LEVELS IN FORT ERIE COMPONENTS. (* = no samples.)



PCBS

FIGURE 4.17 RELATIVE LEVELS OF TOTAL PCBs IN VARIOUS COMPONENTS OF THE NIAGARA RIVER ECOSYSTEM. MEAN CONCENTRATIONS (MEDIAN IN CASE OF BOTTOM SEDIMENTS) FOR EACH SEGMENT ARE EXPRESSED AS A MULTIPLE OF LEVELS IN FORT ERIE COMPONENTS. (* = no samples.)

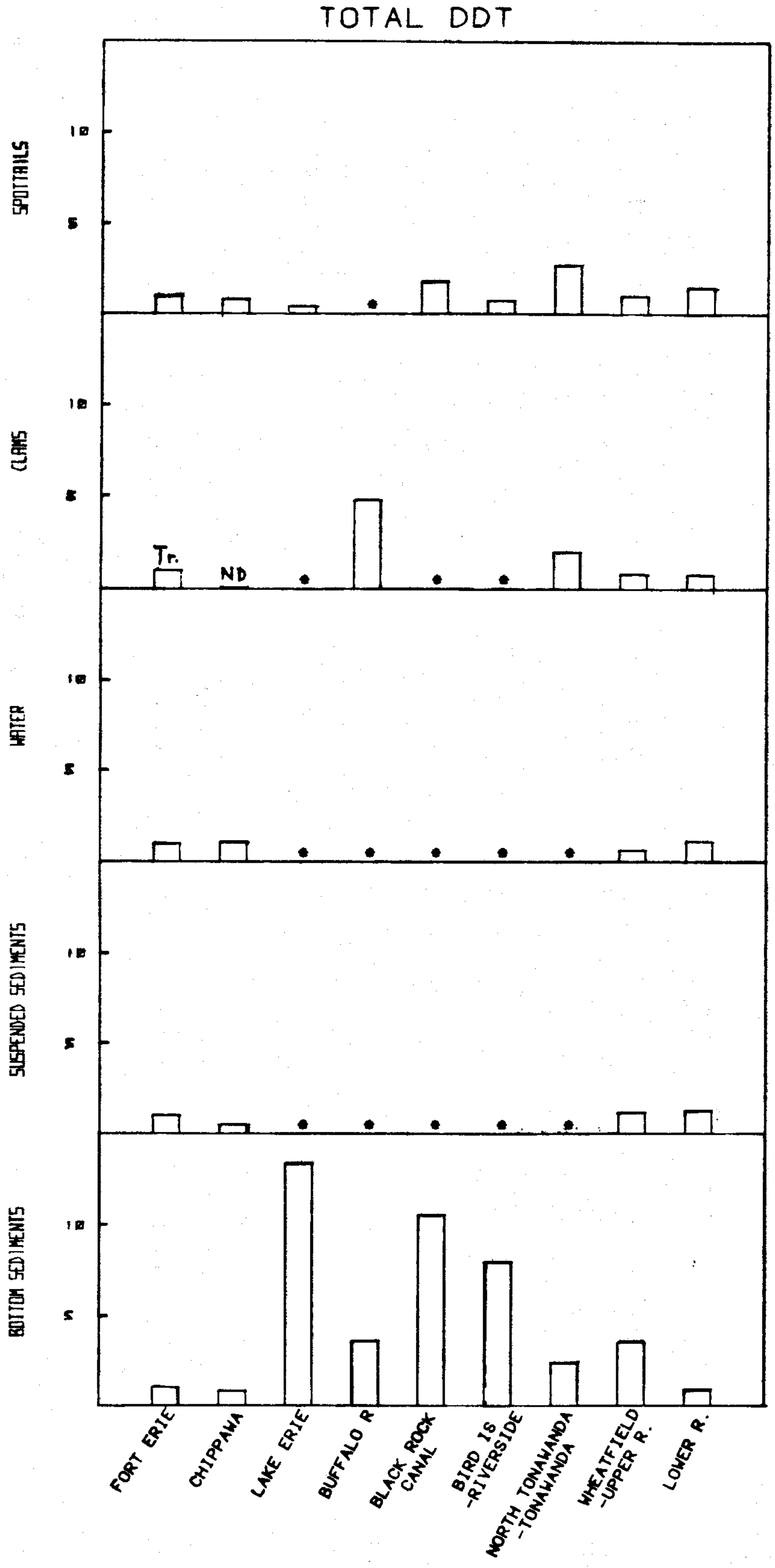


FIGURE 4.18 RELATIVE LEVELS OF TOTAL DDT PLUS METABOLITES IN VARIOUS COMPONENTS OF THE NIAGARA RIVER ECOSYSTEM. MEAN CONCENTRATIONS (MEDIAN IN CASE OF BOTTOM SEDIMENTS) FOR EACH SEGMENT ARE EXPRESSED AS A MULTIPLE OF LEVELS IN FORT ERIE COMPONENTS. (* = no samples.)

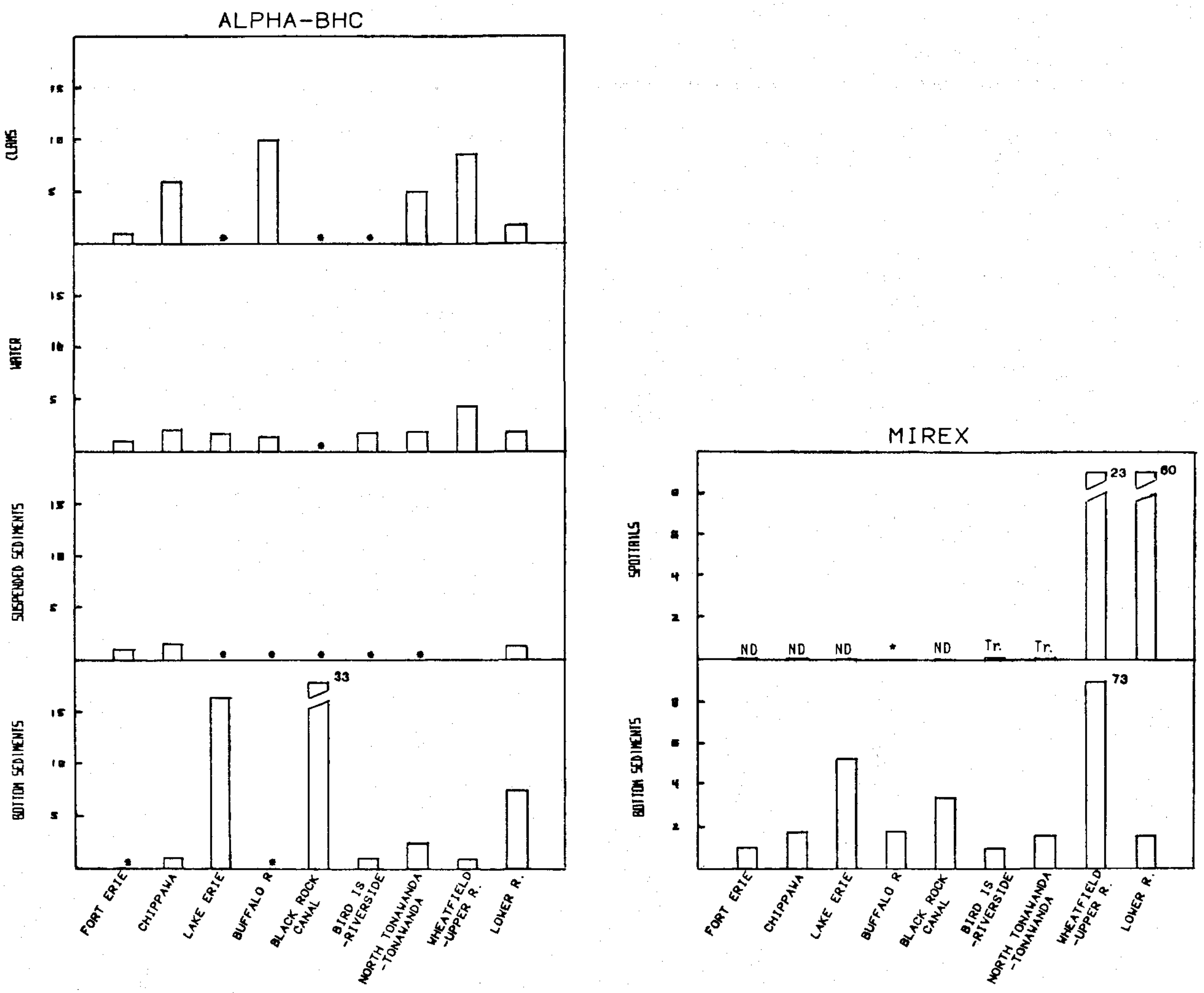


FIGURE 4.19 RELATIVE LEVELS OF ALPHA-BHC AND MIREX IN VARIOUS COMPONENTS OF THE NIAGARA RIVER ECOSYSTEM. MEAN CONCENTRATIONS (MEDIAN IN CASE OF BOTTOM SEDIMENTS) FOR EACH SEGMENT ARE EXPRESSED AS A MULTIPLE OF LEVELS IN FORT ERIE COMPONENTS. (* = no samples.)

and municipal facilities, groundwaters or soils from hazardous waste sites and storm sewer deposits) sub-projects. The purpose of this section is to establish relationships between the ambient and source data with the intention of determining the major sources of contaminants to the river. This comparison was done on a segment by segment basis.

The ability to establish relationships between ambient, point source and non-point source data was difficult. The outfalls of some point source contributors were intentionally designed to minimize local impacts and several substances which were shown to increase along the river's course (tetrohydrofuran, p-chlorotrifluorotoluene) were not analyzed in any source samples.

Conversely, there were also substances, chiefly volatile organics, which were found in high concentrations in groundwater and computed to have high point source loadings which were not measured in biota or ambient water samples. Analytical detection limits sometimes precluded identification of some compounds. High concentrations in ambient samples such as bottom sediments may reflect historic rather than current inputs. Finally, point source and non-point source data are largely comprised of samples from a single point in time, whereas ambient data (in particular biota) represents an integration of contaminant inputs over time.

For the ambient data, samples from the same medium (eg. bottom sediments) but from different data sets taken in close proximity to one another sometimes were found to be very different in terms of contaminant concentration but were similar in terms of contaminant concentration relative to other sample sites. This variation hampered attempts to meld the results of the different programs into a coherent whole. An attempt was, therefore, made to overcome this problem through the use of a weighted ranking procedure on a sub-project basis. This was done by, 1) summing all concentrations of a parameter (non-detected and unquantifiable observations were ignored), 2) identifying the smallest subset of samples required to obtain a total equal to at least half of the total sum. The values thus identified define the "high" concentration samples. While a single extremely high value could result in an underestimate of the total number of "high" values, it was felt that overall, most outliers would be identified using this procedure. Table 4.11 illustrates identification of "high" PCB concentrations in the EPA V sediment survey.

Out of 69 sediment samples analyzed for PCBs in sub-project 1 (USEPA V), 57 exceeded the MOE criterion of 0.05 mg/kg. The ranking procedure identifies four values with concentrations of 20.5, 20.3, 16.25, and 5.81 mg/kg as "high".

The MOE spottail data from 1982 present a similar picture. Out of 11 composite samples, 10 exceeded the GLWQA biota criterion for PCB (0.1 ug/g). The ranking procedure is illustrated in Table 4.12.

TABLE 4.11

ORDERED DISTRIBUTION OF TOTAL PCB CONCENTRATIONS IN
EPA V BUFFALO/NIAGARA RIVER SEDIMENT SURVEY
(All concentrations in mg/kg)

20.5*	2.24	0.9	0.21	0.070
20.33*	2.12	0.85	0.20	0.067
16.25*	1.68	0.84	0.19	0.06
5.81*	1.46	0.74	0.14	MOE CRITERION=0.05
4.07	1.37	0.55	0.14	0.049
3.79	1.34	0.44	0.13	0.04
3.67	1.33	0.43	0.12	0.03
3.17	1.22	0.35	0.12	0.03
3.09	1.18	0.33	0.12	0.03
2.78	0.9	0.3	0.10	0.03
2.62		0.3	0.10	0.01
2.40		0.29	0.09	0.005
2.31		0.26	0.09	ND
		0.23	0.08	ND
			0.079	ND
			0.073	ND
			0.070	

sum = 114.913

$\frac{\text{sum}}{2} = 57.45$

sum of top 4 observations = 62.89

* = "high"

TABLE 4.12

ORDERED DISTRIBUTION OF TOTAL PCB CONCENTRATIONS IN 1982 MOE SPOTTAIL SHINERS FROM THE NIAGARA RIVER

(All concentrations in ug/g)

1.091*
0.880*
0.260*
0.255
0.245
0.216
0.187
0.180
0.124
IJC OBJECTIVE = 0.1
0.096

sum = 4.004
$\frac{\text{sum}}{2}$ = 2.002
sum of top 3 = 2.483
* = "high"

Generally, "high" sediment contaminants met or exceeded minimum agency criteria. On the other hand, "high" organic levels from biota, with the exception of PCBs, tended not to exceed the criteria. Sediment criteria exist for few organic substances (only PCBs) and biota criteria are available for only 14 organic and four inorganic substances.

This ranking system ignores some data that exceed criteria and includes observations falling below minimum agency criteria. It also supposes that the different projects sampled the same sites and that the differences between the projects are due to differences between the media, random errors, and analytical biases. The ranking system does, however, produce lists of sites that focus attention on areas of highest contaminant levels.

In the discussion under Section 4.5.3, tables of ambient data give the largest "high" values for each segment. Substances are only listed if there was a "high" value from that segment. Furthermore, only Group I substances are included.

4.5.2 Location of Sources along the Niagara River

Understanding the relationship between samples requires familiarity with the geography of the Niagara River area and a knowledge of the locations of discharge points and disposal areas. Figure 4.20 is a map of the region with its scale distorted to allow better resolution of the principal areas of interest.

Lake Erie waters sweep along the eastern (New York) shore. Aerial photographs show a turbidity plume coming out of Smoke Creek and hugging the shore by Bethlehem Steel (steelmaking processes closed). Smoke Creek receives treated water wastes from the City of Lackawanna and Bethlehem Steel. Breakwalls partially enclose the Outer Buffalo Harbor.

Two ship canals, the Lackawanna and the Union, project into the heart of the steel manufacturing region. Bethlehem Steel discharges into both canals, however, the Lackawanna Canal was used as a source of plant process water and the net flow was from the Outer Harbor to the Canal.

The Outer Harbor terminates near the mouth of the Buffalo River which is lined with industrial facilities that include Worthington Compressor, Mobile Oil (now closed), Allied Chemical (now closed), PVS Chemical, Republic Steel (now closed), Buffalo Color, Donner-Hanna Coke (now closed), and Airco Gases. The long appendicular Buffalo Ship Canal joins the Buffalo River near its mouth.

The Niagara River narrows and becomes turbulent shortly after it is joined by the Buffalo River. A by-pass, the Black Rock Canal, extends from just north of the mouth of the Buffalo River to locks at the northern end of

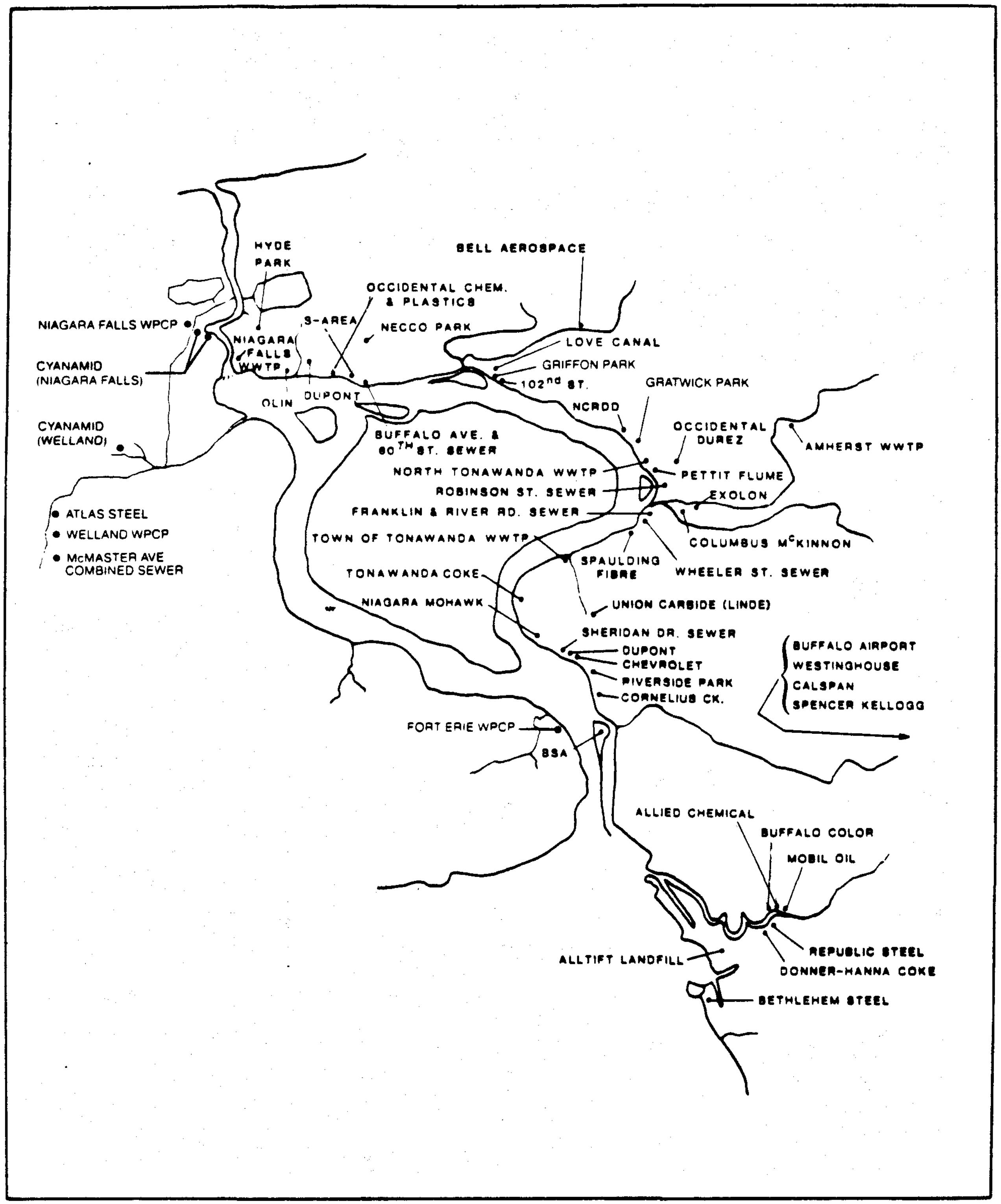


FIGURE 4.20 POTENTIAL SOURCES OF TOXIC SUBSTANCES DISCUSSED IN CHAPTER IV
(Scale Distorted)

Bird Island. Scajaquada Creek flows from the Cheektowaga suburb across Buffalo and into the Black Rock Canal. U-Crest Ditch, a tributary to the Scajaquada, receives discharges from Westinghouse, Calspan, Spencer Kellogg, and the Buffalo International Airport. Bird Island is the site of the Buffalo Sewer Authority (BSA) wastewater treatment plant. Fort Erie, Ontario lies directly west of the Black Rock Canal. Because the Black Rock Canal is controlled by locks, there is little outflow. Some water movement may occur through the porous break water separating it from the river upstream of Squaw Island.

Cornelius Creek, a piped drainage way, enters the Niagara about one-half mile downstream (north of) the Black Rock Canal. Frenchman's Creek, an Ontario stream, enters the Niagara directly west of Cornelius Creek. The Fort Erie, Ontario WPCP discharges about 1,000 feet upstream of the mouth of Frenchman's Creek. Another half mile downstream from Cornelius Creek on the New York side, is Riverside Park.

Grand Island (in New York) splits the Niagara into the western Chippawa Channel (57% of flow) and the eastern Tonawanda Channel (43% of flow). Parks and residential housing line both sides of the Chippawa Channel. Miller's Creek enters the Chippawa Channel from the Ontario side.

The eastern side of the Tonawanda Channel is lined by heavy industry. Facilities discharging directly into this portion of the Niagara River include Chevrolet, Niagara Mohawk, Tonawanda Coke, DuPont (Tonawanda Plant), the Town of Tonawanda WWTP, and Spaulding Fibre. Other discharges to the Tonawanda Channel are the Town of Tonawanda Sheridan Drive storm sewer, Two-Mile Creek (which receives discharges from Union Carbide Linde), and the City of Tonawanda Wheeler and Franklin Street storm sewers.

Two New York streams, Tonawanda and Ellicott Creeks, combine and enter the river just south of Tonawanda Island. During navigation season (April/May to November/December) 30 cms (1,100 cfs) from the Niagara River are withdrawn up Tonawanda Creek for the New York State Barge Canal.

Ellicott Creek receives discharges from Columbus McKinnon and the City of Tonawanda State Street storm sewer. The Amherst WWTP and Exolon discharge to Tonawanda Creek.

Tonawanda Island separates the Tonawanda Channel from the Tonawanda Little River. Two important discharges to the Tonawanda Little River are the City of North Tonawanda Robinson Street storm sewer and the Pettit Flume. The Pettit Flume receives permitted discharges from Occidental Durez.

The North Tonawanda WWTP discharges to the Tonawanda Channel about one half mile north of Tonawanda Island. The Gratwick-Riverside Park and NCRDD disposal sites are located another three quarters of a mile downstream along with the Niagara County Sewer District (NCSD) #1WWTP.

Cayuga Island lies four miles downstream from Tonawanda Island. Three disposal sites, Griffon Park, Love Canal, and 102nd Street, are near Cayuga Island. Cayuga Island is cut off from the northern shore by the Cayuga Little River. Cayuga Creek flows into the Cayuga Little River. A tributary to Cayuga Creek, Bergholtz Creek, receives discharges from Bell Aerospace.

About one mile downstream (west) of Cayuga Island is the outlet of the City of Niagara Falls 60th Street storm sewer. Other facilities discharging from Niagara Falls include Occidental, DuPont, and Olin. Other disposal areas in Niagara Falls are the DuPont and Olin Buffalo Avenue Plant sites and the Occidental Chemical S-Area and other Buffalo Avenue plant sites. An obsolete entrance to a former power station now serves as the Park Rescue Boat Launch near the head of the rapids upstream of the falls.

Aqueducts, located two miles below the western tip of Cayuga Island, feed the Moses Power Plant with flow from the Niagara. A reservoir at the power plant is used to equalize flow through the plant. An effect of the intake is to pull whatever contaminants hug the Niagara Falls, N.Y. shore into the reservoir where some may be sedimented.

Significant Ontario sources; Atlas Steel, City of Welland McMaster Ave. combined sewer, Cyanamid Canada (Welland), Welland WPCP, and Niagara Falls, Ontario WPCP discharge either into the Welland River or the Adam Beck Power Reservoir, which receives the flow from the Welland River through the Power Canal. Cyanamid Canada (Niagara Falls) discharges both to the Power Canal and the Niagara River.

The Niagara Falls, N.Y. Wastewater Treatment Plant (NFWWTP) discharges to the Niagara River immediately below the falls.

4.5.3 Buffalo-Lackawanna Sub-Area

4.5.3.1 Lake Erie Segment

High metals and PAH concentrations characterize sediments in the vicinity of Bethlehem Steel (Tables 4.13, 4.14). Bethlehem Steel (steelmaking has now stopped), was a major discharger of some metals, especially lead (31.8 kg/day) and zinc (120 kg/day). PCBs observed in the facility's effluent are not found in high concentrations in the adjacent lake sediments. DDT was high (0.675 ppm) in sediments at the mouth of the Union Ship Canal.

4.5.3.2 Buffalo River Segment

The ambient projects reported very high concentrations of total DDT (2.3 ppm), hexachlorobenzene (58.7 ppm), and mercury (66.6 ppm) in Buffalo River sediments. The hexachlorobenzene and DDT remain unexplained but the Buffalo Color hazardous waste site soil had 89 ppm mercury (Tables 4.15, 4.16) and is a likely source for at least some of the mercury in the Buffalo River.

4.5.3.3 Black Rock Canal Segment

Zinc (1400 ppm), mercury (12.4 ppm), lead (2900 ppm), copper (1500 ppm), PCBs (16.3 ppm), and chlordane (1.41 ppm) were all either high or

TABLE 4.13

LAKE ERIE SEGMENT - AMBIENT DATA
TABLE OF HIGH CONCENTRATIONS BY PROJECT
(ppm)

SUBSTANCE	SAMPLE TYPE				
	BOTTOM SEDIMENTS				STORM SEWER SEDIMENTS
	EPA V	EPA II	COE	DEC	DEC
Organics					
Total DDT	0.675	NH	NA	0.34	NH
Heptachlor	NH	NH	NA	0.04	NH
PAHs	216	NH	NA	66.5	NH
Inorganics					
Antimony	NA	NH	NH	34	NH
Arsenic	NH	5.4	13.9*	25*	14*
Beryllium	NA	NH	NA	0.77	3.9
Cadmium	NH	1.2*	11.6*	NH	48*
Chromium	89*	43*	92.5*	150*	NH
Copper	NH	12	143*	NH	NH
Lead	1200*	33	344*	NH	NH
Mercury	NH	0.4*	NH	1.2*	NH
Nickel	50*	13	56.1*	47*	NH
Silver	NA	NH	NH	1.8*	NH
Zinc	3300*	130	776*	570*	520*
Cyanides	84*	NH	5.04*	NH	NH

NH - Not High
NA - Not analyzed
* - Exceeds minimum agency criterion
** - PCB and Pesticide identification not confirmed by GC columns or by GC/MS.

TABLE 4.14

LAKE ERIE SEGMENT - SOURCE DATA-NEW YORK SIDE TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES AND CONTAMINANT CONCENTRATIONS (PPM) IN HAZARDOUS WASTE SITES

SUBSTANCE	FACILITIES**	HAZARDOUS WASTE SITES+		
	BETHLEHEM STEEL	BETHLEHEM	ALLTIFT	TIMES BEACH(S)
Organics				
Benzene	0.6	0.004	-	-
Bis(2-ethylhexyl) phthalate	4.91	-	-	3.0
Pesticides	0.15	-	-	-
Phenol	12	-	-	-
Total PAHs	1.15	-		82.0
Total PCBs	0.1	-	0.001	2.25
Inorganics				
Arsenic	0.17	0.03	0.011	22.7
Beryllium	0.12	-	-	-
Cadmium	-	-	-	11.9
Chromium	-	0.04	-	-
Copper	0.82	-	-	251
Lead	31.8	0.12	0.03	497
Mercury	-	-	0.003	4.8
Nickel	0.89	-	-	55.0
Selenium	2.3	-	-	-
Silver	0.44	-	0.002	-
Total cyanides	1.94	0.16	-	-
Zinc	120	0.155	-	1283

+ Analysis is of ground water unless the site is marked (S) which indicates that a soil sample was analyzed.

\- Not significant

** PCB and Pesticide identification not confirmed by GC columns or by GC/MS.

TABLE 4.15

BUFFALO RIVER SEGMENT - AMBIENT DATA - NEW YORK SIDE
TABLE OF HIGH CONCENTRATIONS BY PROJECT
(ppm)

	SAMPLE TYPE							
SUBSTANCE	BOTTOM SEDIMENTS					STORM SEWER SEDIMENTS	BIOTA	
							CLAMS	CLADOPHORA
	EC	EPA V	COE	DEC	MOE	DEC	MOE	MOE
Organics								
alpha-BHC	NH	NA	NA	NH	NH	NH	0.005	NA
Benzene	NA	1.84	NA	NH	NA	NH	NA	NA
Bis(2-ethylhexyl) phthalate	NA	NA	NA	NH	NA	220	NA	NA
Chloroform	NA	0.6	NA	NH	NA	NH	NA	NA
Chlordane	NH	NH	NA	NH	NH	NH	0.026	NA
Total DDT	NH	2.32	NA	NH	NH	NH	NH	NA
Endrin	NH	0.267	NA	NH	NH	NH	NA	NA
beta-Endosulfan	NH	0.153	NA	NH	NH	NH	NA	NA
Heptachlor-epoxide	NH	0.3	NA	NH	NH	NH	NH	NA
Hexachloro-benzene	NH	58.7	NA	NH	NH	NH	NH	NA
Lindane	NH	NH	NA	NH	NH	0.07	NH	NA
Methoxychlor	NH	0.64	NA	NH	NA	NH	NA	NA
Methylene chloride	NA	6.9	NA	NH	NA	0.017	NA	NA
Mirex	NH	0.266	NA	NH	NH	NH	NH	NA
Total PAHs	NA	228	NA	158	NA	NH	NA	NA
Total PCBs	NH	NH	NA	NH	0.71*	NH	1.28*	NH
Inorganics								
Arsenic	16*	NH	27.4*	NH	8.2*	10*	NA	NH
Beryllium	NA	4.1	NA	NH	NA	1.2	NA	NH
Cadmium	NH	NH	NH	NH	NH	48*	NA	NH
Chromium	NH	1000*	85.8*	NH	34*	160*	NA	NH
Copper	NH	1200*	123.4*	NH	40*	NH	NA	18.6
Lead	NH	3300*	225*	NH	NH	2500*	NA	NH
Mercury	NH	24*	66.6*	NH	NH	0.77*	NA	NH
Nickel	NH	120*	43.4*	NH	25	110*	NA	NH
Silver	NA	NH	NH	NH	NA	15*	NA	NH
Selenium	NH	NA	NH	NH	NA	NH	NA	1.17
Zinc	NH	NH	NH	NH	170*	1100*	NA	NH
Cyanides	NA	NH	NH	NH	NA	19*	NA	NH

NA - not analyzed
NH - not "high"
* - exceeds minimum agency criterion
** - PCB and Pesticide identification not confirmed by multiple GC columns or by GC/MS

TABLE 4.16

BUFFALO RIVER SEGMENT - SOURCE DATA - NEW YORK SIDE TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES AND CONTAMINANT CONCENTRATIONS (PPM) IN HAZARDOUS WASTE SITES

SUBSTANCE	FACILITIES**				HAZARDOUS WASTE SITES+		
	BUFFALO COLOR	DONNER HANNA	PVS CHEM	REPUBLIC STEEL	MCNAUGHTON BROOKS(S)	ALLIED CHEM	BUFFALO COLOR(S)
<u>Organics</u>							
Bis(2-ethylhexyl)-phthalate	-	-	-	-	-	-	-
Chloroform	-	-	-	0.21	-	-	-
Methylene chloride	0.35	1.2	-	-	-	-	-
Pesticides	-	0.02	-	-	-	-	-
Total PAHs	-	14.8	-	-	183	-	22.6
<u>Inorganics</u>							
Arsenic	-	-	-	-	-	-	989
Chromium	1.47	-	-	-	-	0.001	904
Copper	-	-	-	1.54	-	0.084	5905
Lead	-	-	-	3.16	175	0.173	41900
Mercury	-	-	-	-	-	-	89
Nickel	1.41	-	-	-	-	0.373	82
Selenium	-	0.7	-	-	-	-	-
Silver	-	-	0.63	-	-	-	-
Total cyanides	0.45	7.0	0.14	-	-	-	-
Zinc	0.73	1.4	0.75	2.7	-	-	1462

+ - Analyses is of groundwater unless site is marked (S) which indicates that a soil sample was analyzed.

\- - not significant

** - PCB and Pesticide identification not confirmed by multiple GC columns or by GC/MS.

TABLE 4.17

BLACK ROCK CANAL SEGMENT - AMBIENT DATA - NEW YORK SIDE
TABLE OF HIGH CONCENTRATION BY PROJECT
(ppm)

SUBSTANCE	SAMPLE TYPE						
	BOTTOM SEDIMENTS				STORM SEWER SEDIMENTS	BIOTA SPOTTAILS	
	EC	EPA V	COE	DEC**	DEC**	DEC	DEC
Organics							
Chlordane	0.049	1.41	NA	NH	NH	0.02	0.017
Total DDT	0.107	NH	NA	NH	NH	0.254	0.112
Dieldrin	NH	NH	NA	NH	NH	0.012	0.009
alpha-Endosulfan	0.078	NH	NA	NH	NH	NH	NA
Endrin	0.181	NH	NA	NH	NH	NH	NH
Heptachlor	NH	NH	NA	NH	NH	0.002	NH
Heptachlor-epoxide	NH	0.301	NA	NH	NH	0.002	0.002
Total PAHs	NA	63.9	NA	NH	57.3	NA	NA
Total PCBs	10.2*#	16.3*#	NA	NH	70*	2.29*	1.68*
Tetrachloroethane	NA	NH	NA	NH	0.011	NH	NA
Inorganics							
Antimony	NA	NA	NH	89	19	NA	NA
Arsenic	16*	NH	NH	NH	13*	NA	NA
Cadmium	19*	25*	16*	NH	150*	NA	NA
Chromium	119*	410*	126*	78*	600*	NA	NA
Copper	169*	1500*	207*	71*	NH	NA	NA
Lead	767*	950*	465*	2900*	NH	NA	NA
Mercury	2.5*	4.2*	12.4*	0.44*	1.3*	NA	NA
Nickel	32*	68*	56*	30*	NH	NA	NA
Selenium	NH	NH	NH	1.2	NH	NA	NA
Silver	NA	8.5*	NH	NH	9.8*	NA	NA
Zinc	1055*	1400*	782*	510*	530*	NA	NA
Cyanides	NA	NH	0.75*	2.3*	NH	NA	NA

NA - not analyzed
\# - although not high by definition; these concentrations are high enough to warrant discussion
NH - not "high"
* - exceeds minimum agency criterion
** - PCB and pesticide identification not confimed by multiple GC columns or by GC/MS

moderately high in sediments at the junction of Scajaquada Creek and the Black Rock Canal (Table 4.17). No significant sources were identified for this segment but DEC found high PCB (70 ppm), chromium (600 ppm), zinc (530 ppm), and mercury (1.3 ppm) in storm sewer sediments receiving permitted discharges from Westinghouse, Calspan, and Spencer Kellogg. Combined sewer overflows from the Buffalo Sewer Authority system discharge into Scajaquada Creek and the Black Rock Canal. Small zinc and lead loadings were also coming from these facilities. A consultant to the City of Buffalo (Wegman Engineers, 1980) reported 11.6 ppm Aroclor 1254 in minnows from Delaware Park Lake, an impoundment on Scajaquada Creek..

4.5.3.4 Bird Island-Riverside Segment

This segment is the smallest and had the fewest ambient samples taken (Table 4.18). A single facility, Buffalo Sewer Authority Wastewater Treatment Plant (BSA), dominates the segment, and for many parameters, the entire river (Table 4.19).

The most striking ambient sediment observations are the high PCB concentrations (20.5 ppm) found off Riverside Park. No PCBs were detected in the effluent of BSA. Loading calculations suggest that about 52% of all point source copper comes from BSA, and high copper sediment concentrations (1600 ppm) below BSA at Cornelius Creek may reflect that loading.

4.5.4 Tonawanda-North Tonawanda Sub-Area

4.5.4.1 Southern Part

In the southern part of this sub-area (from the southern sub-area boundary to Elicott Creek), DEC and EPA GLNPO sediment samples taken off the GMC Chevrolet facility both showed high PCB concentrations (510 ppm and 20.3 ppm respectively). No source is known but EPA GLNPO samples taken from

TABLE 4.18

BIRD ISLAND-RIVERSIDE SEGMENT - AMBIENT DATA - NEW YORK SIDE
TABLE OF HIGH CONCENTRATIONS BY PROJECT
(All concentrations in ppm)

	SAMPLE TYPE				
SUBSTANCE	BOTTOM SEDIMENTS		BIOTA		
			SPOTTAILS		CLADOPHORA
	EC	EPA V	MOE	DEC	MOE
Organics					
Chlordane	NH	0.073	NH	NH	NA
Dieldrin	NH	NH	NH	0.006	NA
Methoxychlor	0.059	NH	NA	NH	NA
Mirex	NH	NH	NH	0.008	NA
Total PAHs	NA	89.3	NA	NA	NA
Total PCBs	NH	20.5*	0.646	0.899*	0.168*
Pentachlorophenol	NA	NA	NH	0.019	NA
2,3,7,8-TCDD	NA	NA	0.000001	NA	NA
Inorganics					
Arsenic	12*	NH	NA	NA	14.8*
Cadmium	NH	NH	NA	NA	2.77
Chromium	44*	NH	NA	NA	55.7
Copper	116*	1600*	NA	NA	36.7
Lead	145*	NH	NA	NA	44*
Mercury	NH	NH	NA	NA	0.21
Nickel	16	56*	NA	NA	21
Zinc	NH	1100*	NA	NA	176

NA - Not analyzed
NH - not "high"
* - exceeds minimum agency criterion

TABLE 4.19

BIRD ISLAND-RIVERSIDE SEGMENT - SOURCE DATA
TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES AND CONTAMINANT CONCENTRATIONS (PPM) IN HAZARDOUS WASTE SITES

SUBSTANCE	FACILITY	HAZARDOUS WASTE SITES+
	BSA	SQUAW ISLAND(S)
Organics		
Bis(2-ethylhexyl) phthalate	3.3	0.006
Chloroform	3.2	-
Total PAHs	-	0.13
Inorganics		
Chromium	96.7	9
Copper	45.7	398
Lead	47.8	-
Mercury	0	-
Nickel	55.1	-
Silver	8.2	-
Zinc	136.60	-
Cyanides	12.7	-

+ - Analysis of groundwater unless site is marked (S) which indicates that a soil sample was analyzed.

\- - not significant

TABLE 4.20

TONAWANDA-NORTH TONAWANDA SUB-AREA (SOUTH) - AMBIENT DATA - NEW YORK SIDE TABLE OF HIGH CONCENTRATIONS BY PROJECT (ppm)

SUBSTANCE	SAMPLE TYPE							
	BOTTOM SEDIMENTS					STORM SEWER SEDIMENT	BIOTA SPOTTAILS	
	EC	EPA V	EPA II	DEC**	MOE	DEC**	DEC	DEC
Organics								
Aldrin	NH	NA	NH	0.45	NH	NH	NH	NA
alpha-BHC	NH	NA	NH	0.19	NH	NH	NH	NH a
Chlordane	NH	1.71	NH	NH	NH	NH	0.013	NH
Chloroform	NA	1.19	NH	NH	NA	NH	NA	NA
Total DDT	NH	NH	NH	NH	NH	NH	0.092	0.084
Dieldrin	NH	NH	NH	NH	NH	NH	0.026	0.008
Heptachlor	NH	NH	NH	NH	NH	3.4	NH	NH
Heptachlor-epoxide	0.019	1.0	NH	NH	NH	NH	0.002	NH
Hexachlorobenzene	NH	NH	NH	0.19	NH	NH	NH	NH
Lindane	NH	3.25	NH	0.05	NH	NH	NH	NH
Methoxychlor	0.103	NH	NH	NH	NA	NH	NH	NA a
Methylene chloride	NA	NH	NH	NH	NA	0.023	NA	NA
Total PAHs	NA	NH	NH	NH	NA	NH	NA	NA
Total PCBs	NH	20.3*	NH	510*	NH	NH	1.06*	0.918*
Pentachlorophenol	NA	NA	NH	NH	NH	NH	0.017	NA
Inorganics								
Antimony	NA	NH	NH	NH	NA	26	NA	NA
Arsenic	20*	NH	NH	NH	NH	27*	NA	NA
Beryllium	NA	NH	NH	1.1	NA	2.6	NA	NA
Cadmium	49*	5.9*	1.1*	41*	NH	57*	NA	NA
Chromium	49*	260*	16	430*	NH	560*	NA	NA
Copper	88*	NH	16	140*	NH	3000*	NA	NA
Lead	NH	NH	30	360*	NH	9900*	NA	NA
Mercury	1.44*	NH	NH	0.89*	NH	1.4*	NA	NA
Nickel	20	51*	7.1	79*	NH	140*	NA	NA
Selenium	0.27	NH	NH	1.4	NA	4.2	NA	NA
Silver	NA	NH	NH	4.8*	NA	5.7*	NA	NA
Zinc	NH	NH	160*	1100*	NH	1300*	NA	NA
Cyanides	NA	NH	NH	4.1*	NA	45*	NA	NA

NA - not analyzed
NH - not "high"
* - exceeds minimum agency criterion
** - PCB and Pesticide identification not confirmed by multiple GC columns or by GC/MS.
a - reported as Total BHC

TABLE 4.21

TONAWANDA-NORTH TONAWANDA SUB-AREA (SOUTH) - SOURCE DATA TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES AND CONTAMINANT CONCENTRATIONS (PPM) IN HAZARDOUS WASTE SITES

	FACILITIES**						HAZARDOUS WASTE SITES+			
SUBSTANCE	Dunlop Tire	FMC	TON(T) WWTP	GMC Chevy	Niagara Mohawk	Spaulding Fibre	Allied (S)	Tonawanda Coke(S)	Huntley Niag. Mo.	Ins. Equip.(S)
Organics										
Bis(2-ethylhexyl) phthalate	-	-	-	-	-	-	0.3	0.003	-	-
Pesticides	-	-	0.05	-	-	-	-	-	-	-
Total PAHs	-	-	-	-	-	-	-	-	-	60.2
Inorganics										
Arsenic	-	-	-	-	-	-	-	-	0.004	-
Cadmium	-	-	-	-	-	-	-	-	0.001	9.5
Beryllium	-	-	1.63	-	-	0.1	-	-	-	-
Chromium	-	-	8.16	-	5.6	0.68	44	-	-	101
Copper	-	1.16	-	-	-	0.10	-	-	-	-
Lead	3.74	-	-	-	7.30	0.14	100	-	0.033	383
Nickel	0.47	-	-	-	135.	-	55	-	0.007	-
Zinc	0.47	1.16	4.9	14.0	-	34.7	-	-	-	-
Total cyanides	0.10	0.05	12.1	0.56	5.41	0.02	-	-	-	-
Selenium	-	-	-	-	-	0.01	-	-	-	-

+ - Analysis is of groundwater unless site is marked (S), which indicates that a soil sample was analyzed.
** - PCB and pesticide identification not confirmed by multiple GC columns or by GC/MS.
\- - Not significant

upstream (the Bird Island-Riverside segment) also showed high PCBs. EPA GLNPO reported high chlordane (1.7 ppm) in sediments from the area. Moderately high PCBs (45 ppm) were also found by DEC in sediments near the mouth of Two-Mile Creek. This was confirmed by DEC spottail sampling (0.739 ppm). No sources for the contaminants have been identified (Tables 4.20 and 4.21).

4.5.4.2 Northern Part

The two major areas of sediment contamination in the northern part of this sub-area (from Ellicott Creek to the northern sub-area boundary) are the Tonawanda Island Little River and the mouths of Tonawanda and Ellicott Creeks (Table 4.22). Sediments from the Pettit Flume, a channel that receives discharge from Occidental-Durez and empties into the Tonawanda Island Little River, contained high concentrations of hexachlorobenzene (58 ppm), PCBs (17.9 ppm), and endrin (34 ppm). DEC tentatively identified PCBs (63 ppm) and heptachlor epoxide (35 ppm) in sediments from a storm sewer discharging upstream from the Pettit Flume (Robinson Street). These were not confirmed in other studies. The Occidental-Durez hazardous waste facility is a possible PCB source. Table 4.23 notes the presence of dioxins in soil at Occidental-Durez. The toxic isomer, 2,3,7,8-TCDD, was identified there and was found in the 1982 work on spottails in Pettit Flume (0.12 ppb, Table 4.22).

The soils around Columbus McKinnon (on Ellicott Creek) were heavily contaminated with PCBs (mean concentration was 78 ppm and maximum was 549 ppm). DEC tentatively identified 13.8 ppm in sediments from the lower Tonawanda Creek but above its junction with Ellicott. Withdrawal of water up the Tonawanda by the Barge Canal during navigation season provides an explanation for the observed PCBs in that water body.

High lead concentrations were observed by EPA V GLNPO in sediments from Ellicott Creek (2100 ppm). Other evidence of lead release in that general area is provided by the DEC storm sewer sediment observation noted on Table 4.20 (9900 ppm).

TABLE 4.22

TONAWANDA-NORTH TONAWANDA (NORTH) - AMBIENT DATA - NEW YORK SIDE
TABLE OF HIGH CONCENTRATIONS BY PROJECT
(ppm)

SUBSTANCE	SAMPLE TYPE									
	BOTTOM SEDIMENTS					STORM SEWER SEDIMENTS	BIOTA			
							SPOTTAILS		CLAMS	CLADOPHORA
	EC	MOE	EPA V	EPA II	DEC**	DEC**	MOE	DEC	MOE	MOE
Organics										
Aldrin	NA	NH	NA	NH	NH	11.0	NA	NH	NH	NH
Benzene	NA	NA	NH	NH	NH	0.82	NA	NH	NA	NA
alpha-BHC	NH	NH	NA	NH	NH	9	NHa	NH	NH	NA
Total DDT	0.287	NH	NH	NH	0.5	6.5	0.065	0.072	NH	NA
Dieldrin	0.01	NH	0.26	NH	0.24	NH	NH	0.005	NH	NA
alpha-Endosulfan	NH	NH	0.07	NH	NH	NH	NA	NH	NA	NA
beta-Endosulfan	NH	NH	0.2	NH	NH	NH	NA	NH	NA	NA
Endrin	NH	NH	NH	NH	NH	34	NH	NH	NA	NA
Hexachlorobenzene	0.088	NH	NH	NH	NH	58	0.261	0.0328	NH	NA
Hexachlorobutadiene	NA	NA	NH	NH	NH	NH	NH	0.018	NA	NA
Heptachlor epoxide	NH	NH	NH	NH	NH	35	NH	NH	NH	NA
Total PAHs	NA	NA	NH	12.5	NH	46	NA	NH	NA	NA
Total PCBs	17.9*	NH	NH	NH	13.8*+	63*	NH	NH	NH	NH
Pentachlorphenol	NA	NA	NA	NH	NH	NH	NA	0.017	NA	NA
2,4,7,8-TCDD	NA	NA	NA	NH	NA	NA	NA	0.00012	NA	NA
2,4,6-Trichloro phenol	NA	NH	NH	NH	NH	NH	NH	0.052	NA	NA
Inorganics										
Arsenic	NH	14*	NH	NH	NH	NH	NA	NA	NA	NH
Beryllium	NA	NA	NH	NH	0.86	9.0	NA	NA	NA	NH
Cadmium	NH	NH	6.0*	1.9*	9.7*	NH	NA	NA	NA	2.27
Chromium	NH	79*	NH	NH	84*	150*	NA	NA	NA	46.3
Copper	NH	110*	390*	10	160*	1300*	NA	NA	NA	30.3
Lead	NH	200*	2100*	60*	NH	NH	NA	NA	NA	45*
Mercury	NH	NH	NH	NH	1.2*	1.4*	NA	NA	NA	0.21
Nickel	NH	38*	35*	NH	81*	NH	NA	NA	NA	20.7
Silver	NA	NA	NH	NH	2.6*	13*	NA	NA	NA	NH
Zinc	NH	460*	780*	170*	1100*	650*	NA	NA	NA	307
Cyanide	NA	NA	NH	NH	NH	59*	NA	NA	NA	NH

NA - not analyzed
\+ - moderately high concentration
NH - not "high"
* - exceeds minimum agency criterion
a - reported as Total BHC
** - PCB and Pesticide identification not confirmed by multiple GC columns or by GC/MS.

TABLE 4.23

TONAWANDA-NORTH TONAWANDA SUB-AREA - (NORTH) - SOURCE DATA TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES AND CONTAMINANT CONCENTRATIONS (PPM) IN HAZARDOUS WASTE SITES

	FACILITIES			HAZARDOUS WASTE SITES^{+}		
SUBSTANCE	Amherst WWTP	N. Ton. WWTP	Occ. Durez	Columbus* McKinnon(S)	Occ. Durez	Gratwick-Riverside Park(S)
Organics						
Bis (2-ethylhexyl) phthalate	-	-	-	-	-	-
Chloroform	-	0.25	-	-	-	-
Dioxins	-	-	-	-	0.00009	-
Total PCBs	-	-	-	78	-	-
Pesticides	0.01	-	-	-	-	-
Phenol	-	-	5.61	-	-	0.405
Tetrachloroethylene	-	-	0.04	-	-	-
Inorganics						
Beryllium	-	-	0.04	-	-	-
Cadmium	-	0.5	-	-	-	-
Chromium	-	1.67	0.04	-	-	-
Copper	-	-	0.42	-	-	-
Lead	15	-	0.21	-	-	0.099
Nickel	6.74	-	0.07	-	-	0.007
Total cyanides	0.15	0.65	0.01	-	-	-
Zinc	3.75	1.67	0.01	-	-	-

\+ -Analysis of groundwater unless sites are marked (S) which indicates that a soil sample was used.

\- -Not significant

TABLE 4.24

WHEATFIELD-UPPER RIVER (EAST) - AMBIENT DATA
TABLE OF HIGH CONCENTRATIONS BY PROJECT
(ppm)

SUBSTANCE	SAMPLE TYPE								
	BOTTOM SEDIMENTS					STORM SEWERS SEDIMENTS	BIOTA		
							Spottails	Clams	Cladophora
	EC	MOE	EPA V	EPA II	DEC**	DEC**	MOE	MOE	MOE
Organics									
alpha-BHC	2.26	NH	NH	NH	NH	NH	0.029a	NH	NA
Chlordane	NH	NH	NH	NH	NH	NH	0.019	0.019	NA
Dieldrin	NH	NH	NH	NH	NH	NH	0.004	NH	NH
Total DDT	NH	NH	NH	NH	0.28	NH	0.05	NH	NA
beta-Endosulfan	0.028	NH	NH	NH	NH	NH	NA	NA	NA
Methylene-Chloride	NA	NA	NH	NH	33	NH	NA	NA	NA
Mirex	0.89	NH	1.89	NA	NH	NH	0.006	NH	NA
Pentachlorophenol	NA	NH	NA	NH	NH	NH	0.07	NA	NA
Total PAHs	NA	NA	83.4	NH	NH	NH	NA	NA	NA
Total PCBs	NH	0.96*	NH	NH	NH	NH	0.88	NH	NH
TCDD	NA	NA	NA	NH	NH	NH	.000059	NA	NA
Inorganics									
Beryllium	NA	NA	NH	NH	0.72	NH	NA	NA	NH
Cadmium	NH	0.88	NH	1.1*	NH	NH	NA	NA	NH
Chromium	NH	NH	NH	NH	110*	150*	NA	NA	30
Lead	NH	NH	NH	33	NH	NH	NA	NA	35.3*
Mercury	2.29*	NH	NH	NH	NH	0.99*	NA	NA	0.92*
Nickel	13	NH	NH	NH	29*	NH	NA	NA	15.7
Selenium	0.52	NA	NH	NH	NH	NH	NA	NA	0.9
Zinc	NH	200*	NH	150*	780*	NH	NA	NA	170

NH - not "high"
NA - not analyzed
a - reported as Total BHC
* - below minimum agency criterion
** - PCB and Pesticide identification not confirmed by multiple GC columns or by GC/MS.

TABLE 4.25

WHEATFIELD-UPPER RIVER (EAST) - SOURCE DATA - NEW YORK SIDE TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES CONTAMINANT CONCENTRATIONS (PPM) IN HAZARDOUS WASTE SITES

SUBSTANCE	FACILITIES		HAZARDOUS WATES SITES+			
	NCSD #1	NCRDD	Love Canal	102nd Street	Griffon(S) Park	Bell Aerospace
Organics						
alpha-BHC	-	-	0.005	0.106a	-	-
Benzene	-	-	0.43	7.7	-	0.066
Bis(2-ethylhexyl) phthalate	-	0.057	-	-	-	-
Chloroform	-	-	0.062	13.0	-	0.91
1,2,-Dichloroethane	-	-	-	-	-	0.015
Dioctyl phthalate	-	0.002	-	-	-	-
Hexachlorobenzene	-	-	-	-	-	-
Lindane	-	-	0.017	-	-	-
Methylene chloride	-	0.001	-	-	-	-
Phenol	-	5.7	0.003	0.044	-	-
TCDD	-	-	NQ	-	-	-
Tetrachloroethylene	-	0.011	0.186	12.0	-	0.038
Inorganics						
Arsenic	-	0.005	-	0.04	-	-
Beryllium	0.23	-	-	-	-	-
Cadmium	0.23	-	-	-	-	-
Copper	-	0.020	-	-	27	-
Lead	1.15	0.032	-	0.14	-	-
Mercury	-	0.0004	-	0.006	16	-
Nickel	0.92	0.020	-	-	-	-
Zinc	0.58	0.061	-	0.42	-	-

+ - Analysis is of groundwater unless site is marked (S) which indicates that a soil sample was used.
NQ - Not quantified
a - All isomers

4.5.5 Niagara Falls, N.Y. Sub-Area

This sub-area is divided into an eastern and western part by a line running from the downstream mouth of the Cayuga Island Little River northward perpendicular to the Niagara River.

4.5.5.1 Wheatfield-Upper River Segment (Eastern Portion)

Ambient (Table 4.24) and source (Table 4.25) data relate BHCs seen in groundwaters of the 102nd Street (0.106 ppm) and Love Canal hazardous waste sites (0.022 ppm) to contaminants of the adjacent river sediments (2.26 ppm) and spottails (0.029 ppm). A possible historical relationship may tie the unquantified 2,3,7,8-TCDD found in sediments from Love Canal storm sewers and the 59 ppt 2,3,7,8-TCDD found by MOE in spottails (1981) taken off 102nd Street. MOE's 1982 spottail work did not report TCDD analyses from fish taken at that site. Pesticides (chlordane, total DDT, and Mirex) had high concentrations (but below minimum agency criteria for biota) in at least two media from the area but source data give no indication of their presences.

4.5.5.2 Wheatfield Upper River Segment (Western Portion)

The amount of information on sources for this area (Table 4.26) illustrates the concentration of the chemical industry in Niagara Falls. The ambient data (Table 4.27) for this stretch are, on the other hand, sparse due to the high current velocities and limited number of quiet areas suitable for sedimentation and spottail habitat. Ambient data point to PCB sources but none were found in the point and non-point source investigations. Cladophora at the mouth of Gill Creek had 16.3 ppm PCBs and 0.75 ppm mercury that probably originated from the Olin or DuPont sites. These samples were all taken after the 1981 Gill Creek remediation work.

TABLE 4.26

WHEATFIELD-UPPER RIVER (WEST) - SOURCE DATA (NEW YORK SIDE) TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES AND CONTAMINANT CONCENTRATIONS (ppm) IN HAZARDOUS WASTE SITES

SUBSTANCE	FACILITIES**			HAZARDOUS WASTE SITES+								
	OCC CHEM	UCC WELDING	DUPONT	BUFF. AVE SITE 83(S)	DUPONT NECCO	HOOKER S-AREA	OCC CHEM SITES 41b-49	SOLVENT CHEM	DUPONT BUFF. AVE	OLIN SITE 58(S)	OLIN SITE 59&248(S)	OLIN DOWN-GRAD.
alpha-BHC	-	-	-	-	-	-	-	-	0.01	0.06a	-	1.29
Benzene	-	-	-	-	0.27	1.8	-	32.5	0.009	-	8.0	-
Bis(2-ethylhexyl) phthalate	0.6	-	-	-	-	-	-	-	0.009	-	-	-
Carbon tetra-chloride	-	-	-	-	25.7	1.5	-	-	-	-	-	-
Chloroform	0.04	0.18	0.01	-	18.3	0.53	-	-	32.2	-	-	-
Hexachlorobenzene	-	-		-	-	5.32	-	-	-	-	-	-
Hexachlorobutadiene	0.2	-	-	0.054	14.6	5.0	-	-	-	0.5	-	-
Lindane	NA	-	-	-	-	-	-	-	0.002	-	-	1.25
Methylene chloride	-	-		-	2.0	-	-	-	464	-	-	-
Mirex	NA	-		-	-	0.463	-	-	-	-	-	-
Tetrachloroethylene	0.36	-		-	12.7	0.59	7.12	-	10.0	-	-	-
2,4,6-Trichloro-phenol	-	-	-	-	-	0.26	-	-	-	-	-	0.049
Pesticides	0.05	-		NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	-	-	-	-	-	1.18	-	-	0.003	-	-	-
Total PAHs	-	-	-	18.4	-		-	-	-	7.0	11.8	-
<u>Inorganics</u>												
Antimony	-	-		-	-	-	-	-	0.001	-	-	-
Arsenic	0.09	0.01	-	-	-	-	-	-	0.01	-	-	-
Beryllium	0.02	-		-	-	-	-	-	0.002	-	-	-
Cadmium	0.14	-		-	-	-	-	-	0.002	-	-	-
Chromium	3.31	0.05	-	-	-	-	-	-	0.007	-	-	-
Copper	0.14	-		-	-	-	-	-	0.018	-	-	-
Cyanide	-	0.03	-	-	-	-	-	-	0.626	1.55	-	-
Lead	2.3	2.5	6.74	-	-	-	-	-	0.105	-	-	-
Mercury	0.03	-	-	-	-	-	-	-	0.002	6.2	0.07	0.014
Nickel	2.4	0.05	1.83	-	-	-	-	-	0.009	-	-	-
Silver	0.75	-		-	-	-	-	-	3.6	-	-	-

a - all BHC isomers
** - PCB and pesticide identification not confirmed by multiple GC columns or by GC/MS
+ - Analysis is of ground water unless site is marked (S) which indicated that a soil sample was used.

TABLE 4.27

WHEATFIELD-UPPER RIVER WEST - AMBIENT DATA - (NEW YORK SIDE)
TABLE OF HIGH CONCENTRATIONS BY PROJECT
(ppm)

SUBSTANCE	SAMPLE TYPE					
	BOTTOM SEDIMENTS		BIOTA			
			SPOTTAILS		CLAMS	CLADOPHORA
	MOE	EPA II	DEC	MOE	MOE	MOE
Organics						
alpha-BHC	NH	NH	NH	NH	0.009	NA
Bis(2-ethyhexyl)-phthalate	NA	0.004	NA	NA	NA	NA
Chlordane	NH	NH	NA	0.013	NA	NA
Total DDT	NH	NH	0.11	NH	NH	NA
Dieldrin	NH	NH	0.009	NH	NH	NA
Hexachlorobenzene	NH	NH	NH	0.008	0.005	NA
Mirex	NH	NA	NH	NH	NH	NA
Total PAHs	NA	4.4	NA	NA	NA	NA
Pentachlorophenol	NH	NH	NH	0.043	NA	NA
Total PCBs	NH	1.05*	1.2	1.09*	0.722*	16.3*
Inorganics						
Arsenic	NH	4.2	NA	NA	NA	11.9*
Cadmium	NH	2.8*	NA	NA	NA	1.7
Chromium	NH	14	NA	NA	NA	NH
Copper	NH	21	NA	NA	NA	20
Lead	NH	61*	NA	NA	NA	32.7*
Mercury	NH	NH	NA	NA	NA	0.75*
Nickel	0.19	10	NA	NA	NA	NH
Selenium	NA	NH	NA	NA	NA	1.5
Zinc	NH	180*	NA	NA	NA	NH

NA - not analyzed
NH - not "high"
* - exceeds minimum agency criterion

TABLE 4.28

LOWER RIVER SEGMENT - AMBIENT DATA
TABLE OF HIGH CONCENTRATIONS BY PROJECT
(ppm)

SUBSTANCE	SAMPLE TYPE						
	BOTTOM SEDIMENTS			BIOTA			
				SM BASS	SPOTTAILS	CLAMS	CLADOPHORA
	EC	MOE	EPA II	DEC**	MOE	MOE	MOE
<u>Organics</u>							
alpha-BHC	NH	0.11	NH	NH	NH	NH	NA
Chlordane	NH	0.357	NH	0.013	0.048	NH	NA
Total DDT	NH	0.19	NH	NH	0.091	0.052	NA
Dieldrin	NH	0.026	NH	NH	0.005	NH	NA
alpha-Endosulfan	NH	0.015	NH	NH	NA	NA	NA
beta-Endosulfan	NH	0.045	NH	NH	NA	NA	NA
Endrin	NH	0.013	NH	NH		NA	NA
Heptachlor epoxide	NH	0.036	NH	NH	0.002	NH	NA
Hexachlorobenzene	0.11	0.25	NH	NH	NH	0.003	NA
Hexachlorobutadiene	NA	NA	NH	0.029	0.029	NA	NA
Lindane	0.087	0.02	NH	NH	NA	NH	NA
Mirex	NH	0.64	NH	0.007	0.007	NH	NA
Pentachlorophenol	NA	NH	NH	0.009	0.045	NA	NA
Total PCBs	NH	2.7*	NH	NH	NH	NH	1.81
2,4,6-Trichlorophenol	NA	NH	NH	NH	0.020	NA	NA
<u>Inorganics</u>							
Arsenic	NA	8.2*	NH	NA	NA	NA	11.3*
Cadmium	NH	0.88	NH	NA	NA	NA	1.53
Chromium	NH	170*	NH	NA	NA	NA	29
Copper	NH	32*	NH	NA	NA	NA	27.3
Lead	NH	60*	NH	NA	NA	NA	51.7*
Mercury	NH	3.2*	NH	NA	NA	NA	NH
Nickel	NH	20	NH	NA	NA	NA	14.7
Selenium	0.43	NA	NH	NA	NA	NA	NH
Zinc	595*	170*	NH	NA	NA	NA	273

NA - not analyzed
NH - not "high"
* - below minimum agency criterion
** - PCB and pesticide identification not confirmed by multiple columns or by GC/MS

TABLE 4.29

LOWER RIVER SEDIMENT - SOURCE DATA
TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES AND CONTAMINANT CONCENTRATIONS (PPM) IN HAZARDOUS WASTE SITES AND SEWERS

SUBSTANCE	FACILITIES				SEWER	HAZARDOUS WASTE SITES
	N. FALLS WWTP	GORGE PUMPING STATION	OLIN	SCA	NIAGARA FALLS CITY DIVERSION[1]	HYDE PARK
Organics						
alpha-BHC	0.2	-	-	-	0.1	0.019(a)
alpha-Endosulfan	-	-	-	-	0.04	-
Benzene	-	-	-		-	0.360
Bis(2-ethylhexyl) phthalate	-	-	-	-	0.8	0.031
Carbon tetrachloride	-	-	0.23	-	-	0.302
Chloroform	10	0.5	7.12	-	-	0.951
1,2-Dichloroethane	-	-	-	-	-	0.361
Endosulfan sulfate	0.1	-	-		-	-
Hexachlorobenzene	-	-	-	-	-	0.108
Hexachlorobutadiene	-	-	-	-	-	0.272
Lindane	0.04	-	-	-	0.5	-
Methylene chloride	7.7	-	0.2	-	-	0.401
Mirex	-	-	-	-	-	0.084
Pesticides	0.4	-	0.04	-	-	NA
Phenol	25	-	-	94.1	-	
TCDD	-	-	-	-	-	NQ-offsite
Tetrachloroethylene	2.3	0.3	12.1	-	0.6	0.942
2,4,6-Trichlorophenol		-	-	-	-	0.148
Inorganics						
Antimony	-	-	-	-	-	0.065
Arsenic	2.1	-	-	0.26	-	0.036
Beryllium	-	0.3	-	-	-	-
Cadmium	-	-	-	0.06	-	-
Chromium	20.9	1.6	-	0.32	-	0.246
Copper	27.1	3.0	-	0.16	-	1.03
Cyanide	-	0.1	0.57	0.06	0.5	-
Lead	-	1.6	0.86	3.2	1.2	1.2
Nickel	-	-	-	5.76	0.4	0.24
Selenium	3.5	0.1	-	0.1	-	0.011
Silver	-	-	0.17	-	0.9	-
Zinc	43.8	3.0	1.84	0.29	-	31.1

a - all isomers
NQ - not quantified
\- - not significant

[1] includes Occidental, DuPont, and Carborundum. Olin listed separately.

TABLE 4.30

FORT ERIE AND CHIPPAWA SEGMENTS-AMBIENT DATA (ONTARIO SIDE)
TABLE OF HIGH CONCENTRATIONS BY SEGMENT AND PROJECT
(ALL CONCENTRATIONS IN PPM)

SUBSTANCE	FORT ERIE		CHIPPAWA			
	Bottom Sediments	BIOTA Spottails	Stream Sediments		Biota Spottails	Cladophora
	MOE	MOE	MOE	EC	MOE	MOE
Organics						
Dieldrin	NH	0.004	NH	NH	0.005	NA
Total DDT	NH	NH	NH	NH	0.057	NA
2,3,7,8-TCDD	NA	NH	NA	NA	NH	NA
Inorganics						
Chromium	NH	NA	NH	NH	NA	35
Nickel	20	NA	19	13	NA	NH
Selenium	NA	NA	NA	250	NA	NH

* - 15 ppt seen in 1981, not detected in 1982.
NA - not analyzed
NH - not "high"

TABLE 4.31

ONTARIO SEGMENTS - SOURCE DATA
TABLE OF LOADINGS (KG/DAY) FROM SIGNIFICANT FACILITIES

SUBSTANCE	FORT ERIE	CHIPPAWA	NIAGARA FALLS					
	Fort Erie WPCP	None	Atlas Steel	Cyanamid NF	Cyanamid Welland	Niagara Falls WPCP	Welland WPCP	McMaster McCombined Sewer
Organics								
Bis(2-ethyhexyl) phthalate	-		-	-	-	0.30	-	0.27
1,2-Dichloroethane	0.32		-	-	-	-	-	-
Hexachlorobenzene	-		-	-	-	-	-	-
Methylene chloride	-		-	-	-	0.39	-	-
Phenolics	0.27		-	-	-	0.87	-	0.37
Inorganics								
Chromium	-		36.6	-	4.87	3.57	-	2.2
Copper	0.49		1.36	-	0.65	0.92	0.70	1.01
Lead	-		4.62	-	-	0.52	13.4	4.64
Nickel	-		27.2	-	2.34	-	-	3.56
Zinc	1.30		4.35	0.60	2.04	11.7	1.71	1.37
Cyanides	-		-	0.96	2.29	0.34	-	-

- not significant

4.5.5.3 Lower River Segment

The lower river was studied in few ambient sub-projects. Some organics reported as coming from the Niagara Falls WWTP facilities and the Hyde Park Site (phenol, chloroform, methylene chloride, tetrachloroethane, bis(2-ethylhexyl) phthalate, carbon tetrachloride, and 1,2-dichloroethane) were not analyzed in the ambient project (Tables 4.28 and 4.29).

4.5.6 Ontario Sub-Areas (Fort Erie, Chippawa and Niagara Falls)

It is difficult to relate ambient and Ontario source data (Tables 4.30 and 4.31). The largest loadings ultimately go into the Adam Beck Power Reservoir and then into the lower river. Metals, especially chromium and nickel, predominate; but, the high concentrations of metals found in the lower river ambient results are less than the high concentrations found in upper river results.

4.6 Summary and Conclusions

Detectable levels of contaminants are present in Lake Erie (outside of project area) sediments and biota and in water entering the Niagara River.

Twenty-four chemicals are in significantly higher concentrations in water samples at the Lake Ontario end of the Niagara River than at the Lake Erie end, indicating inputs of these chemicals along the river.

The most stringent ambient water quality criteria were exceeded at least once for aluminum, cadmium, chromium, copper, lead, silver and zinc somewhere in the river. The frequency of exceedances in the river were usually not much greater than in inlet water samples from Lake Erie (outside of project area). For organic contaminants, alpha-, and gamma-BHC, aldrin, dieldrin, chlordane, and total phenols exceeded the most stringent ambient water quality criteria at least once somewhere in the river. Since no statistical tests have been done on these data the significance of these exceedances cannot be assessed.

Although whole water measurements at both ends of the Niagara River occasionally show measured concentrations that exceed the minimum agency ambient water criteria and 1978 GLWQA objectives for trace metals, no statistical assessment can be made of these data. Of the 36 organic chemicals measured, for which such ambient criteria or objectives exist the median value was always below the criterion, except for chloroform which, at both ends of the river, had a median indistinguishable from the minimum agency criterion. It appears therefore, that the water quality of the Niagara River meets or exceeds all existing water quality criteria.

Highly contaminated pockets of bottom sediments were found at many locations in the study area. Criteria based on dredge disposal guidelines were available for some metals, cyanide, and PCBs. Exceedances of one or more of these criteria were noted in all segments of the river with the exception of the Bird Island-Riverside and Fort Erie segments. The overall pattern of sediment contamination is as follows:

- low pollutant levels in the Bird Island-Riverside, Fort Erie, and Chippawa segments
- intermediate levels of pollutants in the Lake Erie, Black Rock Canal, and Lower River segments
- high pollutant levels in the Buffalo River, Tonawanda-North Tonawanda, and Wheatfield-Upper River segments

1978 GLWQA objectives for the protection of aquatic life and fish-consuming birds were exceeded by concentrations of PCBs in young-of-the-year spottail shiners from 21 of 23 collection sites in the Niagara River but not at the Lake Erie collection site which was outside of the project area. The objective for mirex in the same fish collected at the same 23 sites was exceeded at 3 sites in the Tonawanda Channel and from all 4 sites in the lower river. At all other sites, mirex was undetectable.

Larger sizes of only some sport fish from the lower Niagara River have restricted consumption advisories due to elevated levels of PCBs and mirex. Restricted consumption advisories are also in effect for some fish from the western basin of Lake Ontario due to their content of PCBs, mirex and 2,3,7,8-TCDD. Although Ontario has no advisories for the upper river, N.Y. State includes the upper river under its advisory for state-wide consumption of fish from state waters.

Because of the nature of the data, it is not possible to unequivocally relate the presence of contaminants in the river to specific sources. The following conclusions can be drawn from connections between the presence of a chemical in a point source discharge and the discovery of high levels of the same chemical at a river monitoring station downstream. However, a number of plausible conclusions can be drawn about the source of contaminants that appear in the water, sediments, and biota of the river.

- Lead, zinc, and PAHs found in the sediments around Bethlehem Steel have likely originated from past discharges by this facility.

- The Buffalo Color hazardous waste site has probably contributed mercury to the Buffalo River where it now appears in river sediments and these contributions likely are continuing.

- Storm water sewers leading into the Black Rock Canal segment probably have contributed PCBs, chromium, lead, zinc, and mercury to the sediments in the Canal.

- The Occidental Durez facility and associated landfill sites are the probable source of hexachlorobenzene found in sediments at the mouth of the Pettit Flume. The presence of hexachlorobenzene and 2,3,7,8-TCDD in spottail shiners in the Pettit Flume suggests that this substance may have migrated from the sites to the river.

- Mirex and 2,3,7,8-TCDD, found in fish taken from the Little River probably originated from the Love Canal or 102nd Street hazardous waste sites, or both.

- High PCBs and mercury in <u>Cladophora</u> at the mouth of Gill Creek probably originated at the Olin or DuPont sites.

- PCBs in sediments from lower Tonawanda Creek probably originated from the Columbus McKinnon site on Ellicott Creek.

Data for sediments and for some sports fish from the western basin of Lake Ontario indicate declines in the input of PCBs, DDT, mirex and chlorinated benzenes between the early to mid-1970s and 1980. This is confirmed by the significant declines in PCBs and DDT residues since 1975 in spottail shiners collected at the outlet of the Niagara River (NOTL). Mirex levels in these fish have declined since 1978, whereas trends with time appear to be absent for chlordane and hexachlorocyclohexane (BHC) isomers. Since 1980, however, fluctuations in levels of PCBs and DDT in spottails have occurred which are as yet difficult to interpret with respect to temporal trends. Sport fish trend data are in general agreement with the above.

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