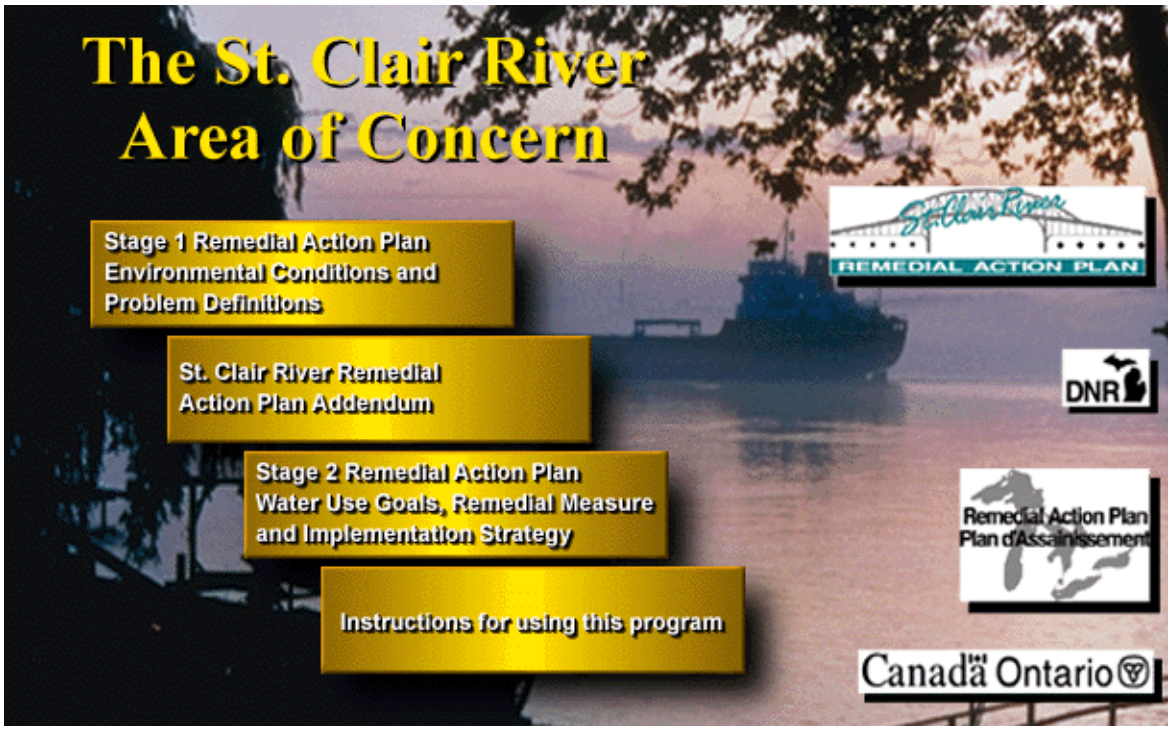
The St. Clair River
Area of Concern
Stage 1 Remedial Action Plan
Environmental Conditions and
Problem Definitions
St. Clair River Remedial
Action Plan Addendum
Stage 2 Remedial Action Plan
Water Use Goals, Remedial Measure
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St. Clair River Remedial Action Plan Addendum

Table of Contents

Executive Summary

This addendum report summarizes water, sediment, biota, point source and non-point source data for the St. Clair River Area of Concern (AOC) collected and/or reported subsequent to the release of the St. Clair River Remedial Action Plan Stage 1 Report (December 1991). Although the Stage 1 report incorporated some data from the 1988 through 1990 period, it primarily reflected conditions as of about 1986-87. Key data summarized in this addendum include water, sediment, and biota ambient data collected by OMOE in 1990 and 1991 as well as the results of the 12 month MISA monitoring studies for the organic and inorganic industrial sectors (1989 to 1991).

In general, the 1990 and 1992 ambient data indicate significant improvements in the St. Clair River ecosystem compared to conditions reported in the Stage 1 report. In particular, the mean concentrations of most parameters in most media are lower and the number of exceedences of ambient guidelines have decreased. Chemicals which have reduced concentrations and fewer guideline exceedences include cadmium, chromium, zinc, oil and grease, total PCBs and OCS. In addition, the extent of the "impaired" and "degraded" zones in the river, based on benthic macroinvertebrate community structure, have been substantially reduced. However, impairments to beneficial uses continue to occur in the St. Clair River AOC.

The industrial and municipal outfalls along the Sarnia/Chemical Valley waterfront, as well as the Cole Drain and Talfourd Creek, continue to be implicated as major sources of contaminants to the St. Clair River. This is shown by the close association of elevated concentrations of, and guideline exceedences by, nutrients, metals and non-pesticide organic contaminants (primarily PAHs, dioxins, furans, HCB, OCS, total phenols, bis-2-ethylhexyl-phthalate, oil and grease, and several volatiles) in most media along this waterfront relative to upstream and downstream locations. The Point Edward and Sarnia Water Pollution Control Plants have been identified as the most significant sources of fecal and other types of bacteria. Sarnia CSOs were also identified as an important wet weather source.

Contaminants which generally have shown little or no reductions from 1985/86 to 1990/91 include fecal bacteria, ammonia, total phosphorus, iron, lead, copper and zinc. Mean mercury and total PCB concentrations show substantial declines, particularly in sediments, however, the number of sediment guideline exceedences for mercury has not changed.

Over the same time period, the mean concentration of HCB in sediments has increased by 3 times (based on same station comparisons). In addition, the more recent data have found relatively high concentrations of PCDDs (dioxins) and PCDFs (furans) in both sediments and some industrial effluents. HCB, PCDD and PCDF sediment concentrations were highest along the Ontario shoreline in the reach from downstream of the Cole Drain, adjacent to Novacor Chemicals (Sarnia), to downsteam of Dow Chemical's 3rd Street Sewer. The greatest loadings of HCB are contributed by the Cole Drain and Dow Chemical. PCDDs and PCDFs were measured in the effluent from Dow Chemical, Chinook Chemicals and DuPont.

Sections 1.1 through 1.3 summarize the date, location and degree of guideline exceedences based on data collected from 1989 through 1991. ***Section 1.4*** summarizes the non-point and point source data for the same period. ***Section 1.5*** provides an updated table showing the impairments to beneficial uses based on Table 1.1/7.1 presented in the Stage 1 document.

For more information, select one of the following topics:

- ***Water***
- ***Bottom Sediments***
- ***Biota***

Sources
Environmental Concerns/Use Impairments

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Executive Summary
Water

PARAMETER	MOST STRINGENT GUIDELINE or OBJECTIVE[1] (mg/L)	YEAR and LOCATION of EXCEEDENCE (mg/L)
Total Phosphorus	GLWQA 5	1989-Talfourd Creek & St. Clair River (355; mean) 1990-Bluewater Bridge to Suncor (10-15; means) 1991-Walpole Is. WTP intake (36; max)
Ammonia	PWQS 20	1989-Talfourd Creek (130,160; max) 1990-Bluewater Bridge & Inner Harbour
Fecal Bacteria	EPA 33 org/100ml	1990-Bluewater Bridge to Suncor (50-8017; geometric means)
Mercury	EPA 0.00018	1990-offshore Suncor (0.03; max)
Iron	ALL 300	1987-1989-Lambton WTP intake (299.1; mean) 1989-Talfourd Creek & St. Clair River (577-2433;means) 1991-Walpole Is. WTP intake (420; max)
Zinc	GLWQA 10	1991-Lambton WTP intake (14.5; mean)
Copper	CCME 2	1990-Bluewater Bridge to Suncor (3-4; max) 1991-Lambton WTP intake (164; mean) 1991-Wallaceburg WTP intake (2.2; mean)
Chromium	CCME 2	1991-Lambton WTP intake (2.1; max) 1991-Wallaceburg WTP intake (3.5; max)
Total Phenols	PWQS 1	1991-Wallaceburg WTP intake (1.2; max)
Octachlorstyrene	OMOE 0.0001	1987-1989-Port Lambton (0.00013; mean)
Total PCBs	EPA 0.000003	1987-1989-Point Edward (0.0022; mean) 1987-1989-Port Lambton (0.0024; mean)
Bis-2-ethylhexyl-phthalate	PWQO 0.6	1990-Bluewater Bridge to Suncor (1.4-6.4; range)

[1] EPA - Environmental Protection Agency; PWQO - Provincial Water Quality Objective; CCME - Canadian Council of Ministers of the Environment; GLWQA - Great Lakes Water Quality Specific Objective

Executive Summary
Bottom Sediments

PARAMETER	MOST STRINGENT GUIDELINE or OBJECTIVE[1] (mg/g)	YEAR and LOCATION of EXCEEDENCE (mg/g)
Oil & Grease	EPA 1000	1989-Talfourd Creek (6% of samples) 1990-St. Clair River (2% of stations; 1772 - max Ontario; 1054 - max Michigan)
Total Phosphorus	EPA 420	1989-Talfourd Creek (720; max)
Total Kjeldahl Nitrogen	PASQG	1989-Talfourd Creek (1970; mean) 1990-St. Clair River (78% of stations; 1580 - max Ontario; 1950 - max Michigan)
Arsenic	EPA 3	1989-Talfourd Creek (8.83-9.10; means) 1990-St. Clair River (6.4 - max Ontario; 7.6 - max Michigan)
Cadmium	PASQG 0.6	1990-Downstream of Dow 3rd St. Sewer (6% of stations; 1.4 - max Ontario)
Chromium	PASQG 26	1989-Talfourd Creek (36.83; mean) 1992-St. Clair Delta distributaries (26; max)
Copper	PASQG 16	1989-Talfourd Creek (11.32-36.83; range) 1990-St. Clair River (39% of stations; 26.2±16.9 - mean; 140 - max Ontario; 72 - max Michigan) 1992-St. Clair Delta distributaries (32; max)
Iron	PASQG 10000	1989-Talfourd Creek (22,333; max) 1991-St. Clair River shipping channel (26,600; max)
Lead	PASQG 31	1989-Talfourd Creek (297.33; mean) 1990-St. Clair River (14% of stations; 62.7±15.2)
Manganese	EPA 300	1989-Talfourd Creek (480; max) 1990-St. Clair Delta distributaries (492; max)
Mercury	PASQG 0.2	1989-Talfourd Creek (0.3-0.7; means) 1990-St. Clair River (61% of stations; 4.92±3.47; 16 - max Ontario; 0.31 -

		max Michigan) 1992-St. Clair Delta distributaries (0.429; mean)
Nickel	PASQG 16	1989-Talfourd Creek (36.33; mean) 1990-St. Clair River (38% of stations; 30 - max Ontario; 55 - max Michigan) 1991-St. Clair River shipping channel (33; max) 1992-St. Clair Delta distributaries (33; max)
Zinc	EPA 90	1990-St. Clair River (2% of stations; 250 - max Ontario)
Total Organic Carbon	PASQG 1%	1989-Talfourd Creek (6.4-30.1%; means) 1990-St. Clair River (38% of stations; 28.1% - max Ontario; 39% - max Michigan)
Total PCBs	PASQG 0.07	1990-St. Clair River (8% of stations; 0.086±0.289; 2.022 - max Ontario) 1992-St. Clair Delta distributaries; (0.0854-0.1400; max)
Total PAHs	PASQG 2	1990-St. Clair River (14% of stations; 54.26 - max Ontario; 8.50 - max Michigan)
Hexachlorobenzene	PASQG 0.01	1989-Talfourd Creek 1990-St. Clair River (39% of stations; 1.562±5.233; 28.933 - max Ontario) 1992-St. Clair Delta distributaries (0.0478 - mean; 0.2305 - max)
Sediment Toxicity	Acute Lethality	1990-downstream of Polysar 42" sewer; Novacor, Sarnia; Dow 1st Street Sewer; Suncor; and Shell

[1] EPA - Environmental Protection Agency
PASQG - Provincial Aquatic Sediment Quality Guideline

St Clair RAP Addendum Contents

Executive Summary
Biota

PARAMETER/ CONCERN	GUIDELINE/OBJECTIVE (mg/L) or PHYSICAL IMPAIRMENT	TYPE OF BIOTA	YEAR and LOCATION (mg/L)
Mercury	Fish Consumption-human (0.5)[1]	freshwater drum	1991-north end of Stag Island/Stag Island
		walleye	1991-Bluewater Bridge; Port Lambton
		white sucker	1991-north end of Stag Island
		yellow perch	1991-north end of Stag Island
PCBs	Fish Consumption-human (2.0)[1]	carp	1991-north end of Stag Island
		gizzard shad	1991-Stag Island; Lambton Generating Station; Port Lambton
	Fish Tissue-wildlife (0.1)[2]	gizzard shad	1991-north end of Stag Island
		carp	1991-north end of Stag Island
		walleye	1991-Bluewater Bridge & Port Lambton
		shiners	1989,1990-Lambton Generating Station 1987-Mitchell Bay
Dioxins and Furans	Fish Consumption - human (15 ppt 2,3,7,8-TCDD [TEQ])[1]	carp	1991-north end of Stag Island
Octachlorostyrene	Fish Tissue-wildilfe (0.02)[3]	shiners	1991-offshore of Shell 1991-offshore of DuPont

[1] Based on the Ontario Fish Consumption Guideline and the Michigan Department of Public Health fish consumption trigger levels.
[2] Based on the Great Lakes Water Quality Agreement Specific Objective for fish tissue.
[3] As per OMOE/MDNR (1991)

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Executive Summary

Sources

The self-monitoring data for each of 12 industrial facilities within Chemical Valley indicated that all were operating within their CofA limits. The only exception was seven monthly exceedences of the suspended solids limits at Novacor Chemicals, Mooretown. In addition, effluents from eight facilities (Dow, DuPont, Esso Chemicals, Ethyl, ICI Nitrogen, Ontario Hydro, Novacor Chemicals-Mooretown and Polysar) were found to be non-lethal to rainbow trout. The only exception was one of nine bioassays using Polysar's combined (outfall #200) effluent, however, an OMOE audit sample was determined not to be acutely lethal. *Daphnia magna* acute lethality toxicity tests conducted on effluent from Dow, DuPont, Esso Chemicals and Novacor (April to September 1990) were either non-lethal or had an LC50 >100% (only one or two mortalities in a 48 hour period). Three combined effluent samples from Ethyl Canada had LC50s of 32.2%, 18.9% and 15.0%. At Polysar, forty *Daphnia magna* acute lethality toxicity tests on combined effluent collected from April to September 1990 were either non-lethal or had and LC50 >100%. A Ministry of the Environment audit sample collected in June 1990 from discharge #200 was lethal with an LC50 of 66.6%.

The twelve month MISA monitoring studies of the organic and inorganic sectors undertaken between 1989 and 1991, indicate that there has been substantial improvements with respect to reduced loadings of most parameters at most facilities in comparison to studies undertaken between 1985 and 1987. Of particular note are the reductions in chlorinated industrial organics (such as OCS, HCB and QCB) and organic volatiles. Reduced loadings of chlorinated industrial organics along with phenolics, oil and grease (solvent extractables) and cadmium have also been recorded for the Cole Drain. These reductions reflect the increased awareness and efforts to reduce contamination to the St. Clair River since the mid 1980's. The effect of the decreased loadings is directly reflected by the improvements to the biota, sediment and water quality of the St. Clair River and Delta observed from the results of the 1990 OMOE ambient surveys.

Notwithstanding the above, several parameters from different facilities continue to be of concern and need to be further addressed in the on-going remediation programs. Parameters which have increased include nickel and zinc at Dow and total PAHs at Ethyl. All three of these parameters continue to exceed sediment quality guidelines. The 1989-1991 MISA survey also identified loadings of PCDDs and PCDDs from three facilities including Dow Chemical, Chinnok Chemicals and DuPont. Relatively high concentrations of these chemicals were found in sediment sampled from below the Cole Drain to offshore of Suncor with maximum concentrations downstream of the Dow 1st Street Sewer complex. Total volatiles from Polysar, Dow and the Cole Drain appear to have increased in 1989-1991 however, these values cannot be compared because the constituent compounds from the surveys are different. In addition, the volatile compounds 1,1-dichloroethane, 1,2-dichloroethane, 1,1,2-trichloroethane, carbon tetrachloride and tetrachloroethylene at Polysar and tetrachloroethylene at Dow all appear to have increased loadings between 1986-1987 and 1989-1991. This increase may not be real and is likely a function of the method used to calculate loadings in the MISA 1989-1991 survey. Concentration levels at or near the regulation method detection limit coupled with high flows will result in loadings that are biased high (Tuszynski 1992).

Air quality monitoring undertaken at Walpole Island by Environment Canada and within Lambton County are by the Lambton Industrial Society indicate the presence of several organic and metal contaminants as well as particulates and sulphur dioxide. Air quality standards have been exceeded in the Chemical Valley area during 1991 for a number of parameters including sulphur dioxide, ethylene, total reduced sulphur, ozone, and average annual particulate. However, loadings to the St. Clair River of atmospherically derived contaminants have not been calculated.

No additional loadings updates are available from Michigan point sources, however, effluent toxicity testing was undertaken during 1991 and 1992 at five facilities. The results of these tests indicate that the effluents from E.B. Eddy Paper in Port Huron, Marysville WWTP, St. Clair WWTP, and Marine City WWTP were not acutely toxic to either *Daphnia magna* nor fathead minnows. In addition,

effluent from the Detroit Edison Company in St. Clair was not acutely toxic to D. *magna*. The Michigan Department of Natural Resources found that each of the five facilities were meeting the toxicity-related requirements of Rule 82 of the MWQ Standards.

St Clair RAP Addendum Contents

Executive Summary

Environmental Concerns/Use Impairments

Impairments to beneficial uses in the St. Clair River AOC were determined from the data presented on physical, chemical and biological environmental conditions in the Stage 1 Remedial Action Plan document (OMOE/MDNR 1991). As a result, the Great Lakes Water Quality Agreement (GLWQA) beneficial use categories were identified as impaired, not impaired or requiring further assessment. In the latter case, further assessment is required prior to concluding whether or not the use is impaired. For some beneficial uses this requires the development of concentration based guidelines for chemicals or species for which none are available. Such guidelines are not necessarily endemic to the St. Clair River AOC, but will require assessment of conditions within the entire Great Lakes ecosystem.

Table A updates the 1991 Stage 1 impairment of GLWQA beneficial uses (Tables 1.1 and 7.1 in the Stage 1 document) based on the more recent findings reported in this addendum report. The status of each impairment is identified based on the new information. All updated text in **Table A** is highlighted by the use of italics.

Although notable improvements, in terms of fewer fish consumption guidelines and much improved benthic invertebrate community structure, have been recorded along the Ontario shore since the Stage 1 RAP was released, the use impairments in the St. Clair River AOC have not changed as result of the most recent data. Those beneficial uses considered to be impaired are: restrictions on fish consumption, bird and animal deformities, degradation of benthos, restrictions on dredging activities, restrictions on drinking water consumption, drinking water taste and odour problems, beach closings, degradation of aesthetics, added cost to agriculture and industry, and loss of fish and wildlife habitat. Beneficial uses determined not to be impaired include dynamics of fish populations, eutrophication or undesirable algae, and degradation of phytoplankton and zooplankton populations.

St Clair RAP Addendum Contents

Introduction

The St. Clair River Remedial Action Plan (RAP) Addendum Report summarizes surveys and programs that have been completed since the release of the St. Clair River Area of Concern Remedial Action Plan, Stage 1 document. In addition, ongoing programs and studies for which data are currently being collected or synthesized, are also summarized in this report.

This addendum report is a synthesis of data collected mostly since 1989/1990, however, some data collected as far back as 1985, have only recently been reported and, therefore, have been included in this report. Where existing data have been updated, additional information is compared with conclusions drawn in the Stage 1 document in order to identify changes in environmental conditions that have occurred since the completion of the Stage 1 RAP.

Since the Stage 1 document was released, the St. Clair River Remedial Action Plan (RAP) Team and the Binational Public Advisory Council (BPAC) have jointly developed water use goals for the cleaning up the St. Clair River and delta. The specific time frame for achieving the goals varies and will be determined by the work required. The goals are consistent with the intent of the Great Lakes Water Quality Agreement (GLWQA), to restore, protect and maintain beneficial water uses, as well as the chemical, physical and biological integrity of the St. Clair River and delta. The water use goals and objectives defined by the RAP Team and BPAC are as follows:

Aesthetics

Achieve and maintain an aesthetically pleasing clean "blue water" and an appropriate balance of natural shoreline and human uses.

There should be sufficient public access to the river for recreation, enjoyment and cultural activities.

Consumption of Fish and Wildlife

Eliminate the need for restrictions on human consumption of fish and wildlife for reasons of health.
A. Human Consumption: By the year 2000, levels of contaminants in fish and wildlife attributable to sources in the AOC will not pose a health hazard to humans based on consumption guidelines.

Ecosystem Health

Attain and maintain healthy, diverse and self-sustaining biological communities and habitats.
Ensure there are no negative impacts on the health of local populations due to water quality.

Ensure no net loss of fish and wildlife habitat and reclaim, rehabilitate and enhance habitat where possible.

B. Wetland & Aquatic Habitats: By the year 2000, protection of existing (1992) habitat and enhancement and appropriate increase of sustainable, viable wetland and aquatic habitats will be achieved.
C. Ecosystem Improvements: By the year 2000, we will demonstrate improvements in ecosystem health through:
-reductions in body burdens of persistent bioaccumulative substances to a level below established effect levels;
-enhancement of abundance and species diversity;
-establishing that no exceptional incidents of tumours or deformities are evident in fish and wildlife populations; and

-achievement of environmental quality guidelines, *e.g.*, water and sediment.

Recreation and Shipping

Ensure that the water quality is safe for body contact at all times.

Eliminate adverse environmental effects caused by recreational and shipping activities.
D. Recreation: By the year 2000, consistently acceptable water quality and access for recreational uses such as swimming, fishing, boating and aesthetic enjoyment will be provided.

Sources of Contaminants

Ensure that no source (point of non-point) impairs water quality.

Eliminate spills.
E. Point Sources (including shipping): By the year 2000, there will be top quality river water as measured against ambient water quality objectives in the AOC through pollution prevention activities and effective control of industrial, municipal, shipping, air and water discharges.
F. Non-Point Sources: By the year 2000, all urban and rural non-point sources (*e.g.*, sources of herbicides/insecticides, soil, nutrients [fertilizers/animal & human waste], bacteria, and input to storm sewers, lawn runoff, septic systems, storm runoff) will be controlled to achieve the overall goals of the RAP.
G. Sediments: By the year 2000, river sediments and associated contaminants will not impair identified beneficial uses.
H. Exotic Species: By the year 2000, the introduction of nuisance exotic species will have been prevented and their expansion will have been controlled.

Water Supply

Ensure that an adequate and affordable water supply, in quality and quantity, is available from the St. Clair River for users at all times.
I. Water Quality and Quantity: By the year 2000, river water meeting quality criteria for municipal, industrial, agricultural and residential non-drinking uses will be available without interruption.

St Clair RAP Addendum Contents

Water Quality

This section is comprised of follow-up or new water quality surveys to those reported in the Stage 1 RAP. Follow-up surveys include:

- OMOE 1990 St. Clair River water quality surveys. These also included sediment and biota surveys using sampling locations comparable to earlier whole river sampling programs;
- OMOE 1991 Drinking Water Surveillance Program, measuring contaminants in raw water from the intakes at the Lambton, Wallaceburg and Walpole Water Treatment Plants (WTPs); and
- Environment Canada water quality and suspended sediment head and mouth surveys of the St. Clair River, from March 1987 to December 1989 (Chan 1992).
- Environment Canada assessment of dry and wet weather fecal bacterial contamination and other contaminants of the near-shore zone of the St. Clair River at Sarnia. The study also included the identification of bacterial sources and an evaluation of remedial measures for bacterial contamination (Marsalek *et al.* 1992);
- A complete contaminant survey was conducted for Talfourd Creek by OMOE. Ambient water, sediment and caged mussels were investigated in order to determine the impact of contaminant input from Talfourd Creek. Ambient water quality and caged mussel results are presented in this section. Sediment results are provided in ***Section 3.3***; and
- Lambton Industrial Society continuous water quality monitoring station.

For more information, select one of the following topics:

- ***Ontario Ministry of the Environment 1990 Water Quality Study***
- ***OMOE 1991 Drinking Water Surveillance Program***
- ***Environment Canada 1987-1989 Head and Mouth Surveys***
- ***Bacteria***
- ***Contaminants In Ambient Water and Caged Mussels from Talfourd Creek***
- ***Lambton Industrial Society Continuous Water Quality Monitoring***

St Clair RAP Addendum Contents

Water Quality

Ontario Ministry of the Environment 1990 Water Quality Study

During late May to mid-June of 1990, physical and chemical data were collected by the (then) OMOE at 10 of the 64 sediment quality-benthic macroinvertebrate sampling stations and at the 3 stations associated with dredging in the lower river and Lake St. Clair (**Figure 1**). Replicate samples, samples taken at the same location at different times, and field data were obtained at 0.15 m off bottom and these results are summarized in **Table 1.**

There was an increase in both the mean and variability of conductivity and chloride levels at stations downstream of Dow Chemical's 1st, 2nd and 3rd Street sewer outfalls (Stations IS14, IS15 and IS16, respectively); however, the greatest increase in chloride and conductivity was detected at Station 24A, immediately downstream of the Suncor discharge. Dissolved oxygen and total reactive phenols concentrations met their respective provincial water quality objectives (PWQOs) in all samples from all stations. Except for one replicate from upstream control Station 13, hydrogen ion concentration (pH) also fell into the acceptable PWQO range.

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Water Quality

OMOE 1991 Drinking Water Surveillance Program

Raw water samples are taken from the intakes of three water treatment plants (WTP), Lambton, Wallaceburg and Walpole, as part of the Ontario Ministry of the Environments (OMOE) Drinking Water Surveillance Program. The locations of these facilities represent upstream conditions (Lambton WTP - Lake Huron water), and downstream conditions (Walpole Island WTP - South Channel; and Wallaceburg - Chenal Ecarte). Raw water samples were taken monthly during the months of January, March, May, July, September and November, 1991. Results were not available from July and September samples from the Lambton WTP.

Data on raw water samples, collected in 1991 from three water treatment plants are summarized in **Table 2.** 1988 results, reported in the Stage 1 RAP are also included in **Table 2** for comparison.

Colour values increase slightly between the head and mouth of the river (**Table 1**). Values cannot be compared to the 1988 data reported in the Stage 1 RAP because of a change in units. 1988 colour values were reported as true colour units (TCU) and 1991 values are in hazen colour units (HCU).

Mean specific conductance values show a slight increase from head to mouth with approximately comparable values in both 1988 and 1991. Guidelines have not been established for specific conductance. Although the specific conductance values at the downstream water intakes appear to have been slightly lower in 1991 compared to 1988, the difference is very small and likely not significant given the small sample population (**Table 2**).

Mean turbidity, in the South Channel during 1991 was almost twice that of 1988, however, one high value in March (38 FTU) has elevated the mean. If this value were not included, the mean turbidity value at the Walpole WTP would be 3.52 FTU. Hence, in 1991 turbidity values have remained relatively consistent to slightly decreasing downstream (**Table 2**). In addition, turbidity values have changed little since 1988.

Ammonia concentrations increase slightly downstream (**Table 2**). Concentrations at all three intakes have decreased between 1988 and 1991. In both years the highest values were recorded at the Wallaceburg water intake however, data is generally in the same range at all three intakes. The PWQO, Michigan WQS (January 1993), Rule 57 value and the GLWQA Specific Objective for unionized ammonia is 0.02 mg/L (for cold water). Because unionized ammonia usually forms less than 20 percent of total ammonia (*i.e.* it is pH and temperature dependent), it is unlikely that these ambient values exceeded any of the water quality guidelines.

Total phosphorus concentrations measured at the three water intakes have generally remained the same between 1988 and 1991. During 1991, only the March sample from the Walpole intake (0.036 mg/L) exceeded the PWQO of 0.03 mg/L to protect against nuisance plant growth in rivers.

Chloride measured in water samples taken at the Lambton, Wallaceburg and Walpole water intakes (**Table 2**) show an increase downstream and, between 1985 and 1988 were found to increase over time (OMOE and MDNR 1991). Levels from 1988 to 1991 have remained relatively constant (**Table 2**). There are no PWQOs for chloride, however, the concentration pattern indicates that industrial and municipal discharges are elevating chloride levels (OMOE and MDNR 1991). The Michigan WQS (January 1991) for chloride states that chlorides should not exceed a 50 mg/L monthly average in Great Lakes waters or their connecting channels. This guideline was not exceeded at the Ontario Water Treatment Plants.

During 1988, mean lead concentration, increased downstream by up to 4 times (**Table 2**). The mean lead concentration at the head of the river (Lambton water intake) has increased by 3 times, from 0.181 to 0.72 mg/L (**Table 2**). The reason for the increase is not known. 1991 mean lead levels decrease slightly downstream, suggesting that lead input along the river has either decreased or

remained the same from 1988 to 1991. The PWQO and the GLWQA Objective (25 μg/L), the Michigan WQS (January 1993), Rule 57 value (2.88 μg/L) and the Canadian Water Quality Guideline (2.0 μg/L) were not exceeded in ambient water samples taken in 1991 (**Table 2**).

Iron levels in ambient water increased from the head to the mouth of the St. Clair River during both 1988 and 1991 (**Table 2**). Concentrations have remained relatively the same during this time period. Only the March 1991 sample from the Walpole intake (420 μg/L) exceeded the GLWQA or PWQO of 300 μg/L.

Zinc concentrations in ambient water increased downstream during 1988 however, in 1991, zinc levels at the head of the river have increased dramatically. The mean zinc concentration increased more than 6 times from 2.24 μg/L in 1988 to 14.5 μg/L in 1991. However, 1991 downstream values decreased (**Table 2**). The maximum zinc level recorded in May, 1991 (31 μg/L) at the Lambton intake exceeded the PWQO and GLWQA Specific Objective of 30 μg/L. The Michigan WQS (January 1993) Rule 57, (49.57 μg/L) was not exceeded.

Copper concentrations at the head of the river have increased greatly from 1988 to 1991. Mean copper concentrations at the Lambton water intake increased from 19.75 μg/L in 1988 to 164 μg/L in 1991 (**Table 2**). The reason for this increase is unknown and should be investigated. All 1991 samples taken at the Lambton water intake exceeded the PWQO and GLWQA Objective of 5.0 μg/L, the Michigan WQS Rule 57 guideline of 10.72 μg/L and the Canadian Guideline of 2.0 μg/L. Downstream copper concentrations either decreased or remained relatively the same between 1988 and 1991. There were no copper exceedences recorded at the Walpole Water Treatment Plant in 1991, however the mean and several monthly samples exceeded the Canadian Guideline at the Wallaceburg Water Treatment Plant.

Nickel, cadmium, chromium and cobalt concentrations measured at the three Ontario water intakes remained relatively constant between 1988 and 1991 (**Table 2**). Nickel and cobalt concentrations increased slightly, both in the downstream direction as well as between years. Mean cobalt concentrations at the Wallaceburg WTP increased from 0.166 μg/L in 1988 to 0.452 μg/L in 1991. There were no guideline exceedences for nickel, cadmium or cobalt. The highest 1991 chromium concentrations at both Lambton and Wallaceburg exceeded the Canadian Water Quality Guideline for total chromium (2.0 μg/L).

Phenolics were detected at all three Ontario water intakes during 1991 (**Table 2**). The highest phenolic concentrations were recorded at the Wallaceburg intake with a mean value of 0.467 μg/L. Low levels of benzene detected in 1991 downstream ambient water samples taken from both the Wallaceburg and Walpole water intakes (**Table 2**). The PWQO for phenols (1.0 μg/L) was exceeded and equalled in the May (1.2 μg/L) and July 1991 (1.0 μg/L) samples taken at the Wallaceburg water intake. The Michigan WQS (January 1993) Rule 57 guidelines for total phenols (1100 μg/L) and benzene (60.0 μg/L) were not exceeded nor were the EPA ambient water quality criteria for phenols (3700 μg/L) or benzene (0.66 μg/L) exceeded.

St Clair RAP Addendum Contents

Water Quality

Environment Canada 1987-1989 Head and Mouth Surveys

Water and suspended sediment samples were collected at the head (intake pipe of the Lambton Water Treatment Plant) and mouth (abandoned pumping station at Port Lambton) of the St. Clair River from March 1987 to December 1989 and analyzed for organic contaminants. The objectives of this program were to assess changes in water quality between the head and mouth of the river; to obtain qualitative loading estimates from Lake Huron and the St. Clair River; and to establish a reliable database for long-term water quality trend assessment on the St. Clair River.

40 L water samples were taken approximately every two weeks and passed through a Westfalia centrifuge in order to separate the suspended sediment from the aqueous phase. Analysis of elutriates from a sample of this size permitted analytic method detection levels up to an order of magnitude lower than standard MDLs to be achieved.

Results from the inorganic analysis are summarized in **Table 3.** In general the differences in major ion concentrations between Point Edward and Port Lambton are small. Slightly higher concentrations of sodium, chloride, TKN, total phosphorus, aluminum, iron, manganese, lead, strontium, nickel and zinc were found at the downstream station (Port Lambton) compared to the upstream station (Point Edward). However, the downstream increase in concentration was statistically significant for only sodium, chloride, ammonia, nickel and lead concentrations at the 95% confidence level (Chan 1993).

Increases in downstream concentrations of sodium and chloride were most pronounced. The mean sodium concentration at Port Lambton was 5.4 mg/L, which was 53% higher than at Point Edward (3.6 mg/L). Similarly, the mean chloride concentration increased by 30% from Point Edward (6.0 mg/L) to Port Lambton (8.6 mg/L). These increases were interpreted by Chan (1993) as indicating that the discharge of sodium salts from sources to the St. Clair River.

Concentrations of heavy metals such as aluminum, chromium, copper, iron, manganese, nickel, lead and zinc in water collected at Port Lambton were anywhere from 50% to six times higher than upstream (**Table 3**) however, only nickel and lead were found to be significantly different (Chan 1993).

Table 4 summarizes the data on organic contaminants in only the aqueous phase (solids removed) of large volume samples from Point Edward and Port Lambton. Twenty organic parameters were found to have higher concentrations at the downstream station, however, only five of these also exhibited higher frequencies of detection. The predominant organochlorine pesticides detected in the St. Clair River were α- and γ-BHCs, heptachlor epoxide, dieldrin and PCBs. Various isomers of chlorobenzene (di-, tri- tetra-, penta- and hexachlorobenzene) and polycyclic aromatic hydrocarbons (PAHs) were present in over 80% of the samples. Most of the organochlorine pesticides were in the subnanogram per litre range with the exception of α-BHC and PCBs whose mean concentrations ranged from 2.20 to 2.84 ng/L. Pyrene, phenanthrene and 2-methylnaphthalene were also in the 1 to 3 ng/L range.

Mean organic contaminant concentrations were calculated using only the samples which produced measurable results. By excluding non-detects from the calculation of means loads associated with the aqueous and solid phases may be somewhat overestimated. This potential bias is however largely compensated for in **Table 6** where only the difference between upstream and downstream loads are considered to estimate in river additions.

Chan (1993) determined that the distribution of contaminants in suspended sediments differed somewhat from those in the aqueous phase samples (**Table 5**). In the suspended sediment fraction, organochlorines, PCBs and dieldrin were much more common than α-BHC and γ-BHC (lindane). Many of the organochlorines (*i.e.* α-BHC, heptachlor epoxide and dieldrin) were found to have lower

concentrations in suspended sediments at the downstream station. Further, there were statistically significant (based on the Sign Test) increases in the downstream concentrations of different organic contaminants in the suspended fraction than in the aqueous phase.

In the aqueous phase, α-BHC, γ-BHC, heptachlor epoxide, dieldrin, 1,3,5-trichlorobenzene, pentachlorobenzene, hexachlorobenzene and hexachlorobutadiene, were all significantly higher at Port Lambton than at Point Edward. In the suspended sediment fraction, 1,2-dichlorobenzene, 1,3,5-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2,3,4-tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene, 1-methylnaphthalene, acenaphthalene, fluorene, phenanthrene, fluoranthene, pyrene, hexachlorobutadiene, and octachlorostyrene were all significantly higher at the downstream station. Octachlorostyrene and hexachlorobutadiene in suspended sediment were found almost exclusively at the Port Lambton station, an indication of active sources downstream of Point Edward (Chan 1993).

Because two full years (1988 and 1989) of water quality and suspended sediment data was collected at the Port Lambton station, Chan (1993) carried out a year to year comparison. In the aqueous phase samples, decreases in mean concentration were observed for α-BHC (3.26 to 2.01 ng/L), lindane (0.45 to 0.44 ng/L), pentachlorobenzene (0.05 to 0.03 ng/L), hexachlorobenzene (0.12 to 0.08 ng/L), hexachlorobutadiene (1.21 to 0.57 ng/L) and most PAHs. Significant increases from 1988 to 1989 were found for concentrations of heptachlor epoxide (0.11 to 0.15 ng/L), dieldrin (0.19 to 0.26 ng/L), 1,4-dichlorobenzene (1.13 to 2.44 ng/L) and 1,2,4-trichlorobenzene (0.07 to 0.11 ng/L).

The suspended sediment showed significant decreases from 1988 to 1989 in 1,3,5-trichlorobenzene (7.7 to 4.7 ng/g), pentachlorobenzene (13.3 to 5.8 ng/g), hexachlorobenzene (130.1 to 53.2 ng/g), hexachlorobutadiene (163.1 to 78.3 ng/g) and octachlorostyrene (26.9 to 15.2 ng/g). Chan (1993) suggested that if these decreases are representative, then there has been a significant reduction in industrial discharges to the river. It should be noted however, that data collected over a longer period of time are required to determine a more meaningful trend.

Contaminant Transport and Loadings

Cross sectional concentration profiles and flow distribution data were used to calculate St. Clair River loadings (Chan 1993). For compounds that are widely distributed in Lake Huron and do not exhibit significant cross stream spatial and temporal variations (*i.e.* organochlorines and PCBs), loadings were estimated as a product of annual average concentration and the annual average flow of the river. For compounds such as penta- and hexa-chlorobenzenes and hexachlorobutadiene which have been shown to have plume-like distributions along the Canadian shore, a transverse mixing model developed by Beltaos (1979) was used to calculate loading estimates. This model enabled one to construct a concentration profile and estimate the flux across the river. Loading estimates from the modelled method are about one third lower than the standard product method (Chan 1993).

Estimated water (aqueous phase) contaminant loads at Point Edward, Port Lambton and the in-river additional loading are summarized in **Table 6.** The in-river loading is also expressed as a percentage of the river loading at Port Lambton. Loadings have not been calculated separately for 1987 and 1989 because samples were only taken during a six month time period in 1987 versus a twelve month sampling period in 1989 and the author believed that this type of comparison could not be done with confidence (Chan pers. comm).

Dissolved mineral constituents (*i.e.* sodium, chloride, nitrogen and phosphorus) exhibit in-river loadings ranging from 20-37% of the total load at Port Lambton (**Table 6**). In terms of tonnage, the combined additional loading of sodium and chloride amounted to over 800 kilotonnes per year. Most organochlorine contaminants contributed in-river loadings of about 10% or less of the loading at Port Lambton with the exception of PCBs which were about 29%. For industrial contaminants, loadings of 1,3,5-trichlorobenzene, pentachlorobenzene, hexachlorobenzene and hexachlorobutadiene originated entirely or mostly downstream of Point Edward and were in the order of between 10 and 70 kg/year.

In addition to the loadings shown in **Table 6**, Lau *et.al.* (1989) showed that contaminants were also being transported by suspended sediments and bed sediment in the St. Clair River. They concluded that, in a 100 m wide strip next to the Canadian shore, contaminant transport of hexachlorobenzene and octachlorostyrene by suspended sediments was significantly larger than by water and the rest of the transect. Chan (1993) showed that octachlorostyrene was associated mostly with suspended sediment and was barely detectable in the aqueous phase. Although the data are limited, he attempted to estimated the transport of octachlorostyrene by suspended sediments by assuming an average suspended sediment concentration of 3.6 mg/L in the St. Clair River and a flow rate of 5100 m^3/sec. Based on these estimates, octachlorostyrene transport associated with suspended sediment would amount to 33.5 g/day (Chan 1993). Without adequate information on the suspended sediment distribution and composition in the St. Clair River, it is difficult to estimate total load however, the above load is conservative and represents the maximum. In light of typical results from the transverse mixing model, the load is more likely on the order of 22.3 g/day.

St Clair RAP Addendum Contents

Water Quality
Bacteria

The St. Clair River Stage 1 Remedial Action Plan (OMOE and MDNR 1991) reported on fecal coliform densities measured at both Michigan and Ontario beaches in 1990. All five Ontario beaches were closed during 1990 because the geometric mean fecal coliform densities exceeded the PWQO (100 organisms/100 mL) at all five beaches for various periods during 1990 (OMOE and MDNR 1991). Combined sewer overflows (CSOs) were identified as the dominant source of bacteria contamination.

In response to the "beach closings" impaired use, the National Water Research Institute of Environment Canada and the Ontario Ministry of the Environment conducted a joint research project in 1990 that would assess the dry and wet weather fecal bacterial contamination of the near-shore zone of the St. Clair River at Sarnia; identify the sources of this contamination; and evaluate the feasibility of remediation (Marsalek *et al.* 1992).

The study of fecal bacterial contamination in Sarnia was focused on the area between the Blue Water Bridge and the south property line of the Suncor Sunoco Group (**Figure 2**). This 9.5 km long reach fully covers the urban and industrial shoreline in Sarnia. Most of the work was done in the upper part of this reach, from the Blue Water Bridge to the Canadian National Rail Yard, because of the large number of water-based recreational activities conducted in this area.

The upper reach of the study area follows the west boundary of two municipalities, the Village of Point Edward and the City of Sarnia, which discharge urban runoff (stormwater), combined sewer overflows, and treated wastewater to the river. These discharges are important sources of fecal bacterial pollution (Marsalek *et al.* 1992). Greck (1990) identified fifty cross-connections between storm and combined sewers in the City of Sarnia which carry combined sewage during wet weather. Twenty-two overflow structures were identified, some internal (*i.e.* between combined and storm sewers) and some external discharging to the river. Three overflows, discharging 80% of the seasonal (May through October) overflow volume will be referred to by the local street names Exmouth, Cromwell and Devine. The location of municipal sewer outfalls is shown in **Figure 3.**

Microbial pollution, originating from urban stormwater discharges, include such sources as pet populations, urban wildlife (particularly birds), cross-connections between storm and sanitary sewers (human fecal pollution), lack of sanitation, deficient solid waste collection and disposal, accumulation of sediment in sewers, rodent habitation in sewers, land wash and growth of bacteria in nutrient rich standing water in storm sewers between events (Marsalek *et al.* 1992).

Densities of indicator bacteria in source discharges and the receiving waters were assessed. Fourteen sampling stations (**Figure 2**) were established. Three types of surveys were conducted: dry weather; wet weather; and an outfall plume sampling to determine if the Point Edward WPCP effluent had an impact on downstream bacterial densities. Samples were collected from August 16 to November 20, 1990. Dry weather sampling was done at all stations during periods of dry weather with a frequency of one to three samples per week. Wet weather samples were collected during periods of significant rain. Sampling runs were repeated every two hours during rain storms. Point Edward effluent plume sampling included the collection of samples at several depths along a series of transects (extending 25 m offshore), starting at the outfall and moving up to 500 m in the downstream direction. Because samples nearest the outfall showed very low bacterial densities, it was impossible to follow the plume and sampling was discontinued. Lack of access to the Sarnia WPCP outfall prevented plume measurements.

Field samples were routinely analyzed for fecal coliform (FC), fecal streptococci (FS), *E. coli* (EC), and *Pseudomonas aeruginosa* (PA) densities. On some samples coliphage tests were also performed. Results are presented as geometric means in **Table 7** and divided into four groups: receiving waters (ambient water quality); stormwater; combined sewer overflows; and wastewater

treatment plant flows.

Figure 2 Bacterial pollution study area and sample collection sites at the City of Sarnia, Ontario August 16 to November 20, 1990 (Marsalek *et al.* 1992).

Figure 3 Location of municipal sewer outfalls in the City of Sarnia, Ontario (Marsalek *et al.* 1992).

Bacterial densities barely changed between the control Station A and the next downstream Station D (**Figure 2** and **Table 7**), but increased sharply when progressing in the downstream direction from Station D to the mid-reach Station H, and then decreased from Station H to the most downstream Station J. A similar trend was exhibited by the coliphage data although changes were less pronounced. These observations indicate that discharges from municipal sewer outfalls, most of which are located upstream of Station H (CNR Ferry Dock), are the most significant sources of fecal bacteria in the study area. High bacterial densities at Station H, even in dry weather, suggest occurrences of dry-weather discharges of sewage along the waterfront. These discharges can be caused by sewer cross-connections, prolonged overflows caused by sewer infiltration (Greck 1990) and malfunctioning controls in the sewer system.

Among the bacteria counted, *Pseudomonas aeruginosa* had the highest densities at all the river stations monitored, but not necessarily in all the sources (**Table 7**). This suggested to Marsalek *et al.* (1992) that bacteria reproduction is occurring wherever nutrient rich water is stored. Such storage includes submerged sewer pipes regulated by backflow check valves and possible stagnant zones in the river, for example in Sarnia Bay. When these storage areas are emptied, unusually high bacteria densities may occur. Results from this study indicate that bacterial levels in submerged sewer pipe outfalls be investigated (Marsalek *et al.* 1992).

In dry-weather, fecal bacteria concentrations in the river are relatively low. In wet-weather, additional sources of bacteria from storm sewers and CSOs contribute to the bacterial pollution on the St. Clair River. **Table 7** shows that bacterial densities observed in the river increased 2.6 to 6.5 times for fecal coliform, 1.9 to 7.6 times for fecal streptococci, 1.5 to 4.9 times for *Pseudomonas aeruginosa*, 2.5 to 5.6 times for *E. coli*, and 1.4 to 4 times for coliphage. Bacterial densities increased up to 46 times in the immediate vicinity of wet-weather sources. Thus, rainfall events (mostly storms with precipitation over 2 mm) result in elevated bacterial densities that may persist long after the cessation of rain. This is caused by prolongation of sewer discharges from high infiltration and by relatively slow decline in fecal bacterial densities in parts of the river with slow flushing (Marsalek *et al.* 1992).

Marsalek *et al.* (1992) calculated the probability of non-exceedence of the OMOE guideline (100 FC/100 mL) and Michigan Surface WQS (200 FC/100 mL) (**Table 8**).

In dry weather, when recreational water use is highest, the estimated probabilities of non-exceedence for 100 FC/100 mL in the Sarnia area ranged from a high of 95% at the upstream control Station A to a low of 2% at the mid-reach Station H (**Table 8**). The combined (wet and dry) values indicate that during the swimming period of 92 days, the concentration of 100 FC/100 mL would not be exceeded during 71-78 days upstream of the city, about 15 days downstream of Station J, and only about 1 day at the mid-reach Station H (**Figure 2**). With the exception of Station H, these non-exceedence durations would be 10 to 14 days longer for the less stringent guideline of 200 FC/100 mL.

Sarnia Bay represents a primary location for water recreation and consequently its water quality is of importance. Under certain climatological conditions flushing of the bay near Station E (**Figure 2**) takes a long time. For certain flow and wind conditions, a counterclockwise circulation develops in the bay and transports contaminants, discharged from sewer outfalls at sites F and G, into the more remote parts of the bay. Additional polluted water is discharged from one storm sewer directly into the Bay.

Although microbial pollution at Station E is relatively minor, it is greater than at upstream Stations A

and D (**Table 7**). However, during wet weather events densities increased about seven times (**Table 7**). Of note, wet-weather densities of *Pseudomonas aeruginosa* (maximum 52000/100 mL) were even greater than those at Station H, the most contaminated site (Marsalek *et al.* 1992).

Modelling and Remedial Measures

Tsanis and Wu (1991a) used the data collected in 1990 to create models that simulated the bacteria in the river under different flow, weather and bacteriological conditions. These models would then be used to assist in planning remedial measures for water quality pollution control.

A planning-level runoff model was used to simulate fecal bacterial loads carried by urban runoff and CSOs, with modelling uncertainties adequate for the assessment of recreational water quality. This model provided input to a receiving water model which simulated river hydrodynamics in the study of bacterial transport. Wet-weather bacterial densities were simulated with acceptable, accuracies however, dry-weather conditions could only be reproduced assuming discharges of fecal pollution occurred.

Hydrodynamic simulations indicated very fast advective transport in the main river channel with a quick flushing. Pollutant discharges into the river are washed through the study area in 1.5 hours. Very different results were found in the two basins with limited water circulation, the Government Harbour and Sarnia Bay. A fast river flow sets up a counter-clockwise circulation in Sarnia Bay and transports contaminated discharges from the sewer outfalls along the east river bank into the bay. Exchange levels in dry weather may take 12 to 24 hours after the cessation of rainfall.

Remedial measures for Sarnia Bay were addressed by Tsanis and Wu (1991b) and included the removal and/or diversion of storm sewer discharges from the bay, prevention of the counter-clockwise circulation and the improvement of bay flushing by creating a clockwise circulation forced by river water pumped into the northwest corner of the bay. Although each measure produces some improvement in the simulated bacteriological quality of water in the bay, a significant improvement in the probability of compliance with the recreational water quality guidelines was achieved only by removing all sources of fecal bacteria from Sarnia Bay.

Remediation along the waterfront will require extensive structural measures including runoff controls, collection system controls and storage and/or treatment of wet weather flows. The planning of such control schemes should start by addressing the dry weather pollution whose control would significantly reduce impairment of recreational water use during the summer months. Preferred alternatives generally represent cost-effective combinations of various types of controls. The final assessment of remedial measures would require a more robust database than the one collected in this 1990 study, more detailed modelling with full model calibration / verification, and extensive public consultations (Marsalek *et al.* 1992). Much of this information is contained within the City of Sarnia Pollution Control Planning (PCP) Environmental Study Report prepared by UMA Engineering.

Additional Water Quality Parameters

As part of the CSO investigations, a total of 110 additional water quality parameters were measued including metals, conventional parameters, chlorinated organics/pesticides and base/neutral extractables (including PAHs). The results of these analyses were not summarized in Marsalek *et al.* (1992). The complete results for all parameters detected at least once are listed in Appendix 1 by station. The data are for six stations including Bluewater Bridge (Station A), Inner Harbour (Station B), Centennial Park (Station E), Point Edward STP (Station L), Sarnia STP (Station M) and offshore of Suncor (Station J). A maximum of eight samples were collected in November, 1990.

A total of 8 metals, 10 chlorinated organics, 5 conventional pollutants and 11 base/neutral extractable organics were detected on at least one occasion. Generally the concentrations in the river stations (Stations A, B, E and J) were very low and exhibited little or no downstream trends (Appendix 1). The only PWQO or CCME water quality guidelines which were exceeded at these stations were for

individual sample concentrations of copper (all four stations), mercury (Station J, only 1 occasion), ammonia (mostly Stations A and B), total phosphorus (all 4 stations) and bis-2-ethylhexylphthalate (all 4 stations). The Michigan Water Quality Standards Rule 57 (January 1993) values were exceeded for ammonia (50 μg/L) and mercury (0.0013 μg/L).

Copper exceeded the CCME Guideline (2.0 μg/L) in 10 of 32 samples (3.0 to 4.0 μg/L). The single mercury exceedence occurred on November 28. The mercury concentration was 0.03 μg/L which exceeded the EPA ambient, Michigan WQS and PWQS. Total phosphorus exceeded the GLWQA Specific Objective (5.0 μg/L) in 28 of 32 samples. Mean total phosphorus concentrations at each station were as follows: Station A, 50 μg/L; Station B, 40 μg/L; Station E, 20 μg/L; and Station J, 10 μg/L. Bis-2-ethylhexylphthalate exceeded the PWQO (0.6 μg/L) in all 8 samples ranging from 1.4 μg/L at Centennial Park (Station E) to 6.4 μg/L at Bluewater Bridge (Station A).

The highest concentrations and most frequent exceedences occurred at the Point Edward and Sarnia STP stations. Mean concentrations of copper, cadmium, zinc, iron, chromium, mercury, HCB, ammonia, total phosphorus, chloride, total phenols, and bis-2-ethylhexylphthalate exceeded the most stringent objective/guideline. However, as these samples are partially representative of the STP outfall, the ambient guidelines/objectives do not strictly apply. The mean concentrations were comparable at both stations (Appendix 1).

St Clair RAP Addendum Contents

Water Quality

Contaminants In Ambient Water and Caged Mussels from Talfourd Creek

The purpose of this study was to investigate current and historical contamination in Talfourd Creek and its potential contaminant input to the St. Clair River. Discharges from Shell Canada Ltd. were evaluated as well as possible upstream sources of chlorinated aromatics, hexachlorobenzene, octachlorostyrene, polycyclic aromatic hydrocarbons and other contaminants. Water and sediment samples (surface and core) were used to identify spatial and temporal trends. Introduced mussels (*Elliptio complanata*) were used to determine if low level organic contaminants are biologically available and bioaccumulating.

Samples were collected at fifteen stations (**Figure 4**). Three replicate water samples were collected at each station on June 12, 1989 when the mussels were deployed, and again on July 6 and 7, 1989 when the mussels were retrieved. Samples were of whole, unfiltered water from a depth of one meter below the surface or from the mid-depth when total depth was less than one metre. Fifteen caged mussels were placed on the bottom at each station with an additional three mussels at Stations 3 to 6 inclusive. Mussels were obtained from a healthy population collected from Balsam Lake where contaminant concentrations are typically below detection and hence also serve as a control.

Figure 4 Location of ambient water, sediment and caged mussel deployment site for the OMOE Talfourd Creek contaminant survey. Samples were collected and mussels deployed on July 6 and 7, 1989. Mussels were collected three weeks later (Bilyea 1992).

Ambient Water Results

Conventional Parameters

Complete results from this survey are presented in Appendix 2 Elevated levels of ammonia occurred at stations 8 to 12 inclusive (**Figure 4**). The PWQO for unionized ammonia (0.02 mg/L) was exceeded on one sampling date at Stations 8, 9 and 11 with calculated values of 0.13, 0.02 and 0.16 mg/L respectively (Bilyea 1992). Station 1 in the St. Clair River, upstream of Talfourd Creek, contained significantly ($p<0.05$) lower ammonia levels than all other stations including Station 2, located downstream of Talfourd Creek. Bilyea (1992) determined that the ammonia concentrations vary with time and that the degree of variation is different at different stations, suggesting a point source to Talfourd Creek which is periodic in nature.

The highest mean nitrate concentrations were found on the first day of sampling at upstream Stations 13 and 14 with values of 10.767 and 11.7 mg/L (Bilyea 1992). There are no PWQO for nitrate however, levels at these stations were significantly higher than all other stations. Nitrate concentrations at Stations 1 to 5 at the downstream end of Talfourd Creek ranged from 0.310 to 0.492 mg/L.

TKN concentrations in lower Talfourd Creek (Stations 3 to 5) were not significantly different from Station 2, downstream in the St. Clair River. Mean TKN concentrations ranged from 0.297 to 0.307 mg/L. These concentrations were significantly higher than those at Station 1, upstream of Talfourd Creek in the St. Clair River. Maximum TKN levels were found at Station 8 (4.883 mg/L) and Station 11 (5.397 mg/L).

The PWQO for total phosphorus (0.030 mg/L) was established to prevent excessive plant growth in rivers and streams. This objective was exceeded at all stations with the exception of Station 1, upstream on the St. Clair River where TP levels were significantly lower. Station 2, downstream on the St. Clair River, exceeded the objective on both sampling dates. The maximum mean TP concentration occurred at Station 14 (0.355 mg/L).

Bilyea (1992) concluded that ammonia, TKN and total phosphorus from Talfourd Creek may be having a localized effect on the St. Clair River immediately downstream of their confluence.

Metals

Aluminum concentrations varied both spatially and temporally with 50% of the variation being explained by spatial factors, 18% by temporal factors and 25% by the interaction of the two (Bilyea 1992). Although there is no PWQO for aluminium, concentrations of 0.1 mg/L may be deleterious to fish growth and survival (OMOE 1984). This concentration was exceeded at all stations except Station 1. Mean aluminum concentrations ranged from 0.1050 mg/L at Station 2 to 3.333 mg/L at Station 9 (Appendix 2). Because aluminium concentrations at Stations 6 to 12 were significantly higher than the others indicates that there may be a source of aluminum between Stations 6 and 13 (**Figure 4**) (Bilyea 1992). A similar pattern is seen for most of the other metals with the exception of copper and zinc.

Mean chromium concentrations ranged from 1.3 μg/L to 7.5 μg/L. The PWQO for chromium (100 μg/L) was not exceeded.

Mean copper concentrations at Stations 3 to 7 and Station 9 exceeded the PWQO (5 μg/L) on one or both days sampled. The highest mean copper concentrations were observed on the first sampling date at lower Talfourd Creek Stations 3 (21.0 μg/L) and 4 (21.0 μg/L) and downstream on the St. Clair River, Station 2 (23.0 μg/L). Mean copper concentrations at upper Talfourd Creek Stations 10 to 15, were significantly elevated relative to Station 1 but were within the PWQO with values ranging from 2.5 to 4.9 μg/L.

Mean iron concentrations at Stations 6 to 12 inclusive exceeded the PWQO (300 μg/L). Values at these stations ranged from 577 to 2,433 μg/L. All other stations had iron concentrations below the PWQO.

Nickel, mercury, lead, arsenic, cadmium, selenium, cobalt and manganese concentrations from all water samples were either below or near their respective detection limits and did not exceed PWQO guidelines.

Zinc concentrations from all Talfourd Creek stations and Station 2 downstream on the St. Clair River were elevated with respect to the St. Clair River upstream Station 1. The PWQO (30 μg/L) was not exceeded.

Organic Contaminants

Detected organic contaminants in ambient water included ethylbenzene, toluene, benzene, chloroform, xylene, chlorodibromomethane, trihalomethanes and tetrachloroethylene. Canadian Water Quality Guidelines (CCREM 1987) exist for benzene, ethylbenzene and tetrachloroethylene. The maximum concentration of each of these three contaminants was two to three orders of magnitude below the applicable Canadian guideline. Tetrachloroethylene was found at only trace levels. These contaminants were detected on the first sampling day in the lower portion of Talfourd Creek downstream of Station 6 and at Station 2 in the St. Clair River. Except for benzene and toluene, these contaminants were not detected at the St. Clair River upstream Station 1.

The data suggest that the source of the organic contaminants is located downstream of Station 6 on Talfourd Creek (**Figure 4**). This source would therefore be in the same vicinity as the Shell cooling water/treated effluent discharges. Shell's once through cooling water and stormwater effluent, monitored in 1989 under the MISA program indicated that average levels of benzene, ethylbenzene, toluene and xylenes were similar to those documented in Talfourd Creek downstream of the discharge locations (Bilyea 1992).

The data also indicated that the source of these organic contaminants is periodic in nature. Bilyea (1992) concluded that Talfourd Creek my be having a localized effect on the water quality of the St. Clair River with respect to the above mentioned organic contaminants.

Caged Mussel Results

Mussels filter large quantities of water to obtain their food and can therefore bioaccumulate contaminants at concentrations exceeding that of surrounding water and sediments. They have the ability to rapidly accumulate organic compounds and metals through feeding and direct absorption (Pugsley *et al.* 1985). Whole body mussel tissue was analyzed for this survey.

The percentage of lipids in the mussel tissue was measured at all stations including the Balsam Lake control group. Lipid proportions at all stations were not significantly different from those at Balsam Lake, however, significant differences between stations in the study area (**Figure 4**) were present (Bilyea 1992). In general, mussels from lower Talfourd Creek, Stations 3 to 7 tended to have higher lipid concentrations than those at upstream stations. This likely reflects the fact that the lower portion of the creek provided a more favourable environment for the mussels (Bilyea 1992).

Metals

There were no significant differences between stations or the control group with respect to arsenic. Mean arsenic concentrations ranged from 0.50 to 0.71 μg/g at all stations except number 13 which had a mean value of 2.00 μg/g. This mean was influence by a single value of 4.70 μg/g while the other replicates were within the range of the other stations.

Cadmium concentrations ranged from 0.567 to 1.433 μg/g while the mean concentration of the control group was 0.608 μg/g. Only Stations 13 and 15 had cadmium concentrations significantly higher than the control group.

The spatial distribution of copper in mussel tissue from Talfourd Creek reflected the same pattern seen in the water samples. Green (1988) found that metal burdens in mussel soft tissue are roughly indicative of metal concentrations in ambient water. Upper Talfourd Creek Stations 7 through 15 were not significantly different from Station 1, upstream in the St. Clair River or the Balsam Lake control group. Mean copper concentrations from these stations ranged from 1.05 to 1.60 μg/g. Mussels from Stations 3 to 5 and downstream in the St. Clair River (Station 2) had significantly higher mean copper concentration than all other stations in the study. This spatial pattern indicates that the source of copper is in the vicinity of Station 6 (**Figure 4**) and not from the incursion of St. Clair River water. Copper concentrations in Talfourd Creek are elevating those in the St. Clair River immediately downstream (Bilyea 1992).

Mean manganese tissue concentrations ranged from 139.33 μg/g at Station 13 to 1031.76 μg/g at Station 1 however, none of the stations were significantly different from the Balsam Lake control group.

Mean nickel concentrations in mussel tissue ranged from 0.393 μg/g at Station 3 to 0.803 μg/g at Station 15. Station 15 was the only station that was significantly higher in nickel than the Balsam Lake control station or Stations 3, 4, 5 and 7. There were no differences between the other stations and no spatial differences in the study area.

Mussel tissue concentrations of lead and selenium did not differ significantly between stations or the Balsam Lake Control station.

Zinc concentrations in mussel tissue from Stations 1 to 12 did not differ significantly from each other or the control station with values ranging from 26.40 to 445.50 μg/g. Stations 13, 14 and 15 (**Figure 4**) were all significantly higher in zinc tissue content with mean values ranging from 51.67 to 61.00

µg/g.

Organic Contaminants

The concentration of certain organic contaminants measured in mussel tissue can be effected by the percentage of lipids in tissue. This is due to the high affinity that some organic contaminants have for lipids. The percentage of lipids did vary significantly between stations, however, this variation did not significantly effect the concentration of the organic contaminants detected in this study with the exception of hexachlorobutadiene.

Octachlorostyrene was detected in mussel tissue from both St. Clair River stations, the stations in lower Talfourd Creek and Station 9. Mean concentrations ranged from below the detection limit to a maximum of 7 ng/g observed at Station 1. One of the three samples from Station 1 had a concentration of 12 ng/g and the others were below detection.

Hexachlorobutadiene was detected only at Stations 1,2,4 and 5 with mean concentrations ranging from below detection (1 ng/g) to 5.667 ng/g at Station 1. One sample at Station 1 contained 13 ng/g hexachlorobutadiene. A covariance analysis demonstrated that levels of hexachlorobutadiene were related to the percentage of mussel lipids. Because of this relationship, a distribution pattern of hexachlorobutadiene in mussel tissue from Talfourd Creek could not be determined.

Hexachlorobenzene was detected at trace levels at Stations 1 to 7 and Station 9. The maximum concentration of a single sample was 7 ng/g, observed at Station 1 in the St. Clair River.

1,2,3,4-tetrachlorobenzene was detected at trace levels at Stations 1 to 6 inclusive. The maximum concentration of 4 ng/g was observed in a single sample from Station 1.

All organic contaminants detected in mussel tissue from the St. Clair River and Talfourd Creek were not detected in the Balsam Lake control group. This clearly indicates that these organic contaminants were accumulated during their three week exposure period (Bilyea 1992). The distribution pattern of these organic contaminants suggested to Bilyea (1992) that the source is located in the St. Clair River upstream of Talfourd Creek.

St Clair RAP Addendum Contents

Water Quality

Lambton Industrial Society Continuous Water Quality Monitoring

The Lambton Industrial Society (LIS) initiated a continuous water quality monitoring program in 1986 in order to determine concentrations of selected volatile organic chemicals (**Table 9**) in the St. Clair River. The continuous monitor is located on the bank of the St. Clair River at the Courtright pumphouse station. The intake is located approximately 30 m offshore at a depth of 3 m. Ambient water quality is monitored hourly on a 24 hour/day basis throughout the year. Performance statistics for 1990 and 1991 were 96% and 98% respectively.

An historical summary of "events" reported by the LIS continuous monitoring program are presented in **Table 10.** An "event" is reported when the concentration of any monitored parameter meets or exceeds 1 µg/L (ppb). "Events" were dramatically reduced from 1989 to 1990 and continued to decrease in 1991 (**Table 10**).

When requested grab samples are taken downstream of the pumphouse for confirmatory purposes at the ORTECH Laboratory. During 1990 there were two occasions when guidelines were exceeded (**Table 10**). Ethylbenzene exceeded the Health and Welfare aesthetic criterion of 2.4 µg/L (ppb) (Thomas *et al.* 1992). Ethylbenzene was again in exceedence on May 7, 1991 (**Table 10**).

In 1991, new lower method detection limits were achieved which allowed an examination of low level trends of target compounds. Detectable concentrations of toluene were observed in June through to the end of the year, with the greatest frequency occurring in June, July, August and September (Kuley *et al.* 1992). Perchloroethylene was detected on two occasions in November and five times in December. Ethylbenzene and m + p-Xylenes were also detected in December (Kuley *et al.* 1992).

In addition to the continuous water quality monitoring program, water grab samples are collected once every two weeks at the downstream pumphouse location and once a month from a control station at the head of the St. Clair River during 1990. In 1991, grab samples were taken at both upstream and downstream locations during May and September. These grab samples are tested for the following seven target compounds and their MDL's are as follows: phenol (0.3 µg/L), di-n-butyl phthalate (10.4 µg/L), naphthalene (0.7 µg/L), phenanthrene (0.2 µg/L), pyrene (0.2 µg/L), hexachlorobenzene (1.5 µg/L), and octachlorostyrene (0.7 µg/L). All seven target compounds were not detected in grab samples from both upstream and downstream locations during 1991 and 1992 (Thomas *et al.* 1992 and Kuley *et al.* 1992).

St Clair RAP Addendum Contents

Sediment Quality

Several follow-up studies on sediment quality in the St. Clair River have been conducted since the OMOE 1985 sediment survey and the 1986 MISA Pilot Site Investigation which were documented in the Stage 1 Remedial Action Plan.

The new surveys are summarized and results compared with the OMOE 1985 and MISA 1986 data. These surveys include:

- OMOE 1990 St. Clair River sediment survey (OMOEE 1993). This also included water quality and biota surveys using sampling locations comparable to earlier whole river sampling programs.
- The OMOE sediment quality survey in 1990 also included laboratory sediment bioassays to test their toxicity to *Hexagenia limbata, Chironomus tentans* and *Pimephales promelas*;
- A complete contaminant survey conducted for Talfourd Creek by OMOE. Ambient water, sediment and caged mussels were investigated in order to determine the impact of contaminant input from Talfourd Creek. Sediment quality results are presented in this section. Ambient water and caged mussel results are provided in ***Section 3.5***;
- 1985 U.S. Fish & Wildlife Service connecting channels sediment survey; and
- U.S. Army Corps of Engineers 1991 channel sediment survey.

For more information, select one of the following topics:

Contaminants in Sediment
Sediment Toxicity
Tributary Sediment
1992 St. Clair Delta Contaminants Study

St Clair RAP Addendum Contents

Sediment Quality

Contaminants in Sediment

- *1985 Connecting Channels Sediment Survey*
- *Ontario Ministry of Environment 1990 Sediment Quality Survey*
- *Other Sediment Surveys*
- *U.S. Army Corps of Engineers 1991 Channel Sediment Survey*

St Clair RAP Addendum Contents

Sediment Quality

Contaminants in Sediment

1985 Connecting Channels Sediment Survey

In 1985 the National Fisheries Research Center-Great Lakes and the U.S. Fish and Wildlife Service conducted a sediment survey sampling 250 stations throughout the St. Marys, St. Clair and Detroit Rivers and Lake St. Clair. Stations were established within a grid covering the river with each grid cell being 2.2 x 2.2 km with only one sampling station. The top 3 cm of sediment was analyzed for mercury, cadmium, chromium, copper, lead nickel and zinc.

Survey results from the St. Clair River are shown in **Table 11.** Copper, nickel, lead and zinc are in exceedence of the OMOE guidelines for the open water disposal of dredged material (now replaced by the Provincial Aquatic Sediment Quality Guidelines) and the moderately polluted USEPA guidelines for the disposal of Great Lakes harbour sediments. Mercury and cadmium exceeded the OMOE guidelines. Sediments were moderately or heavily polluted by at least one metal at 46 percent of the stations. Most of the contaminated stations were clustered near towns along the middle and upper reaches of the river (Nichols *et al.* 1991).

Results from this survey are similar to those from the 1985 OMOE and 1986 MISA sediment surveys reported in the St. Clair River Stage 1 RAP (OMOE and MDNR 1991). The more detailed, 1986 MISA survey also showed levels of chromium were in exceedence of the OMOE dredged material disposal guidelines in sediment collected within 100 m of the Dow Chemical waterfront and downstream of the 1st Street Sewer Complex (OMOE and MDNR 1991).

St Clair RAP Addendum Contents

Sediment Quality

Contaminants in Sediment

Ontario Ministry of Environment 1990 Sediment Quality Survey

During late April-early May of 1990, the OMOE conducted a sediment quality survey of the St. Clair River, sampling a total of 64 stations distributed in the nearshore along both sides of the river and in the main channels of the delta (**Figure 1**). Station locations were identical to earlier river surveys conducted in 1985 and 1977, although some Michigan stations were deleted in favour of additional stations in the upper portion of the river, along the Chemical Valley shoreline, and in the lower portion in the delta. Three of these additions were to evaluate the sediment quality from the South Channel dredging area and in and near the disposal area in upper Lake St. Clair. At each station, the surficial 3 cm (*i.e.*, most recent) sediment layer was collected and analyzed for particle size distribution, nutrients, arsenic and metals, PCBs and organochlorine pesticides, chlorinated aliphatics and aromatics (CAAs), polycyclic aromatic hydrocarbons (PAHs), and solvent extractables.

Benthic macro-invertebrates were also collected at all stations (see section 5.2.2). Furthermore, at 13 of the stations, additional replicate sediment samples were collected to perform laboratory bioassays (section 4.2) and bottom water samples were collected and analyzed for basic chemical and physical parameters (section 3.1).

Finally, caged mussels biomonitors were exposed for a period of three weeks at 10 of these stations (section 5.2.1).

The sediment analytical results for each station are tabulated in Appendix 4; these have been compared to the new Ontario (provincial) aquatic sediment quality guidelines, or PASQGs, (Persaud *et al*. 1992) which include no effect (NEL), lowest effect (LEL) and severe effect level (SEL) categories. For those parameters that do not yet have PASQGs, the sediment concentrations were compared to the previous provincial open water dredged material disposal (OWDD) guidelines. The concentration ranges for sediments from the 49 stations in Ontario waters and from the 15 Michigan stations, as well as the percentage (or frequency) of guideline exceedences are summarized in **Table 12.** (This summary does not include the three dredging-related stations in the South Channel - Lake St. Clair area.) Results for individual replicates at the sediment bioassay stations are provided in Tables 13 and 14 of Appendix 4..

Most of the sediment quality guideline exceedences were due to concentrations being above the LEL; few contaminants also exceeded the SEL. For the entire river, the percentage of LEL guideline exceedences decreased in the order: Kjeldahl nitrogen (78%) > mercury (61%) > copper and hexachlorobenzene (HCB) (39%) > nickel and organic carbon (38%) > phenanthrene and pyrene (20%) > lead, total PAHs, anthracene and fluorene (14%) > chrysene (13%) > arsenic, benzo(g,h,i)perylene, dibenzo(a,h)anthracene and fluoranthene (9%) > benzo(a)anthracene (8%) > cadmium and total PCBs (6%) > benzo(k)fluoranthene, benzo(a)pyrene and indeno(1,2,3-cd)pyrene (5%) > zinc (2%).

When considering Ontario and Michigan stations separately, the percentage exceedences of the LEL guidelines for Kjeldahl nitrogen, cadmium, benzo(a)anthracene, benzo(k)fluoranthene and benzo(a)pyrene were similar and, with the exception of nitrogen, below 10% (**Table 12**). However, a higher percentage of Michigan stations exceeded the LEL guidelines for organic carbon (53%), arsenic (27%), copper (53%) and nickel (53%). These exceedences occurred in sediments in the vicinity of Port Huron, the Pine River discharge at St. Clair, and at Algonac. In comparison, the percentages of stations exceeding the LEL guidelines for mercury (78%), HCB (51%), phenanthrene and pyrene (22%), anthracene (18%), total PAHs and lead (16%), and total PCBs (8%) was notably higher along the Ontario shoreline. This is also true of the maximum concentrations of these contaminants as well as those of cadmium, copper, zinc, the remaining 13 PAH compounds and the

9 other CAAs detected (**Table 12**). In fact, 20% of Ontario stations had sediment mercury concentrations exceeding the SEL guideline, and 76% and 16% of these stations also contained HCB levels above the NEL and the TOC-normalized SEL guidelines, respectively.

The highest sediment concentrations of mercury were found along the Chemical Valley nearshore from the lower end of the Novacor Chemicals property to Corunna, although levels at many Ontario stations in the lower half of the river were still sufficient to exceed the LEL guideline. Copper concentrations were highest and LEL guideline exceedences were most prevalent in sediments from just below the Cole Drain to as far downstream as Courtright. In contrast, the highest lead concentrations and sediment guideline exceedences were mainly associated with the Ethyl Corp. discharge; the peak cadmium concentration occurred downstream of the Dow Chemical 3rd Street sewer; copper was highest downstream of Suncor above the Shell dock, and the maximum zinc concentration was found in sediment along the Imperial Oil waterfront. Elevated concentrations of individual PAH compounds were found along the Ontario nearshore, extending from just downstream of the Cole Drain to Corunna. In Michigan sediments, the highest concentrations of PAHs were detected at Port Huron and in the vicinity of Marine City. In contrast to the other contaminants, the detection of polychlorinated biphenyls and CAAs was almost totally restricted to Ontario stations associated with the Chemical Valley. The highest concentrations of total PCBs, hexachloroethane, hexachlorobutadiene, 1,2,4- and 1,3,5-trichlorobenzene, 2,4,5-trichlorotoluene, 1,2,3,5- and 1,2,4,5-tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene and octachlorostyrene were found in sediments downstream of the Cole Drain in the vicinity of Novacor Chemicals, and along the Dow Chemical waterfront.

Duplicate surficial sediment samples from 20 stations sampled in 1990 were also analyzed for polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) congener groups and toxic (2,3,7,8-substituted) isomers (**Table 13**). Eighteen stations are located near the Ontario shore from Sarnia to Port Lambton and two are located in Michigan waters downstream of the Black River and in the lower river near Algonac (**Table 13** and **Figure 1**).

PCDD + PCDF congener group concentrations in **Table 13** were lowest at the upstream control or background station 6A near Sarnia Bay (89.2 pg/g), followed by stations 20 (112.4 pg/g) and 18 (128.7 pg/g), downstream of an Esso sewer and upstream of the Esso intake, respectively. Concentrations were markedly higher than background at station 13 (560.1 pg/g) near the CN ferry dock, and across the river in Michigan, at station 11 below the Black River (332.0 pg/g). Higher concentrations were detected at stations IS 9 (1,015 pg/g) and IS 12 (788.9 pg/g), downstream of the Cole Drain discharge and the Polysar dock, respectively. Maximum PCDD and PCDF congener group concentrations were recorded at station IS 14, immediately downstream of Dow's 1st Street sewer discharge (congener group total = 14,630 pg/g). Values gradually decreased downstream of this location. Nevertheless, concentrations in sediments at station 68 at Baby Point (166.9 pg/g) and south of Port Lambton, and across the river at station 69 near Algonac (334.0 pg/g) were still above the level at the upstream control station. Both of these stations are located just upstream of the St. Clair Flats, or delta.

Octachloro (8 chlorine-containing) congeners were the most abundant PCDDs or PCDFs in sediments, followed by compounds containing 7 chlorines, 6 chlorines, and then by 5 or 4 chlorines. Exceptions to this trend were, observed for PCDFs in sediments near the head of the river (stations 6A, 11, 13) and in the lower river (stations 62, 68, 69) where concentrations of congeners with 7- and 8 chlorines were similar.

Up to fifteen of the seventeen possible toxic (*i.e.* 2,3,7,8-substituted) isomers were detected in sediment from one or more of the 20 stations analyzed. Sediment from station IS 14 downstream of Dow's 1st St. sewer complex contained the highest concentrations of 2,3,7,8-substituted dioxin and furan isomers (**Table 13**). The most toxic of these isomers, 2,3,7,8-TetraCDD, was not detected in any sediment sample. The isomer 1,2,3,7,8-PentaCDD, with half the toxicity of 2,3,7,8-TetraCDD ("I-TEF" in **Table 13**), was found at four of the stations along the Chemical Valley (IS 9, 24, 32, 34), with concentrations ranging from 1.2 pg/g to 2.3 pg/g. The isomer 2,3,4,7,8-PentaCDF, also with half

the toxicity of 2,3,7,8-TetraCDD, was found at seven of the stations (IS 9, IS 15, 24, 30, 32, 34, 36) at concentrations of 2.4 pg/g to 7.3 pg/g. In contrast, the isomer 2,3,7,8-TetraCDF, with one tenth the toxicity of 2,3,7,8-TetraCDD, was detected at 19 of the stations, at concentrations ranging from 1.2 pg/g to 110 pg/g. The most abundant isomers in terms of concentration as well as their frequency of detection, are the least toxic.

Toxicity Equivalent (TEQ) concentrations were determined for each isomer using the International Toxicity Equivalency Factors (I-TEQ) to convert to the equivalent concentration of 2,3,7,8-TetraCDD and then summed to provide a "Total 2,3,7,8-TetraCDD TEQ" (**Table 13**). In these calculations, a value of "zero" was substituted for "nd", which has possibly resulted in some minimum TEQs (*e.g.* station IS 14).

Although comparison of these aquatic sediment TEQs to terrestrial soil guidelines is perhaps problematic, this does provide some measure of relative impairment. At all but three stations, the Total 2,3,7,8-TetraCDD TEQ was below the Recommended Maximum Total TEQ Guideline of 10 pg/g for agricultural soils (**Table 13**). Total TEQs at stations 32 (11 pg/g) and 34 (12 pg/g) were slightly above this guideline. These stations are situated just downstream of the Ethyl Corp. discharge and upstream of the DuPont discharge, respectively. The highest Total TEQ (77 pg/g) was detected in sediment from station IS 14 below the Dow 1st. St. sewer, but this was still below the Recommended Maximum Total TEQ Guideline of 100 pg/g for sludge disposal.

Although published Provincial Aquatic Sediment Quality Guidelines for individual toxic isomers or for Total 2,3,7,8-TetraCDD TEQ are not yet available, Tentative Guidelines have been calculated for 14 of the 17 isomers. Comparison with these showed that none of the concentrations of 2,3,4,7,8-substituted isomers was above their respective Tentative Aquatic Sediment Quality 'No Effect Level' Guidelines (R. Jaagumagi, Standards Development Branch, pers. comm.).

The relative magnitude and importance, of these St. Clair River data can be put into perspective by comparison with PCDD/F concentrations in sediments from other Great Lakes Areas of Concern with petrochemical industries, such as the Detroit River and the Niagara River (**Table 14**).

The range of the congener group and 2,3,7,8-substituted isomer concentrations in 1990 St. Clair River sediment samples were similar to values detected in 1991 Detroit River sediment (**Table 14**). However, the St. Clair River maxima for Penta-, Hexa-, Hepta- and OctaCDD, and for Penta CDF congeners and isomers were usually lower than the corresponding maxima in the Detroit River. In contrast, the maximum TetraCDD and Hexa-, Hepta- and OctaCDF congener and isomer concentrations in the St. Clair River were usually higher than in the Detroit River. It is noteworthy, however, that the St. Clair River (and Detroit River) maxima for congener groups and isomers were well below the highest concentrations found in sediments near hazardous waste sites in the Niagara River in 1993. The maximum Total 2,3,7,8-TetraCDD TEQ for the St. Clair River (77 pg/g) was well below corresponding values for the Detroit River (210 pg/g) and Niagara River (140,000 pg/g) (**Table 14**).

Trends in Sediment Quality

Prior to the 1990 study, Ministry surveys of St. Clair River surficial sediment quality were conducted in 1985, 1977, 1975 and 1969. The total number of locations or stations sampled has varied somewhat over the years and with the objectives of each survey. Nevertheless, a 'core' group of stations along the Ontario shoreline, from the head of the river to Corunna, has been re-sampled during each of these surveys to provide information on sediment contamination trends. (This number ranges from 5 to 23, depending on the contaminant in question.) These trends reflect both the historical impacts of various Chemical Valley pollution sources and the effectiveness of remedial or control measures implemented.

Sediment samples were analyzed for numerous contaminants in the three most recent surveys. The accompanying **Table 15** contains 1977, 1985 and 1990 data on mean (average) sediment

concentrations of cadmium, chromium, copper, iron, lead, mercury, zinc and total polychlorinated biphenyls (PCBs), as well as the percentage of stations with levels exceeding the new Ontario provincial aquatic sediment quality guidelines (PASQGs). Of these, only copper, iron, lead, mercury and zinc were also analyzed for in 1969 sediment samples. Solvent extractables data was available for 1975, 1985 and 1990, but not 1977. Manganese was analyzed for in 1969, 1977 and 1985 only. The hexachlorobenzene and octachlorostyrene data bases are restricted to the two latest surveys, since routine analytical capability for these compounds is relatively recent.

For some contaminants and in certain years there were substantial station-to-station differences in concentrations, and this resulted in high standard deviations about the means. This makes inferences about the significance of changes between years difficult. Nevertheless, there was a major decrease of about 25-fold in mean sediment mercury concentration between 1968 and 1977, most likely due to reductions in losses from Dow Chemical in the early 1970s. A further decrease was not evident again until 1990, when the mean mercury concentration was about three times lower than in 1977 and 1985; however the 1990 mean and levels at three of the five stations were still above the PASQG Severe Effect Level (SEL) of 2.0 ug/g. There has been no reduction in the percentage of stations exceeding the PASQG Lowest Effect Level (LEL) of 0.2 ug/g; levels at all five stations were still above this guideline in 1990.

Cadmium concentrations and sediment guideline exceedences have decreased steadily during the last three surveys, resulting in a 1990 mean concentration over 50 times lower than in 1977. However, this difference is perhaps exaggerated, since the 1977 mean is biased high due to the much higher detection limit for sediment samples at that time. Both the 1985 and 1990 means were below the LEL guideline of 0.6 ug/g, and only one station of 16 had a sediment concentration above this guideline.

The major decrease in mean chromium concentration (about 13-fold) and in sediment guideline exceedences occurred between the 1977 and 1985 surveys. This resulted in mean levels in 1985 and 1990 that were below the LEL guideline of 26 ug/g. In 1990, none of the 20 stations had concentrations above the SEL (110 ug/g) or LEL.

A 40% decrease in mean iron concentration occurred between 1969 and 1977. Since then, mean concentrations have remained relatively constant. Means in all years were below the PASQG LEL of 20,000 ug/g, and no individual stations have exceeded this guideline since 1969.

With the exception of the 1977 survey, mean lead concentrations have remained essentially unchanged since 1969, and are still above the LEL guideline of 31 ug/g. To a large degree, this reflects the high lead concentrations downstream of Ethyl Corp. in Corunna. The higher 1977 mean was in part related to higher concentrations at stations downstream of the Dow 3rd Street sewer. Overall, the percentage of guideline excedences has decreased over the years, with the reduction in LEL guideline exceedences being the most marked between 1969 (≈69%) and 1990 (≈19%). Only one station of 16 had a lead concentration above the SEL guideline of 250 ug/g in 1990.

Mean manganese concentration rose slightly in the 1985 survey, but was still well below the LEL guideline of 460 ug/g. No individual stations had sediment concentrations above the SEL or LEL guideline.

Mean sediment zinc concentration remained unchanged until the 1990 survey, when the mean value decreased by about 40% from those of the three previous surveys. A similar decrease in guideline exceedences also occurred, with the result that in 1990, sediment at only one of 16 stations contained zinc above the LEL of 120 ug/g.

The mean concentration of solvent extractables (which includes oils and greases), as well as the percentage of stations exceeding the open water dredged material disposal guideline (OWDDG), has decreased steadily since 1975. The 1990 mean was nearly four times lower than in 1975 and also below the OWDDG of 1,500 ug/g. In 1975, nearly 62% of the 13 stations had solvent extractables

concentrations above the guideline; by 1990, this percentage had decreased by ten-fold.

Mean total PCBs concentrations have dropped steadily over the last three surveys so that in 1990, the mean concentration was only about 10% of the 1977 value and just slightly above the LEL guideline of 70 ng/g. The percentage of the 20 stations with concentrations above this guideline has dropped from 65% to 15% during the same period. This improvement is probably due to stoppage of the use of PCBs as dielectric fluids, plasticizers, heat transfer fluids and a number of other open-ended uses.

The mean concentration of octachlorostyrene in sediments decreased about 25% between 1985 and 1990. However, the hexachlorobenzene mean concentration increased nearly three-fold over the same period, and the mean was still above the LEL guideline of 20 ng/g in 1990, as were 65% of the 23 stations. Nearly 35% of these stations also had HCB concentrations exceeding the SEL guideline of 24,000 ng/g (normalized to station TOC concentration). These changes are primarily related to the increased concentrations at stations between the Cole Drain discharge and the Dow 1st Street sewer during the 1990 survey.

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Sediment Quality

Contaminants in Sediment

Other Sediment Surveys

Extracts of sediment samples collected by Canada's National Water Research Institute along the Sarnia nearshore in 1985 and by the University of Windsor in 1984 were re-analyzed by alternative instrumentation under a contract to Eli ECO laboratories by the OMOE. Results showed that dual column capillary chromatography with ECD tends to overestimate PCB concentrations in St. Clair River sediments by a factor of about 3 to 5. This was most likely due to interferences from other previously-unidentified chlorinated compounds in the sediments, such as polychlorinated diphenyl ethers (PCDPEs), polychlorinated naphthalenes (PCNs) and polychlorinated styrenes (PCSs). For example, the range of (approximate) concentrations of PCDPEs and PCNs along the Novacor to Suncor shoreline was from not detected to ≈1,900 ng/g and ≈700 ng/g, respectively (Oliver & Nicol 1988). In comparison, PCDPE levels in Whitby Harbour sediments, ranged from ≈50 ng/g to ≈4,900 ng/g (Coburn & Comba 1981). Studies by Canada's Department of Fisheries and Oceans showed that these compounds can bioaccumulate within the aquatic food chain. Furthermore, there is evidence that PCDPEs can be converted to polychlorinated dibenzofurans (PCDFs) through pyrolytic (550^0 to 650^0C) and photo (i.e., light-mediated)-chlorination reactions.

Although PCS concentrations were not available, it was felt that the greatest interference to PCB quantification came from the numerous isomers of hexachlorostyrene and heptachlorostyrene also present in the sediments (Oliver & Nicol, 1988).

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Sediment Quality

Contaminants in Sediment

U.S. Army Corps of Engineers 1991 Channel Sediment Survey

The U.S. Army Corps of Engineers (USCOE) routinely sample sediment from the shipping channel in the St. Clair River in order to evaluate the level of contaminants in the sediment. This information is used to determine the type of disposal required if dredging were to occur.

Samples taken on September 18 and 19, 1991 are summarized in **Table 16** and sample locations are shown in **Figure 5.** Sediment in the navigation channel at Mooretown (SC9105) contained levels of iron (26,600 µg/g) that exceeded both the OMOE Dredged Material Disposal in Open Water (10,000 µg/g) and the U.S. EPA heavily polluted Guideline for the Disposal of Great Lakes Harbour Sediments (>25,000 µg/g). Nickel (33 µg/g), in the same sample exceeded both the PASQG (25 µg/g) and U.S. EPA moderately polluted (20-50 µg/g) Dredged Material Guidelines.

Sample SC9107, taken from the navigational channel near Marine City, contained 46,000 µg/g COD which exceeded the U.S. EPA moderately polluted disposal guideline of 40,000-80,000 µg/g.

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Sediment Quality
Sediment Toxicity

Sediment toxicity testing is a means to determine the potential lethal effects of contaminated sediment to native organisms. Bottom sediments were collected in May and August of 1990 by OMOE as part of the sediment and benthic survey of the St. Clair River (Bedard and Petro 1992). Ten locations were sampled during May in the upper St. Clair River (Stations 72 to 74, 76, 80, 94 to 97, 143) and at three sites at the outlet of the river and in Lake St. Clair (Stations 252, 207, 208) (**Figure 6**). Additional samples at Stations 72-2, 72-3, 74-1, 94-1, 94-2 and 95-2 were collected in August. At each river station, 3 samples were taken along a transect that extended up to 56 m from the Canadian shore, depending on sediment availability. Sediment collected from Honey Harbour, Georgian Bay was used as a negative control for each bioassay.

In addition to performing the bioassays, sediment subsamples were taken at the time of collection and analyzed for nutrients, trace metals, total PCBs, pesticides and PAHs and particle size characterization.

Bioassays were conducted with burrowing mayflie larvae (*Hexagenia limbata*), juvenile fathead minnows (*Pimephales promelas*) and midge larvae (*Chironomus tentans*). In addition, an elutriate test was performed using fathead minnows. Following the bioassays, whole body tissue samples of surviving fathead minnows were analyzed, on a dry weight basis, for PCBs, pesticides, chlorinated hydrocarbons, PAHs, lipid content, percent ash and percent moisture.

Sediment Characterization

The majority of test sediments were comprised of high amounts of sand (>80%) and low in organic content (<0.2 to 10 mg/g TOC). Pockets of finer-grained, organically enriched sediments were found throughout the upper river study locations (Bedard and Petro 1992).

Substrate type was indicative of high flow conditions with a tendency for softer sediments to be located in shallow, depositional areas. Shoreline modifications contributed to the high sand content. Total phosphorus remained below 0.6 mg/g and was the highest in the negative control sample from Honey Harbour (0.9 mg/g). TKN increased with increasing amounts of percent fines and TOC.

Figure 5 Sample locations for bottom sediment samples collected by the USCOE, September 1991 (USCOE data files).

Figure 6 Sample locations for the OMOE sediment toxicity survey. Samples were collected in May and August, 1990 (Bedard and Petro 1992).

Trace Metal Concentrations

Sediment samples were analyzed for 11 trace metals and concentrations compared to the Provincial Aquatic Sediment Quality Guidelines (PASQG) (Persaud *et al.* 1992). The lowest bulk metal concentrations were found in the lower river and Lake St. Clair at Stations 207, 208 and 252, particularly for arsenic, cadmium, chromium, copper, iron, lead and zinc (**Table 17**).

Copper concentrations were slightly above the PASQG Lowest Effect Level of 16 µg/g at all the upper river stations with the exception of Station 143 (located below Shell intake but above Shell outfall) (**Table 17**). Lead levels in sediment downstream of Novacor, Corunna was 130 µg/g and in exceedence of the PASQG Lowest Effect Level of 31 µg/g (**Table 17**). Lead concentrations in the remaining sediment samples ranged from 2 to 43 µg/g. Nickel concentrations slightly exceeded the PASQG Lowest Effect Level (16 µg/g) at seven of the 13 sample sites (**Table 17**) located within an

area bounded by the upstream site and Dow 1st St. station (**Table 17** and **Figure 6**).

Sediment concentrations of mercury exceeded the PASQG Severe Effect Level of 2.0 μg/g at several of sample locations (**Table 17**). Concentrations were up to 25 times higher than values measured in the Lake St. Clair sediment, Station 208 (average of 0.48 μg/g). In general, mercury concentrations were highest at Dow and at various points downstream of the Dow sites to the Novacor Chemicals, Corunna site and averaged 9.0 μg/g (**Table 17**). Values also decreased further away from the shore suggesting nearshore sources in the vicinity of the Dow 1st and 2nd St. Sewer outfalls. When compared to the OMOE 1985 sediment survey (OMOE and MDNR 1991), mean mercury concentrations in sediment from Dow to Novacor, Corunna have not changed over the four year period.

Mercury concentration in bulk sediment also exceeded the PASQG Lowest Effect Level (0.2 μg/g) for many of the other upper river collection sites except for the upstream Station 72 and at the Cole Drain (**Table 17**). Sediments collected from the South Channel and Lake St. Clair had mercury concentrations that were comparable to the control sediment (from Honey Harbour on Georgian Bay).

Organic Chemical Concentrations

Sediment was analyzed for several chlorinated hydrocarbons including octachlorostyrene, total polychlorinated biphenyls, hexachlorobutadiene, hexachlorobenzene, pentachlorobenzene, hexachloroethane, 2,4,5-trichlorotoluene and total tri- and tetrachlorobenzenes (**Table 18**).

Hexachlorobenzene was found in sediment throughout the study area and was present at one lake location (**Table 18**). Maximum levels were recorded at the nearshore collection site below Polysar (Station 74-1) with a level of 20,400 ng/g. The Dow 1st St. (Station 95) had an average concentration of 29,039 ng/g. At the remaining Dow locations, hexachlorobenzene concentrations ranged from 420 to 2000 ng/g and were comparable to those found at Suncor (**Table 18**).

Point sources of hexachlorobutadiene to the St. Clair River appear to include Polysar (Station 74), and Dow (Station 95) since the higher concentrations occurred closest to shore. Maximum hexachlorobutadiene concentrations were 25,000 ng/g below Polysar and 97,780 ng/g at Dow. Hexachlorobutadiene was not detected further downstream at the Shell Intake and Novacor Chemicals, Corunna (**Table 18**).

The spatial distribution for the other organic contaminants, with the exception of PCBs, followed a similar trend to that described for hexachlorobenzene (**Table 18**). The most heavily contaminated sediments are located from below Polysar (Station 74) and the Dow 1st St. Station 95. In relation to the collection site at Polysar, levels of hexachloroethane increased 25 times, octachlorostyrene, hexachlorobenzene and pentachlorobenzene increased 30 times, hexachlorobutadiene increased 50 times and total chlorobenzenes increased 100 times (**Table 18**). Many compounds were either non-detectable or present only at trace levels at the Shell and Novacor, Corunna collection sites (**Table 18**). Total PCBs were restricted to the Dow locations and values were substantially higher for sediment closest to shore (6 m) at Station 95 (6,150 ng/g) and 12 m offshore at Station 96 (6,225 ng/g).

Provincial Aquatic Sediment Quality Guidelines are available for both HCB and total PCBs. All samples either exceeded or equalled the Lowest Effect Level for HCB (20 ng/g). Total PCBs exceeded the PASQG (70 ng/g) at all three sites offshore of Dow (**Table 18**).

Lethality and Growth Assays

Organism mortality and growth reduction are summarized in **Table 19.** Sediments at Suncor (Station 76) and Shell (Station 143) were moderately to mostly toxic to all three organisms tested (**Table 19**).

Maximum reductions in chironomid growth (>80%) also occurred at these sites. Sediment from below Novacor (Station 94) and Dow 1st St. (Station 95) were toxic to nearly all *Pimephales promelas* and *Hexagenia limbata*.

Test sediment that consisted of large quantities of sand (>94%) accompanied by very low TOC (<2 mg/g) were found to be physically unsuitable for *Hexagenia limbata*. During testing the mayfly nymphs could not burrow into the collapsible hard surface. Sediment unable to support a field population of *Hexagenia limbata* were found at the Suncor, Lake St. Clair disposal area and one sample in the South Channel (**Table 19**).

Chironomid sub-lethal effects were apparent in sediment from the upstream (Station 72) and Cole Drain (Station 73) collection sites which had mortality rates of up to 38% and 15% respectively. Growth rates were reduced by up to 60% at both stations.

Sediment laboratory bioassays performed in 1985 revealed that samples collected downstream of Polysar were acutely toxic to *Hexagenia limbata* nymphs in a 4-day test (86% mortality) (Bedard and Petro 1992). These data are consistent with the 1990 results which revealed up to 80% mortality in 22-day tests.

Sediment laboratory bioassays were also performed in 1985 and 1986 using *Pimephales promelas*. Bottom sediments at Novacor Chemicals (Station 94) and Shell (Station 143) were primarily non-lethal and comparable to levels in the 1990 study despite the difference in exposure duration of 10 days versus 21 days. In 1985, sediment collected at Dow was highly toxic to *Pimephales promelas* and has remained toxic to 1990. Percent mortality was higher below Polysar in 1990 than in 1985 but this may be due in part to the longer test duration (Bedard and Petro 1992).

Sediments collected at Shell (Station 143-1) and Suncor (Station 76-1) caused significant adverse effects on all test species. According to metal analysis data, these sediments contained the highest concentrations of mercury.

Species-specific responses occurred at Petrosar where bulk sediment metal concentrations were in excess of the PASQG Severe Effect Level for mercury and Lowest Effect Level for lead and caused *Hexagenia limbata* mortality.

Bioaccumulation in *Pimephales promelas*

The highest hexachlorobenzene tissue concentrations (dry weight basis) in the surviving *Pimephales promelas* for all test stations were obtained with sediments from Novacor, Sarnia (Station 94) to Novacor, Corunna (Station 80). Tissue concentrations peaked at the Dow 1st St. station (76 μg/g) and adjoining sites, below Polysar (14.473 μg/g) and Dow 2nd St. station (22 μg/g). Organisms exposed to sediments from Stations 252, 207 and 208 (South Channel and Lake St. Clair) also had detectable body burdens of hexachlorobenzene (Bedard and Petro 1992).

Sufficient amounts of octachlorostyrene were accumulated at several locations in the upper river where concentrations ranged from 33.350 μg/g at Dow 1st St. to 1.207 μg/g at Shell.

Total PCB body burdens were similar among the Dow stations and averaged approximately 4 μg/g. PCB levels found downstream at Suncor were about 1 μg/g. These values were 2 to 6 times higher than those recorded at other stations in the 1990 study. Station 95 (Dow 1st St.) minnows accumulated some of the highest tissue concentrations for most organic chemicals. Bedard and Petro (1992) concluded that bottom sediments at the Dow 1st St. could be considered a local source of persistent toxic compounds.

***Pimephales promelas* Lethality and Chemical Bioconcentration in Elutriate Tests**

Sediment elutriate tests were conducted with sediments from Stations 72, 95, 252, 207 and 208 to

examine *Pimephales promelas* survivorship and chemical bioconcentration for a select group of test and control sediments. The elutriate test is beneficial for assessing the effects of water extractable chemicals that may arise during dredging operation or periods of sediment resuspension. *Pimephales promelas* were exposed to filtered elutriate for 7 days. Sediment elutriates were not toxic to *Pimephales promelas* for all test and control sediments since mortality ranged from 0 to 10%. Control mortality in the 21-day bioassay was 16.7% compared to only 3% in the elutriate test. Toxicity of the Dow 1st St. elutriate was reduced relative to the whole sediment test (0 and 90%, respectively).

In general, contaminant body burdens in *Pimephales promelas* surviving the elutriate test were at trace or non-detectable levels.

St Clair RAP Addendum Contents

Sediment Quality

Tributary Sediment, 1989 Talfourd Creek Contaminant Survey

The purpose of this study was to investigate current and historical contamination in Talfourd Creek and its potential contaminant input to the St. Clair River. Discharges from Shell Canada Ltd. were evaluated as well as possible upstream sources of chlorinated aromatics, hexachlorobenzene, octachlorostyrene, polycyclic aromatic hydrocarbons and other contaminants. Water and sediment samples (surface and core) were used to identify spatial and temporal trends. Introduced mussels (*Elliptio complanatus*) were used to determine if low level organic contaminants are bioavailable and bioaccumulating.

Samples were collected at fifteen stations (**Figure 6**). Three replicate sediment core samples were collected at each station using 10 cm coring tubes on June 12, 1989. Cores were divided into two distinct samples, surface (top 3 cm) and subsurface (below 3 cm) where depth of sediments permitted. Sediment depth was insufficient to allow core samples to be taken at Stations 1, 2, 4, 5, 13 and 14. Sediment at these stations was collected by grab samples. A subset of the data was used to examine the effect of core depth on contaminant concentrations.

An analysis of sediment particle size, expressed as percent fine particles, percent sand and percent gravel, demonstrated that significant spatial variation existed between stations. The percentage of fine particles ranged from 1.81% at Station 2, downstream in the St. Clair River, to 24.40% at Station 14 (**Figure 4**). All stations were predominantly sand. The lower core layer had significantly higher proportions of fine particles than the upper layer. The particle size composition of sediment at a station and the degree to which deposition takes place, may affect the concentrations of contaminants at that station (Bilyea 1992). Spatial patterns in contaminant concentrations may be the result of particle size and degree of deposition as well as proximity and relationship to sources of the contaminant (Bilyea 1992).

Sediment data is assessed with respect to the Draft Provincial Aquatic Sediment Quality Guidelines (PASQG) (Persaud *et al.* 1992). The PASQG Lowest Effect Level is the sediment contamination level that can be tolerated by the majority of benthic organisms. The Severe Effect Level for each contaminant represents "the level at which pronounced disturbance of the sediment-dwelling community can be expected...would be detrimental to majority of benthic species" (Persaud *et al.* 1992).

A complete analysis of all sediment samples and tables summarizing non detected and trace level detections are provided in Appendix 2

Conventional Pollutants

Mean TKN concentrations at all Talfourd Creek stations were above the PASQG Lowest Effect Level (550 μg/g) but below the Severe Effect Level. St. Clair River stations were significantly lower and below the PASQG Lowest Effect Level. The highest TKN mean concentrations were found in both the upper and lower core layers at Station 11 with values of 1,970 and 1,800 μg/g respectively. Temporal changes were not present and particle size distribution did not effect TKN concentrations or spatial distribution (Bilyea 1992).

Mean phosphorus concentrations at Stations 6, 11 and 12 (**Figure 4**) were above the PASQG Lowest Effect Level (600 μg/g) with the maximum concentration of 720 μg/g occurring the deeper core layer at Station 11. All other stations were within this guideline, however, Talfourd Creek stations had significantly higher phosphorus concentrations than St. Clair River Stations 1 and 2. Phosphorus concentrations were related to the percentage of fine particles and not simply sources. Core depth analysis did not indicate temporal differences.

Mean total organic carbon (TOC) concentrations were above the PASQG Lowest Effect Level (1%) at all stations expect Station 1 (**Figure 4**) which was significantly lower than all other stations. Mean TOC levels ranged from 6.4% at Station 1 to 30.1% at Station 6. The PASQG Severe Effect Level for TOC (10%) was exceeded by the mean at Station 1. TOC concentrations were significantly effected by both the percentage of fine particles and core depth. TOC levels were higher in the upper core layers at most stations.

There is no PASQG for loss on ignition (LOI) but the former OMOE open water disposal guideline for LOI was 6%. Mean values ranged from 8 to 13% at St. Clair River Stations 1 and 2 to 64.1% at Station 11 (**Figure 4**). LOI values at Stations 1 and 2 were significantly lower than all Talfourd Creek stations. Stations with higher fine particles also had higher LOI values. Upper core layers had significantly higher LOI concentrations than the lower layers indicating an increasing temporal trend.

Solvent extractables (oil and grease) reached maximum concentrations in the upper core layers at Station 6 (1134 μg/g), Station 8 (1150 μg/g) and Station 11 (1150 μg/g). There are no PASQGs for solvent extractables. The OMOE provincial guidelines for open water disposal of dredged material (1500 μg/g) was exceeded by 6% of the individual samples. Most of the samples can be considered as moderately polluted according to the U.S.EPA guidelines for the disposal of Great Lakes harbour sediment (1000-2000 μg/g).

Bilyea (1992) concluded that point and non-point sources of nutrients and organic materials should be controlled.

Metals

Mean arsenic concentrations were below the PASQG Lowest Effect Level (6 μg/g) at all stations except 4 and 5, where values were 8.83 and 9.10 μg/g respectively. A significant increase in arsenic concentration occurred between Stations 5 and 6 (**Figure 4**), in the vicinity the Shell refinery discharges. The MISA monitoring data for Shell Canada reported a mean arsenic concentration of 2.000 μg/L in the process effluent stream (OMOE 1990a).

Mean sediment cadmium concentrations were below the PASQG Lowest Effect Level (0.6 μg/g) at all stations, however, Station 11 approached this level. All Talfourd Creek stations were elevated relative to the St. Clair River stations.

Mean chromium concentrations exceeded the PASQG Lowest Effect Level (26 μg/g) at all Talfourd Creek stations except Stations 4, 5 and 13. The lack of core samples at these three stations indicates that they are non-depositional areas. Mean chromium values ranged from 18.67 to 36.83 μg/g at Talfourd Creek stations. A 1985 sediment sample taken near the mouth of Talfourd Creek contained 52 μg/g chromium (Johnson and Kauss 1989) indicating that chromium levels in Talfourd Creek sediment have remained consistent. Bilyea (1992) concluded that point and non-point sources of chromium into Talfourd Creek should be controlled.

Mean copper concentrations in Talfourd Creek sediments exceeded the PASQG Lowest Effect Level (16 μg/g) at all stations except 13 and the upper core layer of Station 10 (**Figure 4**). Values ranged from 11.33 to 36.83 μg/g. The mean copper concentration in sediment from Station 1, upstream in the St. Clair River was below the Lowest Effect Level while the value at Station 2, downstream in the river, was at the Lowest Effect Level. A 1985 sediment sample from the mouth of Talfourd Creek recorded a copper value of 33 μg/g (Johnson and Kauss 1989) indicating that copper levels have remained consistent or have increased slightly. Bilyea (1992) concluded that point and non-point sources of copper into Talfourd Creek should be controlled.

All stations, with the exception of Stations 4 and 5 and the lower core layer at Stations 9 and 11, were below the PASQG Lowest Effect Level for iron (20,000 μg/g). Concentrations ranged from 9,7000 μg/g at Station 1 to 22,333 μg/g at Station 4. A sediment sample collected from the mouth of

Talfourd Creek in 1985, contained 10,000 μg/g of iron indicating that levels have not changed in the 4 year period.

Mean mercury concentrations found at St. Clair River Stations 1 and 2 and Talfourd Creek Stations 6 to 9 inclusive (**Figure 4**), exceeds the PASQG Lowest Effect Level of 0.2 μg/g. Stations in the St. Clair River contained considerably higher mercury concentrations, with means in the range of 1.2 to 2.0 μg/g. The maximum mean mercury concentration occurred at Station 1 and met the PASQG Severe Effect Level value of 2.0 μg/g. The highest Talfourd Creek mean mercury conentrations were in the range of 0.3 to 0.7 μg/g. Sediment collected from the mouth of Talfourd Creek in 1985 contained 0.76 μg/g mercury. Mercury concentrations in sediment have remained relatively consistent since 1985.

Mean manganese sediment concentrations were below the PASQG Lowest Effect Level (460 μg/g) at all stations except Station 10 where the upper and lower core layers recorded values of 477 and 490 μg/g. Station 14 had a value of 480 μg/g manganese.

Mean nickel concentrations were at or above the PASQG Lowest Effect Level (16 μg/g) at all Talfourd Creek stations with the exception of Station 13. Values ranged from 16.67 to 31.33 μg/g. Both St. Clair River stations were below the Lowest Effect Level. Mean nickel concentrations at Stations 4 and 5, downstream of the Shell refinery discharge, were significantly higher than concentrations upstream and St. Clair River stations.

Station 7 and the lower core level of Station 6 exceeded the PASQG Lowest Effect Level for lead (31 μg/g) with the maximum mean concentration reaching 97.33 μg/g. The significant increase in lead concentrations at Station 7 indicates that there is a lead source between Stations 7 and 8 and that this source is not the tributary on which Station 15 is located (**Figure 4**).

Mean zinc concentrations ranged from 25.50 to 101.67 μg/g and were below the PASQG Lowest Effect Level of 120 μg/g.

Arsenic, mercury and molybdenum were the only metals not positively correlated with the percentage of fine particles (Bilyea 1992). The percentage of fine particles decreased downstream of the Shell discharge area hence, there was a tendency towards lower metal concentrations in this area. The decrease in sediment depth and percentage of fine particles indicate that lower Talfourd Creek downstream of the discharge area is not a depositional area. The impact of the Shell discharge on sediment quality is less likely to be observable (Bilyea 1992). Concentrations of beryllium, cobalt, chromium, copper, iron, nickel, lead, strontium and vanadium are all significantly greater in the lower core layer (Appendix 2).

Although iron, mercury, manganese and lead all exceeded the PASQG Lowest Effect Level at one or more stations in Talfourd Creek, Bilyea (1992) concluded that in general, they were not a potential concern.

Organic Contaminants

Mean hexachlorobenzene concentrations at Stations 1 and 2 in the St. Clair River exceeded the PASQG Lowest Effect Level (0.02 μg/g) with mean values of 0.353 and 0.091 μg/g respectively. Individual samples from Stations 6 and 8 exceeded the PASQG but mean values did not. Trace levels of hexachlorobenzene were detected at Stations 7, 10 and 15.

Concentrations of hexachlorobenzene in the two core layers did not differ significantly indicating the sediments have been mixed by resuspension or that long-term temporal trends do not exist (Bilyea 1992). Particle size did not have a significant effect on hexachlorobenzene concentration. Higher concentrations found in the lower reach of Talfourd Creek may be a result of incursions from the St. Clair River or there may be a source or sources to Talfourd Creek since trace levels were found as

far upstream as Stations 8 and 10 (Bilyea 1992).

St. Clair River station sediments contained significantly higher concentrations of pentachlorobenzene than any of the Talfourd Creek stations. Mean concentrations at Stations 1 and 2 were 0.014 and 0.016 μg/g respectively. Trace levels of pentachlorobenzene were detected at Stations 6, 8, 11 and 12. There are no PASQG for pentachlorobenzene. Concentrations were not affected by particle size or core depth.

Other detected organic contaminants included: octachlorostyrene, 1,2,3,5-tetrachlorobenzene, 1,2,4,5-tetrachlorobenzene, 1,3,5-trichlorobenzene and 1,2,4-trichlorobenzene. These contaminants all demonstrated a similar distribution pattern to that of hexachlorobenzene and pentachlorobenzene. All were found in St. Clair River sediments and mostly not detected in Talfourd Creek sediments.

Hexachloroethane, 1,2,3,4-tetrachlorobenzene and three forms of trichlorotoluene were detected at trace levels.

St Clair RAP Addendum Contents

Sediment Quality

1992 St. Clair Delta Contaminants Study

The Great Lakes University Research Fund, in conjunction with the Walpole Island Heritage Centre, undertook an investigation of metals and organic contaminants in sediments of the St. Clair River Delta channels. The results of this work are very preliminary and the following description provides a brief summary of the 1992 results (The Great Lakes University Research Fund 1993).

Fifty samples from 44 stations in the delta were analyzed for individual PCB congeners, PAHs, pentachlorobenzene, hexachlorobenzene, octochlorostyrene, trans-nonachlor, p,p'-DDE, copper, manganese, nickel, cobalt, lead, zinc, mercury chromium and aluminum. The samples were collected throughout the length of the Chanel Ecarte, Johnston Channel, South Channel, Bassett Channel, and the St. Clair Cutoff Channel as well as in Lake St. Clair and Mitchell Bay. The results of the metal analyses are presented in **Table 20.**

The Provincial Aquatic Sediment Quality Guidelines' Severe Effect Level was not exeeded by the means or individual samples at any station. The Loweset Effect Level was exceeded for copper (17 stations), manganese (1 station), nickel (15 stations) and mercury (31 stations). The EPA moderately polluted guidelines for the disposal of Great Lakes Harbour sediments were also exceeded for copper (7 stations), manganese (5 stations) and nickel (8 stations). The heavily polluted guideline for mercury was exceeded at 4 stations.

The highest concentrations and frequency of sediment guideline exceedences occurred in the channel sediments relative to Lake St. Clair and indicate that these sediments continue to be an active source of contaminants, particularly mercury to Lake St. Clair (Great Lakes University Research Fund 1993).

The PASQG Lowest Effect Levels were also exceeded for HCB (0.02 μg/g) and total PCBs (0.07 μg/g). The mean HCB concentration was 0.0478 μg/g (43 sites); ranging from 0.0006 μg/g in Lake St. Clair to 0.2305 μg/g in Bassett Channel. A total of 27 sites exceeded the LEL, generally evenly distributed among all channels. The mean OCS concentration was 0.0032 μg/g; ranging from a low of non-detectable in Lake St. Clair to 0.0083 μg/g in South Channel. The mean concentration for total PCBs was 0.0225 μg/g; ranging from 0.0081 μg/g in Lake St. Clair to 0.1400 μg/g in South Channel. Two sites, the South Channel site and Chanel Ecarte (0.0854 μg/g) exceeded the PWQG LEL for total PCBs.

Sediments from four of the sites were also subjected to acute and chronic toxicity tests. The results of these tests indicated that sediments from three of the four sites were acutely toxic to fathead minnows (Great Lakes University Research Fund 1993). These sites include one each from Johnston, South and Bassett Channels.

St Clair RAP Addendum Contents

Biota

This section is comprised of follow-up or new surveys to those reported in the Stage 1 RAP. Follow-up surveys include:

- OMOE 1990 St. Clair River benthic survey (OMOEE 1993). This also included water quality and sediment quality surveys using sampling locations comparable to earlier whole river sampling programs.
- an analysis of the OMOE 1990 benthic macroinvertebrate communities (Tarandus 1992);
- metal and organic contaminants in sport fish from Ontario's Sport Fish Contaminant Monitoring Program, 1991;
- 1992 MNR Creel survey in Ontario waters of the St. Clair River; and
- MOEE contaminants in juvenile fish 1989, 1990 and 1991 data for organic contaminants and lead in young-of-the-year spottail shiners.
- OMOE *Cladophora* contaminant data, 1984, 1986-1988;
- USFWS study on production relationships between *Hexagenia limbata* nymphs and contaminated sediment; and
- USFWS analysis of the distribution relationships between *Hexagenia limbata* nymphs and visible oil in sediment.

For more information, select one of the following topics:

Cladophora Contaminant Data
Benthic Macroinvertebrates
Fish

St Clair RAP Addendum Contents

Biota

Cladophora Contaminant Data

Cladophora glomerata (L) Kutz is a freshwater green algae with a wide distribution in the lower Great Lakes. It is a benthic alga, a member of the periphyton, which grows attached to solid substrates as a branched macroscopic thallus. Plants form very dense populations just under the surface and these can extend for kilometres along rocky shores.

Cladophora cells accumulate contaminants (certain metals and synthetic organic compounds) from the surrounding water even when aqueous concentrations are very low (Hollister *et al.* 1993a and b). *Cladophora* is an excellent biomonitor of contaminants in water, especially at locations where contaminant inputs may be at chronic low levels or where significant concentrations occur only after intermittent pulse inputs. *Cladophora* integrates these exposures over time so that the contaminant content of the algae is a measure of "average" contaminant levels in the ambient water (Hollister *et al.* 1993a and b). Regular and long term measurements of *Cladophora* contaminant levels may be one of the best ways of tracking long term trends in certain contaminants, especially at locations where conventional water sampling cannot detect low concentrations and might miss intermittent inputs resulting from spills, illegal discharges, or other irregular inputs determined by weather events.

The following data should be used for general information and not used as a source for rigorous numerical comparisons. Factors such as growth rate, age of the collected plants, previous spill events, long term changes in contaminant loading and sample collection site are quite variable and result in high year-to-year variability in the contaminant data. Future studies can control this variability through the use of "clean" laboratory grown plants of uniform age and growth rate outplanted to field sites for contaminant uptake (Hollister *et al.* 1993a and b).

Cladophora samples were collected from the St. Clair River (**Figure 7**) during 1984 and 1986-1988, for the determination of metals and organic compound levels (dry weight basis). Samples were collected during June and July when *Cladophora* biomass is at its peak. Missing samples represent technical problems in the field or lab; samples either not collected or analyzed as planned; and insufficient amounts of *Cladophora* were available for a complete or even partial analysis. The minimal availability of samples at these sites could reflect locally toxic conditions (Hollister *et al.* 1993a and b). Values reported are the averages of samples which were analyzed in triplicate.

Samples 701 to 705 are located along the Ontario shore from Talfourd Creek to Corunna (**Figure 7**) and were collected only during 1984. Station 706, downstream of the Bluewater Bridge was only sampled in 1984. Samples 708 to 716 were collected from 1986 through 1988 and are located at the head of the St. Clair River (708), along the Ontario shore at the industrial complex (709-713, 716) and at the mouth of the river downstream of Port Lambton on both the Ontario (715) and Michigan (714) shorelines (**Figure 7**).

Results from the *Cladophora* survey are provided in Appendix 3 In 1984, all elemental contaminants except beryllium, were detected in all samples located from Talfourd Creek to Corunna. Stations 704 and 705, the furthest downstream contained the highest concentrations for most elements (Appendix 3). At Station 704, maximum concentrations of aluminum (8,000 µg/g), barium (28 µg/g), beryllium (0.58 µg/g), chromium (27µg/g), iron (11,000 µg/g), TKN (29,000 µg/g), manganese (280 µg/g), nickel (14.8 µg/g), titanium (132 µg/g), vanadium (18 µg/g) and zinc (85 µg/g). *Cladophora* samples from Station 705, a bit further downstream contained maximum concentrations for lead (126.3 µg/g), magnesium (11,500 µg/g), mercury (1.35 µg/g), and total phosphorus (3,400 µg/g).

Station 701, located immediately downstream of Talfourd Creek (**Figure 7**), recorded maximum values for arsenic (32 µg/g), cobalt (9.2 µg/g), copper (34 µg/g), TKN (29,000 µg/g), manganese (280 µg/g), selenium (3.2 µg/g), sulphur (1.45 g/100 g) and total ignition (55% dry wt). Station 703,

downstream of Ethyl Corp, had contained the highest 1984 PCB concentration of 0.177 μg/g (Appendix 3).

Station 706, located downstream of the Bluewater Bridge at the head of the river, contained maximum levels of boron (185 μg/g) and cadmium (1.18 μg/g) in 1984.

Cladophora samples collected from 1986 through 1988 generally show a decreasing trend in elemental content over the three year period and compared to 1984 levels (Appendix 3). *Cladophora* samples from Station 708, at the head of the river at Point Edward, contained maximum levels of boron (285 μg/g), cadmium (2.6 μg/g) and sulphur (3.3 g/100 g). Station 709, downstream of municipal discharges at Sarnia, exhibited maximum levels of copper (56 μg/g), magnesium (5,400 μg/g) and zinc (198 μg/g).

Stations 710-713 and 716, located near the Ontario shore along the industrial complex (**Figure 7**), also showed maximum values for some elements. *Cladophora* at Station 712, downstream of Dow Chemical, contained maximum values of TKN (40,000 μg/g) and total phosphorus (5,500 μg/g). Station 716, at the downstream end of the Sarnia industrial complex showed high levels of arsenic (21.8 μg/g), cobalt (26 μg/g), mercury (0.24 μg/g) and selenium (3 μg/g) in *Cladophora*. Of note, *Cladophora* samples taken from the Michigan shore upstream of Algonac (Station 714) contained the highest concentrations for a larger number of metals than any of the other samples collected between 1986 and 1988. These included: aluminum (45,000 μg/g), barium (32 μg/g), beryllium (0.75 μg/g), chromium (14 μg/g), iron (7,000 μg/g), lead (18 μg/g), manganese (570 μg/g), nickel (13.5 μg/g) and titanium (70 μg/g).

Figure 7 *Cladophora* collection sites in the St. Clair River during 1984 and 1986 through 1988 (Hollister *et al.* 1993a and b).

The 1986-1988 *Cladophora* collections were also analyzed for a large number of organic compounds (Appendix 3). The most common pesticide detected was dieldrin with values ranging from below detection to 60 ng/g. The maximum value was found at Station 708 at the head of the St. Clair River. The majority of the samples were below detection for organochlorine pesticides. Hexachlorobenzene (HCB) concentrations were highest and found in all *Cladophora* samples taken at Stations 712, 713 and 716 towards the downstream end of the Sarnia industrial complex. Values ranged from 6 to 50 ng/g HCB. HCB was also present in all samples from Station 715 near Port Lambton. The same pattern is present in the majority of samples at the same stations for hexachlorobutadiene and octachlorostyrene (Appendix 3). Hexachlorobutadiene levels ranged from 1 to 23 ng/g and octachlorostyrene values ranged from below detection to 13 ng/g.

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Biota

Benthic Macroinvertebrates

- ***Ontario Ministry of Environment 1990 Caged Mussel Biomonitoring Study***
- ***Benthic Community Structure***
- ***Production Relationships Between Hexagenia limbata Nymphs and Contaminated***
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St Clair RAP Addendum Contents

Biota

Benthic Macroinvertebrates

Ontario Ministry of Environment 1990 Caged Mussel Biomonitoring Study

From late May to mid-June of 1990, the (then) OME conducted a caged mussel biomonitoring study at 10 of the 64 sediment quality-benthic macroinvertebrate stations. Clean mussels (*Elliptio complanata*) harvested from Balsam Lake were placed in wire mesh cages and anchored to the river bottom for a three week exposure period at stations in the upper St. Clair River. Only the cages at Station 36 (downstream of Ethyl Corp. and Novacor Chemicals, at Corunna) were not recovered, possibly the result of construction work at this station during the exposure period. The mussel tissue analytical results are summarized in **Table 21.** Mean concentrations of arsenic and most heavy metals did not differ substantially between stations or from levels in mussels from Balsam Lake prior to their exposure to St. Clair River water. However, mean copper concentrations did increase by 50% to 90% in mussels from all river stations except the upstream control (Station 13). Mean zinc concentrations increased approximately 30% in mussels exposed at some of the stations.

With the exception of the upstream control (Station 13), tissues of mussels exposed in the upper St. Clair River contained from nearly 2 to over 7 times higher mean total PAH concentrations than before their three week exposure (**Table 21**), indicating the presence of biologically available contaminants in the water. Mussels exposed at Stations 20, IS12, 22, IS14, IS15, IS16, 24A or 30 usually accumulated higher concentrations of total PAHs as well as of several individual compounds (*i.e.*, chrysene, fluoranthene and pyrene) than those exposed at the upstream control. The highest mean concentration of total PAHs (370 ng/g) and of acenaphthylene (19 ng/g), chrysene (25 ng/g), fluoranthene (49 ng/g), fluorene (33 ng/g) and pyrene (55 ng/g) were found in mussels from Station 30, located just downstream of the Shell intake and upstream of Talfourd Creek. This indicates the presence of important upstream inputs of these PAHs. The second-highest total PAH concentration (303 ng/g) was detected in mussels from Station IS16, just downstream of the Dow 3rd Street sewer discharge. These mussels also contained the highest mean naphthalene concentration (48 ng/g) of the study. The highest mean acenaphthene concentrations were found in mussels from Stations IS16 (22 ng/g) and 30 (29 ng/g). Mean phenanthrene concentrations were also highest at these two stations (124 ng/g).

No polychlorinated biphenyls (PCBs) were found in mussel tissues, despite the fact that sediments at Stations 22, IS14, IS15 and IS16 still contained PCB concentrations above the Lowest Effect Level guideline (see section 4.1.2). This suggests that the sediment-associated PCBs are a result of past inputs and were not biologically available to the filter-feeding mussels. Low concentrations of gamma-BHC (2 ng/g to 8 ng/g) were found in mussels from most St. Clair River stations, reflecting the ubiquitous nature of this pesticide in Great Lakes Basin waters (Socha *et al.* 1992). The gamma isomer of BHC was also found at low concentrations (1 ng/g to 6 ng/g) at a few stations, as was the DDT metabolite, p,p'-DDE (1 ng/g).

In contrast to previous mussel biomonitoring studies, only four chlorinated aromatic compounds, 1,2,4-trichlorobenzene (TCB), 2,4,5-trichlorotoluene (TCT), hexachlorobenzene (HCB) and octachlorostyrene (OCS), were accumulated by mussels from the 1990 study. Furthermore, the concentrations of these four contaminants were lower than in 1982 (Kauss & Hamdy 1995), 1984 (St. Clair River RAP Team 1991) or 1986 (St. Clair River MISA Pilot Site Team 1991). Assuming that the biomonitoring periods were representative of average discharge conditions in each year, this decrease suggests that the point source loadings as well as nearshore water concentrations of chlorinated aliphatic and aromatic compounds have been reduced since the mid-1980s. There is, however, still some low-level input or bioavailability (*e.g.*, from sediments) of 1,2,4-TCB, 2,4,5-TCT, HCB and OCS in the area from the Novacor Chemicals property to just upstream of Talfourd Creek. For example, the highest mean concentrations of HCB (8 ng/g and 11 ng/g) and of OCS (12 ng/g and 15 ng/g) were found in mussels exposed just downstream of the Dow 1st Street and 3rd Street sewer

discharges, respectively.

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Biota

Benthic Macroinvertebrates

Benthic Community Structure

A benthic invertebrate community study was undertaken by the OMOE during April to May of 1990 as part of the St. Clair River Surveys. The benthic fauna was sampled in order to provide a complete identification, enumeration and statistical analysis of benthos in the St. Clair River. These benthic data were analyzed by Tarandus Associates Limited (1992) and interpreted to determine relationships between benthic communities and environmental factors. Results were compared to the 1985 OMOE benthic community survey to determine changes.

The 1990 sampling station locations are shown on **Figure 1.** Station locations were generally similar to those sampled during previous studies, with more stations located along the Canadian side to better characterize current environmental conditions. Statistical methods were modelled after those used in previous St. Clair River studies and included non-hierarchical cluster analysis and discriminant analysis.

Cluster analysis defined 4 macroinvertebrate communities, termed A, B, C and D, in the St. Clair River. Their taxonomic composition is presented **Table 22.** The four communities were classified according to environmental stress based on discriminant analysis using sediment chemistry and physical characteristics. Mean concentrations of sediment parameters associated with each community are provided in **Table 23.** (Complete sediment chemistry data from the 1990 survey are provided in Appendix 4). Community A is considered an "unimpaired" zone which is generally restricted to Sarnia Bay and the St. Clair River delta. Community B represents an "intermediate" zone between the petrochemical complex and the Town of Sombra. Communities C and D represent "impaired" and "degraded" communities, respectively (Tarandus 1992).

The "degraded" zone (community D) is restricted to three areas along the Ontario shoreline of the St. Clair River: at Novacor Chemicals, Sarnia (Stn 22,IS12); downstream of Suncor (Stn 24A); and near DuPont (Stn 34) and Novacor Chemicals, Corunna (Stn 36) (**Figure 8**). This zone is characterized by relatively high numbers of tubificids such as *Limnodrilus hoffmeisteri* and *Quistadrilus multisetosus*, and naidids such as *Paranais frici* and *Vejdovskyella intermedia*. A larger degraded zone was reported in 1985 by Griffiths (1989). Sediments from the degraded zone were defined as "very highly toxic" (Stn 22, 24A), "highly toxic" (Stn IS12) or "moderately toxic" (Stn 36) by Tarandus (1992). Sediments from Station 34 were not evaluated.

Figure 8 Distribution zones of benthic community impairment in the St. Clair River during the spring of 1990 (Tarandus 1992).

The "impaired" zone (community C) was found in several areas in the St. Clair River: upstream and downstream of the Cole Drain (Stn 20 IS9); below the Dow 3rd Street sewer (Stn IS16); near the Shell dock (Stn 29) and intake at Corunna (Stn 30, upstream of Shell's outfall); and below the Corunna WPCP (Stn 37) (**Figure 8**). Sediments from Stations 20 and IS9 were defined as "highly toxic", dominated by tubificids *L. hoffmeisteri* and *Spirosperms ferox* and molluscs. Sediments from other stations were not evaluated.

The "degraded" and "impaired" zones located along Novacor Chemicals Inc., Sarnia (Stn 22, IS12) and downstream of the Cole Drain (Stn 20, IS9) (**Figure 8**), respectivley are likely the result of discharges from the Cole Drain, although discharges from Polysar, Novacor (Sarnia), Esso Petroleum and Esso Chemical may also have had some impact (Tarandus 1992). The Cole Drain collects discharges from and runoff from several industrial, municipal and non-industrial sources before discharging to the St. Clair River. The Scott Road Ditch, carrying stormwater, industrial cooling water and treated disposal leachate from the Scott Road Landfill, also empties into the Cole Drain. Oliver and Pugsley (1986) noted a two-to-three order of magnitude increase in

hexachlorobutadiene, pentachlorobenzene, hexachlorobenzene and octachlorostyrene where the Cole Drain entered the river.

Contaminants discharged by Novacor Chemicals, Sarnia include benzene, styrene, ethylbenzene, chloroform and toluene. Esso Petroleum and Esso Chemical effluents are characterized by low concentrations of some PAHs. Several chemical spills from Polysar, Esso Petroleum and Esso Chemical have also been documented (OMOE and MDNR 1991).

The "impaired" zone located downstream of the Dow Chemical 3rd Street Sewer probably resulted from discharges from the sewer at this location as well as inputs from the upstream 1st and 2nd Street Sewers. Contaminants discharged from Dow Chemical include volatiles such as styrene, ethyl benzene, benzene and carbon tetrachloride. Several accidental spills of styrene, hydrochloric acid, sodium hydroxide, sodium chlorate, sodium chloride, ethylene glycol and perchloroethylene have also been documented (OMOE and MDNR 1991). Elevated levels of mercury have also been reported in sediments offshore from Dow Chemical (OMOE and MDNR 1991).

The small "degraded" zone located offshore of Suncor (**Figure 8**) may be the result of Suncor discharges of aromatics such as benzene, toluene, xylene and PAHs as well as the cumulative effect of upstream sources. Spills of oil and inorganic contaminants have also occurred (OMOE and MDNR 1991). Discharges from upstream industries such as Dow Chemical may also impact on the benthic invertebrate community in this area (Tarandus 1992).

The "degraded" and "impaired" zones near DuPont and below Novacor Chemicals (Corunna) are likely the result of discharges from Talfourd Creek and Ethyl Canada (Tarandus 1992). Tarandus (1992) implicated Shell Canada's discharges to Talfourd Creek as contributing to the benthic impairment. Contaminants from Shell Canada include total solids, suspended solids, chlorides, phenols and TOC. Ethyl Canada is a major source of organic lead and chlorinated hydrocarbons (OMOE and MDNR 1991). Griffiths (1989) noted that DuPont and Nova Petrochemical (Corunna) appeared to have very little additional effect on environmental quality in this area.

The "impaired" zone upstream of Talfourd Creek has been attributed to upstream sources from the Sarnia industrial complex, namely Nova Petrochemical (Sarnia) and Dow Chemical (Tarandus 1992).

A comparison of the 1990 St. Clair River benthic invertebrate communities with those of 1985 indicates a reduction in the sizes of the zones described as "impaired" and "degraded". The "severely degraded:toxic" zone of 1985, noted by Griffiths (1989), downstream of Dow Chemical was not found during the 1990 survey, although Station IS16 (**Figure 1**) was defined as "impaired". Benthic communities at Stations IS14, IS15 and IS16 located in the "impaired" zone have improved dramatically since the 1985 survey, although sediment quality at these sites remains extremely poor. An indication of the improvement at these three Stations is shown by the fact that the numbers of taxa are three to five times higher in 1990 than in 1985 (Tarandus 1992). The size of the "degraded" and "impaired" zones reported in previous studies were also reduced in 1990, with improvements especially noted between Suncor and Talfourd Creek downstream of Corunna.

St Clair RAP Addendum Contents

Biota

Benthic Macroinvertebrates

Production Relationships Between Hexagenia limbata *Nymphs and Contaminated Sediment*

From April through October 1986, bottom sediment and populations of *Hexagenia limbata* nymphs were sampled at 11 locations (**Figure 9**) throughout the upper Great Lakes connecting channels, three of which were in the St. Clair River AOC, in order to determine if sediment contaminants adversely affected nymph production (Edsall *et al.* 1991).

Valid estimates of the portion of annual production that occurred from April to October 1986 were used to examine the effects of contaminated sediments on population performance (**Table 24**). Three sample stations were located in the St. Clair River AOC. From Station 131, located immediately south of the Sarnia industrial area, one sample contained visible oil and another exhibited an oil concentration (1,670 µg/g) that exceeded EPA (1,000 µg/g) and OMOE (1500 µg/g) guidelines for the open water disposal of dredged material. Furthermore, Cu exceeded the PASQG (16 µg/g) and EPA (25 µg/g) guidelines in both samples and Zn exceeded the EPA (90 µg/g) guideline in two samples (**Table 24**). The PASQG for copper was exceeded in sample 157 from the delta as well as sample 177 in Lake St. Clair.

A comparison of the production data with the contaminant data (**Table 24**) showed that *Hexagenia limbata* production was 980 to 9,231 mg/m^2 in sediment that did not exceed the EPA guideline for the disposal of dredged material and sediments that did not have an oily odour or visible sheen of oil. In areas where sediments were polluted the production of *Hexagenia limbata* ranged from 359 to 872 mg/m^2 (**Table 24**).

Results suggest that the lower nymphal production measured in portions of the Upper Great Lakes Connecting Channels where oil, cyanide, and metals in sediments exceeded pollution criteria, can be attributed to those contaminants operating in a manner that adversely affected the health of individual nymphs and the performance of the population (Edsall *et al.* 1991). The production of nymphs was up to nine times higher at stations where sediment was not polluted than at those with polluted sediment.

St Clair RAP Addendum Contents

Biota

Benthic Macroinvertebrates

Distribution Relationships Between Hexagenia limbata *Nymphs and Visible Oil In Sediment*

Hexagenia limbata distribution studies in the St. Clair River during 1968 and 1977 concluded that low spatial and temporal organism densities occurred throughout the AOC and attributed this result to overall substrate characteristics *i.e.*, sand and gravel, rather than environmental quality (OMOE and MDNR 1991).

The National Fisheries Research Center-Great Lakes and the U.S. Fish and Wildlife Service examined the occurrence of *Hexagenia limbata* nymphs and visible oil in sediments at 250 stations throughout the St. Marys River and the St. Clair-Detroit River system from May 14 to June 11, 1985 (Schloesser *et al.* 1991).

Mean densities of *Hexagenia limbata* nymphs per square meter averaged 194 for the total study area, 224 in the St. Marys River, 117 in the St. Clair River, 279 in Lake St. Clair and 94 in the Detroit River (Schloesser *et al.* 1991). Maximum densities ranged from 1,081 to 1,164 per m^2 in the rivers and was 3,099 per m^2 in Lake St. Clair. At 46 stations where oil was observed in sediment considered to be suitable for nymphs, comparisons showed that densities were lower in oiled sediments (61 per m^2) than in sediments without oil (224 per m^2). In general, oiled sediments and low densities of nymphs occurred together downstream from industrial and municipal discharges (Schloesser *et al.* 1991).

Figure 9 Sample locations at which *Hexagenia limbata* nymphs and sediments were collected by the National Fisheries Research Center-Great Lakes, and U.S. Fish and Wildlife Service from April through October, 1986 (Edsall *et al.* 1991).

St Clair RAP Addendum Contents

Biota

Fish

- *Sportfishing, 1992 Creel Survey in Ontario Waters of the St. Clair River*
- *Contaminants in Sport Fish, 1991 Survey*
- *Lambton Industrial Society Biomonitoring Program*
- *Contaminants in Forage Fish, 1991*

St Clair RAP Addendum Contents

Biota

Fish

Sportfishing, 1992 Creel Survey in Ontario Waters of the St. Clair River

A detailed creel survey for the recreational fishery was conducted by OMNR and the Lake St. Clair Fisheries Unit (LSCFU) during the months of June, July and August 1992. The total estimated catch for all species during the summer of 1992 was 78,441 with a total estimated harvest of 23,195. Yellow perch was the single most abundant species caught (47% of the total catch) followed by walleye (13%), gobi (12%), freshwater drum (10%), rock bass (9%) and smallmouth bass (5%) (OMNR and LSCFU data files).

Similar results were found with species specific sportfishing (**Table 25**). Yellow perch (60%) is the most sought after species by recreational anglers on the Ontario side of the St. Clair River. Other specific fish species sought after by anglers include walleye (17%), rock bass (7%), smallmouth bass (6.5%) and white bass (4%).

The average catch per unit effort (CUE) or the number of fish caught per rod-hour for species specific fishing was 0.599. The catch per unit effort for yellow perch and walleye were 1.856 and 0.286 respectively (**Table 25**).

St Clair RAP Addendum Contents

Biota

Fish

Contaminants in Sport Fish, 1991 Survey

Metals and organic contaminants are monitored in fish from the St. Clair River as part of Ontario's Sport Fish Contaminant Monitoring Program. Data from 1991 is summarized in **Table 26** and Appendix 5.

Metals and pesticides detected in walleye collections from three stations on the St. Clair River in 1991 were relatively consistent from the head to the mouth of the river. The maximum mean concentration of mercury was found in freshwater drum collected at the upstream end of Stag Island (**Table 26**) and values ranged from 0.10 to 1.60 μg/g. The guideline for the protection of human health due to mercury contamination of fish flesh is 0.5 μg/g (includes Great Lakes Water Quality Agreement Specific Objective, OMOE/Health and Welfare Canada and Michigan Department of Public Health guidelines). Mercury concentrations measured in individual fish greater than 0.5 μg/g occurred in Walleye downstream of the Bluewater Bridge and at Port Lambton; White Suckers adjacent to Stage Island; Freshwater Drum adjacent to Stag Island; and Yellow Perch adjacent to Stag Island. Lead in fish from all collections was detected at trace levels. Maximum PCB concentrations were found in carp collections adjacent to Stag Island. Values ranged from 0.140 to 2.450 μg/g (**Table 26**). The consumption guideline for lead is 1.0 μg/g where lead is considered to be in the organic form (OMOE/Health and Welfare Canada guideline).

In comparison to the Fish Consumption guidelines based on the 1985 collections, the 1991 collections indicate fewer restrictions. Although individual fish had Hg concentrations in excess of the 0.5 μg/g Ontario consumption guideline, the only mean value above this guideline was for freshwater drum (>30 cm in length) north of Stag Island. The PCB consumption guideline (2.0 μg/g) was not exceeded by mean concentrations in any species or size categories. The guideline was exceeded only by individual samples of larger carp (>50 cm) north of Stag Island and in larger Gizzard Shad at the same location as well as adjacent to the Lambton Generating Station and at Port Lambton. The collections from the upstream end of Stag Island also had the only detectable hexachlorobenzene (0.002 to 0.032 μg/g), which was found in all species sampled, and the highest mean concentrations of octachlorostyrene (0.002 to 0.127 μg/g), also found in all species at this site (**Table 26**).

Fish tissue was also tested for a number of additional pesticides and organic contaminants not shown in **Table 26.** The pesticides heptachlor, aldrin, α-BHC, γ-BHC, ß-BHC, o,p-DDT and toxaphene were not detected in any of the three fish collections from the St. Clair River. Other organic contaminants tested for include: 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, 2,3,4-trichlorophenol, 2,3,5,6-tetrachlorophenol, 2,3,4,5-tetrachlorophenol, pentachlorophenol, hexachloroethane, 1,3,5-trichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobutadiene, 1,2,3-trichlorobenzene, 2,4,5-trichlorotoluene, 2,3,6-trichlorotoluene, 1,2,4,5-tetrachlorobenzene, 1,2,3,4-tetrachlorobenzene and pentachlorobenzene. Except for hexachlorobutadiene and pentachlorobenzene these organic contaminants were not detected in St. Clair River sport fish (Appendix 5). Hexachlorobutadiene was detected in one carp sample (0.003 μg/g) and two walleye samples (0.004 and 0.035 μg/g) from the collections taken at Stag Island. One walleye caught at Port Lambton contained 0.002 μg/g hexachlorobutadiene. One walleye sample from the Stag Island collection detected a small amount of pentachlorobenzene (0.003 μg/g).

Fish collected during 1991 were subsequently analyzed for the presence of Dioxins and Furans following publication of the 1992 Guide to Eating Ontario Sport Fish. This information was recently reported in the 1993-1994 "Guide" identifying the presence of dioxins and furans in a Carp specimen (65-75 cm) exceeding the guideline of 15 parts per trillion (based on the 2,3,7,8-TCDD toxicity equivalency).

St Clair RAP Addendum Contents

Biota

Fish

Lambton Industrial Society Biomonitoring Program

From 1989 through 1992 the Lambton Industrial Society conducted a multi-species bioassay study in order to determine the effect of discharges from the industrial chemical complexes at Sarnia. In-situ monitoring included the use of rainbow trout (*Oncorhynchus mykiss*) eggs for determining hatchability success from the green to swim-up stage; *Daphnia magna* and *Daphnia pulex* life-cycle testing for determining survival and reproductive rates; and fathead minnows (*Pimephales promelas*) for determining fecundity rates. Biomonitoring stations were located at Point Edward, upstream of urban and industrial discharges, and south of Courtright, downstream of the industrial complexes at the same location as the LIS continuous river monitor.

Differences in survival and reproductive rates of *Daphnia magna* and *Daphnia pulex* were not detected between the upstream and downstream stations (Moran *et al.* 1992a). Fecundity rates, monitored in fathead minnows also did not show differences between the biomonitoring stations (Moran *et al.* 1992b).

Rainbow trout eggs, determined to be the most sensitive test material, showed a significant difference existed each year in survival between the stations. Eggs raised at the upstream station had better survival than their downstream counterparts.

The LT25 is the exposure time required to reach 25% mortality in the sample population of rainbow trout eggs. The longer the time required to reach the LT25, the better the water quality. This measure of survival did not detect a difference in LT25 values between stations in 1989. In 1990 eggs at the upstream station required 9 days more than those at the downstream station to reach the LT25, and during 1991, upstream eggs required 13 days more. Preliminary results from 1992 showed a survival rate of 85% at both stations and an LT25 rate could not be calculated.

Moran *et al.* (1992b) concluded that the multi-species biomonitoring results indicated that yearly events and not trends are being evaluated in the St. Clair River. This conclusion is supported by the results of the rainbow trout egg studies where comparable survival rates were recorded in 1990 and 1991 and better rates occurred in 1989 and 1992.

St Clair RAP Addendum Contents

Biota

Fish

Contaminants in Forage Fish, 1991

In 1991, young-of-the-year spottail shiners were collected in order to re-evaluate lead availability in the St. Clair River at Ethyl Corp. Total lead residues in shiners from the 1991 collections were similar to lead concentrations found in young-of-the-year yellow perch in 1984 (K. Suns pers. comm. to D. Veal 1992). A rigorous statistical comparison is not possible due to the potential species-specific differences in lead uptake however, results are consistent with those in 1984. Shiners collected in 1991 downstream of Ethyl Corp. had significantly higher ($p<0.05$) lead residues than any other collections from the river (**Figure 10**). Suns (1992) concluded that lead inputs from Ethyl Corp. had not changed much in the six year period from 1984 to 1991.

A summary of contaminant concentrations in spottail shiner collections from 1985 through 1991 is presented in **Table 27.** Shiner residue data from the Lambton Power Generating Station indicates that PCB, hexachlorobenzene and octachlorostyrene availability in the St. Clair River has declined. Although PCB residue trends in shiners were not significantly ($p>0.05$) correlated with time, 1991 residue levels are considerably lower than those from the 1980s (**Table 27**) (K. Suns pers. comm. to D. Veal 1992). Both hexachlorobenzene and octachlorostyrene declines over time were found to be significant ($p<0.05$) (K. Suns pers. comm. to D. Veal 1992). Suns (1992) concluded that because the Lambton Generating Station is downstream from the Sarnia industrial complex, forage fish collections at the station provide a good basis for detecting environmental change in the St. Clair River.

Figure 10 Total lead residues in juvenile yellow perch collected in 1984 and juvenile spottail shiners collected in 1991 in the St. Clair River. Values represent composite fish analyses (ng/g), wet weight of means and standard deviation (±) (K. Suns pers. comm. to D. Veal 1992).

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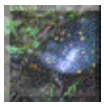

Sources

This section is an update of the "Chapter 8: Sources" from the St. Clair River Remedial Action Plan, Stage 1 (OMOE and MDNR 1991).

Updated information includes:

- preliminary results from OMOE's "Report on the 1990 Industrial Direct Discharges in Ontario" (OMOE 1992a) self monitoring data. Gross annual average loadings for each industry discharging to the St. Clair River Area of Concern are updated in this section;
- Loadings have been updated and summarized using the draft Twelve Month Monitoring Data Report for the Organic Chemical Manufacturing Sector, October 1, 1989 through March 31, 1990;
- Loadings have been updated and summarized using the draft Twelve Month Monitoring Data Report for the Inorganic Chemical Sector, December 1, 1989 to November 30, 1990 and February 1, 1990 to January 31, 1991;
- Ontario spill prevention strategy;
- Air quality monitoring on Walpole Island as a result of the Detroit Incinerator Monitoring Program;
- LIS air quality monitoring data for Sarnia/Chemical Valley; and
- MDNR toxicity/plume studies.

For more information, select one of the following topics:

1990 Industrial Direct Discharge Self Monitoring Data
Loadings Update From Major Point Sources in Ontario
Spill Prevention Strategy (SPS)
Air Quality Monitoring
Michigan Sources Update

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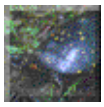

Sources

1990 Industrial Direct Discharge Self Monitoring Data

1984 through 1990 net discharge data (self monitoring data as reported in the OMOE Industrial Dischargers Report) are reported for regularly monitored parameters (industry-specific).

The majority of the companies converted to MISA monitoring as of October 1989 using "gross" loadings and should not be compared to the net loadings of previous years. The reported increase in loadings does not imply a decrease in effluent quality nor an increase in loading to the river. Rather it reflects a change in the method of calculating the loadings.

Industry-specific loadings for regularly monitored parameters were, for the majority of the companies, reported as net loadings in the Stage 1 Remedial Action Plan. Net loadings were generally not available for most facilities, however, in some cases gross loadings for years previous to 1989 were reported and are included for comparison.

For more information, select one of the following topics

Petroleum Sector
Organic Chemicals Sector
Inorganic Chemicals Sector
Thermal Generating Sector

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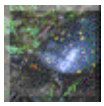

Sources

1990 Industrial Direct Discharge Self Monitoring Data

Petroleum Sector

Esso Petroleum Canada, Sarnia

Provincial, 1990 self monitoring data for Esso Petroleum is shown in **Table 28.** These data include the annual average gross loadings in kg/day and the number of monthly exceedences in parenthesis.

Esso Petroleum was in was in full compliance with provincial guidelines for all monitored parameters (**Table 28**).

Novacor Chemicals (Canada) Ltd., Corunna

Provincial, 1990 self monitoring data for Novacor Chemicals, Corunna is shown in **Table 29.** These data include the annual average gross loadings in kg/day and the number of monthly exceedences in parenthesis.

Novacor Chemicals, Corunna was in was in full compliance with provincial guidelines for all monitored parameters in 1990 (**Table 29**).

Sarnia Manufacturing Centre, Shell Canada Products Limited

Loading data for regularly monitored parameters at Shell Canada Products is shown in **Table 30.** These data include the annual average gross loadings in kg/day and the number of monthly exceedences in parenthesis.

Shell Canada Products was in was in full compliance with provincial guidelines for all monitored parameters in 1990 (**Table 30**).

Suncor Inc., Sarnia

Provincial, 1990 self monitoring data for Suncor Inc., Sarnia is shown in **Table 31.** These data include the annual average gross loadings in kg/day and the number of monthly exceedences in parenthesis.

Suncor Inc., Sarnia was in was in full compliance with provincial guidelines for all monitored parameters except ammonia-nitrogen (NH^3-N) (**Table 31**). The ammonia-nitrogen guideline was exceeded in the month of October, 1990. This exceedence was due to mechanical problems at the sour water/ammonia stripper, during start-up of Plant #1. To correct the problem, Suncor Inc. modified the sour water/ammonia stripping system (C. of A. 4-074-85-866). Modifications were complete in March, 1991.

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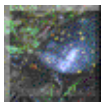

Sources

1990 Industrial Direct Discharge Self Monitoring Data

Organic Chemicals Sector

Dow Chemical Canada Inc., Sarnia Division

Regularly monitored parameters and gross loadings for Dow Chemical in 1989 and 1990 are shown in **Table 32.** The gross total loading represents the combined loadings from all seven outfalls.

Dow Chemical has been in compliance with its monthly objectives in both 1989 and 1990 (**Table 32**). Total average daily flow increased by 27% from 762,666 m^3/day in 1989 to 964,216 m^3/day in 1990. Loadings of total phenols and total organic carbon also increased from 1989 to 1990 however, loadings of suspended solids decreased (**Table 32**).

The data for 47 of 48 trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated all five combined final effluent discharges were not acutely lethal to test fish. The remaining sample produced a 96 hour LC50 of >100% effluent. Five audit samples tested by OMOE were also determined non-lethal (OMOE 1992a).

Twelve trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated both OT cooling water discharges were not acutely lethal to test fish. Two audit samples were also determined non-lethal (OMOE 1992a).

From April through September 1990, under the MISA monitoring regulation, a total of forty-two *Daphnia magna* lethality toxicity tests were conducted on effluent from Dow Chemical. Of the thirty-three samples taken at the five combined effluent discharge points twenty were not acutely lethal, and the remaining thirteen had an LC50 of >100%. Six samples taken from the OT cooling water were non-lethal. Five of six process effluent samples were non-lethal and one had an LC50 of >100% (Lee *et al.* 1992).

DuPont Canada Inc., Corunna

Gross loading data for regularly monitored parameters at DuPont, Corunna are shown in **Table 33.** These data include annual averages with the number of monthly exceedences in parenthesis. There were no exceedences during 1990.

Effluent was in compliance with the monthly flow based guideline for total phenols during 1990. Nine trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated that combined effluent was not acutely lethal to test fish. An OMOE audit sample confirmed this result (OMOE 1992a). Six *Daphnia magna* acute lethality toxicity tests of combined effluent collected from April through September 1990 were not acutely lethal (Lee *et al.* 1992).

Esso Chemical Canada, Sarnia

Loading data for regularly monitored parameters at Esso Chemical Canada are shown in **Table 34.** These data include the 1990 annual averages with the number of monthly exceedences in parenthesis.

There were no loading exceedences during 1990 (**Table 34**). Ten trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated the combined effluent was not acutely lethal to test fish (OMOE 1992a). Six *Daphnia magna* acute lethality toxicity tests of combined effluent collected from April through September 1990 were not acutely lethal. A Ministry audit sample collected in May 1990 was also non-lethal (Lee *et al.* 1992)

Ethyl Canada Inc., Corunna

Loading data for total lead from Ethyl Canada Inc., Corunna are shown in **Table 35.** These data include the annual averages (all years are gross data) with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1990.

Flow and loadings of total lead decreased slightly between 1989 and 1990. There were no monthly exceedences in 1990 (**Table 35**). Nine trout bioassays submitted to OMOE in 1990 under MISA monitoring regulation indicated the combined effluent was not acutely lethal to test fish. An OMOE audit test confirmed this result.

Six *Daphnia magna* acute lethality toxicity tests were conducted on combined effluent collected from April through September 1990 at Ethyl Canada. Two of the six samples were not acutely lethal to *Daphnia magna*. Three samples were acutely lethal. The percentage of effluent required to kill 50% of the *Daphnia magna* by the end of a two day exposure were 32.2%, 18.9% and 15.0%. One sample had an LC50 of >100%. A Ministry audit sample, collected in June, was non-lethal (Lee *et al.* 1992).

Novacor Chemicals (Canada) Ltd., Mooretown

Loading data for regularly monitored parameters at Novacor Chemicals Ltd. are shown in **Table 36.** These data include the annual averages (all years are gross data) with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1990.

Novacor is subject only to Provincial effluent guidelines. Compliance has been interpreted in terms of: 15 mg/L suspended solids; and 1.0 mg/L total phosphorus. Effluent was in compliance with these objectives on an annual average basis for 1984. Since 1985, compliance has been on a monthly average basis. **Table 36** shows that Novacor has had repeated exceedences of the suspended solids guideline. Novacor has taken measures to further reduce its discharge of suspended solids. This is reflected in the 1989 loadings which were lower than in any previous year. 1990 loadings have remained relatively consistent with those in 1989 however, the number of total suspended solid exceedences increased in 1990 (**Table 36**). There are no clear trends over time for total organic carbon or TKN, however, loadings of total phosphorus were approximately half in 1987-1990 when compared to previous years (**Table 36**).

Nine trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated that the combined effluent was not acutely lethal to fish. An OMOE audit sample confirmed this result (OMOE 1992a). Six *Daphnia magna* acute lethality toxicity tests of combined effluent collected from April through September 1990 were not acutely lethal. A Ministry audit sample collected in July 1990 had a LC50 >100% (Lee *et al.* 1992).

Polysar Rubber Corporation/Novacor Chemicals (Canada) Ltd., Sarnia

Gross loading data (1990) for regularly monitored parameters at Polysar/Novacor, Sarnia, are shown in **Table 37.** OMOE's Industrial Discharge Report combine the four outfalls discharging treated wastewater into one table in order to determine total loadings from Polysar/Novacor, Sarnia.

There were no monthly exceedences during 1990 (**Table 37**). Eight of nine trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated the combined #200 effluent to have been not acutely lethal to test fish. However, the remaining sample was determined to have been acutely lethal. Statistically, the percentage effluent required to kill 50% of the test fish by the end of the four day of exposure was 3.2% (OMOE 1992a). An OMOE audit sample was determined not to be acutely lethal (OMOE 1992a).

Nine trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated the combined #400 effluent to have been not acutely lethal to test fish. An OMOE audit sample confirmed this result (OMOE 1992a).

Forty *Daphnia magna* acute lethality toxicity tests were conducted on effluent collected between April and September 1990. Samples were collected from four combined effluent discharges, two once through cooling water discharges, one batch and one process effluent discharge. Nineteen of the twenty-four combined effluent samples were not acutely lethal to *Daphnia magna* and the remaining five samples produced 48 hour LC50s >100% effluent (Lee *et al.* 1992). An audit sample collected from the combined effluent discharge #200 by the Ministry in April, was lethal to *Daphnia magna* with the statistical percentage effluent required to kill 50% of the *Daphnia magna* by the end of two days at 66.6% (Lee *et al.* 1992). All OT cooling water and batch effluent samples were non-lethal. Three of six process effluent samples were non-lethal, while the remaining six had a 48 hour LC50 >100% (Lee *et al.* 1992).

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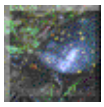

Sources

1990 Industrial Direct Discharge Self Monitoring Data

Inorganic Chemicals Sector

Fiberglas Canada Inc., Sarnia

Loading data for formerly regularly monitored parameters at Fiberglas Canada Inc., are shown in **Table 38.** These data include the annual averages (all years are gross data) with the number of monthly exceedences in parenthesis for the monitored parameters, from 1985 through 1990. The Fiberglas Canada Sarnia facility closed and ceased production in May, 1991.

Fiberglas Canada was in exceedence for total phenols during two months in 1985 and for two months in 1988. The average annual total phenol loading decreased in 1989 to a level less than one-half of the previous years however, it increased slightly in 1990 (**Table 38**). Fiberglas was in compliance for total phenols during all months in 1989 and 1990 (**Table 38**).

Nine of eleven trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated the main effluent was not acutely lethal to test fish. The remaining samples resulted in 96 hour LC50s >100% effluent (OMOE 1992a). An OMOE audit sample was determined to be non-lethal (OMOE 1992a).

ICI Nitrogen Products, Courtright

Loading data for regularly monitored parameters at ICI Nitrogen Products, Courtright, are shown in **Table 39.** These data include the annual gross averages with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1990.

ICI's Control Order was revoked in 1987 (dinitrotoluene was not to be discharged), however, **Table 39** shows that ICI was in full compliance with its guidelines for dinitrotoluene, fluoride, ammonia-nitrogen, nitrite + nitrate and total phosphorus based on annual averages for 1984 and has continued to be in compliance with monthly averages from 1985 through 1990. Average annual loadings of ammonia-nitrogen, total phosphorus and nitrate plus nitrite all decrease by about one-half in 1988-89 compared to earlier years.

In 1990 effluent flow decreased by more than half however, annual average loadings of total ammonia-nitrogen, nitrite + nitrate and total phosphorus increased (**Table 39**). There were no exceedences in 1990. Eleven trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated that plant effluent was not acutely lethal to test fish. OMOE audit samples confirmed this result (OMOE 1992a).

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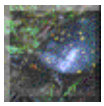

Sources

1990 Industrial Direct Discharge Self Monitoring Data

Thermal Generating Sector

Ontario Hydro Lambton Thermal Generating Station, Courtright

Gross annual average (1990) loading data for regularly monitored parameters at the Ontario Hydro Lambton Thermal Generating Station, Courtright, are shown in **Table 40.** These data include the annual net averages with the number of monthly exceedences in parenthesis for the monitored parameters in 1990.

There were no exceedences in 1990. Two trout bioassays submitted to OMOE in 1990 under the MISA monitoring regulation indicated the CCW-outfall effluent was not acutely lethal to test fish (OMOE 1992a).

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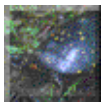

Sources

Loadings Update From Major Point Sources in Ontario

The following is an update of Section "8.2.4.1.7 Results of Point Source Surveys for Ontario Industrial Point Sources" from the St. Clair River Area of Concern, Remedial Action Plan, Stage 1.

Data reviewed in this section include the results of four specific point source surveys conducted from 1985 to 1991. These surveys generally included a wide variety of organic parameters and metals which are not regularly monitored as requirements of Control Orders or Certificates of Approval. MISA monitoring data are the most recent, the most intensive with regard to sampling frequency, and the most extensive with regard to numbers of parameters analyzed. Recent data from the MISA Twelve Month Organic and Inorganic Chemical Manufacturing Sectors are included in this section.

Table 41 compares data from four separate surveys. The 1985 data were collected and reported by Environment Canada and OMOE (Environment Canada/OMOE 1986); the 1986 data were collected by the Point Source Workgroup of the UGLCCS (1988); the 1986/87 data were collected under the MISA St. Clair River Pilot Site Investigation (OMOE 1990b); and the 1989/91 data are those of the draft MISA Twelve Month Monitoring Study for the Organic and the Inorganic Chemicals Sector. Net results reported in **Table 41** for the 1989/91 MISA monitoring were calculated through a simple subtraction of intake loads from outfall loads. A more sophisticated algorithm will be used in the calculation of "net" loads for identifying current and projected loads during the remediation process. Methods to calculate "net" loads must respect the need for a similar sampling frequency on intakes as on discharges. Those facilities which do not have comparable intake/outfall data will be required to report "gross" loadings. In addition, methods for the calculation of "net" loads will be reviewed by Agency staff for their suitability.

The 1985 data were collected in late November under a cooperative federal/provincial effort established specifically to address the issue of the perchloroethylene/carbon tetrachloride puddles found during the summer of 1985 along the bed of the St. Clair River offshore of Dow Chemical (Environment Canada/OMOE 1986). The point source survey was limited to single samples collected at the outfall of the Cole Drain, at each of the major Dow sewers, Esso Petroleum, Esso Petrochemical, Scott Road Landfill, Sarnia WPCP and each major Polysar/Novacor sewer. Analyses were undertaken for several volatile organic and chlorinated organic compounds known to be discharged by local industries (**Table 41**). The results of this study indicated that loadings of toxic organic contaminants were lower than those of 1979/80. UGLCCS (1988) included point source sampling of 16 major industries in the Sarnia area as well as U.S. and Canadian WPCPs. The point source data collected at Canadian facilities were collected during 3 to 6 day surveys carried out in May, June and September to December 1986.

The final UGLCCS report noted that industrial loadings were greater than municipal loadings for most parameters studied. The predominant sources were the petrochemical plants in the 'Chemical Valley' area south of Sarnia, Ontario. The majority of the sources were located in the upper 10 km (6.2 mi) of the St. Clair River. These industrial sources were found to be the source of the majority of the loadings of hexachlorobenzene, octachlorostyrene, PAHs, oil and grease, lead, mercury, copper, nickel, cobalt, iron, chromium, chlorides, total organic carbon (TOC), total suspended solids (TSS), and a spectrum of organic contaminants including volatile hydrocarbons, as well as acid and other base neutral extractables. In terms of effluent loadings, the following Ontario facilities were considered to be the principal contributors of one or more of the parameters studied (**Table 41**).

Sarnia WPCP -phenols, nickel, phosphorus, ammonia,cadmium and zinc.
Cole Drain -PAHs, oil and grease, and cyanide.
Polysar/Novacor-benzene, phenols, cobalt, and ammonia.
Dow Chemical-hexachlorobenzene, octachlorostyrene, PCBs, copper, mercury, and volatiles.
Suncor -volatile aromatics (associated with a process upset at the time of the survey).

Ethyl Canada -lead, mercury, volatiles (chloroethane).
ICI -iron, TSS, and chromium.

The MISA Pilot Site Investigation was conducted between May 1986 and March 1987 (OMOE 1990) investigated the presence and effects of 66 organic compounds and metals in the final discharges from six sewers at Dow Chemical Canada Inc., two outfalls at Polysar/Novacor (Sarnia) and the Cole Drain (**Table 41**).

The MISA Pilot Site Investigation focused its analysis and recommendations on eight 'parameters of potential concern': carbon tetrachloride; tetrachloroethylene; hexachlorobenzene; hexachlorobutadiene; hexachloroethane; octachlorostyrene; 2,4,5-trichlorotoluene and mercury. These chemicals were chosen on the basis that they are intermediate, or end products from organic chemical manufacturing processes; are consistently detectable in effluents discharging to the St. Clair River; and most tend to bioaccumulate in aquatic organisms and have demonstrated potential mutagenic or carcinogenic activity in laboratory experiments (OMOE 1990). Linkages and potential linkages between their discharge and aquatic ecosystem effects (water, biota and sediment) were investigated using field studies. Effluent limits (load allocations) for these eight parameters were established through the use of chemical fate and transport modelling (WASTOX - Water Quality Analysis Simulation for Toxics), other sophisticated mathematical models and comprehensive sample collection.

In comparing the 1986/87 gross loadings data with the 1985 results, it is evident that reductions had occurred for all organic parameters and mercury at all sources with the exception of the Cole Drain. Loadings of seven organic chemicals from this source were higher during 1986/87 than during 1985 (**Table 41**). The most notable reductions were observed for 1,1,2-trichloroethane, carbon tetrachloride, tetrachloroethylene, total volatiles and hexachlorobenzene at Dow Chemical as well as benzene at Polysar.

The report provided conclusions and recommendations with regard to waste load allocations, including mixing zone criteria; long term effluent monitoring; sampling and analytical methods based on the character of the effluents; and water, sediment and biomonitoring sampling protocols and conditions (OMOE 1990).

The proposed allowable chemical-specific load allocations resulting from this study required reductions varying from not exceeding the loadings measured in 1986-87 to a 99.8 percent reduction for octachlorostyrene at the Cole Drain. Recommended reductions for the overall Dow complex were identified for hexachlorobenzene, 75 percent; octachlorostyrene, 99 percent; tetrachloroethylene, 39 percent; and hexachlorobutadiene, 13 percent (OMOE 1990b).

Extensive effluent monitoring undertaken during the 1986/87 MISA Pilot Site Investigation indicated that most effluent sewers demonstrate highly variable effluent quality, with occasional peak discharges accounting for disproportionately high fractions of annual loadings. As a result, this study recommended that remedial actions should focus on minimizing this variability, thereby assisting in achieving compliance with effluent guidelines (OMOE 1990b).

Data from the twelve month MISA Monitoring Study of the Organic Chemicals Sector cover the period October 1, 1989 to July 31, 1991. The study monitored 156 parameters at all outfalls for Akzo, BASF, Chinook, Dow Chemical, DuPont, Esso Chemical, Ethyl, Novacor Chemicals (Mooretown), and Polysar/Novacor. Influent water was also monitored at all facilities except Akzo and Ethyl. Results for most of those parameters found in effluent are shown as gross and/or net loadings in **Table 41.** Individual site parameter totals ranged from 79 parameters at Dow Chemical to only 3 parameters at Akzo Chemicals.

In the 1989/1991 MISA study, concentration values reported as "less than" or at the regulation method detection limit (RMDL) were assigned the value of the detection limit for the purposes of calculating averages. Concentration values less than RMDL/10 were converted to RMDL/10 for use

in the calculation of averages. Because concentration values coded as "less than the method detection limit" can also mean that the parameter was not found, the use of the detection limit substitution for a large number of "less than detection" values may result in averages and hence loadings biased on the high side. In addition reportable loadings result from concentrations around RMDL values when high flows are present. A substitution of zero for values reported as "less than the method detection limit" was rejected by MISA because of the downward bias on the averages. Daily (gross) loadings were calculated as the product of daily flow and daily concentration. Twelve month average (gross) loadings were calculated by summing daily data over the twelve month period and dividing by the number of results. Intake sampling was less rigorous with samples being taken once a month or less. Intake loadings were calculated as the product of intake water flow and concentration. If intake water flow was not provided then the intake loading was calculated as a product of concentration and the corresponding daily plant effluent flow. If the total plant effluent flow was available only monthly, intake loading was calculated as the product of the average twelve month concentration and flow. Net MISA 1989/1991 loadings presented in **Table 41**, were calculated through a subtraction of intake loads from outfall loads for comparison with data collected in previous studies (1986 and 1986/87 studies). As noted earlier, methods to calculate "net" loadings must respect the need for a similar sampling frequency on intakes and outfalls. The MISA issues resolution document suggests that to scientifically support a net loading concept for process effluent outfalls, a mass balance approach needs to be applied to all influent and effluent streams.

In addition to the parameters shown in **Table 41**, polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were also found at Dow Chemical, Chinook Chemicals and DuPont (OMOE 1992b). The highest concentrations at Dow and Chinook exceeded the Ontario Drinking Water Standard of 15 pg TEQ/L of PCDD and PCDF in the final discharges. The Toxic Equivalent (TEQ) value is based on the concentration of all PCDDs and PCDFs converted to their toxic equivalent if all dioxins and furans were present in the tetrachlorodibenzo-p-dioxin form. Total net loadings of dioxins and furans (as TEQ) were as follows: Chinook Chemicals, 0.01 kg/d; Dow Chemical, 40.93 kg/d; and DuPont, 1.70 kg/d.

The 1989-1991 loadings data confirm the trend toward reduced loadings at all facilities within the St. Clair River AOC (**Table 41**). Loadings of total volatiles at Polysar appear to have increased in 1989-1991 (**Table 41**) however, loadings cannot be compared because the constituent compounds comprising "total volatiles" are different for each of the surveys. **Table 41** also indicates that the volatile compounds 1,1-dichloroethane, 1,2-dichloroethane, 1,1,2-trichloroethane, carbon tetrachloride and tetrachloroethylene at Polysar all appear to have increased loadings between 1986-1987 and 1989-1991. This increase may not be real and is likely a function of the method used to calculate loadings in the MISA 1989-1991 survey. Concentration levels for these volatiles were either slightly above, equal to, or below their corresponding RMDL (Tuszynski 1992). Tuszynski (1992) cautions that a large number of concentration levels around the RMDL together with high flows will result in loadings that are biased high.

The net 1989-1991 Dow loading for tetrachloroethylene was higher than the gross loading in 1986/87. Other parameters which were reported higher in the 1989-1991 net data as compared to the 1986 net data are total PAHs at Ethyl and total nickel (order of magnitude increase) and total zinc (approximately 9 times higher) at Dow Chemcial.

Based on the net data for 1986 as compared to the 1989-1991 data, there are significant reductions in volatiles and chlorinated organics from Dow Chemical. In particular, net loadings of total volatiles (likely mostly associated with chloroethanes and carbon tetrachloride), hexachlorobenzene and octachlorostyrene have decreased one third to over 90 percent.

Reductions in loadings have also occurred in effluent from the Cole Drain for most chlorinated hydrocarbons as well as phenolics, oil and grease, and cadmium. The reduction in octachlorostyrene in effluent from the Cole Drain also appears to have exceeded the level recommended in the MISA Pilot Site Investigation report (see above). Most volatile organics, including 1,2-dichlorothane, 1,1,2-trichloroethane, benzene, and carbon tetrachloride, were much higher at the Cole Drain in the

more recent studies as compared to the 1986/87 data. Total volatiles were approximately twice as high. However, these values are all well below the 1985 study results.

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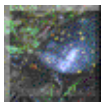

Sources

Spill Prevention Strategy (SPS)

In order to limit and prevent accidental spills to the environment, as required under the *Environmental Protection Act*, the Ontario Ministry of the Environment has developed a comprehensive program referred to as the Spills Prevention Strategy. As part of this strategy, OMOE encourages companies with the potential for spills to develop spill contingency plans. Many companies have taken direct steps to establish cleanup procedures, stockpile equipment, train their spill response staff or in some cases, retain the services of a cleanup contractor. In some situations the Ministry may order potential spillers to install spill detection equipment and spill prevention equipment and to develop spill contingency plans.

OMOE's Spill Prevention Strategy requirements for chronic spillers to develop spill control plans are as follows:

(1) Spill Detection
- know when a spill occurs;
- develop an alerting system; and
- awareness for the "detection" of a spill.

(2) Spill Containment/Diversion Facilities
- collect, treat and dispose;
- prevent off-site impacts;
- catchment areas;
- sorbants; and
- diversion weirs and spill ponds.

(3) Spill Response Plans
- pre-plan for quick response;
- mobilize from lowest possible level in organization (i.e. unit operator);
- emergency response equipment;
- identification and quantification;
- notification requirements; and
- guidelines/practices available from agencies (CSA, OMOE, etc.) and industry associations.

(4) Environmental Awareness Training
- environmental responsibility;
- consequences of spills/discharges;
- response actions and expectations; and
- incorporate into operating practices and training.

(5) Spill Risk Assessment
- review spill history;
- identify high risk areas, combinations, scenarios (*e.g.*, acids in type "ABC" pumps;
- review handling and management practices; and
- set priorities for corrective and preventative measures.

The overall aim of the strategy is to prevent spills to the environment. This is to be accomplished by undertaking on-site plant modifications as necessary and providing adequate education and training to employees. Prevention includes ensuring the spill does not occur in the first place but when it does, ensuring all emergency identification and containment is in-place.

Industry Response

Individual companies within the St. Clair River Area of Concern have developed spill response programs including on-site personnel and equipment. The specific capabilities of 24 major facilities are identified in Appendix 6. These spill response and prevention summaries (Appendix 6) were compiled by the Sarnia OMOE District Office (OMOE 1992d). Of the 24 facilities surveyed by OMOE, 23 have developed specific spill response programs. All 24 companies have on-site personnel and equipment to respond to spill emergencies (Appendix 6).

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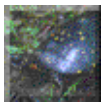

Sources

Air Quality Monitoring

- ***Walpole Island Monitoring Station***
- ***Lambton Industrial Society Sarnia Air Monitoring Program***

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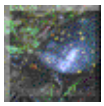

Sources

Air Quality Monitoring

Walpole Island Monitoring Station

In 1986, the Greater Detroit Resource Recovery Authority (GCRRA) began construction of a municipal waste incinerator in downtown Detroit. Because this facility was located only 6 km fro the Canada-United States border and since pollution control equipment consisted of electrostatic precipitators rather than wet/dry srubber-fabric filter combinations which is considered to be the best available technology, public concerns were raised regarding the potential impacts of the incinerator on air quality in Windsor and the surrounding area.

In response to these concerns, Environment Canada in cooperation with OMOE and the Walpole Island Band/Council set up an air quality monitoring network with two stations located in Windsor (Windsor-July 7, 1987; and Windsor 2-May 1990) and one on Walpole Island (January 1988) in Lake St. Clair. Ambient air quality monitoring began prior to the operation of the incinerator. Combustion of the GDRRA plant began in December 1988. The most recent results of the air monitoring program (July 1987 to October 1990) are reported in Environment Canada (1991). Dann (1992) summarizes the monitoring data for the same period and provides an evaluation of impacts of the incinerator on air quality at the Windsor and Walpole Island monitoring sites.

The incinerator consistently failed to meet the mercury emission limits set out in the facility construction permit. The facility was shut down from February 1989 to April 28, 1989. It has since been operating at 45% capacity from May 1989 through December 1991 while being retrofitted with the best available technology.

Air quality monitoring station locations are shown in **Figure 11.** Ambient air is measured for polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated benzofurans (PCDF), polychlorinated biphenyls (PCBs), chlorinated benzenes (CB), chlorinated phenols (CP), polycyclic aromatic hydrocarbons (PAH), volatile organic compounds (VOC), inhalable particulate (IP) matter and associated inorganic compounds. Samples were normally collected over a 24 hour period (midnight to midnight). At both sites (Walpole and Windsor) dioxin/furan samples were collected for a 48 hour sampling period beginning in September 1988. PAH/CP/CB/PCB samples taken on the same date were also collected over 48 hour periods.

The Windsor area monitoring effort is the most comprehensive toxics sampling program currently underway in Canada. This is the first time that many of the compounds measured have been identified and quantified in both rural and urban areas. Because data are available over a three to four year period, short term air toxics trends can be examined.

Measured concentrations for all parameters from both the Windsor and Walpole Island monitoring stations (1987 through 1990) are provided in Appendix 7. Contaminant loadings have not been calculated for the incinerator survey. In addition, Dann (1992) concluded that, based on two and one half years data collection, the impact of the Greater Detroit Resource Recovery Centre on measured pollutant concentrations at the Walpole Island monitoring site could not be conclusively determined.

Dioxins and Furans

At both the Windsor and Walpole Island sites the 2,3,7,8 substituted dibenzofurans accounted for over 70% of the computed TEQ. These included 2,3,4,7,8-pentachloro dibenzo-p-dioxin, 2,3,7,8-tetrachloro dibenzofuran and 1,2,3,4,7,8-hexachloro dibenzofuran (Appendix 7, Tables 7 and 8). The isomer 2,3,7,8-TCDD was detected in 12 out of 17 samples at Windsor with a mean concentration of 11 fg/m^3 and 4 out of 10 samples at Walpole Island with a mean concentration of 2 fg/m^3. This isomer distribution pattern is similar to that measured in Los Angeles and other urban areas (Dann 1992).

Figure 11 Air quality monitoring station locations in Windsor and Walpole Island. Monitoring commenced in July, 1987 (Dann 1992).

In general, total dioxin and furan concentrations in ambient air at Walpole Island were a factor of eight lower than at Windsor. For the period May 1989 to 1990 the mean TEQ concentration at Windsor was 0.17 pg/m^3 and at Walpole Island it was 0.03 pg/m^3.

Polycyclic Aromatic Hydrocarbons (PAH)

Concentrations of 28 different PAH compounds were measured at the two sites (Appendix 7, Tables 10 and 11). At the Windsor site, phenanthrene, fluoranthene and pyrene had the highest mean concentrations and were found predominantly in the vapour phase. Walpole Island PAH concentrations were typically an order of magnitude lower than those measured at Windsor, although most of the compounds were detected on most sampling days. The mean benzo(a)pyrene concentrations at Windsor and Walpole were 0.58 ng/m^3 and 0.08 ng/m^3 respectively. Trends or seasonal patterns were not observed in the Walpole data. The highest 24 hour benzo(a)pyrene concentration recorded at Walpole Island occurred on June 16, 1990.

Polychlorinated Biphenyls (PCBs)

Mean total PCB concentrations at the Windsor site were 0.45 ng/m^3 with most isomer groups found below detection in most samples. An abrupt decrease in PCB concentrations occurred at the beginning of August 1989 (Appendix 7, Table 12, Figure 11). Prior to this time, average PCB concentrations were 0.65 ng/m^3 with tri-chlorobiphenyl detected in most samples.

At the Walpole Island site, most samples had no detectable PCBs. The mean total PCB concentration was 0.07 ng/m^3.

Chlorobenzenes (CB)

The mean total chlorinated benzene concentration was 2.6 ng/m^3 at the Windsor site with trichlorobenzene accounting for 80% of the total. At the Walpole site the mean total chlorobenzene concentration was 1.5 ng/m^3.
Hexachlorobenzene, is potentially the most toxic of the chlorinated benzenes. Mean hexachlorobenzene concentrations at both the Walpole and Windsor site were the same, at 1.3 ng/m^3 (Appendix 7, Tables 12 and 13).

Time series plots shows that a decrease in total chlorobenzenes occurred at both sites at the same time of the PCB decrease recorded at Windsor (August 1989) however, the magnitude of the chlorobenzene decrease was smaller (Appendix 7, Figures 11 and 12).

Chlorophenols (CP)

The mean total chlorinated phenol level was 2.0 ng/m^3 at the Windsor site and 1.3 ng/m^3 at the Walpole Island site. At Windsor, pentachlorophenol was measured in the highest concentrations while at Walpole Island, dichlorophenol was found in the highest concentrations. Mean pentachlorophenol concentrations were 0.88 ng/m^3 at Windsor and 0.36 ng/m^3 at Walpole. Concentrations of chlorinated phenols reached their maximum in the summertime at both sites.

Volatile Organic Compounds (VOC)

Concentrations of aromatic hydrocarbon species at Windsor were 3 to 4 times higher than concentrations at Walpole Island however, levels of a number of chlorinated species such as

chlorobenzene, chloroform, and carbon tetrachloride at Walpole Island were equal to concentrations found at Windsor (Appendix 7, Tables 14 and 15). These chlorinated compounds have few local sources, very long lifetimes in the atmosphere and are found at almost equal concentrations across the globe (Dann 1992).

A number of VOC compounds are suspected or recognized human carcinogens (Dann 1992). These compounds include benzene, 1,3-butadiene, dichloromethane, carbon tetrachloride, trichloroethylene and tetrachloroethylene. At the Windsor site, seasonal variations were observed for benzene however, the season with the highest concentration varied from year to year (Appendix 7, Figure 15). The highest average benzene concentrations at Windsor were measured in the summer and fall of 1987. Average benzene concentrations at Walpole Island showed little variation.

Inhalable Particulate Matter and Associated Elements and Ions

A total of 40 elements plus sulphate and nitrate were determined for the fine (<2.5 μm) and course (2.5-10 μm) fractions of particulate matter. Of the elements measured, iron, chlorine and zinc were found in the highest concentrations at both sites (Appendix 7, Tables 16 and 17). Mean concentrations of other metals were in the range of 1 to 50 ng/m^3 at the Windsor site and in the range of <1 to 15 ng/m^3 at Walpole Island.

Metals of most interest from a health and environmental effects point of view are lead, chromium, cadmium, nickel and arsenic (Dann 1992). A time series plot of lead concentrations at the Windsor site show a steady decline in lead concentrations with an overall decrease of seventy percent between 1987 and 1990 (Appendix 7, Figure 17). This decline is a direct result of the phaseout of leaded gasoline in Canada and the United States (Dann 1992). Antimony, tin and tellurium, potential components of incinerator particulate, were highly correlated with one another at the Windsor site and concentrations increased over the sampling period. Similar trends for the above mentioned metals also occurred at the Walpole Island site (Appendix 7, Figure 18).

Significance of Measured Concentrations

Few national or provincial air quality guidelines have been established for pollutants measured during this study. **Table 42** provides a comparison of measured concentrations at the Windsor and Walpole sites with existing national or province of Ontario guidelines. Maximum annual (0.8 ng/m^3) and 24 hour (6.3 ng/m^3) concentrations of benzo(a)pyrene, recorded at the Windsor site exceeded their respective Ontario Provisional Guideline of 0.3 ng/m^3 and 1.1 ng/m^3 (**Table 42**).

The maximum 24 hour benzo(a)pyrene concentration recorded at Walpole Island (1.08 ng/m^3) approached the Ontario Provisional Guideline (1.1 ng/m^3) (**Table 42**).

Another approach to determining the relative importance of measured concentrations of toxic compounds in ambient air is to use quantitative risk assessment methodology. This approach is most applicable to carcinogens and requires an estimate of a compound's carcinogenic potency expressed as a unit risk value. A unit risk is the excess lifetime risk due to a continuous/constant lifetime exposure to one unit of concentration. For air pollutants, unit risk values are expressed in terms of μg/m^3 or ng/m^3.

A quantitative risk assessment used in this study can only be used to illustrate the potential relative importance of the various compounds measured. A summary of computed lifetime risks due to inhalation exposure to the potential carcinogens measured at Windsor and Walpole are provided in Appendix 7. Because two method can be used to calculate the unit risk, the additive risk is presented as a range. At the Windsor site, total additive risk ranged from 2.5 x 10^{-4} to 5.0 x 10^{-4} (Appendix 7, Table 23). 1,3-butadiene, chromium, benzene, formaldehyde and carbon tetrachloride account for most of the risk. In a recent United States study of nineteen urban areas, the average total cancer

risk associated with air toxics was 7×10^{-4} with a range of 2×10^{-4} to 2×10^{-3} (Dann 1992). Pollutants accounting for most of the risk were the same as those found in Windsor.

A similar lifetime cancer risk analysis was done for the Walpole site (Appendix 7). The computed total risk ranged from 1.4×10^{-4} to 1.8×10^{-4} (Appendix 7, Table 24). The substitution of detection level values for 1,2-dibromoethane and chromium accounted for a substantial fraction of the risk at Walpole Island.

Exposure to dioxins and furans, expressed as 2,3,7,8-TCDD toxic equivalents (TEQs), accounted for approximately one percent of the calculated inhalation cancer risk at the Windsor site and less than one percent of the total at the Walpole Island site (Dann 1992).

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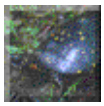

Sources

Air Quality Monitoring

Lambton Industrial Society Sarnia Air Monitoring Program

Air quality monitoring is a major component of the environmental studies conducted by the Lambton Industrial Society (LIS). The results of the 1991 studies have been reported by ORTECH International (1992a and b). Monitoring data are collected from a network of 11 stations located throughout the Chemical Valley (ORTECH International 1992a). The most northerly site is located near Lake Huron, while the most southerly site is just south of Courtright. One of the stations is located in Port Huron, Michigan. The following summary is taken from ORTECH International (1992a).

Overall annual average SO2 levels for the Sarnia area in 1991 were in general similar to those of 1990. The annual air quality criterion of 0.020 ppm was satisfied at all monitoring sites, with levels at all stations being at or below 0.010 ppm. The daily criterion of 0.10 ppm was satisfied at all times and all stations in 1991 with the exception of one occurrence at the Front Street station. The hourly criterion of 0.25 ppm was exceeded on 9 occasions, with 6 of these at Front Street.

Annual ethylene levels in the survey area were slightly higher than the values measured in 1990 with the exception of the Eighth Line Station which has a slight decrease. Both the 6-hour and 24-hour air quality criteria for ethylene were exceeded during 1991 at the Scott Road, LaSalle Road and River Bend Stations.

Annual average total reduced sulphur (TRS) levels in 1991 were similar to those in 1990 at Centennial Park and River Bend, however, the annual TRS mean at Scott Road was almost twice that of 1990 (ORTECH International 1992a). The number of exceedences of the hourly criterion increased from 10 to 50 at the latter station.

Ozone, produced by photochemical reactions between nitrogen oxide and hydrocarbon emissions, displayed a sizable increase in the number of hourly criterion exceedences, especially at Front Street and Centennial Park.

Average annual suspended particulate loadings in Sarnia were lower at Front Street, and higher at River Bend, in 1991 than in 1990. The total number of exceedences of the daily criterion decreased from 4 to 2 at Front Street and the daily aerosol crtierion was not exceeded in 1991.

A total of 23 organic compounds were measured on an on-going basis in 1991. The measured concentrations for all of the target compounds were well below all existing Ontario ambient air quality criteria (ORTECH International 1992a).

Loadings to the St. Clair River can not be determined from the data provided by the LIS air monitoring system.

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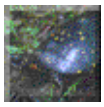

Sources

Michigan Sources Update

This section is based on recent data collected by the Surface Water Quality Division of the Michigan Department of Natural Resources. The data are based on acute toxicity assessments undertaken during 1991 and 1992 for two industrial (MDNR 1991, 1992a) and three municipal facilities (MDNR 1992b,c,d); a water quality investigation of the St. Clair River in St. Clair County (MDNR 1992e); and a biological survey of the Pine River in St. Clair County (MDNR 1993).

- ***Effluent Acute Toxicity Results***
- ***Water Quality Investigation of the St. Clair River***
- ***Biological Survey of the Pine River, St. Clair County***

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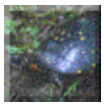

Sources

Michigan Sources Update

Effluent Acute Toxicity Results

E.B. Eddy Paper Inc., Port Huron: This facility manufactures business and technical papers, carbonless paper and thermal print papers, and specialty and packaging papers. During October 7 to 11, 1991, effluent from outfall 009 was evaluated using the fathead minnow 96-hour flow-through acute toxicity test and two *Daphnia magna* 48-hour static acute toxicity tests. A sample from outfall 008 was also evaluated with the *D. magna* test. Samples of both effluents were also analyzed for selected chemical parameters. The objective of the tests was to assess the acute toxicity of the effluents (MDNR 1991).

The results of the tests indicated that neither outfall 008 nor 009 was acutely toxic to *D. magna*. Outfall 009 was not acutely toxic to fathead minnows (MDNR 1991). The Chemical analysis of effluent from outfalls 009 and 008, did not reveal the presence of any chemicals at concentrations predicted to be acutely toxic to *D. magna*.

Immobilization of *D. magna* due to solids (eventhough the test samples were filtered) occurred in effluent samples from the 009 outfall at 83% and 94% effluent. This was noted by MDNR (1991) as indicating that the effluent was not meeting the aquatic toxicity requirements of Rule 82 MWQ Standards.

The chemical characterization included the detection of low concentrations of cadmium, chromium, cyanide, and lead (all <1.0 μg/L) in outfall 009 effluent (3 samples). Concentrations of total copper ranged from 38 to 58 μg/L; total iron from 60 to 70 μg/L; total cyanide, <5 μg/L; total nickel from 4.8 to 5.3 μg/L; and total zinc from 17 to 26 μg/L. Organic parameters detected included butylbenzylphthalate (ND to 2.3 μg/L), di-n-butylphthalate (ND to 1.8 μg/L), chloroform (1.0 to 1.6 μg/L), bromodichloromethane (1.4 to 1.7 μg/L), and dibromochloromethane (1.4 μg/L). Concentrations in one sample from outfall 008 effluent were in the same range with the exception of total zinc (7.0 μg/L), total iron (1120 μg/L), chloroform (6.6 μg/L), and bromodichloromethane (3.3 μg/L). Phthalates (base-neutral extractables) were not detected in outfall 008 effluent.

Detroit Edison Company, St. Clair: MDNR undertook a 48-hour static *D. magna* acute toxicity test on a composite sample of DECO-St. Clair outfall 001 effluent from July 23 to 25, 1992 (MDNR 1992a). The objective of the test was to determine the acute toxicity of the effluent.

The test resulted in no immobiliaztion of *D. magna* after 24 or 48 hours at any percent effluent (ranging from 0 to 100 percent effluent). MDNR (1992a) concluded that the effluent was not acutely toxic to *D. magna* and was meeting the aquatic toxicity-related requirements of Rule 82 of the MWQ Standards.

Marysville WWTP: *D. magna* and fathead minnow acute toxicity tests (48 hour) were performed on a composite sample of outfall 001 effluent collected June 23 to 24, 1992 (MDNR 1992b). The objective of the tests were to assess the acute toxicity of the effluent.

The tests resulted in immobilization of only 5% of *D. magna* after 24 hours in 32% and 56% effluent. No mortality of fathead minnows occurred within the 48 hour test period. As a result, MDNR (1992b) concluded that the effluent was not acutely toxic to either species and the effluent was meeting the aquatic toxicity-related requirements of Rule 82 of the MWQ Standards.

St. Clair WWTP: A 96-hour flow-through acute toxicity test for flathead minnows and two 48-hour *D. magna* acute toxicity tests were undertaken during an on-site evaluation from May 18 to 22, 1992 (MDNR 1992c). The objective of the tests was to assess the acute toxicity of the outfall 001 effluent.

No mortality of fathead minnows and no immobilization of *D. magna* occurred at any effluent concentration. As a result, MDNR (1992c) concluded that the effluent was not acutely toxic to either species and the effluent was meeting the aquatic toxicity-related requirements of Rule 82 of the MWQ Standards.

Marine City WWTP: A 96-hour composite sample acute toxicity test for flathead minnows and a 48-hour *D. magna* acute toxicity test were undertaken on samples collected from July 23 to 27, 1992 (MDNR 1992d). The objective of the tests was to assess the acute toxicity of the outfall 001 effluent.

Five percent mortality of fathead minnows occurred after 24 hours in 56% effluent. No immobilization of *D. magna* occurred at any effluent concentration. As a result, MDNR (1992c) concluded that the effluent was not acutely toxic to either species and the effluent was meeting the aquatic toxicity-related requirements of Rule 82 of the MWQ Standards.

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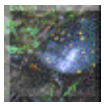

Sources

Michigan Sources Update

Water Quality Investigation of the St. Clair River

As part of the point source pollution surveillance activity, the MDNR conducted a water quality investigation of the St. Clair River at Port Huron on May 15, 1992 (MDNR 1992e). Conductivity, pH and temperature were measured in the vicinity of the E.B. Eddy Paper Company outfall 009 from which the plant discharges treated process water, power plant wastewater and non-contact cooling water. Sediments were sampled with a petite ponar 100 yards downstream of the outfall, upstream of the seawall at the city complex and at a midpoint (MDNR 1992e). The objective of the study was to qualitatively evaluate the the impact of the E.B. Eddy outfall 009 discharge on the St. Clair River.

The results of the study indicated that that there was no downstream change in conductivity and temperature indicating a rapid mixing of the discharge with river water. Foam was observed just upstream of the outfall to Lake Huron along with about 30 dead alewives (MDNR 1992e). The source of the foam was not determined. Paper particles were observed at low concentrations suspended in the water column at Station 3. No sediments were obtained by repeated sampling at all three stations indicating no build-up of paper solids or sludge immediately downstream of the outfall. MDNR (1992e) concluded that this was a result of the rapid flow velocity in the river at this location.

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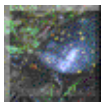

Sources

Michigan Sources Update

Biological Survey of the Pine River, St. Clair County

As part of the non-point source activities, the MDNR conducted a biological survey of the Pine Riveron July 30, 1992 (MDNR 1993). Sediment, biological and grab samples of water were collected at up to three stations. The stations included a headwater tributary (Sparling Road bridge), and two on the main trunk stream, one approximately midpoint between head and mouth (Ravenswood Road Bridge) and one in the downstream reach above St. Clair, Michigan. The objective of the study was to qualitatively evaluate the impact of agricultural non-point sources of pollution on the aquatic macroinvertebrate and fish community structure, physical habitat, sediments and chemical water quality of the Pine River. A secondary objective was to evaluate levels of iron in the water and sediments from sources of input to the St. Clair River based on the findings of the Stage 1 St. Clair River Remedial Action Plan.

The results of the study indicated that the fish community was good (slightly impaired) at the upstream, headwater station which also exhibited the lowest macroinvertebrate community score (rated fair or moderately impaired). Station 2 was also rated moderately impaired with respect to macroinvertebrate communities. Fish collections were not undertaken at either of the downstream stations.

The physical habitat was categorized as poor (severely impaired at the upstream station and fair (moderately impaired) at the midstream station. Habitat degradation was attributed to sedimentation and channel modifications related to agricultural activities.

Detectable concentrations of iron were found in water samples collected from all three stations (one sample each). The upstream station had the highest concentrations (2400 µg/L) compared to the midstream and downstream stations (700 to 1300 µg/L). All other heavy metals were below detection. These high iron concentrations were attributed by the authors (MDNR 1993) as due to a groundwater source.

Detectable concentrations of iron, chromium, copper, nickel, lead, zinc, lithium and manganese were found at all three stations (**Table 43**). Iron and manganese were the most concentrated of the metals, with the highest values at the downstream station. Neither the Ontario's PASQG nor the EPA Interim Guidelines for the Disposal of Great Lakes Harbour Sediments were exceeded for any parameter at any station.

Chlorinated hydrocarbons, pesticides and PCBs were not detected (31 individual parameters were analyzed) in the sediment samples from the upstream or midstream stations (downstream station sample was not analyzed). Detection limits for the organic parameters were either 70 µg/L or 700 µg/L (all PCB Aroclors were 700 µg/L).

Summary Of Data Gaps, Ongoing Programs And Surveys

Summary Of Data Gaps, Ongoing Programs And Surveys

Summary of Data Gaps

The St. Clair River Stage 1 update/addendum report summarizes conditions in the St. Clair River AOC in the time period 1990-1991. Key data summarized in this addendum and identified as ongoing projects in the Stage 1 document include:

- water, sediment and biota ambient data collected by OMOE in 1990 and 1991;
- bacteria loadings from Sarnia CSOs and WPCPs as well as nearshore bacteria densities along the Sarnia waterfront;
- 1991 fish contaminant monitoring data (OMOE, MDNR); and
- the 12 month MISA monitoring studies for the organic and inorganic chemical sectors and thermal generating sectors (1989 to 1991).

Several significant data gaps were identified in the Stage 1 RAP. A number of ongoing surveys (water, sediment and biota) both within the AOC and basin wide, and regulation development programs and remediation plans are described in Section 7.2 and data gaps are addressed below.

The first data gap identified in the Stage 1 RAP is as follows: "additional information is required on ambient conditions within the AOC with which to make definitive conclusions regarding the impairment status for the tainting of fish and wildlife flavour, dynamics of wildlife populations, and fish tumours and deformities."

The attempt to fill the first identified gap is summarized as follows:

Two programs conducted by the Ontario Ministry of Natural Resources and the Lake St. Clair Fisheries Unit will provide baseline information regarding the impairment status of fish tumours and other deformities.

Information regarding the impairment status for the tainting of fish and wildlife flavour still remains as a gap however, work is planned for 1994 to undertake tainting assessment.

Attempts to define dynamics of wildlife populations within the AOC are being addressed by one survey conducted by the CWS and the Walpole Island First Nation Heritage Centre. This survey will identify the effects of contaminants on the reproductionve biology of three wildlife species. Other biota related studies within the AOC focus on benthic organisims and the dynamics of contaminates within indigenous and introduced wildlife in the St. Clair Delta. Additional wildlife population studies are still required to address this gap.

Ongoing programs addressing these issues are described in Section 7.2 as are additional biota, water and sediment surveys that will further define contaminant conditions in the AOC.

The second data gap identified in the Stage 1 RAP includes the development of "wildlife consumption guidelines for the protection of human health with consideration of potentially sensitive populations that rely on the consumption of wild meat."

Wildlife consumption guidelines are developed and administered under Health and Welfare Canada. The EAGLE (Effects on Aboriginals from the Great Lakes Environment) project is a community based environmental epidemiological study on the effects of environmental contaminants on the health of native people in the Great Lakes Basin. Results from this study may be considered in the development of wildlife consumption guidelines and in particular for "high consumers" such as First Nation peoples. The Walpole Island First Nation band is involved in one of several cohort studies occuring under the EAGLE project.

The next identified data gap states that there is a need for "Great Lakes Basin wide assessments of the effects of contaminate body burdens on fish, wildlife and benthic organisms."

Contaminant body burdens in wildlife are being monitored by the CWS in several AOCs throughout the Great Lakes Basin. Contaminants in forage fish are monitored by OMOEE at several AOCs throughout the Great Lakes Basin. There are no basin wide programs designed to assess the effects of contaminant body burdens in fish and benthic organisms hence, this gap is still present.

"Loadings from Michigan tributaries, CSOs and stormwater" is another identified gap. Although loading data for Michigan CSOs and stormwater is not available it should be noted that plans and projects are being developed and implemented respectively to prevent all CSO and stormwater direct discharges to the St. Clair River from Michigan sources. These projects will be addressed in the Stage 2 RAP.

Loadings data from Michigan tributaries remains as a data gap however, watershed studies are being planned.

Another data gap requires the determination of *"more complete upstream loadings data in terms of the number of parameters and lower detection limits (particularly for PCBs)."* This gap has partially been addressed in this Stage 1 Addendum report. Chan (1993) estimated loadings at the head of the St. Clair River for a large number of parameters. The lowering of detection limits is a function of best available technology and the development of new analytical procedures which are ongoing at research labs.

St Clair RAP Addendum Contents

Summary Of Data Gaps, Ongoing Programs And Surveys

Ongoing Programs and Surveys

Surveys Within the AOC

Biota

1. D. MacLennan from the Ontario Ministry of Natural Resources and the Lake St. Clair Fisheries Unit are conducting an index fishing survey in representative habitats in order to monitor relative indices of abundance for key species, species composition in the catch, biological attributes, contaminants and diseases (tumours etc.) for the fish community in the St. Clair River. This is a long-term project that involves an initial survey of "pre-remediation" baseline sampling using electrofishing gear at selected locations and seasons to be compared against subsequent "post-remediation" sampling.

The project will provide fish community statistics which are essential to:
- identify and document impairments on the fish component of the ecosystem;
- provide a basis on which to determine the adequacy of recommended remediation measures towards restoration of beneficial uses; and
- provide baseline information on which to monitor the effects of restoration efforts towards the restoration of beneficial uses and delisting.

Initial baseline monitoring will commence in 1993/94 and continue past year 2000.

2. D. MacLennan from the Ontario Ministry of Natural Resources and the Lake St. Clair Fisheries Unit are conducting an angler survey of the sports fishery in the Ontario waters of the St. Clair River from June through August providing sport fishing effort, catch and harvest statistics and fish community indices of relative abundance, species composition in the catch, biological attributes, contaminants and diseases (tumours etc.) for principle species in the fish community in the St. Clair River. This is a long-term project that involves an initial survey of "pre-remediation" baseline sampling against subsequent "post-remediation" sampling.

The project will provide sport fishery statistics which are essential to:
- identify and document impaired uses/benefits related to the sports fishery and to provide fish community data that would serve as an indicator of impacts on principle species (CUEs, biological data);
- provide a basis on which to determine the adequacy of recommended remediation measures towards restoration of beneficial uses; and
- provide baseline information on which to monitor the effects of restoration efforts towards the restoration of beneficial uses and delisting.

Initial baseline monitoring was commenced in 1992 and will continue past the year 2000.

3. The MOEE in cooperation with Environment Canada (Dr. Bill Warwick - National Hydrology Research Institute, Saskatoon, Sask.) have collected target invertebrate species from locations in the St. Clair River. These samples collected in September 1992 will be assessed against samples collected in 1986 by Ron Dermot (Dept. of Fisheries and Oceans, Burlington, Ont.) for the determination of chironomid mouth part deformities. It is anticipated that the 1992 collections will allow trends to be established.

4. I.W.E Harris at Hazcheck Enterprises has conducted a survey of benthic invertebrate populations (diversity and density) in the St. Clair River from Lake Huron to Chenal Ecarte. Eighteen sample points were sampled once each year from 1990 through 1992. Invertebrates were sorted to family level, counted and preserved. The objective of this study was to evaluate the use of benthic organisms as a means to attenuate waste water toxicity over a short range (200 metres).

5. Contaminants in eggs collected from snapping turtles, black-crowned night herons and Forster's terns nests are being measured. The purpose of this study is to determine if St. Clair River/Lake St. Clair contaminants have an effect on the reproductive biology of these species. The study was conducted from April through July, 1992 and was carried out by Dr. C. Wessloh from the Canadian Wildlife Service and A.B. Bernier from the Walpole Island First Nation Heritage Centre. A draft report is expected in 1993.

6. In 1992, Ontario Hydro initiated a four-year program to detect immediate effects within the benthic community due to discharge of diluted flue gas desulphurization effluents beginning in 1994 at the Lambton Generating Station. The purpose is to verify the hypothesis of no detectable effect on the benthic macroinvertebrate community beyond the scour zone of the cooling water discharge. The program consists of two pre-operational years (1992-93) and two operational years (1994-95). Sampling is by airlift and ponar in 1992 and then by ponar dredge only in subsequent years. Other monitored parameters include: water temperature, water quality, substrate particle size and organic content.

Annual reports will be issued externally by June of the year following field activity (each year of 1993 to 1996).

Ontario Hydro has also conducted seasonal airlift surveys of the benthic community in the St. Clair River immediately upstream and downstream of the Lambton Thermal Generating Station cooling water discharge in 1990 and 1991. The purpose was to investigate the effects of chlorination for zebra mussel control on the downstream zoobenthic community. An Ontario Hydro report has been issued for the 1990 study (Ontario Research Division Report No. 91-81-K). A consultant report on the 1991 study is presently at the draft stage.

7. G.D. Haffner at the Great Lakes Institute in collaboration with the Walpole Island First Nation, has completed 5 years (1989 through 1992) of data collection for contaminant biomonitoring using caged mussels (*Elliptio complanata*). The purpose of the study is to understand contaminant dynamics within the Lake Huron-Lake Erie corridor.

Additional related studies include:
· food web dynamics of contaminants in the food web of Walpole Island; and
· long term biomonitoring (minnows, mayflies, genotoxicity) in Goose Lake and Chenal Ecarte at Walpole Island.

8. T.F. Nalepa, at the Great Lakes Environmental Research Laboratory, has determined the abundance of zebra mussels in Lake St. Clair in 1990 and 1992. Collections were made by scuba divers at 29 stations throughout the Lake. Populations of indigenous unionids were also determined in 1986, 1990 and 1992. The purpose of these surveys is to document the distribution, spread and abundance of zebra mussels and to determine their impact on native species of unionids. Zebra mussel populations will be sampled every two years. Results from this study are expected in late 1993.

Water

9. The Walpole Island First Nation and the University of Michigan have put forward a plan termed Global Rivers Environmental Education Network (GREEN) whose objective is to establish a water quality monitoring program on Walpole Island. Activities will include the establishment of a committee of school and community people that will develop a program designed to relate water quality to the goals and objectives of the school curriculum. Topics will include: watershed past and present uses, laws and regulations, identification of concerns, monitoring the water for organisms, water quality testing and means for taking appropriate actions.

10. The OMOEE, Lambton Health Unit, St. Clair Region Conservation Authority, St. Clair Parkway Commission, and Sombra and Moore Townships are jointly conducting a bacteriological investigation of sources and impacts on beaches in the lower St. Clair River. Sampling will be conducted from May through September, 1993 and is planned to continue annually.

Sediment

11. The Walpole Island First Nation and the Great Lakes Institute have initiated a survey to quantify the current load of organic and metal contaminants contained within the Walpole Island delta. The exposure dynamics of in-place pollutants with regard to the health and economy of the Walpole Island First Nation will be assessed. In addition, an assessment of the efficiency of the delta to absorb chemicals released into the St. Clair River and the importance of chemical movement from the wetlands into the Lake St. Clair food web will also be conducted. This study was commenced in 1992 and will be conducted over a three year period ending in 1994.

Basin Wide Studies

Health

12. Canada's Great Lakes Health Effects Program: An Overview and Status Report has been prepared by A.P. Gilman, and K.L. Maus from the Great Lakes Health Effects Division, Health and Welfare Canada, Ottawa, Ontario. This report summarizes the Great Lakes Health Effect Program (GLHEP) which is a five year, $20 million initiative of the Government of Canada to identify the nature and extent of the risks to health; to provide advice on health risks and how humans can protect themselves; and to facilitate two way communication with the public on environment and health linkages. GLHEP coordinates its Program with other federal and provincial agencies and with key agencies in the USA. Program projects are established through a unique combination of public and agency consultation. There are 32 projects underway in five key areas: epidemiology, toxicology, surveillance, objectives and remedial measures, and consultation.

13. The EAGLE Project: A community based approach to environmental epidemiology is a report prepared by the Medical Services Branch, Department of National Health and Welfare; Assembly of First Nations; and Ecosystem Consulting Inc. (B. Wheatley, C. Mills, F.H. Lickers, N.L. Fraser, and K. Davies).

The Effects on Aboriginals from the Great Lakes Environment (EAGLE) project is a community based environmental epidemiological study of the effects of environmental contaminants on the health of native people in the Great Lakes Basin. It is based on the presumption that native people, because of their high consumption of fish and wildlife, are frequently more exposed to contaminants in the environment than is the general population. The project has been established as a First Nations/Federal Government partnership with emphasis on strong community partnership and a real sense of ownership. There is also a solid scientific component to the study. The approach being used is unique, because it blends scientific methods and techniques with the traditional ecological knowledge and needs of the native communities. This is reflected in the management and administration of the study. Funding is being provided through Medical Services Branch (MSB), Health and Welfare Canada and the Assembly of First Nations (AFN) is responsible for the day to day

operations. There is a Steering Committee which includes representatives of native communities, a Working Group which coordinates the progress of the study and a Scientific Advisory committee with consultants in public health, toxicology, fish and wildlife and epidemiology.

After initial funding from Health and Welfare, funding is now being received from the Green Plan. Work started in September 1990 and is projected to run until 1997. Initially, work has focused on the 63 native communities in the Great Lakes Basin, most of which have been visited and consulted by a team from the AFN. A detailed literature research project has been carried out as a basis for the project. The MSB laboratory is being developed to handle the range of analytical procedures which may be needed and to respond rapidly to community needs. The EAGLE project is taking a holistic approach to the effects of contaminants on human health and well-being. This approach will include looking for exposure in adults and children, possibly using biomarkers, socio-economic effects and effects on traditional ways of life, culture and values.

Biota

14. The Canadian Wildlife Service has bee monitoring levels of contaminants in wildlife over the last 5 to 10 years. The purpose of this activity is to document contaminant level in wildlife from several Great Lakes Areas of Concern and to make spatial comparisons. Work is being conducted by Dr. C. Wessloh from the Canadian Wildlife Service.

15. Dr. M. Munawar at Fisheries and Oceans Canada, has proposed that ecosystem health-plankton surveys be conducted in the St. Marys, St. Clair and Detroit Rivers and in Lake St. Clair. The status of this proposal is unknown at this time.

Regulation, Plan and Program Development

Regulations

16. In February 1992, the International Joint Commission released "Air Quality in the Detroit-Windsor/Port Huron-Sarnia Region" (IJC 1992), a report to the Governments of Canada and the United States pursuant to the 1975 Reference and letters from the Governments of September 30, 1988.

In their 1988 letters the Governments asked the Commission to recommence its work under the 1975 Reference and to examine and report on the actual and potential hazards posed to human health and the environment from airborne emissions in the Detroit-Windsor/Port Huron-Sarnia area.

The report highlights the need for governments to implement pollution prevention programs to eliminate, or phase out, the emission of air toxics in the region and recommends that priority attention be focused on 15 known carcinogens present in the ambient air. The recommendations are based on a study completed by the Commission’s International Air Pollution Advisory Board for the Detroit-Windsor/Port Huron-Sarnia Region, in December 1990, which was the subject of public hearings in March 1991, as well as other studies and submissions to the Commission.

17. A final report entitled "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" prepared by D. Persaud, R. Jaagumagi and A. Hayton (OMOE) was released in June, 1992.

18. The Government of Ontario (1992) has issued a Policy Statement on planning for the protection of *Wetlands* as a matter of Provincial Interest. The statement was issued jointly by the Minister of Municipal Affairs and the Minister of Natural Resources and gives direction to municipalities, planning

boards, public agencies, the private sector and others for the protection of *Wetlands*.

19. In June 1991 the Ontario Ministry of the Environment's Hazardous Contaminants Branch and Water Resources Branch were directed to establish a list of candidate substances to be considered for banning, phasing out or use/release reductions.

In April 1992, OMOE published the "Candidate Substances List for Bans or Phase-Outs" (Socha *et al.* 1992). Twenty-one substances or substance groups were identified in the Primary List of Candidate Substances for Bans or Phase-Outs. These substances are present in or are currently discharged to Ontario surface waters and are most inherently hazardous due to their persistence in water or sediment, potential to bioaccumulate and toxicity. These substances have been recommended as being given first priority for banning, phasing out, or use/release reduction.

The Primary list of substances includes:
anthracene
arsenic
benzo(a)pyrene
benzo(ghi)pyrene
benz(a)anthracene
DDT (+ DDD and DDE)
1,4-dichlorobenzene
3,3'-dichlorobenzidine
dieldrin
hexachlorobenzene
alpha-hexachlorocyclohexane (α-HCH)
gamma-hexachlorocyclohexane (δ-HCH)
mercury
mirex
pentachlorophenol
perylene
phenanthrene
polychlorinated biphenyls (PCBs)
polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs)
toxaphene
tributyl tin

Plans

20. W. Liang (OMOE) and Hugh Fraser (University of McMaster) have a mandate to develop and implement a pollution control plan which will reduce overall pollutant loadings from the City of Sarnia to the St. Clair River and hence improve the water quality of Sarnia Bay and at the waterfront which will result in an increase of recreational activities.

21. The Ontario Ministry of Natural Resources Chatham District Office has conducted a survey of candidate sites on the St. Clair and Detroit Rivers for potential habitat rehabilitation/enhancement. The primary objective of the project is to identify and evaluate potential fisheries and wildlife rehabilitation/enhancement sites within the St. Clair and Detroit Rivers Areas of Concern. The ultimate goal is to implement some of the various rehabilitation plans to remove the "impaired habitat" status from the AOC. The initial phase of the field survey was conducted during July and August, 1992 in order to select potential candidate sites for follow-up mapping and cataloguing of existing habitat conditions. Additional work for the initial phase of this project included: search of background information for each site; development of concept plans, requirements and costs; literature search and review; and preparation of a draft and final report.

During 1992, extensive mapping, video taping and aerial photography of existing habitat conditions was completed as well as literature searches for relevant information on habitat restoration. Concept plans for habitat creation, using natural features in combination with man-made structures, have been drafted. Approximately 75 major rehabilitation sites in the St. Clair and Detroit Rivers now have concept plans. A formal report describing the project, the rationale behind the concept restoration plans, habitat securement methods, partnership opportunities (government, corporations and non-profit agencies), and a proposed monitoring program is now available in draft form.

The next phase of the project is the implementation of a thorough communications plan using the RAP Teams on-going programs. Various agencies, corporations, interest groups, individuals, and landowners will be contacted as part of the communication process to solicit support for the habitat restoration projects. Education on the values of fish and wildlife habitat will play a key role in this process.

22. The OMOEE is currently completing Phase 4 of a four phase investigation into water quality of the Lambton County freshwater aquifer. Additional monitoring wells will be installed in the near future to further define the impact of former waste injection practices on the aquifer.

Other Programs

23. The Ontario Ministry of the Environment (Sarnia Office) are currently conducting studies in modelling needs and applications for the St. Clair River Area of Concern. A variety of models are being used to investigate the following:

- predict the impact of remedial measures on receiving waters;
- predict behaviour of ecosystems under various discharge scenarios;
- ensure the protection of receiving water for substances not slated for zero discharge; and
- assess initial levels of protection and focus on areas needing improvements.

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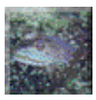

Table A

Summary of impairments to Great Lakes Water Quality Agreement beneficial uses within the St. Clair River AOC.

Impairment status is defined as impaired (I), not impaired (NI) or requires further assessment on a site specific basis1 (A) or on a Great Lakes Basin basis2 (B) and is based on data collected over the period 1983 through 1992.

GLWQA Impairment of Beneficial Use	Status of Impairment	Conditions in the St. Clair River
RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION		
Restrictions on Fish Consumption	I	Fish consumption advisories currently in effect are: Ontario - mercury: walley, white sucker, freshwater drum and yellow perch - PCBs: carp and gizzard shad - Dioxins and Furans (2,3,7,8-TCDD [TEQ]): carp Michigan -mercury and PCBs: freshwater drum, gizzard shad and carp
Consumption of Wildlife	B	There are currently no guidelines directly applicable to the St. Clair River AOC regarding human consumption of wildlife. However concentrations of PCBs in snapping turtles as well as octachlorostyrene, hexachlorobenzene and PCBs in mallards and redheads, which are utilized by human consumers such as residents of the Walpole Island First Nations Band, highlight the need for these guidelines. The Ontario Ministry of Natural Resources has issued a warning for people to use prudence with respect to the regular consumption of turtle meat from some areas including Walpole Island due to PCBs.
TAINTING OF FISH AND WILDLIFE FLAVOUR	A	There have been anecdotal reports of tainting.
DEGRADATION OF FISH AND WILDLIFE POPULATIONS		
Dynamics of Fish Populations	NI	The fish fauna of the St. Clair River are considered diverse and well-balanced.
Body burdens of fish	B	Several contaminants including mercury, PCBs, hexachlorobenzene and octachlorostyrene have been found in adult and juvenile fish on the Ontario side of the river and in the St. Clair Delta. Effects of these chemicals on fish are not known. Research on body burdens and associated effects in fish is required for the entire Great Lakes ecosystem.
Dynamics of Wildlife Populations	A	The use of the wetlands of the St. Clair Delta by true marsh-dwelling waterfowl species declined by 79 percent (spring) and 41 percent (autumn) between 1968 and 1982 due to the loss of wetlands. Continent wide wetland loss is a factor to migrating bird survival, but this has not been assessed for wetland species in the AOC. Guidelines for the protection of fish-eating wildlife have been exceeded in *shiners, gizzard shad, carp and walleye* for PCBs and in *shiners* for octachlorostyrene. The effects of these exceedences, if any, on wildlife populations which consume these fish are not known.
Body burdens of Wildlife	B	Contaminants such as pentachlorobenzene, hexachlorobenzene, octachlorostyrene, PCBs and DDT have been found in snapping turtles, muskrats and ducks in the St. Clair Delta. The effects of these chemicals on wildlife are not known. Research on body burdens and associated effects in wildlife is required for the entire Great Lakes ecosystem.
FISH TUMOURS AND OTHER DEFORMITIES	A	External tumours found in fish are due to natural viral factors. Although studies on the incidence of internal tumours have been limited in the AOC, there is one observation of an early neoplastic tissue change which was observed in a caged fish. Although this finding is not statistically significant, there is a growing consensus that there is sufficient evidence to suggest liver tumours are caused by chemical factors.
BIRD OR ANIMAL DEFORMITIES OR REPRODUCTIVE PROBLEMS	I	Mouth part deformities occur in some chironomid species but no evidence of bird or other animal deformities or reproductive problems has been reported.
DEGRADATION OF BENTHOS		
Dynamics of Benthic Populations	I	Benthic community health is good on the Michigan side of the river but, *as of 1990, was "degraded" or "impaired" in a series of seven short segements along the Ontario shore for a total distance of about 6 km, or about half the distance identified from the 1985 surveys. The "severely degraded" zone was not found in the 1990 surveys.*
Body Burdens of Benthic Organisms	B	Several types of benthic organisms, including native clams, mayflies, aquatic worms (Oligochaetes) have been found to bioaccumulate various organic and inorganic chemicals. The effects of these chemicals on benthic organisms is not known. Research on body burdens and associated effects in benthic organisms is required for the entire Great Lakes ecosystem.

RESTRICTIONS ON DREDGING ACTIVITIES	I	*Concentrations of arsenic, copper, cadmium, chromium, iron, lead, mercury, nickel, zinc, total PCBs, total PAHs, hexachlorobenzene, total organic carbon, TKN, total phosphorus and oil and grease along the Ontario shoreline exceed PASQG and/or U.S. EPA interim guidelines for the disposal of Great Lakes harbour sediments*. Most exceedences occur along the Sarnia industrial waterfront, as far downstream as the Lambton Generating Station, and the mouths of Talfourd Creek, Baby Creek and the Murphy Drain. Confined disposal has been required in some instances due to the presence of HCB. Concentrations of total Kjeldahl nitrogen, oil and grease, arsenic, copper, chromium, iron, lead and manganese from the Michigan shore are considered moderately or heavily polluted by U.S. EPA guidelines and exceed OMOE disposal guidelines or PASQG. There are currently no restrictions on dredging or disposal of dredged material from U.S. waters of the St. Clair River due to the presence of contaminants.
EUTROPHICATION OR UNDESIRABLE ALGAE	NI	The waters of the St. Clair River are mesotrophic and algae do not occur at nuisance levels.
RESTRICTIONS ON DRINKING WATER CONSUMPTION OR TASTE AND ODOUR PROBLEMS		
Consumption	I	Periodic closing of Water Filtration/Treatment Plants occur in both Michigan and Ontario as a result of chemical spills at upstream locations.
Taste and Odour Problems	I	The Health and Welfare Canada taste and odour aesthetic objective for ethylbenzene was exceeded at the Wallaceburg Water Treatment Plant during start-up following a spill in October 1990. Closures of the Wallaceburg WTP intakes based on level II responses are based on factors including taste and odour concerns.
BEACH CLOSINGS	I	There have been no beach closings in Michigan although all areas downstream of Michigan CSOs are identified as impaired areas due to the periodic discharge of inadequately treated sewage. In Ontario, five beaches were closed as recently as the summer of 1990 for up to two months duration due to coliform bacteria levels which exceeded both Ontario and Michigan standards.
DEGRADATION OF AESTHETICS	I	Floating scums, oil slicks, spills and odours have been periodically reported.
ADDED COST TO AGRICULTURE OR INDUSTRY	I	Food processing industries in Ontario and a salt processing facility in Michigan have had to temporarily shut down their intakes due to upstream spills. Costs have also been incurred for proper disposal of contaminated sediment removed from the river for construction or other purposes.
DEGRADATION OF PHYTOPLANKTON AND ZOOPLANKTON POPULATIONS	NI	Phytoplankton and zooplankton species in the river are typical of those in southern Lake Huron.
LOSS OF FISH AND WILDLIFE HABITAT	I	Habitat has been lost due to filling, draining, dredging and bulkheading for industrial (Sarnia), urban, agricultural and navigational uses. Significant losses of wetlands have occurred particularly in the delta region of the AOC. Fish and wildlife management goals are needed to help further determine the degree of impairment and guide rehabilitation strategies.

[1] The Impairment Status `requires assessment' in the St. Clair River AOC.

[2] The Impairment Status `requires assessment' on a Great Lakes Basin basis.

Table 1

Physical and chemical characteristics of the St. Clair River nearshore waters during May 24 - June 11, 1990. Values are means and range (in brackets) of three to nine replicates (samples taken at the same location at different times (OMOEE 1993). Station locations are shown in Figure 1.

			Station												
Parameter	**MRL**	**PWQO**	**13 (CN Ferry dock)**	**20 (d/s Cole Drain)**	**IS 12 (Novacor Chem. Sarnia)**	**22 (d/s Novacor 24" sewer)**	**IS 14 (d/s Dow 1st St. sewer)**	**IS 15 d/s Dow 2nd St. sewer)**	**IS 16 (d/s Dow 3rd St. sewer)**	**24 A (d/s Suncor sewer)**	**30 (d/s Shell intake)**	**36 (d/s Novacor Corunna sewer)**	**252 (South Channel dredging area)**	**207 (Lake St. Clair disposal area)**	**208 (Lake St. Clair control)**
Current Speed	0.0 m/s	-	0.06 (0.06-0.11)	0.05 (0.02-0.15)	0.02 (0.01-0.04)	0.06 (0.03-0.09)	0.08 (0.00-0.36)	0.35 (0.30-0.46)	0.23 (0.13-0.42)	0.04 (0.02-0.15)	0.28 (0.19-0.34)	0.37 (0.34-0.40)	0.20 (0.18-0.22)	-	-
Temperature	0^0C	<10^0C rise	9.8 (9.7-9.8)	11.8 (11.7-11.9)	12.3 (12.0-12.4)	13.2 (11.7-16.5)	12.4 (11.2-13.5)	11.0 (10.6-11.3)	12.2 (10.2-13.8)	11.5 (11.4-11.7)	11.1 (10.8-11.7)	10.7 (10.2-11.2)	12.3 (12.2-12.4)	12.4 (12.3-12.5)	12.8 (12.6-13.2)
Dissolved Oxygen	0 mg/l	6 mg/l*	13.8	11.8 (11.8-11.8)	11.5 (11.4-11.6)	10.9 (10.0-11.4)	11.1 (10.8-11.8)	11.3 (11.2-11.4)	11.2 (11.0-11.9)	11.5 (11.4-11.7)	11.9 (11.8-11.9)	11.6 (11.2-11.8)	11.5 11.4-11.6)	11.4 (11.4-11.4)	11.3 (11.2-11.4)
pH	-	6.5 - 8.5	7.23 (5.65-7.45)	8.30 (8.23-8.39)	8.29 (8.16-8.44)	8.41 (8.36-8.46)	8.18 (7.71-8.47)	8.33 (8.21-8.42)	8.20 (7.70-8.45)	8.17 (7.96-8.29)	8.36 (8.29-8.44)	8.08 (7.70-8.28)	8.11 (8.10-8.13)	8.23 (7.90-8.42)	8.43 (8.36-8.48)
Conductivity at 25^0C	1 us/cm	-	212 (211-212)	211 (210-212)	213 (212-213)	214 (213-217)	218 (212-248)	217 (215-221)	218 (215-223)	283 (269-300)	232 (231-234)	237 (225-255)	214 (213-215)	215 (215-216)	216 (215-216)
Calcium	0.10 mg/l	-	29.10 (28.50-29.60)	29.00 (28.80-29.20)	28.60 (28.40-28.70)	28.72 (28.60-28.90)	29.13 (27.85-30.10)	28.49 (27.70-29.00)	29.34 (27.50-30.00)	28.53 (28.00-28.90)	28.46 (28.20-28.90)	28.96 (28.30-30.00)	28.87 (28.70-29.20)	29.07 (28.80-29.30)	28.73 (28.60-28.80)
Chloride	0.20 mg/l	-	6.20 (6.20-6.20)	6.50 (6.40-6.60)	6.53 (6.30-6.70)	6.78 (6.35-7.45)	7.48 (6.40-15.15)	7.77 (7.30-8.70)	7.61 (6.80-8.70)	27.24 (23.50-32.70)	12.29 (11.90-12.90)	11.76 (10.10-14.00)	6.96 (6.80-7.30)	7.40 (7.30-7.50)	7.30 (7.20-7.40)
total Phenols	0.2 ug/l	1.0 ug/l	nd	0.4<T (0.4<T-0.6<T)	0.5<T (0.4<T-0.6<T)	0.5<T (0.3<T-0.6<T)	0.2<T (nd-0.4<T)	nd	0.2<T (nd-0.6<T)	nd	nd (nd-0.6<T)	nd	0.4<T (nd-0.6<T)	nd	nd
Suspended Solids	0.5 mg/l	-	3.4 (2.2<T-7.7)	2.2 (1.6<T-2.8)	6.8 (3.4-12.8)	2.9 (1.9<T-4.8)	2.6 (1.8<T-3.6)	3.8 (2.8-5.8)	2.5<T (1.9<T-3.1)	4.8 (3.1-11.0)	3.3 (2.7-4.7)	3.9 (2.7-6.5)	6.0 (5.3-7.2)	2.7 (2.3<T-3.2)	2.8 (2.5<T-3.1)

NOTES:

* Dissolved oxygen PWQO is to protect cold-water biota at temperatures between 10^0C and 20^0C.

d/s just downstream of named outfall or location.

MRL Method Reporting Limit; the lowest value that can be reported with confidence and repeatable by a lab

MDL Method Detection Limit; lowest value reported by the instrument. Values at these levels require background and instrument noise to be removed.

nd not detected at method reporting limit (MRL).

<T a measurable trace amount; interpret with caution. Concentration values approaching the MRL are tentative and quanitification is not as certain.

- data or objective not available.

Table 2

Annual mean and (range) of contaminants measured in raw (ambient water quality) water samples taken at water intakes from the Lambton, Wallaceburg and Walpole Water Treatment Plants during 1988 and 1991 (OMOE Drinking Water Surveillance Program (DWSP), 1988a Annual Report, and 1991 DWSP Preliminary Results).

Parameter	1988			1991		
	Lambton WTP	Wallaceburg WTP	Walpole WTP	Lambton WTP	Wallaceburg WTP	Walpole WTP
Colour (HCU)	0.83 TCU (0.5-1.0)	0.96 TCU (ND-3.0)	0.96 TCU (0.5-2.0)	0.25 HCU (ND-0.5)	0.5 HCU (ND-1.0)	0.417 HCU (ND-1.0)
Specific Conductance (umho/cm)	218 (213-255)	236 (230-247)	232 (223-236)	220 (212-239)	226 (222-231)	228 (221-244)
Turbidity (FTU)	2.02 (0.35-15.20)	5.12 (0.81-13.9)	4.93 (1.36-14.10)	4.87 (0.47-14.5)	3.9 (1.98-7.0)	9.26 (1.82-38.0)
Chloride (mg/L)	6.38 (5.7-7.5)	10.02 (8.1-11.4)	9.29 (8.2-10.6)	7.1 (5.3-8.6)	9.1 (7.8-11.2)	9.18 (8.4-10.3)
Ammonia Nitrogen (mg/L)	0.014 (0.002-0.034)	0.025 (0.012-0.040)	0.019 (0.012-0.028)	0.005 (ND-0.010)	0.014 (0.006-0.024)	0.011 (ND-0.020)
Total Phosphorus (mg/L)	0.005 (ND-0.014)	0.008 (0.002-0.013)	0.008 (0.002-0.045)	0.008 (0.002-0.018)	0.008 (0.004-0.012)	0.010 (0.003-0.036)
Cadmium (mg/L)	ND	ND	0.068 (ND-0.15)	NA	ND	ND
Chromium (mg/L)	0.99 (0.22-5.60)	2.41 (0.31-4.90)	2.42 (0.47-5.60)	1.4 (0.71-2.1)	1.12 (ND-3.5)	1.07 (ND-1.9)
Cobalt (mg/L)	0.15 (0.03-0.25)	0.166 (0.07-0.26)	0.134 (<0.02-0.29)	0.083 (0.06-0.12)	0.452 (0.03-2.0)	0.135 (ND-0.25)
Copper (mg/L)	19.75 (0.43-52.0)	2.61 (1.8-3.3)	7.98 (0.71-73.0)	164 (24-280)	2.2 (1.8-2.6)	1.06 (0.76-1.7)
Iron (mg/L)	53.2 (ND-210)	107.2 (31-300)	70.1 (28-240)	62.3 (ND-180)	82 (45-140)	137 (17-420)
Nickel (mg/L)	0.51 (ND-1.00)	0.74 (ND-2.9)	0.46 (ND-1.60)	0.7 (ND-1.6)	1.43 (ND-6.9)	0.87 (ND-1.8)
Lead (mg/L)	0.181 (0.03-0.50)	0.442 (0.25-0.66)	0.875 (0.15-3.90)	0.72 (0.18-1.3)	0.43 (0.3-0.57)	0.35 (0.08-0.51)
Zinc (mg/L)	2.24 (0.29-5.80)	1.99 (1.30-3.0)	8.97 (1.10-66.0)	14.5 (6.0-31.0)	3.2 (2.7-3.8)	2.4 (0.53-4.4)
Phenolics (mg/L)	NA	NA	NA	0.2 (ND-0.4)	0.467 (ND-1.2)	0.167 (ND-0.6)
Benzene (mg/L)	NA	NA	NA	ND	0.033 (ND-0.10)	0.025 (ND-0.15)

ND Not detected
NA Not available
Non detects included as 0 µg/L for calculation of 1988 and 1991 means

Table 3

Summary of inorganic contaminants in whole water samples from Point Edward and Port Lambton between May 1987 and December 1989 (Chan 1993).

Parameter	South Lake Huron*	Point Edward			Port Lambton		
		n	mean	std	n	mean	std
Na (mg/L)	3.5	26	3.6	0.25	33	5.4	0.72
Mg (mg/L)	7.3	27	7.3	0.19	33	7.3	0.18
SiO2 (mg/L)	1.5	27	1.1	0.26	33	1.1	0.27
SO4 (mg/L)	15.8	27	16.1	0.53	34	16.4	0.73
Cl (mg/L)	6.1	27	6.0	0.43	34	8.6	1.10
K (mg/L)	0.9	27	0.9	0.03	34	0.9	0.04
Ca (mg/L)	27.3	27	27.8	0.55	33	28.1	1.35
TKN (mg/L)	214	20	140.0	40.7	26	162.8	59.5
NO3 (mg/L)	319	25	186.2	98.1	33	173.2	111.1
TP (mg/L)	8.4	21	5.0	3.0	32	11.7	18.9
NH3 (mg/L)	3	14	10.4	5.7	17	17.6	7.5
pH	8.11	26	7.87	0.27	34	7.73	0.30
Conductance (mS)	213	12	212.8	4.7	17	226.5	9.9
Turbidity (JTU)		12	0.2	0.2	17	0.6	1.1
Al (mg/L)	12	18	47.1	78.2	28	151.7	355.9
Ba (mg/L)		18	13.0	0.7	28	18.8	22.8
Be (mg/L)		18	22.8	25.6	28	19.3	26.8
Cd (mg/L)	0.02	18	0.04	0.05	28	0.07	0.11
Co (mg/L)		18	0.04	0.05	28	0.19	0.50
Cr (mg/L)	0.15	18	0.31	0.16	28	0.65	0.94
Cu (mg/L)	0.22	18	0.98	0.45	28	1.75	1.99
Fe (mg/L)	9	18	53.0	89.5	28	299.1	833.5
Li (mg/L)		18	1.14	0.16	28	1.50	0.75
Mn (mg/L)	0.67	18	1.57	2.50	28	11.18	33.10
Mo (mg/L)		18	0.34	0.10	28	0.42	0.17
Ni (mg/L)	0.51	18	0.57	0.17	28	0.97	1.17
Pb (mg/L)	0.021	18	0.09	0.11	28	0.85	2.01
Sr (mg/L)		18	97.4	4.1	28	131.4	156.4
V (mg/L)	0.41	18	0.23	0.17	28	0.50	0.91
Zn (mg/L)	0.21	18	0.30	0.47	28	1.84	4.47

std = standard deviation

* Nutrients and major ions from Canada Centre for Inland Waters (1987) and metal data from Rossman (1982).

Table 4

Summary of organic contaminants (ng/L) in water (aqueous phase) samples taken at Point Edward and Port Lambton between May 1987 and December 1989 (Chan 1993).

Parameter	Point Edward			Port Lambton		
	mean* (ng/L)	range (ng/L)	% det'n (N=39)	mean* (ng/L)	range (ng/L)	% det'n (N=64)
a-BHC	2.84	0.86-6.98	100	2.68	1.16-5.85	100
lindane (g-BHC)	0.49	0.20-3.49	100	0.45	0.26-0.73	100
heptachlor	0.03	0.02-0.04	5	0.02	0.01-0.04	8
aldrin	0.13	0.13	3	0.01	0.01	2
heptachlor epoxide	0.11	0.05-0.20	100	0.12	0.07-0.25	97
g-chlordane	0.05	0.01-0.23	15	0.31	0.01-1.11	17
a-chlordane	0.03	0.01-0.15	33	0.05	0.01-0.23	36
a-endosulfan	0.04	0.01-0.24	36	0.05	0.01-0.22	30
p,p'-DDE	0.23	0.03-1.22	18	0.09	0.04-0.17	22
dieldrin	0.21	0.09-0.30	100	0.23	0.05-0.64	100
endrin	0.04	0.03-0.06	41	0.05	0.02-0.14	41
o,p-DDT	0.18	0.03-0.37	8	0.05	0.03-0.10	11
p,p'-TDE	-	-	0	0.08	0.08	2
p,p'-DDT	0.45	0.16-0.62	8	0.12	0.04-0.21	11
b-endosulfan	-	-	0	-	-	0
methoxychlor	-	-	0	-	-	0
PCBs	2.20	0.66-6.82	100	2.41	0.57-11.4	98
1,3-dichlorobenzene	0.49	0.28-0.71	8	0.15	0.08-0.25	6
1,4-dichlorobenzene	2.82	0.29-9.67	90	1.56	0.21-7.02	92
1,2-dichlorobenzene	0.34	0.05-0.89	18	0.34	0.11-0.81	36
1,3,5-trichlorobenzene	0.04	0.02-0.05	8	0.06	0.02-0.30	86
1,2,4-trichlorobenzene	0.10	0.04-0.32	100	0.09	0.01-0.63	97
1,2,3-trichlorobenzene	0.03	0.01-0.12	79	0.04	0.01-0.28	53
1,2,4,5-tetrachlorobenzene	0.02	0.020	5	0.04	0.02-0.06	3
1,2,3,5-tetrachlorobenzene	-	-	0	-	-	0
1,2,3,4-tetrachlorobenzene	0.02	0.01-0.06	82	0.04	0.01-0.69	61
pentachlorobenzene	0.02	0.01-0.13	69	0.05	0.01-0.66	92
hexachlorobenzene	0.03	0.01-0.25	87	0.12	0.02-1.05	91
indene	0.67	0.36-1.42	46	0.61	0.16-0.96	27
1,2,3,4-tetrahydronaphthene	0.64	0.37-1.55	28	0.43	0.17-0.66	5
2-methylnaphthalene	0.98	0.32-3.93	74	1.04	0.07-19.5	69
1-methylnaphthalene	0.84	0.20-4.20	62	1.27	0.19-20.6	41
acenaphthylene	0.38	0.20-0.60	15	2.15	0.33-7.55	6
acenaphthene	0.53	0.26-1.61	21	0.91	0.11-7.25	19
fluorene	0.76	0.27-3.55	49	0.88	0.29-6.92	33
phenanthrene	2.38	0.50-23.7	77	1.86	0.42-11.5	77
fluoranthene	1.24	0.56-2.15	28	1.06	0.20-5.74	38
pyrene	3.03	0.46-27.6	79	1.69	0.23-7.46	81
hexachlorobutadiene	0.12	0.01-0.59	26	1.09	0.10-8.39	86
octachlorostyrene	0.02	0.01-0.03	8	0.13	0.03-0.35	9

* non-detected data point were excluded from the mean concentration calculation

Table 5

Summary of organic contaminants (ng/g) in suspended sediment samples taken at Point Edward and Port Lambton between May 1987 and December 1989 (Chan 1993).

Parameter	Point Edward (May 1987-May 1989)				Port Lambton (May 1987-Dec 1989)			
	n	mean* (ng/g)	range (ng/g)	% det'n	n	mean* (ng/g)	range (ng/g)	% det'n
a-BHC	17	3.27	1.09-8.55	52	19	1.45	0.73-2.31	33
lindane (g-BHC)	4	2.70	0.54-7.42	12	1	2.00	2.00	2
heptachlor	0	-	-	0	0	-	-	0
aldrin	0	-	-	0	1	1.08	1.07	2
heptachlor epoxide	16	3.50	1.04-10.10	48	15	1.07	0.33-2.41	26
g-chlordane	6	16.65	1.67-46.44	18	9	26.87	1.75-70.28	16
a-chlordane	5	8.23	1.18-17.93	15	12	6.31	0.37-26.81	21
a-endosulfan	3	9.94	7.33-14.21	9	6	11.79	2.66-20.55	11
p,p'-DDE	14	6.04	1.23-13.99	42	24	3.36	1.41-15.80	42
dieldrin	30	8.06	0.95-40.66	91	41	5.21	0.76-37.72	72
endrin	2	3.37	2.42-4.30	6	4	7.29	4.13-13.45	7
o,p-DDT	0	-	-	0	2	3.27	2.67-3.86	4
p,p'-TDE	7	6.17	1.91-17.96	21	15	3.68	1.93-5.64	26
p,p'-DDT	1	7.04	7.04	3	7	8.92	2.52-17.00	12
b-endosulfan	1	10.93	10.92	3	1	0.97	0.97	2
methoxychlor	0	-	-	0	2	3.90	3.79-4.02	4
PCBs	23	74.03	14.44-108.9	70	32	158.19	7.24-1385	56
1,3-dichlorobenzene	0	-	-	0	1	26.89	26.89	2
1,4-dichlorobenzene	10	47.11	4.30-27.83	30	18	23.30	7.32-47.65	32
1,2-dichlorobenzene	2	16.07	4.30-27.83	6	19	10.67	2.39-29.51	33
1,3,5-trichlorobenzene	0	-	-	0	52	6.92	2.16-20.40	91
1,2,4-trichlorobenzene	6	10.28	5.93-13.28	18	41	4.90	0.93-59.04	72
1,2,3-trichlorobenzene	2	5.30	4.26-5.97	6	4	3.52	2.13-5.20	7
1,2,3,4-tetrachlorobenzene	0	-	-	0	12	2.17	0.29-6.84	21
pentachlorobenzene	0	-	-	0	53	9.48	0.87-66.12	93
hexachlorobenzene	13	1.86	0.71-3.47	39	57	102.79	3.69-828.9	100
indene	5	195.6	11.03-268.8	15	12	384.2	14.07-3945	21
1,2,3,4-tetrahydronaphthene	7	880.4	20.84-1900	21	14	674.9	7.08-5366	25
2-methylnaphthalene	23	139.2	7.22-770.2	70	53	197.9	10.77-5435	93
1-methylnaphthalene	19	91.6	9.87-404.6	58	50	164.6	12.44-5238	88
acenaphthylene	0	-	-	0	6	924.2	6.13-5468	11
acenaphthene	4	52.0	17.72-112.7	12	33	199.3	11.90-5262	58
fluorene	4	33.2	25.40-48.37	12	39	164.9	10.59-4300	68
phenanthrene	32	121.4	15.70-738.6	97	57	398.9	10.72-4903	100
pyrene	29	99.4	9.28-274.3	88	57	376.6	9.80-4644	100
fluoranthene	31	137.4	11.31-440.1	94	57	459.5	10.72-6605	100
octachlorostyrene	0	-	-	0	57	21.1	1.18-108.6	100
hexachlorobutadiene	1	1.01	1.014	3	55	119.6	9.84-697.7	96

* non-detected data point were excluded from the mean concentration calculation

Table 6

Contaminant transport and loading estimates in the St. Clair River at Point Edward and Port Lambton from March 1987 through December 1989 (Chan 1993).

Parameter	Point Edward (X)		Port Lambton (Y)		In-river addition (Y-X)	
	Tonnes/day	KT/year	Tonnes/day	KT/year	KT/year	% of Y
Na	1569	573	2523	921	348	37.8
Mg	3212	1172	3237	1181	9	0.7
SiO2	464	170	503	184	14	7.6
SO4	7232	2640	7392	2698	58	2.2
Cl	2657	970	3962	1446	476	32.9
K	389	142	391	143	1	0.6
Ca	12267	4478	12303	4490	13	0.3
TKN	62.1	22.7	74.5	27.2	4.5	16.6
NO3	84.2	30.7	70.5	25.7	-5.0	-19.4
TP	1.8	0.6	2.2	0.8	0.2	20.0
Parameter	**g/day**	**kg/year**	**g/day**	**Kg/year**	**kg/year**	**% of Y**
a-BHC	1374	501	1436	524	23	4.4
lindane	186	68	200	73	5	7.3
heptachlor epoxide	42	15	47	17	2	10.4
dieldrin	89	32	85	31	-1	-4.1
PCBs	536	196	755	276	80	29.1
p-dichlorobenzene	1453	530	498	182	-349	-191.8
1,3,5-trichlorobenzene	-	-	7*	3*	3*	100.0
1,2,4-trichlorobenzene	38	14	29	11	-3	-31.8
pentachlorobenzene	6	2	7.8*	3*	3*	100.0
hexachlorobenzene	9	3	17.6*	6.4*	6.4*	100.0
hexachlorobutadiene	-	-	185.6*	67.7*	67.7*	100.0
1-methylnaphthalene	358	131	218	80	-51	-64.2
2-methylnaphthalene	495	181	327	119	-61	-51.5
fluorene	447	163	2458	897	734	81.1
phenanthrene	790	288	614	224	-64	-28.7
pyrene	607	222	616	225	3	1.5

-not detected at station (HCBD detected in only one sample)
* transverse mixing model load

Table 7

Summary of bacteriological data collected from the Sarnia study area (Figure 2) from August 16 to November 20, 1990 (Marsalek et al. 1992). See Figure 2 for station locations.

Station	Geometric Means (counts/100 mL)									
	Coliphage		Fecal Coliform		Fecal Streptococci		*Pseudomonas aeruginosa*		*E. coli*	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
River Street (Ambient Water Quality)										
A (upstream control)	28	46	20	129	11	70	361	1570	17	96
B	59	-	221	5129[1]	79	2483[1]	973	3776[1]	133	6138[1]
C	26	106	50	689	23	375	893	3184	34	454
D	29	-	24	63	8	38	1002	1542	18	62
E	40	63	79	568	34	216	929	6714	71	406
F	36	-	297	1236[1]	94	839[1]	2173	4345[1]	286	818[1]
G	38	50	87	1560[1]	31	520[1]	1991	6776[1]	51	1138[1]
H	83	-	2547	8017	380	705	1574	4853	2046	5129
J	61	85	241	863	26	197	927	4560	197	590
Storm Sewers										
B		-		5129		2483		3776		6138
F		-		1236		839		4345		818
G		50		1560		520		6776		1138
Combined Sewer Overflows										
W		5841		1900000		90600		17300		1140000
Y		529		1180000		162000		17000		810000
Water Pollution Control Plants										
L[2]	413	1006	8800	87700	7350	9420	1220	614	19300	72800
Z	-			4530000		195000		55000		2250000
μ[2]	817	1130	970000	1120000	70300	140000	11900	6270	885000	1290000

1 Stations B, F and G represent storm sewer discharges in wet weather, although samples were collected in river adjacent to outfall, not within the outfall.

2 Samples collected before disinfection (for comparison of fecal pollution in sewage and CSOs)

Table 8

Estimated probabilities of non-exceedence of 100 FC/100 mL and 200 FC/100 mL concentrations in the Sarnia study area (Marsalek et al. 1992).

Station	Probability of Non-Exceedence (%)					
	100 FC/100 mL			200 FC/100 mL		
	Dry	Wet	Dry + Wet	Dry	Wet	Dry + Wet
A	95	41	77	99	64	87
B	31	5	22	48	10	35
C	70	10	50	88	20	65
D	94	65	84	99	85	94
E	60	11	44	76	22	58
F	20	0.6	14	39	4	27
G	53	2	36	75	7	52
H	2	0.1	1	6	0.4	4
J	24	0.0	16	45	0.5	30

Table 9

Compounds in water monitored by the Lambton Industrial Societies "continuous monitoring station" from 1987 through 1991 (LIS 1990, 1991 and Kuley et al. 1992).

1987	1988	1989-1990
benzene	benzene	benzene
toluene	toluene	toluene
styrene	styrene	styrene
perchloroethylene	perchloroethylene	perchloroethylene
ethylbenzene	ethylbenzene	ethylbenzene
1,2 dichlorethane	1,2 dichlorethane	1,2 dichlorethane
	carbon tetrachloride	carbon tetrachloride
	xylene	m & p xylene
		o-xylene
		dichloroethylene
		chloroform
		1,2 dichloropropane
		trichloroethylene
		1,3 diethylbenzene
		1,2 diethylbenzene
		1,3 dichlorobenzene

Table 10

Historical summary of results showing the number of events greater than 1 μg/L[1] (ppb) from 1987 through 1991, for the Lambton Industrial Society continuous monitor (Kuley et al. 1992).

Month	1987*	1988**	1989+	1990+	1991+
January	NA	2	10	2	-
February	NA	-	4	2	3
March	NA	-	1	-	-
April	NA	2	2	-	-
May	-	1	-	-	2++
June	-	1	1	-	-
July	-	3	1	-	-
August	-	-	4	3	-
September	1	2	-	-	-
October	-	3	-	1++	-
November	1	2	3	2++	-
December	-	8	5	-	-
Totals	**2**	**24**	**31**	**10**	**5**

[1] 1 μg/L (ppb) is used as a benchmark value because it serves as a positive indicator and can easily be applied year to year, despite changes in minimum detection limits etc.

NA data not available (instrument came on-line in May 1987)

* six target compounds

** eight target compounds

+ seventeen target compounds

++ Health and Welfare Canada's aesthetic criteria for ethylbenzene (2.4 μg/L) exceeded once during each of these months.

Table 11

Mean, range and number of samples in exceedence of the USEPA guidelines for the disposal of dredged materials. Survey was conducted in 1985 and a total of 35 sediment samples were taken from the St. Clair River (Nichols et al. 1991).

Parameter	Guideline for the Disposal of Dredged Sediment (μg/g)			Concentration (μg/g) Mean (Range)	Number of samples exceeding moderate or heavy pollution criteria	
	OMOE	USEPA Moderate	USEPA Heavy		Moderate	Heavy
Mercury	0.3	-	>1.0	0.15 (0.00-0.60)	0	0
Cadmium	1.0	-	>6	0.44 (0.20-1.20)	0	0
Chromium	25.0	25-75	>75	10.23 (5.20-15.00)	0	0
Copper	25.0	25-50	>50	24.68 (7.10-55.00)	14	1
Nickel	25.0	20-50	>50	13.29 (5.90-24.00)	5	0
Lead	50.0	40-60	>60	29.07 (7.00-92.00)	2	3
Zinc	100.0	90-200	>200	67.85 (28.00-310.00)	4	1

Table 12

Summary of concentrations of nutrients, inorganic and organic contaminants in surficial sediments collected in the St. Clair River nearshore in 1990. Values are on a dry weight basis; units as indicated by MRL (OMOEE 1993).

		Guideline				Ontario (49 stns.)					Michigan (15 stns.)				
Parameter	**MRL**	**NEL**	**LEL**	**SEL**	**OWDD**	**Con'n. Range**	**% >NEL**	**% >LEL**	**% >SEL**	**% >OWDD**	**Con'n. Range**	**% >NEL**	**% >LEL**	**% >SEL**	**% >OWDD**
Loss on Ignition	1.0 mg/g	-	-	-	60	1.0<T - 43.9	-	-	-	0.0	3.0 -45.0	-	-	-	0.0
Total Organic Carbon	0.2 mg/g	-	10	100	-	nd - 28.1	-	32.7	0.0	-	nd -39.0	-	53.3	0.0	-
Kjeldahl Nitrogen	0.025 mg/g	-	0.55	4.80	-	0.17<T - 1.58	-	77.6	0.0	-	0.19<T - 1.95	-	80.0	0.0	-
Phosphorus	- mg/g	-	0.60	2.00	-	0.08 - 0.48	-	0.0	0.0	-	0.06 - 0.50	-	0.0	0.0	-
Metals															
Arsenic	- ug/g	-	6	33	-	1.80 - 6.40	-	4.1	0.0	-	1.90 - 7.60	-	26.7	0.0	-
Cadmium	0.05 ug/g	-	0.6	10	-	nd - 1.40	-	6.1	0.0	-	nd - 0.64	-	6.7	0.0	-
Chromium	ug/g	-	26	110	-	5.10 - 22.0	-	0.0	0.0	-	5.30 - 20.0	-	0.0	0.0	-
Copper	ug/g	-	16	110	-	3.50 - 140	-	34.7	2.0	-	2.75 - 72	-	53.3	0.0	-
Iron	ug/g	-	20000	40000	-	3200 - 17000	-	0.0	0.0	-	3250 - 20000	-	0.0	0.0	-
Lead	ug/g	-	31	250	-	3.80<T - 640	-	16.3	2.0	-	2.45<T - 32.0	-	6.7	0.0	-
Mercury	0.01 ug/g	-	0.2	2	-	nd - 16.0	-	77.6	20.4	-	nd - 0.31	-	6.7	0.0	-
Nickel	- ug/g	-	16	75	-	6.10 - 30	-	32.6	0.0	-	5.75 - 55	-	53.3	0.0	-
Zinc	- ug/g	-	120	820	-	10.00<T - 250	-	2.0	0.0	-	10.75 - 79	-	0.0	0.0	-
Oil and Grease															
Solvent Extractables	1 ug/g	-	-	-	1500	113 -1772	-	-	-	2.0	100 - 1054	-	-	-	0.0
Polycyclic Aromatic Hydrocarbons (PAHs)															
Total PAHs	- ug/g	-	4	10000	-	nd - 54.26	-	16.3	0.0	-	nd - 8.50	-	6.7	0.0	-
Acenaphthene	0.04 ug/g	-	-	-	-	nd - 0.76	-	-	-	-	nd - 0.06<T	-	-	-	-
Acenaphthylene	0.05 ug/g	-	-	-	-	nd - 0.19<T	-	-	-	-	nd - 0.06<T	-	-	-	-
Anthracene	0.01 ug/g	-	0.220	370	-	nd - 2.84	-	18.4	2.0	-	nd - 0.18	-	0.0	0.0	-

Benzo(a)Anthracene	0.02 ug/g	-	0.320	1480	-	nd - 4.93	-	8.2	0.0	-	nd - 0.69	-	6.7	0.0	-
Benzo(b)Fluoranthene	0.06 ug/g	-	-	-	-	nd - 4.13	-	-	-	-	nd - 0.81	-	-	-	-
Benzo(k)Fluoranthene	0.02 ug/g	-	0.240	1340	-	nd - 1.68	-	4.1	0.0	-	nd - 0.37	-	6.7	0.0	-
Benzo(a)Pyrene	0.04 ug/g	-	0.370	1440	-	nd - 2.99	-	4.1	0.0	-	nd - 0.63	-	6.7	0.0	-
Benzo(g,h,i)Perylene	0.04 ug/g	-	0.170	320	-	nd - 1.15	-	10.2	0.0	-	nd - 0.44	-	6.7	0.0	-
Chrysene	0.02 ug/g	-	0.340	360	-	nd - 4.81	-	14.3	2.0	-	nd - 0.71	-	6.7	0.0	-
Dibenzo(a,h)Anthracene	0.04 ug/g	-	0.060	130	-	nd - 0.40<T	-	10.2	0.0	-	nd - 0.09<T	-	6.7	0.0	-
Fluoranthene	0.02 ug/g	-	0.750	1020	-	nd - 11.67	-	10.2	0.0	-	nd - 1.62	-	6.7	0.0	-
Fluorene	0.04 ug/g	-	0.190	160	-	nd - 0.73	-	18.4	0.0	-	nd - 0.10<T	-	0.0	0.0	-
Indeno(1,2,3-cd)Pyrene	0.04 ug/g	-	0.200	320	-	nd - 1.38	-	6.1	0.0	-	nd - 0.17<T	-	0.0	0.0	-
Naphthalene	0.04 ug/g	-	-	-	-	nd - 1.20	-	-	-	-	nd - 0.08<T	-	-	-	-
Phenanthrene	0.07 ug/g	-	0.560	950	-	nd - 8.51	-	22.4	2.0	-	nd - 0.97	-	13.3	0.0	-
Pyrene	0.06 ug/g	-	0.490	850	-	nd - 9.16	-	22.4	2.0	-	nd - 1.31	-	13.3	0.0	-
Polychlorinated Biphenyl (PCB)															
Total PCBs	20 ng/g	10	70	530000	-	nd - 2022	»8.2	8.2	0.0	-	nd	»0.0	0.0	0.0	-
Pesticides															
Aldrin	1 ng/g	-	2	8000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
total BHC	- ng/g	-	3	12000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
alpha-BHC	1 ng/g	-	6	10000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
beta-BHC	1 ng/g	-	5	21000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
gamma-BHC	1 ng/g	0.2	(3)	(1000)	-	nd	»0.0	0.0	0.0	-	nd	»0.0	0.0	0.0	-
total Chlordane	- ng/g	5	7	6000	-	nd	0.0	0.0	0.0	-	nd	0.0	0.0	0.0	-
alpha-Chlordane	2 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
gamma-Chlordane	2 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
Oxychlordane	2 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
total DDT	- ng/g	-	7	12000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
o,p + p,p'-DDT	5 & 5 ng/g	-	8	71000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
p,p'-DDD	5 ng/g	-	8	6000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
p,p'-DDE	1 ng/g	-	5	19000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
Dieldrin	2 ng/g	0.6	2	91000	-	nd	»0.0	0.0	0.0	-	nd	»0.0	0.0	0.0	-
alpha-Endosulfan	2 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-

beta-Endosulfan	4 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
Endosulfan Sulphate	4 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
Endrin	4 ng/g	0.5	3	130000	-	nd	»0.0	0.0	0.0	-	nd	»0.0	»0.0	0.0	-
Heptachlor	1 ng/g	0.3	-	-	-	nd	-	-	-	-	nd	»0.0	-	-	-
Hetachlor Epoxide	1 ng/g	-	5	5000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
Methoxychlor	5 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
Mirex	5 ng/g	-	7	130000	-	nd	-	0.0	0.0	-	nd	-	0.0	0.0	-
Organochlorines															
Hexachloroethane	1 ng/g	-	-	-	-	nd - 1880	-	-	-	-	nd	-	-	-	-
Hexachlorobutadiene	1 ng/g	-	-	-	-	nd - 48786	-	-	-	-	nd	-	-	-	-
1,2,3-Trichlorobenzene	2 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
1,2,4-Trichlorobenzene	2 ng/g	-	-	-	-	nd - 2391	-	-	-	-	nd	-	-	-	-
1,3,5-Trichlorobenzene	2 ng/g	-	-	-	-	nd - 109	-	-	-	-	nd	-	-	-	-
2,3,6-Trichlorotoluene	1 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
2,4,5-Trichlorotoluene	1 ng/g	-	-	-	-	nd - 121	-	-	-	-	nd	-	-	-	-
2,6,a-Trichlorotoluene	1 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
1,2,3,4-Tetrachlorobenzene	1 ng/g	-	-	-	-	nd	-	-	-	-	nd	-	-	-	-
1,2,3,5-Tetrachlorobenzene	1 ng/g	-	-	-	-	nd - 389	-	-	-	-	nd	-	-	-	-
1,2,4,5-Tetrachlorobenzene	1 ng/g	-	-	-	-	nd - 753	-	-	-	-	nd	-	-	-	-
Pentachlorobenzene	1 ng/g	-	-	-	-	nd - 1647	-	-	-	-	nd	-	-	-	-
Hexachlorobenzene	1 ng/g	10	20	24000	-	nd - 28933	75.5	51.0	16.3	-	nd - 3<T	0.0	0.0	0.0	-
Octachlorostyrene	1 ng/g	-	-	-	-	nd - 3020	-	-	-	-	nd	-	-	-	-

NOTES: nd = not detected at method reporting limit (MRL).
<T = a measurable trace amount; interpret with caution.
SEL guideline for organics must first be multiplied by station TOC percentage (as decimal fraction).
"-" = no data or guideline available.

Table 13

Concentrations of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in surficial sediments collected in the St. Clair River nearshore in 1990. Values are in pg/g = ppt (10^{-12}g/g) dry sediment. Sample locations are shown on Figure 1.

Parameter	I-TEF	Station 6A	11	13	18	20	IS 9	IS 12	IS 14	IS 15	IS 16	24	24 A	30	32	34	36	37	62	68	69
								Congener		Groups											
TetraCDD	-	nd(1)	nd(1)	nd(3)	nd(1)	nd(3)	nd(1)	nd(3)	420^{5}	8.2^{3}	29^{3}	4.5^{2}	nd(11)	6.3^{3}	7.1^{3}	16^{4}	7.1^{3}	2.7^{1}	nd(1)	1.7^{1}	1.6^{1}
PentaCDD	-	nd(1)	1.5^{1}	4.7^{1}	nd(1)	nd(5)	1.8^{1}	3.9^{1}	170^{3}	3.6^{2}	9.7^{2}	2.3^{1}	nd(16)	1.8^{1}	6.0^{3}	13^{4}	3.5^{2}	1.6^{1}	nd(1)	nd(1)	1.8^{1}
HexaCDD	-	4.2^{2}	14^{4}	25^{2}	4.0^{2}	nd(3)	5.5^{2}	33^{4}	320^{3}	15^{4}	39^{5}	6.2^{3}	nd(10)	5.4^{2}	5.9^{3}	13^{4}	nd(3)	2.2^{1}	nd(1)	5.2^{2}	12^{3}
HeptaCDD	-	16^{2}	54^{2}	75^{2}	21^{2}	24^{2}	60^{2}	95^{2}	420^{2}	43^{2}	55^{2}	23^{2}	29^{2}	18^{2}	18^{2}	31^{2}	14^{2}	17^{2}	8.2^{2}	21^{2}	44^{2}
OctaCDD *	-	48	200	310	53	71	150	290	1200	110	150	110	56	48	36	82	38	46	60	81	190
TetraCDF	-	3.3^{2}	5.5^{2}	33^{4}	2.7^{2}	13^{3}	7.7^{3}	27^{6}	1900^{8}	110^{12}	190^{17}	31^{7}	53^{6}	37^{14}	41^{9}	45^{8}	59^{12}	18^{7}	1.6^{1}	10^{4}	17^{9}
PentaCDF	-	nd(10)	7.3^{3}	5.4^{1}	nd(20)	nd(4)	17^{6}	23^{2}	300	59^{12}	18^{2}	13^{4}	nd(13)	22^{6}	60^{12}	43^{6}	25^{7}	6.8^{3}	nd(1)	6.5^{3}	6.6^{2}
HexaCDF	-	1.1^{1}	6.7^{2}	12^{1}	10^{4}	nd(5)	28^{7}	53^{4}	1200^{8}	46^{6}	92^{8}	22^{6}	20^{1}	30^{6}	70^{9}	77^{9}	45^{8}	7.7^{3}	nd(2)	7.5^{2}	12^{4}
Hepta CDF	-	9.8^{2}	20^{2}	53^{2}	10^{3}	4.4^{1}	65^{4}	54^{3}	1600^{4}	52^{4}	110^{4}	32^{4}	62^{2}	31^{4}	80^{4}	55^{4}	24^{4}	13^{3}	5.9^{2}	16^{2}	25^{2}
OctaCDF *	-	6.8	23	42	28	nd(12)	680	210	7100	90	480	70	130	52	79	96	71	20	6.0	18	24
Total PCDDs + PCDFs:		**89.2**	**332.0**	**560.1**	**128.7**	**112.4**	**1015**	**788.9**	**14630**	**536.8**	**1173**	**314.0**	**350.0**	**251.5**	**403.0**	**471.0**	**165.0**	**135.0**	**81.7**	**166.9**	**334.0**
								2,3,7,8	- Substituted		Isomers										
2,3,7,8-TetraCDD	1.0	nd(1)	nd(1)	nd(3)	nd(1)	nd(3)	nd(1)	nd(3)	nd(17)	nd(1)	nd(4)	nd(2)	nd(11)	nd(1)	nd(1)	nd(1)	nd(1)	nd(1)	nd(1)	nd(1)	nd(1)
1,2,3,7,8-PentaCDD	0.5	nd(1)	nd(1)	nd(4)	nd(1)	nd(5)	1.8	nd(3)	nd(39)	nd(1)	nd(5)	2.3	nd(16)	nd(1)	1.2	1.9	nd(1)	nd(1)	nd(1)	nd(1)	nd(1)
1,2,3,4,7,8-HexaCDD	0.1	nd(1)	nd(1)	nd(7)	nd(1)	nd(3)	nd(3)	nd(3)	nd(23)	nd(1)	nd(4)	nd(1)	nd(10)	nd(1)	nd(1)	nd(1)	nd(2)	nd(1)	nd(1)	nd(1)	nd(1)
1,2,3,6,7,8-HexaCDD	0.1	nd(1)	1.7	nd(7)	nd(1)	nd(3)	2.0	nd(3)	nd(23)	2.5	5.1	2.8	nd(10)	nd(1)	1.5	2.2	nd(1)	nd(1)	nd(1)	nd(1)	nd(1)
1,2,3,7,8,9-HexaCDD	0.1	nd(1)	1.6	nd(7)	nd(1)	nd(3)	nd(2)	nd(3)	nd(23)	1.9	nd(4)	1.8	nd(10)	nd(1)	1.4	2.0	nd(1)	nd(1)	nd(1)	nd(1)	1.7
1,2,3,4,6,7,8-HeptaCDD	0.01	7.2	26	34	8.4	8.7	23	33	220	25	27	13	14	8.9	8.5	15	6.9	7.0	4.2	9.8	22
1,2,3,4,6,7,8,9-OctaCDD	0.001	48	200	310	53	71	150	290	1200	110	150	110	56	48	36	82	38	60	60	81	190
2,3,7,8-TetraCDF **	0.1	1.8	2.9	12	1.2	nd(3)	4.3	5.7	110	12	22	11	12	7.8	13	18	9.6	4.8	1.6	4.4	4.3
1,2,3,7,8-PentaCDF	0.05	nd(1)	1.2	5.4	nd(1)	nd(4)	3.5	nd(2)	nd(34)	8.9	nd(6)	4.3	nd(13)	5.7	6.0	11	5.9	1.4	nd(1)	1.6	nd(1)
2,3,4,7,8-PentaCDF	0.5	nd(1)	nd(1)	nd(5)	nd(1)	nd(4)	2.4	nd(2)	nd(34)	4.3	nd(6)	3.1	nd(13)	3.0	7.3	7.0	3.5	nd(1)	nd(1)	nd(1)	nd(1)
1,2,3,4,7,8-HexaCDF	0.1	1.1	nd(2)	nd(7)	nd(1)	nd(5)	8.3	nd(4)	310	21	21	10	20	14	23	30	14	3.3	nd(2)	4.4	2.8
1,2,3,6,7,8-HexaCDF	0.1	nd(1)	nd(1)	nd(7)	nd(1)	nd(5)	2.6	nd(4)	69	4.4	13	2.9	nd(14)	2.9	9.7	5.3	2.7	1.2	nd(1)	nd(1)	nd(1)
2,3,4,6,7,8-HexaCDF	0.1	nd(1)	nd(1)	nd(7)	nd(1)	nd(5)	1.8	nd(4)	82	nd(1)	nd(6)	2.0	nd(14)	nd(1)	nd(6)	1.8	nd(1)	nd(1)	nd(1)	nd(1)	nd(1)
1,2,3,7,8,9-HexaCDF	0.1	nd(1)	nd(1)	nd(7)	2.9	nd(5)	nd(1)	nd(4)	nd(37)	nd(1)	7.1	nd(1)	nd(14)	nd(1)	4.4	8.6	5.5	nd(1)	nd(1)	nd(1)	nd(1)
1,2,3,4,6,7,8-HeptaCDF	0.01	5.5	14	31	4.3	4.4	23	24	820	21	64	16	40	16	41	28	13	7.1	3.8	9.4	13
1,2,3,4,7,8,9-HeptaCDF	0.01	nd(1)	nd(1)	nd(9)	2.0	nd(4)	9.9	nd(5)	160	5.7	8.6	4.2	nd(11)	4.3	15	11	4.7	1.3	nd(1)	nd(1)	nd(1)
1,2,3,4,6,7,8,9-OctaCDF	0.001	6.8	23	42	28	nd(12)	680	210	7100	90	480	70	130	52	79	96	71	20	6.0	18	24
Total 2,3,7,8-TetraCDD TEQ:		**0.5**	**1.3**	**2.5**	**0.6**	**0.2**	**5.7**	**1.6**	**77.**	**7.5**	**7.9**	**6.5**	**2.5**	**4.6**	**11.**	**12.**	**5.6**	**1.2**	**0.3**	**1.2**	**1.4**

NOTES: Concentrations are corrected for recovery of isotopically-labelled standards.
nd = not detected; detection limit in pg/g given in brackets ( ).
Superscripts indicate the number of isomers detected.
* = comprised of only a single isomer (1,2,3,4,6,7,8,9-).
** = maximum possible concentration due to potential chromatographic overlap.
I-TEF = International Toxic Equivalency Factor; TEQs were calculated assuming that "nd" = zero.

Table 14

Comparison of PCDD/F Congener Group, 2,3,7,8-Substituted Isomer and Total TEQ Concentrations in St. Clair River Sediments with Values in the Detroit and Niagara Rivers (OMOEE 1993).

Concentrations are in pg/g = ppt (10^{-12} g/g) dry sediment.

Parameter	**St. Clair River** (1990 MOEE study; n = 20)	**Detroit River** (1991 MOEE study; n = 26)	**Niagara River** (1993 MOEE study; n = 5)
TetraCDD	2nd(1) - 420	nd(1) - 150	nd(4) - 110,000
PentaCDD	nd(1) - 170	nd(1) - 240	nd(7) - 77,000
HexaCDD	nd(3) - 320	9.0 - 1,400	110 - 420,000
HeptaCDD	8.2 - 420	34 - 1,900	810 - 560,000
OctaCDD *	36 - 1,200	130 - 4,900	8,200 - 320,000
TetraCDF	1.6 - 1,900	nd(1) - 1,400	22 - 110,000
PentaCDF	nd(1) - 300	nd(3) - 960	28 - 180,000
HexaCDF	nd(2) - 1,200	nd(3) - 720	47 - 450,000
HeptaCDF	4.4 - 1,600	nd(4) - 660	230 - 800,000
OctaCDF *	nd(12) - 7,100	nd(4) - 3,000	200 - 1,100,000
2,3,7,8-TetraCDD	nd(1 - 17)	nd(1) - 22	nd(4) - 100,000
1,2,3,7,8-PentaCDD	nd(1) - 2.3	nd(1) - 29	nd(1) - 3,400
1,2,3,4,7,8-HexaCDD	nd(1 - 23)	nd(1) - 5.5	nd(1) - 10,000
1,2,3,6,7,8-HexaCDD	nd(1) - 5.1	nd(1) - 130	11 - 90,000
1,2,3,7,8,9-HexaCDD	nd(1) - 2.0	nd(1) - 57	4.0 - 57,000
1,2,3,4,6,7,8-HeptaCDD	4.2 - 220	11 - 880	55 - 390,000
1,2,3,4,6,7,8,9-OctaCDD	36 - 1,200	130 - 4,900	240 - 320,000
2,3,7,8-TetraCDF **	nd(3) - 110	nd (1) - 320	nd(1) - 20,000
1,2,3,7,8-PentaCDF	nd(1) - 11	nd(1) - 250	nd(1) - 9,400
2,3,4,7,8-PentaCDF	nd(1) - 7.3	nd(1) - 170	3.1 - 15,000
1,2,3,4,7,8-HexaCDF	nd(1) - 310	nd(1) - 310	nd(10) - 230,000
1,2,3,6,7,8-HexaCDF	nd(1) - 69	nd(1) - 65	nd(4) - 48,000
2,3,4,6,7,8-HexaCDF	nd(1) - 82	nd(1) - 39	nd(2) - 5,000
1,2,3,7,8,9-HexaCDF	nd(1) - 8.6	nd(1) - 2.7	nd(1) - 1,600
1,2,3,4,6,7,8-HeptaCDF	3.8 - 820	nd(4) - 350	56 - 700,000
1,2,3,4,7,8,9-HeptaCDF	nd(1) - 160	nd(1) - 56	nd(9) - 26,000
1,2,3,4,6,7,8,9-OctaCDDF	6.0 - 7,100	nd(4) - 3,000	120 - 1,100,000
Total 2,3,7,8-TetraCDD TEQ:	0.2 - 77	0.3 - 210	17 - 140,000

NOTES: Concentrations are corrected for recovery of isotopically-labelled standards.
nd = not detected; detection limit in pg/g given in brackets ( ).
* = comprised of only a single isomer (1,2,3,4,6,7,8,9-).
** = maximum possible concentration due to potential chromatographic overlap.
Total 2,3,7,8-TetraCDD TEQ calculated using I-TEFs, assuming that "nd" = zero; see Table 13.
n = number of stations analyzed for PCDDs and PCDFs.

Table 15

St. Clair River surficial sediment contaminant trends, 1969-1990. All concentrations on a dry weight basis, units as indicated (OMOEE 1993).

Contaminant	Number of Stations		Year 1969	1975	1977	1985	1990
Cadmium	16	Mean ± S.D., ug/g	-	-	17.19 ± 8.75	0.42 ± 0.45	0.28 ± 0.35
		% >LEL	-	-	>6.3	25.0	6.3
		% >SEL	-	-	>6.3	0.0	0.0
Chromium	20	Mean ± S.D., ug/g	-	-	212 ± 149	16.0 ± 5.2	11.7 ± 2.7
		% >LEL	-	-	100	5.0	0.0
		% >SEL	-	-	60.0	0.0	0.0
Copper	16	Mean ± S.D., ug/g	65.5 ± 56.6	-	62.8 ± 77.9	48.2 ± 44.0	26.2 ± 16.9
		% >LEL	87.5	-	43.8	93.8	75.0
		% >SEL	18.8	-	12.5	0.0	0.0
Iron	16	Mean ± S.D., ug/g	11,099 ± 4,578	-	6,956 ± 5,321	9,231 ± 2,704	8,362 ± 2,083
		% >LEL	6.3	-	0.0	0.0	0.0
		% >SEL	0.0	-	0.0	0.0	0.0
Lead	16	Mean ± S.D., ug/g	42.3 ± 25.8	-	108 ± 76.3	53.4 ± 92.7	62.7 ± 152
		% >LEL	68.9	-	68.9	25.0	18.8
		% >SEL	0.0	-	6.3	12.5	6.3
Mercury	5	Mean ± S.D., ug/g	335 ± 572	-	14.38 ± 21.89	15.85 ± 17.65	4.92 ± 3.47
		% >LEL	100	-	100	100	100
		% >SEL	60.0	-	80.0	100	60.0
Manganese	16	Mean ± S.D., ug/g	165 ± 96.6	-	149 ± 80.1	183 ± 45.7	-
		% >LEL	0.0	-	0.0	0.0	-
		% >SEL	0.0	-	0.0	0.0	-
Zinc	16	Mean ± S.D., ug/g	113 ± 107	-	112 ± 63.0	115 ± 157	71.2 ± 51.5
		% >LEL	31.3	-	43.8	25.0	6.3
		% >SEL	0.0	-	0.0	0.0	0.0
Solvent Extractables	13	Mean ± S.D., ug/g	-	3,280 ± 3,230	-	2,236 ± 1,566	902 ± 412
		% >OWDD	-	61.5	-	53.8	6.3
total PCBs	20	Mean ± S.D., ng/g	-	-	852 ± 2,225	318 ± 642	86 ± 289
		% >LEL	-	-	65.0	55.0	15.0
		% >SEL	-	-	-	0.0	0.0
Hexachlorobenzene	23	Mean ± S.D, ng/g	-	-	-	540 ± 728	1,562 ± 5,233
		% >LEL	-	-	-	65.2	65.2
		% >SEL	-	-	-	47.8	34.8
Octachlorostyrene	23	Mean ± S.D., ng/g	-	-	-	462 ± 1,264	349 ± 732
		% >LEL	-	-	-	- (no LEL)	- (no LEL)

NOTES: Mean = arithmetic mean.
S.D. = standard deviation.
Sediment Quality guidelines as per Table 12.

Table 16

Concentrations of metals, nutrients and conventional contaminants in bottom sediment samples collected by the USACOE on September 18 and 19, 1991 from the shipping channel and near the U.S. shore. Values are in μg/g unless otherwise noted (USCOE Data Files).

Parameter	Sample Number and Location	SC9101 In Channel @ Sarnia Bay	SC9102 Mouth of Black R.	SC9103 In Channel @ Dow Chemical	SC9104 In Channel @ Suncor	SC9105 In Channel @ Mooretown	SC9106 Near US shore @ St. Clair	SC9107 In Channel @ Marine City	SC9108 In South Channel, Ontario side, between Walpole and Russell Is.
Mercury		<0.06	<0.05	-	-	<0.07	<0.05	<0.05	0.18
TOC		11,000	2,000	-	-	27,000	4,500	28,000	26,000
Oil and Grease		<31	<31	-	-	<38	<32	<32	<33
Cyanide		<0.07	<0.07	-	-	<0.09	<0.07	<0.07	<0.08
COD		5,280	770	-	-	39,800	10,500	46,100	16,300
Volatile Solids		0.39%	0.19%	-	-	2.63%	1.17%	3.50%	1.85%
Arsenic		-	-	-	-	5.9	3.6	-	-
Cadmium		-	-	-	-	0.34	0.18	-	-
Chromium		-	-	-	-	24	3.5	-	-
Iron		-	-	-	-	26,600	4,400	-	-
Lead		-	-	-	-	9.1	4.7	-	-
Zinc		-	-	-	-	60	18.9	-	-
Ammonia-Nitrogen		-	-	-	-	8.3	<3.4	-	-
TKN		-	-	-	-	765	250	-	-
Total Phosphorus		-	-	-	-	270	122	-	-
Copper		-	-	-	-	18.3	4.3	-	-
Nickel		-	-	-	-	33	6.5	-	-

- No data available
TOC Total Organic Carbon
COD Chemical Oxygen Demand

Table 17

Concentrations of trace metals (μg/g, dry wt.) in test sediments collected for the OMOE 1990 bioassay survey (Bedard and Petro 1992). The Lowest Effect Level (LEL) of the Provincial Aquatic Sediment Quality Guidelines (PASQG) is provided; those results which exceed the LEL are in bold italics and those which exceed the Severe Effect Level (Hg only) are marked with an asterisk.

Station Name	Station Number (m offshore)	As	Cd	Cr	Cu	Fe%	Hg	Ni	Pb	Zn
Control (Honey Harbour)		2.1	0.3	22	11	2.1	0.02	15	20	62
Ontario PASQG, LEL		6	0.6	26	16	2	0.2	16	31	120
Lake St. Clair	208-1	1.3	0.1	8	6	0.5	***0.52***	10	10	29
	-2	1.3	ND	5	5	0.4	***0.53***	9	3	26
	-3	1.4	ND	7	6	0.4	***0.40***	8	4	24
Upstream of CN Ferry Dock	72-1(30)	6.0	***1.0***	17	***18***	1.2	0.05	***21***	12	59
	-2(40)	5.4	0.5	16	***17***	1.1	0.02	***20***	12	47
	-3(56)	3.9	0.2	11	12	0.9	<.01	15	6	34
Downstream of Cole Drain	73-1(20)	4.2	ND	11	***27***	0.8	0.05	16	16	74
	-2(40)	3.3	ND	8	***27***	0.6	0.04	12	12	85
	-3(50)	3.8	ND	10	***26***	0.8	0.06	***24***	26	110
Novacor	94-1(10)	4.7	0.1	18	***27***	1.2	***0.22***	***23***	***33***	76
	-2(20)	***6.2***	0.1	19	***32***	1.4	***0.28***	***27***	24	95
	-3(25)	4.6	0.1	15	***26***	1.2	0.17	***22***	19	62
Below Polysar	74-1(4)	3.0	0.2	10	***45***	0.7	***1.60***	15	17	59
	-2(10)	3.7	0.5	17	***51***	0.9	***1.60***	***27***	25	100
	-3(15)	3.7	0.2	15	***43***	0.9	***1.10***	***21***	19	94
Downstream of Dow 1st St.	95-1(20)	3.3	0.3	11	***26***	0.8	***2.80****	16	14	76
	-2(12)	5.2	0.2	16	***38***	1.1	***3.90****	***26***	21	110
	-3(6)	5.1	0.2	16	***43***	1.0	***4.00****	***26***	18	105
Downstream of Dow 2nd St.	96-1(15)	2.8	ND	10	***20***	0.7	***8.80****	14	6	61
	-2(10)	4.0	0.1	10	16	0.8	***8.50****	15	20	43
	-3(12)	3.4	0.3	14	***23***	1.1	***15.0****	***19***	13	46
Downstream of Dow 3rd St.	97-1(15)	3.9	ND	11	***22***	0.7	***4.30****	15	13	64
	-2(10)	2.2	ND	12	***23***	0.6	***8.90****	15	7	51
	-3(6)	2.5	ND	8	8	0.6	***9.00****	12	4	42
Downstream of Suncor Outfall	76-1(5)	2.9	0.5	10	***24***	0.8	***5.80****	13	12	45
	-2(12)	3.0	0.1	8	14	0.7	***1.90***	9	16	55
	-3(18)	4.7	0.2	10	12	0.8	***1.80***	14	8	42
Downstream of Shell Intake	143-1(42)	3.2	0.1	12	***23***	0.8	***3.40****	14	***43***	47
	-2(50)	3.1	0.2	10	11	0.9	***1.30***	11	10	46
	-3(45)	***6.9***	0.4	10	13	0.8	***1.20***	13	12	42
Downstream of Novacor, Corunna Sewer	80-1(18)	3.0	0.1	10	***17***	0.7	***2.80****	13	***130***	45
	-2(35)	2.6	0.1	9	12	0.7	***2.20****	11	***130***	41
	-3(25)	2.6	0.5	10	15	0.8	***2.30****	13	***130***	49
Lake St. Clair Disposal Area	207-1	2.5	ND	5	4	0.4	0.19	7	6	15
	-2	2.1	ND	6	4	0.4	0.18	9	5	15
	-3	2.0	ND	5	3	0.4	0.17	6	3	13
South Channel Dredge Area	252-1	1.3	ND	12	4	0.3	0.14	10	3	12
	-2	2.9	ND	8	8	0.6	***0.23***	11	5	30
	-3	3.2	ND	11	15	0.8	***0.31***	***17***	14	47

ND = Not detected

Table 18

Concentrations of organic chemicals (ng/g) in test sediments collected for the OMOE 1990 bioassay survey (Bedard and Petro 1992).

Station Name[1]	Station Number (m offshore)	OCS	Total PCBs	HCBD	HCB	QCB	HCE	3-Chloro Toluene	Total 3- & 4-Chloro Benzene
Cole Drain	73-1(20)	50	ND	190	35	ND	ND	ND	25
Novacor	94-1(10)	60	ND	85	25	ND	20	ND	ND
	-2(20)	200	ND	520	720	40	4<T	ND	130
	-3(25)	110	ND	490	220	10<T	10<T	ND	95
Below Polysar	74-1(4)	3000	-	25000	20400	1250	520	1300	11220
	-2(10)	380	-	6250	5000	330	110	250	2745
	-3(15)	410	-	1545	890	80	40	ND	590
Downstream of Dow 1st St.	95-1(20)	1290	520	97780	26352	2030	1090	1030	910
	-2(12)	2000	-	23130	32390	1190	2020	ND	12366
	-3(6)	3146	6150	42215	28375	1850	3020	1770	21250
Downstream of Dow 2nd St.	96-1(15)	290	700	4800	1680	340	235	ND	270
	-2(10)	1030	520	1050	740	75	10<T	10<T	75
	-3(12)	215	6225	1800	2000	155	340	530	ND
Downstream of Dow 3rd St.	97-1(15)	80	ND	1270	420	80	60	ND	ND
	-2(10)	265	590	1290	1660	140	60	ND	330
	-3(6)	170	685	865	1445	185	ND	ND	310
Downstream of Suncor Sewer	76-1(5)	90	ND	220	1335	45	ND	ND	ND
	-2(12)	30	ND	410	870	35	ND	ND	ND
	-3(18)	20	ND	700	60	30	ND	ND	ND
Downstream of Shell Intake	143-1(42)	ND	ND	ND	50	20	25	ND	40
	-2(50)	ND	ND	ND	50	10<T	10<T	ND	30
	-3(45)	ND	ND	ND	20	5<T	6<T	ND	30
Downstream of Novacor, Corunna Sewer	80-2(35)	ND	ND	ND	25	ND	4<T	ND	ND
	-3(25)	ND	ND	ND	100	25	6<T	ND	40
Lake St. Clair Disposal Area	207-1	ND	ND	85	30	ND	ND	ND	ND
	-2	5<T	ND	ND	40	ND	10<T	ND	ND

Notes:

1 Chemical concentrations were reported in trace amounts or were not detected for the following sediments: Control; Station #208 (Lake St. Clair); Station #72-1,-2,-3; #73-2,-3; #80-1; #207-3; #252-1,-2,-3.

ND Not Detected

<T Trace amount

OCS	Octachlorostyrene	PCBs	Polychlorinated Biphenyls
HCBD	Hexachlorobutadiene	HCB	Hexachlorobenzene
QCB	Pentachlorobenzene	HCE	Hexachloroethane

3-Chloro Toluene = 2,4,5-trichlorotoluene

3-&4-Chloro Benzene = tri- and tetrachlorobenzenes

Table 19

Summary data on test organism percent mortality and growth reduction for St. Clair River sediments, 1990 (Bedard and Petro 1992).

Station Name	Station Number (m offshore)	*Pimephales promelas*	*Chironomus tentans*		*Hexagenia limbata*
		% Mortality	% Mortality	% Growth Reduction	% Mortality
Control (Honey Harbour)		10	8	-	10
		10	0	-	10
		30	8	-	10
Open Lake St. Clair	208-1	0	0	-	0
	-2	0	8	-	0
	-3	0	0	-	10
Upstream of CN Ferry Dock	72-1(30)	10	0	45-60	0
	-2(40)	0	38	-	0
	-3(56)	0	15	-	0
Downstream of Cole Drain	73-1(20)	10	0	-	40
	-2(40)	10	15	-	0
	-3(50)	0	0	45-60	20
Novacor	94-1(10)	20	23	15-30	10*
	-2(20)	10	0	-	10*
	-3(25)	0	0	-	0
Below Polysar 42" Sewer	74-1(4)	100	0	15-30	80*
	-2(10)	100	0	-	10*
	-3(15)	10	0	-	0*
Downstream of Dow 1st St.	95-1(20)	80	0*	-	100
	-2(12)	100	4*	-	10
	-3(6)	100	0*	-	90
Downstream of Dow 2nd St.	96-1(15)	0	0	-	0
	-2(10)	10	8	-	0
	-3(12)	0	0	15-30	0
Downstream of Dow 3rd St.	97-1(15)	0	8*	-	0
	-2(10)	0	4*	-	0
	-3(6)	0	4*	-	0
Downstream of Suncor Sewer	76-1(5)	35*	100	-	100
	-2(12)	10*	15	>80	90
	-3(18)	5*	0	-	100
Downstream of Shell Intake	143-1(42)	30	46	>80	90
	-2(50)	10	15	-	0
	-3(45)	10	8	-	0
Downstream of Novacor, Corunna Sewer	80-1(18)	0*	0	-	50
	-2(35)	0*	0	-	30
	-3(25)	5*	0	-	10
Lake St. Clair Disposal Area	207-1	0	15	-	0
	-2	0	8	-	100
	-3	20	15	-	90
South Channel Dredge Area	252-1	0	0	-	90
	-2	0	8	-	0
	-3	0	8	-	0

* Average value. Number of replicates is 2.

Table 20

Summary of metal data collected from 44 sites in the St. Clair River Delta and Lake St. Clair in 1992 (Great Lakes University Research Fund 1993).

	Cu µg/g	Mn µg/g	Ni µg/g	Co µg/g	Pb µg/g	Zn µg/g	Hg ng/g	Cr µg/g	Al µg/g
PASQG/LEL	16	460	16		31	120	0.2	26	
EPA/mod pol	25	300	20		40	90	1*	25	
mean	15.28	218.35	15.74	6.79	11.47	48.60	428.65	10.51	5468.21
SD	8.56	88.39	6.80	2.39	6.23	19.36	323.50	5.28	3179.48
min	1	61	3	2	1	9	15	4	1411
max	32	492	33	13	23	87	1234	26	14460

* heavily polluted guideline.

Table 21

Concentrations of inorganic and organic contaminants in caged mussels after 3 weeks' exposure in the St. Clair River nearshore during 1990. Values are means and standard deviations of three replicates, units as indicated by MRL, on a wet weight basis (OMOEE 1993).

Parameter	MRL	Station									
		13 (CN Ferry dock)	20 (d/s Cole Drain)	IS 12 (Novacor Chem.)	22 (d/s Novacor 42" sewer)	IS 14 (d/s Dow 1st St. sewer)	IS 15 (d/s Dow 2nd St. sewer)	IS 16 (d/s Dow 3rd St. sewer)	24 A (d/s Suncor sewer)	30 (d/s Shell intake)	Pre-Exposure Control (Balsam Lake)
Metals											
Arsenic	- ug/g	0.67 ± 0.17	0.50 ± 0.14	0.47 ± 0.05	0.55 ± 0.09	0.52 ± 0.08	0.60 ± 0.14	0.71 ± 0.24	0.65 ± 0.19	0.59 ± 0.12	0.52 ± 0.26
Cadmium	- ug/g	0.88 ± 0.31	0.70 ± 0.21	0.89 ± 0.36	0.58 ± 0.30	0.59 ± 0.17	1.03 ± 0.50	0.77 ± 0.22	0.84 ± 0.07	0.70 ± 0.16	0.83 ± 0.47
Copper	- ug/g	1.06 ± 0.12	1.47 ± 0.15	1.60 ± 0.26	1.43 ± 0.46	1.47 ± 0.06	1.47 ± 0.57	1.37 ± 0.41	1.56 ± 0.66	1.77 ± 0.15	0.94 ± 0.15
Lead	0.60 ug/g	<0.63 ± 0.06	<0.60 ± 0.00	<0.63 ± 0.06	<0.63 ± 0.06	<0.67 ± 0.06	<0.63 ± 0.06	<0.63 ± 0.06	<0.67 ± 0.06	<0.60 ± 0.00	<0.63 ± 0.06
Mercury	0.01 ug/g	0.01<T ± 0.01	nd	0.01<T ± 0.01	0.01<T ± 0.01	0.01<T ± 0.01	0.01<T ± 0.01	0.02<T ± 0.01	0.01<T ± 0.01	0.01<T ± 0.01	nd
Nickel	0.40 ug/g	<0.43 ± 0.06	<0.40 ± 0.00	0.43 ± 0.06	0.43 ± 0.06	<0.47 ± 0.06	<0.43 ± 0.06	0.47 ± 0.06	<0.46 ± 0.06	<0.40 ± 0.00	<0.43 ± 0.06
Zinc	- ug/g	38.7 ± 4.2	38.7 ± 9.3	35.3 ± 4.0	38.3 ± 9.3	31.7 ± 6.7	38.0 ± 12.5	33.0 ± 4.6	31.7 ± 8.7	28.7 ± 6.0	29.3 ± 6.5
Lipids											
Lipids	- %	1.10 ± 0.52	0.90 ± 0.26	0.90 ± 0.35	1.07 ± 0.47	0.93 ± 0.21	0.90 ± 0.10	1.37 ± 0.25	0.80 ± 0.36	0.93 ± 0.15	1.10 ± 0.26
Polycyclic Aromatic Hydrocarbon (PAH)											
total PAHs	- ng/g	53	149	106	159	148	84	303	193	370	49
Acenaphthene	8 ng/g	14<T ± 4	17<T ± 13	11 ± 10	13<T ± 3	13<T ± 3	10<T ± 1	22<T ± 9	17<T ± 8	29<T ± 27	9<T ±
Acenaphthylene	5 ng/g	nd	15<T ± 19	nd	nd	trace	trace	trace	5<T ± 9	19<T ± 26	5<T ±
Anthracene	9 ng/g	nd	nd	nd	nd	nd	nd	trace	nd	trace	nd
Benzo(a)Anthracene	6 ng/g	nd	7<T ± 2	trace	trace	trace	nd	trace	trace	9<T ± 8	nd
Benzo(b)Fluoranthene	7 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Benzo(k)Fluoranthene	6 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Benzo(a)Pyrene	8 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Benzo(g,h,i)Perylene	6 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Chrysene	5 ng/g	trace	9<T ± 8	10<T ± 5	12<T ± 5	trace	trace	12<T ± 2	12<T ± 5	25<T ± 11	nd
Dibenzo(a,h)Anthracene	7 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fluoranthene	10 ng/g	trace	27<T ± 5	24<T ± 6	30<T ± 7	28<T ± 7	17<T ± 3	36<T ± 9	29<T ± 10	49<T ± 26	11<T ±
Fluorene	16 ng/g	nd	trace	nd	18<T ± 7	trace	trace	27<T ± 23	25<T ± 7	33<T ± 21	nd
Indeno(1,2,3-cd)Pyrene	6 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Naphthalene	19 ng/g	nd	nd	nd	trace	26<T ± 29	trace	48<T ± 23	trace	36<T ± 19	nd
Phenanthrene	8 ng/g	39<T ± 14	49<T ± 24	40<T ± 12	58<T ± 7	59<T ± 29	44<T ± 5	124 ± 53	81<T ± 55	124 ± 91	24<T ±
Pyrene	8 ng/g	trace	25<T ± 4	21<T ± 7	28<T ± 8	22<T ± 7	13<T ± 3	34<T ± 6	24<T ± 9	55<T ± 30	nd
Polychlorinated Biphenyl (PCB)											
total PCBs	20 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Pesticides											
Aldrin	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
alpha-BHC	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
beta-BHC	1 ng/g	1<T ± 2	nd	1<T ± 2	6<T ± 11	3<T ± 3	nd	nd	nd	nd	nd
gamma-BHC	1 ng/g	6<T ± 7	3<T ± 1	3<T ± 0	8<T ± 3	4<T ± 2	nd	3<T ± 1	2<T ± 3	2<T ± 2	nd
alpha-Chlordane	2 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
gamma-Chlordane	2 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
o,p-DDT	5 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
p,p'-DDT	5 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
p,p'-DDD	5 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
p,p'-DDE	1 ng/g	1<T ± 2	1<T ± 1	1<T ± 1	1<T ± 2	nd	nd	nd	nd	nd	nd
Heptachlor	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Mirex	5 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Organochlorines											
Hexachloroethane	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hexachlorobutadiene	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1,2,3-Trichlorobenzene	2 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1,2,4-Trichlorobenzene	2 ng/g	nd	nd	4<T ± 1	7<T ± 3	8<T ± 3	nd	2<T ± 2	1<T ± 2	5<T ± 2	nd

1,3,5-Trichlorobenzene	2 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2,3,6-Trichlorotoluene	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2,4,5-Trichlorotoluene	1 ng/g	nd	nd	nd	1<T ± 2	1<T ± 1	nd	nd	nd	nd	nd
1,2,3,4-Tetrachlorobenzene	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1,2,4,5-Tetrachlorobenzene	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Pentachlorobenzene	1 ng/g	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hexachlorobenzene	1 ng/g	nd	nd	1<T ± 1	4<T ± 4	8<T ± 2	trace	11 ± 13	1<T ± 2	trace	nd
Octachlorostyrene	1 ng/g	1<T ± 2	nd	3<T ± 3	9<T ± 8	12 ± 2	2<T ±2	15 ± 6	1<T ± 2	3<T ± 3	nd

NOTES:		
	d/s	just downstream of named outfall or location.
	nd	not detected at method reporting limit (MRL).
	<T	a measurable trace amount; interpret with caution.
	<	less than.
	"-"	data not available.
	trace	calculated mean concentration below MRL.

Table 22

Taxonomic composition (mean number per 516 cm2) of the four benthic invertebrate communities A, B, C and D in the St. Clair River, summer 1990. As determined by cluster analysis and presented by Tarandus (1992).

Taxon	Community			
	A	B	C	D
CERATOPOGONIDAE				
Bezzia	P	P		
CHIRONOMIDAE				
Ablabesmyia	P	P	P	
Chironomus	P	P		
Cricotopus	P	P		P
Cryptochironomus	3.72	P	P	P
Demicryptochironomus	P	P	P	P
Epoicocladius	1.60	P		P
Harnischia	P			
Macropelopia	P	P		P
Micropsectra	P			
Paracladopelma	P	P		
Paratendipes	P	P		
Polypedilum	24.90	P	1.44	1.37
Procladius	11.23	P	P	5.97
Pseudochironomus	P	P		
Rheotanytarsus	1.64	P		
Stictochironomus	1.61	P		
Tanytarsus	P	P		
Tribelos	14.13	1.37	P	
TRICHOPTERA				
Brachycentrus	P	P		
Cheumatopsyche	P	P	P	P
Hydropsyche	p	p	p	
Neureclipsis		P	P	
Hydroptila		P	P	
Oecetis		P		
Polycentropus	P	P		
Trianodes	P	P		
LEPIDOPTERA				
Acentria	P	P	P	P
ODONATA	P	P		
EPHEMEROPTERA				
Baetisea	P	P	P	
Caenis	P	P		
Ephemerlla	P	P	P	
Hexagenia	1.45	P	P	P
Stenonema		P		
COLEOPTERA				

Table 23

Mean concentrations of sediment parameters associated with benthic invertebrate communities A, B, C and D from the St. Clair River, spring 1990.

All values are expressed in μg/g (dry weight) unless otherwise specified. Shaded values exceed the Lowest Effect Level (LEL) of the PASQG and astricies (**) indicate values exceeding the Severe Effect Level (SEL) (Tarandus 1992).

Parameter	Community			
	A	B	C	D
Copper	15.46	17.64	41.37	26.56
Nickel	17.19	16.74	13.62	16.30
Lead	14.96	33.62	25.32	63.92
Zinc	49.51	50.16	60.62	61.24
Arsenic	4.56	3.94	4.03	3.78
Chromium	12.72	12.06	11.42	12.36
Mercury	0.20	1.25	4.53**	2.13**
Iron	9480.41	9325.47	7914.00	8743.40
Cadmium	0.25	0.24	0.24	0.22
LOI (mg/g)	20.47	15.26	17.22	24.80
Total Phosphorus (mg/g)	0.29	0.22	0.22	0.28
TKN (mg/g)	1.04	0.66	0.65	0.87
Calcium	49397.06	45655.56	51213.83	53533.20
Chloride	12.48	22.65	27.63	26.94
TOC (mg/g)	11.84	9.31	10.27	14.24
Oil and Grease	627.29	576.06	781.00	1233.00
Hexachlorobenzene (ng/g)	10.12	887.89	456.17	419.00
Octachlorostyrene (ng/g)	2.82	89.46	738.33	303.80
Phenanthrene	0.21	0.57	2.36	1.13
Anthracene	0.04	0.10	0.68	0.21
Fluoranthene	0.25	0.40	2.33	0.76
Pyrene	0.20	0.39	2.09	0.84
Benzo(a)anthracene	0.10	0.14	1.00	0.29
Chrysene	0.12	0.18	1.03	0.38
Benzo(k)fluoranthene	0.05	0.07	0.32	0.15
Benzo(b)fluoranthene	0.12	0.17	0.82	0.35
Benzo(a)pyrene	0.09	0.13	0.62	0.23
Moisture (%)	36.35	26.56	28.85	33.44
Percent Gravel	5.00	18.97	15.18	6.52
Percent Sand	55.12	64.95	60.50	66.22
Percent Silt	39.95	16.44	23.62	35.58

Note: LEL for total PAHs is now 4 μg/g (P. Kauss, MOEE, pers. com.) and individual PAH parameters are shaded for communities C and D as their total exceeds 4 μg/g.

Table 24

Production of Hexagenia limbata nymphs and sediment contaminant levels (mg/kg dry wt) in the Upper Great Lakes Connecting Channels, 1986 (Edsall et al. 1991).

Channel and Station	Production Dry wt (mg/m^2) (95% confidence interval)	Contaminant (mg/kg dry wt)							
		Oil	Cyanide	Cd	Cr	Cu	Ni	Pb	Zn
St. Marys River									
26	3,481	-	-	0.3	7.9	9.8	7.7	12.0	33.0
	(3,082-3,890)		-	0.3	7.9	8.2	9.4	8.6	26.0
30	403	+	-	-	9.0	6.8	6.4	12.0	43.0
	(287-518)	3,170*	2.1*	1.1*	49.0*	44.0*	27.0*	59.0*	210.0*
51	3,333	-	-	0.3	11.0	8.6	7.2	10.0	48.0
	(3,021-3,644)	869	-	0.3	14.0	11.0	9.2	11.0	51.0
112	3,375	-	-	0.3	18.0	12.0	10.0	11.0	30.0
	(2,935-3,815)								
St. Clair River									
131	741	+	-	0.6	13.0	46.0*	15.0	34.0	93.0*
	(605-877)	1,670*	-	0.6	13.0	52.0*	15.0	33.0	100.0*
145	359	+	-	0.3	6.7	14.0	8.9	7.5	46.0
	(288-430)		-	0.7	7.7	18.0	14.0	9.4	63.0
157	980	892	-	0.4	11.0	18.0	15.0	18.0	57.0
	(770-1,189)	793	-	0.4	11.0	18.0	14.0	18.0	55.0
Lake St. Clair									
177	9,231	-	-	0.6	14.0	24.0	18.0	28.0	63.0
	(8,757-9,705)								
Detroit River									
217	376	+	-	1.0*	37.0*	43.0*	42.0*	71.0*	170.0*
	(264-489)								
225	708	-	-	0.4	32.0*	32.0*	39.0	19.0	83.0
	(558-857)	-	-	0.4	30.0*	33.0*	36.0	26.0	83.0
243	873	+,881	-	3.2*	39.0*	48.0*	31.0	55.0*	160.0*
	(708-1,035)	1,020*	-	1.6*	30.0*	38.0*	29.0	46.0*	140.0*

-No data

+ Oil detected by smell or as a visible sheen in sample and exceeded the pollution criterion (IJC 1987)

* Measured value exceeds U.S. Environmental Protection Agency or Ontario Ministry of the Environment guideline for polluted dredged sediments (IJC 1982).

Dubiraphia	P	P	P	P
AMPHIPODA				
Gammarus	2.36	P	P	P
PLATYHELMINTHES	P	P	P	P
HIRUDINEA	1.36	P	5.17	
HYDRA	P	P	1.11	
HYDRACHNIDA	P	P	P	
MOLLUSCA				
HYDROBIIDAE	2.02	1.57	16.31	2.23
PHYSIDAE	P	P	1.17	P
Gyraulus	P	P	P	
Goniobasis	3.09	P	P	
Pleurocera	P	P	P	
Valvata	P	1.26	2.94	P
SPHARIIDAE	2.36	P	7.58	2.10
UNIONIDAE		P		
LUMBRICULIDAE	P	P		P
LUMBRICINA	P	P		
TUBIFICIDAE				
Aulodrilus spp.	P	P	P	P
Bothrioneurum	P	P		
Ilydrilus	P		P	1.07
Isochaetides spp.	P	P		
Limnodrilus cervix	P	P	2.08	P
Limnodrilus hoffmeisteri	5.86	2.78	27.56	13.47
Limnodrilus maumeenis	P			
Limnodrilus profundicola	P	P	P	P
Limnodrilus udekemianus	P	P		
Potomothrix spp.	P	P	1.81	P
Quistadrilus multisetosus	1.18	P	2.97	3.13
Spirosperma ferox	7.96	4.14	15.44	1.17
Spirosperma nikolskyi	P	P		
Tubifex tubifex		P		P
NAIDIDAE				
Nais spp.	P	P	P	3.60
Ophidonais serpentia	P	P	P	P
Paranais frici	P	P	5.36	26.43
Vejdovskyella intermedia	3.88	P	P	24.37
Enchytraeidae	P	P	P	P
NEMATODA	P	P	P	13.20

P denotes a mean density of less than 1 individual per sample

Table 25

Summer (June, July, August), 1992 creel survey from both boat and shore, for species specific anglers within Ontario waters of the St. Clair River (OMNR and LSCFU data files).

Species	Total Estimated Catch	Total Estimated Harvest	Total Estimated Effort	Catch per Unit Effort (CUE)		Harvest Catch per Unit Effort	
				Angler-Hours	Rod-Hours	Angler-Hours	Rod-Hours
Lake sturgeon	108	82	3769	0.030	0.029	0.023	0.022
Chinook salmon	0	0	93	0	0	0	0
Rainbow trout	14	0	619	0.023	0.023	0	0
Brown trout	0	0	33	0	0	0	0
Rainbow smelt	0	0	1	0	0	0	0
Northern pike	79	47	755	0.104	0.104	0.063	0.063
White sucker	98	9	359	0.274	0.274	0.025	0.025
Common carp	32	32	359	0.090	0.090	0.090	0.090
Channel catfish	25	18	344	0.074	0.074	0.052	0.052
White perch	101	91	886	0.114	0.114	0.103	0.103
White bass, silver bass	2361	1798	9235	0.256	0.256	0.195	0.195
Rock bass	4396	1987	5296	0.831	0.830	0.376	0.375
Pumpkinseed	65	0	125	0.517	0.517	0	0
Bluegill	88	0	8	11.573	11.573	0	0
Small mouth bass, black bass	3860	1908	15932	0.243	0.242	0.120	0.120
Largemouth bass	10	0	136	0.076	0.075	0	0
Black crappie	20	0	176	0.116	0.116	0	0
Yellow perch	35484	5894	19401	1.856	1.829	0.308	0.304
Walleye	9935	8241	34783	0.286	0.286	0.237	0.237
Gobi family	865	295	994	0.874	0.871	0.298	0.297
Freshwater drum, sheepshead	1872	960	3271	0.572	0.572	0.293	0.293

Table 26

Heavy metal, organochlorine, hexachlorobenzene and octachlorostyrene contaminants in 1991 sport fish collections from the St. Clair River (OMOE/OMNR data files).

Parameter	Sarnia, downstream of Blue Water Bridge (µg/g)		St. Clair River Upstream End of Stag Is. (µg/g)				Port Lambton (µg/g)
	Walleye mean (range)	White Sucker mean (range)	Carp mean (range)	Walleye mean (range)	Freshwater Drum mean (range)	Gizzard Shad mean (range)	Walleye mean (range)
Length	45.5 cm (35.8-63.2)	36.4 cm (26.3-46.0)	61.2 cm (52.1-71.6)	42.1 cm (22.5-54.0)	36.8 cm (27.5-49.4)	34.6 cm (30.4-39.9)	48.1 cm (40.5-51.7)
Mercury	0.27 (0.07-0.51)	0.22 (0.08-0.46)	0.33 (0.16-0.78)	0.30 (0.06-0.77)	0.61 (0.10-1.60)	0.07 0.06-0.10)	0.40 (0.25-0.65)
Copper	0.50 (0.29-0.78)	0.59 (0.30-0.92)	0.059 (<0.20-1.30)	0.36 (0.19-0.77)	0.34 (<0.20-0.80)	0.89 (0.61-1.50)	0.37 (<0.20-0.51)
Nickel	<0.40 (<0.40-0.58)	<0.40 (<0.40-0.52)	0.48 (<0.40-0.84)	0.45 (<0.40-0.64)	<0.40 (<0.40-0.79	<0.40 (<0.40)	<0.40 (<0.40)
Zinc	5.0 (3.9-7.2)	7.2 (4.5-13.0)	14.3 (4.8-35.0)	5.0 (3.2-7.2)	4.6 (3.2-7.4)	5.1 (3.9-7.1)	4.5 (3.6-5.1)
Lead	<0.60 (<0.60)	<0.60 (<0.60)	<0.60 <0.50-0.71)	<0.60 (<0.60)	<0.60 (<0.60)	<0.60 (<0.60)	<0.60 (<0.60)
Cadmium	<0.04 (<0.04-0.04)	<0.04 (<0.04-0.05)	0.10 (<0.04-0.69)	0.05 (<0.04-0.09)	0.05 (<0.04-0.16)	0.06 (<0.04-0.14)	<0.04 (<0.04)
Manganese	<0.20 (<0.20-0.25)	0.27 <0.20-0.40)	0.25 (<0.20-0.51)	<0.20 (0.19-0.21)	<0.20 (<0.20-0.26)	0.83 (0.44-1.80)	1.22 (<0.20-4.80)
PCBs	0.190 (0.040-0.570)	0.063 (ND-0.320)	0.788 (0.140-2.450)	0.096 (ND-0.235)	0.059 (ND-0.140)	0.460 (0.105-0.950)	0.143 (0.055-0.250)
Mirex	ND	ND	0.007 (ND-0.040)	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	0.0037 (ND-0.012)	0.002 (ND-0.024)	0.002 (ND-0.036)	0.032 (ND-0.088)	ND
pp-DDE	0.024 (0.005-0.070)	0.0077 (ND-0.03)	0.136 (0.013-0.380)	0.015 (ND-0.050)	0.005 (ND-0.011)	0.024 (0.012-0.040)	0.018 (0.005-0.045)
a-Chlordane	0.003 (ND-0.008)	0.0014 (ND-0.004)	0.014 (ND-0.050)	0.0024 (ND-0.012)	0.001 (ND-0.003)	0.009 (0.003-0.025)	0.003 (ND-0.008)
d-Chlordane	ND	ND	0.0057 (ND-0.020)	0.001 (ND-0.003)	ND	0.002 (ND-0.005)	ND
pp-DDD	ND	0.008 (ND-0.035)	0.029 (ND-0.215)	0.003 (ND-0.010)	ND	0.039 (ND-0.175)	ND
pp-DDT	0.0035 (ND-0.008)	ND	ND	0.004 (ND-0.020)	ND	ND	ND
Octachlorostyrene	0.0015 (ND-0.005)	ND	0.032 (ND-0.125)	0.002 (ND-0.010)	0.003 (ND-0.055)	0.127 (ND-0.540)	0.003 (ND-0.010)

NOTE: Non-detectable samples were assigned a value of half the detection limit in order to calculate the mean.

Table 27

Means and standard deviations (±) for total PCBs, hexachlorobenzene (HCB), octachlorostyrene (OCS), total dichlorodiphenyl-trichloroethane (DDT), total chlordane, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and total polychlorinated dibenzofurans (PCDF) concentrations in young-of-the-year spottail shiners from the St. Clair River and Lake St. Clair. Values represent composite fish analyses (ng/g), wet weight (Suns 1987, Suns et al. 1991 and Suns pers. comm. to D. Veal 1992).

Sample Location	Year	No. of Samples	Fish Size (mm)	% Fat	PCBs	HCB	OCS	Total DDT	Total Chlordane	2,3,7,8-TCDD	Total PCDF
Lake Huron											
Port Huron (Mich.)	1986	5	50 ±3	6.0 ±0.7	67 ± 38	3 ± 1	4 ± 2	18 ± 12	ND	NA	NA
St. Clair River											
Point Edward	1986*	2	60	5.8	-	7	13	-	-	-	-
Suncor	1983	4	46 ±7	2.8 ±0.3	146 ± 29	231 ± 26	560 ± 148	16 ± 4	3 ± 1	-	-
	1985*	5	66 ±8	3.7 ±0.4	-	69 ± 43	30 ± 19	-	-	-	-
	1986*	3	59 ±5	5.0 ±0.8	-	25 ± 6	31 ± 6	-	-	-	-
Shell Oil	1991	5	64 ±1	3.9 ±0.4	42 ± 21	6 ± 1	28 ± 12	6 ± 1	ND	-	-
Dupont	1991	5	62 ±2	4.4 ±0.2	28 ± 16	10 ± 3	33 ± 6	5 ± 1	ND	-	-
Lambton Generating	1985	4	62 ±4	3.4 ±0.4	422 ± 152	60 ± 13	81 ± 22	6 ± 5	ND	ND	0.274
Station	1986	5	55 ±4	2.8 ±0.6	283 ± 66	31 ± 13	104 ± 46	10 ± 5	ND	NA	NA
	1987	7	66 ±4	5.0 ±0.7	81 ± 12	13 ± 2	35 ± 3	17 ± 10	2 ± 1	NA	NA
	1988	6	61 ±2	3.7 ±0.4	148 ± 23	8 ± 1	23 ± 5	3 ± 4	ND	NA	NA
	1989	3	58 ±2	6.1 ±0.7	267 ± 191	5 ± 1	18 ± 5	8 ± 4	ND	NA	NA
	1990	7	59 ±1	2.8 ±0.4	75 ± 54	3 ± 1	9 ± 2	6 ± 1	ND	NA	NA
	1991	7	56 ±2	3.9 ±0.3	53 ± 24	4 ± 1	10 ± 2	6 ± 2	ND	NA	NA
South Channel	1982	7	59 ±7	2.0 ±0.3	71 ± 25	13 ± 7	95 ± 10	4 ± 3	11 ± 8	NA	NA
	1986	6	52 ±6	2.0 ±0.3	79 ± 31	12 ± 2	49 ± 9	8 ± 4	ND	NA	NA
	1991	7	57 ±2	1.7 ±0.3	ND	ND	9 ± 1	2 ± 1	ND	NA	NA
Chenal Ecart	1983	7	57 ±4	1.5 ±0.1	62 ± 9	10 ± 3	28 ± 8	10 ± 1	ND	-	-
	1987	7	53 ±4	1.6 ±0.2	ND	6 ± 1	18 ± 6	5 ± 2	4 ± 2	-	-
Lake St. Clair											
Mitchell Bay	1978	8	54 ±3	1.8 ±0.2	94 ± 50	ND	NA	24 ± 15	7 ± 3	NA	NA
	1979	7	55 ±5	1.0 ±0.2	ND	ND	30	11 ± 3	3 ± 1	NA	NA
	1982	7	58 ±5	2.2 ±0.2	33 ± 14	1 ± 0	2 ± 0	4 ± 4	TR	NA	NA
	1984	7	58 ±6	2.4 ±0.4	38 ± 32	ND	ND	4 ± 3	TR	NA	NA
	1985	6	61 ±5	3.4 ±0.8	105 ± 45	10 ± 3	13 ± 4	7 ± 7	ND	NA	NA
	1986	7	57 ±5	1.4 ±0.1	TR	2 ± 2	2 ± 1	4 ± 1	ND	NA	NA
	1987	7	58 ±4	1.8 ±0.1	400 ± 26	2 ± 1	5 ± 4	7 ± 2	ND	NA	NA
	1990	7	57 ±3	0.8 ±0.2	ND	ND	ND	2 ± 2	ND	NA	NA
	1991	7	60 ±1	2.0 ±0.4	ND	ND	ND	5 ± 3	ND	NA	NA
Detection Limits					20	1	1	1	2	0.004	0.009

* Emerald shiners; ND = Not detected; NA = Not analyzed; - = Data not available.

Table 28

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Esso Petroleum Canada, 1990 (OMOE 1992a).

Parameter	1990 Gross Loading
Flow (1000 m^3/day)	221.94
Total NH^3-N (kg/day)	33.6 (0)
Total Phenols (kg/day)	0.295 (0)
Total Suspended Solids (kg/day)	1434 (0)
Oil and Grease (kg/day)	210.9 (0)
Total Organic Carbon (TOC) (kg/day)	1098

Table 29

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Novacor Chemicals (Canada) Ltd., Corunna, 1990 (OMOE 1992a).

Parameter	1990 Gross Loading
Flow (1000 m^3/day)	6.36
Total NH^3-N (kg/day)	2.62 (0)
Total Phenols (kg/day)	0.0298 (0)
Total Suspended Solids (kg/day)	91.8 (0)
Oil and Grease (kg/day)	8.77 (0)
Total Organic Carbon (TOC) (kg/day)	148

Table 30

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Shell Canada Products Limited, Corunna, 1990 (OMOE 1992a).

Parameter	1990 Gross Loading
Flow (1000 m^3/day)	114.886
Total NH^3-N (kg/day)	24.8 (0)
Total Phenols (kg/day)	0.379 (0)
Total Suspended Solids (kg/day)	1281 (0)
Oil and Grease (kg/day)	272 (0)
Total Organic Carbon (TOC) (kg/day)	1550

Table 31

Annual average gross/net loadings in kg/day and exceedences (# of months) of parameters under control at Suncor Inc., Sarnia, 1990 (OMOE 1992a).

Parameter	1990 Gross Loading
Flow (1000 m^3/day)	101.67
Total NH^3-N (kg/day)	29.9(1)/17.7
Total Phenols (kg/day)	0.35 (0)/0.07
Total Suspended Solids (kg/day)	617.5 (0)/52.7
Oil and Grease (kg/day)	12.62 (0)/7.91
Total Organic Carbon (TOC) (kg/day)	257.77/67.62

Table 32

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Dow Chemical Canada Inc., Sarnia Division, 1989 and 1990 (OMOE 1990 and OMOE 1992a).

Parameter	1989	1990
Flow (m^3/day)	762,666	964,216
Total Phenols (kg/day)	2.58 (0)	7.05 (0)
Total Suspended Solids (kg/day)	6463.1	4785
Total Organic Carbon (TOC) (kg/day)	1613.46	2011

Table 33

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at DuPont Canada Inc., Corunna, 1990 (OMOE 1992a).

Parameter	1990
Flow (m^3/day)	55,465
Total Phenol (kg/day)	0.114 (0)

Table 34

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Esso Chemical Canada, Sarnia, 1990 (OMOE 1992a).

Parameter	1990 Gross Loading
Flow (1000 m^3/day)	28.162
Total NH^3-N (kg/day)	2.55 (0)
Total Phenols (kg/day)	0.0602 (0)
Total Suspended Solids (kg/day)	185 (0)
Oil and Grease (kg/day)	31.5 (0)
Total Organic Carbon (TOC) (kg/day)	193

Table 35

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Ethyl Canada Inc., Corunna, 1984 through 1990 (OMOE 1992a, 1990b, 1989, 1988b and 1987).

Parameter	1990[1]	1989[2]	1988[3]	1987[4]	1986[5]	1985[6]	1984[7]
Flow ($1000\ m^3$/day)	30.78	35.37	34.18	33.27	19.34	26.40	33.90
Total Lead (kg/day)	8.29	8.71 (0)	10.60 (0)	7.15 (0)	8.73 (5)*	22.70 (11)	27.20 (all samples)

* Effluent concentration guideline for lead was out of compliance for 5 months. Loading guidelines (calculated in respect to flow) were in compliance.

1 1990 data from OMOE 1992a
2 1989 data from OMOE 1990b
3 1988 data from OMOE 1989
4 1987 data from OMOE 1988b
5 1986 data from OMOE 1987
6 1985 data from OMOE files
7 1984 data from OMOE files

Table 36

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Novacor Chemicals Ltd., Mooretown, 1984 through 1990 (OMOE 1992a, 1990b, 1989, 1988b and 1987).

Parameter	1990[1]	1989[2]	1988[3]	1987[4]	1986[5]	1985[6]	1984[7]
Flow (1000 m^3/day)	1.68	1.52	1.82	1.74	2.22	2.18	2.36
Total Kjeldahl Nitrogen (kg/day)	na	1.59	2.97	4.10	2.34	na	na
Total Phosphorus (kg/day)	0.61 (0)	0.50 (0)	0.61 (0)	0.68 (0)	1.55 (1)	1.50 (2)	3.20
Total Suspended Solids (kg/day)	25.8 (7)	21.67 (2)	81.20 (9)	47.12 (10)	37.44 (4)	58.80 (9)	31.10
Total Organic Carbon (TOC) (kg/day)	11.5	11.60	12.30	19.37	12.38	na	na

na= Data not available.

1 1990 data from OMOE 1992a

1 1989 data from OMOE 1990b

2 1988 data from OMOE 1989

3 1987 data from OMOE 1988b

4 1986 data from OMOE 1987

5 1985 data from OMOE files

6 1984 data from OMOE files

Table 37

Annual average gross/net loadings in kg/day and exceedences (# of months) of parameters under control at Polysar Rubber Corporation and Novacor Chemicals (Canada Ltd., Sarnia, 1990 (OMOE 1992a).

Parameter	1990 Gross Loading
Flow (1000 m^3/day)	387.5
Total NH^3-N (kg/day)	104.4 (0)/7.5
Total Phenols (kg/day)	1.2064 (0)/0.2377
Total Suspended Solids (kg/day)	2646.6 (0)/264.9
Oil and Grease (kg/day)	582.5 (0)/1.3
Total Organic Carbon (TOC) (kg/day)	3223.8/475.8

Table 38

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Fiberglas Canada Inc., Sarnia, 1985 through 1990 (OMOE 1992a, 1990b, 1989, 1988b and 1987).

Parameter	1990[1]	1989[2]	1988[3]	1987[4]	1986[5]	1985[6]
Flow (1000 m^3/day)	5.34	4.69	5.04	5.44	6.35	7.37
Total Phenols (kg/day)	0.022 (0)	0.015 (0)	0.035 (2)	0.030 (0)	0.030 (0)	na (2)

na = data not available.

1 1990 data from OMOE 1992a
2 1989 data from OMOE 1990b
3 1988 data from OMOE 1989
4 1987 data from OMOE 1988b
5 1986 data from OMOE 1987
6 1985 data from OMOE files

Table 39

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at ICI Nitrogen Products, Courtright, (formerly CIL Inc.), 1984 through 1990 (OMOE 1992a, 1990b, 1989, 1988b and 1987).

Parameter	1990[1]	1989[2]	1988[3]	1987[4]	1986[5]	1985[6]	1984[7]
Flow (1000 m^3/day)	168.98	355.86	305.61	303.92	270.70	348.00	288.00
Dinitrotoluene (kg/day)	na	na	na	3.53 (0)	9.30 (0)	na	na
Total Fluoride (kg/day)	14.4	35.40	30.70	68.98	32.50 (0)	39.10 (0)	35.70 (0)
Total NH3-N (kg/day)	242 (0)	226.00 (0)	300.00 (0)	478.33 (0)	430.34 (0)	458.00 (0)	124.00 (0)
NO2 + NO3 -N (kg/day)	228	156.00	153.00	319.34 (0)	275.40	na	na
Total Phosphorus (kg/day)	11.3 (0)	3.91 (0)	16.40 (0)	29.16 (0)	14.40 (0)	24.90 (0)	14.90 (0)

na= Data not available.

1 1990 data from OMOE 1992a

2 1989 data from OMOE 1990b

3 1988 data from OMOE 1989

4 1987 data from OMOE 1988b

5 1986 data from OMOE 1987

6 1985 data from OMOE files

7 1984 data from OMOE files

Table 40

Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Ontario Hydro Lambton Thermal Generating Station, Courtright, 1990 (OMOE 1992a).

Parameter	1990 Gross Loading
Flow (1000 m^3/day)	2548.29
Water Temperature (degrees Celsius)	19.2 (0)
Temperature Rise (degrees Celsius)	5.01 (0)
Total Suspended Solids (kg/day)	12,372 (0)

Table 41

Summary of net and gross loadings data from major point sources in Ontario, discharging to the St. Clair River (kg/d) from 1985 to 1990.

Parameter	Principal Sources	1985[a] GROSS	1986/87[b] GROSS	1989-1991[cd] GROSS	1986[e] NET	1986/87[b] NET	1989-1991[cd] NET*
Organic Contaminants							
1,1-Dichloroethane	Cole Drain[1]	0.504	4.6180	NA		0.0576	0.049
	Dow Chemical[2]	5.090	0.0030	0.408			0.123
	Polysar[3]			0.581			0.365
	Ethyl			4.458			4.443
	DuPont			0.030			0[4]
1,2-Dichloroethane	Cole Drain	8.96	6.3596	NA		0.0318	0.039
	Dow Chemical	10.65	0.0030	2.319			1.731
	Polysar			0.497			0.322
	Ethyl			4.715			4.703
	DuPont			0.024			0
1,1,1-Trichloroethane	Cole Drain	ND	5.1330	NA		0.1311	ND
	Dow Chemical	7.670	0.0130	ND			ND
	Polysar			ND			ND
1,1,2-Trichloroethane	Cole Drain	0.784	0.8891	NA		0.0020	0.06
	Dow Chemical	3.563	0.0180	0.386			0.103
	Polysar			0.714			0.452
	Ethyl			0.311			0.293
Benzene	Cole Drain	ND		NA		0.0040	0.076
	Dow Chemical	61.996	0.6274	0.815			0.501
	Polysar	112.000	25.075	8.110			7.993
	Esso Chemical			0.445			
	Ethyl						0.439
Carbon Tetrachloride	Cole Drain	ND	4.087	NA		0.008	0.03
	Dow Chemical	25.709	0.003	3.806			2.838
	Polysar			0.440			0.303
	Ethyl			0.159			0.15
Tetrachloroethylene	Cole Drain	0.462	3.0538	NA		0.0477	0.024
	Dow Chemical	14.183	0.0070	4.128			3.433
	Polysar			0.370			0.267
	Ethyl			0.113			0.102
Total Volatiles	Cole Drain	15.5	31.409	NA	51.0	1.605	3.230
	Dow Chemical	242		34.819	124.0		14.239[5]
	Polysar	115		223.143	43.2		211.877[6]
	Ethyl			26.223			25.618[7]
	Esso Chemical			0.797			0.706
	DuPont			0.527			0.270
	ICI			2.339			1.147
2,4,5-Trichlorotoluene	Cole Drain		0.0522			0.0095	
	Dow Chemical		ND				
	Polysar						
	Esso Chemical						
Octachlorostyrene	Cole Drain	0.0006	0.0041	NA	0.0047	0.0092	0.001
	Dow Chemical	0.0048	0.0002	0.008		0.0038	0
	Polysar			<0.001			0
Pentachlorobenzene	Cole Drain	0.0032	0.0010	NA		0.0091	0.001
	Dow Chemical	0.0048	ND	ND			ND
	Polysar			<0.001			0
Hexachlorobenzene	Cole Drain	0.0025	0.012	NA	0.0005	0.0089	0.002
	Dow Chemical	0.125	ND	0.004	0.0300	0.0110	0.001
	Polysar			0.002	0.0016		0
	DuPont			0.001			<0.001
Hexachlorobutadiene	Cole Drain		0.042	NA		0.1400	0.007
	Dow Chemical		0.001	0.015		0.0354	0.008
	Polysar			0.003			0
	Esso Chemical			0.001			<0.001
Total PAHs	Cole Drain			NA	0.1720		ND
	Polysar			ND	0.1630		ND
	Sarnia WPCP				0.1180		
	Ethyl			0.483	0.0448		0.255
	Suncor			1.044	0.0199		0
	Dow Chemical						
Total PCBs	Cole Drain	ND		NA	0.0032		ND
	Dow Chemical	ND		ND	ND		ND
	Polysar			ND			ND
Metals and Conventional Pollutants							
Ammonia-nitrogen	Cole Drain			NA			7.102
	Dow Chemical			23.798	350		0.604
	Polysar			52.086	256		0
	ICI			200.000	633		164.600
	Sarnia WPCP						
	BASF			1.918			0
	Chinook			0.173			0.167
	Esso Chemical			2.552			0
	Ethyl			11.720			2.266
	Novacor-Moore.			0.661			0.622
	DuPont			4.356			0
Total Phosphorus	Cole Drain			NA			9.309
	Dow Chemical			93.6			28.657
	Polysar			56.087			15.982
	ICI			11.300	43.6		1.380
	Sarnia WPCP						
	BASF			0.900			0
	Chinook			0.456			0.447
	Esso Chemical			0.718			0.075
	Ethyl			6.238			4.155
	Novacor-Moore.			0.679			0.530

	DuPont		4.212			0
	Linde		0.101			0.052
Total Cyanide	Cole Drain		NA	0.539		ND
	Dow Chemical		4.245			0.534
	Polysar		ND	0.163		ND
	ICI		1.231			0.031
	BASF		ND			ND
	Chinook		ND			ND
	Esso Chemical		0.277			0.149
	Ethyl		ND			ND
	Novacor-Moore.		ND			ND
	DuPont		ND			ND
Total Suspended Solids	Cole Drain	7046	NA		3061	708.704
	Dow Chemical	1882	5229.686			1415.692
	Polysar		2177.012	4980		0
	ICI		1130.000			0
	BASF		48.49			13.235
	Chinook		1.772			1.563
	Esso Chemical		181.103			0
	Ethyl		385.470			219.284
	Novacor-Moore.		24.785			17.468
	DuPont		351.317			9.242
Oil and Grease	Cole Drain		NA	1300		0
	Dow Chemical		1115.609			178.989
	Polysar		656.145			0
	ICI		120.000			0.437
	BASF		12.632			0.026
	Chinook		0.181			4.686
	Esso Chemical		38.147			9.765
	Ethyl		42.278			0.652
	Novacor-Moore.		2.163			4.849
	DuPont		73.391			
Total Phenols	Cole Drain		NA	0.88		0.217
	Dow Chemical		7.723	1.78		0.947
	Polysar		0.931	1.08		0.346
	ICI		1.402			0.652
	Pt. Edward WPCP			1.69		
	Sarnia WPCP			4.32		
	Suncor			0.93		
	BASF		0.024			0
	Chinook		ND			ND
	Esso Chemical		0.062			0
	Ethyl		0.311			0.291
	Novacor-Moore.		0.003			0.002
	DuPont		0.136			0.055
Total Cadmium	Cole Drain	0.0041	NA		0.0465	ND
	Dow Chemical	0.0033	ND			ND
	Polysar		ND			ND
	ICI		0.349	0.137		0
	Sarnia WPCP					
	BASF		ND			ND
	Chinook		ND			ND
	Esso Chemical		ND			ND
	Ethyl		ND			ND
	Novacor-Moore.		ND			ND
	DuPont		ND			ND
Total Chromium	ICI		NA	8.92		ND
	Cole Drain		4.980			1.501
	Dow Chemical		ND			ND
	Polysar		ND			ND
	BASF		0.007			<0.007
	Chinook		ND			ND
	Esso Chemical		0.097			0.037
	Ethyl		ND			ND
	Novacor-Moore.		ND	2.50		ND
	DuPont					
Total Copper	Cole Drain		NA	1.22		ND
	Polysar		ND			ND
	Dow Chemical		5.779	6.24		2.996
	Sarnia WPCP			1.53		
	BASF		0.102			0
	Chinook		0.001			0
	Esso Chemical		0.681			0.247
	Ethyl		0.327			0.253
	Novacor-Moore.		ND			ND
	DuPont		1.439			0.597
Total Iron	ICI			209		
	Sarnia WPCP			137		
Total Lead	Cole Drain	0.514	NA	8.3	0.385	ND
	Dow Chemical	0.082	27.692	1.7		5.426
	Polysar		ND	19.1		ND
	BASF		0.314			0
	Chinook		ND			ND
	Esso Chemical		ND			ND
	Ethyl		12.421			12.121
	Novacor-Moore.		ND			ND
	DuPont		ND			ND
Total Mercury	Cole Drain	0.0163	NA	0.0287	0.0022	ND
	Dow Chemical	0.0004	0.080			0.004
	Polysar		ND			ND
	ICI		ND			ND
	BASF		ND			ND
	Chinook		ND			ND
	Esso Chemical		ND			ND
	Ethyl		0.020			0.019
	Novacor-Moore.		ND			ND
	DuPont		ND			ND
Total Nickel	Cole Drain		NA	0.644		0.830
	Dow Chemical		12.103	0.657		6.536
	Polysar		4.340	0.973		0.238
	Sarnia WPCP					
	BASF		ND			ND
	Chinook		ND			ND
	Esso Chemical		ND			ND
	Ethyl		0.317			O.047
	Novacor-Moore.		ND			ND

	DuPont	ND		ND
Total Zinc	Cole Drain	NA	10.0	0.738
	Dow Chemical	92.365	19.7	89.582
	Polysar	5.381		2.401
	ICI	0.966		0
	Sarnia WPCP			
	BASF	0.231		0.012
	Chinook	0.009		0.006
	Esso Chemical	0.685		0.474
	Ethyl	0.627		0.507
	Novacor-Moore.	0.056		0.046
	DuPont	0.637		0.260

*1989-1991 MISA "net" loads calculated through a subtraction of intake loads from outfall loads
NA = not applicable
ND = below detection.
Blank space denotes no data.
a 1985 data from Environment Canada/OMOE (1986).
b May 1986 to March 1987 data from MISA Pilot Site Investigation (OMOE 1990b); note: intake concentrations unavailable for volatiles, metals and conventionals.
c October 1, 1989 to July 31, 1991 MISA Monitoring for the Organic Chemical Sector (Tuszynski 1992).
d December 1, 1989 to November 30, 1990 & Feb. 1, 1990 to Jan. 31, 1991 MISA Monitoring for the Inorganic Chemical Sector draft results (Frank Ryan, OMOEE, pers. comm.).
e August 1986 data from Point Source Workgroup (1988).
1 All loadings for the Cole Drain are net as there is no influent stream.
2 Dow Chemical for 1985 and 1986/87 data are the sum of the following outfalls: 1st St. 42"; 1st St. 48"; 1st St. 30"; 1st St. 54"; 2nd St.; 3rd St.; and 4th St. Sewers.
3 Polysar data for 1986/87 are the sum of outfalls 220 and 620.
4 `0' denotes influent loading greater than effluent loading (1989/90 data only).
5 Total Volatiles for Dow are primarily 1,2-dichloroethane (1.731 kg/d), carbon tetrachloride (2.838 kg/d), tetrachloroethylene (3.433 kg/d) and ethylbenzene (2.148 kg/d).
6 Total Volatiles for Polysar are primarily chloromethane (162.043 kg/d), bromomethane (17.737 kg/d) and benzene (7.993 kg/d).
7 Total Volatiles for Ethyl are primarily 1,1- and 1,2-dichloroethane (4.443 & 4.703, respectively), methylene chloride (2.885 kg/d), chloromethane (1.798 kg/d), toluene (1.639 kg/d) and vinyl chloride (1.593 kg/d).

Table 42

Comparison of Windsor and Walpole maximum concentrations with existing ambient air quality guidelines or standards for selected toxics. Ambient air samples were collected from 1987 through 1990 (Dann 1992).

Parameter	Guideline Type	Average Time	Conc	Units	Windsor Maximum	Walpole Maximum
2,3,7,8-TCDD (Toxic Equivalents)	CCME Guideline	Annual	5	pg/m^3	0.17	NA
Benzo(a)pyrene	Ontario Provisional Guideline	Annual	0.3	ng/m^3	0.8	NA
Benzo(a)pyrene	Ontario Provisional Guideline	24 hour	1.1	ng/m^3	6.3	1.08
Total PCBs	Ontario Guideline	Annual	35	ng/m^3	0.8	NA
Lead	Ontario Guideline	24 hour	5	mg/m^3	0.15	0.052
Cadmium	Ontario Standard	24 hour	2	mg/m^3	0.02	0.009
Zinc	Ontario Standard	24 hour	120	mg/m^3	0.65	0.22

Table 43

Chemical characterization of sediment samples from the Pine River, St. Clair Co., Michigan, July 30, 1992 (MDNR 1993). All concentrations in μg/g (mg/kg) unless otherwise noted.

PARAMETER	UPSTREAM STATION	MIDSTREAM STATION (TRUNK STREAM)	DOWNSTREAM STATION (TRUNK STATION)
cadmium	ND2*	ND2	ND2
chromium	9	8	8
cobalt	ND5	ND5	ND5
copper	12	9.5	9.8
iron	8750	7450	9220
nickel	11	10	11
lead	21	15	5.4
zinc	49	39	32
lithium	5.5	6.5	5.9
manganese	190	95	250
total inorganic solids (%TS)	49	39	32

* ND = not detected at the noted detection level.

LIST OF FIGURES