Environment Ontario

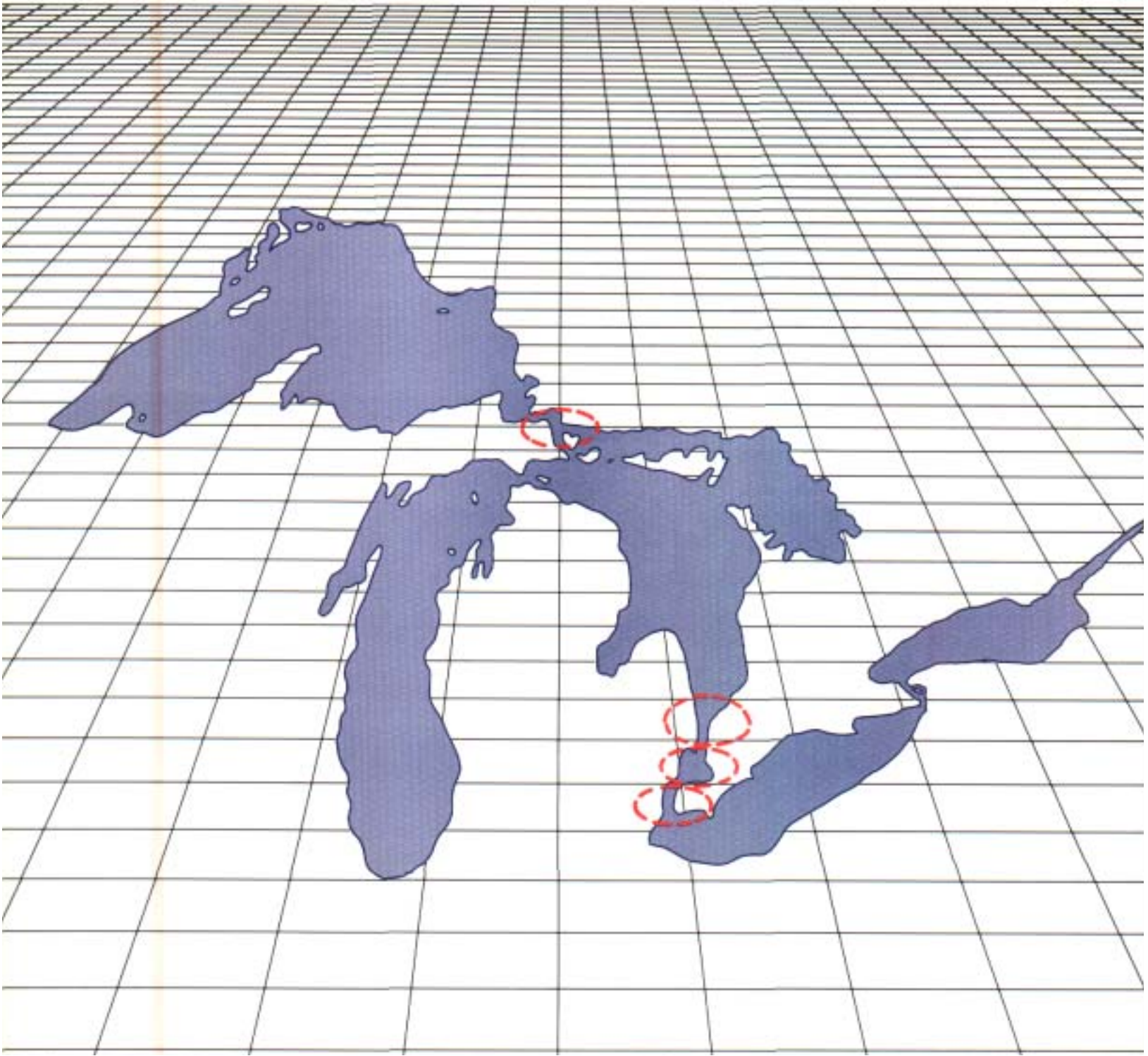
US Army Corps of Engineers

DNR

Environment Canada Environnement Canada

UPPER GREAT LAKES CONNECTING CHANNELS STUDY

Volume I EXECUTIVE SUMMARY



UPPER GREAT LAKES CONNECTING CHANNELS STUDY
ERRATA

VOLUME 1 - EXECUTIVE SUMMARY

Disclaimer: "The contents of this report do not necessarily reflect the views and policies of the participating agencies, nor does mention of trade names, or commercial products constitute endorsement or recommendation for use."

- Page 3, 2nd Column, last paragragh. "The 1987 Protocol..."
- Page 11, Footnote 2. "Leachates have not been detected..."
- Page 38, 1. Water, 1st Column, 1st paragragh. There is no guideline for PAHs. Cadmium should be added to this statement.
- Page 38, 1. Water, 1st Column, 4th paragraph. Mercury should be deleted from this statement.
- Page 38, 1. Water, 1st Column, 6th paragraph. PAHs should be deleted from this statement.
- Page 38, 1. Water, 1st Column, 7th paragraph. There is no lead data for the Ecorse River.
- Page 44, Recommendation 23. Delete "These".
- Page 26, 1st Column, 4th paragraph. "50 tons of perchlorethylene were released to the river" should be replaced with "18 tonnes of perchlorethylene were released to the river of which 14.5 tonnes were recovered."

UPPER GREAT LAKES CONNECTING CHANNELS STUDY

VOLUME I
EXECUTIVE SUMMARY

The Upper Great Lakes Connecting Channels Study
Management Committee

December 1988

LETTER OF TRANSMITTAL

Valdas A. Adamkus
Regional Administrator, Region V
U.S. Environmental Protection Agency

Elizabeth Dowdeswell
Regional Director General, Ontario Region
Environment Canada

David F. Hales
Director
Michigan Department of Natural Resources

J. Walter Giles
Associate Deputy Minister
Ontario Ministry of the Environment

On behalf of the Management Committee we are pleased to submit the final report and executive summary of the Upper Great Lakes Connecting Channels Study. The report is a comprehensive and detailed review of the project studies and their results.

Respectfully submitted, February 1989.

Ron Shimizu
Co-Chair
Environment Canada

Carol Finch
Co-Chair
U.S. Environmental
Protection Agency

PREFACE

This report is an executive summary of the major findings and recommendations of the Upper Great Lakes Connecting Channels Study. These findings and recommendations are based upon data collected in 1985 and 1986. It is Volume I of a 3 volume set containing the complete output of the study. Volume II is the main study report. Volume III consists of the many principal investigator reports, work-group reports and other key supporting documents. Copies of Volume III are on file with each of the participating agencies and with the International Joint Commission in Windsor, Ontario.

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PART I

1. INTRODUCTION

Changes in environmental quality resulting from the intensive use of the Great Lakes waters are becoming better known.

As early as the 1940's researchers recognized that contaminants entered the lakes from many different sources over a wide area. Today it is commonly accepted that toxic and chemical issues are not only scientifically and technically complex, but that interdisciplinary study and interjurisdictional cooperation is required in order to understand and resolve these issues.

The **Upper Great Lakes Connecting Channels Study (UGLCCS)** is a landmark in advancing our overall understanding of the environmental conditions of the Great Lakes Basin. UGLCCS is a unique cooperative undertaking by eleven institutions at the federal, state, provincial and municipal levels to:

i) assess the environmental quality of the Detroit, St. Marys, St. Clair Rivers and Lake St. Clair;

ii) identify and assess the major pollution sources to these waters;

iii) recommend actions to ensure the remediation and protection of these waters.

Initiated in late 1983 by the United States Environmental Protection Agency, UGLCCS became a full bilateral multi-agency investigation in July 1984. The principal agencies involved were the USEPA, Environment Canada (DOE), Ontario Ministry of the Environment (OMOE), Michigan Department of Natural Resources (MDNR), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), U.S. Army Corps of Engineers (COE), the City of Detroit, Fisheries and Oceans Canada (DFO) and the Ontario Ministry of Natural Resources (OMNR).

Despite the reduction in contaminant loadings to the Great Lakes over the past two decades, beneficial uses of these waters continue to be impaired. The Detroit, St. Clair and St. Marys Rivers have been designated by the International Joint Commission as "Areas of Concern" because pollutant levels have exceeded certain water quality objectives of the 1978 Canada-U.S. Great Lakes Water Quality Agreement.

The 1978 Protocol, amending the Agreement calls for a binational effort to develop and implement Remedial Action Plans (RAPs) to restore "Areas of Concern". The findings and recommendations of this study will facilitate the development of RAPs and measure the restoration of these magnificent waters.

FIGURE 1
GREAT LAKES BASIN
SHOWING UPPER CONNECTING CHANNELS
Lake Nipigon
Ontario
Great Lakes Drainage Basin
Lake Superior
CANADA
UNITED STATES
Minnesota
St. Marys River
Michigan
Wisconsin
Lake Huron
Lake Michigan
Michigan
Lake Ontario
New York
Ontario
St. Clair River
Lake St. Clair
Detroit River
Lake Erie
Illinois
Pennsylvania
Ohio
Indiana
N

2. OVERVIEW

The Upper Connecting Channels function as the drainage system for Lakes Superior, Huron and Michigan, funnelling large volumes of water, sediment and nutrients. They form a diversity of habitat conditions attracting numerous species of fish, waterfowl and plants. Tables 1, 2 and 3 summarize hydrological characteristics of the channels, the current water uses and the major contaminant concerns, respectively.

Land use in the vicinity of the channels, although containing concentrations of urban and industrial areas, is mainly rural. The Detroit River watershed is the most industrialized, having the largest population and the Lake St. Clair watershed is the most agricultural.

It is the use of the channels as receiving waters that provide the focus for the UGLCC Study. Wastes from the following industrial sectors are discharged into the connecting channels: pulp and paper, electrical power generation, steel making and casting, mineral extraction, chemical manufacturing, petrochemical and refining, and automobile manufacturing. The channels also receive waste from municipalities, agricultural and urban runoff, waste disposal sites and the atmosphere. Chemicals released include synthetic organics, metals and nutrients.

TABLE 1

Watershed characteristics of the Upper Great Lakes Connecting Channels

	St. Marys River	St. Clair River	Lake St. Clair	Detroit River
Inlet	L. Superior	L. Huron	St. Clair R.	Lake St. Clair
Outlet	L. Huron	L. St. Clair	Detroit River	L. Erie
Length (Area)*	101-121 km	64 km	1115 km^2	51 km
Elevation Fall(m)*	6.75	1.5	—	1.0
Flow m^3/sec x 1000**				
Minimum	1.2	3.0	—	3.2
Average	2.2	5.2	—	5.3
Maximum	3.7	6.7	—	7.1
Average Flow Vel. m/s*	0.6-1.5	0.6-1.8	0.02-0.08	0.3-0.6
Depth (m)*	Shallow-30	9-21	3.4 avg. 8.2 max.	6-15
Width (km)*	0.3-6.4	0.25-1.2	39	0.66-3.0
Retention Times	~2 days	21 hrs	2-9 days	21 hrs
Controlled Flow	Y	N	N	N
Land Drainage Area*** km^2 x 1000 (cumulative total)	49.3	146.6	159.0	160.9

* Limno-Tech. 1985. 1985 Summary of existing status of the Upper Great Lakes Connecting Channels data, unpublished manuscript.

** David Cowgill, U.S. Army Corps of Engineers.

*** Calculated from The Great Lakes: An Environmental Atlas and Resource Book and Limno-Tech manuscript.

TABLE 2

Water use of the Upper Great Lakes Connecting Channels

	St. Marys River	St. Clair River	Lake St. Clair	Detroit River
Shipping	S	S	S	S
Commercial Fishing	L	N	F	N
Sport Fishing	S	S	S	S
Boating/Sailing	F	S	S	S
Swimming	L	F	S	O
SURFACE WATER SUPPLIES TO:				
Drinking Water Intake				
- Municipal	X	X	X	X
- Communal/Private	X	X	X	X
Industrial Intakes				
- Iron & Steel	X			X
- Pulp & Paper	X			
- Petrochemical		X		X
- Refining		X		X
- Thermal Generating		X		
- Hydroelectric	X			
- Navigation (Locks)	X			
- Mineral (Salt & Lime)	X			
RECEIVING WATER FOR:				
Municipal STP	X	X	X	X
Industrial				
- Iron & Steel	X			X
- Pulp & Paper	X			
- Petrochemical		X		X
- Refining		X		
- Thermal Generating		X		X
- Mineral (Salt & Lime)				X
- Fabrication (Auto)				X
Ship Ballast	X	X	X	X

N - Negligible Use
L - Limited Use
O - Occasional Use
F - Frequent Use
S - Significant - High Use
X - Present

TABLE 3

Summary of contaminant concerns in the Upper Great Lakes Connecting Channels

	WATER				SEDIMENT				BIOTA			
CONTAMINANTS	St. Marys River	St. Clair River	Lake St. Clair	Detroit River	St. Marys River	St. Clair River	Lake St. Clair	Detroit River	St. Marys River	St. Clair River	Lake St. Clair	Detroit River
Phosphorus	X		X	X				X				
Ammonia	X			X				X	X			X
Bacteria	X	X		X		X						
Chlorides		X		X						X		X
Oil and Grease	X			X	X	X	X	X	X	X	X	X
Phenols	X			X				X	X			X
Pesticides			X	X			X	X			X	X
PCBs				X	X	X	X	X		X	X	X
PAHs	X			X	X	X	X	X	X	X	X	X
Other Organics		X		X		X	X	X		X		X
Heavy Metals	X		X	X	X	X	X	X	X	X	X	X
Mercury				X	X	X	X	X	X	X	X	X
Cyanide	X							X				

3. PURPOSE AND OBJECTIVES OF THE STUDY

The UGLCC Study was conceived to integrate scientific information and data on the Upper Connecting Channels and to develop recommendations for binational efforts to restore these "Areas of Concern".

The study was carried out in three stages:

1) review existing environmental information.

2) conduct field, laboratory and modeling studies to fill information gaps, and

3) consolidate findings into a single report which will provide guidelines to those developing Remedial Action Plans.

Field studies were undertaken:

1) to identify and measure sources of contaminants and their impacts on beneficial uses and on the ecosystem;

2) to determine the adequacy of existing control measures;

3) to recommend controls, and

4) to recommend surveillance programs to monitor the effects of restoration efforts.

Eight workgroups produced 25 reports developed from 170 studies on water quality, sediments, biota, point sources, non-point sources, modeling, data quality and long-term monitoring. The workgroup reports and committee memberships are listed in the Appendices.

The UGLCC Study pioneered the use of the mass balance concept (pollutant input/output) for planning and design of a large scale environmental study of toxic substances. The calculations identified areas in the channels that acted as sources or sinks for a given pollutant with respect to the remainder of the system. The process models developed provide a suite of tools that can be used to assess the transport, fate and exposure of pollutants in each channel. However, time and resources were insufficient to collect the necessary data to verify the models.

4. GENERAL FINDINGS

Each of the four study areas is unique in terms of its physical characteristics and history of human use. However, a number of issues common to the channels have been identified. The following statements relate to all of the Upper Great Lakes Connecting Channels.

- The UGLCC Study confirms that many of the environmental quality problems of the region cut across political jurisdictions and can only be solved through coordinated, long term planning efforts by the jurisdictions affected.

- All four water bodies suffer from contaminated sediments, high concentrations of oil and grease (except Lake St. Clair) and the bioaccumulation of certain toxic pollutants in local aquatic organisms. There is considerable variation among channels.

- Levels of organic and inorganic toxic substances often exceed standards and guidelines, particularly in the vicinity of the urban and industrial dischanges.

- Point sources are the largest loadings of most contaminants even though most discharges are regulated (see Table 4).

- Combined sewer overflows are major sources of contaminants to the channels.

- Non-point loadings, particularly from agricultural and urban runoff and atmospheric deposition, can be locally significant, however, quantification of the magnitude of these inputs remains poor to nonexistent.

- Several cases of probable transboundary movement of pollutants in the channels were identified. However, whether or not transboundary mixing occurs in the channels is of little consequence as it always occurs in the downstream lakes.

- There have been substantial reductions in conventional pollutants since the early 1970s, however, particular concerns remain related to oil and grease, phosphorus and heavy metals. The effects of historical discharges continue to impact the ecosystem.

- Oil and grease in sediments, particularly in the three rivers, is directly associated with impacts to benthic communities, and should not be detectable in any form in the rivers. The lack of numerical objectives for water and sediment may have reduced the effectiveness of remedial programs.

- Fine-grained sediments in embayments downstream of effluent discharges are polluted from historical and in some cases ongoing discharges and act as exposure sources to aquatic biota.

- Accidental spills of pollutants can result in shock loadings of almost any pollutant in amounts equal to or greater than annual loads from ongoing regulated discharges.

- Waste sites have been identified and ranked (Table 5) however, very little is known about the specific loadings of contaminants to the waters of the St. Marys, St. Clair and Detroit Rivers. More investigations are required to determine if waste sites have an impact on the rivers.

- There is a lack of detailed information on levels of toxic contaminants in waterfowl and aquatic mammals.

- Multi-agency studies require an ongoing data quality management program to ensure a reliable, comparable database for subsequent decision-making.

TABLE 4 Summary of Major Point, Tributary and Nonpoint Source Loadings to the St. Marys, St. Clair and Detroit Rivers

PARAMETER LOADINGS

(kg/day)

MAJOR SOURCES	OIL & GREASE	TOTAL PHOSPHORUS	AMMONIA NITROGEN	SUSPENDED SOLIDS	BOD_5*	CHLORIDE	COPPER	IRON	LEAD	MERCURY	ZINC	NICKEL	CADMIUM	COBALT	CYANIDE	PHENOLS	VOLATILES	PAHs*	PCBs*	HCB*	OCS*
ST. MARYS RIVER:																					
Algoma Steel	1,950- 9,441	20.0	3,990- 6,254	4,234- 8,137	-	18,885	-1.1	1,747- 2,275	4.81	0.005	33.7	-	-	-	72.9	9.0- 114	-	0.20- 1.21	-	-	-
St. Marys Paper	231	4.7	6.0	2,829	-	743	0.33	8.6	0.17	0.0	0.09	-	-	-	-	0.71	-	0.05	-	-	-
East End WWTP	349	89.8	195.5	900	-	2,011	1.4	42.6	1.01	0.0005	1.91	-	-	-	-	0.51	-	0.42	-	-	-
West End WWTP	13	5.7	14.8	39.4	-	598	0.20	5.2	0.19	0.0001	0.36	-	-	-	-	0.02	-	0.004	-	-	-
Michigan POTW	-	6.3	-	47.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E. Davignon Creek	-	2.7	17.6	1,713	-	952	-	71.8	-	-	0.76	-	-	-	0.29	0.61	-	0.04	-	-	-
Fort Creek	-	0.41	0.17	353	-	286	-	12.2	-	-	0.13	-	-	-	0.003	0.004	-	0.006	-	-	-
Bennett Creek	-	0.07	2.8	158	-	671	-	1.22	-	-	0.05	-	-	-	0.02	0.08	-	0.005	-	-	-
Total Point Source[1]	2,544	129.6	4,227-	10,274-	-	24,147	0.83	1,889-	6.175	0.0056	36.99	-	-	-	73.2	10.93-	-	0.723-	-	-	-
Loadings[2]	10,035		6,491	14,177				2,417								115.93		1.733			
Total Nonpoint Source	91.2	17.56	26.8	1,400	-	5,068-	1.57	252	4.3	0.0011	10.0	0.395-	0.006-	0.0-	0.074	0.53	-	0.58-	0.0011-	0.0000055-	-
Loadings[3]						10,137						0.926	0.021	0.721				0.90	0.009	0.000016	
Total Loadings to	2,635-	147.24	4,253-	11,674-	-	29,215-	2.40	2,141-	10.47	0.0067	47.03	0.395-	0.006-	0.0-	73.29	11.4-	-	1.057-	0.0011-	0.0000055-	-
St. Marys River	10,126		6,517	15,577		34,284		2,669				0.926	0.021	0.721		116.4	-	2.385	0.009	0.000016	
ST. CLAIR RIVER:																					
Esso Petroleum	-	20.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dow Chemical	285	-	-	595	-	283,820	6.24	85.5	8.4	0.0287	9.2	0.644	-	-	-	1.78	51.0	-	0.0032	0.03	0.0047
Port Huron WWTP	-	24.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.003	-	-
Pt. Edward WPCP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.69	-	-	-	-	-
Cole (Twp.) Drain	1,300	-	-	341	-	11,400	1.32	23.5	-	-	2.0	-	-	-	0.54	0.88	-	0.172	-	-	0.0001
Polysar Sarnia	303	-	350	596	-	19,900	0.93	-	1.7	-	-	0.657	-	0.67	0.16	1.08	124.0	0.163	-	-	0.0001
Sarnia WPCP	244	43.6	633	-	2,000	-	1.55	137	2.2	-	19.7	0.973	0.137	0.16	-	4.32	-	0.118	-	-	-
Marine City WWTP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8	-	-	-	-	-	-
Ethyl Canada	-	-	-	-	-	29,800	-	-	19.1	0.006	-	-	-	-	-	-	43.2	0.045	-	-	-
CIL Inc.	128	-	256	4,980	-	-	-	209	-	-	2.4	-	-	-	-	-	-	-	-	-	-
St. Clair County (Algonac WWTP)	-	-	181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polysar Corunna	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-	-	-	-	-	-	-	-
Suncor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.93	-	-	-	-	-
Total Point Source	3,170	89.9	1,670	9,400	7.700	356,000	11.8	582	29	0.0443	44.9	4.37	0.143	0.86	3.2	12.2	254	0.335	0.009	0.03	0.0049
Loadings[2]																					
Total Nonpoint Source	129.3-	6.03-	20.0-	-	-	3,223-	1.260	118-	5.6	0.0023-	6.658	0.408-	0.024-	0.0-	1.8	0.332-	-	0.143-	0.0038-	0.002	0.00004
Loadings[3]	201.1	13.97	51.0			6,474		133		0.004		0.663	0.132	0.412		0.373		0.203	0.0041		
Total Loadings to	3,299-	95.9-	1,690-	9,400	7,700	359,233-	13.06	700-	34.6	0.047-	51.6	4.85-	0.169-	0.86-	5.0	12.53-	254	0.478-	0.0138-	0.032	0.00494
St. Clair River	3,371	103.9	1,721			362,474		715		0.048		5.03	0.31	1.27		12.57		0.538	0.019		
DETROIT RIVER:																					
Detroit WWTP	9,090- 14,042	930- 2,023	6,628- 19,700	-	-	281,000	7.13- 92.0	592- 1,887	7.13- 137	0.0636- 0.539	223- 283	95.8- 197	1.4- 13	2.59	59- 106	39.0- 45.4	-	- -	0.200- 0.256	0.001- 0.011	0.000027
Rouge Steel	8,090	-	-	-	-	36,400	15.1	1,550	8.53	-	74.8	-	0.55	-	6.12	17.3	-	5.15	-	-	-
General Chemical (North Drain)	-	-	-	-	-	1,050,000	17.2	-	-	-	-	-	-	5.64	-	-	-	-	-	-	-
Wayne County, Wyandotte WWTP	727	245	3,230	-	-	-	4.95	239	-	0.0136	32.3	-	6.1	-	5.6	9.7	-	-	0.0296	0.00027	0.000045
Wayne County, Trenton WWTP	-	-	-	-	-	-	-	-	-	0.00553	-	-	-	-	-	-	-	-	-	-	-
West Windsor WPCP	1,130	150	-	-	-	-	3.43	-	-	-	-	6.7	-	1.95	-	-	-	0.311	-	-	-
McLouth Steel Trenton Plant	7,060	-	-	-	-	-	-	545	3.77	-	137	-	0.136	-	-	5.4	-	-	-	0.00043	-
Great Lakes Steel 80" Mill	4,260	-	-	-	-	-	-	215	-	0.0027	-	-	-	-	-	-	-	-	-	-	-
Great Lakes Steel Ecorse Plant	3,650	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000014
Great Lakes Steel Zug Island	-	-	-	-	-	-	-	-	-	0.00198	-	-	-	1.9	-	3.2	-	-	0.0093	-	0.000001
Ford Canada	-	-	-	-	-	-	3.44	222	30.3	-	132	-	0.797	-	2.28	48.2	-	0.44	0.0392	-	-
Little River WWTP	-	-	-	-	-	-	-	-	-	-	-	-	-	0.53	-	-	-	-	-	-	-
Pennwalt	-	-	-	-	-	-	-	-	-	0.0103	-	-	-	-	-	-	-	-	-	0.0002	-
BASF Corp.	-	-	-	-	-	-	-	-	-	0.00315	-	-	-	-	-	-	-	-	-	-	-
Trenton WWTP	-	-	-	-	-	-	-	-	-	0.00207	-	-	-	-	-	-	-	-	-	-	-
Wickes Manufacturing	-	-	-	-	-	-	-	-	-	-	-	9.2	-	-	-	-	-	-	-	-	-
Monsanto	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00036	-
Total Point Source	34,007-	1,325-	9,858-	-	-	1,367,400	51.3-	3,363-	49.7-	0.103-	599-	111.7-	8.98-	12.6	73-	122.8	-	5.9	0.278-	0.0023-	0.000087
Loadings[2]	38,959	2,418	22,930				136.1	4,658	179	0.578	659	212.9	20.6		120	129.2			0.334	0.012	
LITTLE & TURKEY RIVERS[4]	-	43	-	3,023	-	9,806	0.49	3	-	.0016	5.33	49.2	0.009	-	-	-	-	-	0.001	-	-
ROUGE & ECORSE RIVERS[4]	-	301	-	82,825	-	209,800	20.5	113	-	0.05	479	9.7	5.89	-	-	-	-	-	0.151	-	-
OTHER NONPOINT[5]	9,384	479	1,749	22,900	-	18,577	3.12	585	55	4.33	73.1	15.4	4.4	0.025	0.23	1.96	-	0.24	0.24	0.00008	-
Total Loadings to	43,391-	2,148-	11,607-	108,748	-	1,614,600	75.4-	4,064-	104.7-	4.49-	1,156-	186-	19.3-	12.63	73.23-	124.8-	-	6.14	0.67-	0.00238-	0.000087
Detroit River	48,343	3,240	24,679				160.2	5,359	234	4.96	1,216	287	30.9		120.23	131.2	-		0.73	0.0121	

1. Point Source Data are based primarily on the 1985 and 1986 UGLCCS survey results. Ranges reflect the difference between UGLCCS data and either MISA (Algoma) or self-monitoring data (Algoma and Detroit WWTP).
2. Totals include additional minor sources.
3. Estimates based on partial databases.
4. Based on Detroit River System mass balance study.
5. Detroit CSO and Windsor Stormwater & CSO.

NOTE: Dashes (-) indicate no data collected.

*BOD_5 = Biochemical Oxygen Demand
PAHs = Polynuclear (Polycyclic) Aromatic Hydrocarbons
PCBs = Polychlorinated Biphenyls
HCB = Hexachlorobenzene
OCS = Octachlorostyrene

TABLE 5

Waste sites in the Upper Great Lakes Connecting Channels[1]

UNITED STATES

St. Marys River

Cannelton Industries, Inc. Site
Superior Sanitation Landfill
Union Carbide Site (Sault Ste. Marie Disposal Site)

St. Clair River

A & B Waste Disposal
Hoover Chemical Reeves Disposal
Wills Street Dump Site
Winchester Landfill

Lake St. Clair

Selfridge Air National Guard Base
Sugarbush Landfill

Detroit River

BASF-Wyandotte (North Works)
BASF-Wyandotte (South Works)
Chrysler-Trenton
Edward C. Levy, Co. (Trenton Plant)
Edward C. Levy, Co. (Plant #3)
Federal Marine Terminal Properties
Huron Valley Steel Corp.
Industrial Landfill (Firestone)
Jones Chemical
Michigan Consolidated Gas (Riverside Park)
Monsanto Co. Site
Pennwalt Corp. Site
Petrochemical Processing Site
Point Hennepin Site
Zug Island (Great Lakes Steel)

CANADA

St. Marys River

Algoma Steel Slag Site
Sault Ste. Marie (Cherokee) Landfill[2]

St. Clair River

Dow Chemical Site (Scott Road)
Polysar Ltd. Site (Scott Road)

Detroit River

Fighting Island Site

1 Sites within 19 kilometres of the connecting channels with known or potential impacts to the connecting channels.

2 Follow-up investigation of this site indicates that leachates have been detected in the groundwater or surface water adjacent to this site.

Information in this table is correct as of January 1988

5. SPECIFIC CONCERNS

The St. Marys, St. Clair and Detroit Rivers are subject to contaminant loadings which have resulted in changes to the water quality, sediments and biota.

i) Major Loadings

Table 4 summarizes the loadings of 21 contaminants (measured in kilograms per day) to the three rivers. These data are based primarily on the 1985 and 1986 UGLCCS point source surveys. Ranges reflect the differences between UGLCCS and either MISA or self-monitoring data.

The largest point sources in each channel were sampled. Below are selected parameters and facilities with the largest loadings.

Oil and Grease	Detroit WWTP	9090-14 042 **kg/day**
	Rouge Steel	8090
	Algoma Steel	1950-9441
	McLouth Steel	7060
	Great Lakes Steel	4260 and 3650
Lead	Ford Canada	30.3
	Ethyl Canada	19.1
	Detroit WWTP	7.13-137
Mercury	Detroit WWTP	0.064-0.54
	Dow Chemical	0.029
Cadmium	Wayne County-Wyandotte WWTP	6.1
	Detroit WWTP	1.4-13.0
Cyanide	Algoma Steel	72.9
	Detroit WWTP	59-106
Phenols	Ford Canada	48.2
	Detroit WWTP	39.0-45.4
	Algoma Steel	9-114
PAHs	Rouge Steel	5.15
	Sault Ste. Marie East End WWTP	0.42
	Algoma Steel	0.2-1.21
PCBs	Detroit WWTP	0.20-0.26
HCB	Dow Chemical	0.03
	Detroit WWTP	0.001-0.011

ii) Water Column

- Water quality impairment continues near municipal and industrial discharges, tributary mouths and in areas of contaminated sediment.

iii) Contaminated Sediments

- Toxic amounts of metals, synthetic organics and conventional pollutants have accumulated in sediments.
- Specific contaminants in sediments are detrimental, to the point of lethality, to benthic organisms.
- Accumulation of oil and grease does not support habitat needs of aquatic insects.
- Some areas of the sediments are completely devoid of life as a result of contamination.
- PAHs found in sediments may be associated with tumor incidence in bottom-feeding fish.
- Sediment contaminants are not likely to diminish through natural processes in the short term.

iv) Bioaccumulation

- Bioaccumulation of toxic contaminants threatens beneficial uses of ecosystem resources such as the commercial and sport fisheries and trapping of fur-bearing mammals.
- Chlorinated organic compounds found in the connecting channels have a potential to bioaccumulate in tissue and to affect reproduction and off-spring of aquatic wildlife and waterfowl.
- Contaminant burdens in fish and wildlife have resulted in consumption advisories for certain species in these areas.

6. RECOMMENDED MANAGEMENT STRATEGY

The study has identified the need to relate pollution abatement to ecosystem concerns. Water quality, effluent quality, sediments and biota standards and guidelines currently are not consistent, not always enforceable and do not cover all chemicals and media.

The current regulatory programs are not fully effective in controlling pollution loadings within the connecting channels.

- Specific discharge limitations vary between jurisdictions.
- A number of persistent contaminants not covered by regulations are discharged into the channels from permitted industrial and municipal discharges.
- Contaminant discharges regulated by concentration limits enter the channels in high volumes causing significant total loadings.
- Permit limits are developed chemical-by-chemical and medium-by-medium and may overlook potential synergistic effects unless whole effluent toxicity testing is utilized.

To correct the situation the Management Committee recommends a comprehensive regulatory program which would include:

- Coordination among all regulatory agencies in setting both ambient and effluent standards and undertaking remedial clean-up actions;
- Consideration of ecosystem objectives in standard setting;
- A multimedia approach;
- Synergistic properties between contaminants taken into account when setting levels for specific substances;
- Developing further controls to cover all persistent toxic chemicals currently discharged, with the ultimate goal of zero discharge built-in through the application of increasingly effective technology;
- Agreement among agencies to a list of chemicals to be monitored using standardized methodologies for sampling, analysis and reporting;
- Detailed assessment of contributions of non-point sources including waste disposal sites, combined sewer overflows, atmospheric loadings and tributary loadings as well as the implementation of effective control measures;
- Reduced pollutant loads from stormwater sources, combined sewer overflows, sewage treatment plant bypasses, industrial pretreatment through technological development and stricter controls;
- Improved reporting of spill incidents and improved on site spill containment facilities;
- Completing the identification of contaminated groundwater and undertaking monitoring where required;
- A coordinated education program emphasizing the benefits (financial and otherwise) of improving the current environmental reality, targetted to dischargers and the general public to encourage responsible actions.

Remedial programs should aim to:

- Prevent further decline in ecosystem quality;
- Achieve improvements in ecosystem quality as evidenced by the return of sensitive species including the benthic invertebrate community and fish-eating aquatic birds;
- Restore beneficial uses of the channels and associated areas;
- Virtually eliminate contaminant discharges at specific sources by regulatory or voluntary measures. In the interim, specific recommendations are suggested for each geographic area for industrial and municipal point sources and non-point sources;
- Remove, treat or allow burial of contaminated sediments, as appropriate, to reduce biotic exposure, restore water quality and beneficial uses;
- Achieve the greatest possible restoration in each area. Restoration will depend on the application of the knowledge obtained from additional research.

7. LONG-TERM MONITORING PROGRAM

The focus of the UGLCCS was to identify problems in the ecosystem and how to remedy them. Long-term monitoring recommendations provide a framework to focus on trends in environmental quality and to assess the effectiveness of remedial actions. Monitoring should be sufficient to 1) detect system-wide trends noted by the UGLCCS, 2) detect changes resulting from specific remedial actions, and 3) assess whether beneficial uses have been restored.

The Great Lakes International Surveillance Plan (GLISP) will contain plans for long-term monitoring. The GLISP for the Upper Great Lakes Connecting Channels will be completed by incorporating results of this study.

Results from UGLCCS will be incorporated into each RAP, and will influence state and provincial monitoring programs. Table 6 summarizes the basic recommendations for long-term monitoring programs.

TABLE 6

Summary of long-term monitoring recommendations.

Monitoring/Study Area	St. Marys River	St. Clair River	Lake St. Clair	Detroit River	Frequency
Head/Mouth Transects	R/MB	R/MB	R/MB	R/MB	R=2/yr MB=5yr
Tributaries	T/MB	T/MB	T/MB	T/MB	Seasonal/ Storm events
Municipal & Industrial Source	R/MB	R/MB	E	R/MB	NS
CSO and Runoff	E/MB	E/MB	E/MB	R/E/MB	NS
Groundwater Inflow	S/MB	E/S/R	S/MB	E/S/R	NS
Sediment Transport	E/MB	E/MB	E	E/MB	Once
Sediment Chemistry	T	T	T	T	St. Marys/ St. Clair: 5 yr
Atmospheric Deposition	E	E	E	E	As needed
Biota					
Sport Fish	R/T	R/T	R/T	E/R/T	1 or 2/yr
Spottail Shiners	S/T	S/T	S/T	E/S/T	Annual
Clams	E/S/T	S/T	E/S/T	S/T	NS
Habitat Survey:					
Mayflies/Benthos	T	T	T	T	*
Wetlands	T	T	T	T	*

* St. Marys: 3yr others 5yr

R = Regulatory Program Needs, S = Site Specific, T = Trend, E = Exploratory/Load Estimate, MB = Mass Balance Needs, NS = Not Specified.

8. REMEDIAL ACTION PLANS (RAPs)

The St. Marys, St. Clair and Detroit Rivers have been identified by the Parties to the Great Lakes Water Quality Agreement as Areas of Concern. RAPs are being developed for each of these geographical areas as a joint effort by Ontario and Michigan with the support of Canadian and U.S. federal governments. The RAPs include a public consultation process now underway to identify the concerns of the community. The individual RAPs will list impaired uses, sources of contaminants, uses to be restored, specific remedial actions, schedules for implementation and detailed monitoring requirements.

PART II

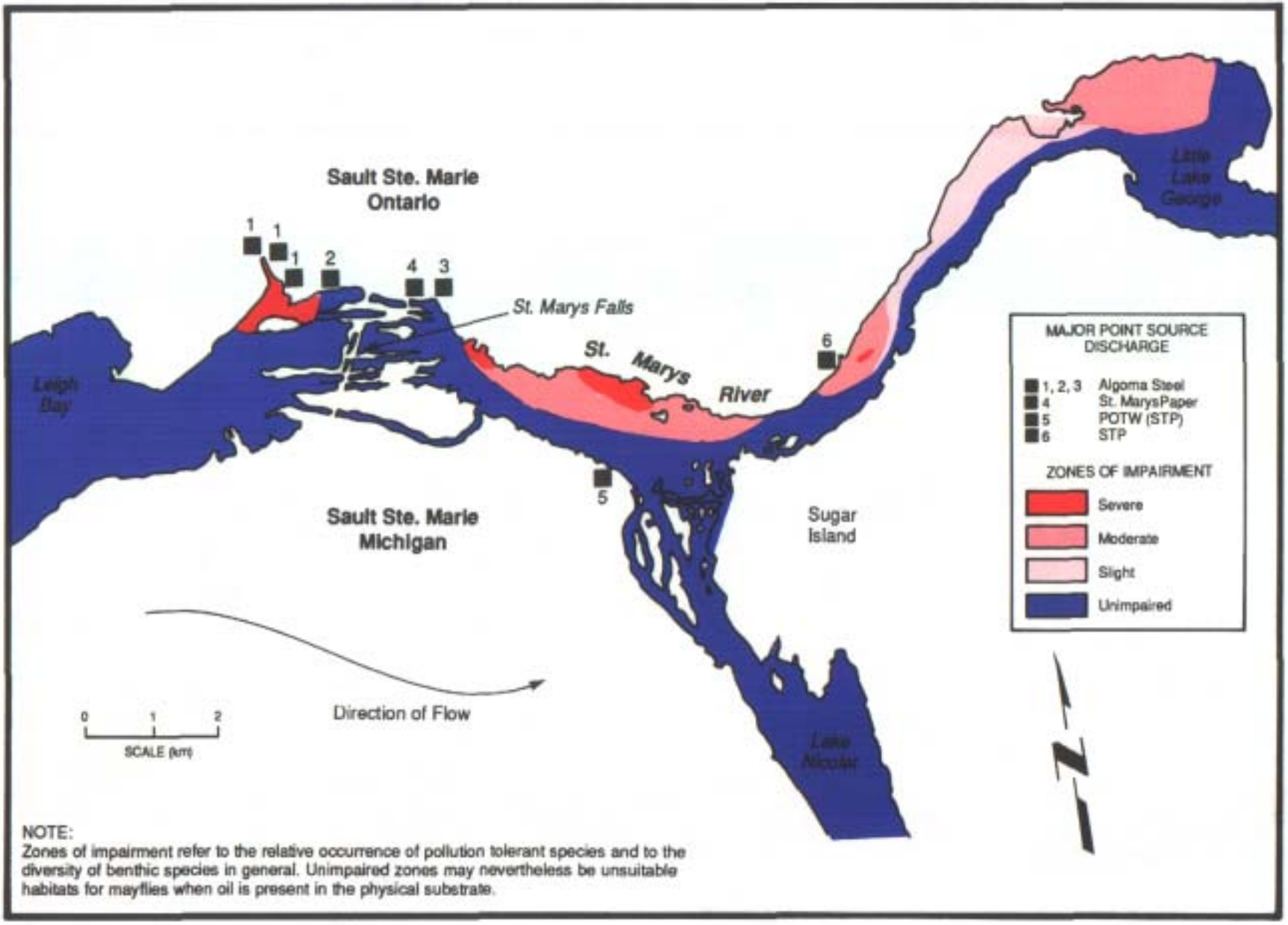


Figure 2. Zones of Impairment of Benthic Fauna in the St. Marys River

ST. MARYS RIVER

ENVIRONMENTAL CONDITIONS

Overall, the St. Marys River is in the best condition of the Upper Connecting Channels. The water quality and biotic diversity are mostly influenced by Lake Superior. However, localized water quality degradation has resulted from steel and paper mills and municipal sewage treatment plant discharges in Canada. On the U.S. side, combined sewer overflow discharges contribute to impairment downstream of the Edison Sault Electric Company canal. Considerable progress has been made since 1970 by Algoma Steel Corporation Ltd. in reducing ammonia-nitrogen, free cyanide, and phenol discharges; by St. Marys Paper in reducing suspended solids loadings; and by the municipal sewage treatment plants in improving the removal of phosphorus and organic matter.

The results of the present study show that significant zones of degraded water, sediment and/or biotic quality still remain along the Canadian shoreline.

- Zones of environmental degradation occur in Sault Ste. Marie, Ontario, particularly in slips and embayments at, and/or downstream of, Algoma Steel and St. Marys Paper.

- Adversely impacted benthic communities generally occur in a band approximately 500 m wide, extending 3 km along the Canadian shore downstream of industrial discharges (Figure 2).

- Some physical habitat destruction has occurred as a result of the construction, maintenance, and operation of navigation structures (e.g., dams and locks), shoreline infilling for slag disposal, channel maintenance activities, and ship passage.

- U.S. and Canadian waters do not mix to a significant extent in the upper river or main channel, but some cross-channel mixing does occur in the lower river downstream of the Sault Ste. Marie, Ontario East End Waste Water Treatment Plant. In particular, transboundary ammonia pollution was observed along the Sugar Island shoreline.

SPECIFIC CONCERNS

1. Water

- Zones of degraded water quality downstream of Sault St. Marie, Ontario exceeded available guidelines for iron, phosphorus, fecal bacteria, phenolics, and benzo(a)pyrene (one type of PAH).

- Although within their respective guidelines, the combined effect of ammonia and cyanide concentrations may result in toxic conditions.

- Spills of contaminated materials in the St. Marys River result in significant short term increases in the concentrations and loadings of some pollutants.

2. Sediment

- Bottom sediments in some areas of the St. Marys River exceeded both OMOE and/or USEPA dredging guidelines for the following pollutants: arsenic, lead, mercury, nickel, zinc, iron, copper, chromium, nutrients, oil and grease, and benzo(a)pyrene.

- Sediments along the Ontario shore near Algoma Steel and Sault Ste. Marie and in Little Lake George were the most contaminated. Sediments upstream of the industrial complexes were uncontaminated.

3. Biota

- Past reductions in pollutant loadings to the St. Marys River have not been adequate to reduce sediment contamination and impacts to benthic organisms. Contaminants remaining in the sediment, particularly oil and grease, metals and PAHs, are a major concern.

- Mercury levels in large specimens of some sport fish exceed the Great Lakes Water Quality Agreement objective of 0.5 mg/kg.

SOURCES OF POLLUTANTS

Municipal and industrial discharges accounting for much of the pollutant loading within the St. Marys River can be found in Table 4. In addition to the major contaminants quantified in Table 4, loadings of xylene, styrene, benzene, toluene, chloroform, methylene chloride, 2,4,6-trichlorophenol, 2,4-dimethylphenol, 1,4-dichlorobenzene and mono and dichloramine totalling 10.7 kg/day have also been identified. Nonpoint sources, particularly surface runoff from industrial sites, contribute equal amounts of some toxic contaminants.

- Algoma Steel had the highest loadings of oil and grease, ammonia, suspended solids, chloride, cyanide, total phenols, total metals, PAHs and total volatiles.

- High concentrations of suspended solids on the Ontario side can be traced to the Algoma Steel and St. Marys Paper facilities.

- The East End Waste Water Treatment Plant (WWTP) in Sault Ste. Marie, Ontario, contributes the highest loadings of total phosphorus, chlorinated benzenes and-chloroethers to the St. Marys River. It is the second greatest contributor of oil and grease, ammonia, chloride, total metals, volatiles, PAHs, and chlorinated phenols.

- Nonpoint sources may contribute up to 50 percent of PAHs, zinc and lead loadings to the river, although no extensive measurements of these sources were made.

- Storm drains of Sault Ste. Marie, Michigan, may be the source of high levels of fecal bacteria found immediately downstream of the Edison Sault Electric Company canal.

- Bennett and East Davignon Creeks which discharge to the St. Marys River receive significant loadings of heavy metals, phenolics, PAHs and oil and grease, from the Algoma Steel and Domtar plants as a result of spills, contaminated groundwater, runoff and scouring of contaminated sediments.

- Of twelve waste disposal sites studied, three present a potentially serious threat to the St. Marys River: the Algoma Slag Dump, the Cannelton Industries Tannery site, the Superior Stations landfill.

RECOMMENDATIONS

Ontario and Michgan should incorporate into their respective regulatory programs, the Great Lakes Water Quality Agreement goal for the virtual elimination of all persistent toxic substances. The following specific recommendations are provided as steps toward that goal.

A. Industrial and Municipal Point Sources

Algoma Steel which was the major contributor of ammonia, phenols, oil and grease, cyanide and suspended solids must continue to reduce loadings of these substances to meet the requirements of the Ontario Ministry of Environment Control Order, the compliance dates of which should be enforced. This recommendation is subject to Recommendations 7, 8 and 9 below.

2. The Sault Ste. Marie, Ontario East End WWTP should be equipped with phosphorus removal in order to bring the total phosphorus concentration in the final effluent down to the required 1 mg/L (this is expected to be on-line in 1989).

3. The treatment capacity of the East End WWTP is frequently exceeded. To reduce the frequency of plant overflows and by-passes, this plant must be upgraded to provide secondary treatment and expanded, or a portion of the wastewater must be rerouted to the West End WWTP.

4. The municipality, with the support of the OMOE, take steps to strictly enforce the Sault Ste. Marie Sewer By-Law and thus prevent the discharge of untreated industrial wastes to municipal sewers. The municipality and/or OMOE should also initiate an educational program to discourage home owners from disposing of hazardous or toxic waste in sewers.

5. Discharges of fecal coliform and fecal streptococci from Algoma Steel, sewage treatment plants and combined sewer overflows must be reduced to meet Provincial Water Quality Objectives.

6. The A.B. McLean aggregate extraction operations is potentially a significant source of suspended solids to the St. Marys River.

The current, permitted extraction must be closely monitored and the requirements must be strictly enforced. Furthermore, the pending permit application must not be issued until a comprehensive environmental review indicates that the increased activity would not result in unacceptable adverse impacts.

7. Discharge limits for point sources should be based on mixing zones with all water quality objectives met at the boundary of each mixing zone. This zone is expected to be reduced (ultimately to zero) as advances in treatment technology are implemented.

8. Depending on the parameter, Algoma Steel samples their effluent on a daily, weekly or monthly basis. Most of the controlled parameters are based on 12 month averages. Due to the variability in effluent characteristics, sampling should be more frequent. The frequency and type of sampling should be re-evaluated and audit sampling by OMOE should be increased.

9. Additional parameters, such as PAHs, should be regulated and incorporated into Algoma's monitoring program.

B. Non-point Sources

10. Ontario and Michigan should conduct additional studies for both urban and rural runoff to better identify and quantify loadings of trace inorganic and organic compounds.

11. Investigate the kinds of contaminants, the pathways of contamination (surface water and groundwater), and the magnitude of the contaminant flux; establish monitoring networks as required; and undertake necessary remedial clean-up activities at the following waste sites:

    i) the Algoma Slag Site;

    ii) Cannelton Industries Tannery disposal site (under CERCLA authority);

    iii) Union Carbide and Superior Sanitation landfills (under Michigan Act 307).

12. Spill containment must be improved at both industrial and municipal facilities to minimize the frequency of shock loadings to the aquatic ecosystem. This will entail spill prevention, development of contingency plans to deal with material reaching the river and the following of established procedures for the reporting of spills.

C. Surveys, Research and Development

13. Many PAHs have been shown to be bioaccumulative or to have toxic effects on aquatic organisms and some are proven carcinogens. The absence of specific, numerical water quality standards makes it difficult to regulate the discharge of PAHs. An accelerated effort to assess the ecological significance of PAHs and to develop compound-specific criteria is required.

14. There are no regulatory guidelines to permit assessment of the biological significance of sediment-associated contaminants. Development of such guidelines is required to aid in site-specific evaluations of contaminated sediments.

15. Impacts to benthic macroinvertebrate communities have been related to sediment quality. Further site-specific work must be completed to prioritize sediment "hot spots" based on biological impacts. In addition, physical and chemical characteristics of the sediment should be evaluated. This information will be used to determine appropriate remedial actions for sediments. Suggested studies include acute and chronic sediment bioassays, as well as physical/chemical and bedload assessments.

16. The development of water quality based effluent limits for specific PAH compounds requires additional monitoring of point source discharges (water as well as air) and determination of PAH concentrations in resident aquatic indicator species.

17. There is a paucity of data on the near-field atmospheric deposition of metals and organics. This information should be obtained, and evaluated relative to other sources (e.g. effluents, urban runoff, Lake Superior) to the river.

18. Suspended solids are of concern due to their ability to deposit contaminants locally or to transport them long distances, before settling

out. An investigation of the combined effects of suspended solids discharges from Algoma Steel, St. Marys Paper, and WWTPs should be completed. This may involve a sediment transport modeling effort that considers the sources, transport and ultimate deposition of sediment and contaminants. This study would also allow prioritization of sources for remedial action.

19. The NPDES Permit for the Sault Ste. Marie, Michigan WWTP includes effluent limits for BOD_5, pH, suspended solids, total phosphorus, fecal coliform, and residual chlorine. No loadings were measured for UGLCCS parameters during the 1986 survey period. Trace contaminant loadings from this facility should be determined to verify the absence of environmentally significant loadings to the river.

20. The OMOE has issued fish consumption advisories for many large game fish due to mercury contamination. Although the main source of mercury is believed to be natural, there are potential sources in the Sault Ste. Marie urban area. Mercury has been detected, for example, in all point source effluents and in stormwater in Sault Ste. Marie, Ontario. Therefore, it is recommended that a study to determine the relative contributions of background and urban source(s) of mercury be completed.

21. Fecal coliform bacteria densities were detected in river water downstream of the Edison Sault Power canal in Michigan. Further sampling must be conducted to determine whether Michigan's fecal coliform standard is being exceeded and, if so, to identify the source(s) and approprimate remedial action.

22. For chemicals where sufficient ambient data and standards are available, the agencies should develop a contaminant fate and exposure model. The model should provide insight into the fate of chemicals entering and leaving the river by various pathways as well as a systematic framework for predicting the relative effectiveness of proposed corrective actions.

ST. CLAIR RIVER

ENVIRONMENTAL CONDITIONS

Conflicting interests for resource utilization among industry, wildlife and recreation pose major challenges for the management of the St. Clair River. Most of the U.S. and Canadian shores are undeveloped and only relatively small urban communities exist. However, a large chemical manufacturing and petro chemical processing complex is situated south of Sarnia on the Canadian side ("Chemical Valley"). Discharges from this complex as well as other small industries and municipalities, on both sides, have contributed to environmental quality problems in the St. Clair River. Some major improvements havew been made since the 1970s, including a substantial reduction in the concentrations of mercury and certain organic chemical (particularly since 1985) and the shrinking of the River's zone of highly contaminated sediment.

Loadings of a number of conventional and organic pollutants, primarily certain toxic industrial solvents and metals, continue to compromise local environmental quality.

- Areas of degraded water quality are located on the Ontario side of the river in the Sarnia-Corunna "Chemical Valley" area of petroleum refining and chemical manufacturing complexes (Figure 3).

- Most zones of severely contaminated sediment were found primarily offshore and immediately downstream of the Chemical Valley.

- There is virtually no cross-channel transport of pollutants across the international boundary. The river acts like three separate flow panels: a central panel bounded by Ontario and Michigan shore panels. Pollutants from outfalls or tributaries tend to remain close to the shorelines, affording little dilution with river flow.

SPECIFIC CONCERNS

The contaminants of conern in the St. Clair River were found to be remarkably consistent among water quality, sediment and biota.

1. Water

- Concentrations of bacteria have exceeded guidelines resulting in the closure of swimming areas on both sides of the river.

- Hexachlorobenzene and perchloroethylene exceed interim guidelines near industrial outfalls on the Canadian side of the river.

- Octachlorostyrene, hexachlorobutadiene, hexachloroethane, pentachlorobenzene, benzene and carbon tetrachloride are chemicals contributed by Canadian sources in concentrations which are of concern. There are, however, no ecosystem or industrial guidelines to which to compare their concentrations.

- Chloride concentrations in the river do not exceed drinking water guidelines, however, the extremely large point source loadings (356 tonnes/day) may have implications for downstream biota.

- Spills and leaks from Chemical Valley continue to be a concern as individual incidents can contribute loadings of toxic chemicals approaching the annual on-going discharges.

2. Sediments

- Sediment contamination is highest on the Canadian side and particularly in the vicinity and downstream of industrial discharges. These sediments are contaminated to varying degrees by hexachlorobenzene, octachlorostyrene, PCBs, oil and grease, hexachlorobutadiene, hexachloroethane, pentachlorobenzene, diphenylether and biphenyl.

- Significantly elevated concentrations of mercury remain in the sediments on the Ontario side, even though industrial sources have been virtually eliminated. The highest concentration, 51 mg/kg, was found adjacent to Dow Chemical.

- Levels of lead were generally low, except for one location near the Ethyl Corporation Plant, were concentrations as high as 330 mg/kg were found.

NOTE:
Zones of impairment refer to the relative occurence of pollution tolerant species and to the diversity of benthic species in general.

Figure 3. Zones of Impairment of Benthic Fauna in the St. Clair River

- On the Michigan side of the river, the concentrations of UGLCC Study pollutants were generally low. Localized areas of oil and grease contamination were found above the Bluewater Bridge adjacent to Port Huron, above the Belle River adjacent to Marine City and along the North Channel downstream of Algonac.

3. Biota

- The following contaminants were detected in caged clams and fish exposed to industrial discharges: hexachlorobenzene, octachlorostyrene, PAHs, hexachloroethane, hexachlorobutadiene, pentachlorobenzene, carbon tetrachloride, perchloroethylene and benzene.

- Some large walleye, northern pike, and white bass contain levels of mercury in edible flesh that exceed the Great lakes Water Quality Agreement objective (0.5 mg/kg).

- Sediments from the Chemical Valley area were found to be lethal to indicator organisms, such as: mayfly nymphs, freshwater scud, and fathead minnows.

- Concentrations of PCBs in the older, larger representatives of a number of fish species exceed the Great Lakes Water Quality Agreement objective (0.1 mg/kg), which is intended to protect sensitive wildlife.

- A number of pollutants also were detected in biota for which no standards, objectives or guidelines have been set: alkyl lead compounds were found in game fish near the Ethyl Corporation-Sarnia Plant, PAHs were found in caged clams, hexachlorobenzene and octachlorostyrene were detected in species from all trophic levels.

- The concentration of persistent pollutants (such as mercury, hexachlorobenzene, octachlorostyrene and PAHs) is higher in some sampled organisms than in the environment, reflecting the tendency of these contaminants to bioaccumulate.

- The potential additive, antagonistic or synergistic effects of multiple contaminant exposures to the river's wildlife and to fish and duck consumers are not well understood.

SOURCES OF POLLUTANTS

Industrial discharges, especially on the Canadian side of the St. Clair River, are major sources of many of the area's toxic contaminants. Tributaries, urban runoff and combined sewer overflows, also contribute to total pollutant loadings.

- The petroleum refineries and chemical plants located on the upper 10 km of the St. Clair River in the Sarnia-Corunna area are major sources of hexachlorobenzene, octachlorostyrene, PAHs, lead, ammonia-nitrogen, chromium and total volatiles (see Table 4 in Part I).

- The Dow-Sarnia Plant is a principal source of a number of toxic pollutants of particular concern: hexachlorobenzene, octachlorostyrene, PCBs, copper, mercury and volatiles.

- Ethyl Corporation is the major source of alkyllead in the St. Clair River System.

- The Cole Drain is a principal source of oil and grease, PAHs and cyanide.

- The Sarnia WWTP is a principal source of total phenols, nickel, phosphorus and ammonia.

- On the Michigan shoreline, three urban areas have storm sewers that drain directly or indirectly to the St. Clair River, contributing PCBs, ammonia, phosphorus, oil and grease and metals: (1) Port Huron; (2) Marine City; and (3) Algonac.

- Based on studies of Sarnia runoff and combined sewer overflow (CSO) systems, overflow incidents are a major source of ammonia and phosphorus; runoff and overflow are roughly equal in the contributions of oil and grease, zinc and mercury.

- Tributaries to the St. Clair River are major sources of phosphorus, a number of pesticide compounds, and other pollutants.

- Seven U.S. and two Canadian waste sites were ranked as high priority based on their potential to impact the river.

- Historical deep-well disposal of liquid industrial wastes in the Sarnia area has resulted in localized phenol contamination of the freshwater aquifer in the vicinity of some disposal wells. Generally, this is not considered a significant source of contamination to the St. Clair River.

- The liquid waste disposed in the deep wells has migrated out of the original disposal zone and the fate of the 8 x 10^6 m^3 of waste is largely unknown. Of particular concern is the presence of high phenol concentrations in bedrock layers above the original disposal zone.

- Spills and accidental discharges also are an important source of pollution. In 1986, a total of 131 surface water spills to the St. Clair River were reported; 10 in Michigan and 121 in Ontario.

- One spill of particular note during the study occurred at Dow Chemical-Sarnia in 1985, when 50 tons of perchloroethylene were released into the river.

RECOMMENDATIONS

Ontario and Michigan should incorporate into their respective regulatory programs, the Great Lakes Water Quality Agreement goal for the virtual elimination of all persistent toxic substances. The following specific recommendations are provided as steps toward that goal.

A. Industrial and Municipal Point Sources

1. Polysar Sarnia should take action to significantly reduce benzene and phenols in the American Petroleum Institute (stereo) separator effluent. The operation of the Biox treatment system should be optimized to attain the Ontario Industrial Effluent objectives for total phenols and ammonia-nitrogen. Effluent requirements (in both concentration and mass loading form) should be implemented for PAHs and HCB at the most stringent levels attainable through the use of the best available technology.

2. Dow Chemical should significantly reduce its discharge of organic chemicals to the river. The facility was a major contributor of 5 of the 7 organic groups studied. It is noted that current self-monitoring data are being made publicly available to demonstrate the effect of recent remedial efforts at this facility. Many improvements in operation have been implemented at Dow Chemical since the time of the UGLCCS survey. Self-monitoring data and other sampling results should be reviewed to determine if additional remedial actions are needed.

3. The sources of ongoing discharges of mercury from Dow Chemical and Ethyl Canada should be identified and eliminated.

4. Ethyl Canada should improve the operation of its treatment plant to reduce concentrations of tetra ethyl lead to meet the GLWQA specific objective and the Provincial Water Quality Objective of 25 μg/L. In addition, enforceable mass loading limitations for lead should be instated at this facility. Volatiles, especially chloroethane, should also be significantly reduced in the effluent.

5. Polysar Corunna should reduce the concentration of chromium and zinc in the final effluent. This facility should consider substituting less persistent additives in the recycle cooling water system.

6. Effluent concentrations for chloride were generally below drinking water objectives, but the total point source loading to the system was very large (356 tonnes/day). Most was from facilities in the Sarnia area. The extreme loadings may be affecting aquatic organisms downstream of these facilities. Chloride concentration and loading limitations should be considered for those facilities discharging significant amounts of chlorides.

7. All potential sources of releases of heat exchanger fluids, as evidenced by the presence of very high concentrations of diphenyl ether and biphenyl in sediments along Sarnia's industrial waterfront, should be identified and controlled.

8. The Sarnia WWTP should be expanded and upgraded to secondary biological treatment with phosphorus removal. In conjunction with the upgrading, the Point Edward WWTP (a primary plant) should be considered for use as a pretreatment facility

which would discharge to the Sarnia Plant. The loading of ammonia-nitrogen, total phenols, heavy metals, and organics to the St. Clair River would be significantly reduced by this action.

9. American Tape in Marysville should be evaluated to ensure compliance with their NPDES permit, Michigan Water Quality Standards and BAT requirements for toluene and xylene in the discharge.

10. The City of Marysville should be evaluated to ensure compliance with their NPDES permit and Michigan Water Quality Standards for toluene in the discharge.

11. The National Pollution Discharge Elimination System permit for the Marine City WWTP should be evaluated to ensure compliance with Michigan Water Quality Standards for cyanide. The pretreatment program should be reviewed to ensure that cyanide is adequately regulated. The facility should be evaluated to determine if acute and chronic bioassays are necessary.

12. A survey should be conducted at the St. Clair County-Algonac WWTP to evaluate the efficiency of the treatment system. An ammonia-nitrogen effluent limitation should be considered for the facility. Nitrogen loading to the river and Lake St. Clair may be reduced by these actions.

13. The City of St. Clair WWTP should be resurveyed to ensure that the expanded plant is operating efectively.

14. A study of industrial contributors to the Port Huron WWTP should be undertaken to identify the source or sources of cyanide and PCBs to this facility. Pretreatment requirements for all industrial contributors should be examined, and modified if needed. Effluent requirements for cyanide and PCBs should be considered in the facility's NPDES permit.

15. Biomonitoring studies should be conducted to determine whole effluent toxicity at industrial and municipal point sources. This study evaluated the point sources only on a parameter-by-parameter basis, with no attempt made to determine the impact of any additive or synergistic effects the parameters may exhibit.

B. Non-point Sources

16. Sources of PAHs and total cyanide to the Cole Drain, Sarnia, should be identified. If the sources are exceeding applicable effluent guidelines, they should be remediated.

17. The loadings via surface water runoff and groundwater discharge from landfills in the Scott Road area to the Cole Drain need to be determined and treated as necessary.

18. Licensing requirements for sludge disposal facilities should ensure that surface water and groundwater are properly monitored and treated.

19. A and B Waste Disposal, Hoover Chemical Reeves Company, and Wills St. Dump Site were all scored under the Superfund Hazard Ranking System (HRS) apparently without consideration of groundwater quality information. The State of Michigan should determine, based upon USGS chemistry information, the State priority for action at each site. Development of more complete groundwater information on-site would allow the State the options of pursuing Federal action under Superfund by rescoring the site under the new HRS (when it is approved), or pursuing remediation under Act 307 (MERA). Furthermore, the facilities needs for RCRA permitting need to be assessed, or reassessed.

20. The proximity of Eltra Corp. Prestolite waste site to the St. Clair River, and the nature of wastes on-site call for careful evaluation of impacts on groundwater and on the St. Clair River prior to facility closure under RCRA authorities. In the event that a satisfactory evaluation of groundwater contamination and runoff impacts upon the St. Clair River are not secured, a Site Investigation (SI) under Superfund authorities should be undertaken. The SI should include assessment of both groundwater and surface runoff impacts upon the St. Clair River.

21. The State of Michigan needs to restrict access of dumpers to Winchester Landfill. The State's development of groundwater information for this site would assist in scoring by the HRS.

22. Michigan and Ontario municipal combined

sewer overflows should be intensively surveyed to determine their contribution of pollutant loadings to the river. In the long term (due to the enormous cost), combined sewers in all municipalities should be eliminated. In the interim, the municipalities should institute in-system controls to minimize the frequency and volume of overflows.

23. The Michigan Pollution Emergency Alerting System and spill reports from the Ontario Spills Action Centre should be improved so that all information on recovery, volume (if known), and final resolution are fed back to the central reporting system to complete each report for inventory purposes.

24. Spill management programs at all facilities should be reviewed and enhanced to reduce the frequency and magnitude of spills to the St. Clair River with the goal of eventually eliminating all spills.

25. Aggressive educational programs on the use of conservation tillage techniques and pesticide, fertilizer, and manure application techniques should be provided to farmers to reduce rural runoff contaminant contributions. Stricter legislation to control such application should be developed and enforce.

C. Surveys, Research and Development

26. Water quality guidelines need to be developed binationally for OCS, individual or total PAHs, hexachloroethane and chlorides. In addition, Canada needs to develop guidelines for hexachlorobutadiene, and the U.S. needs water quality guidelines for hexachlorobenzene, phosphorus and pentachlorobenzene. The Great Lakes Water Quality Agreement needs to develop specific objectives for all of these parameters. Fish consumption and sediment criteria are needed for HCB, OCS, PAHs, alkyl lead, and other chemicals found to be of concern in this study.

27. More data are needed to assess the impact of PAHs on the St. Clair River. Ambient water concentrations, and point and nonpoint source loadings should be measured. Monitoring should be detailed enough to allow for the fingerprinting of sources.

28. The importance of contaminant loadings during rainfall events needs to be evaluated.

29. The loadings of all chemicals with high bioconcentration and bioaccumulation potential should be reduced to minimize contaminant body burdens in resident and spawning fish.

30. Assess the significance of mercury contamination to biota from sediments relative to ongoing discharges and develop remedial actions as necessary.

31. Industrial and municipal facilities discharging to St. Clair River tributaries should be surveyed to determine their contribution of contaminants to the St. Clair River. In particular, contaminant loadings from Talfourd Creek in Ontario and the Black River in Michigan should be determined.

32. The potential PCB source in the vicinity of the Lambton Generating Station should be investigated and quantified.

33. The loadings and sources of PCBs, PAHs, oil and grease, lead, ammonia, and phosphorus from the unnamed creek in Michigan across from the Lambton Generating Station should be determined and controlled to ensure compliance with Michigan Water Quality Standards.

34. The lead source to the Black River in Michigan should be located and controlled.

35. Sources of bacterial contamination to the river should be traced and eliminated.

36. A waterfowl consumption advisory should be considered by Ontario and Michigan for the St. Clair River.

37. A study on the magnitude of contaminant input to the St. Clair River from Michigan urban runoff should be undertaken, and an additional, more refined study on Canadian urban runoff should also be performed. Management control options for urban runoff should be developed.

38. Contamination from waste disposal sites, identified as high priority by the Nonpoint Source Workgroup, needs to be further

investigated with regard to contaminant pathways, including surface water runoff and groundwater seepage, and environmental impacts.

39. Continued monitoring of water levels and water quality in the freshwater aquifer in the Sarnia area is required.

40. The potential for transboundary migration and contamination of the St. Clair River and/or the freshwater aquifer in the Sarnia area from industrial waste in the 74 m and 123 m depth limestone layers should be investigated. Of particular concern, is the 74 m depth horizon which likely flows into the fresh water aquifer in the deeper sections of the bedrock valley.

41. To understand the fate of the industrial waste injected into the Detroit River Geological Group, additional deep boreholes to the disposal formation are required to quantify the current directions and rates of groundwater movement.

42. U.S. and Canadian agencies should cooperate in undertaking deep-well studies. A number of deep wells are needed in St. Clair County to supplement the information from the Ontario studies. If evidence of impacts upon Michigan groundwater is developed, a variety of authorities, including Superfund, may be applicable for remediation of identified problems.

43. The potential biological consequences of increased chloride concentrations in the St. Clair River and downstream should be assessed.

44. Better methods for analysis of PCBs in the St. Clair River need to be undertaken.

45. Studies should be conducted on the bioavailability of particle-bound contaminants, and contaminant desorption from suspended and bottom sediments are required to make a better assessment of the impact of in-place pollutants.

46. Studies on the effects of multi-contaminant exposure to aquatic life are required.

47. Studies to better understand the fate and transport of sediment-borne contaminants are needed. These studies should include profiling the age and contamination of sediments in St. Clair River and delta depositional areas.

LAKE ST. CLAIR

ENVIRONMENTAL CONDITIONS

Four Michigan and three Ontario urban centers are located in the immediate watershed of Lake St. Clair. Only Mt. Clemens, Michigan obtains its drinking water from the lake. Lake St. Clair is also a popular recreational area, with more than 10,000 moorings for sail and power boats and a multitude of sport fishing and duck hunting opportunities.

Unlike the other UGLCCS geographic areas, Lake St. Clair is not an IJC Area of Concern. However, it does receive the direct outflow from two upstream Areas of Concern: the Clinton and St. Clair Rivers.

- The St. Clair River contributes 98% of the flow and the majority of pollutants to the lake. This, along with the short residence time of water in the lake (5 to 7 days), means that water quality in the lake is dominated by the outflow of the St. Clair River.

- Storms result in the intermittent resuspension of Lake St. Clair bottom sediments which become entrained in the water column, eventually exiting the lake via the Detroit River. Hence, an average of only 7 cm of sediment has accumulated in the lake bottom since the last ice age.

- With little removal of pollutants due to sediment deposition or degradation, environmental quality does not change significantly from the mouth of the St. Clair River to the head waters of the Detroit River.

- Overall, water, sediment, and biota quality have improved over the last decade, but additional improvement is necessary to fully restore all of Lake St. Clair's beneficial uses.

SPECIFIC CONCERNS

A. OPEN LAKE

1. Water

- No exceedences of water quality based guidelines were found in Lake St. Clair. Overall, the water quality of the lake is not a concern.

- At the head of the Detroit River, the concentration of PCBs was greater on the U.S. side than on the Canadian side, suggesting that a source of PCBs may exist on the western shore of Lake St. Clair.

- Phosphorus levels increase from the mouth of the St. Clair River to the headwaters of the Detroit River with potential adverse impacts on Lake Erie water quality.

2. Sediments

- Exceedence of Great Lakes Water Quality Board and OMOE dredging guidelines is confined primarily to the central lake, where up to 1.2 ppm of mercury was found in the sediment. However, only 2 of 45 stations were heavily polluted with mercury.

- Overall, Lake St. Clair sediments are classified as lightly polluted; sediments in 4 to 20 percent of the stations sampled contained nickel, chromium, copper, and zinc at moderately polluted levels.

- Sediments collected in the vicinity of the Clinton River, Thames River, and the south central portion of the lake exceed "moderately polluted" (420-650 mg/kg) and "heavily polluted" (> 650 mg/kg) levels for phosphorus.

3. Biota

- PCBs in some fish and duck flesh samples exceed GLWQA objectives.

- Hexachlorobenzene and octachlorostyrene are present in fish and duck flesh in potentially significant concentrations.

- Tissue samples of the larger sizes of certain sport fish species still exceed the Great Lakes Water Quality Agreement Objective for mercury of 0.5 mg/kg. As a result, a Public Health Fish Consumption Advisory exists for both Michigan and Ontario waters. For 1988, Ontario has eliminated the "No Consumption" category for the general population, but the advice for sensitive populations remained in effect. Michigan's advisory remains unchanged.

B. TRIBUTARIES

- Sediment collected at the mouth of the Clinton and Milk Rivers are sufficiently contaminated with some heavy metals to exceed both USEPA and OMOE sediment pollution guidelines.

- Elevated levels of PAHs were found in sediments from Cottrel Drain (13,800 μg/kg), Clinton River (12,100 μg/kg), and Frog Creek (10,700 μg/kg).

- DDT and metabolites, gamma-chlordane and PCBs were detected in 9 of 12 tributary sediments, with the highest levels in the Milk River (383 μg/kg) and Cottrel Drain (196 μg/kg and 1,974 μg/kg, respectively).

- PCBs in some larger members of some species of Clinton River fish, especially bottom feeders, exceed the Great Lakes Water quality Agreement Specific Objectives and the Michigan sport fish advisory.

SOURCES OF POLLUTANTS

- Major sources of pollutants to Lake St. Clair are the St Clair River and six municipal waste water treatment plants (Table 7). There are no direct industrial discharges to the lake.

- The water, sediment and biota quality of the Clinton River is impacted by steadily increasing development in its watershed.

- Agricultural runoff to Lake St. Clair tributaries provides excessive nutrient and pesticide loads.

- Urban runoff and CSOs also contribute some conventional and toxic pollutants. Three Ontario municipalities have combined sewers. Michigan municipalities discharging to the lake do not have combined sewers.

- Because of the large surface area of the lake, atmospheric processes may be relatively important with regard to the deposition of certain contaminants. However, this has yet to be quantified.

TABLE 7

Summary of point source contaminant loadings to Lake St. Clair
(kilograms/day)

CONTAMINANTS	Mt. Clemens WWTP	Warren WWTP	Chatham WPCP	Pontiac WWTP	New Baltimore WWTP	Wallaceberg WPCP	Rochester WWTP	Belle River WPCP	Total
Total PCBs	0.002	0.0073							.009
Hexachlorobenzene	0.00005	0.00059	0.00020						.0008
Hectachlorostyrene	0.00000045								4.5×10^{-7}
Total Phenols	1.03			0.45	0.14	0.13			1.65
PAHs						0.0036			.0036
Total Cyanide	0.11	0.76			0.036		0.044		0.95
Total Mercury	0.009	0.0023	0.0013			0.0002			0.013
Total Copper	0.40	0.62	0.15	0.40		2.45			4.02
Total Nickel		3.09	0.42			2.44			5.95
Total Cobalt	0.0041	0.20							0.204
Total Cadmium	0.0093	0.065				0.020			0.094
Total Lead	0.27	0.16	0.44	0.099					0.97
Total Zinc	1.12	5.65		1.79		0.63	0.26		9.85
Total Iron	13.7	6.52	9.01		4.29	11.2	2.34	1.73	48.8
Oil & Grease	48.0		82.2			23.6	20.9	21.1	195.8
Ammonia as N	133		225			101	54		513
Chloride	1470	8260	4400	5630		1320	4000		25080
Phosphorus as P	32.0	40.2	12.9	21.6			5.9	7.9	120.5

Data are based on the UGLCCS point source surveys of 1985 and 1986.

RECOMMENDATIONS

Ontario and Michigan should incorporate into their respective regulatory programs, the Great Lakes Water Quality Agreement goal for the virtual elimination of all persistent toxic substances. The following specific recommendations are provided as steps toward that goal.

A. Industrial and Municipal Point Sources

1. The City of Mt. Clemens should determine the source of PCBs, total phenols and mercury in the WWTP effluent and, through pretreatment or in-plant controls, reduce the concentrations of these pollutants to acceptable levels. Effluent limitations for these parameters should be considered. Phosphorus concentrations in the effluent should be lowered to meet the 1 mg/L Great Lakes Water Quality Agreement Objective.

2. Site specific effluent limitations for total cadmium, total copper, total chromium and total nickel to protect the water quality for the Sydenham River and Lake St. Clair should be developed for the Wallaceburg WWTP. The operation of the plant should be optimized to meet the Ontario industrial effluent objective of 10 mg/L for ammonia.

3. The Warren WWTP should determine the source of PCBs in its effluent and take the necessary steps to reduce the concentration to acceptable levels.

B. Non-point Sources

4. Soil management practices in agricultural areas with high rates of wind erosion need to be reviewed due to the ability of fine grained soils to transport nutrients and agrichemicals. In particular, conservation tillage should be considered. The primary reasons for this are the effectiveness of residue cover in reducing wind erosion and the low cost of implementing the practice.

5. Rural landowners need to implement with the assistance of federal, state and provincial governments, a comprehensive soil and water management system in order to control, at source, the contribution of conventional and organic pollutants including manure and pesticides to surface and groundwater.

   Agricultural and conservation agencies need to accelerate the implementation of control technologies through technical, financial and information/education programs.

   Environmental and agricultural agencies should assess the adequacy of existing controls, regulations and permits for the use of fertilizer and pesticide products.

   Specific programs, especially in Macomb County, Michigan, should be developed and directed toward pesticide users with respect to the handling, application and storage of pesticide products.

6. Future assessment and control of agricultural non-point sources of pollution would be facilitated by compatible federal, state and provincial monitoring data and more frequent flow-weighted tributary monitoring data. The small water quality monitoring data set available for tributaries indicated the need for increased sampling for all parameters, especially for high flow conditions and for understanding seasonal patterns.

7. Macomb and St. Clair Counties, Michigan, should be targeted for fertilizer management directed at reducing excessive levels of phosphorus. USEPA Region V has requested the U.S. Department of Agriculture Soil Conservation Service Michigan State Office to develop standards and specifications for a nutrient, best management practice that would protect ground and surface waters as well as sustain crop production. The Michigan Departments of Agriculture and Natural Resources are developing a joint action plan to manage livestock waste problems. These programs should be developed quickly and may require a system of permits for concentrated feeding operations.

8. The CSOs from municipal wastewater treatment plants should be intensively surveyed to determine their contribution of pollutant loadings to the surface waters. In the long term (due to enormous cost) combined sewers in all municipalities should be eliminated. In the interim, the municipalities should institute in-system controls to minimize the

frequency and volume of overflows.

9. The Michigan Pollution Emergency Alerting System and the Ontario Spills Action Centre spills reports should be improved so that all information on recovery, volume (if known) and final resolution are fed back to the central reporting system to complete each report for inventory purposes.

10. The Superfund Site Investigations to be undertaken at Selfridge ANGB should focus on groundwater and surface water runoff impacts upon Lake St. Clair and the Clinton River. In the event that this site is not included on the U.S. National Priorities List, the State of Michigan should place high priority upon cleanup on this site.

11. Michigan should require groundwater monitoring as a permit condition for the Sugarbush solid waste landfill.

12. Michigan should include groundwater monitoring as part of the permit for G and L Industries under the Federal Solid Waste Disposal Act.

C. Surveys, Research and Development

13. Data interpretation would be facilitated by the development of more complete water quality objectives for the organic pollutants and pesticides that are used extensively by the agricultural industry.

14. The presence of organic contaminants (PCBs, HCBs and OCS) in the Canadian tributaries illustrates the need to locate the contaminant sources.

15. The cadmium content of the phosphate fertilizer that is being used on agricultural lands should be determined.

16. A study of atmospheric deposition of organic contaminants, particularly PCBs, to Lake St. Clair and to the tributary watersheds would provide quantitative information on loading of these contaminants to the lake. The loading estimates are important for mass balance calculations and the identification of unknown sources of the contaminants.

17. Urban runoff was identified as being a potentially major non-point source of many parameters, including PCBs, oil and grease, zinc, mercury, copper and nickel. The loadings from urban runoff, however, were based on contaminant concentrations from Canadian urban areas outside of the Lake St. Clair basin. Therefore, the loading information provides only a general potential for urban runoff to contribute contaminants to Lake St. Clair. A study should be performed to determine the contribution actually made by urban runoff on the Michigan shore where the shoreline is more urbanized than is that of Ontario.

18. The sediments near the mouth of the Clinton, Sydenham and Thames Rivers contain contaminants that may be impairing benthic communities. Studies are needed to document possible impairment of benthic communities of these sites. Appropriate actions to remedy any observed problems will need to be defined. Techniques and technologies for remediating in-place polluted sediments should be developed.

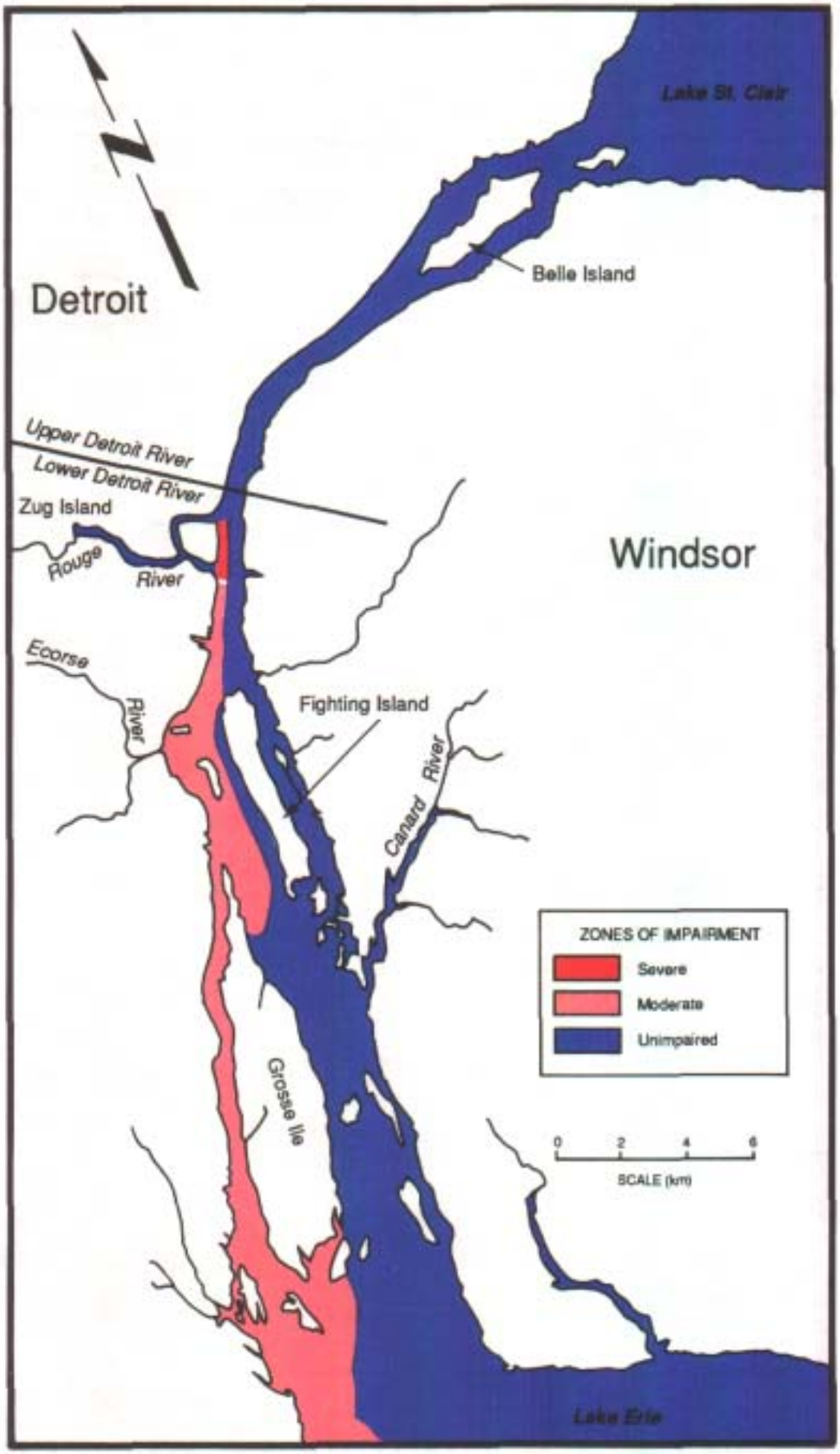
19. Recognizing that the biological effects of a substance are dependent in part on the chemical species of that substance, studies should be conducted to identify the chemical species and valances of the heavy metals in Lake St. Clair and its tributaries. For those forms which are present but for which toxicity information is lacking in the literature, toxicity and bioaccumulation experiments should be conducted on appropriate target organisms.

20. The evaluation of the point source data has been conducted on a parameter by parameter basis. In order to assess the quality of whole effluents, it is recommended that biomonitoring studies, both acute and chronic, be conducted at the major facilities (Wallaceburg WWTP, Chatham WWTP, Warren WWTP, and Mt. Clemens WWTP).

21. An inventory of all point sources,hazardous waste sites, urban and rural runoff, and spills discharging or potentially discharging to the Clinton River should be made. These facilities, sites or incidents should then be examined for their potential to contribute chemicals to the Clinton River.

22. A more complete analysis of sediment, water and biota quality along the entire stretch of the Clinton River is needed. Such information would establish the locations of sources of contaminants.

23. The Thames and the Sydenham Rivers were found to be major contributors of phosphorus, ammonia, lead and cadmium. An inventory of all point sources, hazardous waste sites, urban and rural runoff and spills discharging to thse rivers should be collected. These facilities, sites or incidences should then be examined for their potential to contribute chemicals to the rivers.



NOTE:
Zones of impairment refer to the relative occurence of pollution tolerant species and to the diversity of benthic species in general.

Figure 4. Zones of Impairment of Benthic Fauna in the Detroit River

DETROIT RIVER

ENVIRONMENTAL CONDITIONS

The Detroit River has the most severe environmental quality problems of the Upper Connecting Channels. It is the most intensively developed of the upper channels with extensive urban, commercial and industrial complexes, particularly on the U.S. side. However, over the past two decades, improvements have been made in controlling conventional pollutant point sources in the Detroit River especially discharges of oil and grease, and nutrients. Concentrations of other conventional water quality parameters, including chloride, ammonia and phenols have declined substantially.

The results of the UGLCC Study indicate that severe problems remain with regard to certain conventional pollutants as well as toxic organics and metals.

- The Detroit River is the furthest downstream of the Upper Great Lakes Connecting Channels. Hence, environmental conditions are impacted by upstream pollutant loadings as well as those contributed directly to the river and via tributaries to the river.

- The Rouge River is a major tributary to the Detroit River. It drains an intensively industrialized and urbanized basin and has also been designated an Area of Concern (PAHs, heavy metals).

- Water and sediment entering the head of the Detroit River are subject to contamination from two Areas of Concern: the St. Clair River (organic hydrocarbons, volatile organics, mercury) and the Clinton River (PCBs, heavy metals and phosphorus).

- Cross channel mixing occurs in the lower river where islands and shipping structures result in complex currents and eddies. Transboundary movement of pollutants upstream of Lake Erie thus likely occurs from the U.S. to Canadian shore under certain wind/flow conditions.

- Trend data from 1970 to 1980 indicate levels of mercury in sediments have decreased, in part a result of improvements in industrial treament facilities. Results of two studies indicated that mercury contamination is higher in surficial sediments than in the deeper layers, suggesting that there may be active sources.

- Overall, aquatic biota, especially bottom dwelling organisms show detrimental responses to contamination of Detroit River sediments with organic and inorganic substances, particularly in the lower river on the Michigan side and in the Trenton Channel.

- Normal macrobenthic communities were found upstream of Zug Island and along the entire Canadian shoreline. Severely impacted communities occur along and immediately downstream of Zug Island. Communities displaying intermediate impacts are found along the remainder of the U.S. shore (Figure 4). In the Trenton Channel, the benthos is dominated by pollution tolerant oligochaetes.

- Data on contaminant levels in fish from the Detroit River are insufficient to determine trends; however, limited research indicates continuing high levels of PCBs and chlordane residues and gradual reductions in levels of DDT residues.

- Increased incidence of fish tumors have been detected in the lower river.

SPECIFIC CONCERNS

1. Water

- The concentrations of the following UGLCCS parameters exceed one or more of Michigan Rule 57 criteria, OMOE guidelines or Great Lakes Water Quality Agreement Objectives at one or more locations in the Detroit River: PCBs, hexachlorobenzene, PAHs, lead and mercury.

- Although not measured during these studies, fecal coliform bacteria are of concern in the Detroit River because fecal coliform bacteria standards and criteria are routinely violated on both sides of the river. Beaches have been closed or not developed because of this continuing problem.

- While phosphorus concentrations in the river are below relevant guidelines, the total loading of phosphorus increases 50 to 80 percent along the length of the Detroit River resulting in a significant loading to Lake Erie.

- Mean concentrations of cadmium, copper, mercury, nickel and zinc were significantly higher in the lower river, indicative of inputs from sources along the river.

- PCBs clearly show an increase in downstream concentrations with increases greatest on the U.S. shore. Highest concentrations occur just downstream of the Rouge River and in the Trenton Channel.

- At the Rouge River mouth, Michigan Rule 57 guidelines were violated for cadmium, zinc, mercury, PAHs and some organochlorines.

- Levels of cadmium, mercury, lead, zinc and phosphorus in Ecorse, Canard and Little Rivers, and Turkey Creek violated one or more of the applicable criteria, guidelines or objectives.

- Organochlorine (OC) pesticides (e.g., chlordane, DDT, and dieldrin,) were found in the upper river, however, significantly higher OC levels were observed at many downstream stations on the Michigan side, with highest value at the mouth of the Rouge River.

2. Sediments

- USEPA and OMOE dredging guidelines were exceeded in sediment samples collected at one or all locations along the Michigan and Ontario shores of the Detroit River for mercury, lead, arsenic, cadmium, zinc, chromium, nickel, manganese, iron, cyanide, oil and grease, total phosphorus, total ammonia and PCBs.

- Contaminants for which no guidelines are available but which were found to have high concentrations include: hexachlorobenzene, PAHs, phenols, DDT and metabolites, phthalate esters and volatile organics.

- Generally, sediment contamination in the Detroit River is a concern along the full length of the Michigan shore and immediately adjacent to Windsor and Amherstburg on the Canadian shore. Highest sediment contamination in the river tends to be downstream of the Rouge River and in the Trenton Channel.

- Certain Detroit River depositional zone sediments have demonstrated a range of toxicity to various forms of aquatic life and some sediments have been classified as hazardous waste.

- Sediments from Detroit River tributaries were also found to contain levels of contaminants that exceeded one or more USEPA and OMOE guidelines. The highest sediment concentrations found during the study occurred in certain tributaries (e.g., PCB and PAH concentrations in Monguagon Creek were the highest levels in the system). Tributaries of concern include Monguagon, Conners and Turkey Creeks, and the Rouge and Little Rivers.

3. Biota

- Bioassays using bottom water, sediments and sediment porewater display a range of toxicity and/or mutagenicity to certain kinds of aquatic biota.

- PCB concentrations exceed Michigan and OMOE consumption guideline levels in the edible portion of the Detroit River carp. Several Detroit River fish species also exceed the GLWQA objective of 0.1 mg/kg (wet weight) total PCB in whole fish tissue.

- Concentrations of mercury in the edible portion of several species of fish (rock bass, freshwater drum and walleye) exceed both the GLWQA specific objective and the Ontario fish consumption advisory level (0.5 ppm).

- Other highly persistent, highly bioaccumulative pollutants are present in fish tissue (e.g., hexachlorobenzene, octachlorostyrene, chlordane and DDT metabolites).

- Serious impacts to waterfowl, wildlife and fish, and their habitats, have occurred in the Detroit River. Waterfowl and some tern species, and their eggs, contain high concentrations of persistent compounds (PCBs, DDT and other organochlorine compounds). Oral/dermal tumors and liver tumors are present in brown bullhead, walleye, white suckers and other species in the lower Detroit River.

- Native and caged Detroit River clams showed increased levels of several metals, especially lead, cadmium, PCBs, PAHs and several organochlorine pesticides. Some PAHs found in Detroit River sediments are probable human carcinogens, and are thought to be responsible for some liver, lip and dermal tumors in fish.

- Excessive concentrations of oil and grease are present in many Detroit River depositional zone sediments, and have degraded macroinvertebrate communities.

SOURCES OF POLLUTANTS

There were a total of 75 known point sources discharging 9,233 x $10^3 m^3$/day to the Detroit River basin in 1986. Nine municipal treatment plants and 20 industrial facilities in the Detroit River Study Area were sampled during 1985 and 1986.

- Detroit area WWTPs discharge a daily volume of treated wastewater equal to the combined flows of all the tributaries draining into the Detroit River. The Detroit WWTP alone discharges nearly 95 percent of that treated flow (2,900 x 10^3 m^3/d) from outfalls near the mouth of the Rouge River.

- Major industrial facilities discharging directly to the Michigan side include Great Lakes Steel Mill and Zug Island facilities, McLouth Steel and Pennwalt, while major facilities indirectly discharging to the Detroit River are dominated by Rouge Steel (formerly the Ford Motor Rouge Complex), which discharges to the Rouge River.

- On the Ontario side, major dischargers include the West Windsor WWTP (124 x 10^3 m^3/d), the Windsor Little River WWTP (52.5 x 10^3 m^3/d), Wickes Industries, Ford Canada and General Chemical.

- The Detroit WWTP is a major point source for loadings (>10%) of PCBs, hexachlorobenzene, mercury, nickel, zinc, chromium, cyanide, ammonia-nitrogen, oil and grease, total phosphorus and suspended solids to the Detroit River (Table 4). This source contributed over 67% of the PCBs measured from point sources during the study.

- Other major contributors of contaminants include: Wayne County-Wyandotte WWTP (OCS, cadmium, volatiles); Rouge Steel (iron, PAHs); Ford Canada (total phenols, lead); and General Chemical (copper, chlorides).

- Combined sewer overflows from the Detroit sewage collection system account for between 10 and 90% of total loadings of phosphorus, suspended solids, oil and grease, cadmium, chromium, copper, lead, mercury and PCBs to the Detroit River (based on pre-UGLCCS data).

- Sources on the St. Clair River likely account for the majority of the hexachlorobenzene and octachlorostyrene in the Detroit River.

- Numerous spills of chemicals, oil and raw sewage to the Detroit River or its tributaries were reported during 1986, which is presumably representative of present-day spill incidents.

- Runoff from agricultural areas, particularly from the Canadian portion of the Detroit River watershed, may be an important source of phosphorus and nitrogen (fertilizers) as well as pesticides (atrazine, alachlor, cyanazine and metolachlor). Fertilizer application rates are generally more than twice the required amount.

- There are 17 waste sites (16 U.S. and 1 Canadian) ranked as high priority with regard to potential impacts on the Detroit River. Groundwater monitoring at U.S. sites indicate that some locations may be contributing important loadings of heavy metals and organic contaminants to the river.

- In addition to shoreline waste sites, two waste disposal sites are located on islands in the Detroit River: Fighting Island (Ontario) and Point Hennepin, Grosse Ile (Michigan). Contaminant concentrations in groundwater at Fighting Island are low and the volume of leachate is small, but all the leachate and groundwater will eventually reach the Detroit River. The Point Hennepin site was an industrial waste lagoon/disposal site by BASF Wyandotte (South Works). Little is known about the type and quantity of wastes disposed here, but other waste sites operated by this corporation contain metals and volatile compounds at concentrations of concern. Also, large sinkholes exist on this peninsula which may provide a connection between the surface water and groundwater aquifers. A surface leachate sample taken on the eastern side of the peninsula in 1983 was highly toxic in the Microtox toxicity bioassay.

- There are 234 injection wells on the U.S. side of the river. Six of these are industrial liquid waste wells which discharge below any potential underground drinking water sources. Only 3 are still active, receiving wastes contaminated with chloride, ammonia, phenols, cyanide and sulfide.

RECOMMENDATIONS

Ontario and Michigan should incorporate into their respective regulatory programs, the Great Lakes Water Quality Agreement goal for the virtual elimination of all persistent toxic substances. The following recommendations are provided as steps toward that goal.

A. Industrial and Municipal Point Sources

1. Although the facility was generally in compliance with its NPDES permit, the Detroit WWTP was a major discharger of numerous compounds which impact water, sediment and biotic quality in the Detroit River. Contaminant loadings from this facility should be evaluated to ensure compliance with Michigan Water Quality Standards.

a) In general, contaminant concerntrations in the effluent of the Detroit WWTP are low; major loadings result from the large volume and rate of effluent discharged. Control of contaminants may be obtained through the Industrial Pretreatment Program (IPP). The IPP of the City of Detroit should be reviewed, and compliance of contributors of industrial waste water should be determined. The adequacy of the pretreatment requirements should be assessed to determine if parameters of concern in the Detroit River are adequately regulated. A notice of violation was issued (September 1988) to the Detroit WWTP for problems found in its IPP program. These problems were subsequently resolved by the City of Detroit.

b) The Detroit WWTP currently performs secondary treatment on a large portion of its effluent. During wet weather flow, some effluent receives only primary treatment prior to being mixed with secondary treated effluent and discharged after disinfection. Metals and organics which may be contained on suspended solids not removed in primary treatment are of concern. The City of Detroit should upgrade its treatment process to provide secondary treatment for all of its effluent discharged, based on results of the studies on plant capacity initiated in 1985.

c) The effluent limitations contained in the Detroit WWTP NPDES permit should be reexamined in light of the findings of this study to ensure compliance with Michigan Water Quality Standards. Consideration should be given to increasing the number of parameters monitored by the permit. All effluent limitations should be the lowest technically feasible. Bioassays of the effluent to determine both acute and chronic impacts to aquatic organisms should be considered for inclusion as a condition of the permit. The Detroit

WWTP NPDES permit should be reissued as soon as possible.

2. The Wayne County-Wyandotte WWTP was a major discharger of numerous compounds which impact water, sediment and biota quality in the Detroit River. Although the facility was generally in compliance with its effluent limitations, the NPDES permit monitors very few parameters found to be of concern in the Detroit River.

   In general, contaminant concentrations in the effluent of the Wayne County-Wyandotte WWTP are low; major loadings result from the large volume and rate of effluent discharged. Control of contaminants may be obtained through the Industrial Pretreatment Program (IPP). The IPP of the Wayne County-Wyandotte WWTP should be reviewed. The compliance of industrial contributors should be determined and the adequacy of the pretreatment requirements should be assessed. Pretreatment requirements should be considered for all parameters of concern in the Detroit River system which are being discharged by the industrial dischargers. Contaminant loadings from this facility should be evaluated to ensure compliance with Michigan Water Quality Standards and BAT requirements.

3. The City of Trenton WWTP exceeded its permit limitations for regulated parameters. The treatment provided by this facility should be examined and upgraded, to ensure compliance with effluent requirements.

4. Several industrial facilities were identified as major dischargers of parameters that impact media quality in the Detroit River. These facilities are presented below, and the important facility-specific issues discussed.

a) Rouge Steel was a major contributor of total iron, total copper, total lead, total zinc, and oil and grease to the Detroit River, chemicals which were present in the sediments at concentrations exceeding dredging guidelines. Rouge Steel was the major contributor of total PAHs and a source of total phenols which were found in sediments, but have no sediment dredging or quality guidelines. Rouge Steel's NPDES permit does not regulate total PAHs nor monitor iron or Copper. The discharge of these three parameters should be evaluated to ensure compliance with Michigan Water Quality Standards and BAT requirements. Rouge Steel was in compliance with its permit limitations for total lead (applicable at 3 of 11 outfalls), total zinc (applicable at 3 outfalls), total phenols (applicable at one outfall) and oil and grease (applicable at two outfalls). Considerable amounts of phenol were discharged from outfalls not monitored for phenol, and oil and grease were also discharged from nonregulated outfalls. Discharge of total phenols and oil and grease from all outfalls should be evaluated to ensure compliance with Michigan Water Quality Standards and BAT requirements.

b) Ford Canada was a major contributor of total lead, total zinc, PCBs and total phenols, chemicals which impact the Detroit River system. The stretch of river downstream of Ford Canada had the highest average sediment concentration of PCBs. Sources other than Ford Canada were suggested, but Ford Canada cannot be ruled out as a source. All sources of PCBs should be identified and eliminated. High total phenol, total lead and total zinc concentrations in sediments were also found. This facility met the Ontario Industrial Effluent Objective for lead and zinc of 1 mg/L, but exceeded the Ontario Industrial Effluent Objective of 20 μg/L for total phenols by a substantial amount during the survey (almost two orders of magnitude). Discharge of total phenols should be reduced to ensure compliance with the Ontario Industrial Effluent Objective. Discharges of PCBs should be reduced to the lowest level technologically achievable.

c) Wickes Manufacturing was a major contributor of chromium to the Detroit River, and discharged nickel, as well. High bottom and suspended sediment concentrations of chromium were found in Little River, to which Wickes Manufacturing discharges. Wickes Manufacturing did not meet the Ontario Industrial Effluent Objective for chromium during the survey. Nickel impacted Detroit River sediments in the upper (as well as lower) Detroit River. High water concentrations of nickel were also found in the Little River. Wickes Manufacturing did not achieve the effluent objective for nickel

eight times during 1985 and 1986, in addition to exceeding it during the survey. Discharges of chromium and nickel should be reduced to ensure consistent attainment of the Ontario Industrial Effluent Objective. An effluent requirement should be developed for Wickes Manufacturing at the lowest level technologically feasible.

d) McLouth Steel-Trenton was a major contributor of zinc, iron, HCB and oil and grease, chemicals which impact the Detroit River system. Of these, McLouth Steel-Trenton has an effluent limitation for oil and grease, with which it was in compliance. This facility has no effluent monitoring requirements for zinc, iron or HCB. Such effluent monitoring should be considered for McLouth Steel-Trenton.

e) General Chemical, Amherstburg was a major discharger of copper to the Detroit River. High copper sediment concentrations were found adjacent to Amherstburg. Since the time of the point source survey, General Chemical has split into two distinct companies, Allied Chemical and General Chemical. The two new companies should be surveyed to determine the extent of present day copper discharge, and contingent upon the results, remedial action taken. General Chemical was also a major source of chlorides to the Detroit River; however, the lower Detroit River transect measuring water quality was upstream of General Chemical and did not reflect the facility's impact on water quality. Although no impacts due to elevated concentrations of chlorides were noted during this study, the potential for an increase in halophilic organisms exists. Additional surveys downstream of the General Chemical complex outfalls should be performed to determine if such a shift in organisms has occurred.

f) Great Lakes Steel-Ecorse and Great Lakes Steel-80" Mill both contributed large loadings of oil and grease to the Detroit River, pollutants found to be impacting sediments in the Detroit River. Both facilities have effluent limitations for oil and grease; both were in compliance with these limits in 1986. Consideration should be given to instituting more stringent effluent limitations for oil and grease at these facilities.

B. Non-point Sources

5. The extent of contaminant input to the Detroit River system resulting from Detroit combined sewer overflows is largely unknown, although some estimates have been made. Information available suggests that contaminant inputs may be substantial. The study on the Detroit CSOs, which was initiated in October 1987, should be expedited and an area-wide remediation plan should be developed. Upgrading of the Detroit sewer system by increasing treatment capacities of the facility and eventually separating storm and sanitary sewers to eliminate CSOs should be undertaken.

6. Due to the significance of the Rouge River as a source of loadings of organic and inorganic substances to the Detroit River, the Rouge River Remedial Action Plan should be developed and implemented as expeditiously as possible. The implementation of the recommendations for the Clinton and St. Clair River's RAPS will also assist remediation efforts for the Detroit River.

7. Confirmed or possible groundwater contamination sites within the Detroit River discharge area were identified for this study. Extensive recommendations were made for these sites by the Nonpoint Source Workgroup. The main focus of the Workgroup's recommendations are:

a) Zug Island Great Lakes Steel: MDNR should perform a site visit to clarify the facilities' proper RCRA status, to perform sampling of monitoring wells, to determine the contaminant release to groundwater and to provide information for rescoring of the site for the National Priorities List (NPL) using the new Hazard Ranking System (HRS).

b) Federal Marine Terminal Properties: USEPA should monitor site closure to assess closure impacts and to study groundwater discharge to surface water.

c) Industrial Landfill (Firestone): This site should be rescored for the NPL using data generated by the UGLCC Study and other current studies.

d) Michigan Consolidated Gas-Riverside Park: Remedial action proposed by the company should be reviewed to assess its adequacy in controlling groundwater discharge to surface water.

e) BASF Wyandotte South Works and Chrysler-Trenton: Prompt assessment of site waste operations should be performed by MDNR. Determination of any contaminant releases to groundwater and/or surface water should be made.

f) BASF Wyandotte North Works, Monsanto Company, Huron Valley Steel Corp and Jones Chemical: Prompt performance of a RCRA Facility Assessment should be undertaken by the USEPA, utilizing data generated by the UGLCC Study and other current studies.

g) Edward C. Levy Co, Trenton Plant and Plant #3: The USEPA should monitor the Consent Agreement and Final Order signed by the facility to ensure compliance. Data generated for the UGLCC Study should be used in the evaluation of the recently performed Resource Conservation and Reclamation Act Facility Assessment.

h) Pennwalt and Petrochemical Processing: Data generated for the UGLCC Study should be used in the evaluation of the recently performed RCRA Facility Assessment.

8. The integrity of the abandoned underground injection wells at Pennwalt and BASF Wyandotte should be evaluated through a USEPA inspection to determine if injection of spent waste into caverns under Grosse Ile has led to releases.

9. Michigan and Ontario should develop a five year strategy aimed at reducing spill occurrences and improving spill responses within their jurisdictions. Spill reports from the Michigan Pollution Emergency Alerting System (PEAS), the Ontario Spills Action Centre (SAC) and other agencies should be enhanced to provide accurate information on spill volume and composition, recovery and resolution. Facilities which experience frequent spills should be required to develop stricter spill management plans. Michigan and Ontario should prepare a yearly spill report for public release and for submission to the IJC, to stimulate interaction and follow-up, and to ensure appropriate enforcement and preventative measures.

10. Use of phosphorus and nitrogen fertilizers on agricultural lands and handling of livestock manure in both Ontario and Michigan need to be conservatively managed. Federal, state and provincial environmental and agricultural agencies need to collaborate to develop a comprehensive soil and water management system to reduce impacts on ecosystem quality for these activities. Education on the proper use and application of fertilizers should be provided to farmers, and measures, such as conservation tillage and proper livestock waste management, should be encouraged to ensure minimal loss of phosphorus, nitrogen and other associated chemicals from agricultural lands.

11. The extent of required dredging and remediation of sediments in the Detroit River and its tributaries should be planned and prioritized. To do this, estimations of the volume of sediments required to be removed should be made, and an overall plan for handling these materials should be developed. Financial requirements for such plans should be analyzed, and incorporated into future agency commitments.

C. Surveys, Research and Development

12. Tributaries to the Detroit River were found to provide major loadings of several contaminants, particularly metals and total phosphorus (not all UGLCC Study parameters were analyzed). A thorough investigation of the Rouge, Little, Canard and Ecorse Rivers, Turkey and Monguagon Creeks, and the Frank and Poet Drain, if not presently being performed, should be undertaken. An inventory of all point source dischargers to the tributaries, and an assessment of all non-point contaminant inputs (urban and rural runoff, waste sites/contaminated groundwater, spills, CSOs) should be performed. Water, sediment and biota quality in these tributaries should be determined for the full stretch of the tributary. For tributaries where extensive investigation is presently being undertaken, information provided by this study should be used to supplement ongoing work.

13. A study of the significance of atmospheric deposition of contaminants as a contaminant input mechanism should be undertaken, in conjunction with a survey and evaluation of point sources of atmospheric emissions to the Great Lakes basin.

14. Ambient water quality guidelines for total PAHs need to be developed and adopted, along with guidelines for specific PAH compounds (e.g., benzo(a)pyrene) known to be of importance. Further research on the effects of individual and total PAHs in water on a variety of aquatic species is needed for guideline development.

15. The importance of clams as a food source for wildlife and waterfowl, and the effect of clam flesh contaminants on such wildlife should be studied.

16. Consumption advisories for waterfowl and wildlife should be considered by federal, state and provincial agencies, for the protection of human consumers of these animals.

17. Contaminant concentrations in biota, which are consumed by native populations, should be determined, and the need for consumption advisories considered.

18. Studies to determine the cause/effect linkages of Detroit River contaminants to waterfowl and fish need to be performed.

19. Fish and wildlife habitats along the Detroit River should be protected to the greatest extent possible. The extent of filling or bulkheading of wetlands should be reduced. Remedial plans should be developed for those habitats which are severely impacted, and/or alternative habitats developed to accommodate displaced wildlife.

20. Sediment bioassays should be used to make site-specific determinations of sediment quality. Dischargers responsible for contaminated sediments should be required to conduct bioassays of these contaminated sediments to determine possible impacts. The need for acute and chronic bioassays on the effluent should be considered for all point source discharges to the Detroit River.

21. Development of sediment criteria for organic contaminants found in Detroit River sediments, specifically total phenols and total PAHs, is needed to assess the level of sediment contamination. The USEPA is intending to develop such criteria; such development should be expedited.

22. A study of the significance and impact of urban runoff from Michigan municipalities should be performed. The study should be performed in a manner similar to that of the Ontario study, for comparability purposes. Contingent on the results, remedial and management action may be necessary.

23. The role played by sinkholes and carbonate solution channels on Point Hennepin in the transport of contaminants from these disposal sites should be investigated.

GLOSSARY OF ACRONYMS

AOC(s)	Areas of Concern are geographic locations recognized by the International Joint Commission where water, sediment or fish quality are degraded, and the objectives of the Great Lakes Water Quality Agreement are not being achieved locally.
BAT	Best Available Technology/Treatment.
BATEA	Best Available Technology/Treatment Economically Achievable.
BOD	Biochemical Oxygen Demand: The amount of dissolved oxygen consumed during the decompositon of organic material in water.
COA	Canada-Ontario Agreement Respecting Great Lakes Water Quality.
CSO	Combined Sewer Overflow; combined storm and sanitary sewer systems.
GLWQA	Great Lakes Water Quality Agreement.
HCB	Hexachlorobenzene
IJC	International Joint Commission: A binational organization established in 1909 through which Canada and the United States cooperatively resolve water and air pollution, lake levels, power generation and other issues of mutual concern.
MDNR	Michigan Department of Natural Resources.
MISA	Municipal-Industrial Strategy for Abatement: The principal goal of this program is the virtual elimination of toxics discharged from point sources to surface waters in Ontario.
NPDES	National Pollutant Discharge Elimination System; a permit system limiting municipal and industrial discharges, administered by USEPA and the states.
OCS	Octachlorostyrene
OMNR	Ontario Ministry of Natural Resources.
OMOE	Ontario Ministry of the Environment/Environment Ontario.
PAHs	Polynuclear Aromatic Hydrocarbons; aromatic hydrocarbons composed of at least 2 fused benzene rings, many of which are potential of suspected carcinogens.
PCBs	Polychlorinated biphenyls; a class of persistent organic chemicals with a potential to bioaccumulate.
POTW	Publicly Owned Treatment Works.
RAPs	Remedial Action Plans are to be developed with citizen involvement to restore and protect water quality at each of the 42 Areas of Concern in the Great Lakes Basin.
RCRA	Resource Conservation and Reclamation Act.
SPDES	State Pollutant Discharge Elimination System; a state administered permit limiting municipal and industrial discharges.
USEPA	United States Environmental Protection Agency.
WPCP	Water Pollution Control Plant.
WTP	Water Treatment Plant (for drinking water).
WWTP	Waste Water Treatment Plant.

APPENDIX I

MANAGEMENT COMMITTEE

UNITED STATES

Mrs. Carol Finch, Co-Chair*
Great Lakes National Program Office
U.S. Environmental Protection Agency

Dr. Alfred M. Beeton**
NOAA-Great Lakes Environmental
Research Laboratory

Mr. David Cowgill
North Central Division
U.S. Army Corps of Engineers

Mr. Richard Powers***
Surface Water Division
Michigan Department of Natural Resources

Dr. Khalil Z. Atasi****
Detroit Water and Sewerage Department

Mr. Larry Sisk
Fish and Wildlife Enhancement
Region 3,
U.S. Fish and Wildlife Service

CANADA

Mr. Ron Shimizu, Co-Chair
Great Lakes Environment Office
Environment Canada

Mr. Tony Wagner
Inland Waters, Ontario Region
Environment Canada

Mr. Fred Fleischer*
Water Resources Branch
Ontario Ministry of the Environment

Mr. Douglas A. McTavish
London Regional Office
Ontario Ministry of the Environment

Mr. Ken Richards**
Inter-governmental Relations Office
Ontario Ministry of the Environment

Mr. Kim Shikaze
Environmental Protection
Ontario Region
Environment Canada

Mr. Dave Egar
National Water Research Institute
Environment Canada

George Ziegenhorn
Great Lakes National Program Office - USEPA
Technical Secretary to
the Management and Activities Integration Committees

International Joint Commission (IJC)
(Observer)
Frank J. Horvath
Michigan Department of Natural Resources

* Replaced Mr. Peter L. Wise
** Replaced Dr. Eugene J. Aubert/
Dr. Brian J. Eadie
*** Replaced Mr. William D. Marks
**** Replaced Mr. Darrell G. Suhre/
James W. Ridgeway

* Replaced Mr. Carl F. Schenk
** Replaced Mr. John Moore

ACTIVITIES INTEGRATION COMMITTEE

UNITED STATES

Mr. Vacys J. Saulys, Co-Chair
Great Lakes National Program Office
U.S. Environmental Protection Agency

Mr. Tom Edsall
Chairperson-Biota Workgroup
Great Lakes Fishery Laboratory

Dr. Thomas Fontaine
Chairperson-Modeling Workgroup
NOAA-Great Lakes Environmental
Research Laboratory

Mr. Paul Horvatin
Chairperson-Point Sources Workgroup
Great Lakes National Program Office
U.S. Environmental Protection Agency

Mr. Richard Lundgren
Michigan Representative
Michigan Department of Natural Resources

CANADA

Mr. Daryl Cowell, Co-chair*
Great Lakes Environment Office
Environment Canada

Dr. Alfred S.Y. Chau
Chairperson-Data Quality
Management Workgroup
National Water Research Institute
Environment Canada

Mr. Yousry Hamdy
Chairperson-Sediment Workgroup
Water Resources Branch
Ontario Ministry of the Environment

Mr. Wayne Wager**
Detroit/St. Clair/St. Marys Rivers Project
Ontario Ministry of the Environment

Mr. Griff Sherbin
Chairperson-Nonpoint Source Workgroup
Environmental Protection (Ontario Region)
Environment Canada

Mr. Donald J. Williams
Chairperson-Water Quality Workgroup
Inland Waters (Ontario Region)
Environment Canada

Scientific and Technical Co-ordinators

Mr. William Richardson
Large Lakes Research Station
U.S. Environmental Protection Agency

Dr. G. Keith Rodgers
National Water Research Institute
Environment Canada

* Replaced Mr. Gregory Woodsworth
** Replaced Mr. John Moore

APPENDIX II

LEVEL II WORKGROUP REPORTS

1. Water Workgroup, UGLCCS. 1988. St. Clair and Detroit Rivers. Prepared by Water Workgroup. D.J. Williams, Chair. Unpublished report, 89 pp.

2. Biota Workgroup, UGLCCS. 1988. Detroit River Biota and Their Habitats: A Geographic Area Report. Prepared by Edsall, T.A., P.B. Kauss, D. Kenaga, J. Leach, M. Munawar, T. Nalepa and S Thornley. Unpublished report, 90 pp.

3. Biota Workgroup, UGLCCS. 1988. St. Clair River Biota and Their Habitats: A Geographic Area Report. Prepared by Edsall, T.A., P.B. Kauss, D. Kenaga, J. Leach, M. Munawar, T. Nalepa and S. Thornley. Unpublished report, 90 pp.

4. Biota Workgroup, UGLCCS. 1988. Lake St. Clair Biota and Their Habitats: A Geographic Area Report. Prepared by Edsall, T.A., P.B. Kauss, D. Kenaga, J. Leach, M. Munawar, T. Nalepa, G. Sprules and S. Thornley. Unpublished report, 80 pp.

5. Biota Workgroup, UGLCCS. 1988. St. Marys River Biota and Their Habitats: A Geographic Area Report. Prepared by Edsall, T.A., P.B. Kauss, D. Kenaga, T.Kubiak, J. Leach, M. Munawar, T. Nalepa and S. Thornley. Unpublished report, 80 pp.

6. Modeling Workgroup, UGLCCS. 1988. Modeling Workgroup Geographic Area Synthesis Report. Prepared by Modeling Workgroup, T.D. Fontaine, Chair. Unpublished report, 193 pp.

7. Point Source Workgroup. UGLCCS. 1988. Geographic Area Report: Detroit River. Prepared by Point Source Workgroup, P. Horvatin, Chair. Unpublished report, 160 pp.

8. Point Source Workgroup. UGLCC. 1988. Geographic Area Report: St. Marys River. Prepared by Point Source Workgroup, P. Horvatin, Chair. Unpublished report, 65 pp.

9. Point Source Workgroup. UGLCCS. 1988. Geographic Area Report: St. Clair River. Prepared by Point Source Workgroup, P. Horvatin, Chair. Unpublished report, 125 pp.

10. Point Source Work Group. UGLCC. 1988. Georgraphic Area Report: Lake St. Clair. Prepared by Point Source Workgroup, P. Horvatin, Chair. Unpublished report, 95 pp.

11. Quality Management Workgroup. UGLCCS. 1987, revised. Report of the Quality Management Work Group. Prepared by the Quality Management Workgroup, A.S.Y. Chau, Chair. Unpublished report, 182 pp.

12. Sediments Workgroup, UGLCCS. 1987. Sediments of the Detroit River. Prepared by A.G. Kizlauskas and P.E. Pranckevicius. Unpublished report, 224 pp.

13. Sediments Workgroup, UGLCCS. 1987. Current and Historical Contamination of Sediment in the St. Marys River. Prepared by R.J. Hesselberg and Y. Hamdy. Unpublished report, 42 pp.

14. Sediments Workgroup, UGLCCS. 1987. St. Clair River Sediments. Prepared by B.G. Oliver. Unpublished report, 54 pp.

15. Sediments Workgroup, UGLCCS. 1988. Lake St. Clair Bottom Sediments. Prepared by Sediments Workgroup, Y. Hamdy, Chair. Unpublished report, 80 pp.

16 Nonpoint Source Workgroup, UGLCCS. 1987. Contaminants in Urban Runoff in the Great Lakes Connecting Channels Area. Prepared by J. Marsalek and H.Y.F. Ng. Unpublished report, 71 pp.

17. Nonpoint Source Workgroup, UGLCCS. 1987. Agricultural Sources of Pollution: Detroit River. Prepared by Wall, G.J., E.A. Pringle and T. Dickinson. Unpublished report, 11 pp.

18. Nonpoint Source Workgroup, UGLCCS. 1987. Agricultural Sources of Pollution: Lake St. Clair. Prepared by Wall, G.J., E.A. Pringle and T. Dickinson. Unpublished report, 224 pp.

19. Nonpoint Source Workgroup, UGLCCS. 1987. Agricultural Sources of Pollution: St. Clair River. Prepared by Wall, G.J., E.A. Pringle and T. Dickinson. Unpublished report, 12 pp.

20. Nonpoint Source Workgroup, UGLCCS. 1988. Waste Disposal Sites and Potential Ground Water Contamination: St. Clair River. Prepared by Nonpoint Source Workgroup, G. Sherbin, Chair. Unpublished report, 77 pp.

21. Nonpoint Source Workgroup, UGLCCS. 1988. Waste Disposal Sites and Potential Ground Water Contamination: St. Marys River. Prepared by Nonpoint Source Workgroup, G. Sherbin, Chair. Unpublished report, 39 pp.

22. Nonpoint Source Workgroup, UGLCCS. 1988. Waste Disposal Sites and Potential Ground Water Contamination: Detroit River. Prepared by Nonpoint Source Workgroup, G. Sherbin, Chair. Unpublished report, 75 pp.

23. Nonpoint Source Workgroup. UGLCCS. 1988. Waste Disposal Sites and Potential Ground Water Contamination: Lake St. Clair. Prepared by Nonpoint Source Workgroup, G. Sherbin, Chair. Unpublished report, 45 pp.

24. Quality Management Workgroup. UGLCCS. 1988. Interlaboratory performance evaluation study integrated report Part II: Trace Metals. Prepared by W.C. Li, A.S.Y. Chau and E. Kokotich, NWRI, Environment Canada, Burlington, Ont: 11 pp + Tables and Figures.

25. Quality Management Workgroup. UGLCCS. 1988. Interlaboratory performance evaluation study integrated report Part I: Organic Parameters. Prepared by W.C. Li, A.S.Y. Chau and E. Kokotich, NWRI, Environment Canada, Burlington, Ont: 19 pp + Tables and Figures.