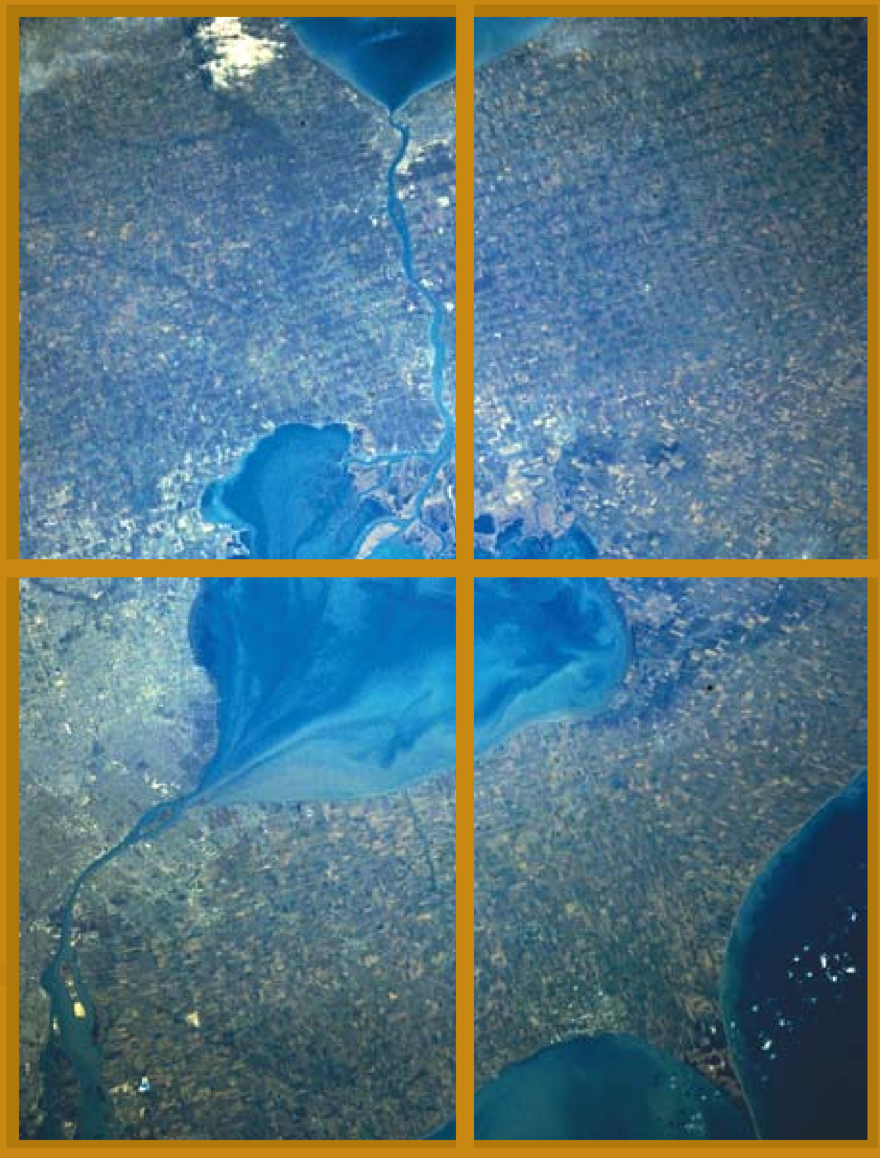
Lake St. Clair
Canadian Watershed Coordination Council

The Lake St. Clair Canadian Watershed Technical Report: An examination of current conditions



The Lake St. Clair Canadian Watershed Technical Report: An examination of current conditions was released as a draft document in January 2005, and released as a final report in January 2008, using best available information and data up to and including the year 2003.

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The Lake St. Clair Canadian Watershed Coordination Council, under the direction of the Four Agency Management Committee, prepared *The Lake St. Clair Canadian Watershed Technical Report: An examination of current conditions*.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

BACKGROUND

Binational Management of Lake St. Clair

Under the *Great Lakes Water Quality Agreement*, the Four Agency Management Committee established a framework for binational coordination of environmental issues on Lake St. Clair (U.S. Environmental Protection Agency et al. 2004).

The purpose of this management framework was to provide a platform for better coordination of Lake St. Clair issues and efforts so that decision makers may more efficiently and effectively focus their efforts and resources. This framework also enabled participants to have a greater opportunity for consistent interaction and representation of issues at all levels of government.

Five key elements form the basis of the management framework: a Binational Partnership Agreement (Four Agency Letter of Commitment), a binational Four Agency Management Committee, a Binational Working Group, separate local Canadian and U.S. Watershed Coordinating Councils, and a Biennial State of Lake St. Clair Conference.

Binational Partnership Agreement (Four Agency Letter of Commitment)

The basis for the Binational Partnership Agreement is a commitment by the Four Agency Management Committee to binational management roles and responsibilities for the shared binational Areas of Concern (St. Marys River, Detroit River and St. Clair River). The Agreement, in the form of a Four Agency Letter of Commitment, was signed in 1998.

The need for a focus on Lake St. Clair to coordinate and communicate the various on-going programs and to identify areas where work is still needed was recognized by the Four Agency Management Committee and was included under the Four Agency Letter of Commitment in 2000. Under this commitment, a framework for managing Lake St. Clair was completed, a binational monitoring committee was established, and two binational monitoring inventories (Environment Canada et al. 2000, 2002) were published.

Four Agency Management Committee

The Four Agency Management Committee is an existing structure mandated to lead efforts under the Four Agency Letter of Commitment and the *Great Lakes Water Quality Agreement* for the St. Marys, Detroit and St. Clair Rivers, and Lake St. Clair. The Four Agency Management Committee members are directors from Environment Canada, U.S. Environmental Protection Agency, Ontario Ministry of the Environment and Michigan Department of Environmental Quality.

Binational Working Group

The Binational Working Group reports to the Four Agency Management Committee and is comprised of staff from Canadian and U.S. federal and provincial/state agencies with responsibility for the resources and/or natural environment of the Lake St. Clair watershed. The Binational Working Group serves as the binational link between the Canadian and U.S. efforts and works directly in support of both regional and local efforts.

Local Canadian and U.S. Watershed Coordinating Councils

The Watershed Coordination Councils undertake the coordination of activities within their respective Canadian and U.S. watersheds that support the management of the Lake St. Clair ecosystem.

Biennial State of Lake St. Clair Conference

A binational conference, held every two years, provides the opportunity to distribute information to the public regarding activities in the Lake St. Clair watershed within the previous two years, and provides a forum for public input on activities anticipated for the next two years.

The Need for a Binational Management Plan

Lake St. Clair forms part of the international boundary water between Canada and the United States. Its management is complex with responsibilities lying with both federal governments, the Province of Ontario, the State of Michigan and local governments. The efforts of many government programs over the last 30 years have improved the health of the Lake St. Clair watershed. However, the focus of these programs has been on specific areas of pollution or habitat rather than the entire Lake St. Clair ecosystem.

In 1987, the *Great Lakes Water Quality Agreement* (*GLWQA*) was amended to direct the governments of Canada and the United States to develop Remedial Action Plans (RAPs) for designated Areas of Concern, defined as areas where localized pollution was deemed to impair the beneficial uses of the ecosystem. Within the Lake St. Clair watershed, RAPs were developed for the St. Clair River and the Clinton River. Environmental agencies recognized that efforts to correct specific pollution issues in the St. Clair and Clinton Rivers would benefit Lake St. Clair (Environment Canada et al. 1988a). Significant progress has been made in these Areas of Concern. For example, the St. Clair River RAP 2000 Progress Report (Environment Canada et al. in press) documents a continuing downward trend in contamination.

The *GLWQA* was also amended to include the requirement for Lakewide Management Plans (LaMPs) for each Great Lake. The Lake Erie LaMP recognizes the St. Clair River-Detroit River corridor (including Lake St. Clair) as an important tributary to Lake Erie (Environment Canada and U.S. Environmental Protection Agency 2000).

In 1999, the United States Congress authorized the development of a Lake St. Clair – St. Clair River Comprehensive Binational Management Plan as part of the U.S. *Water Resources Development Act*. The management plan was to be written for a general public audience. The United States Army Corps of Engineers (U.S. ACE) was designated as the lead agency and began work in 2001. While this plan is a U.S. ACE document, the need for binational participation was recognized early on in the process.

Using the Four Agency Letter of Commitment as a conduit into the Canadian agencies, the Lake St. Clair Canadian Watershed Coordination Council, led by Environment Canada, contributed summarized technical information to the U.S. ACE for inclusion in the Lake St. Clair – St. Clair River Comprehensive Binational Management Plan. However, it was decided that the Lake St. Clair Canadian Watershed Coordination Council would not contribute recommendations for the Canadian watershed until a detailed technical report for the Canadian watershed was drafted and recommendations were developed in consultation with Canadian stakeholders.

The U.S. ACE Lake St. Clair – St. Clair River Comprehensive Binational Management Plan (U.S. Army Corps of Engineers in preparation) provides a brief and strategic overview of the issues affecting the binational Lake St. Clair watershed. It is intended to be a starting point from which more detailed action plans will be developed.

The Need for a Canadian Watershed Management Plan

In 2002, Environment Canada established a technical working group, the Lake St. Clair Canadian Watershed Coordination Council, comprised of agencies with a responsibility for the environmental health of the Canadian portion of the Lake St. Clair watershed. The Lake St. Clair Canadian Watershed Coordination Council was tasked with gathering and interpreting the Canadian information to be included into the U.S. ACE Lake St. Clair – St. Clair River Comprehensive Binational Management Plan.

Quite early on the Lake St. Clair Canadian Watershed Coordination Council recognized that although U.S. actions impact the Canadian Lake St. Clair ecosystem (and vice versa), Canadians only have the ability to manage actions within the Canadian watershed. In order to determine what remedial or program actions were needed, the Lake St. Clair Canadian Watershed Coordination Council first needed to document the current state of the Canadian watershed and identify ongoing Canadian environmental programs. Only after the current state of the watershed was described could management issues be identified and recommendations developed.

The Lake St. Clair Canadian Watershed Coordination Council approach to developing recommendations required the completion of the technical report followed by stakeholder consultation process to obtain input into the development of the Canadian watershed recommendations. The consultation with stakeholders and the development of the recommendations are expected to be completed by 2006. The final product will be a Lake St. Clair Canadian Watershed Management Plan that will complement efforts in the United States portion of the Lake St. Clair watershed.

The Canadian Planning Approach for the Lake St. Clair Watershed

The approach for the Canadian watershed management plan involves three steps:

1. determine the state of the ecosystem in the Canadian portion of the Lake St. Clair watershed and identify management issues;
2. complete a comprehensive consultation of responsible government agencies, First Nations, landowners, and interested non-government organizations to solicit comments on the management issues identified and on possible management recommendations; and
3. develop a Canadian watershed management plan including an implementation plan.

The Lake St. Clair Canadian Watershed Technical Report: An examination of current conditions satisfies step one of this planning approach. It provides detailed technical information on the environmental conditions within the Lake St. Clair Canadian watershed, describes some of the environmental programs being implemented, and identifies management issues. This report is presented as Background, Basin Characteristics, Stressors on the Environment, Effects of Stressors on the Environment, and Monitoring the Environment. Management issues are presented at the end of each section.

The Lake St. Clair Canadian Watershed Technical Report contains information readily available to the Lake St. Clair Canadian Watershed Coordination Council, summarizing the best available information. It was recognized that more information existed for some topics or geographic regions than for others. *The Lake St. Clair Canadian Watershed Technical Report* does not, at this time, contain information regarding the current conditions within the significant land holdings of Walpole Island First Nation. A data sharing agreement between Environment Canada – Ontario Region and the Walpole Island Heritage Centre, on behalf of Walpole Island First Nation, will facilitate the inclusion of this information at a later date.

This approach focused on the needs of the Canadian Lake St. Clair watershed. The Lake St. Clair Canadian Watershed Coordination Council recognized that communication and partnerships with the U.S. Lake St. Clair Watershed Coordination Council will be needed to ensure that the entire Lake St. Clair ecosystem is managed cooperatively.

The Canadian Governance System for the Lake St. Clair Watershed

In Canada, a combination of federal and provincial laws and policies, together with the controls exercised by local municipal authorities, provide for the protection of water resources, public health and the environment. The division of responsibilities for water and other environmental issues is complex and responsibility is often shared.

By virtue of the *Constitution Act*, the provinces own water resources and have the authority to legislate areas of water supply and pollution control. Water on federal lands and on the reserves of Canada's aboriginal peoples falls under federal jurisdiction. The federal government has specific responsibility for fish habitat as well as for navigation, international undertakings, and native affairs. While the two levels of government cannot transfer any of their powers to each other, "administrative delegation" provides important flexibility to allow the administration of a federal or provincial act to be delegated.

Federal Government

Canada is a signatory to several treaties and agreements with the United States dealing with waters that flow along or across the common boundary. Canada has signed International Protocols and North American Regional Action Plans to address contaminants, such as persistent organic pollutants and mercury that can bioaccumulate in the aquatic environment. The federal government has a fiduciary responsibility to the First Nations within the Lake St. Clair watershed.

The Boundary Waters Treaty established the International Joint Commission (IJC) in 1909 and set the basic principle for guiding boundary water relations between Canada and the United States. Article 4 of the Treaty anticipated concern about water quality with a provision that neither party should cause pollution that would injure the health or property of the other side. Prompted by concern about waterborne disease, an investigation on water pollution began in 1912. The IJC report was submitted in 1919 but the recommendations were not acted upon. In 1946, the IJC was asked to report on increasing pollution levels in the St. Marys, Detroit, St. Clair, and Niagara Rivers and Lake St. Clair. A 1950 report recommended urgent action to set objectives for boundary water quality control and the *Great Lakes Water Quality Agreement* (*GLWQA*) grew directly out of a joint 1964 reference to pollution in lakes Erie and Ontario. The IJC is not a regulatory agency but evaluates the efforts of both governments to reduce pollution and improve the environment. The primary responsibility for the coordination and/or delivery of programs to achieve the objectives of the Agreement rests with the two principal federal environmental agencies, Environment Canada and the U.S. Environmental Protection Agency (U.S. EPA).

Environment Canada has a mandate under the *Department of the Environment Act* to preserve and enhance the natural environment, carry out the objectives of the *GLWQA* and co-ordinate federal environmental policies. The *Canada Water Act* provides for management of the water resources of Canada in co-operation with the provincial governments. In 1978, Environment Canada was assigned responsibility for Section 36(3) of the *Fisheries Act* that prohibits the deposit of a deleterious substance in water frequented by fish. Enforcement of this Section has led to several regulations such as the Petroleum Refinery Liquid Effluent Regulations that together with provincial regulations provide environmental controls for Canadian refineries located on the St. Clair River. Under the *Canadian Environmental Protection Act* (*CEPA*), Environment Canada and Health Canada share the task of managing risks associated with toxic substances and fill gaps for environmental protection where there is no coverage under other federal acts. Work under the *CEPA* has resulted in the Toxic Substances List and a Toxic Substances Management Policy to severely limit or ban 12 persistent organic pollutants. The Great Lakes Binational Toxics Strategy provides a framework for actions to reduce or eliminate persistent toxic substances, especially those that bioaccumulate, from the Great Lakes basin. Environment Canada and the U.S. EPA, in consultation with other federal departments and agencies, Great Lakes states, the Province of Ontario, tribes, and First Nations, are working towards a goal of virtual elimination of a designated list of persistent toxic substances resulting from human activity. While this is the long-term objective, the current focus is on a framework that will achieve specific reduction actions over ten years, from a period that began in 1997 through 2006. Information on the strategy is available at www.binational.net. Sections of the *CEPA* outline the responsibilities of the federal Minister of the Environment to deal with both water and air pollution issues that have international impacts.

The Canadian Wildlife Service (CWS) branch of Environment Canada handles federal wildlife matters under the *Migratory Bird Convention Act* that implements the 1916 treaty between Canada and the United States. The *Canada Wildlife Act* gives the federal government the authority to acquire habitat for migratory birds such as the St. Clair National Wildlife Area that is managed by CWS.

The *Species at Risk Act* (*SARA*) received Royal Assent in December 2002 and came into force in July 2003. Under *SARA*, there is increased protection for endangered species and species at risk. Environment Canada, Fisheries and Oceans Canada (DFO), and Parks Canada will share responsibility for implementing the Act with DFO responsible for aquatic species and aquatic habitat.

Fisheries and Oceans Canada has legislative responsibility for administration and enforcement of the *Fisheries Act*. A Memorandum of Understanding between DFO and Environment Canada outlines the responsibilities of both departments for administering the *Fisheries Act*. The DFO manages the protection of fish habitat under Section 35 of the *Fisheries Act* controlling work done in or near water that could result in the harmful alteration, disruption or destruction of fish habitat. The works can range in size and complexity from the installation of a culvert for a road crossing to the development of a large mine. The DFO has developed working arrangements with many Ontario conservation authorities to undertake review of project proposals. Depending on the significance of the project, an environmental assessment under the *Canadian Environmental Assessment Act*, administered by the Canadian Environmental Assessment

Agency, may be required. The Canadian Environmental Assessment Agency and DFO conduct and co-ordinate the assessment review concurrent with the review process for the issuance of an authorization under the *Fisheries Act*.

The Canadian Coast Guard (CCG), an agency within Fisheries and Oceans Canada, is a complex multi-layered organization that deals with a collection of marine programs and services. The CCG's activities are mandated by a number of legislative acts, including *The Canada Shipping Act*. The CCG has primary responsibility for marine spills and boating safety.

Registration or licensing of ships and boats is undertaken by the Office of Ship Registration, Marine Safety, within the Department of Transport. The Department of Transport has legislative responsibility for administration and enforcement of *The Navigable Waters Protection Act*.

Health Canada, in partnership with provincial and territorial governments, provides national leadership to develop health policy, promotes disease prevention, enhances healthy living, and enforces health regulations. Health Canada works closely with other federal agencies and stakeholders to reduce health and safety risks for all Canadians and ensures that health services are available and accessible to First Nation and Inuit communities.

Agriculture is a shared responsibility of the federal and provincial governments. The federal government, under the Canadian Food Inspection Agency (CFIA) is responsible for food and beverage inspection. Agriculture and Agri-Food Canada has traditionally taken a leadership role with respect to research, national and international market and industry services, international trade, and national policy coordination. In June 2002, Agriculture and Agri-Food Canada, in cooperation with the provinces, announced a new Agricultural Policy Framework for agriculture in Canada. Four key environmental performance goals are contained in the framework. One of the goals is to minimize agricultural impacts on water, with special attention paid to the effects of nutrients, pathogens and pesticides in aquatic ecosystems. The goals will be accomplished through federal-provincial negotiations that will set environmental targets, and through federal-provincial programs that will address the on-farm use of land, nutrients, pesticides and other substances.

Ontario Provincial Government

The government of Ontario shares responsibility with the government of Canada to protect the environment and public health. The clean up and restoration of the Great Lakes has been a high priority for both governments and, in 1971, the Province signed the first Canada-Ontario Agreement (COA) Respecting the Great Lakes Basin Ecosystem. The COA helps Canada meet its goals under the *GLWQA* and has been renewed and revised several times to reflect the changing challenges within the Great Lakes. The Ontario Ministry of the Environment (OMOE) and Environment Canada are the lead agencies for the agreement. In 2002, an updated COA was signed with several annexes that address specific environmental issues in detail and set specific commitments for each government. The current annexes cover Areas of Concern, harmful pollutants, Lakewide Management Plans, and monitoring and information management. New annexes can be added at any time to address emerging issues.

The OMOE has primary responsibility for pollution control for the provincial government. The major pieces of provincial legislation are the *Ontario Water Resources Act* (*OWRA*), the *Ontario Environmental Protection Act*, the *Ontario Environmental Assessment Act*, the *Environmental Bill of Rights* and the *Pesticides Act*. The Acts provide general prohibitions or control of activities such as use of water resources, waste management, discharges to land, water and air, and the use of pesticides. Regulations made under these Acts provide more specific control of activities. Acts and regulations are created or updated as needed to deal with new or evolving environmental issues. In the mid-1990s, the Municipal-Industrial Strategy for Abatement (MISA) regulations were developed under the *Environmental Protection Act* to limit wastewater discharges from nine industrial sectors. All of the industrial discharges to the St. Clair River from the major Chemical Valley industries are covered by these regulations. To support the *GLWQA* and the COA, the Airborne Contaminant Discharge-Monitoring and Reporting Regulation 127/01 of the *Environmental Protection Act* was passed in 2001, covering 358 contaminants of domestic, transboundary and international interest. The Escherichia coli contamination of the water supply in Walkerton resulted in seven deaths in May 2000. As a result of this incident, new Drinking Water Protection Regulations (Regulation 459/00 & Regulation 505/01) were established under the *OWRA*, the *Nutrient Management Act* was enacted in July 2002, and in December 2002, the *Safe Drinking Water Act* was passed consolidating all the legislation and regulations related to drinking water.

In addition to a direct regulatory role, OMOE is actively involved in programs to increase public awareness. In co-operation with the Ontario Ministry of Natural Resources, the Sport Fish Contaminant Monitoring Program has been used for more than 25 years to produce the Guide to Eating Ontario Sport Fish.

Under the *Environmental Bill of Rights* (*EBR*), Ontario has established a method for the people of Ontario to participate in government decisions about the environment and hold the government accountable for decisions. The Environmental Commissioner of Ontario is an independent officer of the Legislative Assembly of Ontario who monitors and reports on compliance with the *EBR*. The annual report submitted to the Legislative Assembly covers a wide range of issues and evaluates the performance of the provincial ministries as prescribed under the *EBR*.

Under the *Public Health Act*, the Ontario Ministry of Health and Long-Term Care is responsible for administering Ontario's health care system and protecting public health. As part of this responsibility, the Ministry establishes Public Health Units according to guidelines established by the *Health Protection and Promotion Act*. Each health unit is governed by a board of health, which is an autonomous corporation under the *Health Protection and Promotion Act*, and is administered by the medical officer of health who reports to the local board of health. The board is largely made up of elected representatives from the local municipal councils. The Ontario Ministry of Health and Long-Term Care cost-shares the expenses with the municipalities.

The Ontario Ministry of Agriculture and Food (OMAF) is involved with research and extension activities to support the agri-food industry. A recent OMAF program, Healthy Futures, focused on improving rural water quality, enhancing the safety and quality of Ontario food, and applied research to enhance food safety and water quality. In Canada, the regulation of farm activities, as they impact on water, falls within the responsibilities of the provinces and/or municipalities. Ontario enacted the *Nutrient Management Act* in July 2002 to help reduce agricultural nutrient loadings. This Act aims to set clear, consistent standards for nutrient management on farms and protect the environment. As part of the Ontario Clean Water Strategy, the *Nutrient Management Act* provides for province-wide standards to address the effects of agricultural practices on the environment, such as the application of manure to land.

The Ontario Ministry of Natural Resources' (OMNR) vision is to achieve sustainable development of natural resources and benefit the economics of communities that depend on them. OMNR protects and conserves soil, fish, forests and wildlife resources to ensure the long-term health and availability of these natural resources. OMNR provides for sustainable use and development of Crown land and waters, protects natural and biological features of provincial significance, provides a wide range of outdoor recreational opportunities, and protects human life, natural resources and property from forest fires, floods and erosion. OMNR creates, maintains and provides access to geographic information about provincial lands, waters, natural resources and infrastructure. A number of acts and regulations govern the activities of resource users and are administered by the OMNR (e.g., *Lakes and Rivers Improvement Act*, *Public Lands Act*). The *Fish and Wildlife Conservation Act* is the main provincial law regulating fishing, hunting and trapping. Both federal and provincial laws regulate fishing in Ontario and OMNR conservation officers enforce the laws. The *Fisheries Act*, through regulations, places controls on seasons, catch limit, size limits and fishing gear. Provincial law controls, among other things, the different types of fishing licences and regulates fish huts. Most hunting in the province is controlled by provincial regulations with the exception of some activities, such as hunting migratory game birds that require federal permits in addition to the Ontario licence. Conservation officers also enforce laws enacted by the *Endangered Species Act* and the *Migratory Bird Convention Act*. The *Endangered Species Act* protects 29 species of animals and plants in Ontario and their habitat. OMNR is a partner in the Eastern Habitat Joint Venture under the North American Waterfowl Management Plan and initiated the Ontario Stewardship Program to help private landowners care for the land and enhance it for the enjoyment of future generations.

The OMNR Aylmer District has a long history of legislated responsibility to manage natural resources in southwestern Ontario. As the steward for all Crown lands and water with accountability for Crown resources on private lands, OMNR works on behalf of the people of Ontario to manage natural resources, with the mandate “ensuring Ontario’s forest, fish, and wildlife, and lands and water resources are managed in a sustainable manner to provide environmental, social, and economic benefits.”

The OMNR Lake Erie Management Unit was established in recognition of the need to manage fisheries and other aquatic natural resources in lakes St. Clair and Erie, including the lake effect zones of the tributary rivers and the connecting waters (St. Clair, Detroit, and upper Niagara Rivers). International collaborations under the auspices of the Great Lakes Fisheries Commission enable formal documents (e.g., Fish Community Goals and Objectives for Lake St. Clair and Connecting Waters (St. Clair System)) to be prepared.

The Ontario Ministry of Municipal Affairs and Housing (OMMAH) manages four major businesses: local government, land use planning, housing market and building regulation. Many of the actions and efforts of the OMMAH have direct or indirect impacts on the environment. In 1998, under the *Service Improvement Act*, most of the regulation for on-site septic systems was transferred from the *Environmental Protection Act* to the *Building Code Act*. This was done to provide a one-window approach to issuing building permits (the OMOE continued to approve large and communal systems). As part of land use planning under the *Municipal Planning Act*, OMMAH promotes sound infrastructure planning and environmental protection. In 2001, the OMMAH introduced the *Brownfields Statute Law Amendment Act* to help remove obstacles to cleaning up former industrial sites.

Municipal Government

The responsibility for the delivery of a wide range of local services rests with the municipalities. The local municipal structure varies across the province but in general, these municipal duties are divided between upper tier municipalities (county or region) and lower tier municipalities (township, village, town or city) that are part of the federation of municipalities forming a county or region. There are a number of separated towns and cities that are geographically part of a county but do not belong to the federation that makes up the county government. Where there is only one level of municipal government in an area it is called a single tier municipality. The restructuring of municipal government has been a high priority of the provincial government. Between 1996 and 2002, the number of municipalities in Ontario was reduced from 815 to 447.

Four lower tier municipalities share the Lake St. Clair shoreline. The Corporation of the Municipality of Chatham-Kent, formed by combining 23 local municipalities, reaches from the head of the Chenal Ecarte to the mouth of the Thames River at the southeastern corner of Lake St. Clair. The Town of Lakeshore (formerly Maidstone, Belle River, Rochester, Tilbury North and Tilbury West) and the Town of Tecumseh (formerly St. Clair Beach, Sandwich South and Tecumseh) are found on the south shore of the lake. The City of Windsor is located at the head of the Detroit River.

Municipal governments are responsible for many services such as planning, public health, water supply and sewage treatment that have a direct bearing on the environmental well-being of a community. The Province of Ontario has restructured local government and reduced the number of municipalities. There has been a comprehensive overhaul of Ontario's municipal legislation and a new *Municipal Act* came into effect in January 2003 giving municipalities broad authority in a number of spheres of jurisdiction and specific powers in areas where there is a potential for duplication of provincial responsibility.

As directed and empowered by the *Municipal Planning Act*, municipalities develop official plans, zoning by-laws and other controls such as storm water management plans that reduce effects to the environment of human activities and community growth..

Conservation Authorities

The Province of Ontario enacted the *Conservation Authorities Act* in 1946. This allowed municipalities to establish local conservation authorities that could provide comprehensive watershed planning and management activities. The *Conservation Authorities Act* was based on the premises that the logical way to co-ordinate conservation work was in a watershed and that the initiative must come from the local people. Created through a partnership of municipalities (at least two-thirds of the municipalities in a watershed had to agree to form a conservation authority) and governed by a municipally appointed Board of Directors, a conservation authority could deal with watershed issues across all of the municipal boundaries.

After the devastation of Hurricane Hazel in 1954, flood and erosion control was the backbone of the conservation authority program but authorities have grown to provide a framework to manage natural resources on an ecosystem and watershed basis. Conservation authorities have a broad mandate to manage natural resources with the exception of minerals and energy sources (oil, gas and coal). Business functions for conservation authorities have evolved over the past 50 years. For example, while recreation was not specified in the 1946 Act, public lands acquired by conservation authorities in connection with flood control are now an important part of the recreational land available for public use in Ontario. Similarly, public education is now regarded as an important business function of conservation authorities. They undertake many programs that provide a direct benefit to their member municipalities such as providing advice on natural hazards (flooding, erosion) and heritage (wetlands, woodlots) for land use planning matters. The administration of flood and erosion control projects, flood warnings, low water response teams, and watershed planning are some of the programs undertaken by Authorities as part of their role in local watershed management. Water quality emerged as a key management issue for conservation authorities in the late

1970s during the Pollution from Land Use Activities Reference Group studies. Many conservation authorities identified non-point source pollution control as critical to maintaining and improving local water quality.

Conservation authorities partner with many organizations and agencies to deliver practical solutions to a range of natural resource issues. Fisheries and Oceans Canada has recognized the value of improved local delivery of fish habitat protection under Section 35 of the *Fisheries Act* by signing agreements with conservation authorities to review project proposals that have the potential to impact fish habitat. The Province has asked conservation authorities to co-ordinate the establishment of a Low Water Response Teams, help to re-establish a Provincial Groundwater Monitoring Network, administer funding for landowner extension programs, such as the Healthy Futures program, and offer technical and financial assistance to improve and protect rural water quality. Conservation authorities work with the OMNR to manage watersheds to protect human life, natural resources, and property from floods and erosion. They also work with corporations and private citizens to utilize funds to undertake or support habitat improvements.

There are four watershed-based conservation authorities that deal with the tributaries of Lake St. Clair and the St. Clair River. The St. Clair Region Conservation Authority has jurisdiction over all the watersheds of streams that drain into the St. Clair River, the Sydenham River, and Lake St. Clair north of the mouth of Thames River. The Lower Thames Valley Conservation Authority has responsibility for the watersheds of all streams that drain into the Thames River from the community of Delaware to Lake St. Clair. The Upper Thames River Conservation Authority has responsibility for all the watersheds of streams that drain into the Thames River above the community of Delaware. The Essex Region Conservation Authority has jurisdiction over the watersheds of streams in Essex County draining directly into Lake St. Clair.

BASIN CHARACTERISTICS

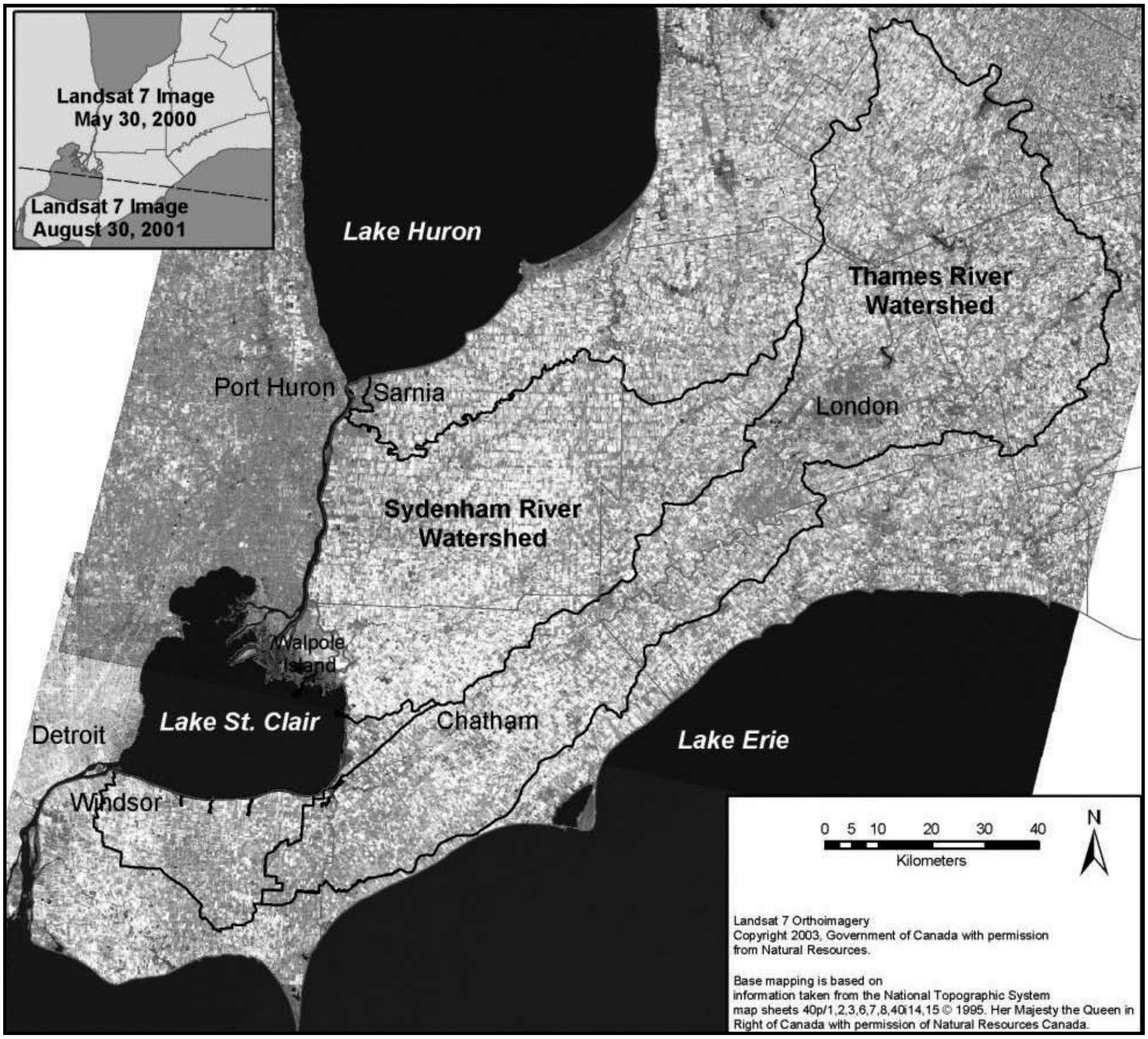


Figure 1: Satellite photo of the St. Clair River and the Lake St. Clair Canadian watershed.
(Source: Landsat 7Orthoimagery and St. Clair Region Conservation Authority)

Lake St. Clair, together with the St. Clair and Detroit Rivers, provides the connecting channel between Lake Huron and Lake Erie (Figure 1). This corridor is part of the international boundary between Canada and the United States, and serves as an integral link in the major shipping channel that connects the Great Lakes.

Beginning at Lake Huron, the St. Clair River flows approximately 64 km in a southerly direction to Lake St. Clair where it divides into several channels to travel through the delta (Figure 2). Both sides of the river have highly urbanized portions. The river is predominately a straight channel with hardened shoreline structures such as riprap and retaining walls lining much of the shoreline, narrow beaches, and vegetated cliffs.

The rapid deceleration of the flow in the St. Clair River as it enters Lake St. Clair allows the suspended sediment loads held in the river to settle out forming the St. Clair delta.

This unique delta area is predominately wetland with some dyking and land reclamation in the northern sections. It has a complex shoreline with many channels and shallow bays, contributing to one of the most significant wildlife habitats in the Great Lakes.

Lake St. Clair has an area of 1,115 km^2 (430 mi^2) with a shoreline length of 272 km (169 mi) not including the delta shoreline area. It has a mean depth of only 3.7 m (12.1 ft) with a maximum natural depth of 6.4 m (21 ft). The Detroit River is the only natural outlet from the lake. To accommodate commercial shipping, an 8.3 m (27.2 ft) navigational channel was dredged in a northeast-southwest direction from the St. Clair River to the Detroit River. Almost two-thirds of the surface area of Lake St. Clair and 77% of the drainage basin area (total area 13 500 km^2) is in Ontario (Bolsenga and Ladewski 1993; Leach 1991).

The Lake St. Clair Canadian shoreline includes the eastern and southern shorelines. The eastern shoreline of the lake is low lying and characterized by agricultural and recreational land uses with dyked and undyked wetlands providing important wildlife habitat. The southern shoreline is largely agricultural with some urban development. The Thames and Sydenham Rivers, together with several smaller tributaries, drain a large area of southwestern Ontario into the southeastern portion of the lake (Figure 1). The land drained by these tributaries is characterized as one of the most productive agricultural areas in Canada.

Water Levels

Lake St. Clair is shallow and therefore vulnerable to annual and seasonal changes in water level. Long-term historical data (1918-1999) indicated that lake levels ranged between 174.2 m (in 1934) and 175.9 m (in 1986) (MacLennan et al. in preparation). Regional trends in precipitation and ice cover are the main factors that influence annual and long-term water level cycles in Lake St. Clair (Figure 3).

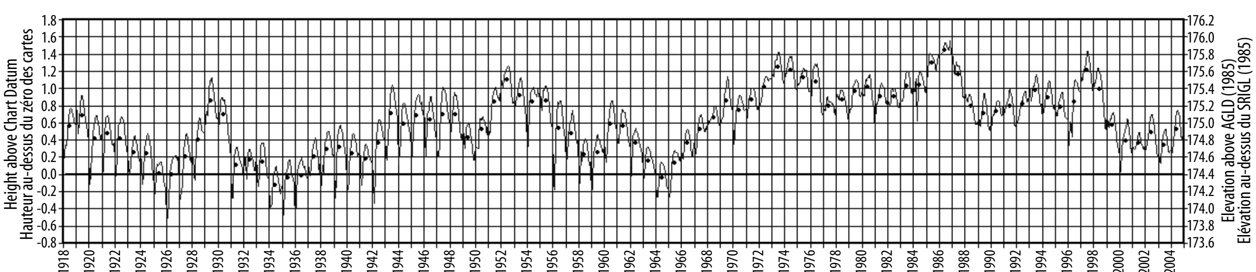


Figure 3: St. Clair River mean annual water levels, 1918-2004. (Source: Canadian Water Survey)

Fluctuating water levels are an important part of coastal wetland development and function. Large shallow areas that are naturally impacted by water level changes characterize the nearshore habitat. Variable water levels tend to result in greater overall plant diversity in coastal wetlands. Known as pulse-stable systems, these systems have plants and animals that are adapted to, and depend on, a highly changeable wetland environment.

The littoral (nearshore) habitat is characterized by large shallow areas that can be significantly impacted by water level changes. This is of particular concern for littoral zones on the eastern and northern shores that are influenced by prevailing southwest winds. If water levels were to drop below a certain threshold, wave energy can be dissipated at an offshore bar, and this may cause significant changes to the water transparency and sediment re-suspension in the littoral zone (MacLennan et al. in preparation). Increased transparency in the littoral zone creates a more extensive euphotic zone (upper layers of water where light penetrates and photosynthesis occurs) enabling

Figure 2: Satellite photo of Lake St. Clair and the St. Clair River. (Source: Landsat 7 Orthoimagery and St. Clair Region Conservation Authority)

the density and distribution of submerged aquatic vegetation to increase (MacLennan et al. in preparation). This, in turn, affects the fish, invertebrate, and waterfowl communities of the lake.

Drought conditions and mild winter temperatures in 1997 and 1998 brought about a drop in lake levels and reduced ice cover that subsequently resulted in increased winter evaporation and lower water levels in later years. Overall, from 1997-2000, the drop in Lake St. Clair water levels was approximately one third of the average depth of the lake. The future impact of climate warming on lake levels and the ecosystem of Lake St. Clair will be important.

Flow Rates

Roughly 98% of the water entering Lake St. Clair originates in the upper Great Lakes, which have a combined drainage basin of 146,600 km^2. The St. Clair River has a short retention time (approximately 21 hours) as it drains into Lake St. Clair. The annual average discharge is approximately 5,000 m^3/s. The flow is relatively consistent and fluctuates slightly with the water level in Lake Huron.

The flow from the St. Clair River into the lake is divided by the St. Clair delta into three main channels (North Channel, South Channel and Chenal Ecarte) in the upper portion of the delta and a number of secondary channels in the lower portion of the delta (Figure 2). The opening of the South Channel Cutoff in 1962, to improve commercial shipping, decreased the flow in the North Channel and the proportion of river water entering the lake through Anchor Bay. The eastern (Canadian) part of the lake receives a relatively small amount (8%) of St. Clair River inflow via the Bassett Channel and Chenal Ecarte (Environment Canada et al. 1994). The channels and the islands of the delta are shown in Figure 1.

Based on the volume of the lake and inflow from the St. Clair River, the average residence time for Lake St. Clair is about nine days. Wind direction and velocity can have significant impacts on the residence times and circulation patterns in the lake. The residence time for the water from the individual channels and the major tributaries can range from four days for the Middle Channel to more than 30 days for water from the Thames River (Schwab et al. 1989).

The watershed area for the Canadian tributaries draining into Lake St. Clair is approximately 10,000 km^2 (1,000,000 hectares). The two largest tributaries are the Thames River (582,700 ha) and the Sydenham River (272,400 ha). The Thames River discharges into the southeast corner of the lake and the Sydenham River discharges into the Chenal Ecarte. Along the eastern shore, Rankin Creek and several agricultural drains discharge from a small triangle of land located between the Thames and Sydenham Rivers. Along the south shore, the Ruscom, Belle and Puce Rivers, together with small creeks, drain approximately 66,000 ha of Essex County north to the lake (Figure 2).

Circulation Pattern

The North Channel, Middle Channel and Clinton River flow into the northwestern side of the lake and frequently form a gyre (i.e. a circulatory current) bounded by the shoreline and the navigation channel. The South and Cutoff Channels enter the lake and remain in or adjacent to, the navigation channel and flow directly into the Detroit River. Flows from the Basset Channel, Chenal Ecarte, Thames and Sydenham Rivers flow into the southeastern side of the lake and frequently form an easterly gyre.

Water quality measurements made in Lake St. Clair show distinctly different areas of the lake indicating that these water masses rarely mix. The area is dominated by a southeastern mass of relatively stable water that is enriched by nutrients from inflowing tributaries, agricultural drainage and urban development (Leach 1980, 1991). Temperature and concentrations of nutrients, major ions, and plant pigments increase from northwest to southeast in the lake (Leach 1991). The southeastern water mass is very productive and helps to define the community ecology in the Canadian waters. The northwestern water mass that drains from Lake Huron through the Lake St. Clair delta is less productive (Leach 1980).

STRESSORS ON THE ENVIRONMENT

For the purposes of this technical report, stressors on the environment are those human induced changes to the environment that have produced a corresponding detrimental effect on the ecosystem. Two key stressors, land use and commercial navigation and recreational boating, have been identified in this technical report as being detrimental or as having the potential to detrimentally affect the Lake St. Clair Canadian watershed ecosystem. A summary of each stressor and the identification of management issues are contained here.

Land Use

Land use is the single largest stressor to the Lake St. Clair ecosystem. The appropriate management of this stressor will result in the greatest improvement to the Lake St. Clair ecosystem.

The creation of impervious landscapes associated with urban, industrial and agricultural environments has altered the natural hydrologic cycle, fragmented forests and wetlands into isolated components, degraded aquatic communities and reduced the habitat of floral and faunal populations. These pressures have created the challenge of protecting and sustaining the natural environment while providing opportunities for people to thrive and prosper.

Settlement History

Prior to European settlement, the southern Ontario landscape was primarily forest with some tallgrass prairie and large areas of wetlands that included wooded swamps.

From about AD 900 to the initial European contact, the presence of Aboriginal peoples had a limited impact on the ecosystem of the Lake St. Clair watershed (Federation of Ontario Naturalists 1999). Their agricultural society involved regular 10 to 30 year cycles of clearing new locations. Farming based on corn (and later squash, beans, sunflowers and tobacco) supported large villages. Water travel made the St. Clair River, Lake St. Clair and their tributaries an important part of the pre-European settlement.

There was a drastic decrease in the Aboriginal population through disease, displacement and warfare after European contact in the 1600s. The Thames River valley was greatly de-populated after the 1650s when the Iroquois dispersed the Neutral peoples. Other First Nation groups began to re-settle along the Thames River prior to 1700. The history and cultural heritage of the four First Nations located on the Thames River are described in the *Thames River Watershed Background Study* (Upper Thames River Conservation Authority 1998). Along the St. Clair River, the Aamjiwnaung First Nation is located at Sarnia, and the St. Clair delta is home to the Walpole Island First Nation.

By the time organized land surveys were being done in the late 1700s and early 1800s, regenerated forest had erased the impacts of native agriculture. Most of southern Ontario had relatively mature forest cover and old growth forests were common.

Early European settlers recognized the potential for harvesting lumber and the ecosystem began to change as the mature forest was harvested. Access to water transport to float logs and ship timber made the larger watercourses a primary focus for the lumber industry and subsequent agricultural development. Early farmers viewed forests more as impediments to development rather than a resource. If a tree was not fit for square timber it was burned for ashes that were sold for the manufacturing of potash. Mechanization and the development of new farm equipment in the latter part of the 1800s and early 1900s hastened the process of deforestation and conversion of natural landscapes to farmland.

Over a period of 100 to 150 years, forest, swamp and prairie lands were converted into a rural agricultural landscape. The drainage of wetlands to develop agricultural land and to improve the network of roads resulted in a significant change to the ecosystem. In Ontario, the *Drainage Act* supported construction of municipal drains in the 1880s and beyond. Intricate farm and township drainage systems were developed and now link virtually every farm in the watershed. Most of the wetlands were drained for agricultural purposes. Tallgrass prairie was easily converted to farmland and very little prairie remains. By the early 1900s, most of the original woodlands had been converted to non-forest land use, primarily agriculture.

Urban settlement was part of the rural-agricultural development throughout the 1800s. Successful farming resulted in the need for grist (flour and feed) mills, distilling and brewing and early textile manufacture (wool and flax) to convert farm products into commercial goods. Within the watershed, a number of villages, towns and cities emerged. Urban development often started at strategic river crossings and at mill sites where the availability of waterpower contributed to industrial development. Small plants that began by manufacturing farm equipment were often the start of larger industrial developments that led to the employment and residential growth of a community. London, the largest Canadian city in the Lake St. Clair watershed, grew in association with several mill sites located along both the north and south branches of the Thames River.

Water transportation supported urban development and most early urban centres began as strategic trans-shipment points. The cities of Sarnia and Windsor, located at the heads the St. Clair and the Detroit Rivers respectively, were important terminals for goods and people. Lake St. Clair did not have a good harbour but Chatham, near the mouth of the Thames River, provided access for both lake and river vessels. It became an important port within the water-based transportation system. The pattern of urban development in southwestern Ontario owes much to the availability of water for transport. Rail transport and, more recently, road transport replaced the water transport system that served early settlers. The rail lines and major roads were built to connect the urban communities that had become established based on water transport and power.

A notable exception to the early agricultural-based industry was the development of the petroleum industry in Lambton County (Ford 1964). Beginning at Oil Springs and Petrolia in the 1860s, the oil industry in Ontario grew and prospered to supply a demand for fuel with the advent of the automobile and later the airplane. Water was an important component of the major refinery operations developing in Sarnia where water transport was available and there were good water supplies for industrial operations. Over the course of time, the petrochemical complex located along the St. Clair River became collectively known as Chemical Valley.

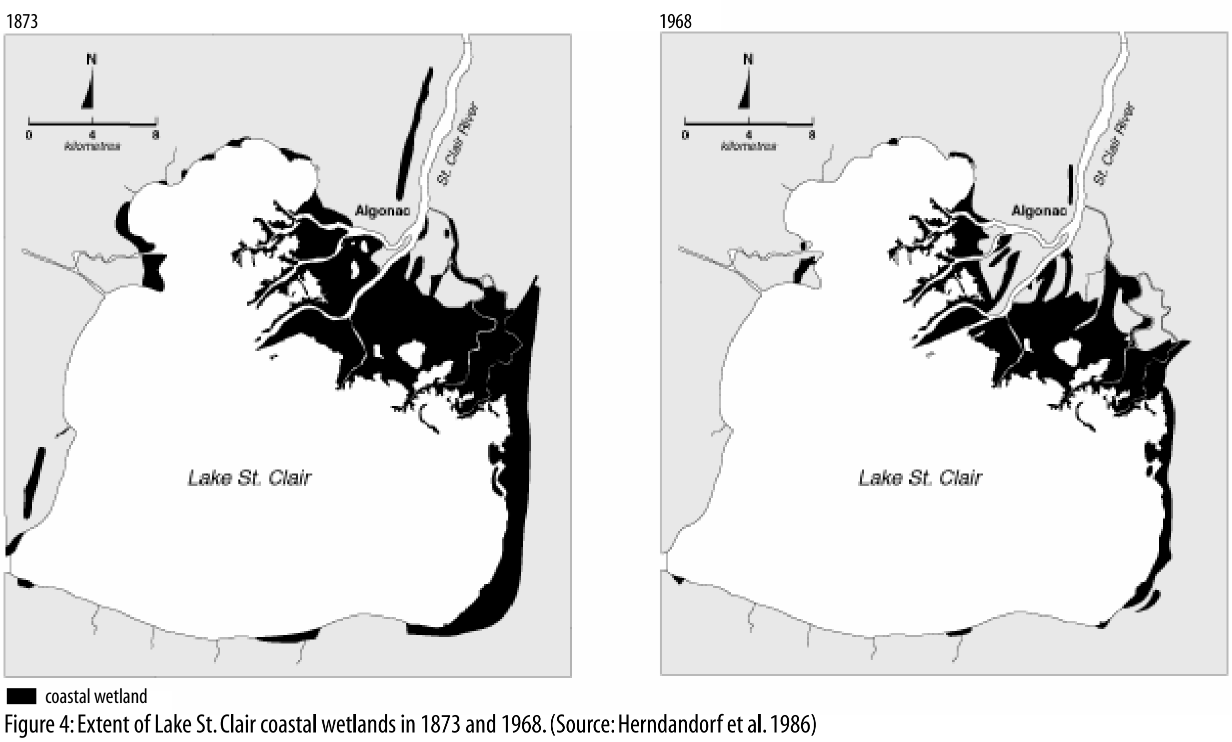
The combination of changing land use, population growth, and industrial development resulted in increasing water pollution problems into the 1960s when more stringent controls began to be applied to both municipal and industrial sources. The lack of adequate treatment for both domestic and industrial sewage resulted in bacterial contamination and other pollutants entering the local watercourses. In 1888, the case of the Queen v. City of London ruled that the "emptying of sewage into the river (Thames) had rendered the waters of it less fit for domestic use." In 1919, the International Joint Commission documented the levels of pollution along the St. Clair River - Detroit River corridor but action was not taken by the governments of the day.

Over the last 40 years, government regulations, together with voluntary efforts, have addressed the worst pollution problems, including reductions to the amount of chemical and bacterial contaminants discharged into the local watercourses.

Present Settlement

The Canadian Lake St. Clair watershed is predominately agricultural and supports approximately 750,000 residents (Statistics Canada 2001a). The U.S. Lake St. Clair watershed is highly urbanized and is home to nearly six million residents of the greater Detroit area (U.S. Army Corps of Engineers in preparation).

Development to support agricultural, residential, industrial, commercial, recreational and other human activities has had a dramatic effect on the landscape of southwestern Ontario. Figure 4 shows the change in the Lake St. Clair coastal wetlands between 1873 and 1968 as the land was drained for settlement and agriculture. Agricultural drainage to reclaim land for cropland began late in the 19th century. Dykes, canals and pumps were used to systematically drain the areas, and by the mid-1960s more than 40% of the wetlands directly associated with the lake had been destroyed. The wetlands from the mouth of the Thames River north to the Chenal Ecarte continued to dwindle and these wetlands were reduced from 3,574 ha in 1965 to 2,510 ha in 1984, as shown in Figure 5 (McCollough 1985). Draining for agriculture accounted for 89% of the wetland loss while marina or cottage development consumed the remainder. By 1982, Kent and surrounding counties had lost 80-100% of their original wetland areas. The resulting agricultural land is among the most productive and intensively farmed in Canada. Shoreline dykes, constructed by the Agricultural and Rural Development Agency, protect existing farmland and facilitate the conversion of remaining wetlands. The rate of conversion to agriculture has slowed in recent years. Decisions to convert wetlands



coastal wetland

Figure 4: Extent of Lake St. Clair coastal wetlands in 1873 and 1968. (Source: Herndandorf et al. 1986)

are often influenced by climate and economics. Today, agriculture is the dominant land use and about 75% of the land in the watershed is rural farmland. Approximately 13% of the land is urban including the rail and road transport systems. Only about 12% of the watershed remains as forest or wetland.

In recent years (1996-2001), the overall growth rate in the Lake St. Clair watershed area was approximately half the provincial average of 6.1%. Only Essex County (7%) had a growth rate that exceeded the provincial average. Lambton County (-1.6%) and the Municipality of Chatham-Kent (-1.8%) experienced a reduction in populations. Middlesex, Perth, Oxford and Elgin Counties had growth rates that ranged from 2.2% to 3.5% (Statistics Canada 2001a).

Planning for Future Growth

The population of Ontario is 11.4 million, over one-third the population of Canada (Statistics Canada 2001a), with a large part of the population in the Greater Toronto Area. Of the eight counties that are (partially) in the watershed, six are projected to have growth of fewer than 1,000 people per year while two counties are expected to grow at rates of fewer than 5,000 people per year.

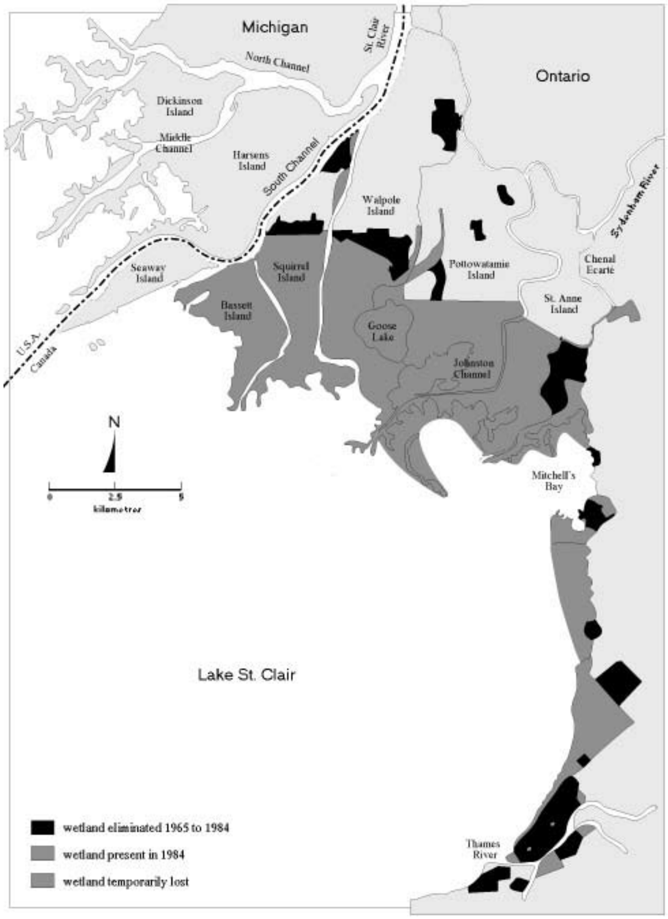


Figure 5: Wetland loss on the Ontario portion of Lake St. Clair from 1965 to 1984. Source: McCullough 1985)

Based on information obtained from the Ontario Ministry of Agriculture and Food, Figure 6 provides an overview of land uses for the municipalities in the Lake St. Clair watershed. The projected growth in population for area municipalities indicates that there will be limited urban land development demands over the next decade. Most of the land in the watershed is expected to remain as agricultural or rural.

To aid municipalities in directing where local growth and development should occur, Municipal Official Plans are key planning documents required for each municipality under the *Ontario Municipal Planning Act*. Municipal Official Plans incorporate provincial policies and recognize federal, provincial and local land use, and environmental, social and economic issues related to anticipated municipal development. They provide information regarding present land use and plans for future

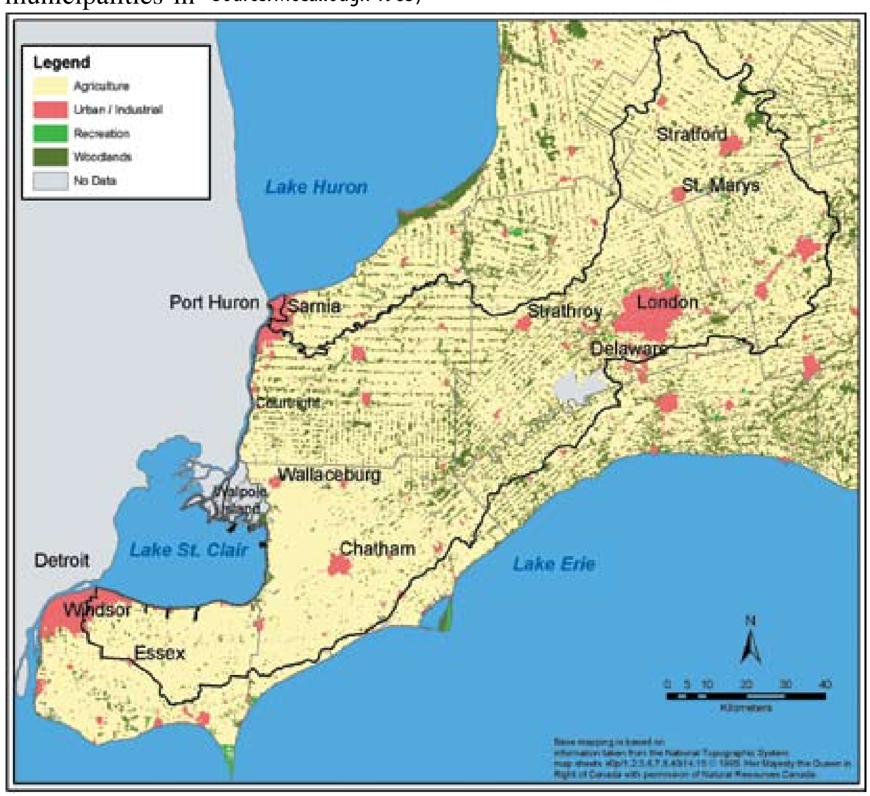


Figure 6: Land use in the Lake St. Clair Canadian watershed. (Source: St. Clair Region Conservation Authority)

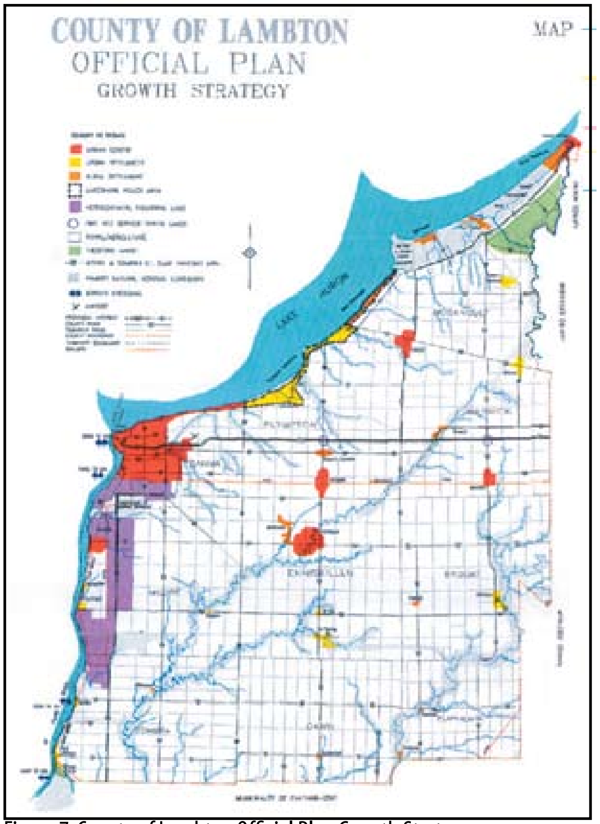


Figure 7: County of Lambton Official Plan Growth Strategy. (Source: County of Lambton)

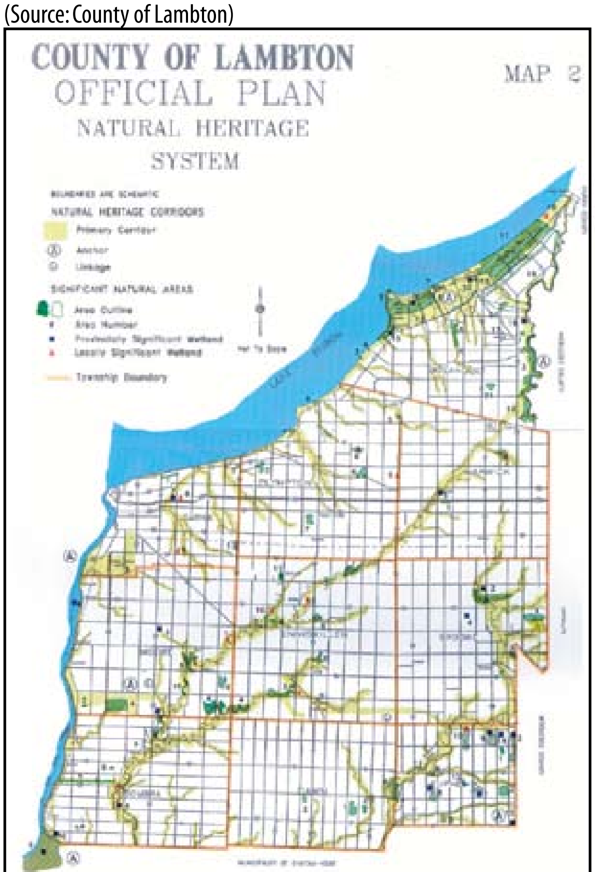


Figure 8: County of Lambton Official Plan Natural Heritage Strategy. (Source: County of Lambton)

development in the Lake St. Clair watershed. For example, the Provincial Policy Statement states that "Development and site alteration will not be permitted in: significant wetlands south and east of the Canadian Shield and significant portions of the habitat of endangered and threatened species." In the lake, the largest remaining wetland areas are in the St. Clair River delta and along the eastern shore of Lake St. Clair.

Section 3 of the *Municipal Planning Act* requires that, in exercising any authority that affects planning matters, planning authorities "shall have regard to" policy statements issued under the Act. The Provincial Policy Statement is intended to promote a policy-led system that recognizes the complex inter-relationships among environmental, economic and social factors in land use planning. The provincial policies focus on key provincial interests related to land use planning with the expectation that they will be complemented by locally generated policies regarding matters of local interest.

For example, the County of Lambton Official Plan has a growth strategy that encourages growth in urban centres and urban settlement areas where there will be development of full municipal services. The 1996 population was 128,975 (Statistics Canada 2001a) and the Official Plan projects that the County population could reach 142,000 by the year 2016 (Figure 7). The Official Plan recognizes the significance of the petrochemical industry in the County and land is designated to accommodate existing and future large-scale industrial uses. This petrochemical industrial land is located along a major highway that runs parallel to the St. Clair River and newer development is set back from the river. Rural and agricultural land uses will continue as the major land uses in Lambton County. The Lambton County Official Plan also includes a Natural Heritage System with a goal of protecting and restoring natural heritage corridors that will promote and protect the biodiversity of species found within the local ecosystem. Figure 8 provides an outline of the Natural Heritage System. The intent of the Official Plan is to direct development away from the Natural Heritage System. Similar planning efforts have been completed in Essex County and are underway in Chatham-Kent and Middlesex Counties.

Land Use Impacts on the Watershed

Development for agricultural, municipal, industrial, and recreational uses has had the most significant impact on the local ecosystem. Development has resulted in much of the natural habitat in the watershed being removed or fragmented. Impacts and threats to natural areas from development include removal or degradation of natural areas that once buffered significant habitats (e.g., wetlands), fragmentation and loss of connections between habitat areas on landscape, loss of habitat for endangered species, and decreases in biodiversity.

Agricultural and Rural Land Use

As previously discussed, agricultural and rural land use dominates the landscape (75%) of southwestern Ontario and is expected to continue to be the major land use. The agricultural landscape has changed from small parcel farms to fewer, larger, more intensive farms and there continues to be a demand to convert remaining natural areas into productive farmland.

The removal of natural or permanent vegetative cover (buffers) along tributaries, shorelines, drains and ditches threatens biodiversity. This occurs by increasing sedimentation into tributaries and wetlands, and impairing water quality by increasing nutrients and chemicals entering the system. The extensive use of tile drainage techniques for agriculture results in field run-off flowing directly into the tributaries, thus altering the hydraulic cycle and removing the benefit of the water being filtered by buffers. In addition, faulty private septic systems in many rural areas have resulted in inadequate treatment of private sewage.

Alterations to the lands and hydrologic cycle have resulted in increased runoff, erosion, and the associated discharges of contaminants, such as bacteria, nutrients, and chemicals. Impacts to the watercourses affect the quality and quantity of habitat, the quality and quantity of water, and the quality of recreational water uses. Recent dry weather years have further exacerbated the water quantity problem by increasing the demand for water to irrigate crops and this can be a concern during low water flow conditions in local watercourses.

There is a need for continued efforts to increase buffers and improve management practices along watercourses, including agricultural drains, to mitigate environmental impacts. Regulations under the *Nutrient Management Act* and the development of Nutrient Management Plans will provide significantly more filtering of agricultural run-off than is currently occurring. In addition, Agriculture and Agri-Food Canada's national Greencover Program will encourage permanent cover, buffers, and shelterbelts. Ontario's Environmental Farm Plan Program is an on-farm voluntary risk assessment and strategy to address environmental issues that has been widely adopted in southern Ontario.

Some of the drained pasturelands and poorer cropland in the areas have been reflooded and returned to wetland habitat. Hunt clubs such as Balmoral, Bradley's, St. Lukes and Snake Island, and Dover Marsh (now St. Clair National Wildlife Area) are all restored wetlands. In addition, some farmland near the lake is seasonally leased for waterfowl hunting after the corn is harvested. Recently, many of the hunt clubs have drained and farmed some of their wetlands in an effort to offset the rising costs of maintaining these lands for hunting, thus demonstrating the vulnerability of these wetlands to the economic climate.

Municipal, Recreational and Industrial Land Use

Residential and industrial land uses in the Lake St. Clair watershed comprise approximately 13% of the total land use.

Past residential growth has led to the destruction of natural habitat, increased amounts of impervious surfaces, increased volumes of stormwater runoff, and increased discharges of sediments and other contaminants (e.g., oil, salt and fertilizers). Often untreated or poorly treated human sewage from wastewater control plants or combined sanitary and storm sewer overflows was discharged into local watercourses resulting in bacterial contamination, increased oxygen demand, and elevated nutrient levels. Routine sampling and several studies completed in the 1980s by the conservation authorities found that watersheds with faulty septic systems can lead to beach closings. However, the impacts of faulty septic systems on the waters of Lake St. Clair are difficult to quantify.

Over the past 50 years, increased government regulation has resulted in improved protection of natural habitats through Municipal Official Plans, enhanced municipal sewage treatment plants, control of combined sewer discharges, the use of stormwater retention/treatment facilities and improved private sewage treatment systems. Installing new sanitary sewers and repairing individual systems have addressed some problem areas.

Recreational land uses can have both adverse and beneficial impacts. Marina and residential development in the Lake St. Clair marshes have resulted in the hardening of the shoreline and the removal of bottom sediments. Dredging and the corresponding movement of these sediments to another location (called translocation) can remove the original marsh habitat and can significantly alter the hydrology (properties, distribution and circulation of water) of the lake. The altered hydrology can permanently change the movement of sediment within the lake and can irreversibly change the location, extent, and habitat diversity of wetlands.

There are several marinas and boat launches located along the Canadian shores of Lake St. Clair and the St. Clair River. The municipal docks at Wallaceburg and Chatham have facilities to accommodate over 150 transient boats. In addition to the marinas and public docks, private facilities and docks located along the shoreline give cottage and homeowners sites to moor their boats. The impacts of recreational boating are discussed in the section on Commercial Navigation and Recreational Boating.

Public interest in using the land for recreational purposes helps support efforts to protect and restore the local environment. Recreational uses are changing as the demographics of the watershed population changes. Walkways, bike paths and associated parking lots often intrude into the riparian zone replacing vegetation and increasing stormwater runoff.

Discharges from industrial sources have had severe impacts on local watercourses in the past. Increased government regulation and voluntary actions have reduced the contaminant concentrations and loads discharged from industrial sources across the Lake St. Clair watershed. Larger industries with significant wastewater discharges have been the focus of provincial regulatory controls under the *Clean Water Act* and federal controls such as the Petroleum Refinery Liquid Effluent Regulations.

New industries and expansions of existing industries are subject to stringent government regulations and controls to prevent adverse environmental impacts. Contaminated sediments from past discharges and the brownfield sites of former industries are issues of concern. The St. Clair River Remedial Action Plan identified areas of sediment contamination that impact Lake St. Clair and that require remediation. Fish utilizing the St. Clair River-Detroit River corridor are exposed to contaminated sediments in the St. Clair and Detroit Rivers that contribute to fish consumption advisories for the lake. Additional information about this is available at a number of websites (e.g., www.ec.gc.ca).

Climate Change and Land Use

In the spring of 2003, the Union of Concerned Scientists and the Ecological Society of America released a comprehensive report that detailed what was known and predicted about climate change in the Great Lakes. This document, *Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems*, stated that human activities that release gases, such as carbon dioxide, into the atmosphere are blanketing the planet and trapping heat. As a direct result, the climate is changing and indicators of the changes include increases in average annual temperature, shorter winters, increased frequency of severe rainstorms and decreases in the amount of time lakes are covered with ice. The future impacts of climate change may be broad, affecting the ecosystem, land use and human health.

Numerous changes are expected to occur as climate change impacts current land use. There is expected to be increased pressure for water extraction and increased erosion and alteration in runoff patterns that may prevent flushing of nutrients, pesticides and other toxins. Despite some positive changes for agriculture, such as a longer growing season and warmer temperatures, declining soil moisture, thin soils and severe rainstorms might outweigh any benefits to local farms. In addition, pests and pathogens might become more difficult to control and new species are likely to expand their current ranges northward and expose livestock and crops to additional stressors. In urban areas, municipalities may be forced to upgrade water related infrastructure (e.g., sewers) to prevent property damage associated with frequent extreme rainfalls and flooding, and ensure public safety. Marinas and industries may have increased costs resulting from lower water levels, including costs for dredging, adjusting docks, extensions to water intake pipes, and alterations to other infrastructure.

Management Issues

- Detrimental impacts to water quality and quantity resulting from land use (e.g., reduced natural cover, increased imperviousness) have increased sediment, nutrient, bacterial and chemical inputs.
- Challenges exist for municipal governments to provide a balance among a healthy environment, a healthy lifestyle, and a healthy economy.
- Impacts of climate change on land use, human health and the ecosystem require ongoing research and monitoring, and adaptive and preventative management strategies.

Commercial Navigation and Recreational Boating

Commercial navigation and recreational boating have been stressors to the Lake St. Clair ecosystem (Johnson 2001; Jude and Crawford 1995; and Edsall et al. 1988) and have the potential to be a future problem in the watershed (U.S. Army Corps of Engineers 2002). Appropriate management actions are needed to ensure these stressors do not detrimentally alter the Lake St. Clair ecosystem.

Commercial and recreational vessels move throughout Lake St. Clair and have access to the other Great Lakes and beyond via the St. Lawrence Seaway. Lake St. Clair is an integral part of the St. Lawrence Seaway system because it links the upper Great Lakes with the lower Great Lakes and the Atlantic Ocean. Therefore, the importance of Lake St. Clair to commercial navigation cannot be over stated.

The navigational channel has impacted the natural environment of Lake St. Clair. Shorelines have been hardened in nearshore areas removing or reducing habitat, dredging has permanently altered habitat and flow regimes, and shipping traffic has introduced the risk of spills and ballast water being released from commercial ships.

There is a wide range of motorized and non-motorized recreational watercraft in use on Lake St. Clair and they are important to the local economy. However, the large numbers of recreational boats plying Lake St. Clair has not been without environmental impact. Boats accessing environmentally sensitive areas disturb wildlife and damage habitat, boat wakes erode shorelines, two-stroke engines release pollutants into the water, and dredging to accommodate marina access permanently alters the habitat and biodiversity of the system. These impacts can be significantly reduced when boaters use more environmentally friendly boating practices while on the water.

Commercial Navigation

The main commercial navigation season is generally from mid-March to mid-January. The St. Lawrence Seaway is usually open from the end of March to the end of December. Commercial navigation between upper Great Lakes ports continues throughout the winter months with the assistance of Canadian Coast Guard (CCG) icebreakers. Vessels over 20 m in length are required to report to the CCG Marine Traffic Center in Sarnia. In recent years, commercial traffic through Lake St. Clair has been estimated to range between 61 and 71 million tonnes (60 to 70 million tons). The CCG records indicate that there were a total of 6,262 up-bound and down-bound transit calls from ships passing through Lake St. Clair in 2000. These data apply to the total number of vessels moving through Lake St. Clair including ocean-plying vessels and lake liners that remain within the Great Lakes.

Historical shoreline hardening to protect against ship or boat wakes and flooding has resulted in restrictions to the necessary landward movement of wetland communities during high water periods. This reduces the size and diversity of wetland communities and changes the way water interacts with the shoreline, resulting in changes to coastal currents patterns, sediment transportation, and deposition within the lake.

Navigational dredging of the St. Clair River-Detroit River shipping corridor began in 1873. In the 1950s, the opening of the St. Lawrence Seaway required that the minimum channel depth be maintained throughout the seaway. The maximum natural depth of the St. Clair River is 30.5 m (100 ft) with a mean depth of 11 m (36.1 ft). Lake St. Clair has an average depth of 3.7 m (12.1 ft), a maximum natural depth of 6.4 m (21 ft), and maximum dredged shipping channel depth of 8.3 m (27.2 ft). The construction of the St. Clair Cutoff Channel created a large volume of dredged material that was deposited beside the new channel at the edge of Lake St. Clair, creating Seaway Island.

Dredging is usually associated with the removal of bottom sediments to maintain and improve shipping channels. Navigational dredging has altered the St. Clair River delta area and Lake St. Clair by replacing shoal habitat with channel habitat and by altering flow regimes. Until 1976, dredged material removed from the shipping channel was disposed of in the lake. The U.S. Army Corps of Engineers established confined disposal facilities and constructed two diked facilities on Dickinson Island adjacent to the North Channel in the St. Clair River delta. Neither site infringed upon adjacent wetlands. The Ontario Guidelines for the Protection and Management of Aquatic Sediment Quality sets safe levels for metals, nutrients and organic compounds, thereby protecting the aquatic environment. Published in 1993, these guidelines replaced the 1976 Open Water Disposal Guidelines. The Aquatic Sediment Quality guidelines are available at the Ontario Ministry of Environment website www.ene.gov.on.ca. Any dredging activities require a permit issued by the Fisheries and Oceans Canada under the *Fisheries Act*.

Shipping traffic associated with the presence of the large petrochemical industry upstream of the lake represents an ongoing risk to the ecology of the lake. There are four *Canada Shipping Act* designated oil handing facilities along the St. Clair River where petroleum products are loaded or unloaded from ships. The Response Organizations and Oil Handling Facilities Regulations govern these facilities. These regulations require that the facility have an oil pollution emergency plan, programs in place for oil spills, and an arrangement with a response organization that is certified by the CCG. The only organization that is certified by CCG for the Great Lakes is the Eastern Canada Response Corporation located in Corunna.

The Great Lakes Sewage Pollution Prevention Regulations control the treatment and discharge of human sewage on commercial vessels.

The St. Lawrence Seaway locks and channels currently can accommodate only 13% of the world's merchant fleet (and only 5% of the container fleet). The U.S. Army Corps of Engineers has completed the first phase of a Great Lakes Navigation Study (U.S. Army Corps of Engineers 2002) to address the feasibility of improving commercial navigation on the entire Great Lakes–St. Lawrence Seaway system to accommodate larger ships. Under Option 4 in the study, the locks and channels would be re-constructed to accommodate vessels drafting up to 10.7 m (35 ft) throughout the system from the Atlantic Ocean to Chicago, Illinois. The study reports that the St. Clair River, Lake St. Clair and the Detroit River would have to be deepened by 9.5 feet and concludes that the dredging and construction required to accomplish this would result in large habitat losses, increased turbulence, increased wave disturbance and added stress on remaining habitat. In addition to dredging and construction altering habitat, flow patterns might be altered through the system and that, in turn, could change the current distribution of wildlife and plants within the lake, nearshore areas and adjacent wetlands. An expansion to the current seaway system would provide significantly larger vessels with access to the Great Lakes. While not necessarily increasing the risk of environmental disasters (i.e., spills), the magnitude of disasters could change.

The majority of unintentional species introductions to the Great Lakes have been attributed to commercial ships. One of the most common methods of invasion is from the ballast (water and sediment) of commercial ships plying the Great Lakes from overseas ports. Other methods of invasion include hull fouling, intentional and accidental transfer or release of animals into the watershed, as well as the spread of invasive species from connecting waters.

A number of invasive species have arrived and spread throughout Lake St. Clair, the St. Clair River and the Detroit River. Invasive species have been found the Lake St. Clair watershed periodically for decades. Some recent invading species have had very little impact on the community ecology of the lake (e.g., tubenose goby), while others have profoundly disrupted the ecology (e.g., zebra mussels or purple loosestrife) by causing food web changes and extirpating native species from their preferred habitats (Nalepa et al. 1996).

Substantial changes occurred following the invasion of the zebra mussel. Zebra mussels arrived in ballast water and first became established in Lake St. Clair in 1988. The mussels caused wide-spread changes to the ecology of Lake St. Clair and became a costly nuisance species because of their ability to attach to metal items including the water intake pipes of power plants, factories, and municipal drinking water supply plants. Current control measures are limited and costly (e.g., chlorine flushing).

Another invading species that caused problems in the Lake St. Clair watershed is the round goby which was first observed in the St. Clair River in 1990. Believed to have been present in the Michigan waters of Lake St. Clair since the early 1990s, the round goby was found in the Ontario waters of the lake in 1993 (MacLennan et al. in preparation). Now one of the lake's most abundant fish species, round gobies are found throughout the lake inhabiting both nearshore and offshore areas. In contrast, the tubenose goby, first observed in the St. Clair River in 1990, is less abundant, has established only around the perimeter of Lake St. Clair, and is uncommon in offshore areas. Both fish species are believed to have arrived via ballast water.

At least one third of the aquatic invasive species that have entered the Great Lakes did so in the ballast water discharged by ocean-going ships. Currently, there is no known treatment technology that is both effective and practical to deal with aquatic organisms in ballast water or in ballast sediment. Researchers are continuing to investigate ballast treatment options. One of the best ways to prevent invasions is to identify routes that enable species to enter the Great Lakes and establish regulations that help to reduce invasive species dispersal.

Transport Canada is responsible for the management of ballast water on board ship. Guidelines regarding ballast water in the Great Lakes and St. Lawrence Seaway were developed in 1989 and guidelines were extended to all Canadian waters in 2000. Under these guidelines, all ships entering Canadian waters and bound for a Canadian port must have a valid ballast water management plan specific to their ship and must provide a Ballast Water Report to the appropriate Marine Communications and Traffic Centre prior to entering Canadian waters. Samples may be taken from their ballast water by government staff to verify compliance with the guidelines. Currently, this is a voluntary program for the purpose of reducing the risk of introducing harmful invasive aquatic organisms and pathogens. However, it is an offence under the *Canada Shipping Act* to refuse to provide information or to knowingly provide false information to a Marine Communications and Traffic Officer when such information is requested for the purposes of environmental protection. Flushing and refilling a ship's ballast tanks with mid-ocean saltwater while still at sea is currently the most accepted method of control, but it is not always effective.

In February 2004, the U.S. and Canadian delegations of the International Maritime Organization signed a Ballast Water Convention that will require all ships to implement ballast management plans and procedures and carry a record book. This is an important first step toward reducing the arrival and spread of invasive species.

The potential exists for invasive species to spread throughout the Great Lakes watershed when ballast is exchanged at ports along the transport corridor. In some cases, this may help to distribute a species that has no strong dispersal ability or may enable some species to reach locations more quickly than natural distribution patterns would normally permit. Even if ocean going ships do not travel the entire length of the Great Lakes–St. Lawrence Seaway, the arrival and spread of invasive species is a continuous threat to the Lake St. Clair watershed via lake liners that transport goods among local harbours.

In addition to species that arrive in the Lake St. Clair watershed in ballast water and ballast sediment, invasive species continue to be problematic as they spread throughout the Great Lakes watershed. Action is needed now, as there are several species that are present in or near the Great Lakes watershed and may be on the verge of entering the Lake St. Clair watershed. These species include the fish hook flea, the European ruffe, and the four species of Asian carp, all of which have the potential to disrupt the current aquatic community. The fish hook flea feeds on zooplankton and has the potential to compete with juvenile fish for this food resource. The fish hook flea has already caused problems for recreational anglers and boaters as well as for the commercial fishing industry in other areas of the Great Lakes. The European ruffe is an adaptable species that reproduces quickly. It may compete with native fish species for food and/or habitat but is unlikely to become a significant food item for native predators. Asian carp eat considerable amounts of plankton and/or vegetation and grow rapidly, and therefore may out-compete native species for resources. Asian carp are reported to become agitated by propeller noise causing these fish to leap out of the water, a potentially dangerous situation for recreational boaters that may be hit by these large fish.

The Asian carp have not yet established in the Great Lakes watershed and to try to prevent this from occurring, a dispersal barrier has being constructed on the Chicago Sanitary and Ship Canal. The Ontario Ministry of Natural Resources has recently prohibited the sale of live Asian carp (four species), snakehead (28 species) and goby (two species). These fish will also be banned from sale for use in aquariums and backyard ponds.

The National Alien Invasive Species Strategy is currently being developed by federal and provincial agencies and is scheduled to be completed in fall 2004. These are positive steps in the deterrence of invasive species dispersal in the Great Lakes watershed.

Invasive plants such as purple loosestrife, *Phragmites*, and eastern frogbit can dominate wetland areas and replace native vegetation leading to decreases in biodiversity. Invasive wild mute swans defend large territories, up to 6 ha, and they can attack and displace native waterfowl from breeding and feeding habitats. Mute swans uproot vegetation and consume large amounts of submergent aquatic vegetation. Expanding populations of mute swans have the potential to reduce the carrying capacity of wetlands for native species of migratory birds and waterfowl (Petrie and Francis 2003).

Recreational Boating

In Canada, all recreational vessels under 15 gross tons and powered by an engine 10 horsepower (5.5 kilowatts) or more must be licensed or registered. Licensing is done through the Canada Customs and Revenue Agency on behalf of the Canadian Coast Guard (CCG). Vessels over 15 gross tons must be registered. The Office of Ship Registration, Marine Safety, within the Department of Transport Canada handles registration. The licensing program is not computerized and information detailing local boating is not available.

There are 13 marinas located along the Canadian shores of the St. Clair River and Lake St. Clair with more than 2,300 boat slips and 10 boat launches. Most of the boat slips at the marinas are rented on a seasonal basis. The Sarnia Bay Marina has approximately 190 visitor slips and the municipal docks at Wallaceburg and Chatham have facilities to accommodate over 150 visiting boats. In addition to the marinas and public docks, private facilities and docks located along the shoreline give cottage and homeowners sites to moor their boats, jet skis, canoes, etc. By comparison, along the U.S. shoreline there are 211 marinas found in three U.S. counties and more than 200,000 boats registered in the four U.S. counties adjacent to or near Lake St. Clair (U.S. Army Corps of Engineers in preparation).

Significant alteration to the original shoreline of Lake St. Clair has occurred during the last century to the detriment of fish and wildlife populations. Altered shorelines change the sediment erosion and depositional areas of the lake, and alter wave action and current direction impacting the habitat that fish and wildlife depend upon. Marinas, boat launch facilities, and dredged channels constructed to accommodate recreational boating have contributed to near-shore alterations that are detrimental to fish and wildlife and their habitats. Fisheries and Oceans Canada (DFO) is responsible for the management and protection of fish habitat under Section 35 of the *Fisheries Act*. Approval must be obtained before making any alterations to the shoreline or undergoing any construction associated with building or modifying a dock, boathouse or boat ramp. To improve client services, DFO has agreements with local conservation authorities to review such projects.

Canadian Wildlife Service observations, along with those of local marsh managers, indicate that as fall fishing and boating pressure increased the amount of disturbance experienced by staging waterfowl has also increased. The increase in disturbance is viewed as a potentially serious problem for Ontario's premier waterfowl staging area. The small islands and wetlands within the lake and delta are particularly subject to disturbance by watercraft. The popularity of jet-propelled personal watercraft that can operate in extremely shallow water presents several potential problems as increased wave action can uproot aquatic vegetation, bottom sediments can be re-suspended leading to decreases in water quality, and increased traffic and noise can reduce waterfowl nesting success and disrupt waterfowl in traditional feeding and resting areas.

Recreational boaters have the potential to inadvertently spread invasive species within and beyond the Lake St. Clair watershed. Hull fouling is a potential dispersal mechanism for organisms that can withstand short periods of dessication (e.g., zebra mussels). Other mechanisms include water from live wells that may contain invasive species, and fouled fishing gear, boat trailers, water skis, or inner tubes. Attention is needed to appropriately clean all items when transferring between two waterbodies.

The two-stroke marine engines manufactured in the United States pre-1998 or currently manufactured in Canada, can vent between 30% and 50% of their fuel through the combustion chamber unburned and into the water, along with much of the oil that is mixed with the fuel. In two-stroke engines, the intake and exhaust cycles are combined into a single piston stroke, and a mixture of air and fuel blows the exhaust products out of the engine. Environment Canada's Environmental Technology Centre tested outboard exhaust for total hydrocarbons, nitrogen oxides, carbon monoxide, carbon dioxide, oil and grease, and BTEX (benzene, toluene, ethylbenzene, xylenes). Results showed that two-stroke engines can produce 12 times as much BTEX as four-stroke engines, and five times as much oil and grease. The two-stroke engine can also emit 15 times more unburned hydrocarbons than the four-stroke engine, and nearly 125 times more than a small van (Environment Canada 2000). Studies completed by the Sarnia-Lambton Environmental Association have shown elevated levels of toluene that are linked to high recreational boating use periods in the St. Clair River (Munro et al. 2002). In February 2001, the Canadian government announced a 10 year Clean Air Strategy that will include introducing emission standards for new spark-ignition (gas) marine engines used in personal watercraft, and jet boat applications that are predicted to result in significant reductions in hydrocarbon emissions (Environment Canada 2002).

Sewage discharges from recreational watercraft are controlled under Regulation 343 of the Ontario *Environmental Protection Act*. The law requires that no person shall discharge or deposit, cause or permit to be discharged or deposited into any water, sewage from a pleasure boat. Sewage means organic and inorganic waste, and includes fuel, lubricants, litter, paper, plastics, glass, metal, containers, bottles, crockery, rags, junk or similar refuse or garbage, and human excrement. The owner and the operator of every pleasure boat that has a toilet shall ensure that, while the boat is on water, the boat is equipped with storage equipment, and such toilet and storage equipment are installed so as to be non-portable. Regulation 351 of the Ontario *Environmental Protection Act* requires that the operator of a marina shall have a pump-out facility that is easily accessible to, and can be conveniently used by, occupants of pleasure boats that have toilets. The Ontario Ministry of Environment encourages voluntary compliance through education and outreach activities such as the Clean Marine Partnership Program. There are currently no regulations in Ontario for the disposal of grey water including bilge pump out, sink and shower waters.

Marinas are audited by an independent third party as part of the Clean Marine Partnership Program and given an Eco-rating ranging from low (1) to high (5). As of 2004, four marinas on Lake St. Clair and the St. Clair River have their Eco-ratings: Sarnia Bay Marine, Radlin's Marina and Café, Rochester Place Resort, and Deerbrook Marina. Certified marinas are listed at the Ontario Marine Operators Association's website www.omoa.com.

Management Issues

- Shoreline hardening to accommodate commercial navigation and marina development, as well as to protect exposed shorelines against wave-erosion, has resulted in significant reductions in coastal habitat and altered current and sediment deposition patterns.
- The increased seasonal boating pressures and the popularity of jet-propelled personal watercraft that can operate in very shallow waters have the potential to increase wave action, uproot aquatic vegetation, and re-suspend bottom sediments, leading to habitat degradation at the shoreline and in nearshore areas.
- Knowledge of the effects of BTEX (benzene, toluene, ethylbenzene, xylenes) emissions from two-stroke marine engines on the environment is limited.
- Efforts to restrict or prevent the arrival and spread of invasive species into the Great Lakes via hull fouling or the de-ballasting of water and sediment have been limited.
- The shipping traffic associated with the presence of the large petrochemical industry upstream of the lake represents an ongoing risk to ecology of the lake.
- The potential expansion of the seaway system may alter existing habitat by increasing habitat losses, turbulence and wave disturbance, altering flow patterns, and disrupting the distribution of wildlife and plants within the lake, nearshore or adjacent areas.

EFFECTS OF STRESSORS ON THE ENVIRONMENT

In this technical report, stressors on the environment have been identified as those human induced changes to the environment that have produced a corresponding detrimental effect on the ecosystem. Stressors affect the ecosystem in a variety of ways and the effects, or end products of theses stressors, are identified below. The effects noted here include sources and loads of pollution, impacts to human health, alterations to habitat and biodiversity, and fishing and hunting.

Sources and Loads of Pollution

Discharges from industrial, municipal and private sources to Lake St. Clair have caused serious environmental problems. The 1988 Upper Great Lakes Connecting Channels Study reports (Environment Canada et al. 1988a, b, c) documented the environmental quality of Lake St. Clair and identified some of the pollution sources. Contaminant loading from the Ontario watershed, excluding the input from the St. Clair River, was found to be predominately associated with the tributaries discharging to the lake. Other studies of water quality for the Ontario tributaries have supported these findings; for example, Lang et al. (1988) calculated a phosphorus budget for Lake St. Clair stating that 52% of the annual phosphorus load was supplied by Lake Huron, 25% from the Thames River, and less than 4% from the Clinton River, and concluded that the input of phosphorus was approximately equal to phosphorus output.

Historical contamination, found in the bottom sediments, is difficult and expensive to address. Work is underway in the St. Clair River to remove the most contaminated sediments. Efforts are also underway to eliminate the source of the contamination, thereby ensuring that sediments do not become re-contaminated.

As a result of increased government regulation and industrial awareness, the contribution of contaminants from several point sources has decreased. Point sources include wastewater pollution control plants, combined sewer overflows, industrial discharge, and contaminated sediment. Several studies of water quality in the Canadian tributaries have identified diffuse sources such as faulty septic systems, agricultural inputs and erosion as significant causes of increased bacteria, nutrients and turbidity in local watercourses. The implementation of best management practices to address non-point or diffuse sources of contaminants has achieved some reductions, but progress has been slow.

Water and Sediment Contamination

Contaminants originating from point, non-point, and atmospheric discharges originating from municipal, industrial, rural and agricultural sources of pollution accumulate in the sediments and water of Lake St. Clair. Sources can be local, regional, national or international. They can be recent and historic discharges. Contaminants can often bioaccumulate through the food chain impacting the health of fish and wildlife communities and causing advisories for human consumption. Currently there are advisories on the consumption of some fish species in Lake St. Clair due to mercury and PCB contamination. Correcting these problems is difficult and very expensive. Removing the source of the contaminant is the preferred option.

Environment Canada (EC) has been monitoring toxic chemicals in the St. Clair River-Detroit River corridor for a wide range of heavy metals and persistent organic pollutants since 1986. The project assesses changes in concentrations of contaminants in both water and suspended sediments at the head and mouth of the St. Clair River. Samples are collected from land-based stations located on the Canadian shoreline at Point Edward and Port Lambton. Declining concentrations of several organochlorine pesticides in water have been observed over the period of record, suggesting loadings from the St. Clair River to Lake St. Clair have also been reduced.

More recently, several other EC studies to assess contaminants in sediments have been initiated and include suspended sediment sampling in the St. Clair River-Detroit River corridor, bottom sediment surveys in Lake St. Clair, and bottom sediment sampling of tributaries that drain directly into the St. Clair River, Lake St. Clair and the Detroit River. Whole-water samples are being collected from upstream and downstream sites in both the St. Clair and Detroit Rivers. These samples are analyzed for toxic metals (mercury, cadmium, chromium, lead) and a wide range of organic contaminants, including PCBs, PAHs, dioxins, furans, organochlorine pesticides, PBDEs, chlorinated alkanes, chlorinated naphthalenes, and nonyl-phenol.

Mercury contamination in the aquatic environment of the corridor is a major concern. Whole-water mercury concentrations in the upper portion of the St. Clair River were below the most stringent guidelines for protection of humans and wildlife. In the lower portion of the river, concentrations were consistently above the guidelines on the Canadian side and intermittently above the guidelines on the American side. Concentrations at the outlet of Lake St. Clair were considerably higher than those found at the St. Clair River downstream sites. This indicated that other significant sources of mercury to, or from, Lake St. Clair exist. These sources are not directly detectable by the EC sampling programs.

Canadian tributary sediment samples indicated that mercury concentrations exceeded the Canadian Council of Ministers of the Environment (CCME) probable effects level in Talfourd Creek and Bowens Creek, two tributaries of the St. Clair River. Creek samples were obtained in close proximity to the St. Clair River and, therefore, a portion of the mercury found might have originated from the St. Clair River itself. No exceedences were found in sediments collected from the Canadian tributaries that drain directly into Lake St. Clair. Lake St. Clair sediment data revealed that the lowest mercury concentrations were found in the northwest and southeast portions of the lake. The central region of Lake St. Clair had relatively high mercury concentrations with two sites exceeding the CCME probable effects level.

In the St. Clair River–Detroit River corridor overall, the highest mercury concentrations were found in the lower Detroit River with concentrations increasing 12-fold, when compared to levels found at the Lake Huron outlet. Figure 9 illustrates mercury concentration in the St. Clair River-Detroit River corridor, based on 2001 and 2002 data from the above studies.

The most significant increases in whole-water concentrations were found for a wide range of organic contaminants. For instance, contaminants, such as PCBs, had 30-fold to 50-fold increases in concentration in the lower Detroit River, when compared to levels found at the Lake Huron outlet (Figure 10). Whole-water, suspended sediment, and bottom sediment concentrations in the St. Clair River and Lake St. Clair were modest in comparison to levels in the Trenton Channel (lower Detroit River). Much of the total PCB contamination found in the Trenton Channel is likely due to re-suspension of contaminants in bed sediments, and sources that discharge along the west shoreline of Lake St. Clair and the American side of the Detroit River.

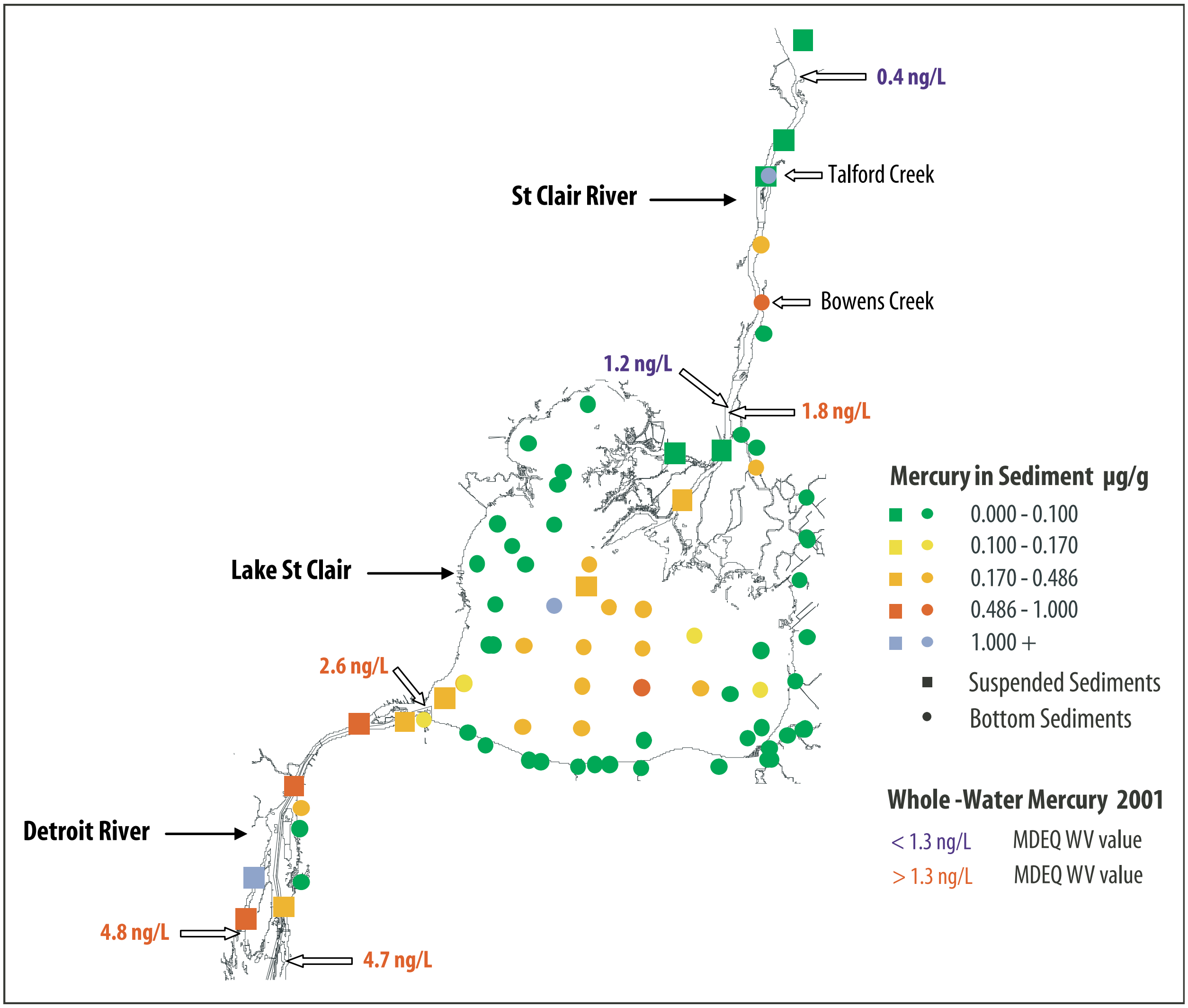


Figure 9: Mercury concentrations in sediments and water in the St. Clair River - Detroit River corridor. (Source: Environment Canada)

Lake St. Clair is well known for its sport fisheries, which are of major economic and recreational importance. Protection of this resource is of concern to resource managers and anglers alike. There are fish consumption advisories related to mercury and PCB contamination of Lake St. Clair fish. Given that the Detroit River corridor is important for the movement of fish between Lake Erie and Lake Huron, and some of the highest levels of the above contaminants are found in the lower Detroit River (water and sediments), exposure and uptake of these contaminants by migrating fish should be of concern. Monitoring programs designed to assess, manage and protect Lake St. Clair's natural resources should, therefore, be linked to contaminant monitoring and assessment programs conducted in the Detroit River. The linkage among programs is important because some management actions (such as removal of contaminated sediment) have the potential to re-introduce contaminants into the food web.

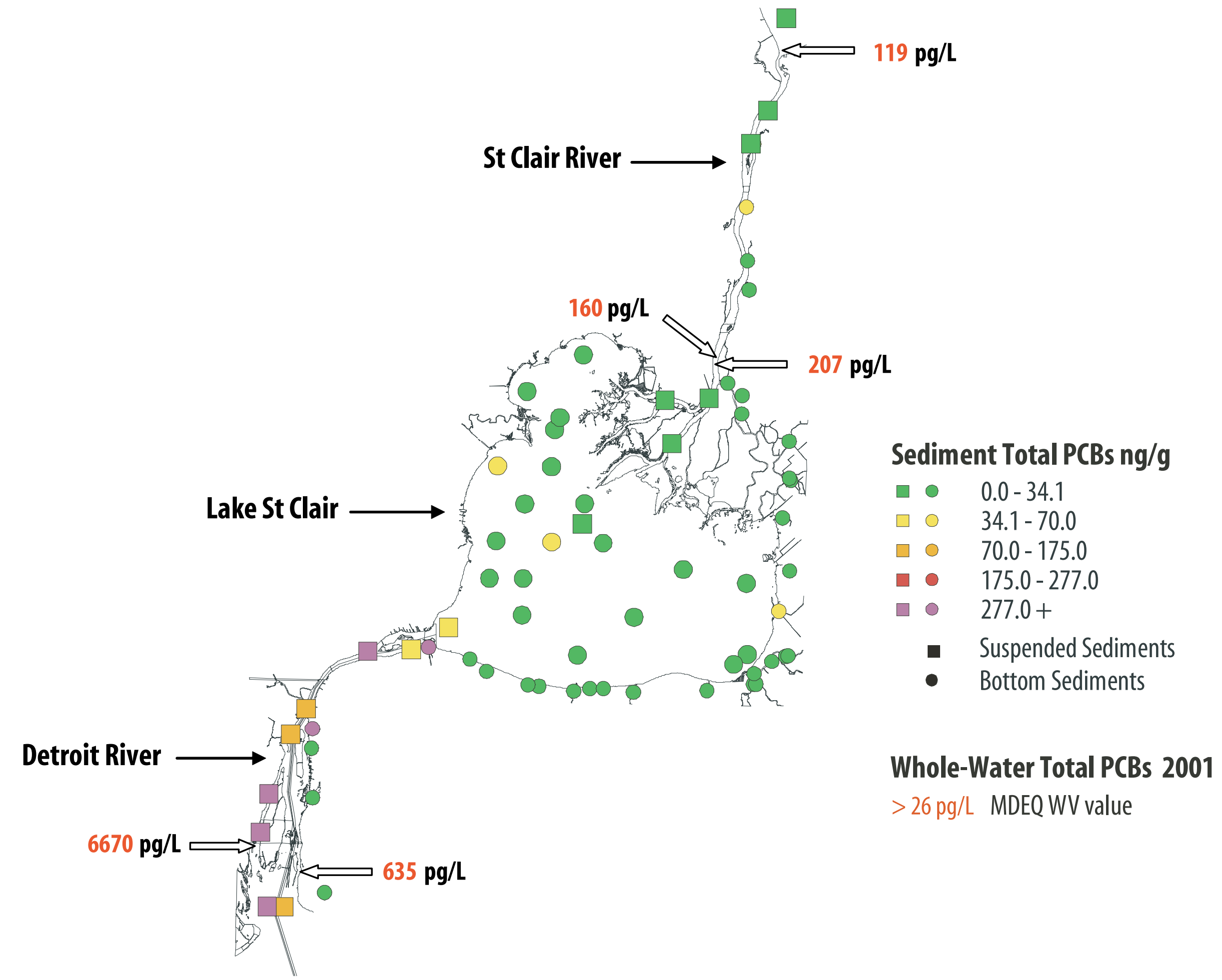


Figure 10: Total PCB concentrations in sediment and whole water samples taken from the St. Clair River - Detroit River corridor. (Source: Environment Canada)

Point Source Pollution

The Regulatory System

The Ontario Ministry of Environment (OMOE) issues Certificates of Approval (CofAs) under the *Ontario Water Resources Act* (OWRA) permitting the discharge of wastewater from industrial, municipal, commercial or private sources into a surface watercourse. The effluent quality is controlled by the conditions imposed as part of a CofA. Certain industrial sectors are also subject to control by provincial Clean Water Regulations (also known as Municipal-Industrial Strategy for Abatement Regulations) that were made under the *Ontario Environmental Protection Act*. In addition, facilities with provincial CofAs are still subject to federal requirements under Section 36(3) of the *Fisheries Act* and specific federal regulations, such as the Petroleum Refinery Liquid Effluent Regulations. In most situations, federal requirements are satisfied when compliance with the requirements imposed by the conditions in a provincial CofA or the Clean Water Regulations are met. Large septic systems and other treatment facilities with subsurface effluent disposal require approval under the provisions of the OWRA. A septic system serving an individual house is approved as part of the *Building Code Act*. More information on provincial approvals is available at the OMOE website at www.ene.gov.on.ca.

The *Ontario Environmental Assessment Act* (EAA) stipulates that projects subject to the EAA must have satisfied the EAA requirements before any CofA can be issued. The

EAA applies to projects undertaken by the provincial government, municipalities, or any of their agencies. Industrial, private and commercial sewage projects are not subject to the *EAA* unless specifically designated.

Applications for CofAs are subject to the Environmental Bill of Rights requirement for public participation in the approval process. In general, this requires that applications be placed on the Environmental Registry for a minimum of thirty days for public comment. Environmental Bill of Rights Regulation 681/94, Classification of Proposals for Instruments, classifies the types of proposals subject to the requirements of the EBR and the OMOE publication entitled Requirements of the Environmental Bill of Rights for Prescribed Instruments provides details on the applicability. Information on the EBR can be obtained at www.ene.gov.on.ca.

The OMOE website also provides information about non-compliant discharges that exceed legal allowable limits from industrial and municipal facilities that are regulated by the OMOE. Since 1999, Environmental Compliance Reports have provided a brief summary giving the name and location of the facility, the non-compliance issue, facility action, and the OMOE action. Prior to 1999, the OMOE prepared Waste Water Discharges Reports. Summaries for the 1994 to 1998 reports are posted at the website.

Municipal Wastewater Pollution Control Plants Sources

Wastewater pollution control plants (WPCPs) remove pathogens and nutrients from household and industrial sewage before discharging to the local watercourse. Potential contaminants in the discharge include suspended solids, total phosphorus, and traces of metals, organic pollutants, and pharmaceuticals.

Six municipal WPCPs in Ontario discharge directly into the St. Clair River. The St. Clair River RAP recognized a need to upgrade two (Point Edward and Sarnia) primary sewage treatment plants to secondary sewage treatment plants. The Point Edward plant was upgraded in 1992 and the Sarnia plant was upgraded in 2001. In addition to the standard effluent parameters (biochemical oxygen demand, suspended solids and phosphorus), both plants must meet requirements for total ammonia nitrogen and *Escherichia coli*. Both plants have ultra-violet light systems that eliminate the use of chlorine for disinfection of the effluent.

More than thirty municipal WPCPs are located along the tributaries entering Lake St. Clair while only two municipal WPCPs discharge directly into the lake. All of the WPCPs provide secondary or tertiary treatment of the sewage. The OMOE website provides information on municipal sewage discharges that exceed legal limits (non-compliance) or policies and guidelines (non-conformance) for sewage treatment. Provincial compliance requires that municipal WPCPs satisfy all of their discharge requirements each calendar year. Exceeding any effluent discharge requirement for a single incident during the year results in the plant being reported as non-compliant or non-conformant. The 2001 Environmental Compliance Report indicated that one municipal WPCP discharging into the St. Clair River and one municipal WPCP discharging directly into Lake St. Clair were in non-compliance. Fourteen WPCPs discharging into the tributaries were reported to be in non-compliance with their CofAs and four were in non-conformance with policy or guidelines. The report stated that all problems had been assessed by the OMOE and two plants had voluntary abatement programs underway with one plant under investigation and the other not requiring further action (Ontario Ministry of the Environment 2001).

Municipal Combined Sewer Overflows Sources

Combined sewers carry both sanitary and storm water. During storm events, if the flow is large enough, the two portions will mix causing sewage to be released into local watercourses.

The City of Sarnia constructed a storage tank in 1997 to collect the overflows from two (Devine and Wellington) of the four combined sewer overflows (CSOs) discharging into the St. Clair River. Overflows from the two combined sewers areas are contained in the tank during a storm event and re-routed to the WPCP after the storm. Sarnia has commenced a master stormwater management retrofit plan that will extend over 2003/04 and 2004/05. The plan will include consideration of treatment options for the remaining two CSOs (Cromwell and Exmouth Streets).

Industrial Sources

On the Canadian side of Lake St. Clair most industrial sources of contaminants input to the St. Clair River. Along the St. Clair River, the refining of local crude oil began in the 1860s. Several small refineries, consisting of little more than a large black iron pot and a condenser for recovering the liquids that boiled off from the crude oil, were built at Oil Springs and Petrolia. Major expansions of refineries and petrochemical facilities occurred in the 1940s, 1950s and 1970s. The resulting large industrial operations, collectively known as Chemical Valley, were historically the sources of many of the environmental problems that led to the International Joint Commission identifying the St. Clair River as an Area of Concern.

Increased government regulation and voluntary efforts throughout the 1970s and 1980s resulted in reductions in contaminant discharges. Both the St. Clair River RAP Stage 1 Report and the 1991 State of Canada's Environment (SOE) Report (Minister of the Environment 1991) acknowledged these changes. The 1991 SOE report included a number of graphs to illustrate the reductions in phenol, ammonia, suspended solids, total organic carbon and oil and grease. Figure 11 shows that in 1990 the daily discharge of total organic carbon was approximately 3% of the amount that was being discharged in 1975. The 1996 SOE report (Minister of the Environment 1996) indicated that the annual loadings of five different pollutant categories had continued to be reduced. Figure 12 shows the decline in the loadings for total suspended solids, total organic carbon, ammonia, oil and grease, and phenols over the twenty years from 1975 to 1994.

The Sarnia-Lambton Environmental Association (formerly the Lambton Industrial Society) maintains a real time water quality monitoring system approximately 5 km south of Courtright. This monitoring system provides hourly analyses of river water samples from the Canadian side of the St. Clair River. The intake for the system is located 30 m off shore at a depth of about 3 m. In operation since 1987, the equipment

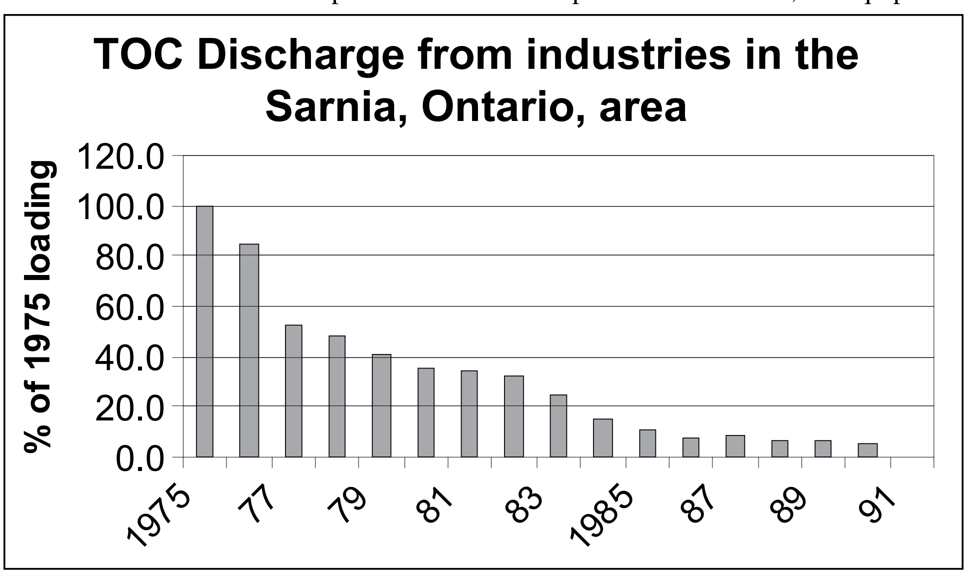


Figure 11: Total organic carbon (TOC) loadings to the St. Clair River, 1975-1990, as a percentage of 1975 loading. (1975 loading 30,887 kg/day) (Source: The State of Canada's Environment 1991)

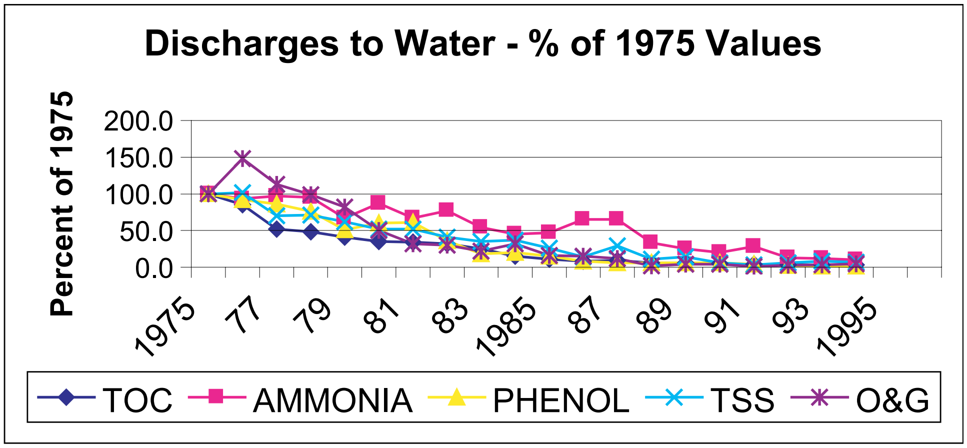


Figure 12: Annual loadings of total organic carbon (TOC), ammonia, phenol, total suspended sediments (TSS) and oil and grease (O&G) to the St. Clair River, 1975-1994, as a percentage of 1975 loadings. (Source: The State of Canada's Environment 1996)

provides detection for twenty volatile organic compounds at minimum detection limits in the range of 0.05 to 0.20 ppb. The sensitivity of the monitor means that quite small quantities can be detected if discharged from Canadian shore-based sources. Information on the chemical monitoring program is available at the Sarnia-Lambton Environmental Association website at www.sarniaenvironment.com.

Early in the 1990s Ontario established a regulatory program, the Municipal-Industrial Strategy for Abatement (MISA) to develop pollution control requirements based on Best Available Technology Economically Achievable. Across the province, larger industries were grouped into nine industrial sectors. Under MISA, specific Clean Water Regulations were developed for each sector with limits for each industry covered by the regulations. The Chemical Valley industries are controlled by Clean Water Regulations under the electric power, inorganic chemicals, organic chemicals and petroleum sectors.

The OMOE website, www.ene.gov.on.ca, provides information on industrial sewage discharges that exceed legal limits (non-compliance). Provincial compliance requires that industries satisfy all discharge requirements in the regulations and/or Certificates of Approval each calendar year. The exceedance of any effluent discharge requirement for a single incident during the year results in the plant being reported as non-compliant.

In addition to provincial regulations and Certificate of Approval requirements, the federal Petroleum Refinery Liquid Effluent Regulations apply to one of the four local refineries. The three refineries that existed prior to the federal regulations coming into force in 1973 are subject only to guidelines under the federal regulation. The Inspections and Technical Services Section of Environment Canada monitors compliance with the federal regulations under the *Fisheries Act* and the *Canadian Environmental Protection Act*. Information on enforcement is available at www.on.ec.gc.ca (under Emergencies and Enforcement). The 1996/97 Compliance Inspection Summary indicates that the overall compliance rate for the regulation was 99% for all refineries in Ontario.

There are four *Canada Shipping Act* designated oil handing facilities along the St. Clair River where petroleum products are being loaded or unloaded from ships. The Response Organizations and Oil Handling Facilities Regulations control these facilities. Generally, these regulations require that the facility have an oil pollution emergency plan, training and exercise programs for oil spills, and an arrangement with a response organization that is certified by the Canadian Coast Guard (CCG). The only organization that is certified by CCG for the Great Lakes is the Eastern Canada Response Corporation located in Corunna.

Spill Sources

Within the Canadian regulatory system, spills that originate from land-based sources are handled by the province (OMOE). The provincial *Environmental Protection Act* stipulates that spills that are likely to cause an adverse effect are to be reported to the OMOE and the municipality forthwith. The OMOE has a Spills Action Centre to receive spill reports and determine appropriate responses.

A spill dispersion model (Spillman) for the St. Clair River was developed in 1988 to assist the OMOE when dealing with the numerous spills that were occurring at that time. The model was used to predict the concentration of pollutants from spills to the river and to help assess the potential impact on downstream water users. The dispersion model predicted that the Canadian (Wallaceburg and Walpole Island) water intakes would be the most impacted by spills from Canadian shore-based discharges while American shore-based sources were most likely to affect water intakes on the American side of the river. In the early 1990s, during several spill incidents, field sampling confirmed the viability of the modelling to help evaluate the potential impact of spills from shore-based Canadian sources. Some minor changes were made to the model in 1992 to improve the accuracy.

The OMOE is in the process of enhancing its dispersion modelling capabilities by acquiring state of the art modelling packages that are capable of assessing spills under fully dynamic flow conditions and examining the impacts. The intent is to provide a greater range and flexibility of assessment for any potential spill in the future, and to help assure safe downstream water conditions during specialized activities, such as the removal of toxic sediments from the industrial portion of the St. Clair River.

Stage 1 of the St. Clair River RAP identified restrictions on drinking water consumption as one of the beneficial use impairments in the St. Clair River. The primary cause was spills from chemical industries affecting downstream water supplies. The delisting guideline for the drinking water use is “No water intake closures due to spills for two years.” There were no spill incidents that resulted in a water intake closure advisory between 1995 and 1997. The 1997 Stage 1 Update for the St. Clair River RAP stated that drinking water was no longer considered impaired. The 2000 St. Clair River RAP Progress Report (in press) states that the number of spills remained low in 1998, 1999 and 2000. No water treatment plant shutdowns were ordered by public agencies. The numbers of spills (eight or nine annually) reported for those years were fewer than half of those reported in 1996 and well below those reported between 1986 and 1989 (70 to 135 spills annually).

The 2001 OMOE Environmental Compliance Report indicated that the OMOE had to evaluate non-compliance with Clean Water Regulation requirements at seven industrial plants discharging into the St. Clair River. A Provincial Officer’s Order was issued to one plant and a Director’s Control Order was being prepared for another. The remaining plants either had voluntary abatement programs in place or did not require further action because events were isolated incidents. The 2002 Environmental Compliance Report indicates that all facilities achieved 100% compliance with their Clean Water Regulations.

Despite the significant reduction in the number of spills from Ontario point sources, five large spills occurred between December 2000 and February 2004. An incident in December 2000 at the NOVA Chemicals Corunna facility involved a large volume of aromatic hydrocarbons such as benzene. While the spill was largely contained within the plant site, some did enter to the St. Clair River. Public agencies evaluating the incident did not order a water treatment plant shutdown. The downstream Sarnia-Lambton Environmental Association river water monitoring system recorded a peak benzene concentration of 0.7 ppb. The Ontario Drinking Water Standard is 5.0 ppb (0.005 mg/L). Another incident in January 2001 involved product spilled into a field from a ruptured pipeline at the Novacor Styrene Plant in Sarnia. No material entered the river.

In August 2003, the OMOE responded to two vinyl chloride spills into the St. Clair River from Royal Polymers in Sarnia. As a precaution, downstream water users as well as local health agencies were notified of the spills. The results from water samples taken after the spills showed that vinyl chloride was not detected in the treated drinking water supplies. The OMOE investigated both the failure to notify the Spills Action Centre of the discharge and the impairment of water quality. The OMOE issued an Order to the company on August 28, 2003. In response to the order, the company implemented a number of safeguards aimed at reducing the potential for future spills to the St. Clair River.

In February 2004, the OMOE responded to a spill of methyl ethyl ketone and methyl isobutyl ketone into the St. Clair River from Imperial Oil Ltd. in Sarnia. As per established notification procedures, the downstream water users were notified along with local health agencies. The water intakes were subsequently shut down at Walpole Island and Wallaceburg. The OMOE issued an Order to the company requiring the submission of a report on the cause of the spill and the submission of a spill prevention plan to prevent a similar re-occurrence. The incident was referred to the Investigations and Enforcement Branch of the OMOE.

Sediment Sources

Remediation of highly contaminated sediment is an important step towards restoring the St. Clair-Detroit River corridor. The St. Clair River RAP program is focusing on removing contaminated sediments in the upper reaches of the St. Clair River. Dredging is being done to remove sediments along the Canadian shoreline that were contaminated by historical point source loadings. While this shoreline contamination is not in the shipping channel, the possibility of contaminated sediment being disturbed by the wake from commercial vessels and recreational boats was identified as an issue of concern in the St. Clair River RAP.

Field studies done during 1984/85 for the St. Clair River RAP documented the extent of contaminated sediment in the upper St. Clair River (Johnson and Kauss 1989; Kauss et al. 2001). These studies have shown that the highly impacted sediment zones are located in the upper St. Clair River on the Canadian side in three relatively small pockets. In July 1998, a report by Tomczak and McCorquodale concluded that based on findings from the 1984/85 studies that there were approximately 4,500 m^3 of highly contaminated sediments in the most upstream pocket that warranted remediation. These sediments were considered hazardous to benthic organisms and contained elevated concentrations of mercury, cadmium, lead, and several chlorinated compounds.

In 1996, Dow Chemical Canada Inc. completed clean up by removing approximately 200 m^3 of sediments contaminated with several chlorinated compounds. Removal took place in the St. Clair River 1 km south of the Cole Drain and 30 m offshore.

Dow Chemical Canada Inc. has implemented a St. Clair River Sediment Remediation Project that focuses on a strip of riverbed, called the Outfall Area, immediately adjacent to their Sarnia site. In 2002, a pilot project was initiated by Dow Chemical Canada Inc. to test the removal technology by removing approximately 2,000 m^3 of sediment from an area 100 m long. Intensive monitoring and engineering evaluation of the pilot project indicated that the removal technology was well suited to the unique conditions present at the St. Clair River site. Downstream monitoring during the pilot phase determined there was no adverse impact on drinking water anywhere in the river and no significant movement of sediment downstream. In total the project removed nearly 13,370 m^3 of bottom sediment. The OMOE has been monitoring the effects of the dredging in order to complement and audit the monitoring program established by Dow Chemical Canada Inc.

The St. Clair River RAP Progress Report: 2000 (Environment Canada et al. in press) provides summaries of studies of the quality of river sediment and the health of the benthic communities completed in the past few years. Additional information on the RAP is available at the Friends of the St. Clair website www.friendsofstclair.ca.

Marine Vessel Pollutant Sources

The Canadian Coast Guard (CCG) deals with spills from marine vessels or boats including mystery (unknown sources) spills in navigable waters. The Pollutant Discharge Reporting Regulations, under the *Canada Shipping Act*, require that spills from ships and designated oil handling facilities be reported. Ships are required to have a Shipboard Oil Emergency Plan (reviewed by Transport Canada). Also, tankers of 150 Gross Registered Tonnes (GRT) or greater and ships of 400 GRT or greater must have an arrangement with a certified response organization to handle a spill.

The CCG staffs a Regional Operations Centre to deal with incident reports and information is stored in a Marine Pollution Incident Reporting System. The provincial and federal centres relay information to each other and to their counter parts in the United States to avoid duplication of efforts and to co-ordinate response in international boundary waters.

The Environmental Response Branch of the CCG records show that the St. Clair River-Detroit River corridor has a high percentage of the incident reports. The frequency of calls reflects the high level of shipping and recreational usage of this waterway. They increase when the Seaway opens and peak during the summer recreational boating season. Most of the incidents involve petroleum products. The CCG records indicate that recreational boats and commercial vessels are the most significant sources. The majority (75%- 90%) of the incidents reported are not a threat to the environment and only a small percentage (approximately 2%) requires deployment of response equipment (J. Munroe. Canadian Coast Guard. Sarnia, Ontario. Personal communication).

Long-term monitoring of St. Clair River water quality by the Sarnia-Lambton Environmental Association (SLEA) has identified toluene as the contaminant most frequently observed at levels above the detection limits for the 20 volatile organic compounds being tested. Toluene is below detection (less than 0.08 ppb) about 15% of the time. When detected, the toluene concentrations, typically within the range of 0.1 – 0.5 ppb, are well below both the Ontario Provincial Water Quality Objective (0.8 ppb) and the Ontario Drinking Water Standard (24.0 ppb). No measurable health or environmental impacts would be expected at these concentrations.

Using the information from the SLEA monitoring system and the results of additional grab sampling, the estimated annual toluene load to the St. Clair River is three times the Canadian industrial contribution that is reported in the National Pollutant Release Inventory. On the Labour Day weekend, 2001, it was estimated that the contributions of toluene were 60 times greater than the daily loading being discharged from Canadian industries (Munro et al. 2002). Analysis of these results indicates that the most likely sources of toluene are pre-1998 U.S. manufactured and current Canadian manufactured two-stroke outboard motors that release toluene during the combustion process.

Non-point Sources of Pollution

The two largest sources of non-point pollution to Lake St. Clair are the Sydenham River and Thames River watersheds.

The Upper Great Lakes Connecting Channel Study (UGLCCS) (Environment Canada et al. 1988b, c) provided estimates based on water quality data from 1984 and 1985 for six Lake St. Clair tributaries (Thames, Sydenham, Puce, Belle and Ruscom Rivers in Ontario, and the Clinton River in Michigan). The UGLCCS reported that the phosphorus concentration in all six tributaries exceeded the Provincial Water Quality Objective of 30 µg/L.

The Sydenham River Recovery Plan (Jacques Whitford Environment Limited 2001) reported that the Sydenham River is a hard-water aquatic environment that is enriched

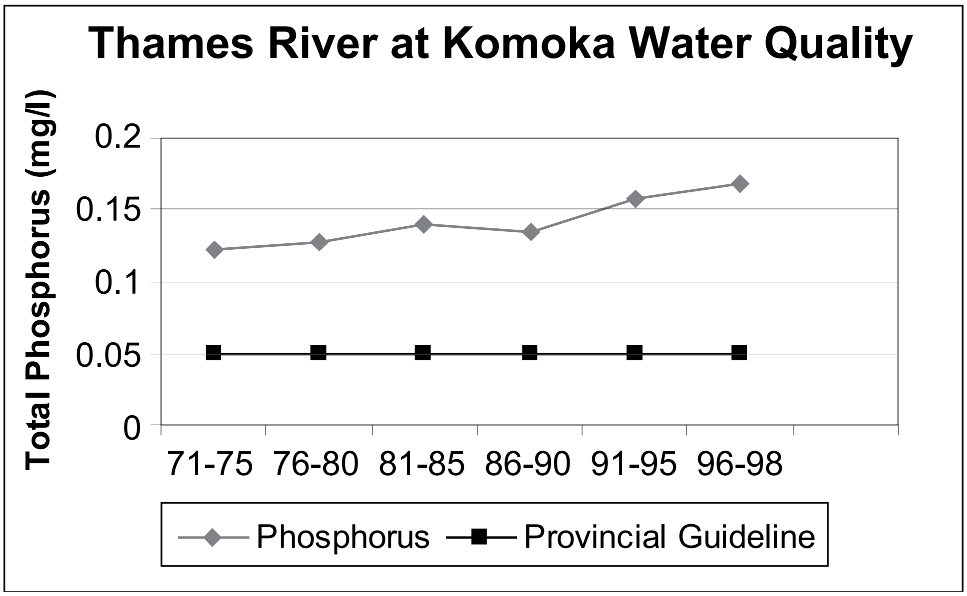


Figure 13: Total phosphorus in the Thames River, measured at Komoka, compared to the Ontario provincial water quality guidelines. (Source: Provincial Water Quality Network)

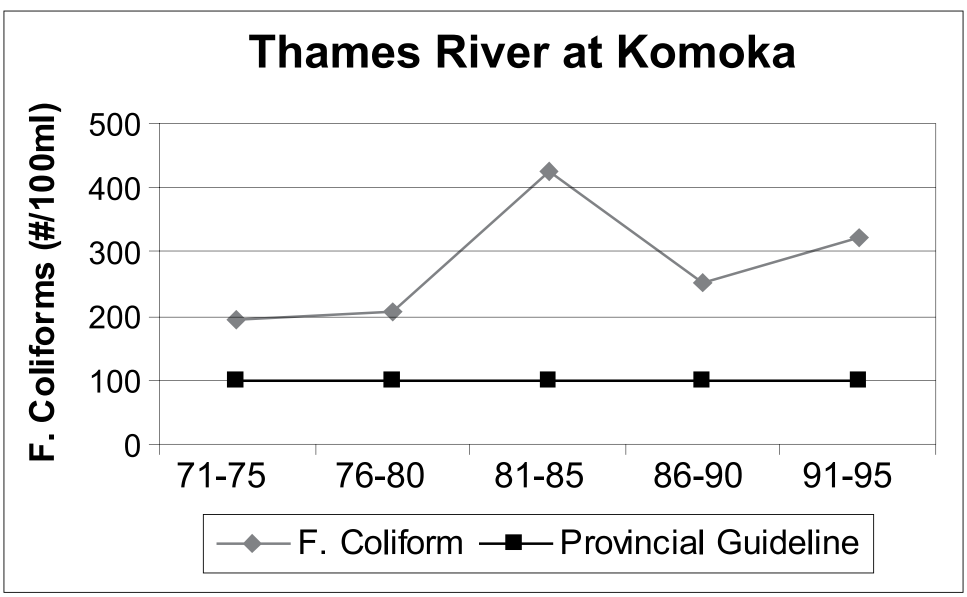


Figure 14: Fecal Coliform concentrations in the Thames River, measured at Komoka, compared to the Ontario provincial water quality guidelines. (Source: Provincial Water Quality Network)

by nutrients and is turbid. Total phosphorus concentrations were reported to range from 30 µg/L to 200 µg/L. Water quality monitoring of the Thames River at Komoka has shown a steady increase in the average phosphorus concentration from about 120 µg/L in 1975 to approximately 170 µg/L in 1996 (Figure 13).

As part of the Provincial Water Quality Monitoring Network, the OMOE and conservation authorities have cooperated to collect more than thirty years of water quality monitoring data for many watershed areas. The 2000 State of the Thames River Watershed Water Report (Upper Thames River Conservation Authority 2001) information was used in part to assess water quality trends. The concentration of phosphorus and fecal coliform bacteria counts in the Thames River at Komoka exceeded Provincial Water Quality Objectives and showed a trend of increasing concentrations from 1971 to 1998 as illustrated in Figures 13 and 14.

A Water Management Study for the Thames River (Ontario Ministry of the Environment and Ontario Ministry of Natural Resources 1975) documented sources and causes of pollution for the Thames River. Impairment of surface water quality was primarily caused by excessive inputs of nutrients, bacteria, oxygen consuming materials, and suspended solids. This study indicated that 95% of the total nitrogen load and 74% of the total phosphorus load were estimated to be from diffuse sources. Diffuse sources were defined as sources other than point source discharges from treatment plants and included the load from urban runoff. Although this study was conducted 30 years ago, the results continue to be applicable.

Failing Septic Systems Sources

Most domestic sewage from residential, commercial and industrial sources in the Canadian watershed is collected and treated at municipal wastewater treatment plants. It is estimated that less than 15% of the population living in the Lake St. Clair and the St. Clair River watershed have private wastewater treatment systems (including septic systems). Failing septic systems can result in elevated levels of bacteria and nutrients in local waterways potentially leading to beach closures, nuisance algae, and stress to aquatic organisms. For example, Figure 14 shows variable, but increasing, counts of fecal coliform bacteria in the Thames River at Komoka.

The Essex Region Conservation Authority has established a monitoring program to assess the water quality for tributaries in that region. The program involves chemical testing, biological sampling and habitat assessment. This monitoring has confirmed that there are serious problems of bacterial contamination (primarily from faulty septic systems) and nitrates (from faulty septic tanks and agricultural runoff) in the tributaries entering Lake St. Clair from Essex County.

As reviewed in more detail in the Human Health section, bacterial counts in the Lake St. Clair tributaries routinely exceed the provincial recreational water quality objective of 100 *E. coli* per 100 ml. Additional information on the tributaries to Lake St. Clair can be obtained from the conservation authorities at the following websites: www.erca.org, www.lowerthames-conservation.on.ca, www.thamesriver.on.ca, and www.scrca.on.ca.

The heavy clay soil present in much of the watershed represents a particular concern for the proper design and construction of private wastewater treatment systems. Additional problems such as increased water usage where piped municipal water is available, the lack of proper maintenance, and aging systems can contribute to septic system failure. The discharge of poorly treated sewage from faulty septic systems can be a significant source of pollutants, including bacterial and nutrient pollution, to local watercourses.

As part of the OMOE Provincial Rural Beaches Strategy Program and with the support of the Ontario Ministry Agriculture and Food, local conservation authorities completed a number of Clean Up Rural Beaches (CURB) studies to identify the relative impact of pollution sources within the Lake St. Clair tributary watersheds. The Upper Thames River CURB study report (Upper Thames River Conservation Authority and Ministry of Environment 1989) stated that 27 to 49% of the bacterial contamination in the upper Thames River could be attributed to failing septic systems or grey water (sinks, showers, laundry, etc.) that was being bypassed around the septic system. A similar CURB study for Essex Region (Essex Region Conservation Authority and Ministry of Environment 1992) reported that up to 75% of the bacterial contamination was attributable to faulty septic systems and estimated that half of the systems did not work properly. The CURB study for Bear Creek, a tributary of the Sydenham River, reported that 65% of the bacterial pollution was from faulty septic systems (St. Clair Region Conservation Authority and Ministry of the Environment 1989a, b). Implementation programs to repair problems and improve local water quality followed the CURB studies.

Municipalities conducted a number of pollution prevention studies in the 1990s to assess and document problems, as part of a provincial program to replace individual systems with municipal sanitary sewers to collect the sewage where needed and practical. Surveys of properties along the St. Clair River in St. Clair Township (formerly Moore and Sombra Townships) documented that up to 100% of the septic systems surveyed were discharging sewage directly into the river. These studies resulted in the construction of sewers to collect sewage and direct it to the existing municipal treatment facilities.

From 2000 to 2003, the provincial Healthy Futures program offered technical and financial assistance to protect rural water quality. In Lambton County, the St. Clair Region Conservation Authority administered the program and found that the applications to correct failing septic systems exceeded available funding. This shows that failing septic systems continue to be a problem particularly in areas with heavy clay soils. Similar programs were available at the Essex Region Conservation Authority and the Lower Thames Valley Conservation Authority.

The Clean Water Project (CWP) was launched in 2001 in the rural areas of Middlesex, Oxford and Perth Counties, the Cities of London and Stratford, and the Town of St. Marys. This initiative provides technical assistance and financial incentives to improve and protect water quality, and is delivered by conservation authority staff. Funding for the CWP has come from many sources, including local municipalities, the Healthy Futures program, the federal Habitat Stewardship program, and the Great Lakes Renewal Foundation. Septic system upgrades are among the most popular CWP projects. For information on the CWP, go to www.cleanwaterproject.ca.

Agricultural / Rural Sources

Clean Up Rural Beaches (CURB) studies found that faulty agricultural sources (milkhouse washwater discharges, livestock access, manure spills and run off from manure storage) were sources of between 25% and 73% of the bacterial pollution in the study tributaries (Upper Thames River Conservation Authority and Ministry of the Environment 1989, Essex Region Conservation Authority and Ministry of the Environment 1992, St. Clair Region Conservation Authority and Ministry of the Environment 1989a, b). The St. Clair Region Conservation Authority identified agricultural sources (cattle access, manure spreading, and runoff from manure storage) as the second largest bacterial pollution contributor after faulty septic systems (St. Clair Region Conservation Authority and Ministry of the Environment 1989a, b). The conservation authorities' CURB studies have also found that livestock and soil erosion had significant impacts on local watercourses. In the upper Thames River watershed, the CURB study (Upper Thames

River Conservation Authority and Ministry of the Environment 1989) reported that controlling livestock access to streams and drains was the most cost-effective remedial measure to reduce bacterial contamination from livestock, and that milkhouse wastewater treatment appeared to be the most cost-effective measure for phosphorus control. Once these problems were identified, the OMOE provided technical and financial support, during the early 1990s, to help control the pollution sources.

A manure study completed on the upper Thames River showed that with no rain almost 2% of manure applied to a silt loam field moved to a watercourse through the field tiles (Wall et al. 1997) Manure spills are reported to have caused more fish kills in Ontario between 1988 and 2000 than all other types of spills. Thus, nutrient management and best management practices for manure handling and spreading are critical to maintaining a healthy watercourse and improving water quality.

The Sydenham River Recovery Plan (Jacques Whitford Environment Limited 2001) lists five general threats (sediments, nutrients, toxic contaminants, thermal changes and invasive species) to species at risk in the Sydenham River. With the exception of invasive species, agriculture was identified as one of the significant causes for each issue. Agriculture was identified as the most likely source of suspended solid loadings to the river resulting in increased turbidity (Jacques Whitford Environment Limited 2001) and was also considered to be a significant source of nutrients (phosphorus and nitrogen). Since much of the phosphorus was bound to suspended solids, it likely originated from farmland. Agriculture now covers 85% of the land in the Sydenham River watershed that prior to European settlement was 30% swamp and 70% forest.

Out of Basin Sources

Much of the mercury currently entering the waters of the region settles from the air or is deposited in precipitation. Mercury enters the atmosphere through the release of geologically bound mercury by both natural processes and human activities. Waste incinerators, coal-fired power plants and base metal smelting plants are the major contributors of airborne mercury. In addition, the global reservoir of atmospheric mercury makes long-range transportation of mercury a concern. In Ontario, mercury is classified as a no discharge substance and no permits are given to discharge mercury into the environment. Mercury is listed as a toxic substance under the *Canadian Environmental Protection Act* and is subject to federal control. While air deposition is the largest current source of mercury, sediments still contain the largest mass of mercury in the Great Lakes system.

Persistent organic pollutants (POPs) enter the environment as a result of human activity. The manufacturing and use of most POPs, such as PCBs, DDT, chlordane, dioxins and furans, have been banned or severely restricted in Canada for years. POPs currently entering the Canadian environment come from local, regional, and international sources. Under certain temperature and moisture conditions, residuals of persistent pesticides that were used many years ago can be released into the atmosphere from farmland and contribute to the overall loading in the Great Lakes basin. Long-range transport of POPs occurs through a process of multiple cycles of evaporation, transport by air and condensation.

The Great Lakes Binational Toxics Strategy (GLBTS) is a Canada – U.S. strategy (www.binational.net) for the virtual elimination of persistent toxic substances. The strategy focuses on protecting and ensuring the health and integrity of the Great Lakes ecosystem by reducing or eliminating those substances that bioaccumulate. The strategy targets persistent toxic substances that are the result of in basin and out of basin atmospheric deposition, release from contaminated bottom sediments, releases from various industrial processes, releases from non-point sources, and the continuous cycling anthropogenic substances within the Great Lakes themselves. The GLBTS 2002 Progress Report (Environment Canada and U.S. Environmental Protection Agency 2002) states that Canadian mercury releases were reduced by 78% from 1988 baseline figures, a reduction of more than 11,000 kg of mercury, and that 84% of Canadian high-level PCBs have been destroyed since the 1993 baseline.

Management Issues

- Non-point sources of pollution are having a detrimental impact on water and habitat quality (e.g., beach closures, sedimentation).
- Out of basin sources of pollution cannot be addressed through a watershed management plan for Lake St. Clair, but rather should be addressed through national and international plans.
- Further reductions in pollutants from all point sources are needed.
- The risks of chemical and fuel spills threaten fish, wildlife and natural habitat, particularly at certain times of the year (e.g., breeding, migration).

Impacts to Human Health

Edible fish, safe recreational waters and reliable drinking water are three important components of water resource utilization. They provide a measure of the overall well-being of the aquatic environment and reflect the impacts of human activities within the watershed.

Elevated concentrations of mercury and PCBs in fish have resulted in advisories being issued to restrict the consumption of fish taken from Lake St. Clair and its tributaries. Monitoring programs have shown that there have been improvements over the last thirty years but local, regional and global sources continue to contribute to the restrictions.

Beach postings and closures from elevated bacteria counts show the need to address sources of bacteria to improve and protect local recreational waters. Good water quality at Mitchell's Bay shows that safe public swimming areas do exist.

Once treated, water taken from Lake St. Clair provides a safe supply of drinking water for the public. However, nutrients and trace levels of pesticides (herbicides and insecticides) in untreated water show the need to address non-point pollution sources to protect drinking water supplies.

Standing water poses potential hazards to human health such as the spread viral diseases such as West Nile Virus if mosquitoes are able to breed and carry the disease. Although West Nile Virus is found in mosquitoes that breed in predominantly suburban and urban regions, vigilance is required as the risk to rural areas does exist.

Fish Consumption

Since 1977, the Guide to Eating Ontario Sport Fish has provided advice on the consumption of fish taken from Ontario's lakes and rivers. The Ontario Ministry of the Environment and the Ontario Ministry of Natural Resources use the test results from about 1,700 locations across the province to produce the guide. The fish consumption advisories are based on Tolerable Daily Intake values developed by Health Canada, and take into consideration other environmental pathways such as air, drinking water and other food sources that expose the general public to contaminants. Both the Tolerable Daily Intake and the consumption advice provide for a higher level of protection for women of childbearing age and children as they are considered to be the most health-sensitive groups.

While the advice in the guide targets those who consume fish caught in Ontario waters, the results from the fish testing and the information summarized in the guide provides an overview of contaminants in fish taken from waters in Ontario. The fish are tested for a wide variety of contaminants and the sampling program has shown that contamination occurs across the province.

Since contaminant concentrations can vary in different parts of large lakes and major rivers, the fish advisory areas are divided into blocks or regions. Ontario sport fish consumption advice is provided for the eastern (Canadian) basin of Lake St. Clair, nine locations along the Thames River, and one location on the Sydenham River. At inland locations, such as along the Thames and Sydenham Rivers, more than 99% of the advisories are reported to be as a result of mercury (Ontario Ministry of the Environment 2002a). Fish from Lake St. Clair have advisories limiting consumption because of mercury or PCBs. In 1970, mercury contamination was identified in fish in high enough quantities that all commercial fishing was banned in the Canadian waters of Lake St. Clair until 1980. Since 1970, federal and provincial regulations have classified both mercury and PCBs as no discharge substances in Ontario. The sources and efforts to control mercury and PCBs are discussed in more detail in the section on Sources and Loads of Pollution.

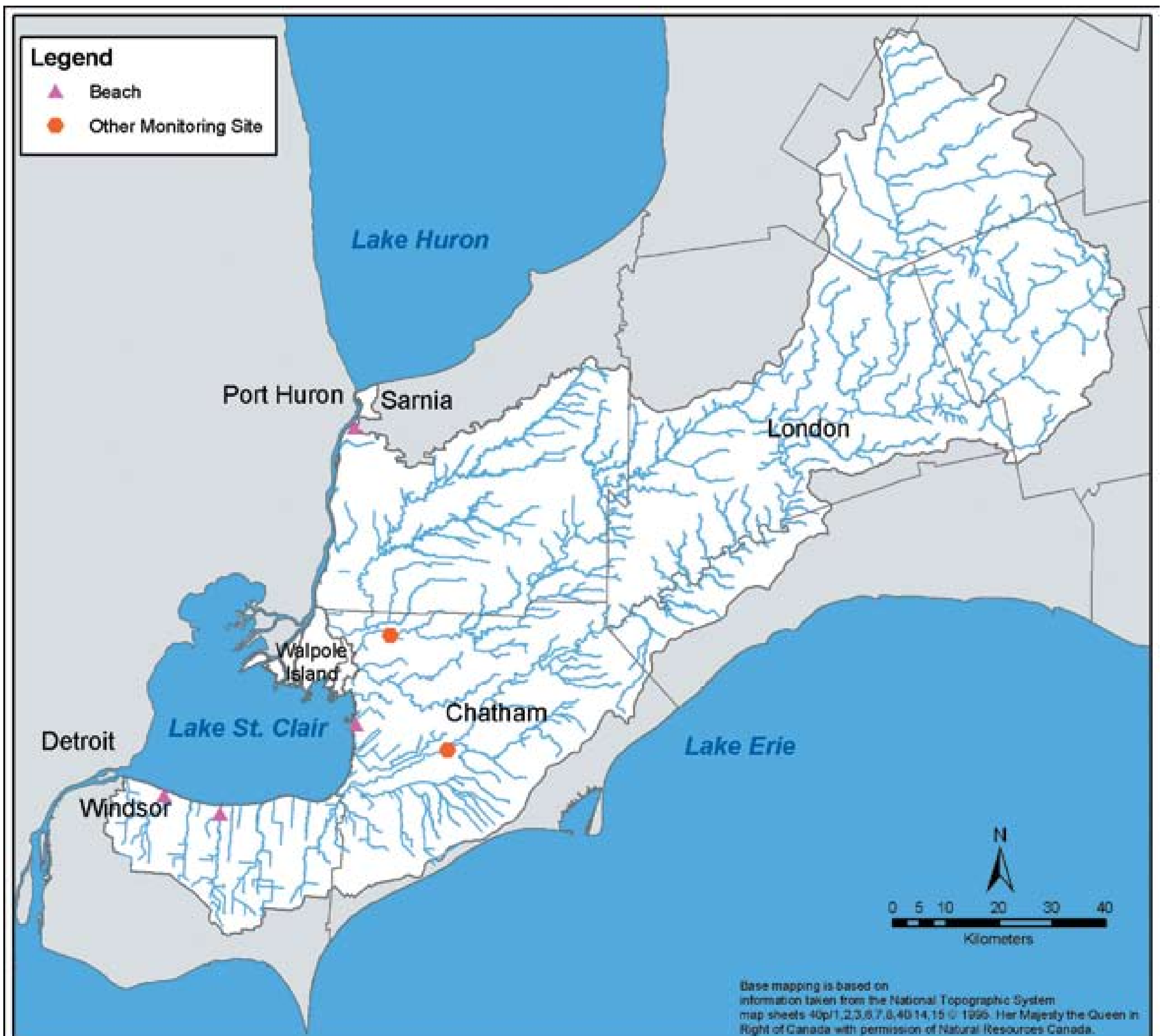


Figure 15: Map showing bacterial monitoring locations in the Lake St. Clair Canadian watershed. (Source: St. Clair Region Conservation Authority)

Mercury concentrations in the edible portion of Lake St. Clair walleye (Environment Canada and U.S. Environmental Protection Agency 2001) have decreased from the concentrations reported in the early 1970s. After fishing closures due to mercury were lifted in 1980, advisories on consumption have remained. Lake St. Clair is one of the most highly monitored areas in the Great Lakes owing to the very important sport fishery in the lake and the historic contamination from industries located on the St. Clair River. Monitoring has shown improvements such as an 80% reduction in the concentration of octachlorostyrene in channel catfish from Lake St. Clair.

Beach Postings/Closures

In Ontario, the *Health Protection and Promotion Act* provides for the organization and delivery of public health programs. Local municipalities, in partnership with the Ontario Ministry of Health and Long-Term Care, establish a Public Health Unit or Public Health Department as the official health agency to provide a wide variety of community health programs including monitoring public beaches. The Ontario Ministry of Health and Long-Term Care has set the recreational water quality guideline of 100 *E. coli* per 100 ml of water as a standard for swimming and bathing. The Ontario Ministry of Health and Long-Term Care provides a protocol to assist local health agencies in determining the beaches that should be sampled, and a standard procedure to evaluate water quality. Local health agencies monitor water quality each week throughout the summer to ensure public health is protected and warnings of unacceptable bacterial levels are posted as necessary. In addition, local health agencies usually give the public on-going advisories warning that there can be high bacterial levels following a rainstorm or when heavy wave action re-suspends sediments making the water cloudy. The locations of the beaches and other sites monitored within the Canadian Lake St. Clair watershed are shown in Figure 15.

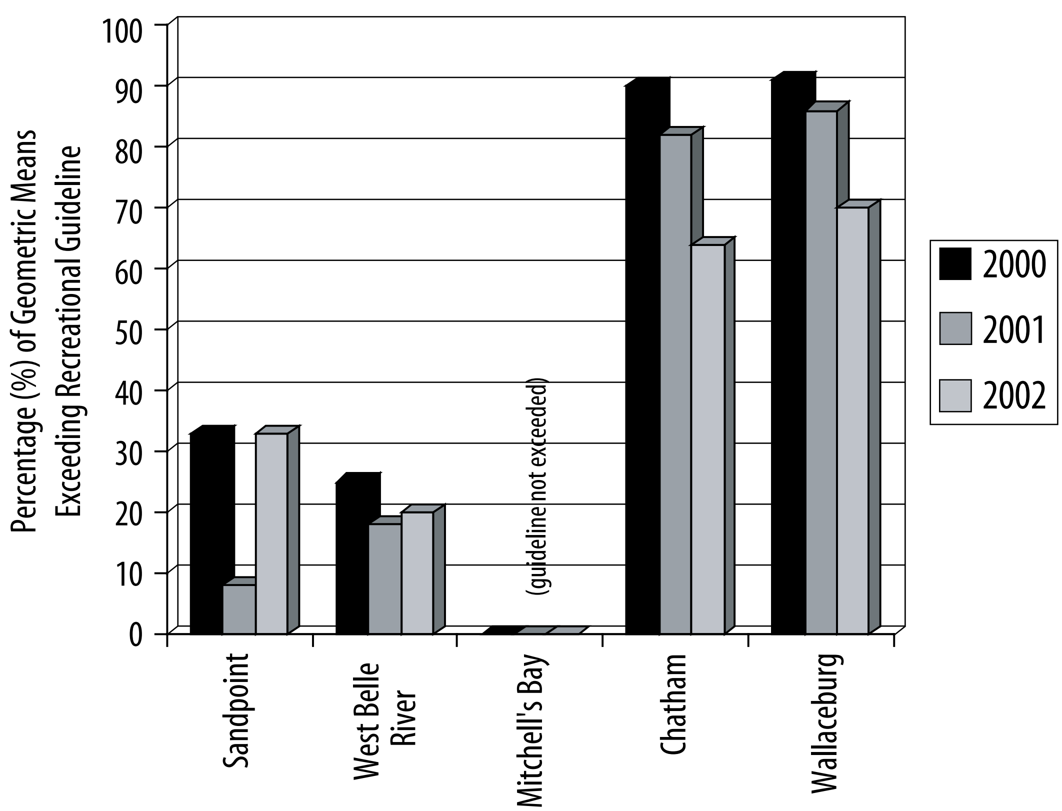


Figure 16: Bacterial monitoring results from weekly summer samples collected at Lake St. Clair Canadian beaches showing the percentage of sampling that exceeded the recreational water quality guideline for full body contact. (Source: St. Clair Region Conservation Authority)

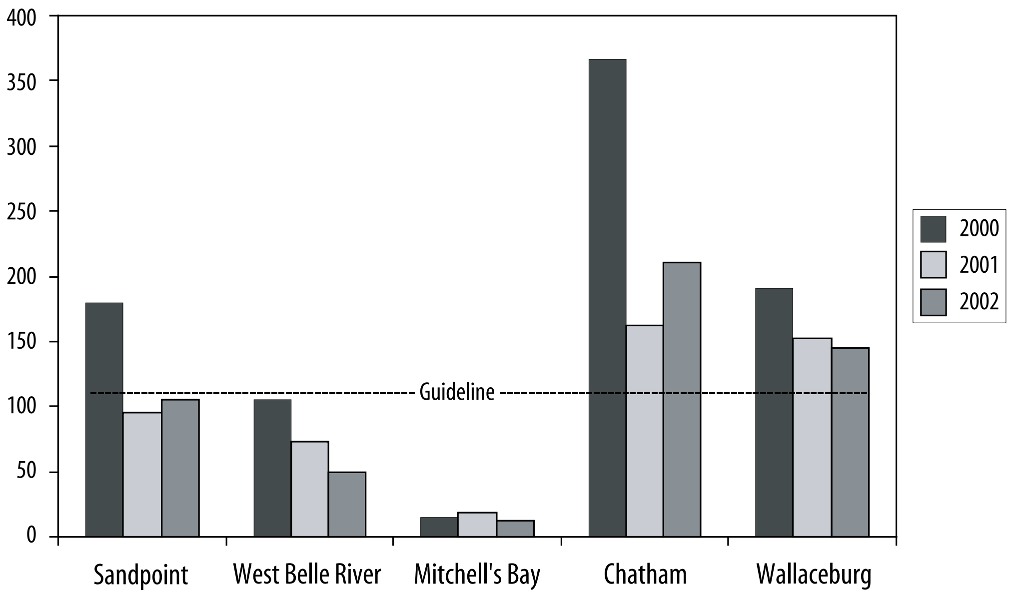


Figure 17: Summer average mean *Escherichia coli* counts for each Lake St. Clair Canadian sampling site. (Source: St. Clair Region Conservation Authority)

Along the Lake St. Clair shoreline, three Canadian public beaches are sampled: Mitchell's Bay in Chatham-Kent, West Belle River beach in Lakeshore, and Sandpoint beach in Windsor. Figure 16 shows the percentage of the weekly samples exceeding the recreation water quality guidelines over three years (2000-2002). Figure 17 shows the summer average mean *E. coli* counts for each sampling site.

Both the West Belle River and Sandpoint beaches, located on the south shore of Lake St. Clair, have had incidents involving high bacterial counts (Windsor-Essex County Health Unit 2002). Beach postings can occur several times a year. Non-point sources and urban development contribute to problems at these beaches. The West Belle River beach has had up to 25% of the weekly samples taken each year exceed the recreation water quality guideline for *E. coli* and Sandpoint beach has had as high as 33% of samples exceed the guideline. At each of the beaches, there have been occasions when there were exceptionally high counts (over 1,000 *E. coli*) during non-storm events with no known source(s) for the contamination. The Essex Region Conservation Authority monitors the tributaries discharging into Lake St. Clair to support their rural non-point source program. The results for the summers of 2000 to 2002 showed poor water quality with counts as high as 5,000 *E. coli* per 100 ml in the tributaries. These levels likely contributed the postings at West Belle River and Sandpoint beaches. Rural non-point sources such as failing septic systems are key contributors of bacteria to the tributaries.

Located on the east shore of Lake St. Clair, Mitchell's Bay has good water quality. Between 2000 and 2002, there were no incidents of bacteria high counts (Municipality of Chatham-Kent 2002). The Chatham-Kent Public Health Division also routinely samples the Sydenham River at Wallaceburg and the Thames River at Chatham. The test results at these locations normally exceed the acceptable recreational water quality guideline and the Chatham-Kent Public Health Division has permanently posted signs at these locations indicating that the areas are unacceptable for swimming or bathing. During the summers of 2000 to 2002 as many as 90% of the weekly test results for the Thames River at Chatham and 91% for the Sydenham River at Wallaceburg had *E. coli* counts above the guideline for recreational water usage (Municipality of Chatham-Kent 2002).

This monitoring provides background information on water quality for the major Canadian tributaries discharging into Lake St. Clair. The poor water quality in the tributaries is attributed to non-point source pollution (urban stormwater, failing septic systems, animals, birds and agricultural drainage) and beach postings or closures continue to be a problem at most sites. Both the recreational water quality monitoring program and the tributary monitoring have identified a need to address the bacterial contamination that can impact water quality in Lake St. Clair and the tributaries draining into it.

Drinking Water

Lake St. Clair is the drinking water supply source for over 285,000 Ontario residents. Three Ontario municipal water treatment plants (Belle River, Stoney Point and Tecumseh) take their untreated water directly from Lake St. Clair. In addition, the City of Windsor takes raw water from the Fleming Channel of the Detroit River opposite Belle Isle and, therefore, is directly impacted by Lake St. Clair water quality. The plants have a combined rated capability of 337,600 m^3/day. The intake locations are shown on Figure 18. All of the municipal water treatment plants have reported good treated water quality in their Regulation 459/00 quarterly reports for 2002 (Ontario Ministry of the Environment 2002b).

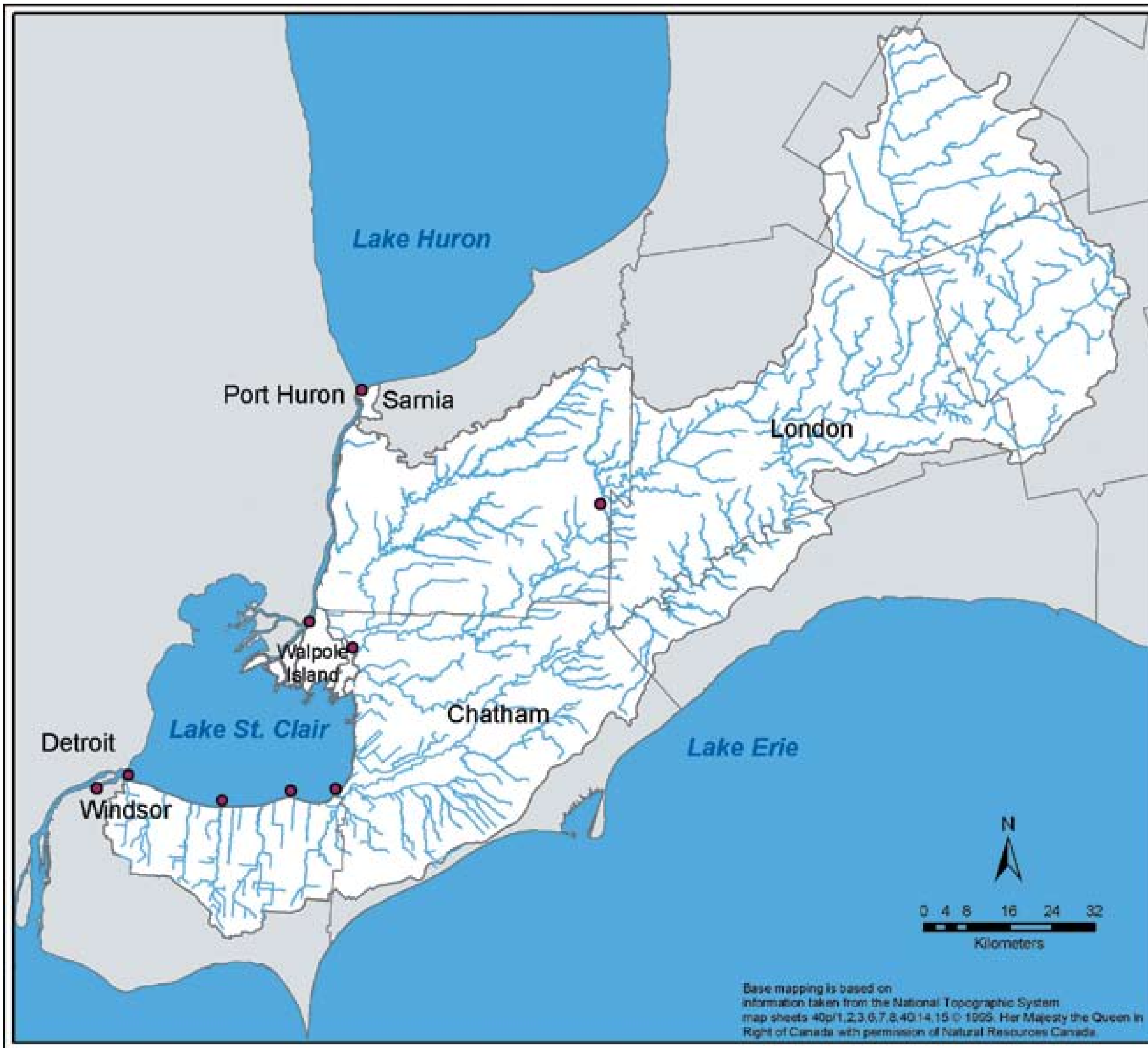


Figure 18: Map showing the location of Canadian municipal water intakes. (Source: St. Clair Region Conservation Authority)

In Canada, the provincial and territorial governments have the primary responsibility for managing and protecting water quality including the regulation of drinking water. The federal government is responsible for ensuring the safety of drinking water in areas of federal jurisdiction such as national parks and First Nation reserves. Bottled water is controlled by federal government regulations under the *Food and Drugs Act*.

Urban growth resulted in the development of public water supplies in Ontario. By the early 1900s, inadequate groundwater supplies and pollution problems led many municipalities to take water from larger surface water sources, install off-shore intakes and chlorinate the water to reduce the potential for outbreaks of diseases such as typhoid, diphtheria and scarlet fever. In the early 1900s, the Sarnia water plant that was downstream from Sarnia Bay was relocated to take water from Lake Huron at the head of the St. Clair River. Along the major tributaries of Lake St. Clair, most of the inland communities do not use the local surface water as a drinking water source. A pipeline from Lake Erie supplies the City of Chatham. The City of London has water supplied by pipelines from both Lake Huron and Lake Erie.

Over time, increasing levels of treatment, such as chemical flocculation and filtration systems to remove fine suspended solids and reduce turbidity, were installed to improve the public water supply. The Ontario Department (now Ministry) of Health was responsible for water quality until 1956 when the Ontario Water Resources Commission (OWRC) was created by the Province. The OWRC mandate was the development, utilization and management of Ontario’s water resources including pollution control. Under the OWRC, several large municipal water treatment plants and numerous smaller projects were built. In 1973, the OWRC became part of the Ministry of the Environment (OMOE). The OMOE continued to use the *Ontario Water Resources Act* (OWRA) to control drinking water supplies based on the Ontario Drinking Water Objectives (ODWO) that were compatible with the drinking water values in the Canadian Environmental Quality Guidelines developed by the Canadian Council of Ministers of the Environment (CCME). Any public or private system that serves six or more residences is subject to provincial control.

The OMOE began a voluntary Drinking Water Surveillance Program (DWSP) in 1986 to collect information on many of the public water supplies in Ontario. The DWSP was established to complement the routine monitoring done by local operating authorities and was not intended as a compliance program. As part of the DWSP monitoring, water quality is evaluated by testing for microbiological, inorganic, organic and radioactive components. Water samples are also monitored for insecticides and herbicides. However, water samples are not monitored for emerging chemicals, such as pharmaceuticals, that may be of concern. The OMOE website, www.ene.gov.on.ca/water, includes information on the monitoring results from 1993 to 1999. The DWSP samples collected between 1993 and 1999 for the Canadian public water supplies from Lake St. Clair indicated that the municipalities produced good quality treated water for their communities (Ontario Ministry of the Environment 1999). However, prior to treatment, the detection of ammonia and traces of pesticides in the raw water show that the source (Lake St. Clair) is influenced by agricultural activity. DWSP monitoring has shown a similar impact on the raw water supplies for the two inland communities (Dresden and Alvinston) using water from the Sydenham River. Between 1993 and 1999, total nitrate concentrations above the ODWO of 10.0 mg/L were found in raw water on several occasions. No health related guidelines were exceeded for any other compounds but the detection of atrazine, 2,4-D and metolachlor with traces of other pesticides in the raw water prior to treatment showed an influence of non-point sources and agricultural activities. For incidents involving compounds that exceed acceptable concentrations, the local health agency advises the public regarding health concerns and the OMOE requires that the local municipality address the problem. The Dresden treatment plant was replaced with a piped water supply from Lake Erie in 1997. Alvinston has completed an Environmental Assessment with the recommendation that the existing plant be replaced by a piped water supply from Lake Huron.

In May 2000, the need for safe water supplies was highlighted by the events in Walkerton. The municipal well water was contaminated by *E. coli* from manure causing seven deaths and more than 2000 illnesses. In August 2000, the Ontario Government passed a new Drinking Water Protection Regulation (Regulation 459/00) under the OWRA. The former Ontario Drinking Water Objectives became the Ontario Drinking Water Standards. The Regulation clarified requirements for treatment, testing and reporting associated with water works. Owners/operators must publish quarterly reports summarizing the operation and make these reports available to the public. In addition, a Drinking Water Protection Regulation for Smaller Waterworks Serving Designated Facilities (Regulation 505/01) was passed to provide protection at schools, day nurseries, nursing and retirement homes, and social and health care facilities with their own water supply that did not fall under Regulation 459/00. Owners/operators must report incidents when drinking water objectives are exceeded. The OMOE posts Adverse Drinking Water Quality Incidents reports on the website together with the actions taken to resolve the issues. An "adverse water quality incident" is an umbrella term used to refer to any unusual test result including aesthetic measures, like taste and odour, and does not mean that a drinking water supply is unsafe.

A public inquiry was held regarding the incident in Walkerton and the two-part report of the Walkerton Inquiry (O'Conner 2002) had a total of 121 recommendations regarding the protection of public water supplies. The report is available at www.attorneygeneral.jus.gov.on.ca. Based on the recommendations, the province is in the process of enacting a *Safe Drinking Water Act* that will assemble all legislation and regulations relating to the treatment and distribution of water. In June 2002, the *Nutrient Management Act* was passed to form an important part of watershed protection as envisioned by the Commissioner for the Walkerton Inquiry. The report also recommended that watershed-based Source Protection Plans (SPPs) be established to help safeguard drinking water supplies. Source Protection Planning Committees have been created for 19 planning areas across the province. Two of these areas encompass the Lake St. Clair watershed. Additional information is available at the OMOE website at www.ene.gov.on.ca.

The introduction of zebra mussels in 1988 was cause for concern for municipal and industrial water supplies. The growth of zebra mussel colonies in the raw water intake pipes and associated works had the potential to cause serious restrictions in the ability of the plants to produce adequate water supplies. Most of the municipal intakes were modified to deal with the potential problem by installing equipment to pre-chlorinate the raw water to prevent zebra mussels from growing in the intake pipes.

In the latter part of the 1990s, distinct taste and odour problems were noted in several municipal water supplies. Attributed to the decomposition of aquatic plants including blue-green algae, the problems can occur after summer algal blooms. As a result, many of the water treatment plants installed activated carbon systems to reduce the problems of taste and odour.

In summary, routine operational monitoring and DWSP sampling indicate that Lake St. Clair can be considered a safe water source for public water supply. Operators of both public and private water supplies continue to be challenged to produce adequate quantities of water due to threats, such as zebra mussel colonization, restricting the raw water intake pipes. Agricultural and other non-point source chemicals can be detected in surface waters as discussed in the section on Sources and Loads of Pollution. The *Nutrient Management Act* and the *Safe Drinking Water Act* are intended to strengthen the protection of drinking water in Ontario. Source Protection Plans will also help to protect drinking water supplies.

Climate Change and Human Health

Exposure to extreme temperatures, cold in winter and hot in summer, will likely be problematic for some people, particularly the very young and very old. Although approximately 300 km (186 mi) away from Lake St. Clair, Toronto is predicted to experience a doubling of the number of hot days (greater than 32ºC) by the 2030s (Union of Concerned Scientists and Ecological Society of America 2003). Increased dependence upon electricity generation (for air conditioning and heating) may increase smog in urban centers and cause additional problems for people with asthma and other respiratory diseases. In addition, the occurrence of infectious diseases may increase if disease carrying insects spread throughout the region (e.g., Lyme disease spread by ticks and West Nile Virus spread by mosquitoes).

Management Issues

- Elevated concentrations of mercury and PCBs in fish continue to cause advisories on the consumption of fish caught in the Lake St. Clair watershed.
- Point and non-point sources of pollution are having a detrimental impact on water quality (e.g., beach closures, source water).
- The quality and quantity of treated water is satisfactory; however, there are concerns with existing and emerging pollutants (e.g., pharmaceuticals), and ensuring an adequate supply to consumers.

Alterations to Habitat and Biodiversity

The Lake St. Clair watershed spans the transition zone between the Carolinian and the Lower Great Lakes-St. Lawrence Forest zones. There are many types of habitat within Lake St. Clair including open water communities, wetlands, river channel communities, abandoned river channel communities, upland forests, residual tallgrass prairie, and transition zones of scrub, savanna, meadows, marshes and beaches. The availability of these many different habitats, combined with a climate moderated by the Great Lakes, results in tremendous biodiversity of native flora and fauna.

The *Canadian Environmental Protection Act* (CEPA) defines biological diversity as "the variability among living organisms from all sources, including, without limiting the generality of the foregoing, terrestrial and marine and other aquatic ecosystems and the ecological complexes of which they form a part and includes the diversity within and between species and of ecosystems." CEPA defines ecosystem as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit." The definition of fish habitat found in Section 34(1) of the *Fisheries Act* includes "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes."

The original Lake St. Clair watershed has changed to accommodate agricultural, municipal, industrial, commercial, recreational and shipping activities, leaving only approximately 12% of the watershed as natural habitat. These changes were further exacerbated by the introductions of invasive species. The result has altered hydrology, reduced habitat quality, and fragmented native species distribution and abundance in the Lake St. Clair watershed.

Aquatic Ecosystem

This section provides a brief overview of the main ecosystems found in the Lake St. Clair watershed.

Open Lake

Lake St. Clair has an average depth of 3.0 m (9.8 ft), a maximum natural depth of 6.4 m (21 ft), and a maximum dredged shipping channel depth of 8.0 m (26.2 ft). The northwestern water mass has a shorter retention time in the lake and contains fewer nutrients than the southeastern water mass. These differences contribute to the diversity of habitat and where different habitat types and species are found in the lake.

Increased water transparency and, thus, increased light penetration, has occurred in the last 30 years. This has been attributed, in part, to lower water levels, but also relates to the impact of zebra mussels that colonized the lake in 1988. Prior to the zebra mussel invasion, average water transparency was measured at 1.4 m (data from 1976-1988 at six sites in Ontario waters of Lake St. Clair; range 0.9-1.9 m), providing favourable light conditions for walleye (MacLennan et al. in preparation). Following colonization, transparency increased noticeably in most areas, with average water transparency being 2.8 m (range 1.2-4.0 m from 1989-1993). This overall change in transparency has been implicated in additional ecological changes such as decreased preferred habitat for walleye, an extended light penetration zone, and increased submerged aquatic vegetation distribution and density (MacLennan et al. in preparation). These changes to the Ontario side of Lake St. Clair were not observed to the same extent on the Michigan side primarily because of the moderating effect of the northwestern oligotrophic (nutrient poor) water mass moving into Lake St. Clair from Lake Huron.

Submerged aquatic vegetation populations, particularly in Ontario waters, have changed dramatically in density, distribution and species composition since the mid-1980s. Attributed to increased transparency, the changes in these communities have led to changes in the fish community. Submerged aquatic vegetation surveys conducted by the OMNR on the eastern shore of Lake St. Clair showed that the biomass (wet weight) of submerged aquatic vegetation had increased approximately five-fold from 244 gm/m2 in 1985-86 to 1144 gm/m2 in 1994 (MacLennan et al. in preparation). Species composition had also changed. In both surveys, the submerged aquatic vegetation communities were dominated by *Chara* (muskgrass) and *Vallisneria* (wild celery) that made up more than 80% of the total submerged aquatic vegetation biomass and were found at 70% of the survey sites. However, *Naja*, *Zosterella*, *Elodea*, *Potamogeton*, and *Ceratophylum* species became more prominent (combined density of these species was 21 gm/m2 in 1985-86 and 244 gm/m2 in 1994) (MacLennan et al. in preparation). Schloesser et al. (1996) attributed similar changes to the submerged aquatic vegetation community (from 1978 to 1995) in Anchor Bay, Michigan, to changes in one or more limiting factors (such as light) during the period between surveys.

Changes in water transparency and submerged aquatic vegetation community structure have not been the only alterations to the Lake St. Clair ecosystem that have occurred coincident with the colonization of the zebra mussels. There were also changes in benthic invertebrate communities, most notably in native mussel populations. In 1988, the year zebra mussels were found in Lake St. Clair, there were 18 native species of mussels found throughout the lake. As early as 1991 declines in the abundance of native mussels had been noted and by 1994, only five of the original 18 native mussel species were present in the open lake (Nalepa et al.1996). Surveys conducted since 1994 indicated that native mussels had essentially been extirpated from the open lake (MacLennan et al. in preparation). Zebra mussels were commonly found attached to native mussels, preventing normal valve opening and closing and obstructing the siphons (Mackie 1993).

In high enough numbers, zebra mussels likely interfered with respiration and feeding leading to reductions in native mussel populations (MacLennan et al. in preparation).

Additional changes to the benthic invertebrate communities of Lake St. Clair included an increase in the relative abundances of amphipods, flatworms, snails and worms (Griffiths 1993). These invertebrates made up as much as 2.5% of the benthic invertebrate communities in the southeastern portion of the lake prior to the invasion of zebra mussels, increasing to comprise 10% to 29% of the communities after zebra mussels became established (Griffiths 1993). Griffiths (1987) had previously described the benthic macroinvertebrate fauna of the northwestern portion of Lake St. Clair as different from the fauna in the southcentral area. In 1993, Griffiths noted that the fauna in the southeastern area had become more similar to that found in the northwestern area, a shift toward benthic species that are more typical of oligotrophic conditions.

The fish community of the Lake St. Clair watershed historically has been, and presently is, comprised of a mixture of warmwater and coolwater species. Coldwater species, mostly exotics (e.g., rainbow and brown trout, chinook and coho salmon, rainbow smelt), are found in the lake, but are not year-round residents. More than 70 fish species were reported as residents or migrants in the lake and 34 of these species used the lake for spawning. These numbers will have increased in recent years because of new arrivals of invasive fish species.

Fishing, extensive nearshore modifications (e.g., wetland dyking and drainage, breakwall construction, etc.), increased human activities in the watershed, and the introduction of various invasive species all had an impact on the composition of fish communities of the early 1900s through to about 1970. In general, the changes pre-1970 were minor, with the notable exception of the near extirpations of lake herring and lake whitefish. Since 1970, the changes in the fish community have been substantial and rapid. White perch colonized in 1977, became abundant in Ontario catches in 1987, and were implicated as a contributing cause of poor walleye and yellow perch recruitment (adding young individuals to the population) in the 1980s and early 1990s because of their competition with, or predation on, young walleye. Increases in water transparency and aquatic vegetation in the late 1980s made the habitat structure less suitable for walleye, and in turn, favoured species like muskellunge and smallmouth bass. Angler data and tag recovery data indicated that walleye distribution had changed and walleye were more often found in the centre of the lake where increased water depth and turbidity from commercial shipping traffic provided a lower light refuge.

By the mid-1990s, the Ontario Ministry of Natural Resources was developing a conservation program to assist walleye stock recovery. Regulation changes came into effect in Canadian waters of Lake St. Clair restricting anglers to a 17” maximum size limit (MacLennan 1995), and there was a co-management agreement established with First Nations fishers in the Thames River that, among other management directions, promoted the release of larger female walleye. Promoting the recovery of local walleye stocks was also important because genetic data and tag returns showed that there was substantial movement of walleye from Lakes Huron and Erie through the St. Clair River-Detroit River corridor and around Lake St. Clair (McParland and Ferguson 1999).

The St. Clair River and Lake St. Clair provide habitat and are an important corridor for lake sturgeon that are distributed from Lake St. Clair, through the St. Clair River and into Lake Huron. Once abundant in Lake St. Clair, sturgeon populations declined because of habitat loss and over exploitation. The population of sturgeon was estimated to be 5,000 individuals by the late 1990s. Recovery of the population may have occurred since the early 1970s in response to improved water quality and protection of spawning adults. Recent data suggest that lake sturgeon will feed on two invasive species, the zebra mussel and the round goby. However, round gobies will feed on lake sturgeon eggs and larva, and therefore pose a substantial threat to the population structure of the long lived lake sturgeon.

Threats to the open-lake ecosystem include boating activities during sensitive periods of migration and breeding, the arrival and spread of invasive flora and fauna, nutrient and chemical inputs, alterations to the lake hydrology and sedimentation processes (such as deposition along the shoreline), and climate change.

A proportion of recreational boaters are recreational fishers. Fishers travel from areas in southwestern Ontario, southeastern Michigan and Ohio to fish both summer and winter fisheries. Most anglers that fish Lake St. Clair access the fishery using private boat slips and the majority of anglers (>60%) travel into Ontario waters directly from U.S. waters. As a result, much of the economic revenue from the recreational fisheries does not benefit Ontario.

Coastal Wetlands

The flat topography of the Lake St. Clair basin and seasonal water level changes contribute to very productive and diverse wetlands, supporting a variety of fish and wildlife that utilize both the emergent wetlands and the extensive beds of submerged aquatic vegetation in the open lake. Within Lake St. Clair, the largest wetland complex is the St. Clair River Delta found largely on Walpole Island. Much smaller wetland areas are found near the mouths of rivers and creeks along the northern and eastern shores of the lake. Very few wetlands occur along the highly developed southern and western shores. The only area in the Great Lakes comparable to Lake St. Clair is the extensive wetland/open water complex at Long Point on the north shore of Lake Erie (G. McCollough, Environment Canada, Ontario Region, London, Ontario. Personal communication).

The St. Clair Delta is the largest freshwater delta in the world and a critical biological feature in the Great Lakes (G. McCollough, Environment Canada, Ontario Region, London, Ontario. Personal communication). Water from the river is dispersed through

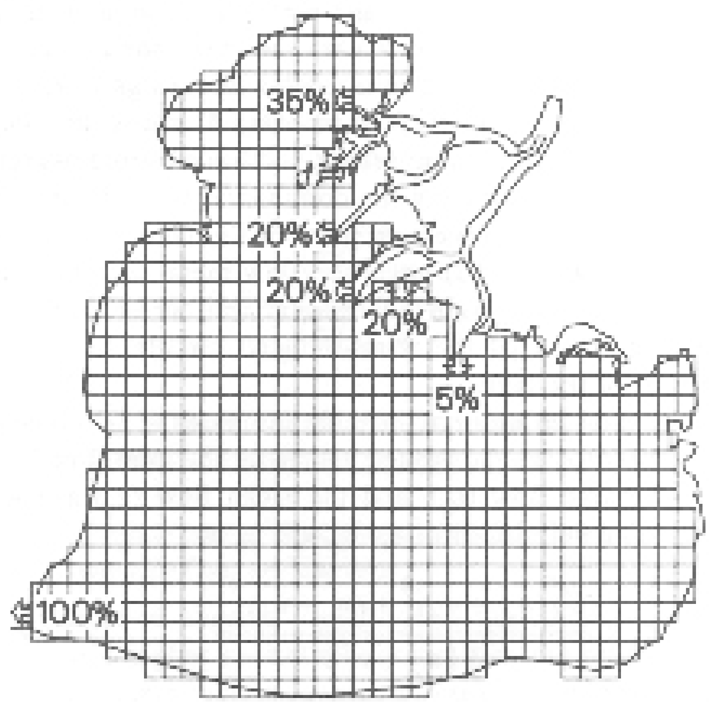


Figure 19: St. Clair River flow dispersion through the delta. (Source: Leach 1991)

the delta with 53% of the flow moving through the North and Middle Channels, 42% through the South and Bassett Channels and the remaining 5% through Chenal Ecarte (Figure 19) (Leach 1991). The inflow of water through the delta influences water circulation in the lake, as does wind direction (Leach 1991). While there has been agricultural and residential development at Walpole Island First Nation, approximately 6,900 ha of wetland still exist. In addition, the delta's islands host a rich mosaic of natural areas including tallgrass prairie, oak savanna and Carolinian forest. Some of the species considered rare or at risk in Canada are locally abundant in the delta.

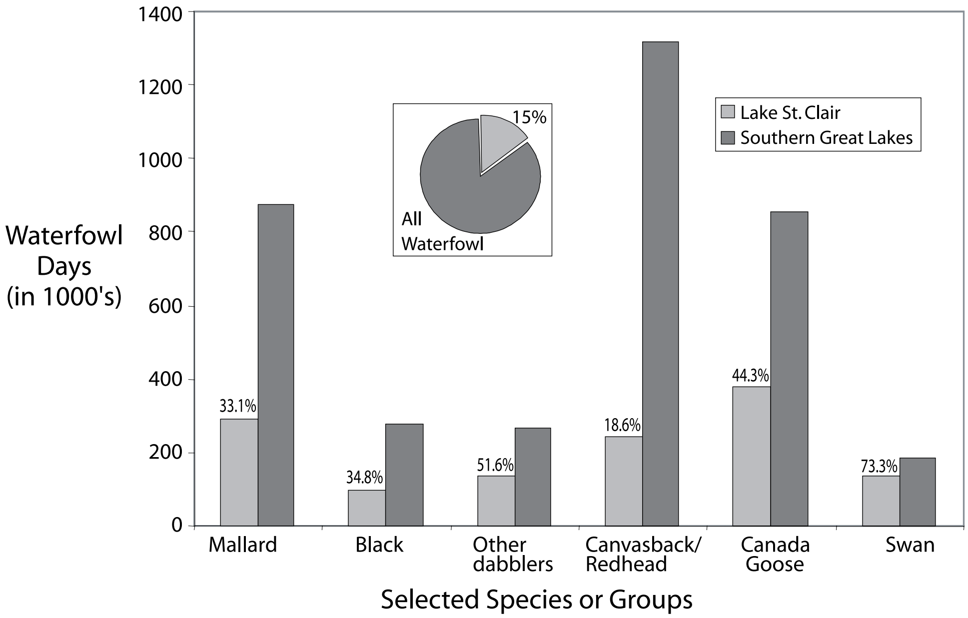


Figure 20: Spring waterfowl days (in thousands) for Lake St. Clair compared to those recorded along the full Canadian southern Great Lakes. (Source: Environment Canada)

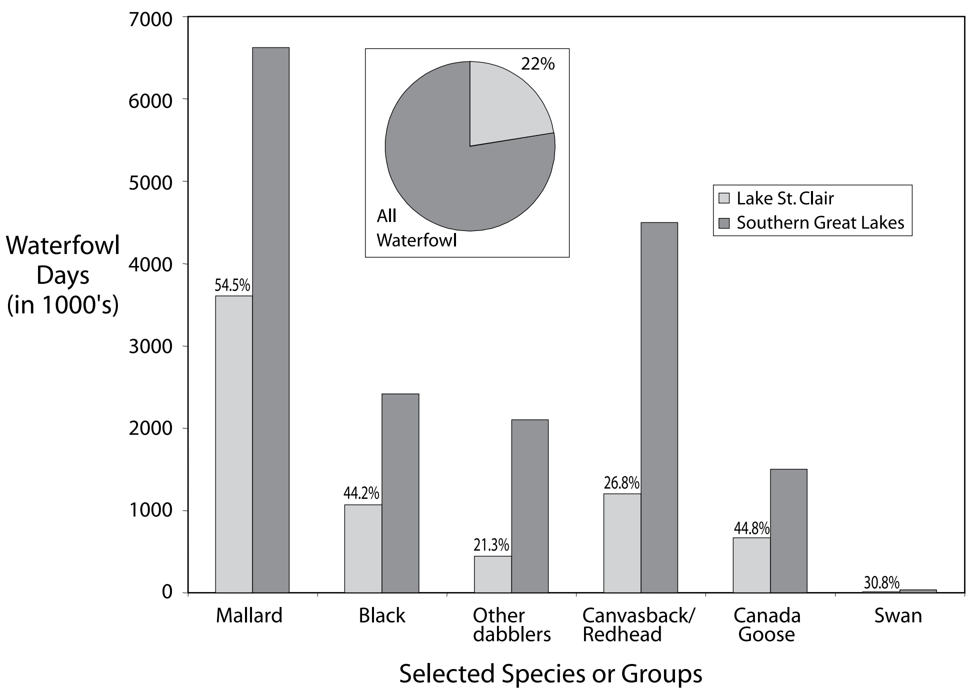


Figure 21: Fall waterfowl days (in thousands) for Lake St. Clair compared to those recorded along the full Canadian southern Great Lakes. (Source: Environment Canada)

Much of the remaining coastal wetlands are dyked and managed by private hunt clubs for waterfowl production. At present all existing wetlands along the eastern shore of Lake St. Clair are maintained primarily as private duck hunting clubs, with the exception of the St. Clair National Wildlife Area managed by the Canadian Wildlife Service of Environment Canada. It is designated as a Wetland of International Importance under the Ramsar Convention, and is part of a provincially designated Area of Natural and Scientific Interest. Management agreements between many of these private owners and Ducks Unlimited Canada have contributed to the retention of these vital areas of wildlife habitat.

Wetlands represent the most biologically significant habitat for migratory birds in the watershed. Many bird species rely on the diversity of aquatic plants found in the lake's wetlands and open lake areas for feeding and resting during migration and breeding. The Canadian Wildlife Service conducted aerial surveys in the 1970s and 1980s of the southern Great Lakes shoreline during migration. They found that the wetlands associated with the eastern shore of Lake St. Clair are the most important migration staging areas in southern Ontario for mallards, black ducks, Canada geese and tundra swans (Dennis and North 1984). In addition, significant portions of the North American populations

Figure 22: Proportion of the North American canvasback population at Lake St. Clair in the fall of 2000. (Source: Environment Canada)

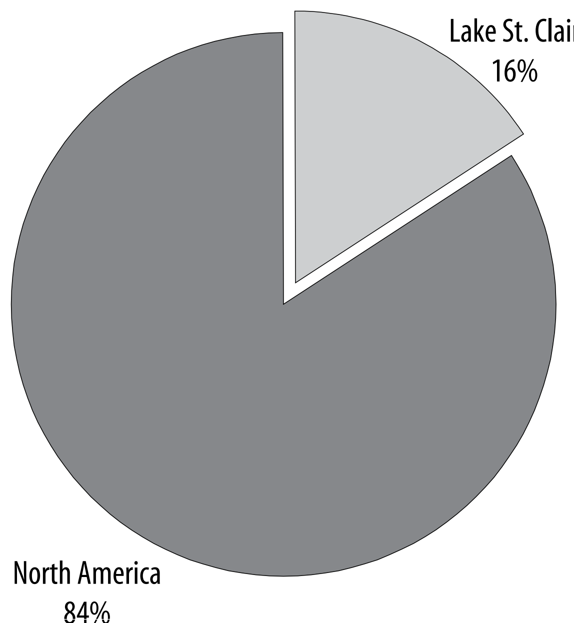
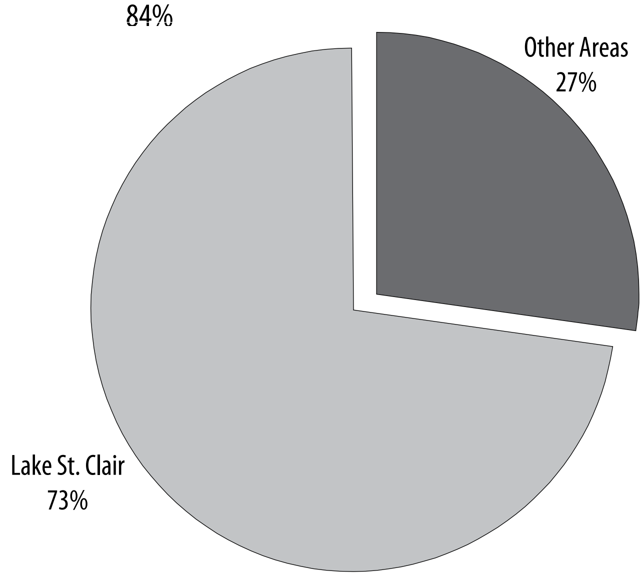


Figure 23: Proportion of the Ontario canvasback population at Lake St. Clair in the fall of 2000. (Source: Environment Canada)



of canvasback and redhead ducks utilize the Lake St. Clair wetlands during migration periods. Peak fall use occurs between late October and early November, while spring migration generally peaks in the first week of April. Figures 20 and 21 illustrate the time spent in the Lake St. Clair watershed by various waterfowl species during their annual migrations.

The Coordinated Canvasback Survey, conducted by various Canadian and American federal and provincial/state agencies, documents the importance of Lake St. Clair to migrating canvasbacks. Data from coordinated aerial surveys indicate that 16% of all canvasbacks in North America use the Lake St. Clair watershed (Figure 22) and two-thirds of all canvasbacks within Ontario use the watershed (Figure 23) during the fall migration period. Therefore, the waters, wetlands and marshes are important to successful migration. Canvasbacks are diving ducks and they depend on extensive beds of wild celery in the open lake and large undisturbed areas in which to feed and rest, and, therefore, may be vulnerable if these beds are altered.

The Lake St. Clair wetlands provide habitat for more than 65 species of fish at different times in their life cycles. Some fish species such as northern pike and bowfin are particularly dependent on wetland habitat, while other species (e.g., yellow perch, white bass) use the wetlands during some portion of their life, but they are not dependent upon the habitat.

Twenty-nine amphibian and reptile species live or have been recorded historically as living in the wetlands of the Lake St. Clair watershed. Some of these species are listed as species at risk in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Table 1). These include the endangered species prothonotary warbler, pugnose shiner, wavy-rayed lampmussel and the drooping trillium. Many of these species have experienced declines in their populations and are in imminent danger of disappearing from the wild.

More than two dozen species of mammal use the Lake St. Clair wetlands. The Virginia opossum, eastern cottontail rabbit, muskrat, raccoon, striped skunk and white-tailed deer are common.

The St. Clair wetlands provide critical breeding habitat for marsh birds including the nationally endangered King rail and threatened least bittern, black tern, Forster’s tern, American bittern, great egret and black-crowned night heron. Wetland use by true marsh-dwelling species of waterfowl declined significantly from the 1960s to the 1980s as 48% of the emergent aquatic vegetation found in wetlands was converted to alternate use, primarily agriculture. Additional threats to migratory birds relate to specific environmental conditions and, in many areas, to the impacts of invasive species, such as purple loosestrife, *Phragmites* and mute swans. Both loosestrife and *Phragmites* can out-compete native vegetation under certain environmental conditions and in many areas now dominate the vegetation community, to the detriment of most wildlife species. Wild mute swans, another invasive species, impact marsh vegetation communities due to their feeding behaviour and their aggressive demeanour scares off native marsh birds.

Fourteen plant species have been found in the coastal wetlands of Lake St. Clair including the very rare four-angled spikerush, southern tickseed, Emory’s sedge, honey locust, tapered rush, swamp rose mallow, American lotus, many-fruited false loosestrife and prairie fringed orchid.

The principal threats to wetlands in the Lake St. Clair watershed include alterations to the lake hydrology and sediment movement processes; direct wetland loss and degradation; wildlife disturbance during migration and breeding seasons; increases in non-native fauna and flora; the risk of nutrient, chemical and fuel spills; a lack of buffers; and increases in marina and residential development within or adjacent to wetlands.

Table 1: Species designated at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as of May 2003 that are found in the Lake St. Clair Canadian Watershed.

	ENDANGERED	THREATENED	SPECIAL CONCERN
Mammals	American Badger *jacksoni* subspecies	Grey Fox	Eastern Mole Southern Flying Squirrel Woodland Vole
Birds	Acadian Flycatcher Barn Owl Henslow's Sparrow King Rail Northern Bobwhite Prothonotary Warbler	Peregrine Falcon *anatum* subspecies Hooded Warbler Least Bittern	Cerulean Warbler Yellow-breasted Chat *virens* subspecies Louisiana Waterthrush Red-headed Woodpecker Red-shouldered Hawk Short-eared Owl
Reptiles		Butler's Gartersnake Eastern Foxsnake Eastern Hog-nosed Snake Eastern Ratsnake Queen Snake Spiny Softshell Stinkpot	Eastern Ribbonsnake (Great Lakes population) Milksnake Northern Map Turtle Spotted Turtle Wood Turtle Five-lined Skink
Amphibians	None	Jefferson Salamander	None
Fishes	Northern Madtom Pugnose Shiner	Black Redhorse Channel Darter Eastern Sand Darter Lake Chubsucker Spotted Gar	Bigmouth Buffalo Blackstripe Topminnow Greenside Darter Northern Brook Lamprey Orangespotted Sunfish Pugnose Minnow Redside Dace Silver Chub Silver Shiner Spotted Sucker
Lepidopterans	None	None	Monarch Butterfly
Molluscs	Kidneyshell Mudpuppy Mussel Northern Riffleshell Rayed Bean Snuffbox Round Hickorynut Wavy-rayed Lampmussel	None	None
Plants	American Ginseng Drooping Trillium Eastern Prairie Fringed Orchid False Hop Sedge Gattinger's Agalinis Large Whorled Pogonia Pink Milkwort Purple Twayblade Showy Goldenrod Skinner's Agalinis Small White Lady's-slipper White Prairie Gentian Wood-poppy	American Chestnut Colicroot Common Hop-tree Crooked-stem Aster Dense Blazing Star Goldenseal Kentucky Coffee-tree Willowleaf Aster	Blue Ash Climbing Prairie Rose False Rue-anemone Green Dragon Riddell's Goldenrod Shumard Oak Swamp Rose-mallow Tuberous Indian-plantain
Mosses	None	None	None
Lichens	None	None	None

Extirpated: A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered: A species facing imminent extirpation or extinction throughout all or a significant portion of its Canadian range.
Threatened: A species likely to become endangered in Canada if limiting factors are not reversed.
Special Concern: A species whose characteristics make it particularly sensitive to human activities or natural events.

The species in Table 1 meet two criteria:
1. they are endangered, threatened or special concern in Canada, and
2. they spend most of their life cycle and/or breed in the Lake St. Clair Watershed.

Inlet and Outlet: The St. Clair and Detroit Rivers

In 1985, the International Joint Commission identified the St. Clair River as an Area of Concern within the Great Lakes basin.

The benthic invertebrate communities in the St. Clair River are diverse with a reported 98 species, considerably more than the 65 species reported from the lake (Hudson et al. 1986). A total of 90 fish species have been recorded as residents or migrants in the St. Clair River, 28 of which used the river for spawning (Goodyear et al. 1982). In general, bays and wetlands provide important fish spawning and nursery habitat, in particular the St. Clair Flats area (Goodyear et al. 1982). In 1991, the St. Clair River RAP concluded that the diversity of fish species present in the river was attributed to the abundant assortment of habitat types that provide valuable spawning and nursery habitat in the main river, its tributaries and the delta (Environment Canada et al. 1994). Juvenile and adult fish were also reported to use the river for feeding, shelter and migration.

The St. Clair River RAP stated that in the early 1990s there was no commercial fishery in the St. Clair River north of Walpole Island; however, there was an important baitfish fishery in the Ontario waters of the river at that time. This area is also valuable for the recreational fishery that exists, particularly for walleye. In the area of the St. Clair Flats, the Walpole Island First Nation regulates recreational fishing by issuing licenses to anglers.

As with the St. Clair River, the Detroit River was also identified as an AOC. The benthic invertebrate community is diverse, with 80 reported species (Hudson et al. 1986) and 60 resident or migrant fish species (27 of which used the river for spawning) (Goodyear et al. 1982). Aside from the importance of the Detroit River as a spawning and nursery habitat, the wetland habitat present along the river was reported in the Detroit River RAP to be valuable to the river's fish community. The RAP further reported on a study that found aquatic vegetation provided habitat for young of the year and older fish from 16 species.

Throughout the 1900s the sport fishery on the Detroit River maintained its popularity, with yellow perch and walleye being the dominant species harvested prior to 1950, and walleye and white bass being the target species from the 1950s to 1980s. The commercial fishery was closed in 1970 because of high levels of mercury in fish. Despite the reduction in the mercury levels, the commercial fishery was not re-opened in 1980 when commercial activities resumed on the lake. Baitfish harvest did exist on the Detroit River in the late 1980s with harvested fish being sold to bait wholesalers in Ontario and Michigan.

Tributaries: The Sydenham and Thames Rivers

The Sydenham and the Thames Rivers (Figure 2) are the two major tributaries to Lake St. Clair within the Canadian watershed.

Historically, the Sydenham River drainage included the Great Enniskillen Swamp that covered 22% of the watershed (60,000 ha). Today, agriculture is the predominant land use in the watershed, and less than 1% (2,400 ha) of the watershed remains as wetland. Upstream of Wallaceburg, the Sydenham River divides into the east and north branches. The river bottom substrate varies between the two branches providing distinctly different aquatic habitats. The East Sydenham River is the longer of the two branches, has a more varied substrate, and a relatively diverse aquatic community.

The Sydenham River has a similar diverse fish community with 80 species reported in the system; eight of these are listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Table 2). The Sydenham is host to 34 freshwater mussel species, six of which are listed in Canada. Historically, the mudpuppy mussel

Table 2: Species designated at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as of May 2003 that are found in the Sydenham and Thames Watersheds, and Essex Region.

	Sydenham River	Thames River	Essex Region
Fish	Bigmouth Buffalo Blackstripe Topminnow Eastern Sand Darter Greenside Darter Northern Madtom Pugnose Minnow Spotted Gar Spotted Sucker	Bigmouth Buffalo Black Redhorse Eastern Sand Darter Gravel Chub Greenside Darter Northern Brook Lamprey Northern Madtom Pugnose Minnow Silver Shiner	Channel Darter Eastern Sand Darter Lake Chubsucker Pugnose Shiner Spotted Gar
Mussels	Kidneyshell Mudpuppy Mussel Northern Riffleshell Round Hickorynut Snuffbox Wavy-rayed Lampmussel	Kidneyshell Mudpuppy Mussel Rayed Bean Round Hickorynut Snuffbox Wavy-rayed Lampmussel	Mudpuppy Mussel Northern Riffleshell Rayed Bean Snuffbox Wavy-rayed Lampmussel
Reptiles	Spiny Softshell	Northern Map Turtle Eastern Ribbonsnake Queen Snake Spiny Softshell Spotted Turtle	Blue Racer Butler's Gartersnake Eastern Foxsnake Eastern Hog-nosed Snake Eastern Ratsnake Lake Erie Watersnake Massasauga Queen Snake Spiny Softshell

and the snuffbox mussel were present in several southern Ontario rivers but they are now found only in sections of the east branch of the Sydenham River. The wavy-rayed lampmussel requires clear water for successful reproduction and it is believed to be extirpated from the Sydenham River. Implementing the Sydenham River Recovery Plan involves all levels of government and will work towards restoring habitats and populations of aquatic species at risk in the watershed.

The original habitat of the Thames River watershed has also undergone change, with 78% of the land now in agricultural use, 9% in urban and roads, and only 13% remaining as forest or wetlands (Upper Thames River Conservation Authority 2001). The Thames River watershed can be divided at the Town of Delaware into upper and lower portions for discussion purposes. From the large swamp at the headwaters of the river to Delaware, the river drops ten times more steeply than the lower portion between Delaware and Lake St. Clair. The upper river is fast flowing with many rapids while the lower river flows more gently. The upper Thames River is an area where there is an overlap of the Carolinian Forest and the Great Lakes-St. Lawrence Forest regions.

The Thames River sustains one of the most diverse fish communities in Canada. The river's complex system of interconnected springs, swales, ravines and tributaries provide a broad range of habitats for 90 fish species. Not all of the 90 species can be found in every section of the Thames River, nor are all present at any given time. Approximately 25-30 species persist in the main branch and 58-63 species are more commonly found in the connecting streams. Ten species including walleye are migratory, spending their summers in Lake St. Clair, Lake Erie or Lake Huron and moving up the Thames River to spawn. Like the Sydenham River, the Thames River supports many aquatic species that have been designated by COSEWIC (Table 2) such as the eastern sand darter, the wavy-rayed lampmussel and the spiny softshell.

Surveys conducted by the Ontario Ministry of Natural Resources found very low numbers of larval walleye near the mouth of their primary spawning area, the Thames River, from 1992 to 1996. Flood and Lee (1996) determined that egg hatchability and fry survival were not related to nitrate levels, nor had there been a change in the quality or quantity of available spawning habitat. One possible causal factor may have been the reduction in chlorophyll levels that, in turn, contributed to a decline in zooplankton, an important food resource for larval walleye (Griffiths 1993).

The principle threats to tributary biodiversity are loss of riparian (streamside) buffers, anthropogenic erosion, non-point source runoff of nutrients and chemicals, and urban development.

Terrestrial Ecosystems

The flora in the Lake St. Clair watershed is extremely rich and diverse with more than 2,200 species of vascular plants, including 70 species of trees. Broad-leaf deciduous trees characterize the upland forests of the region. Trees that are common in this region include American beech, sugar maple, basswood, red oak and white ash. There are many less common species such as black walnut, butternut, sassafras, sycamore, tulip tree and black oak that survive here because of the long growing season. Coniferous trees are few, but include eastern hemlock, white pine, and red cedar. The transitional zone, between the upland forest areas and the open water of the lake or river, provides habitat for a number of water-tolerant species including eastern cottonwood, quaking aspen, and green ash. Interesting vines and shrubs can be found such as moonseed, burning bush and spice bush. Numerous species of wildflowers, ferns and sedges occupy the forest floor.

Tallgrass prairie is primarily grassland with few trees and a combination of grasses, sedges and forbes (wildflowers). Savanna is a term applied to places where prairie-type vegetation grows within scattered open-grown trees. The oak savanna ecosystem lies along a continuum between the tallgrass prairie and the true woodland ecosystem. Slender grasses with deep roots characterize these areas, including Canada wild rye, Indian grass, little blue stem and needle grass. Some of the sun-loving and colourful flowering plants include butterfly weed, wild bergamot and black-eyed Susan. Periodic burning was critical in maintaining the open conditions that kept many prairie and savanna plant species from being shaded or choked out. These open spaces were easy to convert to agricultural uses and it is estimated that less than 3% of the original habitat remains. Small pockets of tallgrass prairie are being re-established in areas with suitable habitat. The most extensive remnant prairie and oak savanna habitats can be found on Walpole Island in the St. Clair Delta.

The watershed supports a diverse mammal population and 36 species of mammals have been recorded. The Carolinian influence is reflected in the mammal community by species such as the southern flying squirrel and woodland vole, which are at the northern edge of their ranges in Ontario. At the same time, species such as porcupine, beaver and hairy-tailed moles that are associated with more northerly locations can be found in parts of the watershed. There are three migratory species of bats (hoary, eastern red and silver-haired) reported in the Atlas of the Mammals of Ontario (Dobbyn 1994). The badger, a mammal of the open grasslands, has a small remnant population in the Thames River watershed.

In addition to year-round resident bird species, the Lake St. Clair watershed provides breeding habitat, resting areas and wintering grounds for many different species. According to records collected for the Atlas of Breeding Birds of Ontario, 1981-1985 (Cadman et al. 1987), over 157 species of birds have been reported to breed in this area. This represents almost 55% of the bird species that breed in all of Ontario. In addition, another 86 species regularly migrate through the area. The St. Clair River RAP listed

90 bird species occurring in the vicinity of Lake St. Clair with 20 resident, 36 breeding, 25 migrant, and nine wintering species.

One of the more destructive invasive species to arrive in the Lake St. Clair watershed has been the emerald ash borer. This insect was first discovered in Canada in 2002 and has caused huge losses of ash trees in Essex County. The Canadian Food Inspection Agency (CFIA) has imposed a quarantine by Ministerial Order to prohibit the movement of all ash wood from Essex County. In addition, the CFIA has established an Ash-free Zone, an 8 km to 10 km zone free of ash trees, that runs from the northeast end of Essex Country from Lake St. Clair southeast for approximately 30 km. The purpose of the barrier is to prevent the eastward spread of the emerald ash borer. The CFIA is also removing all known infested ash trees in the county and all ash trees within a 500 m buffer of infested trees.

Fragmentation of habitat can have a significant effect on some species and terrestrial habitats have been highly impacted by changing land use. For example, forest birds can generally be classified as area sensitive or not area sensitive. Interior forest birds are area sensitive, require larger woodlands or more forest cover and will be adversely affected by fragmentation of the forest habitat. Often, no sheltered interiors remain for species adapted to forest habitats. The open edges have higher levels of light, nest parasitism and predation.

Habitat loss, invasive species, and fragmentation of remaining habitats threaten terrestrial biodiversity. The loss of natural areas for the development of agricultural and urban land uses has significantly impacted vegetation and wildlife populations. Tools such as the Essex County Biodiversity Conservation Strategy (Essex Region Conservation Authority 2002) and the Lambton County Natural Heritage Strategy (Corporation of the County of Lambton 1997), discussed in the Land Use section, promote sustainable development, restore habitat connectivity and increase the extent of remnant habitats.

Climate Change and the Ecosystem

Warmer temperatures and reduced ice cover are expected to result in lowered lake levels, potentially increasing the likelihood that wetlands will be altered and water quality will decline. Aquatic plant and animal species assemblages are likely to change as habitat alters. For example, with shorter seasons and lower water levels, aquatic plants may not survive in areas where they have existed for decades. As temperatures increase, cold water fish and invertebrate species will be found less frequently, and cool water and warm water species will increase in abundance as they expand their ranges northward. Shorebirds and waterfowl will likely experience alterations in their current migration patterns because of their dependence upon local wetland habitat. Losses of habitat and changes in flood patterns may reduce the ability of birds to successfully breed and may force migratory species to move farther north to reproduce.

Management Issues

- Disturbances and interruptions in the use of habitat by terrestrial and aquatic biota during sensitive periods of their life history (e.g., breeding, migration) caused by on-water activities (e.g., recreational boating).
- Impacts of land use activities on the hydrologic and/or sediment cycles are reflected in impaired quality or reduced quantity of aquatic habitats.
- Habitat loss and fragmentation associated with existing and future land uses have the potential to adversely affect fish and wildlife populations and species diversity.
- Invasive species have affected, and are expected to continue to affect, the ecology of Lake St. Clair and the diversity of species that live in and around it.
- Lake use activities are impacting terrestrial and aquatic biota, especially species at risk (i.e., species considered to be endangered, threatened, or of special concern).

Fishing and Hunting

Natural resources, including fish, waterfowl and mammals, are renewable and, if managed properly, can provide sustainable fishing and hunting opportunities for current and future generations of Ontarians. Appropriate management actions and informed decision making can ensure that game species are not over harvested and that they do not over populate limited habitat or food resources.

Recreational Fishing

The majority of anglers (56%) fishing in the Ontario waters of Lake St. Clair in 2002 were from Ontario (the majority were from Essex, Kent and Lambton Counties) with 44% of anglers from the United States. The region does provide numerous tourism opportunities with local sales of fishing licenses and bait, boat slips rentals, overnight accommodations, and charter and guiding services.

The OMNR conducted angler surveys regularly between 1978 and 1989, then again in 1992 and 2002. In general, angler surveys have shown that the overall time spent fishing in 2002 was 31% lower than it was a decade earlier in 1992. It was estimated that anglers spend almost 2.5 million hours annually fishing, including both summer and winter fisheries in Lake St. Clair (Michigan and Ontario waters combined), with an estimated harvest of 1.5 million fish (or 2 million pounds) annually. When the St. Clair River and Detroit River fisheries are included the angler effort increases to 5.0 million hours.

Survey results have also shown a dramatic shift in the preferences of recreational anglers. In the late 1970s and 1980s, 69% of anglers were interested in fishing Lake St. Clair for walleye. Other species of interest to anglers during those years included yellow perch, muskellunge, and smallmouth bass, ranked in decreasing order. In 1992, only 37% of anglers surveyed said they were fishing for walleye. Yellow perch and smallmouth bass were ranked second and third and their popularity with anglers had increased substantially to 24% and 20%, respectively. Interest in muskellunge fishing remained the same (approximately 10%). By 2002, yellow perch (31%), smallmouth bass (24%) and muskellunge (22%) were the preferred species for anglers and walleye (17%) had dropped to fourth place as ranked by angler preference.

Anglers come to fish in the Lake St. Clair watershed for a variety of reasons. Almost half of the yellow perch caught in Lake St. Clair are harvested and provide tasty and nutritional meals. In contrast, many smallmouth bass and most muskellunge anglers prefer to practise catch and release. In fact, only an estimated 1% of all muskellunge caught by anglers are harvested annually from Lake St. Clair.

The muskellunge fishery has become world renown and has become more appealing in recent years, in part because, on average, it took only six hours to catch a muskie in 2002 compared with the 33 hours it often took to catch a muskie in the 1970s and 1980s.

Overall, the current fishery is more similar to the fishery observed on Lake St. Clair in the 1940s. Smallmouth bass is again a species targeted by many anglers and this exceptional fishery is important to one quarter of Ontario anglers and attracts anglers from neighbouring states such as Ohio.

Although fishing is a potential stressor on the fish communities that reside in Lake St. Clair, the angling pressure currently observed on the lake is not viewed as a problem. One emerging issue that may develop with the growing popularity of spring and early summer fishing is the potential for high mortality rates for reproducing smallmouth bass that are caught and released out of season by anglers fishing for other species. The

OMNR is aware of this emerging issue and will address it with appropriate management actions if necessary.

Traditional Fishing

A traditional fishery exists in Lake St. Clair, on the Thames River and the St. Clair River using dip nets, roll nets and seine nets to harvest walleye on the Thames River and other species in the lake. Annual harvests for walleye have been estimated at 60,000 kg in the 1970s, 30,000 kg in the 1980s and 13,000 kg in the mid-1990s (MacLennan et al. in preparation).

There is one commercial licence held within the Walpole Island First Nation, and several families do exercise their right to harvest fish for subsistence.

Commercial Fishing

Commercial fishing prior to the 1900s contributed extensively to the decline of the lake herring and lake whitefish populations in Lake St. Clair. Commercial fishing activities have been exclusive to Canadian waters since the closure of the commercial fishery in Michigan waters in 1908. In 1970 all commercial fishing was closed because of high levels of mercury contamination in fish. The commercial fishery was opened in the fall of 1980 once mercury contamination had sufficiently abated. The re-opening of the fishery was under permit, with quota allocations (no walleye allocated) set by the OMNR and mandatory landings of some underutilized fish species (e.g., freshwater drum, white perch). From 1980-1984, the total fish landed was 110,000 kg (240,000 lbs) and catches were comprised primarily of carp, catfish, freshwater drum and suckers. Freshwater drum and carp populations had increased substantially while the fishery was closed, but were reduced in the early 1980s, suggesting that the commercial fishery harvest could be used as a tool to control populations of abundant, but underutilized, fish species (MacLennan et al. in preparation).

Low economic returns to the fishers from the sale of underutilized species, and the lack of walleye quota allocation to the commercial fishery (walleye were allocated to the sport fishery only), motivated 7 of 10 licensees to relinquish their licences back to the OMNR in 1985. After 1985, total annual catches were approximately 64,000 kg (140,000 lbs) dropping again to fewer than 9,000 kg (20,000 lbs) in the 1990s. By the late 1990s, the Lake St. Clair commercial fishery had been reduced to limited hook and line fishing for catfish and sturgeon, and seining for carp.

Several baitfish species such as emerald, mimic and spottail shiners, are captured live in Lake St. Clair and sold at local bait shops. There are two bait harvest areas with a total of 10 licence holders. In addition to baitfish, crayfish are also taken from the lake by bait harvesters.

Commercial fishing activities no longer represent an important stressor on Lake St. Clair.

Waterfowl Hunting

Lake St. Clair is the most important area in southern Ontario for migrating waterfowl, based on Canadian Wildlife Service (CWS) aerial waterfowl surveys. During the fall migration waterfowl use of the open shallow waters of Lake St. Clair and adjoining wetlands is higher than all other areas where waterfowl congregate in the fall in the Great Lakes region. Waterfowl hunters also flock to Lake St. Clair.

While the sale of migratory game bird hunting permits has declined in Ontario (Boyd et al. 2002), the Lake St. Clair area continues to host thousands of waterfowl hunters each fall. The marshes of Lake St. Clair have a long history as one of the premier waterfowling areas in the province. Mallards, canvasbacks, and scaup are the most common species harvested at Lake St. Clair.

Private hunt clubs, owned by Canadians and Americans, the St. Clair National Wildlife Area, and the Walpole Island First Nation have maintained and managed most of the remaining wetlands, preserving the extensive, critically important wetlands for a wide variety of wildlife species.

Waterfowl hunting continues to provide significant economic benefits, as well as heritage and cultural benefits. Waterfowl hunting opportunities are a mix of private clubs, commercial outfitters operating on private and public lands, Walpole Island First Nation, and the general public utilizing the public shoreline. The clubs contribute municipal taxes and employment for managers, guides and other staff, maintain facilities, and purchase and maintain equipment such as boats, outboards, fuel, tractors, pumps and vehicles. Many owners of farmland near the lake lease land for waterfowl hunting after the corn is harvested, thereby generating additional farm revenue.

Waterfowl hunters frequenting this area come from both Ontario and the United States and each hunter is required to purchase both an Ontario hunting license and a Federal Migratory Game Bird Hunting Permit. Those hunting on Walpole Island First Nation are also required purchase a Walpole Island First Nation hunting license.

On the Ontario side of Lake St. Clair waterfowl hunting is restricted by regulation (*Migratory Bird Conservation Act*) to within 300 metres of the shoreline, rush bed or stake line. This regulation was implemented to provide an extensive, low disturbance feeding and resting area for tens of thousands of waterfowl during the fall. However, the recent increase in fall recreational boating and fishing potentially threatens the benefits of this regulation and has resulted in locals clubs and individuals reporting declines in waterfowl use in some areas.

Wildlife Hunting

Turkey, pheasant, rabbit, deer, coyote and fox are hunted in the Lake St. Clair watershed. Harvest of these populations is regulated by season and by licence condition and is managed by the OMNR.

In 2003, the OMNR conducted a provincial mail survey of hunters holding a wild turkey licence. The results indicated that, of those hunters surveyed, approximately 4% of provincial turkey hunters hunted in management units within the Lake St. Clair watershed. The wild turkey is a native species in Ontario, but was extirpated a century ago because of unregulated harvest and loss of forest habitat. The OMNR, Ontario Federation of Anglers and Hunters and the Federation of Ontario Naturalists began a wild turkey restoration program in 1984 that has been successful in rebuilding the provincial populations.

Coyote and fox are hunted throughout the watershed. Rabbits, also hunted in the watershed, are primarily found in agricultural fields and in bush fringe areas.

Deer are managed by the OMNR using hunting licences and controlled hunts that have limited quota available for harvest. In the management unit that directly borders Lake St. Clair there have been 700-879 archery tags issued to deer hunters annually since 1999. In general, the time spent hunting in this management unit has increased annually from 8,160 days (in 2000) to 11,582 days (in 2003). Average annual deer harvest between 1999 and 2003 was 148 deer.

Controlled deer hunts do not occur on lands adjacent to Lake St. Clair but do occur in the watershed. In years when deer quotas are available, there are approximately 1,000 deer tags available to hunters. The OMNR estimates that deer harvests have increased in recent years, from 585 in 2001, 749 in 2002, to 765 in 2003 (all areas combined). In these controlled hunts it takes between seven and nine hunter days per deer and hunters usually take hunting trips that last between two and five days.

With continued management of wildlife hunting in the watershed, hunting should continue to be a recreational activity that does not put populations at risk.

Trapping

Muskrat and raccoon are important furbearers and are extensively trapped in the region. Fox and mink are also trapped in the watershed. Current harvest of these mammals by trapping does not put the populations at risk.

Management Issues

- Declining waterfowl use of some traditional feeding and resting areas has been linked to increases in fall recreational boating and fishing activities.
- Current levels of fishing and hunting are not detrimentally impacting on the fish and wildlife communities that reside in Lake St. Clair; however, spring and early summer fishing activity may harm populations of smallmouth bass if reproduction is interrupted.

MONITORING THE ENVIRONMENT

In general, monitoring programs and scientific studies cover an extremely wide range of parameters, often including emerging issues such as chemical pollutants. They are established to collect and analyze data, and to generate information. The data collected are used to assess the status of the ecosystem and the success (or failure) of corrective actions, determine the level of control of the treatment processes, and determine the compliance with the law. This information is needed to develop policy and legislation to address impacts. Specifically this information can be used to protect human health, determine ecosystem health, evaluate the impacts of discharges to the environment, and provide important insights into changes in the ecosystem.

Managing Monitoring Programs

Agency coordination of monitoring activities reduces duplication of effort and enables more efficient use of resources. This is challenging as monitoring programs and studies are created to support specific agency programs or legislation. The data are often collected during multi-year programs that have very specific protocols; thus, data are not always transferable from one program to another.

Standardized or harmonized sampling techniques and analyses are critical to obtain comparable data and interpretation of results. Current data collection programs establish quality assurance and quality control procedures to maintain accurate, relevant and useful databases. From time to time, procedures are upgraded and changed to reflect new information, equipment and technology.

Recognizing these concerns, Environment Canada, U.S. Environmental Protection Agency, Ontario Ministry of Environment and Michigan Department of Environmental Quality agreed in 1998 to establish a Monitoring Upper Great Lakes Connecting Channels (MUGLCC) committee to aid in coordinating monitoring efforts binationally. This committee was to identify and report biennially on the status of existing monitoring programs, identify gaps in monitoring activities to address management concerns, and facilitate collaboration and coordination of monitoring. In 2000, the MUGLCC committee released the *Monitoring Upper Great Lakes Connecting Channels Inventory of Activities* report. The report was updated in 2002.

In the fall of 2001, the Binational Executive Committee (BEC), formed under the *Great Lakes Water Quality Agreement*, directed the U.S. and Canadian federal, state and provincial governments with environmental manadates to develop an on-line monitoring inventory for the Great Lakes basin, including Lake St. Clair. This on-line monitoring inventory is now available at www.binational.net. BEC further directed that annual workshops be hosted to provide opportunities to enhance monitoring coordination, and that annual status reports be prepared that included gap analyses and recommendations for steps to improve monitoring coordination.

In 2002, Conservation Ontario released *Recommendations for Monitoring Ontario's Water Quality*. The recommendations will help conservation authorities consider improvements to their water quality networks in their planning activities, and will assist with the implementation of a holistic water quality monitoring system. The recommendations will also serve as a focal point for discussions with municipal, provincial, and federal agencies.

Additional information is being collected as part of the St. Clair River RAP monitoring of the St. Clair River Area of Concern. Efforts towards protecting species at risk are helping to synthesize the existing biophysical information for the Sydenham and Thames Rivers. New and evolving issues may require adjustments to the monitoring programs and additional studies to obtain information and develop policy.

Managing Monitoring and Scientific Information

Managing the information from monitoring programs and studies is critical to adaptive, results-based watershed management. To this end, a Lake St. Clair watershed monitoring program should include the entire St. Clair River, Lake St. Clair and Detroit River corridor.

Reporting is an end product of the information management process. Providing the public with current information is an important component. Many agencies involved in the monitoring programs are now taking advantage of modern technology to establish websites that provide public access to information. For example, Canada and Ontario have been actively involved in the development of a binational on-line monitoring inventory as directed by BEC. The ultimate goal of this is an on-line inventory system. As a first step towards realizing this, a St. Clair River-Detroit River corridor monitoring inventory, that includes information about where data and information are maintained and accessible, can be accessed through the web. Throughout this report a number of websites have been identified that provide information.

The conversion of scientific data and reports into a format for communication to the general public is one of the challenges facing the scientific community. Attention to standardized reporting helps the interpretation of monitoring data and analyses. In 2002, a *Conservation Authority Guide to Watershed Reporting* was produced to develop standards for reporting by Ontario's conservation authorities. The intent was to have practical and achievable standards to produce effective and comparable state of the watershed reports.

Current Data Collection Programs

Appendix 1 contains a summary of monitoring and science programs that have provided information to this report. It is intended to provide a brief reference for monitoring activities in the Lake St. Clair watershed. A more complete listing of monitoring programs in the Canadian waters of Lake St. Clair has been created by the Committee for Monitoring Upper Great Lakes Connecting Channels and can be found on the Binational Executive Committee website at www.binational.net.

Management Issues

- A program or policy approach to watershed research, monitoring, and reporting, is not as effective as a coordinated, ecosystem approach.

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APPENDICES

Appendix I: List of Monitoring / Science Programs Referenced in the Text

Topic	Program Name	Lead Agency
Drinking Water	Ontario Drinking Water Surveillance Program	OMOE
	Mandatory sampling as required by regulations	Owners/Operators
Recreational Waters	Beach sampling programs	Local Health Units
	Angler creel surveys	OMNR
Fish and Wildlife Consumption	Ontario Sport Fish Contaminants Monitoring Program	OMNR & OMOE
	Ontario Young-of-the-year Fish Monitoring Program	OMOE
Status of the Ecosystem	Ontario Provincial Water Quality Monitoring Network	OMOE, local Conservation Authorities
	Great Lakes Nearshore Monitoring Program	OMOE
	Investigative Monitoring Program (Dow Chemical Canada Inc.)	OMOE
	Sydenham River Habitat Stewardship sampling program	St. Clair Region Conservation Authority
	Municipal Drain Classification Project	Fisheries and Oceans Canada & local conservation authorities
	Ontario Provincial Ground Water Monitoring Network	OMOE, local Conservation Authorities
	St. Clair River Water Quality Assessment Program	Sarnia-Lambton Environmental Association
	Great Lakes Marsh Monitoring Program	Environment Canada, Bird Studies Canada
	Southern Ontario Bald Eagle Monitoring Project	Environment Canada
	Great Lakes Herring Gull Egg Monitoring Program	Environment Canada
	Corridor Water Quality Monitoring Program	Environment Canada
	St. Clair River, Lake St. Clair & Detroit River Suspended Sediment Characteization	Environment Canada
	Benthic Sampling Program: St. Clair River	St. Clair Region Conservation Authority
	Benthic Sampling Program: Thames River	Upper Thames River Conservation Authority
	Benthic Sampling Program: Sydenham River	St. Clair Region Conservation Authority
	Benthic Sampling Program: Essex County	Essex Region Conservation Authority
	Lake St. Clair/St. Clair Delta Native Freshwater Mussel Survey	Environment Canada
	Status of fish stocks in Lake St. Clair	OMNR - Lake Erie Management Unit
Discharges to the Environment	Clean Water Regulations (MISA) Monitoring Data Ontario Point Sources	OMOE
	Other point source monitoring data	OMOE
	Integrated Atmospheric Deposition Network	Environment Canada
	Provincial Air Quality Monitoring Network	OMOE
	National Pollutant Release Inventory (NPRI)	Environment Canada

Appendix 2: List of Acronyms Referenced in the Text

AOC: Area of Concern
BEC: Binational Executive Committee
BTEX: benzene, toluene, ethylbenzene, xylenes
CCG: Canadian Coast Guard
CCME: Canadian Council of Ministers of the Environment
CEPA: Canadian Environmental Protection Act
CFIA: Canadian Food Inspection Agency
COA: Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem
CofA: Certificates of Approval
COSEWIC: Committee on the Status of Endangered Wildlife in Canada
CSO: combined sewer overflows
CURB: Clean Up Rural Beaches
CWS: Canadian Wildlife Service
DDT: Dichloro-diphenyl-trichloroethane
DFO: Fisheries and Oceans Canada
DWS: Drinking Water Surveillance Program
EAA: Ontario Environmental Assessment Act
EBR: Environmental Bill of Rights
EC: Environment Canada
GLWQA: Great Lakes Water Quality Agreement
GRT: Gross Registered Tonnes
IJC: International Joint Commission
LaMP: Lakewide Management Plan
MISA: Municipal-Industrial Strategy for Abatement
MUGLCC: Monitoring Upper Great Lakes Connecting Channels
ODWO: Ontario Drinking Water Objectives
OMAF: Ontario Ministry of Agriculture and Food
OMMAH: Ontario Ministry of Municipal Affairs and Housing
OMNR: Ontario Ministry of Natural Resources
OMOE: Ontario Ministry of Environment
OWRA: Ontario Water Resources Act
OWRC: Ontario Water Resources Commission
PAH: polycyclic aromatic hydrocarbons
PBDE: polybrominated diphyenyl ether
PCB: polychlorinated biphenyls
POP: Persistent Organic Pollutants, include PCBs, DDT, Chlordane, dioxins and furans
RAP: Remedial Action Plan
SARA: Species at Risk Act
SLEA: Sarnia-Lambton Environmental Association (formerly the Lambton Industrial Society)
SOE: State of Canada's Environment
SPP: Source Protection Plans
TOC: total organic carbon
UGLCCS: Upper Great Lakes Connecting Channels Study
U.S. ACE: United States Army Corps of Engineers
U.S. EPA: United States Environmental Protection Agency
WPCP: Wastewater pollution control plants