



# Thames-Sydenham and Region Watershed Characterization Report

**St. Clair Region Source Protection Area**

*Volume 1*

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Prepared by --



-- in cooperation with --



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# **Watershed Characterization Report**

## **St. Clair Region Source Protection Area**

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# Watershed Characterization Report

## St. Clair Region Source Protection Area

### 1 Introduction

In May of 2000, bacteria entered the drinking water supply of Walkerton, making more than 2000 people sick and resulting in the deaths of seven people. The government of Ontario called an inquiry into the incident. Justice Dennis O'Connor was mandated to determine what caused the deaths and to make recommendations to improve drinking water safety.

In 2002, Justice O'Connor's findings were released in two volumes. Part One<sup>1</sup> presented his findings related to the events. Part Two<sup>2</sup> provided recommendations to safeguard drinking water. He recommended that drinking water be protected by means of a multiple barrier approach including water source protection.

Recommendation 1 of Part 2 of the O'Connor Report stated that "Drinking water sources should be protected by developing watershed-based source protection plans. Source protection plans should be required for all watersheds in Ontario"<sup>3</sup>.

Recommendation 2 indicated that "The Ministry of the Environment should ensure that draft source protection plans are prepared through an inclusive process of local consultation. Where appropriate, this process should be managed by Conservation Authorities".

The Lower Thames Valley, Upper Thames River and St. Clair Region Conservation Authorities (LTVCA, UTRCA, and SCRCA) formed a partnership in 2005 to share source protection efforts and resources. The CAs saw this as an opportunity to co-ordinate the development of source protection plans for their Source Protection Areas. Under the Clean Water Act, the three Source Protection Areas are designated as the Thames-Sydenham and Region Source Protection Region. The Upper Thames River Conservation Authority is the lead agency to co-ordinate the work.

Since forming the partnership, staff members from the three Conservation Authorities have worked to collect available background information. As part of this work, Watershed Characterization Reports have been prepared summarizing the physical characteristics, water quality and water use for the local areas. This Watershed Characterization Report outlines the information for the St. Clair Region Source Protection Area. A similar report summarizes information for the combined watersheds of the Lower Thames Valley and the Upper Thames River Source Protection Areas.

Ultimately, it is expected that local stakeholders, through their representation on the Source Protection Planning Committee (SPPC) and the associated working groups, will guide the development of the Source Protection Plans. It is anticipated that the role of the Conservation Authorities will be one of facilitation in the development of the plans. Technical expertise will be available to the Source Protection Planning Committee as well as communications and consultation services.

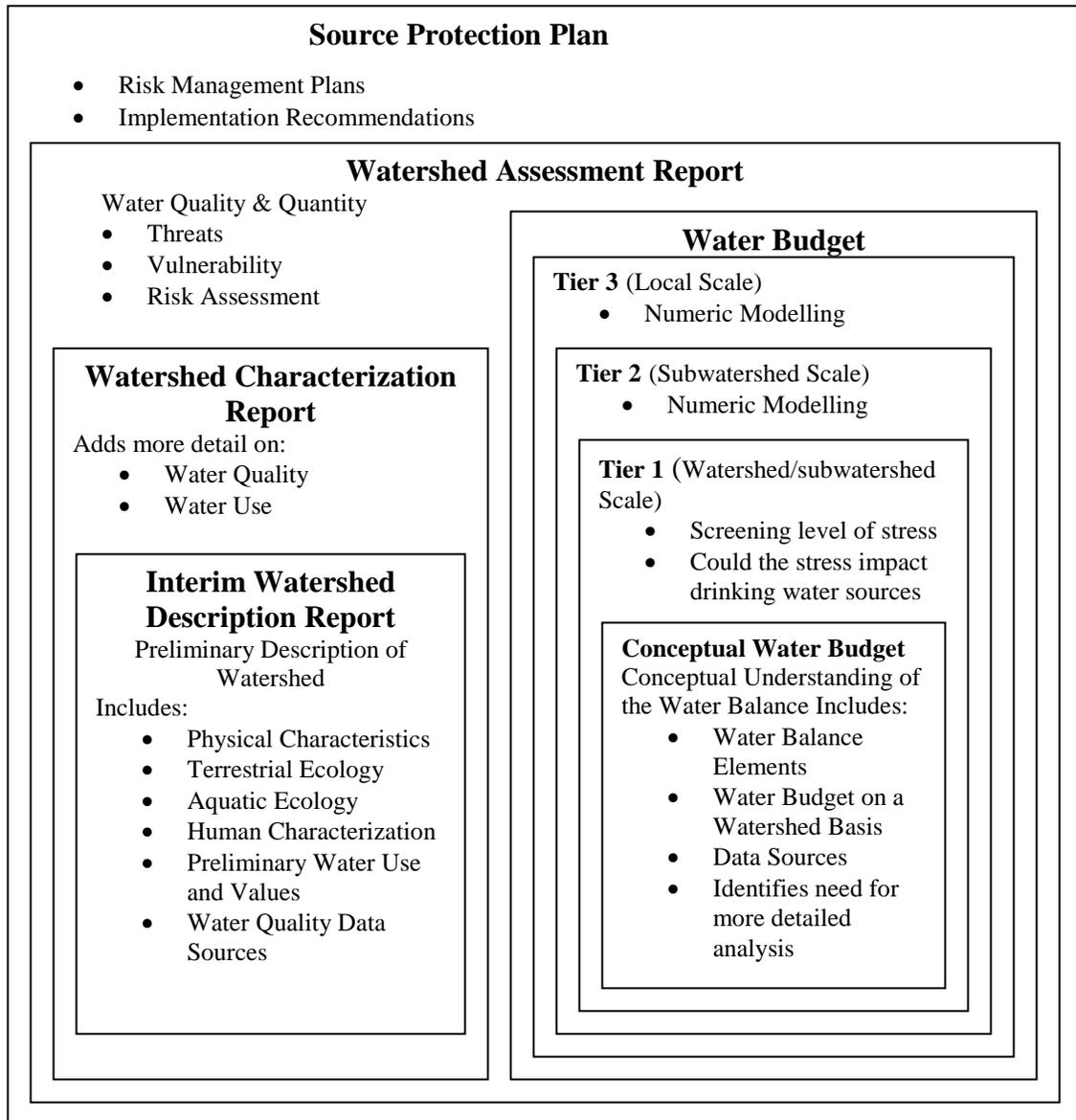
**Figure 1.0-1: Summary of Components for Source Protection Plans** illustrates the "building block" nature anticipated for source protection.

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<sup>1</sup> Ontario Ministry of the Attorney General. 2002a. Part One. Report of the Walkerton Inquiry: The Events of May 2000 and Related Issues.

<sup>2</sup> Ontario Ministry of the Attorney General. 2002b. Part Two. Report of the Walkerton Inquiry: A Strategy for Safe Drinking Water.

<sup>3</sup> Status of Part Two Recommendations, Report of the Walkerton Inquiry. OMOE website, May 2006.



**Figure 1.0-1: Summary of Components for Source Protection Plans**

The **Interim Watershed Description Report** compiled information on the physical, sociological and economic characteristics of the local watershed. This interim product was circulated to local municipalities for preliminary review and comment.

The **Watershed Characterization Report** is divided into three volumes. **Volume 1** of the report includes the information collected for the Interim Watershed Description Report, with revisions made to address comments received from the municipalities. **Volume 2** provides a summary and review of existing information on surface water, groundwater and drinking water quality for the St. Clair Region Source Protection Area. **Volume 3** provides a preliminary review of water usage, an outline of known issues pertaining to drinking water sources and a brief discussion of potential drinking water threats. It also includes a summary of data and knowledge gaps, list of references and list of acronyms. A **Book of Maps** has also been Prepared and contains the series of maps that help illustrate the information in the report.

The **Water Budget** focuses on water supply and is being prepared in parallel with the Watershed Characterization Report. A **Draft Conceptual Water Budget Report** has been completed for the Source Protection Region. Work is underway on the next stages of the Water Budget by developing a **Tier 1 Water Budget Report** for the St. Clair Region Source Protection Area. A combined report for the Upper Thames River and Lower Thames Valley Source Protection Areas is also being prepared.

The **Watershed Assessment Report** will be developed using information from the Watershed Characterization Report and the Water Budget.

The **Source Protection Plans** will be established based on the Watershed Assessment Reports for the Source Protection Areas.

## 1.1 Data Sources

A wide range of data sources have been used as resources to prepare the Watershed Characterization Report and the accompanying maps.

Water quality data sources include information from the Provincial Water Quality Monitoring Network (PWQMN), the Provincial Groundwater Monitoring Network (PGMN), the Drinking Water Information System (DWIS), the Drinking Water Surveillance Program (DWSP) and water plant operation reports.

In the report, references for the data sources are provided as footnotes. For the maps, sources of information are identified in the map legends.

## 1.2 Data and Knowledge Gaps

During the preparation of the report, some data and knowledge gaps were found due to data being unavailable, incomplete, inadequate or inaccurate.

For the Watershed Characterization Report, the data gaps are discussed in the sections where they are identified. The identified data gaps are also summarized in a spreadsheet in **Volume 3, Appendix A: Data and Knowledge Gaps**.

On the maps, information gaps are identified as part of the map legend.

## 2 Watershed Description

**Map 1: Thames-Sydenham and Region Source Protection Region** shows the regional boundary and the watersheds of the three Source Protection Areas that make up the Source Protection Region.

The Watershed Description Section is intended to provide an assessment of the fundamental natural and human-made characteristics of the St. Clair Region Source Protection Area.

### 2.1 Source Protection Region

In 2002, Justice O'Connor recommended that drinking water be protected by means of a multiple barrier approach. This multi-barrier approach includes:

- Source protection
- Treatment
- Monitoring and testing
- Distribution system
- Training

The Province of Ontario made a commitment to implement the recommendations in the O'Connor report, including the development of source protection plans.

In 2003, acting on the recommendations<sup>4</sup> of the Advisory Committee on Watershed-based Source Protection, the provincial government established two expert committees: the Technical Experts Committee (TEC) and the Implementation Committee (IC). The Technical Experts Committee was asked to produce a set of recommendations<sup>5</sup> related to a “threats assessment framework” while the Implementation Committee was asked to provide advice<sup>6</sup> on tools and approaches to implement watershed-based source protection planning.

In 2004, the government's White Paper<sup>7</sup> on Watershed-based Source Protection Planning provided an opportunity for stakeholder comment and public input on proposed legislation. A Source Water Implementation Group (SWIG) was formed to draft guidance modules<sup>8</sup> for developing assessment reports.

Conservation Authorities (CAs) were recognized by many to be a logical organization to facilitate the development of Source Protection Plans on a watershed basis. They are organized on a watershed basis pursuant to the Conservation Authorities Act (1946).

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<sup>4</sup> Ontario Ministry of the Environment. April 2003. The Final Report: Protecting Ontario's Drinking Water: Toward a Watershed-based Source Protection Planning Framework. Advisory Committee on Watershed-based Source Protection Planning. Final Report.

<sup>5</sup> OMOE. November 2004. Watershed-based Source Protection Planning - Science-based Decision-making for Protecting Ontario's Drinking Water Resources: A Threats Assessment Framework. Technical Experts Committee Report to the Minister of the Environment.

<sup>6</sup> OMOE. November 2004. Watershed-based Source Protection. Implementation Committee Report to the Minister of the Environment.

<sup>7</sup> OMOE. February 2004. White Paper on Watershed-based Source Protection Planning.

<sup>8</sup> OMOE. April 2006. Assessment Report: Guidance Modules.

The White Paper on Watershed-based Source Protection Planning recognized that planning might be developed over an area that was larger than an individual CA's area. Co-ordination of the work to prepare plans would allow for the pooling of resources and the sharing of expertise. In light of this recommendation, many CAs developed partnerships in anticipation of legislation that would support establishing Source Protection Regions.

The Lower Thames Valley Conservation Authority (LTVCA), Upper Thames River Conservation Authority (UTRCA), and St. Clair Region Conservation Authority (SCRCA) formed such a partnership in 2005.

In 2007, Ontario Regulation 284/07 under the Clean Water Act established the Thames-Sydenham and Region Source Protection Region (SPR) that includes three Source Protection Areas corresponding to the watersheds of the three Conservation Authorities. The Source Protection Region and the three Source Protection Areas are shown in **Map 1: Thames-Sydenham and Region Source Protection Region**.

The St. Clair Region Source Protection Area covers the St. Clair Region Conservation Authority (SCRCA) watershed. **Map 2: Drainage Areas** provides an overview of the major subwatersheds in the St. Clair Region Source Protection Area. The main watercourse is the Sydenham River. As part of the discussion of naturally vegetated areas and aquatic ecology, the Sydenham River has been divided into seven subwatersheds that reflect differences in the watercourses, soil and other characteristics of the drainage area. The rest of the SCRCA watershed is subdivided into the three areas that drain into Lake Huron, the St. Clair River or Lake St. Clair. Each of these areas has several smaller watercourses that discharge directly into Lake Huron, the St. Clair River or Lake St. Clair.

The SCRCA was originally established in 1961 as the Sydenham Valley Conservation Authority under the Conservation Authorities Act to conserve renewable natural resources in the local watersheds. It had a jurisdiction that included all areas draining into the Sydenham River. In 1973, the area of jurisdiction was expanded to add in several small watersheds including: three that drain directly into Lake St. Clair, four that drain into the St. Clair River and several watersheds that drain directly into Lake Huron. In 2005, the jurisdiction was expanded again to include small watercourses draining to Lake Huron west of the Ausable-Bayfield Conservation Authority's watershed.

The Vision of the SCRCA reflects the future desired state of the region as:

*The St. Clair Region Conservation Authority has as its vision, watersheds where human needs are met in balance with the needs of the natural environment.*

This vision cannot be achieved in isolation and the SCRCA Mission is summarized as:

*The St. Clair Region Conservation Authority has as its mission, to provide leadership through coordination of watershed planning, implementation of resource management programs and promotion of conservation awareness, in cooperation with others.*

To minimize duplication and maximize effectiveness, partnerships are forged and cooperation with other organizations fostered to meet the challenges facing the organization. Several past and current projects reflect the Vision and Mission of the Conservation Authority.

In 1965, the Sydenham Valley Conservation Report was completed summarizing information on land, forest, wildlife and recreation. A separate report was also completed on water identifying several flood control measures that should be considered as funds became available. These reports provided the basis for land acquisition and construction of dykes and dams along the Sydenham River both for flood control and recreation.

For example, in 1970, the Coldstream Dam and Reservoir were completed creating a 16-acre lake to provide recreational and water storage. Also, approximately 140 acres of land were acquired in the vicinity of Warwick Village to provide for a new dam and lake similar to Coldstream.

In the early to mid 1970s, the Authority coordinated the construction of more than 16 km of dykes along the watercourses in the southern part of the St. Clair Region to prevent flooding caused by high water levels in Lake St. Clair.

One of the largest flood protection projects was the W. Darcy McKeough Floodway, located on the North Sydenham River. The floodway is designed to protect Wallaceburg and portions of the former Townships of Chatham and Sombra from severe flooding. Completed in 1984, the dam can be operated to divert high flows to the St. Clair River via the floodway water.

Flood protection and erosion control continues to be a significant part of the Authority's role in protecting life and property. In 2006, the final phase of the Point Edward Waterfront Shore Protection Project was undertaken. The waterfront protection and public access project began in 1995 and over 1 kilometre of shoreline is now available to the public. The stepped armour stone slope provides natural and durable shore protection.

In 2007, the St. Clair River Shoreline Inventory was completed to document the condition of the shore protection along the river and identify opportunities for shoreline habitat improvement.

Water quality monitoring and evaluation is also an important aspect of the Authority's ongoing operation. In the late 1980s and early 1990s, as part of the Clean Up Rural Beaches (CURB) program, the Bear Creek Water Quality Study 1988-89, the Highland Creek Water Quality Study 1989-90, and the CURB Plan for the Bear Creek and Perch Creek Watershed 1992 were prepared. More recently the Conservation Authority has initiated a process to develop Watershed Report Cards to provide a user friendly method of reporting environmental monitoring to the public.

As shown in **Map 25: Generalized Land Cover**, the watershed is primarily agricultural with several areas of urban/industrial development. It supports a variety of natural landscapes including wetlands and forests with Carolinian Canada sites that are home to many species at risk.

## 2.1.1 Stakeholders and Partners

The St. Clair Region Conservation Authority includes most of Lambton County, part of Middlesex County, and part of the Municipality of Chatham-Kent. The watershed area covers approximately 4,100 square kilometres with a total population of 167,000 in the year 2000.

### *Municipalities*

As shown on **Map 2: Drainage Areas**, the SCRCA membership includes the following municipalities.

- The single-tier Municipality of Chatham-Kent
- The Lambton County lower-tier municipalities of:
  - Municipality of Brooke-Alvinston
  - Township of Dawn-Euphemia
  - Township of Enniskillen
  - Municipality of Lambton Shores
  - Village of Oil Springs
  - Town of Petrolia
  - Town of Plympton-Wyoming
  - Village of Point Edward
  - City of Sarnia
  - Township of St. Clair

- Township of Warwick
- The Middlesex County lower-tier municipalities of:
  - Township of Adelaide-Metcalf
  - Municipality of Middlesex Centre
  - Village of Newbury
  - Municipality of Southwest Middlesex
  - Municipality of Strathroy-Caradoc

The Conservation Authority has been assisting with the development of the Point Edward Waterfront Park including shore protection along the river. Partners included the Province of Ontario, Bluewater Bridge Authority, Lambton Area Water Supply System, and Village of Point Edward.

In addition to the member municipalities, SCRCA has a good working relationship with both upper-tier county municipalities.

### ***First Nations***

Three First Nations are located in the St. Clair Region Source Protection Area watershed:

- Chippewas of Kettle & Stony Point First Nation
- Aamjiwnaang First Nation
- Bkejwanong Territory (Walpole Island First Nation)

### ***Provincial Agencies***

Conservation Authorities have ongoing interaction with a number of Provincial Ministries and Agencies. Some examples include:

*Ministry of the Environment:* The SCRCA is a partner in both the Provincial Water Quality Monitoring Network for surface water and the Provincial Groundwater Monitoring Network.

*Ministry of Natural Resources:* The SCRCA helped to map wetlands in the region and provides land use planning comments to local municipalities regarding the protection of wetlands from development activities.

*Ministry of Agriculture, Food and Rural Affairs:* SCRCA provides inspection services and minor maintenance for the Agricultural and Rural Development Act dykes and, in 2002-04, undertook the Healthy Futures Program in Lambton County.

*Ministry of Municipal Affairs and Housing:* SCRCA exchanges comments regarding planning issues for plans of subdivision, official plans and Ontario Municipal Board hearings.

*Ministry of Northern Development and Mining:* There is little recent involvement with the Mining and Lands Commissioner but there was some in the past.

*Neighbouring Conservation Authorities:* SCRCA and adjacent CAs use joint Public Service Announcements to advertise species at risk in watersheds and grants available for landowners. SCRCA provides forestry services to the Ausable-Bayfield Conservation Authority and has worked in co-operation with the Upper Thames River Conservation Authority to sample fish communities within the SCRCA watershed. Staff members sit on combined local technical committees such as the Southwestern Ontario Flood Forecasting Alliance.

*Conservation Ontario:* The SCRCA General Manager serves on the CO executive and staff members participate on CO committees.

## ***Federal Government***

The St. Clair Region Conservation Authority has had and continues to have involvement with various federal government agencies. Some examples include:

*Fisheries and Oceans Canada (DFO):* SCRCA carried out field work to characterize municipal drains under the Fisheries Act Class Authorization System and currently provides the initial review of applications for work on drains.

*Environment Canada:* SCRCA was one of the lead agencies involved in the development of The Lake St. Clair Canadian Watershed Draft Technical Report (January 2005). As part of the involvement with the St. Clair River Area of Concern, SCRCA carried out a field investigation to inventory and document the condition of shore protection along the river. This work was intended to identify opportunities for shoreline habitat improvements to support the Remedial Action Plan. A grant from Environment Canada through the EcoAction Community Funding Program was used to enhance the shoreline of the Strathroy Reservoir on the East Sydenham.

## ***Interested Stakeholders, Engaged Public and Non-Governmental Organizations***

- Health units
- Agricultural groups
- Environmental non-government organizations
- Ratepayer/neighbourhood groups
- Sports and recreation groups
- Educational institutions
  - Elementary schools
  - Post secondary institutions
  - Libraries
  - Other organizations with public education programs
- Industrial and commercial organizations and major industries
- Media

There are a number of agricultural organizations including commodity groups and conservation groups. In general, every farm belongs to one of the following organizations: Ontario Federation of Agriculture, Christian Farmers Federation of Ontario, or the National Farmers Union. The agricultural sector was engaged with the assistance of the Ontario Ministry of Agriculture, Food and Rural Affairs County Representatives, e-newsletters and advertisements in provincial and local farm media (39 newspapers), and letters to representatives of Farm Associations.

Major industry or commercial activities within the area include chemical, manufacturing and retail. The petro-chemical industry in Sarnia and St. Clair Township can be engaged through the Sarnia Lambton Environmental Association, a cooperative of chemical valley companies with 20 members. Membership lists from local Chambers of Commerce were used to direct mail to other industries and businesses that could be impacted by or have an interest in the Clean Water Act. A total of 47 industries and 15 commercial businesses in the St. Clair Region were contacted. In addition, advertisements for forums targeted to business were placed in 39 newspapers throughout the region. Oil and gas operations are particularly prominent in Lambton County and in Chatham-Kent. Contact was made with the Ontario Petroleum Institute to engage this group. A list of aggregate operations in the region was obtained from the Ontario Aggregate Resources Corporation which included contacts in the St. Clair region.

Recreation: Golf courses, marinas, campgrounds and cottage associations were targeted as recreation activities that may be impacted by the Clean Water Act. Twenty golf courses, seven marinas, 18 campgrounds and seven cottage associations were contacted in the St. Clair Region. In addition, advertisements for forums targeted to business were placed on 39 newspapers throughout the region.

Academics: The region includes the University of Western Ontario, Fanshawe College and Lambton College. Contacts were made with appropriate faculty at each of these institutions.

## 2.2 Physical Description

This section is intended to provide background on the physical setting for the St. Clair Region Source Protection Area.

The physical characteristics of the region include a wide range of unique properties. The bedrock, overburden, surficial geology, soil characteristics, physiography and topography all have significant impacts on groundwater hydrology and surface water drainage.

The availability of water and the physical characteristics of the region had significant impacts on the area's human settlement and development. In turn, human activities have had an effect on water quality and flow in the watershed.

### 2.2.1 Bedrock Geology

The bedrock geology has been interpreted by the Ontario Ministry of Northern Development and Mines and the Ontario Ministry of Natural Resources, using information from water well records and borehole logs from oil and gas wells.

The entire Province of Ontario is underlain by ancient Precambrian rocks<sup>9</sup>. These rocks were laid down during the Proterozoic Period (2.5 billion to 545 million years ago), as landmasses or terrains separated by small oceans pushed together. This period of continental collision formed the Grenville Province portion of the Canadian Shield<sup>10</sup>. In southern Ontario, the Canadian Shield gneisses, granites and volcanic rocks are buried deep beneath Paleozoic rocks, which were then covered by Quaternary (glacial and interglacial) sediments.

The bedrock topography for the St. Clair Region Source Protection Area is shown in **Map 3: Bedrock Topography**. There is an area of higher bedrock in the Warwick area with a general slope to the west toward the St. Clair River. The bedrock topography approximates the surface topography with the lowest bedrock surface elevations correlating with the shorelines of Lake Huron, Lake St. Clair and the St. Clair River.

The Proterozoic basement rocks underwent varying amounts of crustal displacement from the time of their deposition (1.3 to 1.1 billion years ago) to the time when the overlying Paleozoic rocks were deposited approximately 545-300 million years ago<sup>11</sup>. This intense crustal displacement caused differential regional uplift and depression of the Precambrian basement. This resulted in the formation of three main structural elements: the Michigan Basin, the Appalachian Basin, and the Findlay-Algonquin Arch, shown in **Figure 2.2.1-1: Bedrock Structural Elements**<sup>12</sup>. These three structural elements had a significant impact on the nature and form of the sedimentary rocks deposited beneath the region.

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<sup>9</sup> Ontario Geoscience Resources Network. Ontario Through Time. [www.ontariogeoscience.net](http://www.ontariogeoscience.net).

<sup>10</sup> Easton, M. 1992. The Grenville Province and the Proterozoic history of central and southern Ontario. *In*: Thurston, P.C., H.R. Williams, R.H. Sutcliffe, G.M. Stott (Eds.), *Geology of Ontario, Special Volume 4, Part 2*. Ontario Geological Survey, Toronto, p. 714-904.

<sup>11</sup> Johnson, M.D., D.K. Armstrong, B.V. Sanford, P.G. Telford and M.A. Rutka. 1992. Paleozoic and Mesozoic Geology of Ontario. *In*: *Geology of Ontario, Ontario Geological Survey, Special Vol. 4, Pt. 2*, p. 907-1010.

<sup>12</sup> Michigan State University Department of Geography. Geo. 333 Geography of Michigan and the Great Lakes Region, [www.geo.msu.edu/geo333/MIbasin.html](http://www.geo.msu.edu/geo333/MIbasin.html).

The broad Findlay-Algonquin Arch is a basement ridge forming the spine of the southwestern Ontario peninsula. This Precambrian structural feature is comprised of the Algonquin Arch, stretching from Chatham to Collingwood, and the Findlay Arch, extending from Essex County to Cincinnati, Ohio.

The Findlay-Algonquin Arch was active until the late Devonian Period in the middle of the Paleozoic Era. It acted as an open, shallow water barrier or transition zone that greatly influenced sedimentation patterns by separating the Michigan Basin and Appalachian Basin. The basins served as catchment areas for sediments and over time, the sediments became rock. The deposits in the basins initially overlapped and ultimately overlapped the arch. As a result, several of the geologic formations within southern Ontario thin towards the Findlay-Algonquin Arch<sup>13</sup>.

The Michigan Basin is a large, regional geologic structure that is generally a circular, deep (approximately 4200 m), carbonate-dominated sedimentary basin centred in the State of Michigan. It consists of a large bedrock depression with a series of concentric rings of outcropping rock units that get progressively older as you move outward from the basin centre.

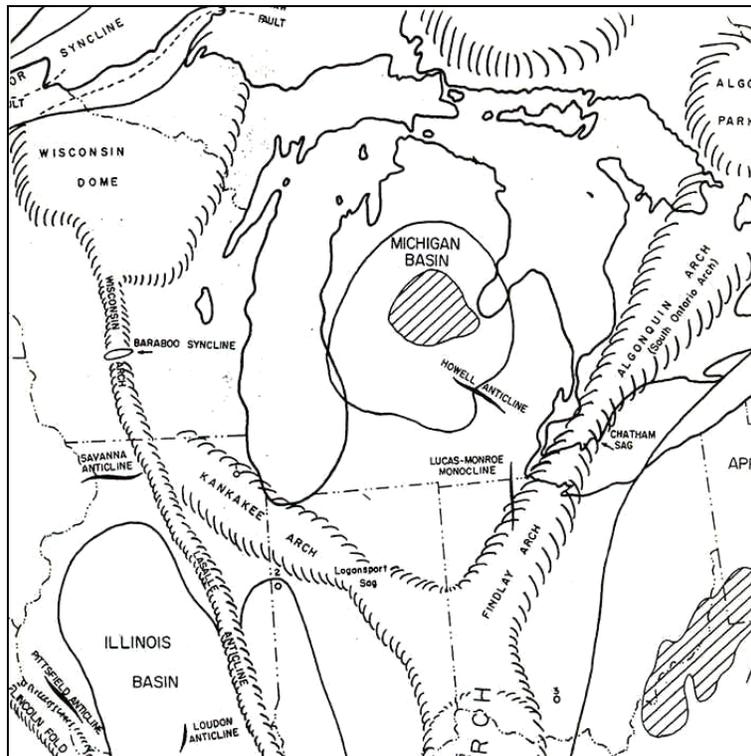
The St. Clair Region Source Protection Area is located on the eastern edge of the Michigan Basin. In the western portion of the source protection area, the bedrock units exhibit a regional dip (slope) of 0.2% to the southwest similar to what is observed across the eastern side of the Michigan Basin.

The bedrock topography is slightly depressed in the Chatham area. This broad, low-lying area between the crests of the Findlay and Algonquin Arches is commonly referred to as the “Chatham Sag”<sup>14</sup>. To the south, the northern edge of the Appalachian Basin reaches under Lake Erie and parts of southern Ontario. It is a large, elongate siliciclastic-dominated foreland basin located in eastern United States. The bedrock units near Lake Erie exhibit a regional dip of 0.5% to the south as is observed across the Appalachian Basin (Johnson et al., 1992).

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<sup>13</sup> Johnson, M.D., D.K. Armstrong, B.V. Sanford, P.G. Telford and M.A. Rutka. 1992. Paleozoic and Mesozoic Geology of Ontario: *in* Geology of Ontario, Ont. Geol. Surv., Special Vol. 4, Pt. 2, p. 907-1010.

<sup>14</sup> Ontario Geological Survey. 1992. Geology of Ontario Special Volume 4, the Paleozoic and Mesozoic Geology of Ontario, Part 2.



**Figure 2.2.1-1: Bedrock Structural Elements**

## Paleozoic Bedrock of Southern Ontario

The rise and fall of the Canadian Shield during the Paleozoic Era led to the deposition of shallow (carbonates, sandstones) and deep water (shales, siltstones) groups of rocks within the interior of North America. Carbonate rocks include the Salina, Dundee, Lucas, Bass Island, Bois Blanc, Amherstburg, Guelph and Ipperwash Formations. Shale rocks include the Kettle Point Formation, Marcellus Formation, Port Lambton Group and some members of the Hamilton Group.

The vast majority of Paleozoic rocks underlying the area were deposited within the Michigan Basin. The bedrock units consist of sedimentary rocks, composed of limestone, dolostone, sandstone and shale that overlie the Precambrian basement. The thickness of the Paleozoic strata increases in a southwesterly direction and reaches up to 1500 m of interbedded carbonates, shales, and sandstones near Sarnia<sup>15</sup>.

As a result of the sloping nature of the bedrock units, several different types of rock including Port Lambton, Kettle Point, Hamilton and Dundee outcrop in the area. **Map 4: Bedrock Geology** provides an overview of the bedrock formations that outcrop across the St. Clair Source Protection Area. These bedrock units overlay several older layers of sedimentary rock covering the Precambrian basement. **Table 2.2.1-1: Bedrock Geology** provides a summary of the bedrock formations for southwestern Ontario. Most of the information in the table was originally presented in the Six Conservation Authorities FEFLOW Groundwater Model: Conceptual Model Report. 2004.<sup>16</sup>

<sup>15</sup> Boyce, J.I, and W.A. Morris. 2002. Basement-controlled faulting of Paleozoic strata in southern Ontario, Canada: new evidence from geophysical lineament mapping: *Tectonophysics*, 353, (1-4), 151-171.

<sup>16</sup> Waterloo Hydrogeologic. 2004. Six Conservation Authorities FEFLOW Groundwater Model: Conceptual Model Report. Unpublished report prepared for the Upper Thames River Conservation Authority. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

**Table 2.2.1-1: Bedrock Geology**

Formation		Geology	Thickness
Precambrian		Canadian Shield gneisses, granites and volcanic rocks	
Ordovician		Sandy shale, limestones, carbonate mudstones, calcareous shales and non-calcareous shales	Varying
Salina		Interbedded shale, mudstone, dolostone, and evaporates (including gypsum and salt)	Avg. 120-200 m >500 m at Lake Huron
Bass Islands		Oolitic dolostone with minor thin beds of shaley dolostone	30 m; thickens to southwest
Bois Blanc		Cherty brownish grey, fossiliferous limestone	45 m
Detroit River Group	Sylvanian	Orthoquartzitic sandstone	60 to 90 m
	Lucas	Microcrystalline limestone	
	Amherstburg	Crinoidal limestone and dolostone	
Dundee Formation		Fossiliferous limestone	35 to 45 m
Marcellus Formation		Black, organic-rich shale	Up to 15 m
Hamilton Group	Bell	Blue-grey shale beds with minor limestone lenses	Up to 90 m
	Rockport Quarry	Fine-grained limestone with occasional thin shaley beds	
	Arkona	Blue-grey shale with minor discontinuous limestone beds	
	Hungry Hollow	Interbedded grey shale and fossiliferous limestone	
	Widder	Interbedded shale and fossil rich limestone	
	Ipperwash	Coarse-grained, grey-brown bioclastic limestone	
Kettle Point		Black, organic-rich, shale with minor beds of silty shale	30 m at Chatham (>300 under L. Erie)
Port Lambton		Grey-black shales and sandstone	Up to 60 m

The following sections discuss the depositional history (oldest to youngest) and the geological characteristics of the Paleozoic bedrock underlying southwestern Ontario. The Ordovician, Salina Formation, Bass Islands Formation, Bois Blanc Formation, and Detroit Group do not outcrop in the St. Clair Region Source Protection Area but are part of the Michigan Basin lying below the other layers of bedrock that do outcrop in the area.

### Ordovician

The Precambrian rocks of the Grenville Province are overlain by a succession of Ordovician age rocks including sandy shale, limestones, carbonate mudstones, calcareous shales and non-calcareous shales. The Queenston Formation is the uppermost unit.

### Salina Formation

The Salina Formation consists of approximately 120 to 200 m of alternating beds of shale, mudstone, dolostone, and evaporates (including gypsum and salt). It reaches a total thickness of over 500 m near the southern extent of Lake Huron.

The Salina Formation is subdivided into eight members designated by the letters A1, A2, B, C, D, E, F, and G<sup>17</sup>. Units A1, A2, B and D are mainly evaporite deposits of salt and anhydrite that are well developed in many areas of southwestern Ontario. Units C, E, F and G are varying combinations of shale, dolomitic shale and shaly dolomite.

### **Bass Islands Formation**

The younger Upper Silurian aged Bass Islands Formation forms a narrow band of oolitic brown dolostone (with minor thin beds of shaley dolostone). The unit is approximately 30 m thick and thickens to the northwest<sup>18</sup>.

### **Bois Blanc Formation**

The Devonian aged Bois Blanc Formation is arranged above the Bass Island Formation. It consists of cherty brownish grey limestone containing fossils and is estimated to be 45 m thick. The Bois Blanc Formation and the Silurian aged Bass Islands are separated by a disconformity (a break in the sequence of sedimentary rocks).

### **Detroit River Group**

This 60 to 90 m thick unit of limestone and dolomite is arranged in strata over the Bois Blanc Formation. This Middle Devonian aged unit includes the Sylvania Formation, an orthoquartzitic sandstone restricted to the subsurface in the Windsor area; the Lucas Formation, a microcrystalline limestone; and the Amherstburg Formation, a crinoidal limestone and dolostone. The Lucas Formation is believed to be karstic (irregular limestone with sinks, underground streams and caverns).

### **Dundee Formation**

The Dundee Formation, a grey to brown limestone containing fossils, lies above the Detroit River Group. On average, it is 35 to 45 m thick. The Dundee Formation is believed to be karstic (irregular limestone with sinks, underground streams and caverns).

### **Marcellus Formation**

The Marcellus Formation is part of the Appalachian Basin sedimentary rock and not part of the bedrock layer found under the St. Clair Area. The Marcellus Formation has been described as black, organic-rich shale (Kelly, 1995).

### **Hamilton Group**

The Hamilton Group of interbedded mudstones, shales and thin carbonate horizons overlie the Dundee Formation. It is made up of the following Formations from oldest to youngest: Bell, Rockport Quarry, Arkona, Hungry Hollow, Widder and Ipperwash (Kelly, 1995).

The Bell Formation consists of blue and grey shale beds with minor limestone lenses. The Rockport Quarry Formation is described as a grey and brown fine-grained limestone with occasional thin shaley beds with an estimated total thickness of approximately 6 m. The Arkona Formation is a blue-grey shale unit with minor thin discontinuous limestone beds with thicknesses of up to 37 m recorded. The thin (2 m) Hungry Hollow Formation consists of interbedded grey shale and fossil containing limestone. The Widder Formation is described as interbedded shale and fossil rich limestone with thicknesses of up to 14 m. The Ipperwash Formation is the uppermost formation in the Hamilton Group. It consists of coarse-grained, grey-brown bioclastic limestone.

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<sup>17</sup> Hewitt, D.F. 1972. Paleozoic Geology of Southern Ontario. Ontario Division of Mines, Geological Report 105, 18 p.

<sup>18</sup> Karrow, P.F. 1993. Quaternary Geology of the Stratford-Conestogo Area, southern Ontario. Ontario Geological Survey Report 283, 104 p.

The shales of the Hamilton Group are reported to have a total thickness of 90 m<sup>19</sup>. The Hamilton Group outcrops in parts of Middlesex, Elgin, Lambton, Kent and Essex Counties (Hewitt, 1972). The Hamilton Group forms the Ipperwash Escarpment, which extends from Lake Huron southeast towards Strathroy. This bedrock escarpment is named after the Ipperwash Formation, which forms the caprock of the feature<sup>20</sup>. The western side of the Escarpment rises approximately 30 to 60 m above the bedrock to the east. This lower area of bedrock has been interpreted to be part of a buried bedrock valley drainage network (see discussion on Erosion Bedrock Features and Valleys) extending from Lake Huron to Lake Erie.

### **Kettle Point Formation**

The Kettle Point Formation is a black, organic-rich (up to 15% by weight organic carbon), siliciclastic, and non-calcareous shale with minor beds of silty shale<sup>21</sup>. A major unconformity separates the Kettle Point Formation from the underlying Hamilton Group. This formation is part of a widespread black shale sequence that extends through the eastern United States and parts of central Canada. The Kettle Point Formation is unique as it contains large (up to 1.2 m) spherical or sub spherical calcite concretions locally referred to as ‘kettles’. This formation outcrops mainly in Lambton and Kent Counties in southern Ontario. It ranges from 30 m thick southwest of Chatham, to over 300 m beneath Lake Erie<sup>22</sup>.

### **Port Lambton Group**

The Port Lambton Group is a group of clastic rocks consisting mainly of grey and black shales and sandstones with a thickness of up to 60 m. Within southern Ontario, the Port Lambton Group strata are restricted to the subsurface in a small area south of Sarnia along the St. Clair River.

### ***Erosion Bedrock Features and Valleys***

A major nonconformity separates Paleozoic rocks from overlying Quaternary (glacial and interglacial) deposits across southern Ontario. This nonconformity represents a 200 million year period of non-deposition between the end of the Paleozoic Period and the beginning of Quaternary Period. The Paleozoic bedrock surface was exposed and eroded (Johnson et al., 1992). Exposure to the elements (wind, rain, etc.), repeated glacial advances, and other forms of weathering (freeze-thaw action, biological, etc.) likely caused intense fracturing of the upper portions of the bedrock surface prior to deposition of glacial sediments. This weathering and fracturing is expected to have greatly increased the capability of the uppermost bedrock formations to transmit water.

Millions of years ago when the bedrock was exposed, stream erosion played a major role in sculpting the bedrock topography of southern Ontario. Similar to our modern day river valleys, these ancient channels formed persistent topographic lows into which surface drainage was focused over long periods of time<sup>23</sup>. A few small scale bedrock valleys are believed to exist beneath the planning area.

A broad low-lying bedrock depression occurs between Lake Huron and Lake Erie. The western extent of this valley is marked by the Ipperwash Escarpment, which rises 30 to 60 m above the bedrock valley (Cooper, 1979). This feature was mapped to extend beneath the towns of Strathroy, Parkhill and Mount

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<sup>19</sup> Bobba, A. 1993. Field Validation of ‘SUTRA’ Groundwater Flow Model to Lambton County, Ontario, Canada. *Water Resources Management*, 7, 289-310.

<sup>20</sup> Cooper, A.J. 1979. Quaternary Geology of the Grand Bend-Parkhill Area, southern Ontario. Ontario Geological Survey Report 188, 70 p.

<sup>21</sup> Coniglio, M. and J.S. Cameron. 1990. Early diagenesis in a potential oil shale: evidence from calcite concretions in the Upper Devonian Kettle Point Formation, southwestern Ontario. *Bulletin of Canadian Petroleum Geology*, v. 38, p. 64-77.

<sup>22</sup> Ontario Geological Survey. 1991. Aggregate Resource Inventory of Raleigh and Harwich Townships, Kent County, Southern Ontario. Ontario Geological Survey, Ministry of Northern Development and Mines. Aggregate Resources Inventory Paper 126.

<sup>23</sup> Eyles, N., E. Arnaud, A.E. Scheidegger and C.H. Eyles. 1997. Bedrock jointing and geomorphology in southern Ontario, Canada; an example of tectonic pre-design. *Geomorphology*, 19, 17-34.

Brydges<sup>24</sup> and is shown on **Map 3: Bedrock Topography**. This depression was interpreted to represent ancestral drainage between Lake Huron and Lake Erie<sup>25</sup>. Glaciation likely broadened a stream drainage feature, leading to a broad (approximately 10 km wide) bedrock depression.

A buried bedrock valley has also been identified in the Sarnia-Corunna area. This valley is parallel to the St. Clair River approximately 300 to 1,000 metres east of the river. The valley is 30 to 35 metres below surrounding bedrock and is generally 60 to 70 metres below ground. It is generally filled with sand and gravel deposits.<sup>26</sup>

## 2.2.2 Surficial Geology

In southwestern Ontario, the overburden covering the bedrock consists mainly of deposits that were associated with geologically recent glacial activity. Retreating glaciers deposited massive amounts of glacial debris. The lakes, rivers and spillways created by successive glacial advances and retreats shaped the landscape.

Sand plains were created as early rivers emptied into the lakes. Clay and silt plains were formed in the deeper, quiet water basins of glacial lakes where fine grained materials were deposited. Receding glaciers created moraines that are generally regional topographic highs. In some areas, sandy shoreline features were also deposited as a result of different glacial lake levels.

There are some recent (post glacial) overburden deposits of organic materials or alluvial sediments. Organic deposits of peat, muck and marl are deposited in localized low-lying marshy or swampy wetland areas. Modern alluvial sediments, consisting of sand and gravel, occur along the flood plains of major watercourses and smaller tributaries.

The depth to bedrock throughout the study area was determined by subtracting the bedrock topography grid from the surface topography grid, based on information from the Southwest Region Edge Matching Study<sup>27</sup>. As shown in **Map 5: Overburden Thickness**, the bedrock depth varies throughout the St. Clair Region Source Protection Area. The depths to bedrock are greatest within bedrock valleys and under moraines deposited by receding glaciers.

The majority of Lambton County has an overburden thickness between 10 and 60 metres<sup>28</sup>. However, overburden can be less than 10 metres where the Kettle Point Formation is exposed west of Port Franks. In the Chatham-Kent portion of the area, the overburden is seldom less than 10 metres in thickness<sup>29</sup>. On the eastern side of the area, overburden thicknesses in the order of 60 metres<sup>30</sup> are associated with the infilling of the bedrock valley in the Strathroy-Caradoc area as discussed in Section 2.2.1 Bedrock Geology.

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<sup>24</sup> Dillon Consulting and Golder Associates. 2004. Middlesex-Elgin Groundwater Study Final Report. File 02-0394. Unpublished report.

<sup>25</sup> Karrow. 1973. Bedrock Topography in Southwestern Ontario: A Progress Report. The Geological Association of Canada, Proceedings, 25, 67-77.

<sup>26</sup> INTERA Technologies Ltd., 1992, Hydrogeologic Study of the Fresh Water Aquifer and Deep Geologic Formations, Sarnia Ontario.

<sup>27</sup> Waterloo Hydrogeologic for Ontario Ministry of the Environment. 2005. Southwestern Region Edge-Matching Study.

<sup>28</sup> Dillon Consulting and Golder Associates. December 2004. Lambton County Groundwater Study, Final Report.

<sup>29</sup> Dillon Consulting and Golder Associates. 2004. Essex Region/Chatham-Kent Region Groundwater Study, Volume 1, Geological/Hydrogeologic Evaluation.

<sup>30</sup> Dillon Consulting and Golder Associates. July 2004. Middlesex-Elgin Groundwater Study, Final Report.

The surficial geology and physiography of southern Ontario was altered considerably by the glacial and interglacial episodes that took place throughout the Quaternary Period (2 million years to present).

Southern Ontario's glacial history is very complex<sup>31</sup>. The sedimentary record of southern Ontario provides evidence for three distinct climatic stages during the Quaternary Period. However, the Wisconsinan glacial stage deposits (110,000-10,000 years before present) are the dominant surficial material in the area. The records of the earlier Illinoian glacial stage and the Sangamonian interglacial stage are limited to very few exposures near Toronto and, as such, they will not be discussed in this report.

A continental scale glacier, termed the Laurentide Ice Sheet, advanced and retreated over Ontario<sup>32</sup> during the Wisconsinan glacial period. The ice front advanced in cold periods (glacial stades), and retreated when the climate temporarily warmed (glacial interstades). These advances and retreats left behind a complex subsurface sediment record as outlined in **Table 2.2.2-1: Wisconsinan Quaternary Deposits in the Great Lakes Region**. Most of the current landscape was formed between 12,000 to 25,000 years before present (y.b.p.) during the Late Wisconsinan maximum of the Laurentide Ice Sheet.

As the ice sheet advanced over southern Ontario, it scoured the bedrock surface and reworked the vast majority of pre-existing glacial and interglacial sediments. This essentially erased the deposition of pre-Wisconsinan overburden (115,000 y.b.p.).

Sediments deposited prior to the last advance are rare and found only in topographic lows on the bedrock surface, such as buried bedrock valleys and lake basins<sup>33</sup>.

**Table 2.2.2-1: Wisconsinan Quaternary Deposits in the Great Lakes Region**

Approximate Age (y.b.p)*	Glacial Stage	Sub Stage	Glacial Stade/ Interstade	Associated Deposits	
Present-5,000	Recent and Holocene Deglaciation			Modern alluvium, organic deposits	
5,000-10,000				Glacial Lake Algonquin shoreline deposits	
10,000-12,000	Wisconsinan	Late Wisconsinan	Twocreekean Interstade	Shoreline formation, glaciolacustrine deposits	
12,000-13,500			Port Huron Stade	St. Joseph's Till, Lake Warren and Lake Whittlesey shoreline deposits	
13,500-14,000			Mackinaw Interstade	Lake Arkona shoreline deposits, Paris/Galt Moraines	
14,000-15,500			Port Bruce Stade	Elma, Mornington, Tavistock, Stratford, Port Stanley, Wartburg, and Rannoch Till, glaciolacustrine deposits	
15,500-16,500			Erie Interstade	Wildwood Silts, glaciolacustrine deposits	
16,500-20,000			Nissouri Stade	Catfish Creek Till	
20,000-60,000			Middle Wisconsinan		Unnamed/ undifferentiated silty tills (Huron-Georgian Bay lobe)
60,000-115,000			Early Wisconsinan		Canning Till (Erie-Ontario lobe) estimated between 80,000-53,000

<sup>31</sup> Barnett, P.J. 1992. Quaternary Geology of Ontario. *In* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 2, pp. 1011-1088.

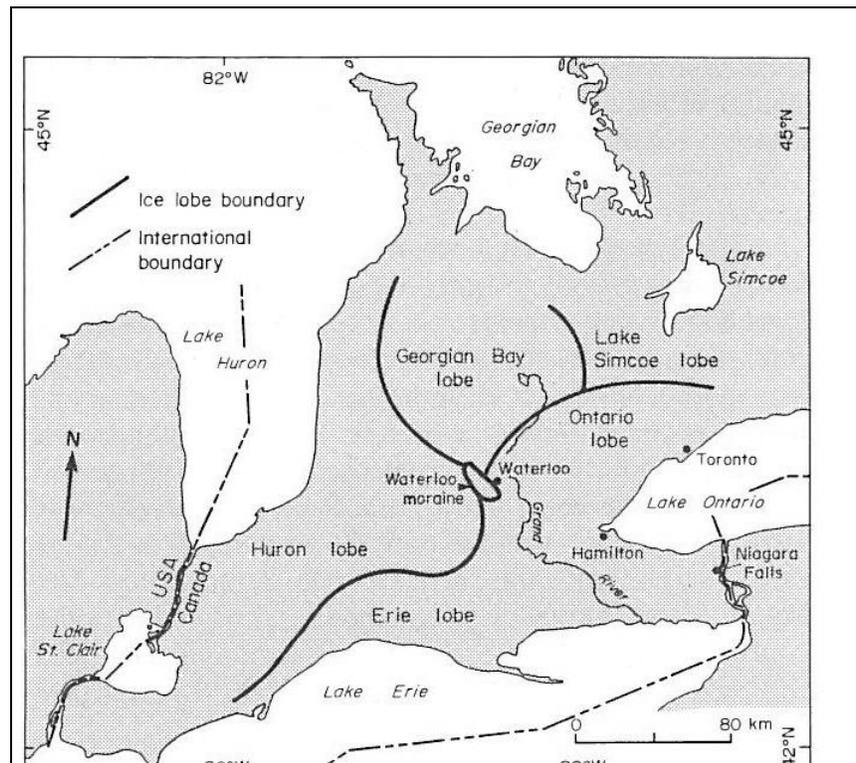
<sup>32</sup> Dreimanis, A. and R.P. Goldthwait. 1973. Wisconsin Glaciation in the Huron, Erie and Ontario Lobes: Geological Society of America, Memoir 136.

<sup>33</sup> Eyles, N., B.M. Clark, B.G. Kaye, K.W.F. Howard and C.H. Eyles. 1985. The Application of Basin Analysis Techniques to Glaciated Terrains: An Example from the Lake Ontario Basin, Canada. *Geoscience Canada*, 12, 22-32.

\* y.b.p. represents number of years before present (based primarily on Barnett, 1992. Quaternary Geology of Ontario. *In* Geology of Ontario, Ontario Geological Survey. Special Volume 4, Part 2, pp. 1011-1088).

The flow of the ice through southern Ontario was largely controlled by the broad topographic depressions of the Great Lakes basins (Barnett, 1992). Ice lobes developed in these basins and extended out of the main body of the ice sheet. At times, these lobes acted independently to one another in response to local conditions at the base of the glacier, rather than, or in addition to, climatic change.

The individual lobes bear the name of the lake basin(s) in which they are located. As shown in **Figure 2.2.2-1: Influence Zones**<sup>34</sup>, the Huron lobe had the most impact on the St. Clair portion of the Thames-Sydenham and Region Source Protection Region. The Erie lobe's influence was mainly outside the St. Clair area in the southeast part of the region.



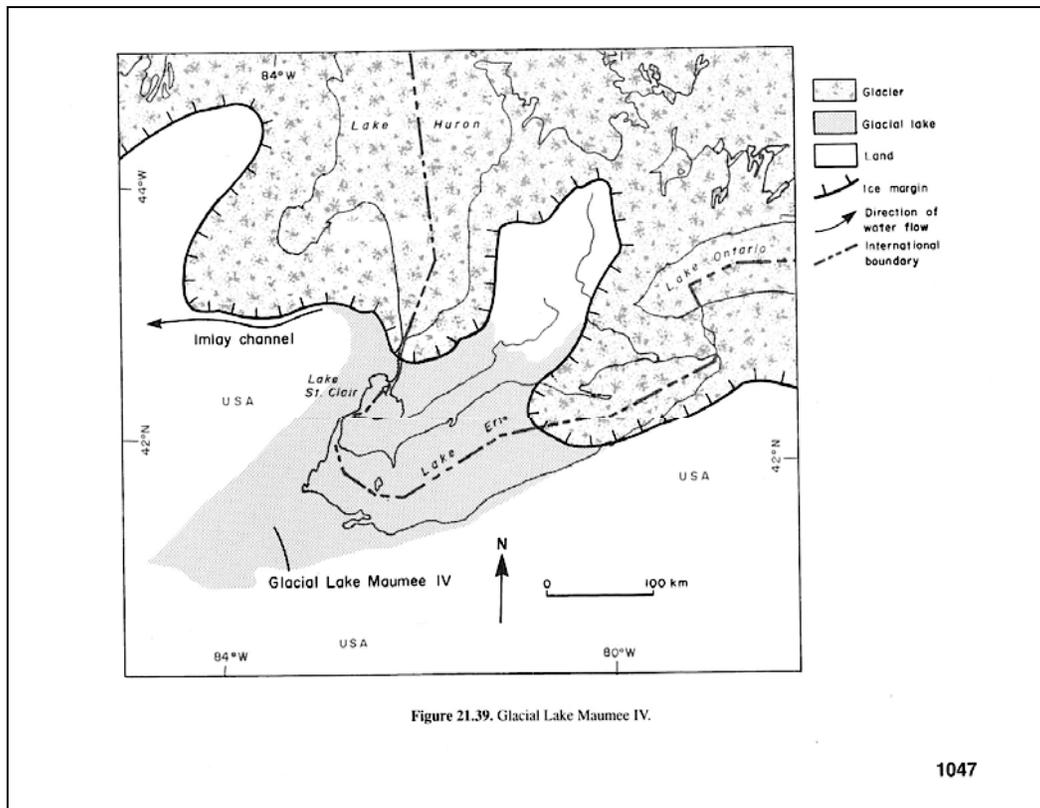
**Figure 2.2.2-1: Influence Zones**

As the glacier advanced and retreated, a series of glacial lakes were established with different water levels and shorelines. The flow of melt water in the valley area between the Huron and the Erie lobes had a significant effect on parts of the St. Clair Region. Sand plains were created as early rivers emptied into the different glacial lakes and fine-grained clay and silt were deposited in relatively flat, quiet water basins. **Figure 2.2.2-2: Glacial Lake Maumee IV**<sup>35</sup> shows an example of the extended ice lobes and melt water valley.

<sup>34</sup> Figure 21.32, page 1038 from Barnett, P.J. 1992. Quaternary Geology of Ontario. *In* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 2, pp. 1011-1088.

<sup>35</sup> Figure 21.39, page 1047 from Barnett, 1992.

Till sheets are the most continuous and extensive sediments deposited within the area. Till is the name for “sediment that has been transported and deposited by or from glacier ice, with little or no sorting by water”. In general terms, till can be divided into two main types: subglacial (deposited by melt-out processes at the base of the glacier) and supraglacial (deposited by flow from the upper surface).



**Figure 2.2.2-2: Glacial Lake Maumee IV**

Surficial geology for the region was obtained from the Ontario Geological Survey and is presented in **Map 6: Surficial Geology**. The following sections describe the different Quaternary deposits located within the Thames-Sydenham and Region area.

The Late Wisconsinan sediments (notably the widespread till sheets) found within the area are discussed in detail below. The Wisconsinan is commonly subdivided into the Early, Middle and Late substages as shown in **Table 2.2.2-1: Wisconsinan Quaternary Deposits**.

### Early to Middle Wisconsinan

There is little sediment preserved within the area that can be attributed to the Early and Middle Wisconsinan substages. Some unnamed and undifferentiated tills are found locally in small outcrops along creek and river channels and at the base of borehole logs scattered throughout the area.

### Late Wisconsinan Glacial Stage

The Late Wisconsinan lasted from 23,000 years ago to 10,000 years ago<sup>36</sup> and is divided into several different stades and interstades. It was during this period that the Laurentide Ice Sheet reached its most

<sup>36</sup> Dreimanis, A. and R.P. Goldthwait. 1973. Wisconsin Glaciation in the Huron, Erie and Ontario Lobes. Geological Society of America, Memoir 136.

southerly extent, advancing through Ontario and extending into the United States. Also, the ice sheet thinned and formed a series of sublobes, each moving independently of one another at different rates, and in different directions. Each of these sublobes deposited a series of distinct subglacial tills and associated landforms.

The discussion of the different stades and interstades progresses chronologically from oldest to youngest as illustrated in **Table 2.2.2-1: Wisconsinan Quaternary Deposits**. Within the St. Clair Region area, the Quaternary deposits are mainly associated with the Huron ice lobe and are believed to have been deposited during or after the Port Bruce Stade.

### **Nissouri Stade**

The Nissouri Stade (25,000 to 18,000 years ago) represents the initial stage of ice advance of the Laurentide Ice Sheet<sup>37</sup>. It was during this time period that the Laurentide Ice Sheet last moved as one thick, cohesive ice sheet. It deposited the most extensive subglacial till sheet in southern Ontario, known as the Catfish Creek Till.

### **Erie Interstade**

The Erie Interstade was estimated to take place between 16,500 and 15,500 years ago. During this period, the ice margin of the Erie-Ontario lobe of the Laurentide Ice Sheet retreated eastward to the Niagara Escarpment, while the Huron lobe margin retreated northward to the Goderich and Port Elgin areas<sup>38</sup>. A series of large ice contact lakes are believed to have formed in front of these receding ice margins with the deposit of fine-grained silts and clays. Subsequent ice advances may have reworked the glaciolacustrine muds, removing a substantial portion of the Erie Interstadial sediment record while leaving the fine-grained tills.

### **Port Bruce Stade**

The Port Bruce Stade (approximately 14,800 years ago) records the second advance of the Laurentide Ice Sheet into the United States during the Late Wisconsinan. The Great Lakes basins controlled the direction of flow of the individual sublobes, with glacial flow occurring radically outward from the centre of each lake basin<sup>39</sup>.

Various silt- and clay-rich subglacial tills were deposited during this Stade, each bearing the name of their type location and/or distribution such as the Port Stanley Till, the Stratford Till and the Tavistock Till. The grain size of the matrix of the subglacial tills, as well as their clast composition, is largely dependent on the substrate over which the ice passed. The majority of the tills deposited during the Port Bruce Stade are fine-grained, suggesting the ice overrode and incorporated extensive fine-grained glaciolacustrine sediments deposited throughout the area during the Erie Interstade.

In the early stages of the Port Bruce Stade, the southward advancing ice sheet blocked the drainage of the Lake Huron and Lake Erie basins, leading to the formation of a glacial lake (Lake Leverett) over much of the southern portion of the area. The Chatham-Kent area was inundated with water leading to the deposition of clay-rich massive (structureless) to faintly laminated glaciolacustrine sediments.

The Tavistock, Mornington, Stratford, Wartburg, Elma, and Rannoch Tills are associated with the advance of the Huron-Georgian Bay ice lobe. Most of these were deposited outside the St. Clair area but,

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<sup>37</sup> Barnett, P.J. 1992. Quaternary Geology of Ontario. *In* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 2, pp. 1011-1088.

<sup>38</sup> Ontario Geological Survey. 1983. Aggregate Resource Inventory of Delaware Township, Middlesex County, Southern Ontario. Ontario Geological Survey, Ministry of Natural Resources. Aggregate Resources Inventory Paper 76.

<sup>39</sup> Barnett, 1992.

as shown in **Map 7: Physiography**, till plains are located in the northeastern portion of the St. Clair area. This is most likely the Rannoch Till.

### **Rannoch Till (Huron Lobe)**

The Rannoch Till was deposited subglacially beneath the Huron ice lobe. The name is taken from a small village along the Mitchell Moraine, west of St. Marys within Perth County. This till is described as a strongly calcareous, silt to silty clay till with a low clast content (<2%) near Mitchell (Karrow, 1977), but it is much more gritty or stony in areas further west (Cooper, 1979).

The Rannoch Till occurs as a surface till sheet across much of the area east of the Wyoming Moraine to the Mitchell Moraine and is also associated with several end moraines including the Dublin, Lucan, and Seaforth Moraines. The thickness of the Rannoch Till is between 2 and 6 m but it has been mapped up to 70 m.

This till has not been identified beneath the St. Joseph's Till at any point west of the Wyoming Moraine, leading one to infer that the glacier reworked the Rannoch Till to form the St. Joseph's Till during the later Port Huron Stage. Cumming and Al-Aasm (1999)<sup>40</sup> identified the Rannoch Till as a buried till on Walpole Island at the mouth of the St. Clair River; however, it is possible that the authors interpreted a lower/older till (possibly the Catfish Creek Till) at this site to be the Rannoch Till.

As the ice lobes began to retreat from southern Ontario, melt water began to pond at the southern end of Lake Huron and the western end of Lake Erie, forming a large lake referred to as Lake Maumee. At this time, the Caradoc Sand Plain was formed by a melt water stream depositing silts, sands and gravels (Barnett, 1992) as it emptied into Lake Maumee.

### **Mackinaw Interstade**

The Mackinaw Interstade took place from approximately 13,500 to 14,000 years ago. The onset of this Interstade was characterized by the rapid retreat of ice out of southern Ontario. The Ontario-Erie lobe retreated into the Ontario basin east of Toronto, and the Huron lobe retreated into northern Michigan (Dreimanis and Goldthwait, 1973).

During this ice-free time, thin glaciofluvial outwash deposits were laid down across much of the study area as sediment-laden melt water streams discharged from the front of the melting glacier. This led to the deposition of pebbly sands and gravels (OGS, 1983, 1989<sup>41</sup>, 1991<sup>42</sup>).

As the Erie-Ontario ice lobe retreated northeastward, the drainage outlet for the Lake Ontario basin returned to the east (Rome, NY), and the outlet for Lake Huron became ice free. This created progressively lower lake levels in the Lake Erie and Lake Huron basins (Barnett, 1992; Dreimanis and Goldthwait, 1973). Higher lake levels (e.g. Glacial Lake Whittlesey) created sand plains. These changing lake levels also created elevated sand and gravel ridges often distant from the present Great Lake shorelines. These and several other features are shown on **Map 7: Physiography**.

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<sup>40</sup> Cumming and Al-Aasm. 1999. Sediment Characterization and Porewater Isotope Chemistry of Quaternary Deposits from the St. Clair Delta, Ontario, Canada. *Quaternary Research*, 51, 174-186.

<sup>41</sup> Ontario Geological Survey. 1989. Aggregate Resource Inventory of Mersea, Gosfield North and Gosfield South Townships, Essex County, Southern Ontario. Mines and Minerals Division, Ministry of Northern Development and Mines. Aggregate Resources Inventory Paper 125.

<sup>42</sup> Ontario Geological Survey. 1991. Aggregate Resource Inventory of Raleigh and Harwich Townships, Kent County, Southern Ontario. Ontario Geological Survey, Ministry of Northern Development and Mines. Aggregate Resources Inventory Paper 126.

## **Port Huron Stade**

The Port Huron Stade took place from approximately 13,500 to 13,000 years ago when three distinct lobes of the Laurentide Ice Sheet advanced for the last time over southern Ontario.

In the St. Clair Region area, the St. Joseph's Till was deposited beneath the Huron-Georgian Bay ice lobe. The St. Joseph's Till is strongly calcareous silt to silty clay till with low clast content (1-2%; Barnett, 1992). This till incorporated pre-existing fine-grained glaciolacustrine silts and clays deposited during the Mackinaw Interstade, and the Port Bruce Stade. This combination gives the till its fine texture. The extent of the St. Joseph's till plain is marked by the Wyoming Moraine which runs parallel to the modern day Lake Huron shoreline. The St. Joseph's Till is commonly overlain by outwash sands and gravels and various glaciolacustrine sediments (Barnett, 1992).

Glacial Lake Whittlesey is another glacial lake that was formed over the southern reaches of Lake Huron and the western reaches of Lake Erie (Barnett, 1992). Associated with this glacial lake are several sandy shorelines and beach deposits that are visible on the surface in portions of the area.

As ice retreated from the Port Huron maximum, elevated lake levels in the Huron and Erie basins began to fall. In the wake of this ice retreat, glacial Lake Warren developed in place of Lake Whittlesey. Several sandy shoreline features associated with Lake Warren were deposited throughout the area (OGS, 1989).

Thick sequences of fine-grained glaciolacustrine sediments were deposited into the proglacial lakes mentioned above. These sediments exhibit a general coarsening upward trend whereby fine-grained silts and clays are overlain by silts and sands. For example, some of the largest sand plains (Caradoc and Bothwell) and clay plains (St. Clair and Ekfrid), are underlain by glaciolacustrine sediments deposited when lake levels fell in the Huron and Erie basins (Barnett, 1992).

## **Twocreekean Interstade and the Greatlakean Stade**

The Twocreekean Interstade represents a period of continued ice retreat out of southern Ontario, which began approximately 12,500 years ago (Barnett, 1992). By this time, the ice front had fully retreated from the area. Ice marginal lakes began to drain as the retreating ice uncovered drainage outlets. Lake Huron and Lake Michigan merged to form one large lake (Lake Algonquin) and separate lakes formed in the Lake Ontario (Lake Iroquois) and Lake Erie (Early Lake Erie) basins.

## **Holocene Deglaciation**

The Holocene Deglaciation began approximately 10,000 years ago. At this time, Ontario was still undergoing massive deglaciation throughout much of the north. Lake Superior was still covered with ice. An isostatic depression in the North Bay area allowed the upper Great Lakes to drain through the Ottawa River. This resulted in lower water levels in the Great Lakes than those seen today. The lower lake levels resulting from the isostatic rebound also caused subaerial exposure of the St. Clair Clay Plain (Cumming and Al-Aasm, 1999).

Approximately 5,000 years ago, isostatic uplift closed the outlet to the Ottawa River near North Bay. From this point in time to the present day, the lake basins have rebounded and the lake levels returned to those found in the Great Lakes today. After the uplift, water flows in the St. Clair River provided a high suspended sediments load and delta deposits began to form again where there was a rapid deceleration of the river's flow as it enters Lake St. Clair (Cumming and Al-Aasm, 1999).

Postglacial and erosion processes continued to shape the landscape within the area. For example, aeolian dunes were formed on the surface of the Bothwell Sand Plain as northwesterly winds reworked the fine sand (OGS, 1991). Organic deposits of peat, muck and marl were deposited in localized low-lying marshy or swampy wetland areas. Modern alluvial sediments, consisting of sand and gravel, occurred along the flood plains of major watercourses and smaller tributaries.

## Summary of Quaternary Geology

The Quaternary Geology within the St. Clair Region Source Protection Area is primarily the result of the Late Wisconsinan Glaciation beginning approximately 25,000 years ago. The present day geologic setting consists of eroded Paleozoic sedimentary bedrock units, overlain by glacial deposits and more recent alluvial deposits, shown on **Map 6: Surficial Geology**.

The surficial geology of the Thames-Sydenham and Region Source Protection Region has been mapped in phases throughout the last 30 years by various geologists (Cowan, 1975, 1979<sup>43</sup>; Cooper, 1979; Karrow, 1977, 1988, 1993; Barnett, 1982<sup>44</sup>; Kelly, 1995).

The surface geology can be grouped into the following general features:

- Low permeability, low relief, lacustrine clay plains
- Low permeability, moderate relief till plains
- Higher permeability, low relief, outwash sand and gravel deposits
- Higher permeability, moderate relief, coarse-grained moraines
- Higher permeability, low relief, recent alluvial deposits

More recently these maps have been seamlessly assembled into a cohesive map covering the entire study area (Bajc et al., 2001<sup>45</sup>). This map and its associated GIS metadata will be used to help delineate the spatial extent of the above geological features.

### 2.2.3 Physiography

Physiography is the study of natural landscape features. The physiographic characteristics of the St. Clair area are dominated by the effects of continental glaciation. As discussed in the previous section on surficial geology, a series of glacial advances and retreats resulted in the moraines, sand plains, till plains and clay plains that characterize this part of southwestern Ontario.

### Physiographic Regions

The sections below describe the significant physiographic regions identified within the area, as presented in *The Physiography of Southern Ontario*<sup>46</sup>. **Map 7: Physiography** shows several of these features.

#### *Sand Plains*

Sand plains are generally the result of water-laid alluvial/beach deposits.

#### **Caradoc Sand Plain**

The Caradoc Sand Plain is located in the Strathroy-Caradoc area. It is a large (78,500 ha) sand and gravel deltaic deposit that was formed when the early Thames River discharged sediment into Glacial Lake Warren. The Caradoc Sand Plain is composed predominantly of sand but contains some gravel. There are prominent dunes and sand ridges (terrace escarpments) that were formed by the wave action and wind as Glacial Lake Warren receded. This deposit thins towards the west where the glacial lake water became deeper, and blends into the Ekfrid Clay Plain. To the east, the Komoka Delta has more gravel and heavier materials.

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<sup>43</sup> Cowan, W.R. 1979. Quaternary Geology of the Palmerston Area, southern Ontario. Ontario Geological Survey Report 187, 64 p.

<sup>44</sup> Barnett, P.J. 1982. Quaternary Geology of the Tillsonburg Area, southern Ontario. Ontario Geological Survey Report 220, 87 p.

<sup>45</sup> Bajc, A.F., Leney, S., Evers, S., van Haaften, S. and Ernsting, J., 2001. A seamless Quaternary geology map of southern Ontario; *in* Summary of Field Work and Other Activities 2001. Ontario Geological Survey, Open File Report 6070, p. 33-1 to 33-5.

<sup>46</sup> Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario, 3<sup>rd</sup> edition. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

### **Bothwell Sand Plain**

This sand plain is very similar to the Caradoc Sand Plain. It was created by the early Thames River depositing sediment in the Chatham-Kent area as Glacial Lake Warren receded to the west. The Bothwell Sand Plain also shows dunes and terrace escarpments, though they are not as abundant as they are on the Caradoc Sand Plain.

### ***Clay Plains***

Clay plains occur in association with sand plains and represent the sediment that was deposited in deeper water farther offshore than the alluvial/beach deposits (sand plains). The fine-grained clay and silt were deposited in a relatively flat, quiet water basin, resulting in the development of a somewhat featureless topography.

### **Ekfrid Clay Plain**

The Ekfrid Clay Plain is situated between the Caradoc and Bothwell Sand Plains. As described above, the deposition of the clays and silt make for a featureless, flat lying area.

### **Lambton Clay Plain**

The Lambton Clay Plain is a bevelled till plain and is the dominant physiographic region in Lambton County. The Lambton Clay Plain is bordered by the Lake Huron and St. Clair River shorelines. It extends eastward to the Ekfrid Clay Plain, southeast to the Bothwell Sand Plain and southwest to the Chatham Flats.

Bevelled till plains were deposited beneath the glaciers and are relatively flat, reworked till plains. The material was previously deposited and then over-ridden by a subsequent glacial event. The till is a poorly sorted mixture of clay, sand and gravel referred to as diamicton. The landscape of the clay plain was further smoothed by local shallow deposits of lacustrine clay that infill depressions in the till plain.

The different characteristics of this area are illustrated in **Map 6: Surficial Geology** which shows most of the area as diamicton/till; in **Map 7: Physiography** which shows the area as a bevelled till plain; and **Map 8: Soils Information** which shows the area as predominately silt and clay.

### **Chatham Flats/Clay Plain**

The Chatham Flats are the dominant clay feature in Chatham-Kent and are characterized by deep lacustrine clay deposits with extreme flatness. The plain parallels the St. Clair River and Lake St. Clair shorelines and stretches from southern Lambton County south to a line running east west from Ridgetown to Tilbury. A long narrow strip of the “Flats” also runs along the Thames River from Chatham east to the boundary with Elgin County.

### ***Till Plains***

Till is a heterogeneous mixture of clay, silt, sand, and pebbles. Till soils are very dense, stiff materials and are often covered by a thin veneer of topsoil with glacial till as the surficial soil type. They often display surface features such as prominent moraines, terrace escarpments, and beach/bar/spit deposits. There are several different types of till plains including streamlined and bevelled till plains, till moraines, and drumlinized/un-drumlinized till plains.

Bevelled till plains are relatively flat, reworked till plains that were previously deposited and were over-ridden by a subsequent glacial advance.

Till moraines occur as mounds of till deposited at the end of a glacier and are expressed as prominent topographic features.

Streamlined landforms such as drumlins and flutings are formed by variations in stress on the sediment bed by a glacier and indicate glacier flow direction. Drumlinized or un-drumlinized till plains simply refers to the presence or absence of drumlins on the surface of a till plain.

### **Stratford Till Plain**

This un-drumlinized plain consists of calcareous silty clay and contains very little coarse-grained material. The Stratford Till Plain is a large till plain of ground moraine features interrupted by terminal moraines such as the Lucan, Mitchell, and Arva Moraines. A portion of the Stratford Till Plain extends westward into the St. Clair area in Warwick Township between the Wyoming and Seaforth Moraines and in Middlesex Centre between the Seaforth and Lucan Moraines.

### ***Moraine Dominated Regions***

Moraine dominated areas have regional topographic highs and are characterized by hummocky terrain and till soils. Moraines commonly occur in subparallel groups as they are deposited by the receding glacier.

### **Huron Lobe Moraines**

The orientation of these recessional moraines and end moraines mimic the shape of the shore of Lake Huron forming a concentric pattern of topographically high ridges. Three Huron Lobe moraines (Wyoming, Seaforth and Lucan) impact the drainage pattern in the northeastern part of the St. Clair area.

The Wyoming Moraine is the largest moraine in the area at over 20 km wide. This long moraine begins approximately 6 km southwest of Wyoming and extends far to the east and north of the St. Clair area. The soil is pale brown, calcareous, fine-textured till. The Wyoming Moraine creates a drainage divide between creeks that drain north to Lake Huron and tributaries of the Sydenham River that drains southwesterly to Lake St. Clair.

The Seaforth Moraine is very similar in shape to the Wyoming Moraine, but it is much narrower (5-10 km wide). The west end of the Seaforth Moraine is in the St. Clair area. The land between the Seaforth and Wyoming Moraines forms part of the headwaters of the North Sydenham River.

The Lucan Moraine is concentric with both the Wyoming and Seaforth Moraines. The Lucan Moraine begins west of London and bends northwards to the east of Lucan. The eastern tip of the St. Clair Source Protection Area is located between the Seaforth and Lucan Moraines and is the headwater of the East Branch of the Sydenham River.

### **Erie Lobe Moraines**

The recessional and end moraines formed by the Erie Lobe are located outside the St. Clair area. They are oriented in an east-west direction in the London area and trend more southwest/northeast as they approach the shore of Lake Erie.

### ***Glacial Beaches and Shore Cliffs***

A number of beaches and shore cliffs remnant from glacial lakes occur in Lambton and Chatham-Kent. Beach deposits of glacial Lakes Warren, Whittlesey, Algonquin and Lundy occur throughout the region.

The landscape includes the broad expanse of level lands beginning in the Strathroy-Caradoc area and extending south, east and north to Lakes Erie, St. Clair, and Huron. Long ridges of sandy gravel interrupt what would otherwise be great expanses of flat land. Also, many sand dunes occur along the inland margins of the old beach ridges, far from any current body of water.

Terraces (from each elevated lake level) leading down to the Great Lakes transect the level lands. Each terrace is separated from its neighbour by a high or low step cliff. These terraced areas have areas of heavy clay interspersed with stretches of water-washed sand and gravel. The flat areas were once lake Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

beds and the ridges of gravel were beaches. The flat, stratified sand and gravel plains and clay plains with a veneer of sand or gravel were fillings of old bays or ancient lake basins and the deltas of rivers flowing into them (Komoka and the Caradoc Sand Plain). Elevated glacial lakes reworked pre-existing till plains and sand and gravel sediments were deposited along the now relic lake margins.

Some of these lake margins are shown as narrow bands of sand and/or gravel on **Map 8: Soils Information** and **Map 6: Surficial Geology**. For example, a band of sand and gravel in Plympton-Wyoming generally runs parallel to the Lake Huron shoreline. Local soil conditions can be affected by these deposits. The difference in elevation between glacial lakes and current lake levels resulted in stream and river beds that eroded and downcut channels to the current lake levels, creating misfit channels on the present landscape.

### ***Modern Shorelines***

There are two types of natural Great Lakes shorelines in the region: low lying areas dominated by sand, and bluffs between 10 and 20 metres high dominated by clay and till. In several areas, development has replaced natural shorelines with hardened erosion control structures.

#### **Lake Huron Shoreline**

At the northeast edge of the watershed, a shale bedrock shelf is situated at Kettle Point. Large round concretions called kettles are exposed, giving the point its name. Moving to the west, the shoreline is characterized by clay and till bluffs. Approaching the St. Clair River, the southwestern portion of the shoreline in the Sarnia area is characterized by sandy beaches.

Several small watercourses flow north and northwest across the bluffs and low lying sand plains. The bluffs are often cut by deep ravines where the creeks discharge to the lake. In the low lying areas, the creeks form more of a meander pattern.

#### **St. Clair River Shoreline**

The river is a relatively straight channel and hardened erosion control structures line most of the shoreline. Much of the land adjacent to the river is developed in a mixture of residential, commercial and industrial land uses. There are some narrow beaches, vegetated cliffs, and parks.

A number of small creeks discharge into the river. Also, a man-made floodway provides a connection from the Sydenham River to bypass water around Wallaceburg during flood conditions.

The St. Clair River enters the northern end of Lake St. Clair through a number of distributaries across the largest freshwater delta in the Great Lakes. There is some dyking and land reclamation in the northern sections of the delta. Much of this unique delta area is predominately wetland and has a complex shoreline with many channels and shallow bays<sup>47</sup>. The shorelines of the distributaries range from hardened erosion control structures in the north to broad wetlands in the south.

#### **Lake St. Clair Shoreline**

Between the Thames River and the Sydenham River, a relatively small triangle of land drains directly into Lake St. Clair. The shoreline varies from broad wetland to hardened retaining walls.

The area is characterized by a low gradient. Much of this area has been dyked inland from the lake to allow dewatering by pumping to permit cultivation.

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<sup>47</sup> Lake St. Clair Canadian Watershed Coordination Council. 2005. The Lake St. Clair Canadian Draft Technical Report: An examination of current conditions.  
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## Summary of Physiographic Regions

The major physiographic regions in the area are the extensive clay plains including the Lambton, Ekfrid and Chatham Flats clay plains. These have varying characteristics depending on their origin.

The Bothwell and Caradoc sand plains are the other large physiographic features of the St. Clair area. In the northeastern part of the area, remnant glacial moraines, beaches and shorecliffs have localized impacts on the drainage and landscape.

The physiographic characteristics, together with the surficial geology of the region, led to the development of several different types of soil.

### 2.2.4 Soil Characteristics

The development of different soil types is an intriguing story. Beginning with a relatively uniform parent material, a combination of climate, drainage, and vegetation resulted in different soils developing over a period of time<sup>48</sup>.

The characteristics of the soil at any given place depend on:

- The physical and mineralogical composition of the parent material,
- The climate under which the soil developed,
- The plants and animals that live in and on the soil,
- The relief and drainage,
- The length of time the forces of development have been acting on the parent material.

The parent material and the local relief/drainage are the major factors that affected the development of the different soils in the St. Clair area. Most of the other factors were relatively uniform over the area.

For example, the ages of the various soils in southwestern Ontario are relatively the same and differences due to the effects of weathering are difficult to establish. Similarly, the climate has been relatively uniform and did not result in soil differences that are readily noticeable. Also, prior to clearing for cultivation, most of the area was covered by deciduous forest. Most variations in vegetation were related to differences in drainage and/or the texture of the parent material. While there were some areas of grassland, marsh or coniferous forest, they were a comparatively small part of the overall area.

### *Soil Groups*

Soils are classified into Great Soil Groups. Soils that have developed where the factors of climate and vegetation have reached their full expression are known as zonal soils. In areas where inadequate drainage has hindered normal soil development, intrazonal soils develop. Azonal soils develop in areas where relief or excess drainage prevented the development of a normal soil profile.

The soils of Southern Ontario generally fall into the zonal great soil group Grey-Brown Podzolic Soils or Grey-Brown Forest Soils<sup>49</sup>. These soils are formed from the decay of leaves and wood in locations where moisture and nutrients were favourable for the growth of hardwood trees.

Some intrazonal great soil groups are found in the area, including the poorly drained Dark Grey Gleisolic and Organic. The poorly drained soils tend to have a higher pH than the Grey-Brown Podzolic Soils. Organic soils have a layer of muck or peat overlying the poorly drained soil.

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<sup>48</sup> Ontario Soil Survey Report 22. 1957. Soil Survey of Lambton County.

<sup>49</sup> Department of Planning and Development. 1952. Upper Thames Valley Conservation Report. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

Azonal soils (Alluvial and Regosol) are also found in localized parts of the area. Alluvial soils occur in stream bottoms or other areas where soil horizons have not developed because of recent deposition of soil materials. Regosol soils occur on drifting dune sand or shaley gravel.

### ***Soil Profile***

A single parent (raw) material can result in several different classifications of soil. For example, one area may have compact subsoil that restricts water movement and root penetration while another may have open porous subsoil that permits rapid water movement and easy root penetration. Therefore, the entire soil profile is considered in classifying soils.

Most soils are made up of layers called horizons formed by the acid reaction of surplus water percolating downwards through the soils. A vertical cross-section is cut through all layers from the topsoil to the unaltered parent material to form a soil profile. The soil profile reflects influences such as type of bedrock, climate, slope, vegetation and drainage. In general, the main soil layers or horizons are designed as A, B, G and C. These may be divided into sub layers.

The “A” horizon (topsoil or surface layer) is the uppermost layer. A<sub>0</sub> is the thin surface layer of partially decomposed litter. A<sub>1</sub> contains accumulated organic matter that has been leached of mineral constituents. A<sub>2</sub> is immediately below A<sub>1</sub> and contains little or no organic material. It is the most strongly leached layer in the profile.

The “B” horizon or subsoil contains some of the materials, chiefly iron, alumina and clay, removed from the A horizon by the leaching process. The B horizons are usually browner than the A<sub>2</sub> and finer in texture.

In poorly drained soils, a B horizon does not develop and a “G” horizon appears. The G horizon is usually a grey/mottled reddish brown coloured layer. The mottled colour is a result of alternating oxidation and reduction caused by a fluctuating water table.

The deepest layer is the “C” horizon also known as the parent material.<sup>50</sup> The upper, slightly weathered part of the C horizon may be designated as the C<sub>1</sub> horizon.

### ***Soil Type and Soil Series***

Soil type consists of a group of soils with similar genetic horizons that developed from similar parent material. A given soil type may include a limited range of properties and the boundaries between different soil types vary in sharpness. Also, there is often a zone between two soil types that includes features of both.

Two or more soil types that developed from similar parent material and similar drainage conditions but have differing texture in the surface horizon are grouped together as a soil series.

### ***Soil Catena***

Well drained, imperfectly drained and poorly drained soils often occur in close association. The term “catena” is used to designate two or more soil series that have developed from the same parent material with differing drainage.

## **Thames-Sydenham and Region Soils**

Extensive and detailed soil surveys have been made on a county basis for most of Ontario, including all of the region area. **Table 2.2.4-1: Soil Surveys in the Thames-Sydenham and Region** provides a summary of the soil surveys for this area.

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<sup>50</sup> Ontario Ministry of Agriculture and Food and Agriculture Canada. 1957. Soil Survey of Lambton County. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

**Table 2.2.4-1: Soil Surveys in the Thames-Sydenham and Region**

County	Soil Report Number	Year Completed
Huron	13	1952
Perth	15	1952
Oxford	28	1961
Middlesex	56	1992
Lambton	22	1957
Elgin	2	1929
Kent	64	1996
Essex	11	1947

The Ontario soil surveys follow a convention of naming various soil series after the locality in which it was first identified. Given the wide variation in drainage or relief that can be combined with an assortment of parent materials, a complex variety of soils types and soil series can occur in a relatively small area. For example, Lambton County was reported to have had 35 different soils recognized and delineated on the county soil survey map.

The variety of soils based on parent material and drainage is illustrated by the following **Table 2.2.4-2: Classification of Soil Series in Lambton County**, which has been taken from the Soil Survey of Lambton County Report Number 22 of the Ontario Soil Survey.

The differences associated with drainage and parent material are shown in **Table 2.2.4-3: Characteristics of the Soil Series in Lambton County**, which has been extracted from the same report on Lambton County soils.

**Table 2.2.4-4: Soil Series and Types in the Thames-Sydenham and Region** summarizes some of the catena of soils in area and lists the associated soil types found within each catena.

**Table 2.2.4-2: Classification of Soil Series in Lambton County**

Parent Material	Great Soil Group					
	Grey-Brown Podzolic		Dark Grey Gleisolic	Bog	Alluvial	Regosol
	Well Drained	Imperfectly Drained	Poorly Drained	Very Poorly Drained	Poorly Drained	Well Drained
<i>Glacial Till</i> Loamy calcareous Water modified clay till Shaley clay till	Guelph Huron -	- Perth Caistor	- Brookston -			
<i>Outwash Materials</i> Sand Gravels Sand over clay till	Fox Burford -	Brady Brisbane Berrien	Granby Gilford -			Plainfield Shashawandah -
<i>Lacustrine material</i> Fine sandy loam and silt Silt and clay Silt and clay (grass) Silt and clay till		- - - Lambton	Colwood Toledo Clyde -			
<i>Recent Alluvium</i>					Blackwell	
<i>Organic deposits</i> Well decomposed Poorly decomposed				Muck Marsh & peat		

**Table 2.2.4-3: Characteristics of the Soil Series in Lambton County**

Parent Material	Texture of Surface Soil	Drainage				
		Excessive	Good	Imperfect	Poor	Very Poor
Outwash sand Outwash sand over clay	Sand, sandy loam Sand, sandy loam	Plainfield Eastport	Fox	Brady Berrien	Granby	
Outwash medium gravel Shaley gravel Loamy till	Loam Loam Loam		Burford Shashawandah Guelph			
Clay till	Clay loam, clay		Huron	Perth Caistor	Brookston	
Lacustrine fine sand	Fine sandy loam				Colwood	
Silt and clay	Clay, clay loam Loam, silt loam			Toledo Lambton	Clyde	
Recent alluvium Organic	Clay				Blackwell	Muck, peat

**Table 2.2.4-4: Soil Series and Types in the Thames-Sydenham and Region**

Catena	Associated Types
Huron	Huron Perth Brookston Brantford Bennington Bryanston Muriel
Guelph	Guelph London Parkhill Maplewood Honeywood Embro Crombie Bennington Tavistock
Dumfries	Dumfries Lyons
Fox	Fox Brady Granby Barrien Bookton Wauseon Watford
Burford	Burford Brisbane Gilford Donnybrook Caledon Teeswater
Waterloo	Waterloo
Harriston	Listowell
Plainfield	Plainfield
Walsher	Walsher
Brant	Brant

Within the St. Clair area, silt and clay soils predominate and cover approximately 67% of the St. Clair Region Conservation Authority watershed. Various types of loams make up the major portion of the remaining soils.

Utilizing the OMAF database and the generalized soil groupings, **Table 2.2.4-5: Percentage of Soils in the St. Clair Region** was prepared based on **Map 8: Soils Information**.

**Table 2.2.4-5: Percentage of Soils in the St. Clair Region**

General Soil Grouping	Square Kilometres	Percentage (%)
Silt and clay	2,831	67
Sand loams	615	15
Silt and clay loams	187	5
Loams	197	5
Bottom land and beach	149	4
Organic	82	2
Not mapped and other	62	2
<b>Total</b>	<b>4,123</b>	<b>100</b>

The different soil surveys were completed on a county-by-county basis, in different years and with different degrees of detail. Therefore, it was difficult to use the surveys to compare the different soil series across the watershed. In 2004, the Ontario Ministry of Agriculture and Food undertook a Soils Ontario Project to consolidate the soil data in a seamless digital database. This consolidated information has allowed the production of soils information maps for the Thames-Sydenham and Region watersheds.

For the purposes of protecting source water, hydrological classification in terms of porosity or infiltration potential is of more interest than specific soil types. Thus, the various soil series in the watershed area have been grouped into several hydrologic soil classifications including:

- Fine sand
- Loam
- Sand loams
- Silt and clay
- Silt and clay loams

These groupings are shown in **Table 2.2.4-6: Generalized Soil Textures**.

**Table 2.2.4-6: Generalized Soil Textures**

Generalized Soil Classification	Hydrologic Soil Classification	Soil Survey Soil Association
Fine sand	Fine sand	Plainfield
Loam	Loam	Parkhill Loam London Loam London Silt Loam Perth Silt Loam Parkhill Silt Loam Guelph Loam Guelph Silt Loam Burford Loam Guilford Loam
Sand loams	Fine sand loam Gravelly loam Gravelly silt loam Loamy fine sand Loamy sand Loamy very fine sand Sand loam Very fine sandy loam	Bookton Walsher Fox Waterloo Sandy Loam Brady Sandy Loam Granby Sandy Loam Brisbane Sandy Loam Burford Loam Berrian Sandy Loam Burford Sandy Loam Brady Loamy Sand Burford Caledon Watford
Silt and clay	Clay Clay loam Silt clay loam Silty clay Silty loam	Brookston Clay Loam Huron Clay Loam Perth Clay Loam Brookston Clay Loam Huron Clay Loam Perth Clay Loam Huron Silt Loam Brookston Silt Loam Donnybrook Sandy Loam Harriston Silt Loam Huron Silt Loam Listowell Silt Loam Perth Silt Loam Bennington Silt Loam Embro Silt Loam Honeywood Silt Loam Maplewood Silt loam Crombie Silt Loam Tavistock Silt Loam Bryanston Brantford Bennington Honeywood Brant Huron Teeswater Muriel

## 2.2.5 Topography

The topography in the St. Clair area is divided into four main subwatersheds. The Sydenham River drains approximately 67% of the area to the Chenal Ecarte, which discharges into Lake St. Clair. The three shoreline subwatershed areas have several smaller watercourses that drain about 15% of the area to Lake Huron, 12% to Lake St. Clair, and 6% to the St. Clair River. **Map 2: Drainage Areas** shows the four main subwatersheds. **Map 9: Topography** gives an overview of the St. Clair Region Source Protection Area drainage.

### *Sydenham River*

The main Sydenham River is only approximately 5 kilometres in length running from Wallaceburg to the river's outlet in the Chenal Ecarte, which is the eastern channel of the St. Clair River as it discharges into Lake St. Clair. The main Sydenham River is very flat with a gradient of less than 0.1 m per kilometre and water levels are affected by lake levels and wind conditions. Downstream of the Sydenham River, the Chenal Ecarte divides into two distinct channels and flows for 2.4 kilometres to Lake St. Clair through a large area of low swampy land that forms Walpole and St. Anne Islands.<sup>51</sup>

In Wallaceburg, the river divides into the East and North Branches. Both branches have a very flat gradient for several kilometres upstream of Wallaceburg. Water levels in these sections can also be affected by lake levels and wind conditions.

The East Branch of the Sydenham River has its source near Ilderton at an elevation of approximately 282 metres above sea level (masl). During its course of 161 km to its confluence with the North Sydenham at Wallaceburg, it drops to an elevation of 175 masl for an average gradient of 0.7 metres per kilometre. The valley of the East Branch is best developed in the Alvinston area where it is over 15 m deep and a number of tributaries enter it in narrow V-shaped gullies. These and other tributary gullies have elaborately incised the adjacent clay plain.<sup>52</sup>

The North Branch of the Sydenham River is approximately 137 kilometres long. It has a flat gradient between Wallaceburg and Wilkesport where it divides into Bear and Black Creeks. To protect the community of Wallaceburg, the W. Darcy McKeough Floodway and Dam were built in the early 1980s downstream of Wilkesport to divert floodwaters from the North Sydenham west to the St. Clair River. The source of Black Creek near Inwood is at an elevation of approximately 206 masl while the source of Bear Creek near Arkona is at an elevation of approximately 245 masl<sup>53</sup>. Both Black and Bear Creek are relatively flat with gradients of 0.6 and 0.7 metres per kilometre respectively.

### *Lake St. Clair*

The lands draining Lake St. Clair form the southwestern portion of the St. Clair Region area. These lands, similar to the lands around the main Sydenham River, have little relief. Much of the area is dyked and dewatered by pumping to support agricultural activities.

### *St. Clair River*

The St. Clair River serves as a connecting channel draining Lake Huron south into Lake St. Clair, and forms the western boundary of the St. Clair Region. Historically, the majority of the flat area along the St. Clair River was wetland with a small number of creeks draining a narrow area of land adjacent to the river. Much of the shoreline now has hardened shore protection and the majority of wetlands have been removed by systematic tiling of the land.

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<sup>51</sup> Department of Energy and Resource Management. 1965. Sydenham Valley Conservation Report.

<sup>52</sup> Chapman, L.J. and D. F. Putnam. 1966. The Physiography of Southern Ontario. 2<sup>nd</sup> edition.

<sup>53</sup> Department of Energy and Resource Management. 1965.

Before discharging to Lake St. Clair, the St. Clair River divides into several channels creating an extensive delta known as the St. Clair Delta or St. Clair Flats.<sup>54</sup> Chapman and Putnam describe the St. Clair Delta as “a splendid example of a bird’s foot delta; the several channels drawn on a map produce the fanciful resemblance to a bird’s foot.” The delta is made up of discrete islands: Walpole Island, the largest one, is accompanied by Bassett, Squirrel Island and St. Anne Island on the Canadian side. Dickinson Island and Harsens Island are on the American side of the river. The delta is marshy with meadows along the outer borders.<sup>55</sup>

### ***Lake Huron***

The shoreline of Lake Huron forms the northern boundary of the St. Clair Region area. It has varied topography ranging from delta areas in Sarnia to bluffs at Kettle Point.

The Lake Huron shoreline from Point Edward to Bright’s Grove has sandy beaches protecting a marshy lagoon. Historically, there was a shallow lake in the lagoon that was drained to reclaim the marshland for specialty crops.<sup>56</sup>

To the east of Bright’s Grove in the Blue Point area, the northeast section of the Lake Huron shoreline is characterized by incised valleys that have been cut into the till and clay plain. The creeks in the area originate from the Wyoming moraine approximately 10 km inland of the present shore.

In the Kettle Point area, Chapman and Putnam (1966) describe the area as “a shelf of bedrock which has not yet been worn away but stands uncovered so that big round concentrations, called kettles, are exposed. These peculiar forms are like cannon balls of stone; the term “kettle” seems to be something of a misnomer.”

## **2.2.6 Land Forms and Human Character of the Watershed**

The historic and present farming community reflects the suitable soil types combined with the relatively flat topographical features across much of the St. Clair Region Source Protection Area. Initially, the relatively flat topography and resulting lack of drainage in some parts of the watershed were a limitation on agricultural usage. However, over 125 years of drainage works have made most lands available for farming. As shown in **Map 25: Generalized Land Cover**, the watershed is over 80% agricultural. **Map 28: Land Capability for Agriculture** illustrates that most of the land has no significant or only moderate limitations on use for crops.

The presence of oil in the bedrock has also had a significant impact on the human character of the St. Clair Region Source Protection Area. The first oil well in North America, at Oil Springs, was completed in Devonian strata in the Dundee Formation<sup>57</sup>. The Hamilton Formation generally forms an upper seal for the Lucas and Dundee oil and gas formations. In Lambton County, the Dundee and Lucas formations are generally shallow. The first oil well was a primitive hole in the ground where oil bubbled to the surface under its own pressure. Water flowing at depth had an upward gradient and there was a poor seal in the Oil Springs location. Flowing groundwater under artesian conditions pushed oil to the surface. To date, oil production has been largely restricted to the Dundee and Lucas formations. Minor amounts of oil and gas have been found in the overlying Hamilton Group carbonate beds.

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<sup>54</sup> The St. Clair River Area of Concern Water Use Goals Remedial Measures and Implementation Strategy Remedial Action Plan Stage 2 – Recommended Plan, MOEE, St. Clair River RAP Project, Michigan Department of Natural Resources, Surface Water Quality Division, 1995.

<sup>55</sup> Chapman, L.J. and D. F. Putnam. 1966. *The Physiography of Southern Ontario*. 2<sup>nd</sup> edition.

<sup>56</sup> Chapman, L.J. and D. F. Putnam. 1966.

<sup>57</sup> *Geology of Ontario*, p. 977.

Beginning with the development of the Oil Springs and Petrolia communities, the discovery of oil led to the development of the petrochemical industries that located along the St. Clair River, which provides water for processing and shipping connections across the Great Lakes.

Several topographical features, especially those related to water, played an important part in the development and human character of the Source Protection Area.

The St. Clair River provides a connecting channel between Lake Erie and Lake Huron. Sarnia Bay on the St. Clair River supported Great Lakes shipping activities and resulted in development in the City of Sarnia and Village of Point Edward. Other communities (Corunna, Mooretown, Sombra and Port Lambton) were also established along the St. Clair River.

The community of Wallaceburg benefited from having the Sydenham River connection to the St. Clair River and being located at the junction of the North and East Branches of the Sydenham. Several other communities (Dresden, Alvinston and Strathroy) also developed along the East Branch of the Sydenham River. The initial construction of a grist mill (using water power from the East Sydenham River) in 1832 led to the establishment of the Town of Strathroy in 1870.

The Lake Huron shoreline has been a magnet for cottage and residential development. Heavy clay soils restricted installation of private (septic) sewage treatment systems but municipal sewer systems now service most of the Sarnia and Plympton-Wyoming shoreline areas. Erosion of the shoreline does restrict development close to the existing shoreline.

## 2.3 Hydrology & Climate

This section provides an overview of the climatic character and hydrology for the St. Clair Region Source Protection Area.

### 2.3.1 Climate and Meteorological Trends

There are many factors influencing climate in the Thames-Sydenham and Region Source Protection Region. Generally, from a Source Protection perspective, climatic factors influencing the rainfall-runoff process are of the most interest. These include:

- rainfall volume and intensity
- snow accumulation
- air temperature
- wind speed and direction
- solar radiation

#### 2.3.1.1 Climate Monitoring Stations

The two main meteorological systems in the St. Clair Region Source Protection Area are the Environment Canada network, and the Conservation Authority network. The Environment Canada network of automatic and synoptic stations is best for observing long-term trends. These stations have longer periods of record, measure winter precipitation and have uniform quality control. The locations of the Environment Canada main stations in the Thames-Sydenham and Region Source Water Protection Region are listed in **Table 2.3.1.1-1: Environment Canada Climate Monitoring Stations**. **Map 10: Environment Canada Climate Stations** shows the stations in the St. Clair Region.

**Table 2.3.1.1-1: Environment Canada Climate Monitoring Stations**<sup>58</sup>

Station	Period of Record
Chatham	1879 - present
Ridgetown	1883 - present
Wallaceburg	1905 - 1997
Petrolia	1953 - present
Sarnia	1882 - present
London	1871 - present
Stratford	1865 - present
Strathroy	1879 - present
Dorchester	1976 - present
Foldens	1963 - present
Ingersoll	1870 - 1969
Woodstock	1870 - present

Conservation Authorities also maintain their own climate networks. Generally, these were established for the purposes of flood forecasting and warning by measuring rainfall and snow pack depth. The Conservation Authority managed tipping bucket rain gauges to measure hourly rain. They are useful for measuring spring, summer and fall events. Station names and histories are summarized in **Table 2.3.1.1-2 SCRCA Rain Gauge Network**. Because these stations do not measure winter precipitation directly, they do not provide as complete an information base as Environment Canada's climate network. Also, they are often located on the roofs of stream station huts and may not meet all World Meteorological Organization standards for placement and calibration. However, these gauges can support modelling storm events by helping to fill in information gaps in the Environment Canada network.

**Table 2.3.1.1-2: SCRCA Rain Gauge Network**

Station	Period of Record
Brigden	1980 - present
Dresden	1980 - present
Strathroy	1980 - present
Alvinston	1981 - present

The Conservation Authority snow course networks are used for the purposes of spring flood prediction by recording the accumulated snow depth. The station names and histories are summarized in **Table 2.3.1.1-3: SCRCA Snow Course Network**. These stations are generally monitored on a monthly basis. They provide a cumulative history of the water content in the snow pack for each winter season and provide a fairly good data set.

<sup>58</sup> Environment Canada. Canadian Daily Climate Data on CD-ROM - Eastern Canada, 2002 Version. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

**Table 2.3.1.1-3: SCRCA Snow Course Network**

<b>Station</b>	<b>Period of Record</b>
Warwick	1986 - present
McKeough	1986 - present
Henderson	1986 - present
A.W. Campbell	1986 - present
Clarke Wright	1991 - present

The locations of climate data stations maintained by the SCRCA are illustrated on **Map 11: Watershed Hydrologic Conditions Monitoring**.

### **2.3.1.2 Meteorological & Climatic Trends**

Variations in climate conditions have significant impacts on local watercourses and the recharge of groundwater aquifers. Water levels vary from season to season and from year to year because of the combined effects of precipitation, runoff and evaporation.

Climate normals are used to summarize or describe the average climatic conditions of a particular location. The World Meteorological Organization considers 30 years to be long enough to eliminate year-to-year variations. At the end of each decade, Environment Canada updates as many climatic characteristics as possible.

The most recent Canadian climate normals are based on stations that have at least 15 years of data from 1971 to 2000. **Table 2.3.1.2-1: Normal Precipitation** illustrates monthly and annual precipitation normals based on the thirty year period between 1971 and 2000. **Table 2.3.1.2-2: Normal Air Temperatures** provides similar information for air temperature normals.

Data from some of the Environment Canada Climate stations in the Source Protection Region has been tabulated and plotted to illustrate climatic differences across the region.

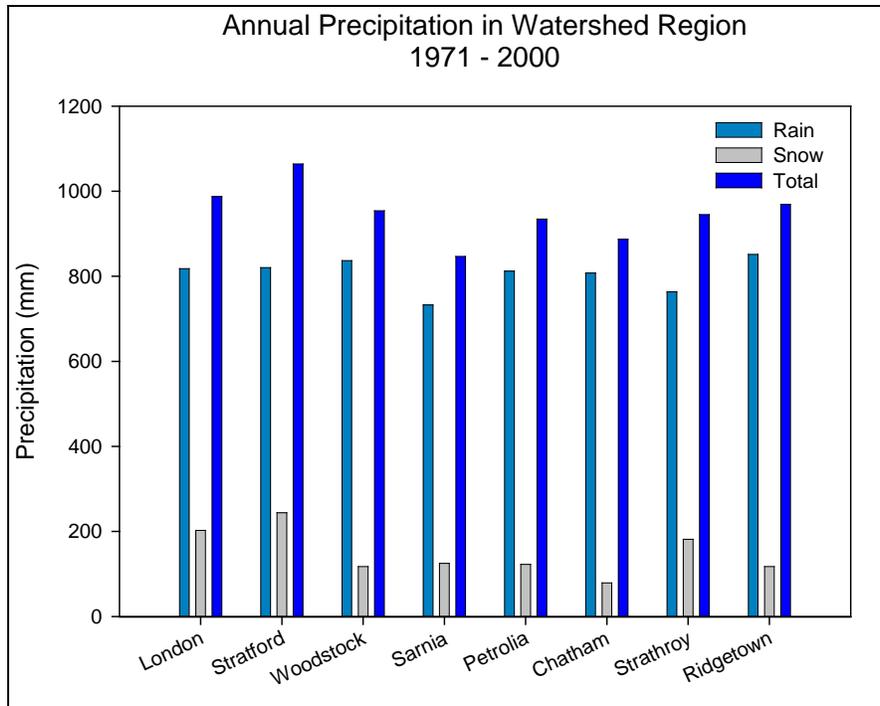
**Figure 2.3.1.2-1: Annual Precipitation Normals** and **Figure 2.3.1.2-2: Annual Average Temperature** provide comparisons of average annual precipitation and average temperatures respectively for the same period from 1971 to 2000.

**Table 2.3.1.2-1: Normal Precipitation (mm) Measured in Watershed Region, 1971 - 2000**

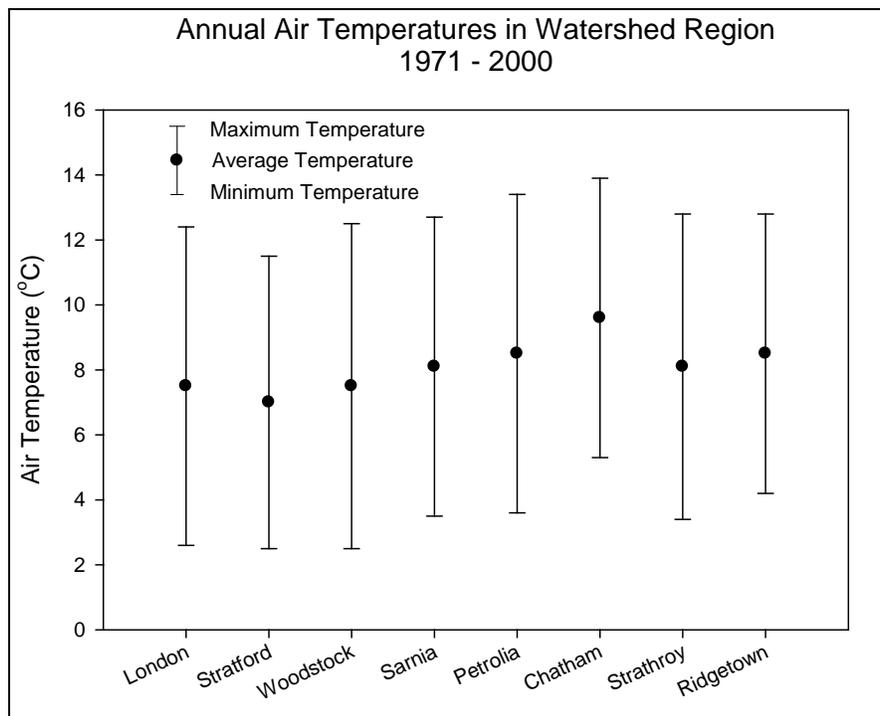
	London			Stratford			Woodstock			Sarnia			Petrolia			Chatham			Strathroy			Ridgetown		
	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total
Jan	31.1	52.6	74.2	28.7	75	104	32.4	31.9	64.3	22.1	31.6	50.1	27.5	40.7	68.3	30	31.1	61.1	27.2	48.1	75.3	25.6	28.6	54.2
Feb	29.1	38.1	60	25.4	43.6	69	32.1	21.6	53.7	24	26.3	47.7	29.5	23.8	53.3	35.3	19.1	54.4	26.9	34.2	61.1	36.1	25.4	61.4
Mar	53.8	28.6	78.4	46.8	28.3	75.1	52.9	19	71.9	44.1	19.3	62.6	49.5	16.6	66.1	49.5	10.8	60.2	51.2	23.8	74.9	66.6	15.2	81.9
Apr	73.8	9.2	82.2	76	9	85.1	75.2	5.2	80.3	70.1	5.4	75.4	81.5	3.8	85.4	76.8	1.4	78.2	75.2	8.8	84	73	4.5	77.5
May	82.6	0.3	82.9	82.2	0.3	82.5	80.4	0.1	80.5	69.9	0	69.9	79.2	0	79.2	74.5	0	74.5	73.9	0.1	74	76.8	0	76.9
Jun	86.8	0	86.8	77.4	0	77.4	84.3	0	84.3	85.6	0	85.6	89.2	0	89.2	83.4	0	83.4	74.5	0	74.5	82.1	0	82.1
Jul	82.2	0	82.2	90.1	0	90.1	95.5	0	95.5	74.1	0	74.1	76	0	76	86.1	0	86.1	71.7	0	71.7	92.8	0	92.8
Aug	85.3	0	85.3	83.3	0	83.3	91.5	0	91.5	77.1	0	77.1	82.2	0	82.2	86.3	0	86.3	82.1	0	82.1	105	0	105
Sep	97.7	0	97.7	104	0	104	93.9	0	93.9	94	0	94	97.5	0	97.5	92.6	0	92.6	89.8	0	89.8	92.9	0	92.9
Oct	74.9	2.7	77.6	79.2	1.6	80.8	72.8	1.2	73.9	64.2	1.8	66	72.6	0.6	73.3	68.6	0.1	68.6	67.4	3.4	70.8	55.4	0.1	55.4
Nov	73.7	19.7	91.1	79.3	22.5	102	75.8	9.9	85.6	67	10.2	76.4	76.7	7.9	84.6	72.9	1.7	74.6	77.6	16.9	94.5	84.2	9	93.3
Dec	47	51.1	88.6	47.7	63.4	111	49.9	28.7	78.6	40.5	30.3	68	50.5	29	79.6	51.7	15.1	66.7	45.9	46.5	92.4	61.1	34.5	95.6
Annual	818	202	987	820	244	1064	837	117	954	733	125	847	812	123	935	808	79.2	887	764	182	945	851	117	969

**Table 2.3.1.2-2: Normal Air Temperature (°C) Measured in Watershed Region, 1971 - 2000**

	London			Stratford			Woodstock			Sarnia			Petrolia			Chatham			Strathroy			Ridgetown		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Jan	-6.25	-2.41	-10.1	-6.72	-3.21	-10.2	-6.27	-2.31	-10.2	-5.36	-1.73	-8.94	-5.32	-1.58	-9.01	-3.68	-0.32	-7.02	-5.78	-2.16	-9.37	-6.04	-2.52	-9.54
Feb	-5.5	-1.4	-9.7	-6	-2.2	-9.7	-5.4	-1.1	-9.6	-4.4	-0.6	-8.3	-4.4	-0.3	-8.5	-2.4	1.1	-6	-5.2	-1.2	-9.2	-4.6	-1	-8.2
Mar	-0.3	4.2	-4.7	-1	3.1	-5	-0.3	4.2	-4.8	0.7	4.8	-3.5	1	5.7	-3.6	2	6.1	-2.1	0.5	4.7	-3.7	0.7	4.5	-3.1
Apr	6.3	11.6	1	5.8	10.6	1	6.4	11.6	1.1	6.5	11.4	1.5	7.2	12.6	1.8	8.3	13.2	3.4	7	12	1.9	7.1	11.9	2.2
May	13	19	7	12.6	18.3	6.8	13.2	19.2	7.1	12.7	18.3	6.9	13.8	19.8	7.7	14.8	20.2	9.4	13.6	19.4	7.7	13.6	18.9	8.3
Jun	18	23.8	12.1	17.4	23.1	11.8	18.2	24.1	12.2	18	23.6	12.4	18.8	24.9	12.8	20.2	25.5	14.9	18.6	24.3	12.8	18.8	23.9	13.5
Jul	20.5	26.3	14.6	19.7	25.4	14	20.4	26.4	14.5	20.9	26.3	15.5	21.5	27.4	15.5	22.5	27.5	17.4	21.2	27	15.3	21.5	26.8	16.2
Aug	19.5	25.2	13.7	18.9	24.3	13.3	19.6	25.3	13.7	20	25.3	14.8	20.6	26.3	14.8	21.4	26.3	16.6	20.2	25.8	14.5	20.6	25.5	15.6
Sep	15.3	20.9	9.6	14.9	20	9.7	15.4	20.9	9.8	16.1	21.3	10.7	16.6	22.2	11	17.6	22.4	12.7	16	21.4	10.5	16.8	21.6	12
Oct	9	14	4	8.8	13.1	4.4	9.1	14.1	4.1	9.9	14.7	5.1	10.3	15.2	5.3	11.2	15.6	6.9	9.8	14.5	5.2	10.6	14.8	6.3
Nov	3.1	6.9	-0.7	2.5	5.6	-0.6	3.1	6.8	-0.7	3.9	7.6	0.2	3.9	7.6	0.2	4.8	8.1	1.5	3.8	7.3	0.3	4.5	8	1
Dec	-3	0.6	-6.5	-3.5	-0.4	-6.5	-3	0.5	-6.5	-2.3	1.1	-5.6	-2.2	1.2	-5.5	-1.2	1.8	-4.3	-2.5	0.7	-5.7	-1.9	1.4	-5.2
Annual	7.5	12.4	2.5	7	11.5	2.4	7.5	12.5	2.6	8.1	12.7	3.4	8.5	13.4	3.5	9.6	13.9	5.3	8.1	12.8	3.3	8.5	12.8	4.1



**Figure 2.3.1.2-1: Annual Precipitation Normals**



**Figure 2.3.1.2-2: Annual Average Temperature**

Environment Canada data from 1950 to 2005 has been used to provide background information on the total annual precipitation at the Sarnia, Wallaceburg and Strathroy climate stations in the St. Clair Source Protection Area. The meteorological files have been reviewed to clean up records and fill in missing data

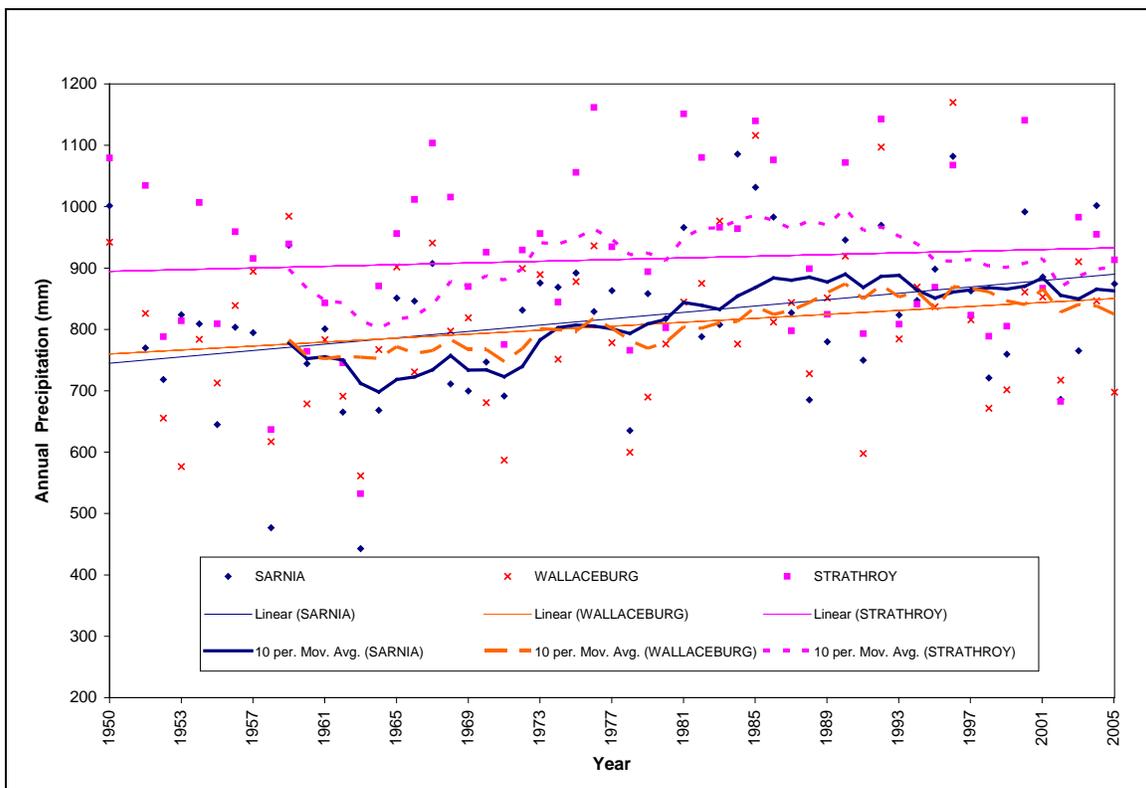
values using the procedures outlined in the paper *Filling Gaps In Meteorological Data Sets Used For Long –Term Watershed Modelling* presented at the Ontario Water Conference in 2000<sup>59</sup>.

**Table 2.3.1.2-3: St. Clair Region Annual Precipitation 1959-2005** illustrates the variation over the years. Annual precipitation can vary by over two times from year to year. For example, at Sarnia, the minimum annual precipitation was as low as 443 mm in 1963 and the maximum precipitation was as high as 1,092 mm in 1984. The variation in precipitation from year to year means that there can be a significant difference in the water available to recharge groundwater aquifers or maintain stream flow.

**Table 2.3.1.2-3: St. Clair Region Annual Precipitation 1950-2005 in mm**

Location	Average	Max (year)	Min (year)
Sarnia	819	1086 (1984)	443 (1963)
Wallaceburg	806	1170 (1996)	561 (1963)
Strathroy	914	1162 (1976)	532 (1963)

Environment Canada data from 1950 to 2005 has also been used to plot graphs of the total annual precipitation for the Sarnia, Wallaceburg and Strathroy climate stations. These plots are shown in **Figure 2.3.1.2-3: St. Clair Region Annual Precipitation**.



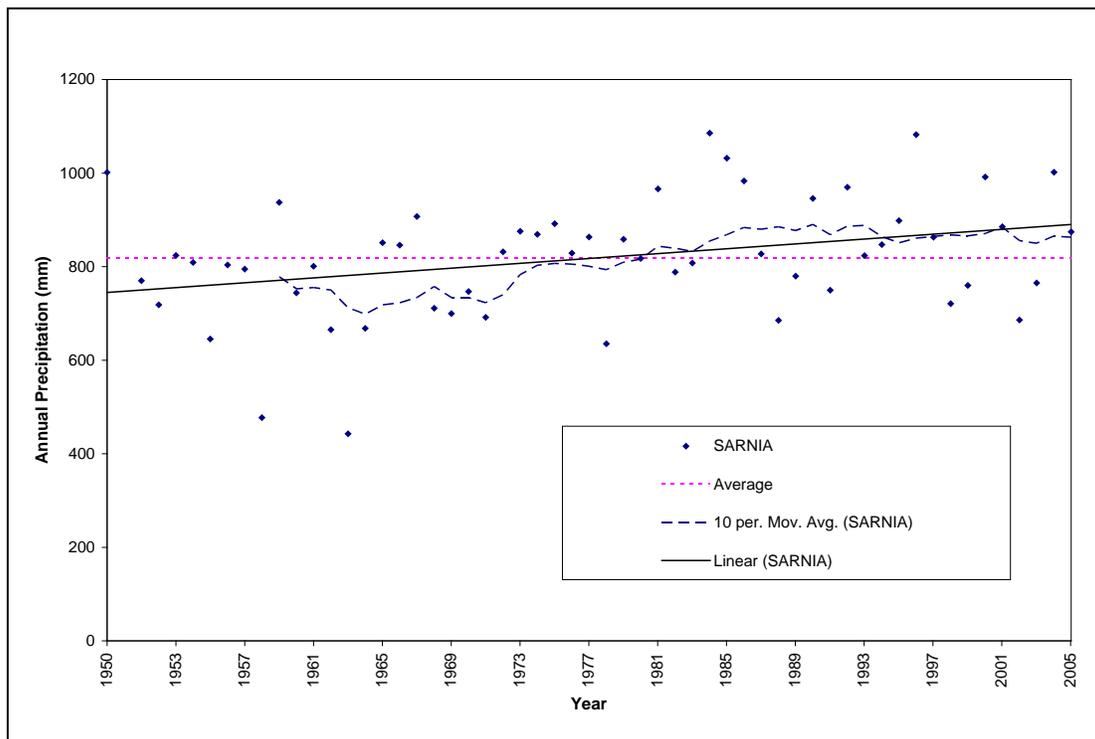
**Figure 2.3.1.2-3: St. Clair Region Annual Precipitation (1950-2005)**

<sup>59</sup> Schroeter & Associates. March 6, 2007. Meteorological Data Missing –Value Fill-in Study for Ontario (Draft 1). Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

The linear trend lines are shown for each station. All three stations have slightly increasing linear trend lines. As a way to smooth out the year-to-year fluctuations while trying to capture trends, 10 year running averages<sup>60</sup> have also been calculated and plotted on the graphs.

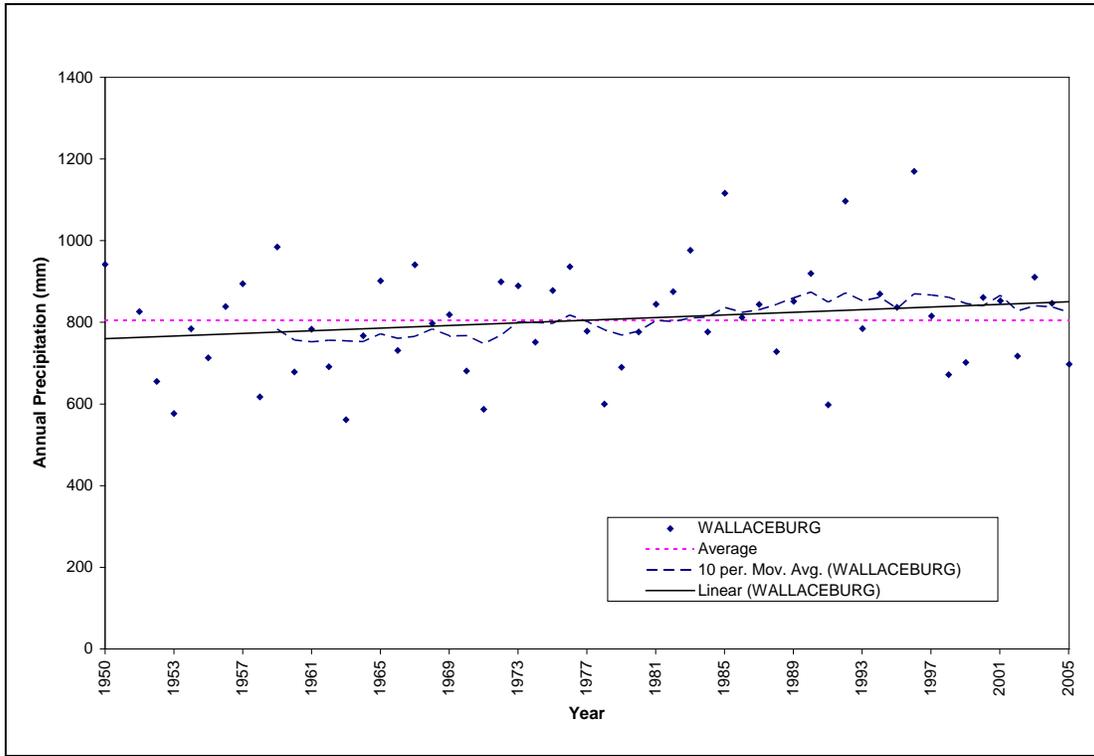
The data sets for the individual stations have been plotted in separate figures for Sarnia, Wallaceburg and Strathroy to provide a clearer picture for the different locations. The average precipitation for each station over the 56 years also has been plotted on these figures to provide some additional reference and to help show the variation in annual precipitation.

The 10 year running averages begin in 1959, which is the first year a 10 year average can be calculated for this data set. In general, the 10 year averages are less than the 56 year average during the 1960s and 1970s and have been higher than the long-term average in the 1980s and early 1990s. More recently, the 10 year averages have decreased.

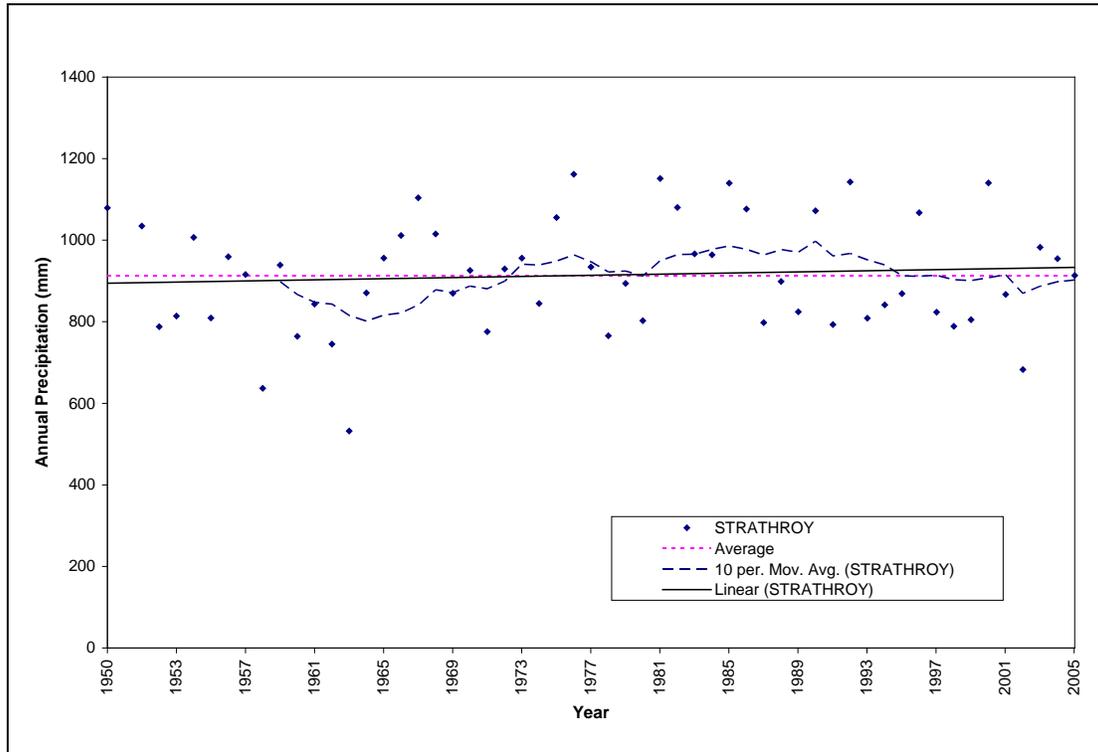


**Figure 2.3.1.2-4: Sarnia Precipitation (1950-2005)**

<sup>60</sup> NOAA's National Weather Service Weather Forecast Office. Climate Trends in Southeast South Dakota from 1895 through 2005. [www.crh.noaa.gov](http://www.crh.noaa.gov)  
Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1



**Figure 2.3.1.2-5: Wallaceburg Precipitation (1950-2005)**

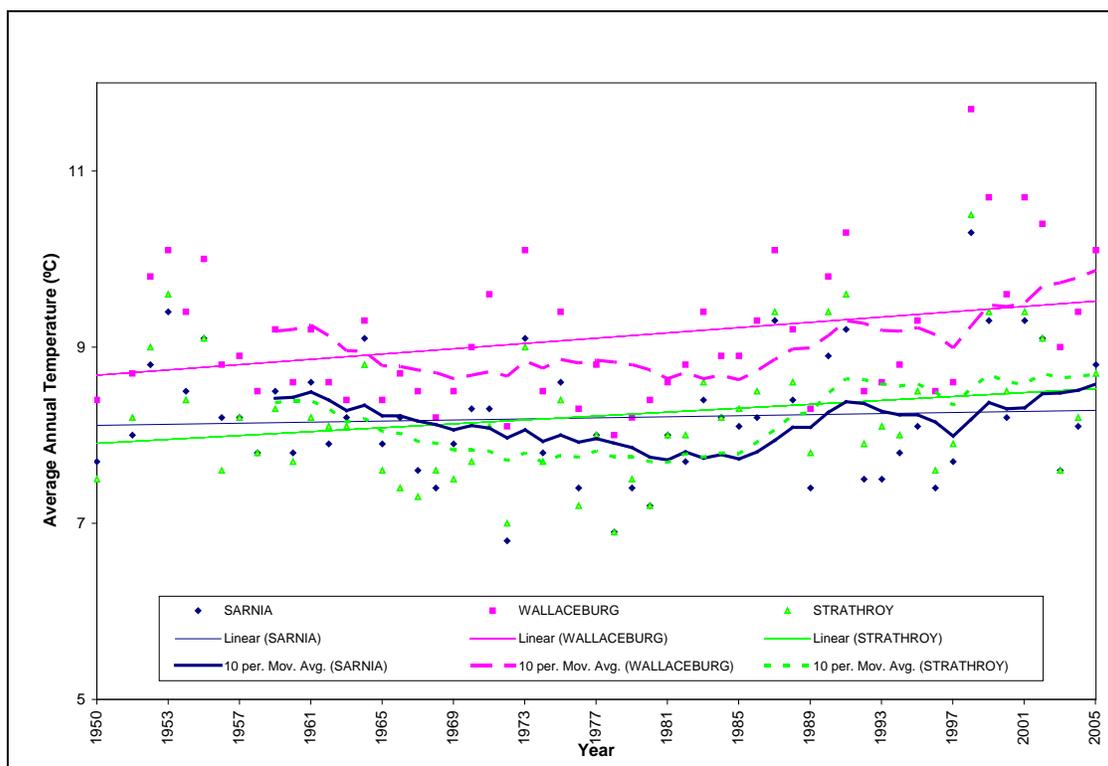


**Figure 2.3.1.2-6: Strathroy Precipitation (1950-2005)**

The average annual temperatures for the three stations also have been plotted and are shown in **Figure 2.3.1.2-7: St. Clair Region Average Temperature 1950-2005**. The ten year running averages are shown to try to smooth out year to year fluctuations and capture possible trends<sup>61</sup>. The linear lines of best fit also are shown. The minimum annual average temperature was 6.8°C (Sarnia – 1972) and the maximum was 11.2 (Wallaceburg – 1998).

In general, the stations have similar highs and lows in the 10 year running averages. The most southerly station, Wallaceburg, has higher 10 year averages and linear trend lines than the other stations. The Sarnia station appears to show a more moderate linear trend line that may reflect the proximity to a large body of water.

The temperature data sets for the individual stations have been plotted in separate figures to provide a clearer picture for the different locations. The average temperature for each station over the 56 years has also been plotted on the figures to provide some additional reference and to help show the variation in annual temperature.



**Figure 2.3.1.2-7: St. Clair Region Average Temperature (1950-2005)**

<sup>61</sup> NOAA's National Weather Service Weather Forecast Office. Climate Trends in Southeast South Dakota from 1895 through 2005. [www.crh.noaa.gov](http://www.crh.noaa.gov)

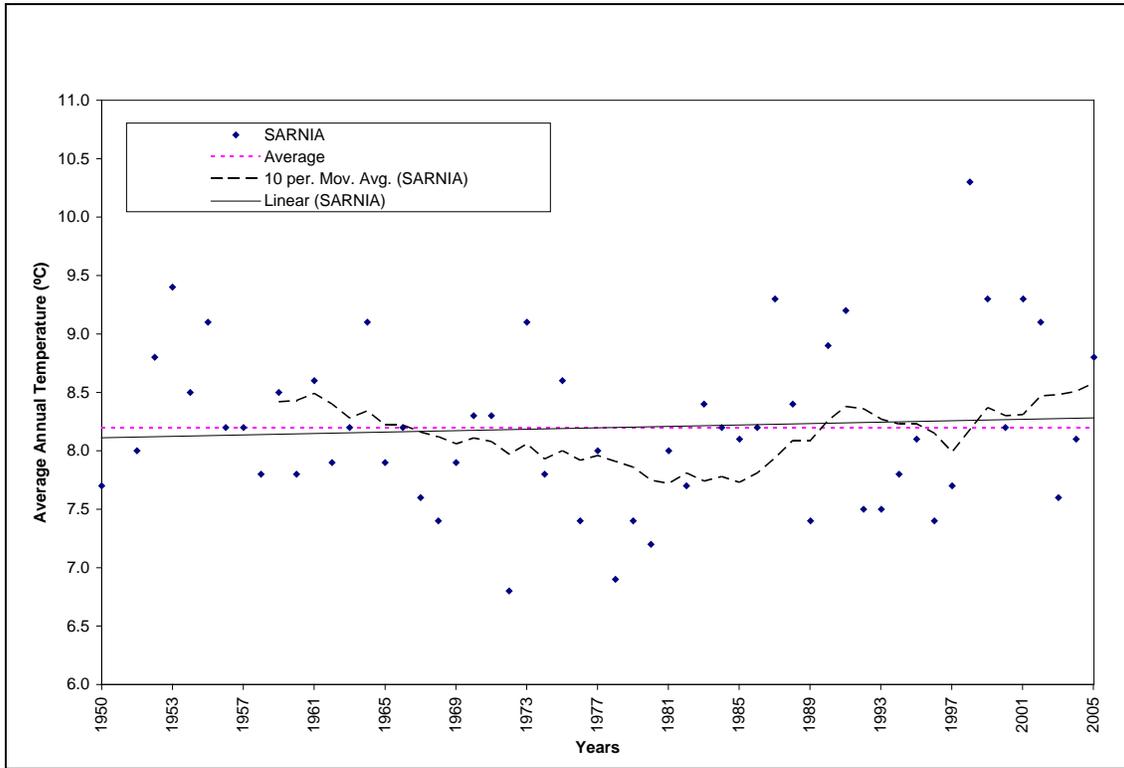


Figure 2.3.1.2-8: Sarnia Temperature (1950-2005)

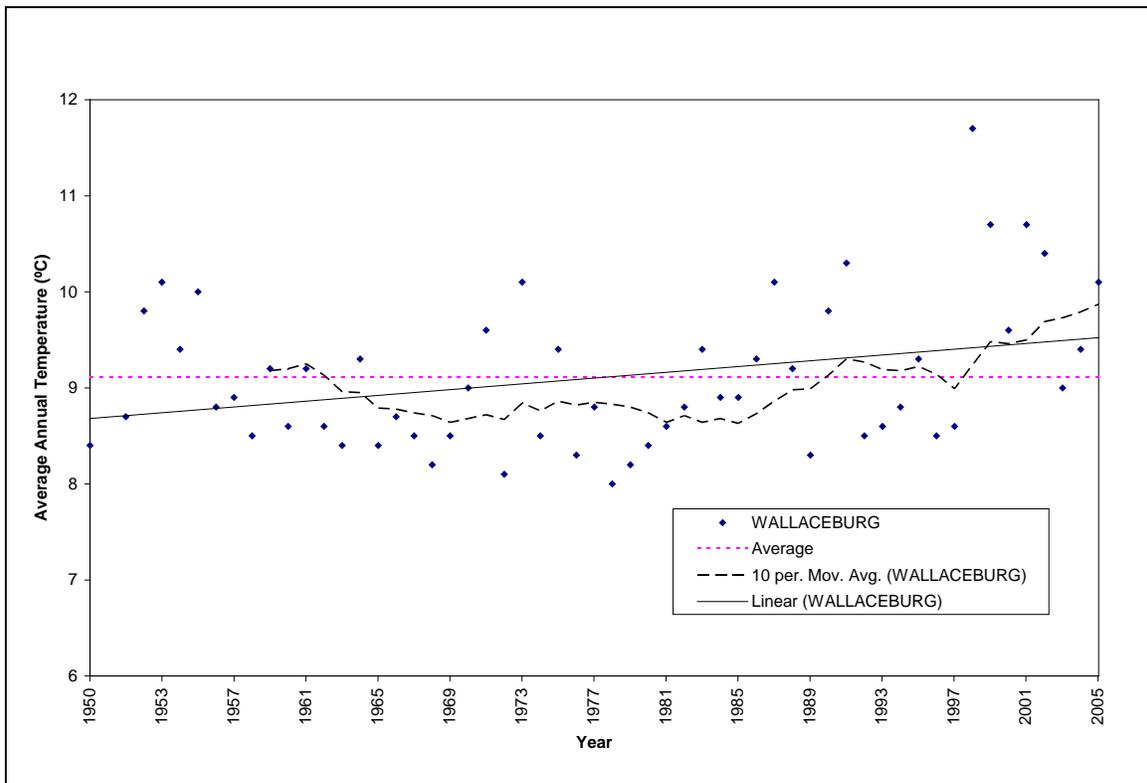
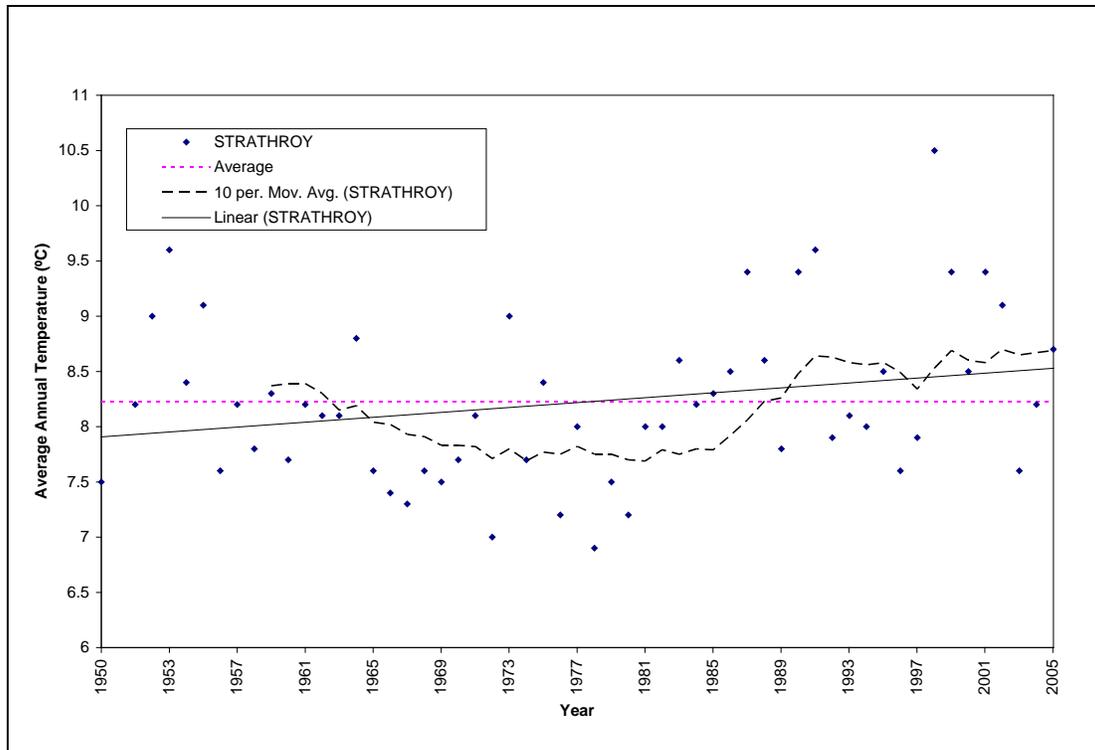


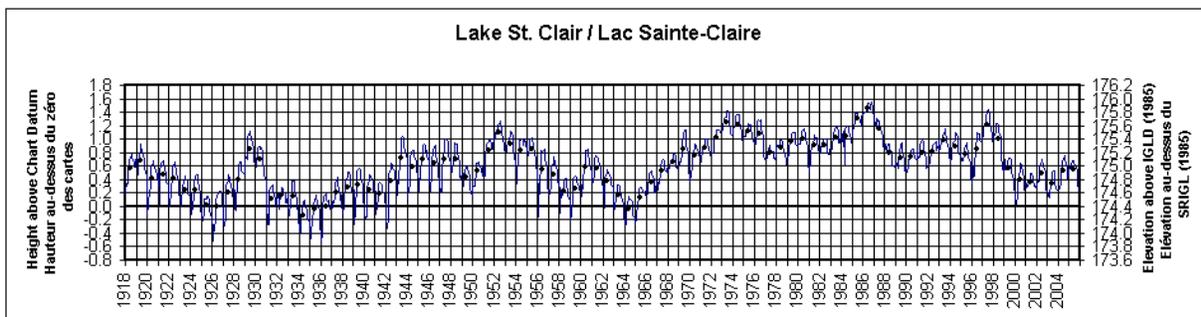
Figure 2.3.1.2-9: Wallaceburg Temperature (1950-2005)



**Figure 2.3.1.2-10: Strathroy Temperature (1950-2005)**

The Thames-Sydenham and Region Source Protection Region is part of the Great Lakes basin. The Great Lakes receive their water supplies from the precipitation that falls on the lakes themselves and the portion of the precipitation in their drainage basins that eventually flows into the lakes. Great Lakes water levels vary from season to season and from year to year because of the combined effects of precipitation, runoff and evaporation.

A plot of the average annual water level recorded in Lake St. Clair since 1918 is provided in **Figure 2.3.1.2-11: Lake St. Clair Water Levels**. More than a century of records in the Great Lakes basin indicates no regular, predictable cycle. However, it does illustrate the effect that climatic and meteorological conditions can have on water supplies.



**Figure 2.3.1.2-11: Lake St. Clair Water Levels**

Over a period of years, there are long-term fluctuations that result from persistent low or high net water supplies to the Great Lakes basin<sup>62</sup>. Extremely low levels were recorded in 1926, the mid-1930s and mid-1960s, while high levels occurred in 1952, 1973 and 1985-86.<sup>63</sup> From the mid 1970s to the late 1990s, there has been a 20 year period of high water levels. In the early 2000s, they have returned to the lower levels experienced in the past.

### 2.3.1.3 Ontario Low Water Response

Southwestern Ontario has experienced periods of low summer (and fall) rainfall in recent years. Combined with high temperatures, this has resulted in all of the Thames-Sydenham and Region Source Protection Region experiencing low water conditions of varying severity during the years of 1998, 1999, 2001, 2002, 2003, 2004 and 2005.

In 2000, the Provincial Government started the Ontario Low Water Response Program to deal with low water issues. Definitions of low water and drought were established. The plan currently uses precipitation and stream flow (surface water flow) measurements as the primary indicators for defining low water levels and drought. (Indicators for base flow, groundwater and aquifer levels are to be developed).

The plan established three low water condition levels: Level I (Conservation), Level II (Conservation, Restriction) and Level III (Conservation, Restriction, Regulation). **Table 2.3.1.3-1: Summary of Levels and Thresholds – Low Water Response** provides a simplified outline of the indicators used to determine when low water level conditions exist.

**Table 2.3.1.3-1: Summary of Levels and Thresholds – Low Water Response**

Condition	Indicator	
	Precipitation	Stream Flow
Level I	Less than 80% of average	Spring: monthly flow less than 100% of lowest average summer month flow Other times: monthly flow less than 70% of lowest average summer month flow
Level II	Less than 60% of average Weeks with less than 7.6 mm	Spring: monthly flow less than 70% of lowest average summer month flow Other times: monthly flow less than 50% of lowest average summer month flow
Level III	Less than 40% of average	Spring: monthly flow less than 50% of lowest average summer month flow Other times: monthly flow less than 30% of lowest average summer month flow

Under the Ontario Low Water Response plan, a local Water Response Team has been created to handle the responsibilities of the response process for the St. Clair Region. For the province, a standing Low Water Committee has been established. This provincial committee must be notified and becomes active when any watershed enters a Level II condition.

Low water conditions generally begin with low precipitation (and high temperatures) in the summer. Cooler temperature, reduced evapotranspiration and increased rains in the fall restore stream flow.

<sup>62</sup> Fisheries and Oceans Canada, Canadian Hydrographic Service Central and Arctic Region. June 2006. Fluctuations in Lake Levels.

<sup>63</sup> Environment Canada. Freshwater Website, Fluctuating Water Levels (Great Lakes), July 2006.

Since the Low Water Response Program was established, the St. Clair Region Conservation Authority has had Level I conditions occur in each year from 2001 to 2005. The occurrences are summarized in **Table 2.3.1.3-2: Low Water Level I Advisory History**. While the spring of 2006 was also dry, there was enough rainfall to avoid the Level I threshold in 2006.

**Table 2.3.1.3-2: Low Water Level I Advisory History - St. Clair Region**

Year	Start	End
2001	August	October
2002	August	May (2003)
2003	September	November
2004	October	January (2005)
2005	July	December

In 2002, low precipitation extended through the fall and into winter with low snowfall. These circumstances resulted in the Level I condition continuing until May 2003.

In 2004, dry conditions in the late summer and fall together with low snowfall delayed a return to normal conditions until January 2005.

### 2.3.1.4 Climate Change

The Canada Country Study: Climate Impacts and Adaptation<sup>64</sup> was the first national assessment of the social, biological and economic impacts of climate change for Canada. There has been warming of about 1°C over the past century with increased annual precipitation over the past 50 years in Canada. These figures are consistent with global trends. Climate change projections suggest that over the next century, further warming of 1 to 3.5°C will occur. Based on this scenario, the Canada Country Study found that the implications of climate change for water resources are a key to defining overall impacts for all sectors and regions of the country<sup>65</sup>.

The Ontario Region Executive Summary<sup>66</sup> for the Canada Country Study provides a synopsis of the impacts expected for southern Ontario. The results of the Global Circulation Model (GCM) simulations considered for the study suggested an average annual warming of some 2 to 5°C by the latter part of the 21<sup>st</sup> century for Ontario. However, it was also noted that even the most sophisticated GCMs do not incorporate the effects of important local climate controls, such as the Great Lakes. For this and other reasons, there was considerable uncertainty about the application of GCM results on a regional scale.

In southern Ontario, the climate is highly modified by the influence of the Great Lakes. The addition of moisture from the Great Lakes in autumn and winter increases precipitation amounts. The Great Lakes also protect the region from the worst of winter's cold and in summer, they act to moderate the potentially oppressive heat of tropical air which regularly approaches the region.

In 2007, the Ontario Ministry of Natural Resources and the Canadian Forest Service prepared a new website<sup>67</sup> (Go Green Ontario – Climate Change Projections for Ontario) to allow people to see projections of possible future climates in Ontario over the 21<sup>st</sup> century. Since climate change projections depend on

<sup>64</sup> Environment Canada. The Canada Country Study: Climate Impacts and Adaptation.

<sup>65</sup> Environment Canada. The Science and the Environment Bulletin, November/December 1997.

<sup>66</sup> Environment Canada. The Canada Country Study – Ontario Region Executive Summary, [www.on.ec.gc.ca/canada-country-study](http://www.on.ec.gc.ca/canada-country-study).

<sup>67</sup> Go Green Ontario – Climate Change Projections for Ontario, [www.gogreenontario.ca](http://www.gogreenontario.ca).

many factors, the two scenarios used for the website are considered intermediate scenarios that were approved by the Intergovernmental Panel on Climate Change.

The scenario with lower emissions of greenhouse gases indicates that in southern Ontario at the end of the century, temperatures would be 2 to 4°C warmer in summer and 3 to 5°C warmer in winter. By 2071-3000, most of southern Ontario would receive up to 10% less precipitation in summer and up to 20% less precipitation in winter compared to 1971-2000.

The scenario with the higher emissions of greenhouse gases indicates that most of southern Ontario would be 4 to 5°C hotter in summer and 20% less rain will fall from April to September. Winters in some southern Ontario locations will be up to 6°C warmer with 10 to 20% less precipitation from October to March by 2071-3000.

While the level of change varies depending on the model assumptions, the projection of warming by the latter part of the 21<sup>st</sup> century is expected to cause Ontario to experience:

- fewer weeks of snow
- longer growing season
- less moisture in the soil
- increase in frequency and severity of droughts
- changes to aquatic ecosystems and alterations to wetlands
- the Great Lakes levels declining to record lows
- increases in extreme weather (hot days, severe thunderstorms, freezing rain).

The overall impacts are difficult to predict but there are several potential changes that are of concern for water quality and quantity for drinking water sources.

- Less rainfall and rainfall at different times could increase the demand for irrigation water especially on drought-prone soils or shallow-rooted crops such as potatoes.
- Less rainfall and snow could have an impact on groundwater aquifers and base flow in streams.
- In the Great Lakes, higher water temperatures could lead to reduced water quality by creating more favourable environmental conditions for microbes and algae and lower water levels may affect the ability of intakes to draw water.

## 2.3.2 Hydrogeology

Hydrogeology is the science that deals with the occurrence and movement of water below the ground's surface. To a large extent, groundwater studies deal with the unseen and, therefore, depend on modelling of the perceived underground water pathways. Groundwater modelling requires an integrated approach that incorporates geology, chemistry, physics, meteorology and engineering.

The first step in conceptualizing the groundwater flow regime is to study well driller's logs. These can provide observations of the material that characterize overburden layers.

The primary differentiation is based on whether the material has the properties of an aquifer (readily transmits water) or has the properties of an aquitard (prohibiting the movement of water).

In most cases, groundwater flow obeys Darcy's Law which states that the velocity of groundwater is proportional to both the hydraulic conductivity (water conducting capacity of the material) of the formation and the hydraulic gradient (slope of the groundwater surface).

Most of this section was taken directly from the (unpublished) report<sup>68</sup> by Waterloo Hydrogeologic, Inc. The discussion begins with a review of the regional setting and moves to more specific groundwater flow interpretation with the identification of aquifers and aquitards.

### Regional Hydrogeologic Setting

Groundwater occurrence and flow within the region is primarily controlled by:

- precipitation and evapotranspiration,
- topography and enhanced (tile) drainage,
- water table (piezometric) levels and soil moisture conditions,
- surficial geologic units, which define porosity and hydraulic conductivity, and
- the spatial distribution and connectivity of geologic units.

In some areas, rivers, lakes and streams may recharge aquifers. However, we are most concerned with groundwater recharge associated with precipitation over large land areas. This recharge is controlled by a number of factors including permeability and porosity of surficial units, topography and land use.

Precipitation is the primary source of groundwater recharge. Groundwater recharge is determined by three factors: the amount of precipitation that is not lost by evapotranspiration and runoff; the vertical hydraulic conductivity of the surficial deposits (the ability for the water to move downwards); and the gradient of the water table (potentiometric surface) which determines how fast or slow the water can move away from the recharge area.

Within the region, there are a number of aquifers and aquitards that vary greatly in spatial extent and thickness. Two distinct aquifer types, bedrock and overburden, were identified during cross-section interpretations. Bedrock aquifers can usually be subdivided into "contact" and "deeper" bedrock aquifers. Overburden aquifers may be divided into shallow, intermediate and deep overburden aquifers. In addition, aquifers are classified as either confined (bounded by two low permeability units) or unconfined (the upper surface is defined by the water table).

#### 2.3.2.1 Bedrock Aquifers

Bedrock groundwater is less affected by surface watershed boundaries than overburden aquifers. In the Thames, Sydenham Source Protection Region, groundwater moves faster in areas where there is more of

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<sup>68</sup> Waterloo Hydrogeologic. 2004. Six Conservation Authorities FEFLOW Groundwater Model. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

a slope in the bedrock water table, such as Shakespeare or St. Marys. It moves more slowly where the water table is relatively flat in Chatham-Kent and Lambton. In bedrock groundwater terms, “fast” means it takes tens or hundreds of years to move a small distance under natural conditions and “slow” means it takes thousands of years.

Bedrock aquifers are regionally extensive and are productive aquifers for both municipal and domestic water supply. Groundwater in higher recharge areas where the water moves faster is aesthetically good (i.e. low mineral content). Groundwater in low recharge areas carries more minerals such as sulphur and iron because it has had more time to leach or react with minerals from the rock.

As discussed earlier, the majority of the Paleozoic bedrock units within the St. Clair area dip regionally to the southwest toward the centre of the Michigan Basin

The bedrock aquifers can usually be subdivided into “contact” and “deeper” bedrock aquifers. The upper three to five metres of the bedrock’s surface is more weathered and fractured and, therefore, forms a more transmissive “contact” aquifer than the underlying “deeper” competent bedrock units.

**Map 12: Bedrock Water Table** presents a generalized groundwater level (potentiometric surface) map for the bedrock units in the area. In the St. Clair area, the bedrock table is highest in the Warwick and Middlesex Centre parts of the watershed. The bedrock water table elevation across the combined watersheds of the Thames-Sydenham and Region ranges from 355 to 170 metres above sea level (masl). This information is based on the Southwestern Edge-Matching Study<sup>69</sup> which compiled data from the Essex/Chatham-Kent<sup>70</sup>, Lambton<sup>71</sup>, Middlesex/Elgin<sup>72</sup>, Huron<sup>73</sup>, Perth<sup>74</sup> and Oxford<sup>75</sup> municipal groundwater studies.

Regionally, the “contact” aquifer groundwater in the fractured bedrock flows from the topographically high areas to the lower elevations where it discharges to rivers, streams and the Great Lakes basins. Therefore, the contact aquifer behaves like an overburden aquifer in many areas.

The bedrock within the regional area includes numerous limestone, dolostone shale and lesser sandstone Paleozoic rock formations. The shale units act as regional aquitards while the limestone and dolostone bedrock formations form excellent aquifers. The bedrock aquifers including the limestone and dolostone formations typically form confined aquifers since the bedrock is buried throughout the region (outcropping in only a few locations).

The Silurian aged Bass Islands and the Devonian aged Bois Blanc Formation are separated by a disconformity (a break in the sequence of sedimentary rocks). This feature may be significant from a hydrogeologic perspective as the upper surface of the Bass Islands is interpreted to be weathered, and highly fractured. Sand and pebbles from the Devonian age are commonly present in cracks and joints of the Bass Islands. Therefore, the upper surface of the Bass Islands may be able to transmit greater volumes of water than the rock at depth.

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<sup>69</sup> Waterloo Hydrogeologic for Ontario Ministry of the Environment. 2005. Southwestern Region Edge-Matching Study.

<sup>70</sup> Dillon Consulting and Golder Associates. December 2004. Essex Region/Chatham-Kent Region Groundwater Study.

<sup>71</sup> Dillon Consulting and Golder Associates. December 2004. Lambton County Groundwater Study, Final Report.

<sup>72</sup> Dillon Consulting and Golder Associates. July 2004. Middlesex-Elgin Groundwater Study, Final Report.

<sup>73</sup> Golder Associates. 2002. Groundwater Resource Assessment, County of Huron.

<sup>74</sup> Waterloo Hydrogeologic. April 2003. Perth County Groundwater Study, Final Report.

<sup>75</sup> Golder Associates. 2001. Phase II Groundwater Protection Study, County of Oxford.

The Lucas Formation is known to be a good aquifer<sup>76</sup>. Both the Lucas Formation and Dundee Formation are believed to be karstic (irregular limestone with sinks, underground streams and caverns). In Huron-Perth, bedrock water levels decrease dramatically from east to west at the sub crop boundary between the Dundee Formation (west) and the underlying Lucas Formation (east).

Groundwater associated with the Salina Formation is generally of poor quality as the evaporite deposits (anhydrite, gypsum and salt) often result in sulphurous qualities including sulfate and/or hydrogen sulfide gas. This formation is used primarily for irrigation. Due to the sulfurous qualities, it is seldom used for domestic water supply. Several companies extract salt from Salina Formation with deep brine wells at Windsor, Sarnia and Goderich<sup>77</sup>.

Due to their depth below the ground surface, the older basement rocks are not expected to have a significant influence on groundwater flow directly.

### **2.3.2.2 Overburden Aquifers**

Overburden aquifers in the region include the coarse-grained sands and gravels of the various sand plains, kame moraines and coarse-grained interstadial sediments that lie between till sheets.

Coarse-grained overburden deposits (e.g. outwash deposits and kame moraines) are the most transmissive units. Groundwater flows rapidly through these units making them excellent regional and local aquifers.

Fine-grained overburden units such as till plains or clay plains represent local and regional aquitards that impede groundwater flow and recharge to deep aquifers. While aquitards are not suitable for groundwater supply, they can serve to protect adjacent aquifers from contamination as they restrict migration of contaminants.

The overburden aquifers can be surficial unconfined (the upper surface is defined by the water table) or confined (bounded by two low permeability units). Overburden aquifers may also be divided into shallow, intermediate and deep aquifers.

Within the area, the majority of the overburden aquifers are unconfined. Smaller scale features of the terrain, such as hummocky topography and moraine ridges, can influence local groundwater flow directions.

#### ***Surficial Unconfined Aquifers***

These shallow aquifers are commonly used in private and domestic water use. This type of aquifer is associated with the coarse-grained surficial deposits such as the extensive sand plains such of Caradoc and Bothwell Sand Plains, or outwash sand deposits that blanket the flanks of the end moraines within the area such as the Wyoming Moraine. As they are highly susceptible to groundwater contamination, they are not often used as municipal groundwater resources.

#### ***Confined Overburden Aquifers***

Confined overburden aquifers include intermediate and deep aquifers. Intermediate overburden aquifers are present erratically within the region. These are interpreted to be interstadial outwash sands and gravels that lie at an in-between depth. Generally, these are pockets of material surrounded by aquitard layers.

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<sup>76</sup> Waterloo Hydrogeologic for Ontario Ministry of the Environment. 2005. Southwestern Region Edge-Matching Study.

<sup>77</sup> Hewitt, D.F. 1972. Paleozoic Geology of Southern Ontario. Ontario Division of Mines, Geological Report 105. 18p.

Deep overburden aquifers consist of saturated sand and gravel deposits and can be discontinuous in nature due to glacially-related erosional and depositional conditions<sup>71</sup>. These deep overburden aquifers are spatially discontinuous, but can act as highly productive aquifers in some areas.

Sand and gravel deposits have been identified between the St. Joseph’s Till and the underlying black shale till. As well, sand and gravel deposits can occur at the base of the overburden overlying the bedrock and may be part of the “contact” bedrock aquifer in the first few metres of weathered and fractured bedrock.

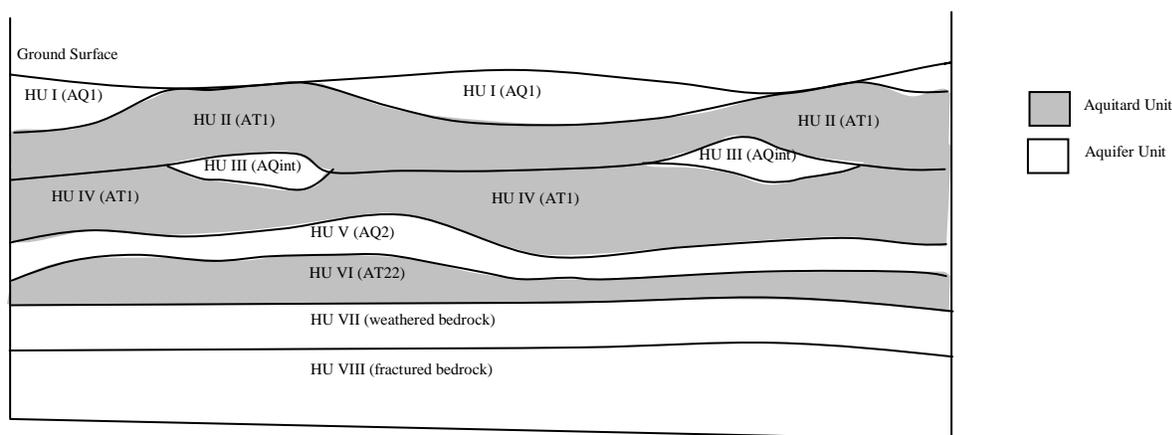
### 2.3.2.3 Aquifer Interaction (Aquifer Hydrostratigraphy)

#### *Hydrostratigraphic Units*

Grouping geologic units allows the subsurface to be simplified into a series of ‘packages’ that can be examined for the analysis of groundwater flow.

Complex geologic units with similar hydrogeologic properties, textural characteristics and a similar stratigraphic position can be grouped together to form a ‘hydrostratigraphic unit’. A hydrostratigraphic unit can be a formation, a part of a formation, or a group of formations that possess similar hydrologic characteristics. This allows the subsurface to be divided into aquifers and aquitards.

**Figure 2.3.2.3-1: Schematic Cross-section of Hydrostratigraphic Units** gives a visual presentation of the various units in a conceptual geological model for the region.



**Figure 2.3.2.3-1: Schematic Cross-section of Hydrostratigraphic Units**

**Table 2.3.2.3-1: Hydrostratigraphic Units in the Thames-Sydenham and Region** provides an outline of the units in the region. The type of hydrostratigraphic unit (aquifer/aquitard), a brief description, and the geologic subunits are summarized.

**Table 2.3.2.3-1: Hydrostratigraphic Units in the Thames-Sydenham and Region.**

<b>Hydrostratigraphic Unit</b>	<b>Description</b>	<b>Specific Geologic Subunits</b>
HU I Aquifer AQ1	Coarse-grained glaciofluvial/ glaciolacustrine/ ice-contact sands and gravels	Includes: Bothwell, Caradoc, Norfolk and Leamington Sand Plains as well as Easthope and Staffa Kame Moraines
HU II Aquitard AT1	Fine-grained subglacial till sheets, glaciolacustrine diamicts and lacustrine clay plains	Tills include: Rannoch, Stratford, Wartburg, St. Joseph's, Elma. Clay plains include: Ekfrid and St. Clair Clay Plains
HU III Aquifer AQint	Intermediate depth interstadial outwash sands and gravels	Includes intermediate aquifers located in Elgin and Middlesex Counties
HU IV Aquitard AT1	Lower fine-grained subglacial till sheets, and lacustrine clays	Tills include: Tavistock and Port Stanley
HU V Aquifer	Basal outwash sand and gravel (interstadial complex) overlying Catfish Creek and older tills	Discontinuous sands and gravels
HU VI Aquitard	Subglacial lodgement (overconsolidated) tills	Tills include: Catfish Creek, Canning, and Early and Mid-Wisconsinan tills
HU VII Aquifer	Weathered and highly fractured upper portion (3-5 m) of the bedrock surface	Variable bedrock depending on location
HU VIII Bedrock Aquifer	Fractured Paleozoic bedrock	Carbonates (limestone, dolostone), sandstone and shales

Mapping of the distribution of each of these hydrostratigraphic units in the study area was undertaken by interpreting subsurface information from well drilling and other sources by Waterloo Hydrogeologic, Inc. as part of the Six Conservation Authorities FEFLOW Groundwater Model: Conceptual Model Report. The cross-sections were completed on a 10 km grid spacing throughout the study area and are available on CD-ROM.

## **Conceptual Hydrostratigraphic Units (HUs)**

### ***Hydrostratigraphic Unit I (HU I), Aquifer 1 (AQ1)***

HU I includes coarse-grained glaciofluvial/glaciolacustrine/ice-contact sands and gravels such as portions of the Bothwell, Caradoc and Norfolk Sand Plains as well as Easthope, and Staffa Kame Moraines. The thickness of this hydrostratigraphic unit varies from 0 to 50 m throughout the study area.

### ***Hydrostratigraphic Units II, and IV (HU II to IV), Aquitard 1 (AT1) and Intermediate Aquifer (AQint)***

In many portions of the study area, HU II and HU IV are in direct contact. It is very difficult to differentiate between the geologic subunits in HU II and the geologic subunits in HU IV where the intermediate aquifer (HU III) is not present. The geological descriptions provided on drilling logs generally do not provide enough detail to differentiate between these two fine-grained units. Where this occurs, the combined units represent the thickness of aquitard material between the upper aquifer HU I, and the lower aquifer HU V.

The package of HU II (Rannoch, Stratford, Wartburg, St. Joseph's, and Elma Till; and the Ekfrid and St. Clair Clay Plains), and IV (Tavistock and Port Stanley Tills) is extensive across the study area, ranging in thickness from 1 m to nearly 100 m. This package is interpreted to be thickest near Strathroy, London, St. Thomas, and along the Lake Erie shoreline west of St. Thomas. The bedrock valley interpreted to exist

between Grand Bend, Strathroy, and St. Thomas explains the increased thickness of the overburden package in these areas.

### ***Hydrostratigraphic Unit III (HU III), Intermediate Aquifer (AQint)***

The intermediate aquifer (HU III) is present erratically within the study area where HU II and HU IV are not in direct contact. This unit is interpreted to be interstadial outwash sands and gravels that lie at an intermediate depth below the ground surface. The thickness of HU III varies between 0 and 30 m, and is thickest near Strathroy, London, Ingersoll, and Woodstock. The unit is also identified in Perth County at the Easthope Moraine and in Chatham-Kent east of Chatham, north and south of Highway 401.

### ***Hydrostratigraphic Unit V (HU V), Aquifer 2***

HU V represents discontinuous sands and gravels that are interpreted to be outwash sand and gravel (interstadial complex) overlying the Catfish Creek Till and other older well consolidated tills. (This subsurface layer is similar to what is seen on the present surficial geology.) The thickness of HU V varies from 0 to 40 m, with the thickest areas located near St. Thomas.

### ***Hydrostratigraphic Unit VI (HU VI), Aquitard 2***

HU VI is interpreted to be the Catfish Creek Till, and other older tills such as the Canning Till that lie immediately on top of the Paleozoic bedrock. The thickness of HU VI varies from 0 to more than 50 m. HU VI is regionally extensive in the northern portion of the study area, throughout most of Perth County.

## **Surface Water - Groundwater Interactions**

The Thames-Sydenham and Region Source Protection Region comprises three Conservation Authorities with two major river systems and many more subwatersheds.

In rivers and subwatersheds, stream flow rates measured during base flow (low flow) periods can be used to identify areas of significant groundwater discharge. The base flow is assumed to be equal to the quantity of groundwater that discharges to the upstream reach of the river and its tributaries. Comparison of the flows present at each stream measurement station can be used as a means of identifying groundwater discharge areas.

**Map 13: Potential Groundwater Discharge Areas** shows zones of potential discharge within the watershed. To differentiate areas where water is moving downward through the overburden, from areas where water is moving upwards from the bedrock to the overburden, bedrock recharge and discharge areas were mapped. These areas were mapped by comparing the static water levels in the bedrock aquifer and the ground surface topography. Discharge is expected to occur where the static water level is greater than the ground surface elevation.

This map shows the potential discharge along the major river systems and their tributaries. The location and quantity of groundwater discharges to the Great Lakes is not fully understood.

## **Estimation of Hydraulic Properties of the Aquifers and Aquitards Recharge**

Precipitation is the primary source of groundwater recharge. When precipitation falls on the ground, a portion of this water moves overland to rivers and creeks as overland flow (or interflow) and another portion is returned to the atmosphere by evaporation. The remainder infiltrates into the ground and may become groundwater recharge water.

Recharge is the portion of precipitation that infiltrates into the ground, and is not lost to evapotranspiration, or retained as soil moisture. Recharge occurs in all areas except where water is applied directly to surface water features<sup>78</sup>.

The rate of recharge is dependent on the ground surface topography, land use cover and surficial geology. Areas with steep topography experience greater overland flow and, therefore, less groundwater recharge than areas where the terrain is more subdued. Areas of hummocky topography are locations where enhanced recharge may occur as water that would otherwise be lost to runoff becomes trapped in storage depressions.

Land use also plays a role on the amount of recharge entering the groundwater system. Built-up urban areas have reduced recharge as water flows over concrete, buildings and streets into managed storm drains rather than recharging the groundwater system. Areas with artificial drainage (tile drains) are expected to have lower groundwater recharge rates than similar areas without artificial drainage.

Recharge will be greatest on the sand plains and kame moraines where water infiltrates rapidly into the deeper groundwater system. Clay and till plains are expected to have reduced recharge as a larger proportion of precipitation will likely be lost as overland flow to rivers and streams rather than infiltrating.

**Table 2.3.2.3-2: Recharge Estimates (mm/year) for Surficial Geologic Material** presents the estimates of recharge determined from a number of previous studies carried out in the region. These include Municipal Groundwater Studies for Perth, Middlesex-Elgin, Lambton and Oxford. (Recharge estimates were not provided in the Essex/Chatham-Kent study.) Information from the (unpublished) Six Conservation Authorities FEFLOW Report is also included. In most studies, the ice-contact stratified drift is estimated to have a higher net recharge than the sandy silt to sandy till. (Drift is a general term that encompasses all tills and stratified drift is a till deposited in a subaquatic environment e.g. areas west of Strathroy-Caradoc.)

**Table 2.3.2.3-2: Recharge Estimates (mm/year) for Surficial Geologic Material**

Material	Perth	Lambton	Middlesex-Elgin	Oxford	Six CA report, WHI
Sand and Gravel Kames or Outwash	150	n/a	300	250-350	250
Sand Plains	n/a	n/a	130-300	50-200	Not reported
Clay Plains	n/a	80	n/a	50	10-25
Clay/ Silt Till	65-100	n/a	9 – 55	20-50	100-150
Sand/ Silt Till	85 - 130	n/a	9 – 55	100	150
Urban Areas	40	n/a	n/a	n/a	Not reported

## Groundwater Inflow / Outflow

The basic groundwater summarization<sup>79</sup> in this section is from Piggott, A., S. Day, B. Neff and J. Nicholas, 2005. (Base Flow Due to Groundwater Discharge (Indicator 7102): State of the Great Lakes). Additional analyses and interpretation are required to validate this tentative assessment and the water quantity portion of groundwater will be investigated in more detail in the Water Budget Report.

<sup>78</sup> Singer, S.N., C.K. Cheng and M.G. Scafe. 1997. The Hydrogeology of Southern Ontario. Hydrogeology of Ontario Series, Ministry of the Environment and Energy.

<sup>79</sup> Piggott, A., S. Day, B. Neff and J. Nicholas, 2005. Base Flow Due to Groundwater Discharge (Indicator 7102): State of the Great Lakes.

The Great Lakes form one of the boundaries of the Thames-Sydenham and Region Source Protection Region and influence the inflow/outflow of groundwater. To date, the location and quantity of groundwater in the region and the interaction with the Great Lakes basin is not fully understood.

Basically, a significant portion of precipitation over the inland portion of the Great Lakes basin returns to the atmosphere by evapotranspiration<sup>80</sup>. Water that does not return to the atmosphere, either flows across the land to surface water features (rivers, lakes and wetlands) or infiltrates the subsurface to recharge groundwater aquifers. Water that infiltrates into the subsurface and recharges groundwater also results in flow toward the Great Lakes<sup>80</sup>.

The component of stream flow due to runoff from surface flow is transient and variable. Base flow due to groundwater discharge is less variable and is a more consistent part of stream flow. Another source of groundwater discharge is the regional flow through bedrock and overburden units to the Great Lakes (Lakes Erie, Huron and Ontario). The major groundwater resource issues revolve around 1) groundwater quantity interaction with the Great Lakes; 2) groundwater and surface water interaction and how this quantity impacts the Great Lakes.

While some recharge to groundwater occurs from surface water sources, the primary source of recharge to groundwater is that portion of precipitation that is not lost to evapotranspiration or through runoff. Groundwater recharge is highest when the soil is saturated, but diminishes when the soil is completely saturated<sup>81</sup> (reaches field capacity). In the Thames-Sydenham and Region, saturation occurs primarily between March and early May based on the data from the Provincial Groundwater Monitoring Network (PGMN). However, winter thaws can produce recharge events. The PGMN is an extensive system and several sites are located in the St. Clair Region Conservation Authority's watershed. The locations are shown on **Map 14: Provincial Groundwater Monitoring Network**.

Groundwater recharge is estimated by a variety of methods and the Water Budget Report will provide a more detailed discussion. The rate of recharge is dependent on a number of factors such as ground surface topography, land use and surficial geology. Singer<sup>81</sup> averaged groundwater recharge from 33 gauging stations throughout the province and found that recharge rates varied between 83.3 to 284.9 mm/yr (baseflow separation techniques were not outlined).

More recently, shallow groundwater recharge was estimated in the Great Lakes basin, based on HYSEP baseflow separation techniques. The Sydenham River basin recharge rate was estimated to be 160 mm/yr while the rate for the Thames River basin was estimated to be between 200 and 210 mm/yr<sup>80</sup>. Based on modelling completed for the Six Conservation Authorities FEFLOW Groundwater project (WHI, 2006 draft), recharge rate estimates ranged between 25 and 250 mm/yr.

Most shallow groundwater flow discharges to local streams and most deep flow discharges to regional sinks. The Great Lakes watershed divide serves as a groundwater divide for shallow flow; however, the deep groundwater aquifer divide can be distant from the watershed divides.

Groundwater outflow provides a base flow for the various rivers and streams in the region. As discussed earlier and shown on **Map 13**, the potential groundwater discharge areas are predominantly located along river courses. Actual discharges at these potential locations have not been confirmed by field investigations. However, as illustrated on **Map 18: Municipal Drain Classifications**, some cold/cool water streams are located in areas of potential groundwater discharge.

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<sup>80</sup> B.P. Neff, A.R. Piggott, and R.A. Sheets. Estimation of Shallow Groundwater recharge in the Great Lakes basin. USGS Scientific Investigations Report 2005-5284.

<sup>81</sup> Singer, S. N., C.K. Cheng, and M.G. Scafe. 2003. The Hydrogeology of Southern Ontario. 2<sup>nd</sup> edition. Environmental, Monitoring and Reporting Branch, Ontario Ministry of the Environment. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

Prior to 2006, there were no base flow studies for the St. Clair Region. As part of the work for the Water Budget component for Source Protection, low streamflow surveys were conducted on several streams in the Thames-Sydenham and Region Source Protection Region. For the St. Clair Region Source Protection Area, this work resulted in calculations for baseflow in seven creeks discharging into Lake Huron, and several locations on Bear and Black Creeks. This information was summarized<sup>82</sup> in October 2006 and is being incorporated into the Tier 1 Water Budget.

Groundwater, primarily from shallow aquifers, also discharges directly to the Great Lakes. Based on modelling completed for the Six Conservation Authorities FEFLOW Groundwater project, it is estimated that about 3% of the total water discharges directly to Lake Erie, 1.1 per cent to Lake St. Clair and 2% to Lake Huron. This does not include the groundwater component of stream flow to the Great Lakes.

Another source of groundwater discharge is the regional flow through bedrock and overburden units to the Great Lakes (Lakes Erie, Huron and Ontario). To date, the location and quantity of groundwater to the Great Lakes is not fully understood.

Large groundwater takings by municipal wells and industrial water takings (e.g. quarry dewatering) also represent an outflow of groundwater within the region. For municipal wells, information on well operation may also be contained in Well Operations Reports. For agricultural irrigation wells, where pumping is for a short time period and a portion of the pumped volume re-infiltrates, rates may be estimated. More detailed discussion will be presented in the Water Budget Report.

Information on significant wells and other water taking operations is contained in the MOE Permit to Take Water (PTTW) database. Information from this database was used to produce **Map 15: Permit to Take Water Locations by Type** and **Map 16: Permit to Take Water Locations by Usage**. Section 2.7 Water Uses provides information on permitted water usage.

## Hydraulic Conductivity

Hydraulic conductivity refers to the capability of subsurface materials such as sand, rock, etc. to transmit water. It is a property that can vary considerably from one geologic unit to the next. Estimates of hydraulic conductivity are typically derived from aquifer test data, literature values, and previous groundwater flow studies or models.

**Table 2.3.2.3-3: Range of Hydraulic Conductivity Values** presents the estimated lateral hydraulic conductivity values for each hydrostratigraphic unit along with values used in local wellhead protection area models completed as part of the MOE funded Municipal Groundwater Studies (Perth, Lambton, Oxford and Middlesex-Elgin). The Huron and Essex/Chatham-Kent studies did not report these values. Some overburden units are not present in individual counties. Also, some bedrock units are not present or are too deep to be used as a water supply source.

Typically, the vertical hydraulic conductivity is assumed to be one order of magnitude less than the horizontal hydraulic conductivity. The variation in hydraulic conductivity between different studies reflects the degree of heterogeneity of the hydrostratigraphic unit. A heterogeneous mixture is one that consists of many different types of sediment that are often difficult to sort or separate though they are clearly distinct. These differences result in varying hydraulic conductivity values being reported. The largest discrepancy lies in the bedrock aquifers where the bedrock formation and intensity of fracturing vary widely across the study area.

A groundwater model is used to represent nature and provide a numerical representation of the geology and hydrogeology. Models need input parameters and boundaries. The FEFLOW model is a finite

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<sup>82</sup> Adriana Csiba. October 2006. The Spatial Distribution of Low Streamflow within the Thames-Sydenham and Region Source Protection Region, Final Report.  
Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

element (FE) groundwater model that was utilized to simulate the groundwater system in a complex glacial and bedrock environment. FEFLOW was used as it is capable of a realistic representation of the stratigraphy, the water table and water budget. Groundwater stresses can be simulated to evaluate the response of the groundwater system to stress or to evaluate future conditions.

Within the groundwater flow model, hydraulic conductivity will vary across each hydrostratigraphic unit. For example, the Stratford and Mornington Till are grouped with other similar subglacial tills to form HU II. Although these will be represented in the model as one layer, the area of the Stratford Till Plain (sandy silt till) will be assigned a higher hydraulic conductivity than that of the Mornington Till (clay till) to account for the differences in matrix grain size.

**Table 2.3.2.3-3: Range of Hydraulic Conductivity Values (m/s) of Hydrostratigraphic Units Tabulated from the Municipal Groundwater Studies**

Hydrostratigraphic Unit (HU)		Literature Values	Perth	Lambton	Middlesex-Elgin	Oxford
HU I – Surficial Sands		6x10 <sup>-3</sup> to 1x10 <sup>-7</sup>	n/a	n/a	1x10 <sup>-4</sup> to 5x10 <sup>-4</sup>	1x10 <sup>-4</sup> to 6x10 <sup>-4</sup>
HU II – Fine-grained tills and lacustrine sediments		1x10 <sup>-6</sup> to 1x10 <sup>-11</sup>	2x10 <sup>-6</sup> to 2x10 <sup>-8</sup>	1x10 <sup>-7</sup>	1x10 <sup>-6</sup> to 5x10 <sup>-8</sup>	3.5x10 <sup>-6</sup> to 1x10 <sup>-7</sup>
HU III – Interstadial sands and gravels		3x10 <sup>-2</sup> to 1x10 <sup>-6</sup>	n/a	n/a	1x10 <sup>-4</sup> to 2x10 <sup>-4</sup>	5x10 <sup>-5</sup> to 5x10 <sup>-4</sup>
HU IV – Fine-grained tills and lacustrine sediments		1x10 <sup>-6</sup> to 1x10 <sup>-11</sup>	2x10 <sup>-6</sup> to 2x10 <sup>-8</sup>	n/a	1x10 <sup>-6</sup> to 5x10 <sup>-8</sup>	3.5x10 <sup>-6</sup> to 1x10 <sup>-8</sup>
HU V – Basal sands and gravels		3x10 <sup>-2</sup> to 1x10 <sup>-6</sup>	n/a	n/a	1x10 <sup>-4</sup> to 2x10 <sup>-4</sup>	1x10 <sup>-4</sup>
HU VI – overconsolidated tills		2x10 <sup>-7</sup> to 1x10 <sup>-12</sup>	n/a	n/a	n/a	n/a
HU VIII – Bedrock Formations	Salina Formation	1x10 <sup>-4</sup> to 1x10 <sup>-7</sup>	n/a	n/a	n/a	n/a
	Bass Islands Fmn	1x10 <sup>-4</sup> to 1x10 <sup>-7</sup>	1x10 <sup>-5</sup>	n/a	n/a	n/a
	Bois Blanc Fmn	1x10 <sup>-4</sup> to 1x10 <sup>-7</sup>	8x10 <sup>-5</sup> , 8x10 <sup>-6</sup>	n/a	n/a	1x10 <sup>-4</sup> to 5x10 <sup>-5</sup>
	Lucas/ Sylvania Fmn	1x10 <sup>-4</sup> to 1x10 <sup>-7</sup>	7x10 <sup>-5</sup>	n/a	n/a	5x10 <sup>-5</sup> to 7.5x10 <sup>-5</sup>
	Amherstburg Fmn	1x10 <sup>-4</sup> to 1x10 <sup>-7</sup>	7x10 <sup>-5</sup>	n/a	n/a	1.3x10 <sup>-4</sup> to 3x10 <sup>-5</sup>
	Dundee Fmn	1x10 <sup>-4</sup> to 1x10 <sup>-7</sup>	2x10 <sup>-4</sup> to 1x10 <sup>-5</sup> (IWS)	1.6x10 <sup>-4</sup>	5x10 <sup>-6</sup>	1.2x10 <sup>-4</sup>
	Marcellus Fmn	There is very little information available on these formations at the present time. Where these formations subcrop in the study area, the communities rely on surface water for drinking water supplies.				
	Hamilton Group					
Kettle Point Fmn						
Port Lambton Fmn						

During the development and calibration of the FEFLOW groundwater model, initial and calibrated hydraulic conductivity values used in the model will aim to be consistent with the range of values utilized within previous models, and also with hydraulic conductivities cited in literature for studies completed within the study area.

### 2.3.2.4 Groundwater Monitoring

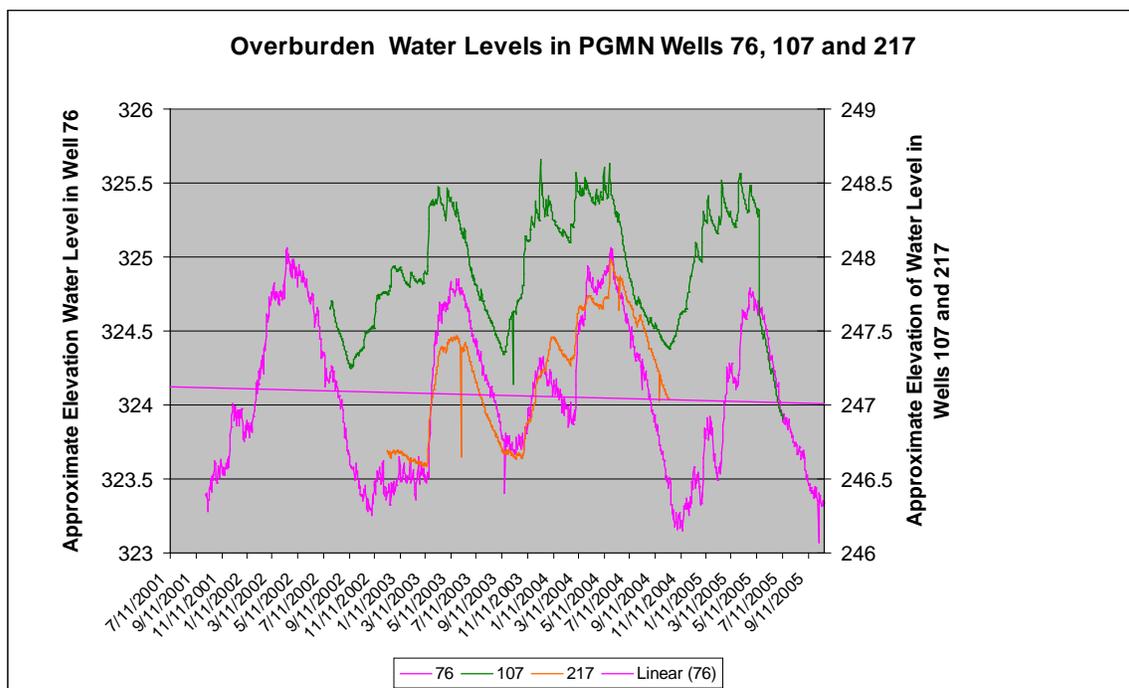
Historically the Ministry of the Environment monitored water levels at about 450 observation wells throughout the province. The original network operated between 1946 and 1979. In general, the monitoring wells were used to monitor groundwater levels for detailed hydrogeologic studies, water supply forecasting, and resolution of interference complaints. This monitoring was substantially reduced in the 1980s and virtually eliminated in the Thames-Sydenham and Region Source Protection Region.

In 2001, in recognition of the need for the data, a Provincial Groundwater Monitoring Network (PGMN) was re-established due to concerns that included quantity issues associated with depletion resulting from competing demand, sustainability issues, and quality concerns associated with a range in anthropogenic (human) activities. Most of the wells are new to the monitoring system and there may not be new locations near the original locations.

The St. Clair Region Conservation Authority has nine wells in the PGMN. The locations of the wells are shown in **Map 14: Provincial Groundwater Monitoring Network**. Wells in the monitoring network vary in depth, elevation and geology between bedrock and overburden wells.

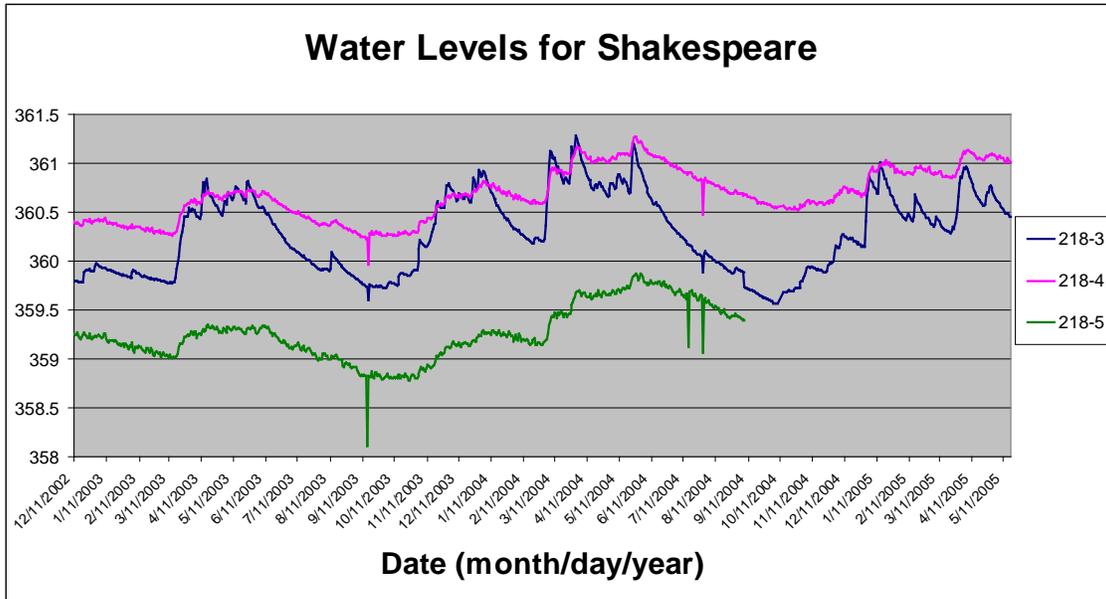
Water levels vary on an annual, seasonal and daily basis. Some of these variations are illustrated in the following discussion. Since there is a limited amount of data available from the wells in the St. Clair Source Protection Area, examples have been used from the wells in the Upper Thames River Source Protection Area.

Seasonally, water levels are elevated in the wells during the late fall, winter and early spring and decline during the summer months. They generally reach the lowest point in late September or October. **Figure 2.3.2.4-1: Seasonal Variation in Well Water Levels** illustrates the variation in three overburden wells. The long-term trend in water level variation in well 76 (linear) is an overall decrease between 2001 and 2005. However, at this time, there is an insufficient number of years to determine a true long-term trend.



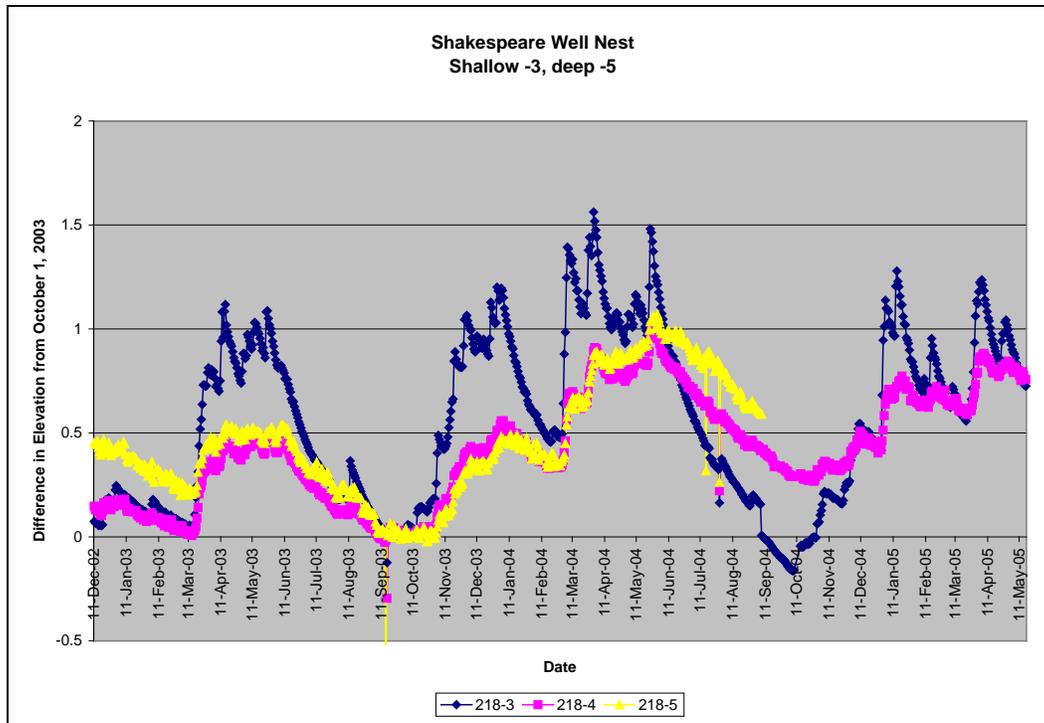
**Figure 2.3.2.4-1: Seasonal Variation in Well Water Levels**

Water level variations are also affected by the geology and depth of the well. The water level variations of a well nest in Shakespeare are shown in **Figure 2.3.2.4-2: Geology and Depth of Well**. The shallow well has a depth of 7.1 metres (218-3), the intermediate well has a depth of 24.4 metres (218-4) and the deepest well is completed in bedrock at 61.6 metres (218-5) depth.



**Figure 2.3.2.4-2: Geology and Depth of Well**

To compare the relative water level changes in the three wells, which are within a few metres of each other at the surface, relative amplitudes were calculated with reference to October 1, 2005 (a common low point). The shallowest well has the largest amplitude variations in water level relative to October 1, 2005 as shown in **Figure 2.3.2.4-3: Geology and Depth of Well - Detail**.



**Figure 2.3.2.4-3: Geology and Depth of Well - Detail**

The intermediate and deep aquifers both have approximately the same variation pattern as the shallow well but with lesser relative water level changes.

Daily fluctuations occur in many wells due to stresses such as pumping of adjacent wells and dewatering for quarrying operations. Usually, the apparent decline will rebound after the pumping stops. The seasonal and daily fluctuations can make it difficult to assess yearly and long-term trends, because it requires several years of data to identify a trend.

**Figure 2.3.2.4-4: Impact of Pumping** illustrates that monitoring well 53 at Thamesford has the same seasonal variations but, on closer examination, other factors such as pumping are apparent. For example, there is a sudden drop in water level at 3:00 on September 6, 2005 or September 4, 2005 as shown in **Figure 2.3.2.4-5: Impact of Pumping - Detail**. The drawdown curve is characterized by a sharp decline and a squared off appearance.

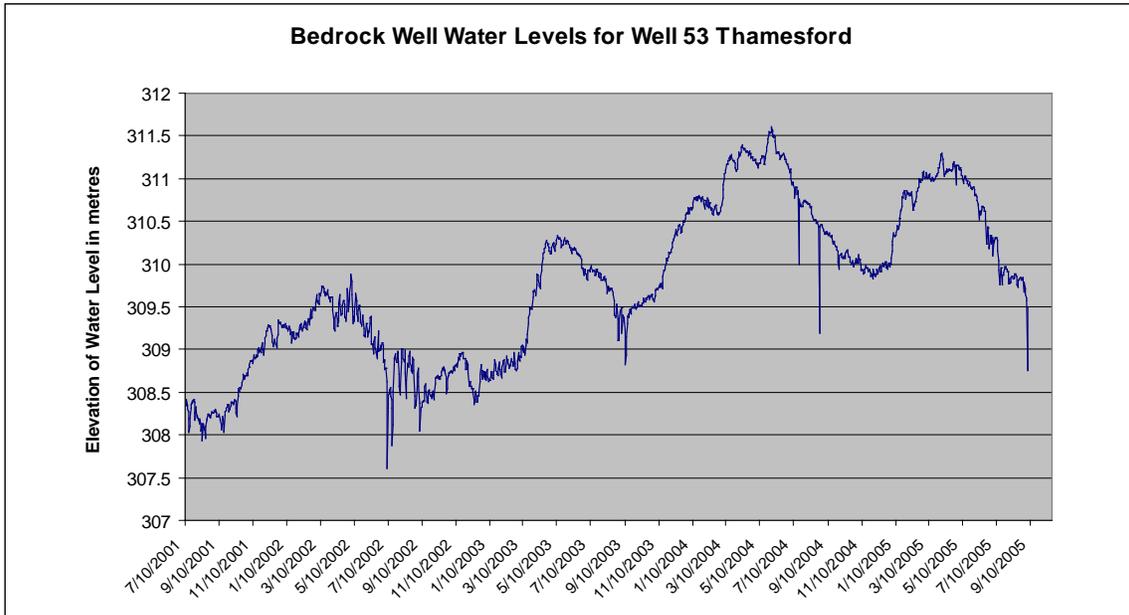


Figure 2.3.2.4-4: Impact of Pumping

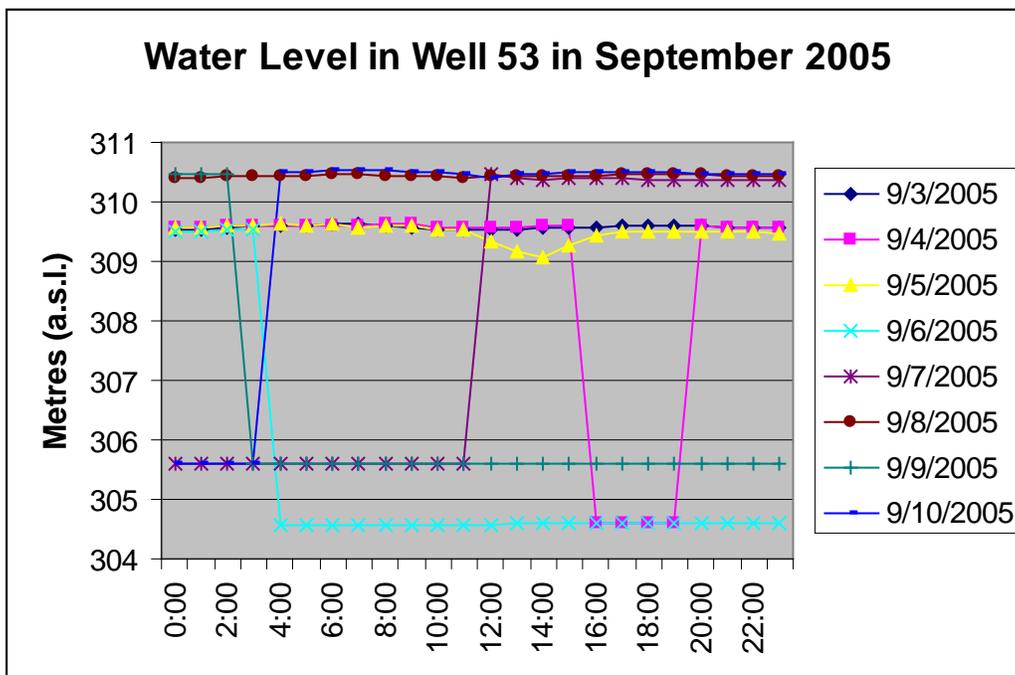


Figure 2.3.2.4-5: Impact of Pumping - Detail

In summary, the wells in the PGMN monitoring network show annual, seasonal and daily variations. Water level variations are also affected by the geology and depth of the well. All of these factors together with other impacts such as localized water usage or changes in the recharge have to be considered when assessing groundwater levels.

### 2.3.2.5 Aquifer Vulnerability

The two key attributes considered that affect aquifer vulnerability are the depth to water table and the conductivity of geologic material in the unsaturated zone (or above a confined aquifer). Intrinsically, fine unfractured media retard contaminant migration whereas fractured media, or coarse porous media, provide faster travel times and less retardation and hence more vulnerability. For example, 20 metres of silt over a confined aquifer would have a low intrinsic susceptibility. However, 10 metres of clean coarse sand or fractured rock would have a high susceptibility to contamination.

The method is based on calculating a susceptibility index at each well, then mapping the indices using an interpolation. Although the method considers only the intrinsic susceptibility of the shallowest aquifer, assessments of deeper aquifers were completed in some municipalities. This method assesses intrinsic vulnerability or susceptibility with limited consideration of the specific attributes of the hydrogeologic system or the behaviour of contaminants.

The intrinsic susceptibility of groundwater resources is evaluated using an Intrinsic Susceptibility Index (ISI). This calculated value estimates the vulnerability of the groundwater resource to contamination at a given point. The ISI values are characterized as falling into one of three groupings; low (>80), medium (30-80) or high (<30) based on the original terms of reference used for the various groundwater studies.

ISI values are calculated on a well-by-well basis by examining the geology and the aquifer/aquitard relationships found within each well of the Water Well Information System (WWIS). This is accomplished by multiplying different geologic sequences by their respective conductivity factor (K-factor) for each WWIS record, as defined in the Technical Terms of Reference for the study (MOE, 2001a).

The susceptibility of the water table was also calculated by examining the depth to water table in each well of the WWIS. In calculating the susceptibility of the bedrock aquifer, the overburden thickness and geology were used to calculate ISI values.

The ISI values were subsequently interpolated across the entire county to provide ISI maps on a county basis. The county ISI maps were then somewhat seamlessly mapped into a regional map of Southwestern Ontario. **Map 17: Intrinsic Susceptibility Index** provides a map of the SCRCA watershed. When preparing the regional map, differences of one or two levels between counties were identified and are shown on the map.

This process has limitations, as it does not take land use, slope, or hummocky topography into consideration. These factors, however, in addition to Quaternary geology and soil composition were considered when developing an infiltration map of Perth County (UTRCA et al., 2001<sup>83</sup>). These maps were used to evaluate the susceptibility maps for the Perth County Groundwater Study, (UTRCA et al., 2001<sup>84</sup>). In many cases, the susceptibility maps are similar to the infiltration potential map of the county.

### 2.3.3 Surface Water Hydrology

There are over 6,000 km of watercourses in the St. Clair Source Protection Area watershed. The surface water hydrology of the area has been modified by extensive drainage projects. Dredging and straightening of watercourses for agricultural, residential and industrial development has had a significant impact over the past 125 years. Open ditches and in-ground tile drainage have modified the natural surface drainage patterns for the majority of the first and second order streams. These changes are evident from the linear patterns of municipal drains on the watercourse classifications map of the area, shown in **Map 18: Municipal Drain Classifications**.

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<sup>83</sup> Upper Thames River Conservation Authority, 2001. Perth County Groundwater Study, Final Report.

<sup>84</sup> Upper Thames River Conservation Authority, 2001.

Significant drainage works in this area began with the passage of the provincial Municipal Drainage Aid Act in 1872. Brooke Township, in eastern Lambton, was one of the first municipalities in Ontario to take advantage of the new legislation<sup>85</sup>. Today, the majority of the lower order surface watercourses in the St. Clair Region have been dredged, straightened or enclosed. In the area around Wallaceburg and western Chatham-Kent, there is an extensive network of ditches or canals and dikes. In most cases, there is a pumping system to remove water from these canals.

### 2.3.3.1 Watercourse Classification

Fish habitat in Ontario's agricultural drains makes a significant contribution towards sustainable fisheries. Drain maintenance activities can alter essential fish habitat components by changing riparian vegetation, substrate composition, and width to depth ratios. The resiliency of drains can be categorized according to flow, temperature, fish species present, and stability. The most sensitive drains are those with permanent flow, cool or cold water, and top level predator or cold water fish species; or those drains that have not been recently cleaned and may have reached an equilibrium state. This section is intended to provide background on the development of the municipal drain classification program and summarize some of the information that was collected during the drain evaluations.

A watercourse classification scheme was developed by Fisheries and Oceans Canada (DFO) in the 1990s. The intent was to expedite the process of reviewing municipal drain maintenance proposals for fisheries concerns while protecting sensitive fish species and fish habitat under the federal Fisheries Act. The Fisheries Act Class Authorization System only applies to Municipal Drains; however, the information collected as part of the classification project helps to provide a summary of the watercourses in the region.

From 1999 to 2004, the St. Clair Region Conservation Authority carried out field work to analyze watercourses in the region. Site inspections were completed at bridge locations where public roads provided access to the watercourses. Drains that were not accessible from public roads were not classified.

Watercourses were characterized based on stream flow, thermal regime, and the presence/absence of top predators or their habitat. For municipal drains, the time since the last full cleanout was also a factor in determining the classification. The watercourses were then classified using the characterization and additional information such as that obtained from consultation with Drainage Superintendents who were familiar with their municipal drains.

Many closed or tiled systems or newly constructed drains are not identified on the GIS mapping product. While some closed or tiled systems are shown on the map, this does not accurately reflect the large number of privately installed drains in the region. The protocol for including closed or tiled systems in the Municipal Drain Classification mapping was not well defined. Thus, classifications done by the Ausable-Bayfield CA in the portion of Lambton Shores that recently became part of the St. Clair Region may not match the classifications in other SCRCA watersheds.

**Table 2.3.3.1-1: Fisheries Act Classifications** summarizes the derivation of the classification scheme as it was originally developed and used from 2000 to 2003. DFO modified the considerations for drain classification in 2004 and 2005. The presence of "Sensitive Species or their Habitat" replaced the category regarding "Top Predators". However, almost all of the SCRCA field work had been completed prior to this change and the classifications were completed based on the Top Predator characterization.

Watercourses were classified as N (natural or not municipal drain), T (tiled or closed surface), U (unclassified) and open Municipal Drains which were categorized as Type A, B, C, D, E or F. The

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<sup>85</sup> DesRivieres, Dennis 1972. The Great Enniskillen Swamp: Speculation, drainage and settlement. Western Ontario Historical Notes. 25:25-35.

classification system enabled routine maintenance of Class F Municipal Drains and permits Class Authorizations for routine maintenance of Type A, B or C Municipal Drains. Class D and E with significant or sensitive fish habitats are afforded more protection.

The St. Clair Region has four watershed drainage areas: Lake Huron, St. Clair River, Lake St. Clair and the Sydenham River. The Sydenham River has been further subdivided into seven subwatershed areas to reflect some physiographic differences. For example, the Upper East-Sydenham subwatershed flows out of the Caradoc Sand Plain and it has very different characteristics from the other head waters coming from the Brown Creek subwatershed which arises on clay plain.

Drain Classification by subwatersheds illustrates the setting for the different types of drains. **Map 19: Watercourse Classifications** distinguishes watercourses that are classified as “natural.”

**Table 2.3.3.1-1: Fisheries Act Classifications**

Watercourse Classification	Criteria			
	Stream Flow	Thermal Regime	Top Predator Species or their Habitat	Time since last full cleanout
<b>N (natural)</b>	Either	Either	Either	Not Applicable
<b>T (tiled)</b>	Unknown	Unknown	Not Applicable	Not Applicable
<b>U (unclassified)</b>	Unknown	Unknown	Unknown	Unknown
<b>Municipal Drains</b>				
<b>A</b>	Permanent	Cold/Cool	Not Present	Not Applicable
<b>B</b>	Permanent	Warm	Present	Less than 10 years
<b>C</b>	Permanent	Warm	Not Present	Not Applicable
<b>D</b>	Permanent	Cold/Cool	Present	Not Applicable
<b>E</b>	Permanent	Warm	Present	More than 10 years
<b>F</b>	Intermittent	Neither	Not Present	Not Applicable

With respect to the table, the terms are described as:

- N: Natural or not municipal drains
- T: Tiled or closed surface watercourses/drains
- U: Unclassified/not yet classified
- Stream Flow
  - Permanent: aquatic ecosystems that have water in them, with a constant inflow and outflow, or with standing or pooled water year round.
  - Intermittent (or Ephemeral): aquatic systems that are dry for long periods of time.
- Thermal Regime<sup>86</sup>
  - Cold: water temperatures less than 19° C
  - Cool: water temperatures between 19 and 25° C
  - Warm: water temperatures greater than 25° C
- Top Predator Species or their Habitat
  - Field observations of habitat and fish (may have included electro-fishing)
- Time since last full cleanout
  - The date of the last recorded full cleanout on a municipal drain will indicate whether it was more or less than 10 years ago.

<sup>86</sup> Stoneman, C.L. and M.L. Jones. 1996. A Simple Method to Determine the Thermal Stability of Southern Ontario Trout Streams. In Habitat Management Series by Fisheries and Oceans Canada and Ontario Ministry of Natural Resources.

The change to the classification process to use “Sensitive Species or their Habitat” means that some Municipal Drains would be re-classified. Drains containing baitfish species that are identified as “sensitive species,” such as Pearl Dace, Mottled Sculpin and Grass Pickerel, would be subject to change. Re-classification has not been completed for the St. Clair Region. Application of the “Sensitive Species” to the Watercourse Classifications of the region is an information gap.

Species at Risk (SAR) are also included in the sensitive species category. An explanation and discussion of the sensitive species category, which includes Species at Risk, can be found in Section 2.5 Aquatic Ecology. The listing of “Sensitive Species” relevant to watershed characterization can be found in Section 2.5.4.1.

Between 50% and 80% of a natural river network is composed of first and second order systems<sup>87</sup>. Small streams provide the greatest degree of connection between terrestrial and aquatic systems. Scientific research indicates that healthy headwater systems are vital for the healthy functioning of the downstream watercourses.

Tiling of the first order streams and the loss of this interface between water and land is presumed to have negative impacts on water quality and quantity although very little scientific assessment has occurred.<sup>88</sup> As discussed, only 500 km of tiled watercourses have been mapped to date in the St. Clair Region, but it can be expected that several thousand kilometres of tiles actually exist. Identification and mapping of tiled drains is an information gap in the St. Clair Region.

**Table 2.3.3.1-2: Watercourse Classifications** summarizes the watercourse classifications in the region. There are over 6,000 km of watercourses in this region. Most of these watercourses form the Sydenham River and a summary of the classifications for the main branches of the river has also been provided in the table.

Intermittent Watercourses (Type F) are the largest category of classified watercourses in the St. Clair Region with over 2,000 km of Type F drains mapped. Intermittent watercourses overshadow the other categories as they comprise over one third of the classified watercourses. Type C drains which provide warm water habitat for common baitfish species are the second-most common category with 1,100 km mapped. Natural watercourses are the third most common mapped category, with 900 km mapped. One quarter of the watercourses (over 1,500 km) have not been classified, as they begin between public roads and were not accessible.

**Table 2.3.3.1-3: Drains Classifications (Thermal and Permanency)** combines some of the classifications to summarize the thermal regime and permanency of drains in the region. Warm water drains (over 1,300 km) dominate the permanently flowing drains. Only 23 km of permanent cool or cold water drains have been identified in the St. Clair Region.

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<sup>87</sup> Meyers, Judy, et al. September 2003. Where Rivers Are Born: The Scientific Imperative for Defending Small Streams and Wetlands. Sponsored by American Rivers and Sierra Club. Obtained from [www.amrivers.org/docs/WhereRiversAreBorn.pdf](http://www.amrivers.org/docs/WhereRiversAreBorn.pdf) January 2004.

<sup>88</sup> Veliz, Mari and Jane Sadler Richards. 2005. Enclosing Surface Drains: What’s the Story? Volume 60, Number 3, Journal of Soil and Water Conservation.

**Table 2.3.3.1-2: Watercourse Classifications**

Watercourse Classification	Lake Huron Tributaries				Lake St. Clair Tributaries		St. Clair River Tributaries		Sydenham River		Total Region	
	Sarnia, Plympton-Wyoming, Warwick		Lambton Shores		km	%	km	%	km	%	km	%
	km	%	km	%								
A	2	0.3	2	1.3	0	0.0	0	0.0	17	0.4	21	0.3
B	0	0.0	0	0.0	17	2.9	0	0.0	61	1.3	78	1.2
C	178	22.9	61	38.9	112	19.0	31	9.8	812	17.0	1195	18.0
D	0	0.0	0	0.0	0	0.0	0	0.0	6	0.1	6	0.1
E	44	5.6	0	0.0	109	18.5	16	5.0	117	2.4	286	4.3
F	184	23.6	78	49.8	263	44.5	138	42.7	1487	31.1	2150	32.4
N	94	12.0	0	0.0	0	0.0	36	11.2	752	15.7	882	13.3
T	64	8.2	10	6.4	5	0.8	2	0.5	408	8.5	488	7.4
U	213	27.4	6	3.7	84	14.3	99	30.8	1124	23.5	1526	23.0
TOTAL	779	100	156	100	591	100	322	100	4784	100	6631	100
% of Region	11.7		2.4		8.9		4.9		72.1		100	

Watercourse Classification	Sydenham River														Total Sydenham	
	Bear Creek		Black Creek		Brown Creek		Lower East		Lower North		Middle East		Upper East		km	%
	km	%	km	%	km	%	km	%	km	%	km	%	km	%		
A	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	17	2.3	17	0.4
B	0	0.0	20	3.3	11	3.4	0	0.0	12	2.8	17	1.9	0	0.0	61	1.3
C	205	19.1	92	15.1	19	5.6	143	21.6	74	17.8	149	15.8	130	17.4	812	17.0
D	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	0.8	6	0.1
E	0	0.0	0	0.0	16	4.9	23	3.5	3	0.8	53	5.6	20	2.7	117	2.4
F	319	29.8	242	39.7	51	15.2	298	44.8	220	52.7	263	27.8	96	12.8	1487	31.1
N	217	20.2	93	15.3	49	14.7	108	16.3	37	8.8	106	11.2	143	19.2	752	15.7
T	156	14.6	20	3.3	90	27.1	9	1.3	0	0.0	40	4.2	92	12.4	408	8.5
U	174	16.3	142	23.3	97	29.1	82	12.4	71	17.1	317	33.5	241	32.3	1124	23.5
TOTAL	1071	100	609	100	332	100	664	100	417	100	944	100	745	100	4784	100
% of Sydenham	22.4		12.7		6.9		13.9		8.7		19.7		15.6		100	
% of Region	16.1		9.2		5.0		10.0		6.3		14.2		11.2		72.1	

**Table 2.3.3.1-3: Drain Classifications (Thermal and Permanency)**

	Lake Huron Tributaries				Lake St. Clair Tributaries		St. Clair River Tributaries		Sydenham River		Total Region	
	Sarnia, Plympton-Wyoming, Warwick		Lambton Shores									
	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%
Natural Watercourses	94	13.1	0	0.0	0	0.0	36	11.3	752	17.2	882	14.4
Permanent Cool/Cold Drains	2	0.3	2	1.4	0	0.0	0	0.0	23	0.5	27	0.4
Permanent Warm Drains	222	31.1	61	41.5	239	40.7	48	14.8	990	22.6	1559	25.4
Intermittent Drains	184	25.7	78	53.2	263	44.9	138	42.9	1487	34.0	2150	35.0
Unclassified	213	29.8	6	3.9	84	14.4	99	31.0	1124	25.7	1526	24.8
<b>TOTAL</b>	<b>715</b>	<b>100</b>	<b>146</b>	<b>100</b>	<b>586</b>	<b>100</b>	<b>321</b>	<b>100</b>	<b>4376</b>	<b>100</b>	<b>6144</b>	<b>100</b>
<b>% of Region</b>	11.6		2.4		9.5		5.2		71.2		100	

	Sydenham River														Total Sydenham	
	Bear Creek		Black Creek		Brown Creek		Lower East		Lower North		Middle East		Upper East			
	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%
Natural Watercourses	217	23.7	93	15.8	49	20.1	108	16.5	37	8.8	106	11.7	143	21.9	752	17.2
Permanent Cool/Cold Drains	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	23	3.5	23	0.5
Permanent Warm Drains	205	22.4	112	19.1	46	19.1	167	25.4	90	21.5	220	24.3	150	23.0	990	22.6
Intermittent Drains	319	34.9	242	41.0	51	20.9	298	45.4	220	52.7	263	29.0	96	14.7	1487	34.0
Unclassified	174	19.0	142	24.1	97	39.9	82	12.6	71	17.1	317	35.0	241	36.9	1124	25.7
<b>TOTAL</b>	<b>915</b>	<b>100</b>	<b>589</b>	<b>100</b>	<b>242</b>	<b>100</b>	<b>655</b>	<b>100</b>	<b>417</b>	<b>100</b>	<b>904</b>	<b>100</b>	<b>653</b>	<b>100</b>	<b>4376</b>	<b>100</b>
<b>% of Sydenham</b>	20.9		13.5		5.5		15.0		9.5		20.7		14.9		100	
<b>% of Region</b>	14.9		9.6		3.9		10.7		6.8		14.7		10.6		71.2	

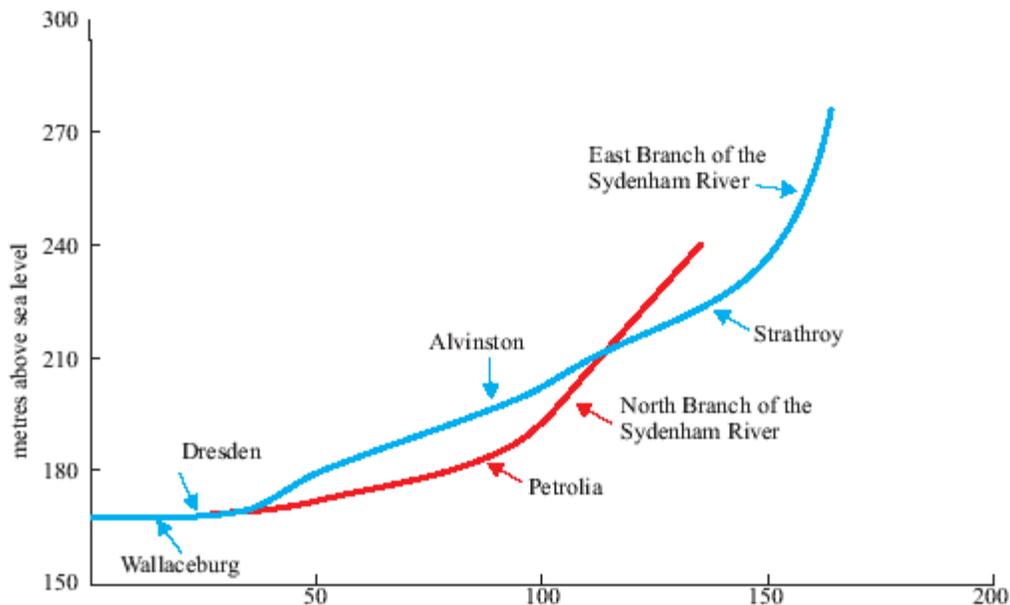
### 2.3.3.2. Travel Times

The Sydenham River is the largest watercourse in the St. Clair Region Conservation Authority's area of jurisdiction. However, the main branch is only approximately 5 kilometres long. It runs from the mouth at the Chenal Ecarte to Wallaceburg, where the river divides into the North and East branches. There is a very flat gradient between Wallaceburg and the Chenal Ecarte and the travel time for the main branch is affected by the water level in Lake St. Clair and wind conditions. Thus, the travel time can range from hours to days.

The flat slope extends in the East Branch from Wallaceburg to Dresden and in the North Branch from Wallaceburg to the outlet of the McKeough Dam at the Brown's Bridge Stream Gauging Station. Travel time in these sections can also be affected by lake levels and wind conditions.

The East Branch of the river has a total length of 165 kilometres with a fall of 106 metres. The North Branch is 137 kilometres long with a fall of 77 metres. The North Branch is divided into two subwatersheds, Bear Creek and Black Creek as shown in **Map 19: Watercourse Classifications** and **Map 20: Percent Wetland Cover by Subwatershed**.

The East and North branches of the Sydenham River are significantly different in nature. In addition to the length and fall, several factors including the supine nature of the branches, substrate of the river and soils adjacent to the river contribute to different travel times in various sections of the branches. **Figure 2.3.3.2-1: Sydenham River Length and Fall** provides a schematic view of the river elevations. **Table 2.3.3.2-1: Travel Times** provides the approximate travel times for bank full flows.



**Figure 2.3.3.2-1: Sydenham River Length and Fall**

**Table 2.3.3.2-1: Travel Times**

<b>Approximate Travel Time<sup>89</sup></b>	
<b>Location</b>	<b>Bank Full Travel Time (hrs)</b>
<b><i>East Sydenham</i></b>	
East Branch of Sydenham River Strathroy to Alvinston	13.5
East Branch of Sydenham River Alvinston to Florence	18.1
East Branch of Sydenham River Florence to Dresden	10.8
East Branch of Sydenham River Dresden to Wallaceburg	11.7
<b><i>North Sydenham</i></b>	
Bear Creek (North Branch) Upstream of Petrolia to Brigden	14.0
Bear Creek (North Branch) Downstream of Brigden to McKeough Dam	10.3
Black Creek (North Branch) at Bickford Line to McKeough Dam	12.5
North Branch of Sydenham River McKeough Dam to Wallaceburg	7.9

The St. Clair Region also has numerous short watercourses that discharge into Lake Huron, the St. Clair River or Lake St. Clair. With the exception of a few watercourses in the northeastern corner of the region that discharge into Lake Huron, most of the creeks have fairly flat gradients. In general, travel times are a few hours to a day for these smaller watercourses. However, the travel times for the creeks discharging to Lake St. Clair are complicated since much of the area is dyked with pumping stations removing the water.

### **2.3.3.3. Floodway Area**

In Ontario, either storm centred events, observed events or a flood frequency based event may be used to determine the extent of the flooding hazard limit<sup>90</sup> (previously defined as the regulatory flood criteria). Frequency based events are normally calculated as incidents that have a return of at least once every 100 years. A storm centred event refers to a major storm of record such as Hurricane Hazel. An observed event is a flood that has been experienced in a particular watershed and was greater than the frequency and storm centred events.

Flooding of rivers and streams typically occurs following the spring freshet but storm events anytime of the year may cause increased runoff and flooding. The flood plain (flooding hazard limit) for rivers and streams is defined as the area adjacent to the watercourse that would be inundated by a flood event. The floodway of a river or stream is the area of the flood plain required to allow safe passage of the high stream flows associated with the flood event. The flood fringe is the remaining portion of the flood plain.

The St. Clair Region is approximately 4,100 square kilometres in size. The efforts to map and define floodway and flood plain limits have focused primarily on areas of urban development. Therefore, limits have only been defined in certain specific areas of the watershed.

<sup>89</sup> BM Ross & Associates. 1997, Model Calibration Manual.

<sup>90</sup> Understanding Natural Hazards, River and Stream Systems, Ontario Ministry of Natural Resources. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

## ***Wallaceburg***

The Wallaceburg area is one of the most flood prone parts of the St. Clair Region due to its location on low ground at the confluence of the East and North branches of the Sydenham River. To protect the community, the W. Darcy McKeough Floodway and Dam were built in the early 1980s to divert floodwaters from the North Sydenham west to the St. Clair River. It is the largest flood diversion project in Ontario.

Located approximately 12 km north of Wallaceburg, the floodway and dam control floodwater from over 33% of the Sydenham drainage basin. In addition to diverting floodwater, operation of the dam results in the temporary storage of water in an area above the dam. An engineering study provides a boundary line for a flood limit for upstream lands with the dam in operation.

The community of Wallaceburg is still subject to flooding due to the remaining 67% of the total flow combined with ice jamming and/or high water levels in the Chenal Ecarte. Much of the community is protected by dykes and flood planning areas that provide controls for development.

## ***Dresden***

The community of Dresden is subject to flooding from high water levels in the East Sydenham River. This community is located in an oxbow of the river and the floodway and flood fringe areas have been mapped<sup>91</sup>.

## ***Strathroy***

The flood plain areas have been mapped for the wide river valley area in the community of Strathroy<sup>92</sup>.

## ***Sarnia***

Along the Lake Huron shoreline in the Bright's Grove part of Sarnia, the flood plain areas have been mapped for Perch Creek and for portions of Cow Creek<sup>93</sup>.

## ***Petrolia***

In the 1970s, flood prone lands in the community of Petrolia were purchased and existing buildings removed to provide a flood protected area. This reduced the need to establish detailed flood mapping in this part of Bear Creek.

## ***Agricultural Lands***

There is very little data on the extent of farm lands that are prone to flooding. The St. Clair Region Conservation Authority has had active programs to support Best Management Practices for Healthy Watersheds. These help to lower the effect of flooding on agricultural operations adjacent to streams.

## ***Great Lakes***

Shorelines along large inland lakes are subject to flooding, erosion and dynamic beach hazards<sup>94</sup>. A shoreline classification system has been developed to determine the factors and processes that influence the severity of potential hazards.

For Great Lakes flood controls, a combination of the highest known water level and the strongest wind "setup" is used to establish the flood level. Along shorelines subject to wave action, the area further

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<sup>91</sup> MacLaren, James F. April 1979. Report of Town of Dresden Flood Plain Study.

<sup>92</sup> Fenco MacLaren. 1994. Strathroy Two Zone Flood Line Mapping Study.

<sup>93</sup> Tottem Sims Hubicki Associates. July 1998. Cow Creek Two-Zone Floodline Mapping Study Final Report.

<sup>94</sup> Ontario Ministry of Natural Resources. Understanding Natural Hazards, Great Lakes-St Lawrence River System and Large Inland Lakes, Ontario Ministry of Natural Resources Publications.

inland covered by wave up rush must be taken into consideration. Other water related hazards that should be taken into account along the lake shoreline are ship-generated waves, ice piling and ice jamming.

Erosion hazards are determined using the erosion rate and an allowance for slope stability. Dynamic beach hazards occur along shorelines where elevations can change due to the build-up or erosion of sand, cobbles and other beach deposits. Areas on the Great Lakes, that experience chronic flood and erosion damages, were typically constructed during low lake levels.

### ***Lake Huron***

High lake levels in the early 1970s and mid 1980s combined with storm events resulted in significant flood and erosion damages. The St. Clair Region Conservation Authority completed a Lake Huron Shoreline Management Plan<sup>95</sup> for approximately 32 kilometres of shoreline for the Village of Point Edward, City of Sarnia and Town of Plympton-Wyoming (formerly Plympton Township).

Shoreline conditions include hardened erosion control river banks in Point Edward and sand beaches with low bluffs in Sarnia increasing to high bluffs in Plympton-Wyoming. The high bluffs are a noncohesive material that is sensitive to toe erosion especially during high lake levels.

### ***St. Clair River***

Most of the river shoreline has been hardened to deal with ship-generated waves, ice piling and ice jamming.

### ***Lake St. Clair***

The low lying area between the Sydenham and Thames Rivers, drains to Lake St. Clair and is subject to flooding. An extensive system of dyking together with drains and pumping stations provides protection from lake orientated flooding.

#### **2.3.3.4. Mean Monthly Flows at Representative Gauges**

There are 11 stream gauges operating in the St. Clair Region watershed. These are listed in **Table 2.3.3.5-1: St. Clair Stream Gauging Stations** and marked on **Map 11: Watershed Hydrologic Conditions Monitoring Stations**.

The information from five of these stations has been used to plot the mean monthly flows for various sections of the Sydenham River Watershed in the following figures:

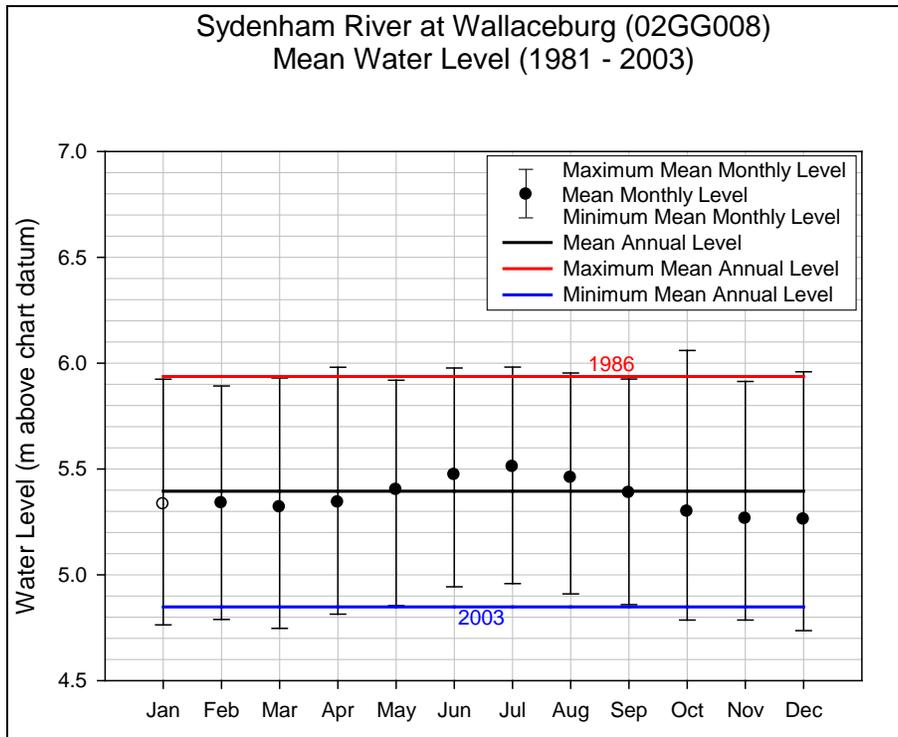
- Figure 2.3.3.4-1: Sydenham River at Wallaceburg
- Figure 2.3.3.4-2: East Sydenham River at Strathroy
- Figure 2.3.3.4-3: East Sydenham River near Alvinston
- Figure 2.3.3.4-4: North Sydenham River, Bear Creek below Brigden
- Figure 2.3.3.4-5: North Sydenham River, Bear Creek near Petrolia

The Sydenham River at Wallaceburg stream gauge is influenced by the water level in Lake St. Clair. Also, the wind direction (and speed) can have a significant impact on the water level at the gauge. Thus, this gauge is not used to calculate stream flow and only water levels are recorded at this location.

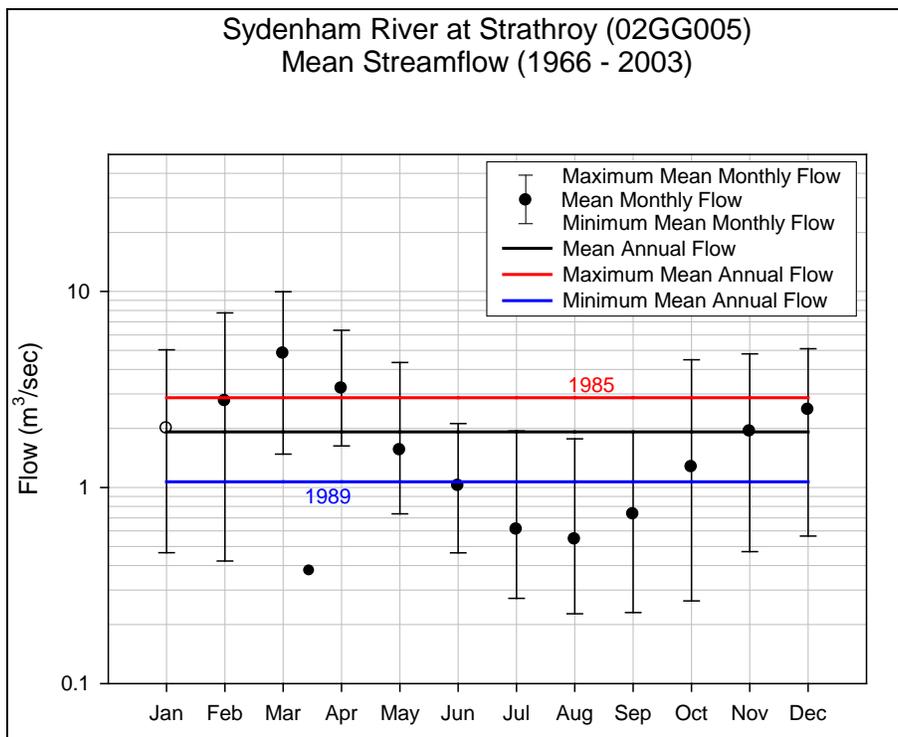
All of the other stations show a similar pattern of stream flow with the highest mean monthly flows occurring early in the year during spring runoff and the lowest flows in the late summer.

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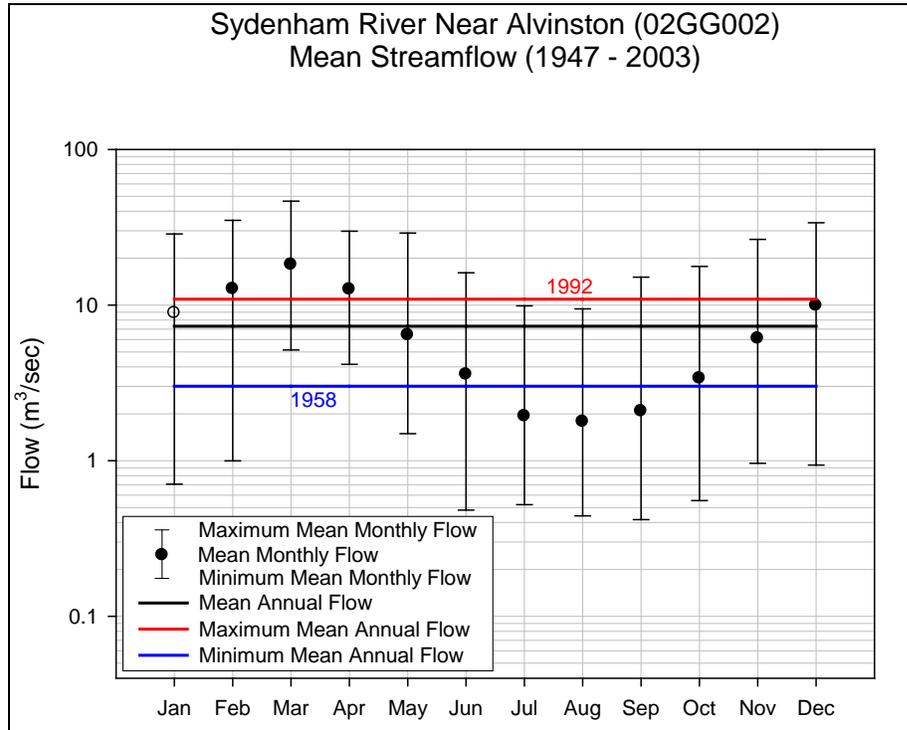
<sup>95</sup> St. Clair Region Conservation Authority. November 1996. Shoreline Management Plan. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1



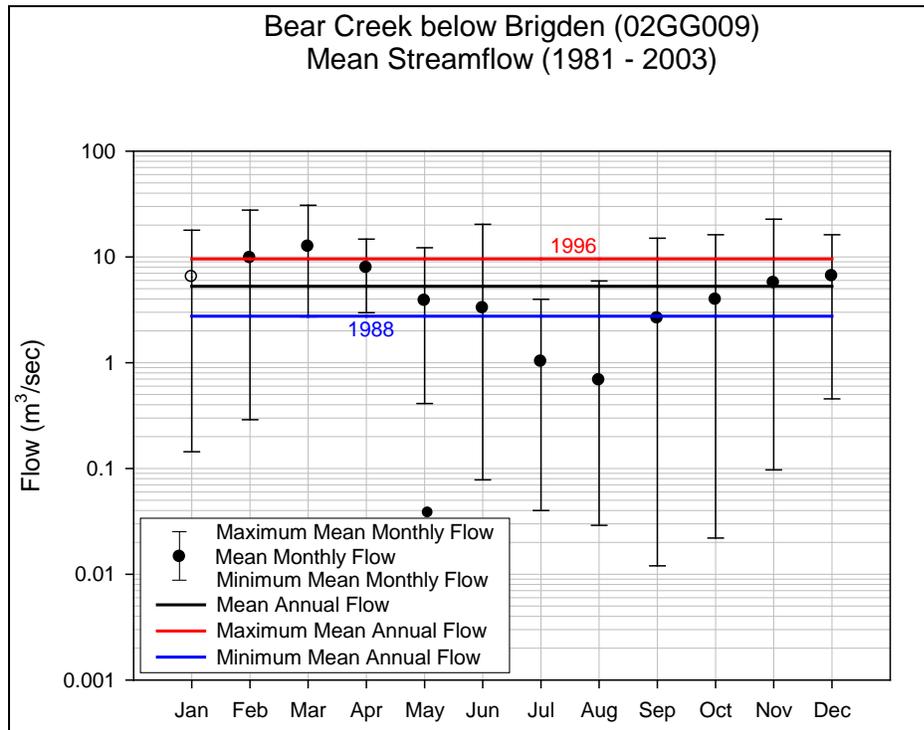
**Figure 2.3.3.4-1: Sydenham River at Wallaceburg**



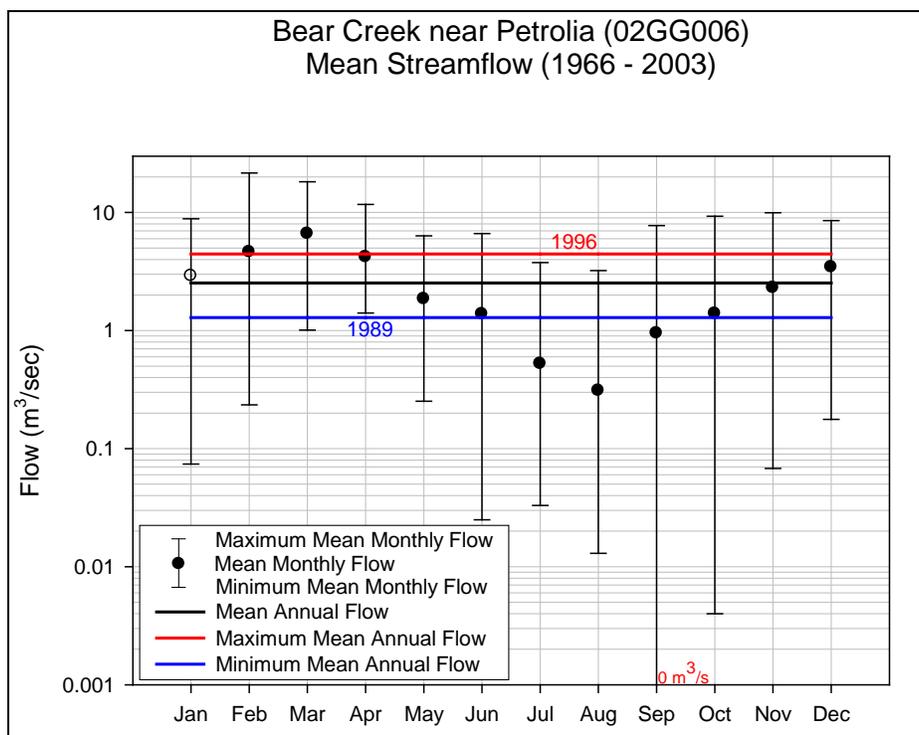
**Figure 2.3.3.4-2: East Sydenham River at Strathroy**



**Figure 2.3.3.4-3: East Sydenham River near Alvinston**



**Figure 2.3.3.4-4: North Sydenham River, Bear Creek below Brigden**



**Figure 2.3.3.4-5: North Sydenham River, Bear Creek near Petrolia**

### 2.3.3.5 Surface Water Monitoring - Quantity

Flooding on the Lower Sydenham has been a significant issue since the area was developed. Severe flood events occurred in the 1890s and 1920s. The flood potential prompted the installation of monitoring equipment on the Sydenham River in 1947.

The monitoring network on the Sydenham was expanded after the creation of the Conservation Authority to provide additional flood warning and avoid loss of life. More recently, a concern regarding flooding in the City of Sarnia in the 1990s spurred the installation of a stream gauge on Perch Creek in 2002.

**Table 2.3.3.5-1: St. Clair Region Stream Gauging Stations** details the location and period of record for these gauges. The station locations are shown on **Map 11: Watershed Hydrologic Conditions Monitoring**.

**Table 2.3.3.5-1: St. Clair Region Stream Gauging Stations**

<b>Stream Gauge Station Name</b>	<b>Stream Gauge Station Number</b>	<b>Period of Record (years)</b>	<b>Additional Information</b>
<i>Petrolia *</i>	<i>02GG006</i>	<i>35</i>	
<i>Brigden *</i>	<i>02GG009</i>	<i>20</i>	<i>Data used in McKeough Floodway operation</i>
<i>Black Creek*</i>	<i>02GG013</i>	<i>3 (1995-97)</i>	<i>Station started again in Nov 05</i>
<i>McKeough Dam</i>	<i>No # assigned</i>	<i>15</i>	<i>Upstream and downstream water levels and flow used in operation of McKeough Dam. Stations are not used for Water Survey of Canada.</i>
<i>Brown's Bridge</i>	<i>No # assigned</i>	<i>20</i>	
<i>Strathroy*</i>	<i>02GG005</i>	<i>35</i>	<i>Data Gap in 1990s</i>
<i>Alvinston*</i>	<i>02GG002</i>	<i>45</i>	<i>Precipitation Data</i>
<i>Florence*</i>	<i>02GG03</i>	<i>20</i>	
<i>Dresden</i>	<i>02GGC08</i>	<i>40</i>	<i>Precipitation Data</i>
<i>Wallaceburg*</i>	<i>02GG008</i>	<i>20</i>	<i>Level only (Lake St. Clair influence used in McKeough operation)</i>
<i>Perch Creek*</i>	<i>02GG013</i>	<i>4</i>	<i>Started due to flooding concern</i>
<i>Avonry</i>	<i>02GG004</i>	<i>20 (1964-84)</i>	<i>No longer in operation</i>

\* These stations correspond to stations currently owned and operated by the Water Survey of Canada

## 2.4 Naturally Vegetated Areas

Terrestrial ecology involves a wide variety of habitats ranging from wetlands to upland forest. Discussion of the terrestrial ecology has been divided into three types of habitat: wetlands, riparian zone and woodlands/forest. The riparian zone is the land adjacent to water bodies. It is usually saturated with groundwater or intermittently flooded with surface water resulting in the presence of vegetation adapted to life in this transition area.

The St. Clair Region Conservation Authority includes the Sydenham River and many smaller watercourses. The four main drainage areas are shown in **Map 2: Drainage Areas**.

For this report, the region has been divided into ten watershed areas in order to allow closer analysis of local differences. The division is based on the receiving basin and physiographic differences in the watershed.

Three of the watershed areas have been established by grouping the smaller watercourses according to their receiving basin. The combined catchment areas of the watercourses that drain into Lake St. Clair, together with the St. Clair delta, are referred to as “Lake St. Clair Tributaries”. Similarly, the comparable drainage area for the St. Clair River is called the “St. Clair River Tributaries”. The combined catchment areas draining into Lake Huron are referred to as the “Lake Huron Tributaries”.

The Sydenham River basin is the major drainage area shown in **Map 2: Drainage Areas**. The river’s drainage has been divided into seven subwatersheds. These subwatersheds are shown on **Map 20: Percentage Wetland Cover by Subwatershed**. Four subwatersheds were established on the East Sydenham by splitting the river into three reaches (Upper, Middle and Lower) and identifying the Brown Creek tributary as a separate subwatershed. The North Sydenham watershed was divided into three areas: the two tributaries (Bear Creek and Black Creek) and the area below their confluence forming the Lower North Sydenham.

This seven-part division of the Sydenham was initiated during the Sydenham River Recovery Planning process to reflect some of the physiographic differences of the river. The East branch flows from sand plains through a glacial beach ridge into clay plains, and the North branch flows from a moraine across clay plains. This division allows closer examination of terrestrial and aquatic differences between smaller catchment areas.

## 2.4.1 Wetlands

Wetlands are areas where water and land come together. They occur along lakes, rivers and streams and intermittently across the landscape in other areas where the water table is close to the surface. Wetlands store and filter water, provide critical habitat for many wildlife species, act as a carbon sink, filter the air, and provide valuable social and educational resources.

There are a variety of wetlands including:

- swamps dominated by trees and shrubs;
- marshes where emergent plants such as cattails, rushes and sedges dominate;
- bogs characterized by substantial peat accumulation, high water tables and acidic loving vegetation; and
- fens that are similar to bogs but support marsh-like vegetation including sedges and wildflowers.

Environment Canada has provided guidelines indicating that greater than 10% of each major watershed should be in wetland habitat; greater than six percent of each subwatershed should be in wetland habitat; or the original percentage of wetlands in the watershed should be restored<sup>96</sup>.

Review of the historical surveyors' notes from the early 1800s revealed that approximately 30% of the Sydenham River watershed was wetland swamps<sup>97</sup>. The largest wetland in the region was the Great Enniskillen Swamp in central Lambton County, "...a flat, wet tract of more than 150,000 acres spreading over large sections of Enniskillen, Brooke, Dawn and Sombra Townships."<sup>98</sup> This swamp included both deciduous and coniferous trees.

Outside of the Sydenham River watershed and close to Lake Huron, there was a natural interior lake known as Lake Wawanosh. Historical records indicate that this lake was only six to eight feet deep. The lake was drained in 1859 by the Cull Drain which discharges into Lake Huron. An unknown acreage of marsh that rimmed the lake was lost when the 1,800 acres of black muck soil were exposed<sup>99</sup> by the drainage project. There was one known historic bog in this region, located on the Wyoming moraine.

Down river from Wallaceburg, the surveyor for Dover Township noted an area of wet meadow and open marsh that stretched south. This wetland was part of the once extensive Lake St. Clair marshes.

Widespread drainage works over the past 150 years have reduced the wetland cover to less than 1% in the St. Clair Region. The diversity of wetlands has also been affected, as there are no bogs or extensive cedar coniferous swamps. A few hectares of cedar swamp remain on the upper east Sydenham, but the majority of the wetlands in the St. Clair Region are now deciduous swamps.

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<sup>96</sup> Environment Canada. 2004. How much habitat is enough? A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern. 2<sup>nd</sup> edition. Available from Canadian Wildlife Service or [wildlife.ontario.ec.gc.ca](http://wildlife.ontario.ec.gc.ca).

<sup>97</sup> Nelson, M. 2001. Sydenham River – Landuse and Landcover Assessment. Unpublished report from School of Rural Planning and Development, University of Guelph. 24pp. [www.sydenhamriver.on.ca/Reports/LandUse](http://www.sydenhamriver.on.ca/Reports/LandUse)

<sup>98</sup> DesRivieres, Dennis. 1972. The Great Enniskillen Swamp: Speculation, drainage and settlement. Western Ontario Historical Notes. 25:25-35.

<sup>99</sup> Tremain, Bob. Lambton County Heritage Museum, pers.comm.1982.

Recently, there have been efforts to preserve existing wetlands and re-establish wetlands in the region. Along Lake St. Clair, there are remnants of marsh and some marshlands have also been re-created with dykes and pump works. The creation of man-made wetlands has also resulted in isolated pockets of marsh-type wetlands along the St. Clair River. In part of the original bed of Lake Wawanosh where the black muck had been completely extracted, a man-made wetland has produced a small marsh.

Wetlands in this region were evaluated from 1984 through 1995 by the Ontario Ministry of Natural Resources and Conservation Authority staff using “An Evaluation System for Wetlands of Ontario”<sup>100</sup>. Based on this system, the total area of evaluated wetlands in the SCRCA is currently estimated to be 3,260 hectares, or 33 sq. km., excluding First Nation lands. However, preliminary mapping received from OMNR in July 2005 under the Southern Ontario Land Resources Information System (SOLRIS) project indicates that there may be numerous small wetland swamps in woodlots across the region. OMNR is undertaking a more detailed ground survey of these areas.

**Table 2.4.1-1: Percent Wetland Cover** provides a summary of the percentage of wetland for the watersheds areas in the St. Clair Region. **Map 20: Percent Wetland Cover by Subwatershed** shows the values for the 10 subwatersheds and illustrates the lack of wetlands across the region.

Currently, the largest evaluated wetland complex in the region is the East Sydenham-South Strathroy Creek swamp complex in the Upper East Sydenham, which results in 2.8% wetland cover for this subwatershed.

The Lake St. Clair Marsh complex is over 1,200 hectares and the Lake St. Clair Tributaries watershed area averages 2.8% wetland cover. This does not include large wetlands that are part of the St. Clair River Delta in the Bkejwanong Territory (Walpole Island First Nation).

The other subwatershed areas in the region have less than 1% wetland cover. The Middle East Sydenham has 0.8% wetland while the Lower East Sydenham watershed has no significant wetlands identified at this time.

**Table 2.4.1-1: Percent Wetland Cover by Subwatershed Areas in the St. Clair Region**

Watershed Area	Locally Significant Wetlands		Provincially Significant Wetlands		Total Significant Wetlands	
	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent
Bear Creek	50.10	0.08	77.63	0.12	127.73	0.2
Black Creek	39.13	0.12	7.248	0.02	46.38	0.1
Brown Creek			14.54	0.09	14.54	0.1
Lake Huron Tributaries	33.38	0.07	15.32	0.03	48.70	0.1
Lake St. Clair Tributaries			1249	2.8	1249	2.8
Lower East Sydenham						
Lower North Sydenham	18.69	0.07	29.24	0.12	47.93	0.2
Middle East Sydenham	41.66	0.08	390.4	0.72	432.06	0.8
St. Clair River Tributaries	1.121	0.00	2.458	0.01	3.58	0.01
Upper East Sydenham	15.13	0.03	1265	2.76	1280.13	2.8
<b>TOTAL</b>	199.2	0.05	3061	0.74	3260	0.8

<sup>100</sup> Ontario Ministry of Natural Resources and Canadian Wildlife Services, Environment Canada. 1984. An Evaluation System for Wetlands of Ontario. Unpublished report. 169 pp.  
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Environment Canada's guidelines for habitat cover recommends that more than 10% of each major watershed should be wetland habitat, and that either six percent of each subwatershed should be wetland habitat or the original percentage of wetlands in the watershed should be restored<sup>96</sup>.

### **Data Gaps - Wetland**

Wetland data has not been considered with respect to distribution by size of wetland, degree of overlap with woodland cover, distribution in recharge areas, or status with respect to significant natural areas.

Wetland evaluations for the Bkejwanong Territory (Walpole Island First Nation), Chippewas of Kettle & Stony Point First Nation, and Aamjiwnaang First Nation lands have not been included. Also, no data was available for the Lambton Shores portion of the Lake Huron Tributaries drainage area.

## **2.4.2 Riparian Zones**

The area of land adjacent to the watercourse is often called the riparian zone or buffer zone. Natural or permanent vegetation adjacent to streams and rivers provides many benefits to the watercourse. The vegetation filters sediment and pollutants from surface runoff, shades and cools the water, provides shoreline habitat for fish, reduces bank erosion, and contributes organic matter such as woody debris and leaves for aquatic organisms.

Environment Canada's riparian habitat guidelines recommend 75% of stream length be naturally vegetated, ideally with 30 metre wide buffers of natural vegetation<sup>96</sup>.

The only area in the St. Clair Region with analyses of riparian zones is the Sydenham River. The Department of Fisheries and Oceans analyzed the riparian zones of the Sydenham in 2003, to address a priority identified in the Recovery Strategy for Species at Risk in the Sydenham River.<sup>101</sup>

Staton and Doolittle<sup>102</sup> created overview maps of 30 m riparian zones along main tributaries and low order tributaries in the entire Sydenham River watershed. They used infrared aerial photography (IAP) data from 1995 to 1998, Indian Research Satellite (IRS) data (1998) from OMNR, and digital tile drainage coverage from the School of Rural Planning and Development at the University of Guelph. For the study, the Sydenham was divided into seven subwatershed areas. As mentioned earlier, the division helps to reflect the impact that physiographic differences such as sand or clay plains have on the various tributaries.

Both the 15 m and the 30 m buffer zones were analyzed. For both buffer widths, the information was used to calculate the percentages for three riparian classes:

- natural (including wooded, scrub and grassland/pasture),
- agriculture (bare soil or lands under cultivation), and
- built-up (residential and commercial use land including lawns).

**Table 2.4.2-1** provides a summary of the natural vegetation calculated for the 15 m Riparian Buffer Zone and **Table 2.4.2-2** summarizes the calculation for the 30 m Riparian Zone.

It should be noted that there were some limitations for the analysis. The IRS data had only a 20 m resolution and the IAP data had some gaps in coverage. This may have resulted in overestimation of the

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<sup>101</sup> Dextrase A.J., S.K. Staton, and J.L. Metcalfe-Smith. 2003. National Recovery Strategy for Species at Risk in the Sydenham River: An Ecosystem Approach. National Recovery Plan No. 25. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, Ontario. 73pp.

<sup>102</sup> Staton, S. and A. Doolittle, July 2003 Sydenham River Riparian Inventory. Annual Report to the IRF, Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences. 29pp. + maps.

agricultural lands category. It is also important to remember that “natural vegetation” included some pasture.

**Table 2.4.2-1: Percentage of Natural Vegetation Riparian 15 Metre Buffer Zone in the Sydenham River**

Watershed Area	Main Tributaries	Low Order Tributaries	All Tributaries
Lower East Branch	85	21	27
Middle East Branch	89	36	43
Upper East Branch	89	29	38
Brown Creek	82	29	36
Lower North Branch	74	27	40
Black Creek	96	37	42
Bear Creek	88	33	41

For the 15 m buffer zone, Staton and Doolittle found the main tributaries had a high percentage (74 to 96%) of naturally vegetated riparian zones. The low order tributaries had much less natural vegetation, ranging from 21 to 37%.

**Table 2.4.2-2: Percentage of Natural Vegetation Riparian 30 Metre Buffer Zone in the Sydenham River**

Watershed Area	Main Tributaries	Low Order Tributaries	All Tributaries
Lower East Branch	67	20	25
Middle East Branch	80	34	41
Upper East Branch	84	27	35
Brown Creek	78	27	35
Lower North Branch	61	18	25
Black Creek	91	35	40
Bear Creek	82	32	39

Analysis of the 30 m buffer composition indicated that between 61% and 91% of main tributaries had natural vegetation buffers. As would be expected in areas dominated by agricultural land use, low order tributaries had less (18% to 35%) coverage in natural vegetation. The lowest riparian cover occurs in the lower reaches of the Sydenham River. The highest cover is in the Middle East Sydenham and Black Creek watershed areas.

### **Riparian Zones - Data Gaps**

The evaluation of riparian zones was focused on the Sydenham River. A comparable level of information is not available for the other watercourses in the region.

## **2.4.3 Woodlands**

Environment Canada<sup>96</sup> has provided guidelines on forest habitats, specifically indicating that at least 30% of the watershed should be in forest cover in order to support viable fish and wildlife populations.

Historic records of the St. Clair Region indicate that there were extensive deciduous woodlands across the region. The area is classified as Great Lakes Deciduous Forest, which includes sugar maple, American beech, red oak, basswood and white ash. There are many less common, southerly “Carolinian” species including black cherry, black walnut, sycamore, white oak, swamp white oak, chinquapin oak, and shagbark hickory. Several rarities such as tulip tree, blue ash, Kentucky coffee tree, hoptree, shumard oak, big shellbark hickory and pawpaw are also found in the region.

Review of the original surveyors’ land cover records for the Sydenham watershed in the early 1800s revealed that 67% of the Sydenham watershed was “Forest” and 29% was “Swamp”. Unfortunately, the surveyors’ maps for 4% of the area have been lost<sup>97</sup>. Swamp categories included tamarack swamp, black ash swamp and willow swamp. The “forest” species noted by the surveyors included oak stands and beech/maple stands.

Today, in Lambton County, the largest areas of woodland are within the Bkejwanong Territory (Walpole Island First Nation), Aamjiwnaang First Nation, and Chippewas of Kettle & Stony Point First Nation. The largest contiguous forest outside of the First Nation lands is Bickford Oak Woods, in St. Clair Township. Significant woodlands have also been recognized in the Shetland Kentucky Coffee Tree Woods and Sydenham River Corridor Woods. The rich oak-hickory forests that were considered typical of the clay plain of Lambton County are best represented on Bear Creek and its tributary, Plum Creek<sup>103</sup>.

The linear east-west pattern of most woodlots in Lambton County is due to the practice of clearing the acreage closest to the concession road for farming, while retaining the “back 40” in treed cover. In south Lambton, the concessions of Dawn-Euphemia Township(s) were surveyed to run north-south, rather than east-west, and the difference in the woodlot distribution is obvious. Similarly, the Middlesex County portion of the region has a pattern of southeast-northwest woodlots parallel to the roads.

**Table 2.4.3-1** provides a summary of the percentage of woodland cover by watershed area for this region. The OMNR SOLRIS mapping used for this analysis was based on air photography interpretation. Since the information was available for First Nation lands, it was included in the evaluation of the watersheds. **Map 21: Percent Woodland Cover by Subwatershed** also shows the woodland cover. The areas with the highest percentage woodland cover are the lands of the Chippewas of Kettle & Stony Point First Nation, Aamijwnaang First Nation, and Bkejwanong Territory (Walpole Island First Nation).

At present, only 11.7% of the St. Clair Region is wooded. The Bickford Oak Woods results in relatively high cover for the St. Clair River Tributaries area. The upper and middle reaches of the East Sydenham River also have above average forest cover. The lowest amount of cover is found in the Lake St. Clair Tributaries area, where marshland occurred historically prior to European settlement. The lower reaches of the East and North Sydenham also have very low woodland cover.

Over the past century, several diseases and pests introduced by man have had a significant impact on the local tree species. The American Chestnut was destroyed by chestnut blight, which is caused by an Asian bark fungus accidentally introduced to America on imported Asiatic chestnut trees. The blight was probably imported into North America from Asia in the early 1900s. Similarly, the American Elm has been seriously affected by an introduced fungal disease, Dutch Elm Disease (DED), with heavy mortality. The disease was accidentally introduced into North America in 1931, in shipments of logs from the Netherlands destined for use as veneer.

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<sup>103</sup> Carolinian Canada Identification Subcommittee. 1985. Critical Unprotected Natural Areas in the Carolinian Life Zone of Canada. Nature Conservancy of Canada, Ontario Heritage Foundation, World Wildlife Fund Canada. 400 pp.

**Table 2.4.3-1: Percent Woodland Cover by Watershed Area in the St. Clair Region**

Watershed Area	Area of Watershed (km <sup>2</sup> )	Area of Woodland (km <sup>2</sup> )	Percent Woodland Cover
Bear Creek	632	87	14
Black Creek	324	44	14
Brown Creek	156	20	13
Lake Huron Tributaries	646	88	14
Lake St. Clair Tributaries	448	29	6
Lower East Sydenham	396	24	6
Lower North Sydenham	252	24	10
Middle East Sydenham	539	84	16
St. Clair River Tributaries	261	43	16
Upper East Sydenham	459	72	16
TOTAL	4113	512	12

More recently, the Emerald Ash Borer<sup>104</sup>, which is native to China and eastern Asia, has left a path of destruction in Essex County in southwestern Ontario (as well as southeastern Michigan, northern Ohio and Indiana). In the St. Clair region, it was found in Chatham-Kent and Lambton County. Its significance for woodlands in the region is not yet known but ash trees form an important part of the local tree cover in many woodlots.

#### **2.4.4 Watershed Report Cards**

The St. Clair Region Conservation Authority is in the process of preparing watershed report cards that will summarize information on the subwatershed areas. When completed, the report cards will be posted on the SCRCA website.

It should be noted that the watershed report cards further divide the drainage areas into 14 subwatershed areas. The changes to the subwatersheds used in this report are:

- The Lake Huron Tributaries are subdivided into three as the Lambton Shores Tributaries; the Plympton Shores Tributaries; and the Cow & Perth Creeks Tributaries.
- Bear Creek is divided into the Bear Creek Headwaters and the Lower Bear Creek.
- The Upper East Sydenham is divided into the Sydenham Headwaters and the Upper Sydenham River.

The division of the watersheds, additional data or different data sets may result in slight differences between the information that is presented in this report and the reviews that are presented in the watershed report cards.

## **2.5 Aquatic Ecology**

Aquatic ecosystems include watercourses (streams, rivers, and drains), water bodies (lakes, reservoirs, and ponds), and wetlands. They provide habitat for aquatic organisms and for some specific life stages of semi-aquatic species. These systems supply food for sustenance, cover for protection, and habitat for reproduction. For some species, they may also provide corridors for movement.

<sup>104</sup> Canadian Food Inspection Agency. Emerald Ash Borer, [www.inspection.gc.ca](http://www.inspection.gc.ca)  
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An aquatic ecosystem is a function of the living and non-living components, as well as the natural and unnatural stresses placed upon them. The landscape (soils, valleys, etc.) forms the non-living portion of the aquatic ecosystem, and contributes to the habitat conditions that determine the living portion of the aquatic ecosystem. The habitat conditions (quality) and the quantity of habitat available determine the type of aquatic community that will occupy a given aquatic ecosystem. The living component of the aquatic ecosystem is comprised of the organisms living in the aquatic portion and others that impact the aquatic habitat. Each component plays a vital role in the aquatic ecosystem.

## 2.5.1 Fisheries

There is a great diversity of fish that currently inhabit the waters of the St. Clair region. In addition, historic fish records, available from the Royal Ontario Museum, include several species of fish that have not been observed for many decades. These include American Brook Lamprey (1918) and Brook Trout (1931) recorded in the upper reaches the East Sydenham in Middlesex Centre near Coldstream.

During the last thirty years, 82 species of fish have been recorded in the St. Clair Region<sup>105</sup>. This represents almost half of the 165 fish species known from Ontario. This master species list was prepared using information from the Ontario Ministry of Natural Resources (OMNR), the Royal Ontario Museum (ROM), Fisheries and Oceans Canada (DFO), and SCRCA and UTRCA staff, who have sampled the fish communities using seine netting, minnow trapping, backpack electro-fishing and boat electro-fishing.

These species are listed in **Table 2.5.1-1: Fish Species Documented within the St. Clair Region**, with both the common and scientific names. The table indicates various characteristics of these species and their ranking by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)<sup>106</sup>. Nine of these species are considered Species At Risk (SAR) by COSEWIC. An additional six species are Candidates for ranking by COSEWIC. Additional information on SAR is provided in Section 2.5.4 Species At Risk.

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<sup>105</sup> St. Clair Region Conservation Authority. 2000. "Get To Know Your Watershed" poster. Unpublished report.

<sup>106</sup> Natural Heritage Information Centre. <http://nhic.mnr.gov.on.ca/MNR/nhic/areas.cfm>  
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Table 2.5.1-1:

## Fish Species Documented within the St. Clair Region

Common Name	Scientific Name	COSEWIC Status*	Sensitive Species	Thermal Regime	Introduced
			Species Comments		
Bigmouth Buffalo	<i>Ictiobus cyprinellus</i>	SC	+	warm	
Black Bullhead	<i>Ameiurus melas</i>			warm	
Black Crappie	<i>Pomoxis nigromaculatus</i>			cool	
Blacknose Dace	<i>Rhinichthys atratulus</i>			cool/warm	
Blackside Darter	<i>Percina maculata</i>			cool	
Blackstripe Topminnow	<i>Fundulus notatus</i>	SC		cool/warm	
Bluegill	<i>Lepomis macrochirus</i>			warm	
Bluntnose Minnow	<i>Pimephales notatus</i>	NAR		warm	
Brassy Minnow	<i>Hybognathus hankinsoni</i>	Candidate		cool	
Brindled Madtom	<i>Noturus miurus</i>	NAR		warm	
Brook Silverside	<i>Labidesthes sicculus</i>	NAR		cool/warm	
Brook Stickleback	<i>Culaea inconstans</i>			cool	
Brown Bullhead	<i>Ameiurus nebulosus</i>			warm	
Central Mudminnow	<i>Umbra limi</i>			cool/warm	
Channel Catfish	<i>Ictalurus punctatus</i>			warm	
Chinook Salmon	<i>Oncorhynchus tshawytscha</i>			cold	+
Coho Salmon	<i>Oncorhynchus kisutch</i>			cold	+
Common Carp	<i>Cyprinus carpio</i>			warm	+
Common Shiner	<i>Luxilus cornutus</i>			cool	
Creek Chub	<i>Semotilus atromaculatus</i>			cool	
Eastern Sand Darter	<i>Ammocrypta pellucida</i>	THR	+	cool/warm	
Emerald Shiner	<i>Notropis atherinoides</i>			cool	
Fantail Darter	<i>Etheostoma flabellare</i>			cool	
Fathead Minnow	<i>Pimephales promelas</i>			warm	
Freshwater Drum	<i>Aplodinotus grunniens</i>			warm	
Ghost Shiner	<i>Notropis buechanani</i>	NAR		warm	
Gizzard Shad	<i>Dorosoma cepedianum</i>			cool	
Golden Redhorse	<i>Moxostoma erythrurum</i>	NAR		warm	
Golden Shiner	<i>Notemigonus crysoleucas</i>			cool	
Goldfish	<i>Carassius auratus</i>			warm	+
Goldfish x Carp					
Grass Pickerel	<i>Esox americanus vermiculatus</i>	SC	+	warm	
Greater Redhorse	<i>Moxostoma valenciennesi</i>	Candidate	+	cool/warm	
Green Sunfish	<i>Lepomis cyanellus</i>	NAR		warm	
Greenside Darter	<i>Etheostoma blennioides</i>	SC		cool/warm	
Hornyhead Chub	<i>Nocomis biguttatus</i>	NAR		cool/warm	
Iowa Darter	<i>Etheostoma exile</i>			cool	
Johnny Darter	<i>Etheostoma nigrum</i>			cool	
Largemouth Bass	<i>Micropterus salmoides</i>			warm	
Least Darter	<i>Etheostoma microperca</i>			cool/warm	
Log Perch	<i>Percina caprodes</i>			cool/warm	
Longear Sunfish	<i>Lepomis megalotis</i>	NAR	+	warm	
Longnose Dace	<i>Rhinichthys cataractae</i>			cool	
Longnose Gar	<i>Lepisosteus osseus</i>			warm	

Common Name	Scientific Name	COSEWIC Status*	Sensitive Species	Thermal Regime	Introduced
			Species Comments		
Mimic Shiner	<i>Notropis volucellus</i>			warm	
Mooneye	<i>Hiodon tergisus</i>			cool/warm	
Mottled Sculpin	<i>Cottus bairdi</i>		+	cold	
Northern Hog Sucker	<i>Hypentelium nigricans</i>			warm	
Northern Madtom	<i>Noturus stigmosus</i>	END		warm	
Northern Pike	<i>Esox lucius</i>		+	cool	
Northern Redbelly Dace	<i>Phoxinus eos</i>	Candidate		cool/warm	
Pearl Dace	<i>Margariscus margarita</i>		+	cool	
Pink Salmon	<i>Oncorhynchus gorbuscha</i>			cold	+
Pugnose Minnow	<i>Opsopoeodus emiliae</i>	SC		cool/warm	
Pugnose Shiner	<i>Notropis anogenus</i>	END		cool	
Pumpkinseed	<i>Lepomis gibbosus</i>			warm	
Quillback	<i>Carpionodes cyprinus</i>			cool	
Rainbow Darter	<i>Etheostoma caeruleum</i>			cool	
Rainbow Smelt	<i>Osmerus mordax</i>			cold	
Rainbow Trout	<i>Oncorhynchus mykiss</i>		+	cold	
Redfin Shiner	<i>Lythrurus umbratilis</i>	NAR		cool	
Rock Bass	<i>Ambloplites rupestris</i>			cool	
Rosyface Shiner	<i>Notropis rubellus</i>	NAR		warm	
Round Goby	<i>Neogobius melanostomus</i>			cool	+
Sand Shiner	<i>Notropis stramineus</i>			warm	
Shorthead Redhorse	<i>Moxostoma macrolepidotum</i>		+	warm	
Silver Redhorse	<i>Moxostoma anisurum</i>			cool	
Smallmouth Bass	<i>Micropterus dolomieu</i>		+	warm	
Spotfin Shiner	<i>Cyprinella spiloptera</i>			warm	
Spottail Shiner	<i>Notropis hudsonius</i>			cool/cold	
Spotted Gar	<i>Lepisosteus oculatus</i>	THR		warm	
Spotted Sucker	<i>Minytrema melanops</i>	SC	+	warm	
Stonecat	<i>Noturus flavus</i>	Candidate		warm	
Striped Shiner	<i>Luxilus chrysocephalus</i>	NAR		cool	
Tadpole Madtom	<i>Noturus gyrinus</i>			warm	
Trout-Perch	<i>Percopsis omiscomaycus</i>			cold	
Walleye	<i>Stizostedion vitreum</i>		+	cool	
White Bass	<i>Morone chrysops</i>			warm	
White Crappie	<i>Pomoxis annularis</i>			cool	
White Perch	<i>Morone americana</i>	Candidate		warm	
White Sucker	<i>Catostomus commersoni</i>			cool	
Yellow Bullhead	<i>Ameiurus natalis</i>	Candidate		warm	
Yellow Perch	<i>Perca flavescens</i>			cool	

\* October 2005

COSEWIC and "Introduced" status from NHIC website

Sensitive Species rating from Peter Brunette, DFO, 2005, unpublished list.

Thermal Regime from Coker, Portt, and Minns, 2004.

Since 1999, several surveys have been conducted in the St. Clair region. Between 1999 and 2004, SCRCA staff working with UTRCA and DFO staff carried out surveys for the Municipal Drain Classification project. This includes some additional sampling that was carried out in 2004 to meet fisheries habitat management recommendations for the upper East Sydenham. The work involved electro-fishing at 180 sites, including some sites in each of the 10 watershed areas of the St. Clair region. Most of these sites were municipal drains or small natural watercourses.

In 2002 and 2003, Mark Poos, a DFO employee and Master's student at the University of Guelph, carried out extensive sampling at 100 sites along the East Sydenham and the Bear and Black Creek tributaries of the North Sydenham. He used a variety of techniques including backpack electro-fishing, seining and Windemere traps<sup>107</sup>. Mark Poos and his supervisor, Dr. Nick Mandrak, provided the SCRCA with presence and absence data for the fish species that were captured during this fieldwork. These two sources of information have been used to generate **Map 22: Electro-fishing Sites**.

A third source of recent information was provided by DFO.<sup>108</sup> Several bridges were to be re-constructed, and a requirement of DFO was detailed electro-fishing surveys, before authorization under the Fisheries Act for these projects. These surveys were conducted in 2004 and added the Pugnose Shiner, which had not been identified previously, to the regional records.

Anecdotal information on fish presence and distribution is also available from watershed landowners, the Ontario Bait Association and the OMNR Scientific Fish Collection Permit program. However, this information has not been incorporated in the tables.

The current records are summarized in **Table 2.5.1-2: Distribution of Fish Species Confirmed within the St. Clair Region from 1999 to 2004**. A total of 72 fish species (plus goldfish x carp hybrid) were identified during these surveys. Ten species of fish historically known from the region were not found in these recent surveys, including introduced species such as Pink, Coho and Chinook Salmon; rare species such as Spotted Gar, Pugnose Minnow and Northern Madtom; and relatively common species such as Mooneye, Rainbow Smelt and Sand Shiner.

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<sup>107</sup> Poos, Mark. 2004. Science in support of policy: assessment and recovery of fish species at risk in the Sydenham River. M.Sc. thesis, University of Guelph. 76pp.

<sup>108</sup> Staton, Shawn. 2004. DFO Species at Risk Biologist. Pers. Comm.

Table 2.5.1-2:

## Distribution of Fish Species Confirmed within the St. Clair Region from 1999 to 2004

Common Name	Scientific Name	COSEWIC Status*	Watersheds				
			Lake Huron Tributaries	Lake St. Clair Tributaries	Lambton Shore	St. Clair River Tributaries	Sydenham River
Bigmouth Buffalo	<i>Ictiobus cyprinellus</i>	SC					2
Black Bullhead	<i>Ameiurus melas</i>		1			1	1 2
Black Crappie	<i>Pomoxis nigromaculatus</i>						2
Blacknose Dace	<i>Rhinichthys atratulus</i>						1 2
Blackside Darter	<i>Percina maculata</i>		1				1
Blackstripe Topminnow	<i>Fundulus notatus</i>	SC				3	1 2
Bluegill	<i>Lepomis macrochirus</i>			1		1	1 2
Bluntnose Minnow	<i>Pimephales notatus</i>	NAR	1			1	1 2
Brassy Minnow	<i>Hybognathus hankinsoni</i>	Candidate	1				1
Brindled Madtom	<i>Noturus miurus</i>	NAR					1 2
Brook Silverside	<i>Labidesthes sicculus</i>	NAR					2
Brook Stickleback	<i>Culaea inconstans</i>		1				1 2
Brown Bullhead	<i>Ameiurus nebulosus</i>		1				1
Central Mudminnow	<i>Umbra limi</i>		1	1		1	1 2
Channel Catfish	<i>Ictalurus punctatus</i>						1 2
Common Carp	<i>Cyprinus carpio</i>		1	1		1	1 2
Common Shiner	<i>Luxilus cornutus</i>		1			1	1 2
Creek Chub	<i>Semotilus atromaculatus</i>		1			1	1 2
Eastern Sand Darter	<i>Ammocrypta pellucida</i>	THR					1 2
Emerald Shiner	<i>Notropis atherinoides</i>						1 2
Fantail Darter	<i>Etheostoma flabellare</i>						2
Fathead Minnow	<i>Pimephales promelas</i>		1				1 2
Freshwater Drum	<i>Aplodinotus grunniens</i>						2
Ghost Shiner	<i>Notropis buchmanii</i>	NAR					2
Gizzard Shad	<i>Dorosoma cepedianum</i>						1 2
Golden Redhorse	<i>Moxostoma erythrurum</i>	NAR					1 2
Golden Shiner	<i>Notemigonus crysoleucas</i>			1			1 2
Goldfish	<i>Carassius auratus</i>		1				1 2
Goldfish x Carp							1
Grass Pickerel	<i>Esox americanus vermiculatus</i>	SC		1 3		3	1
Greater Redhorse	<i>Moxostoma valenciennesi</i>	Candidate					2
Green Sunfish	<i>Lepomis cyanellus</i>	NAR	1	1		1	1 2
Greenside Darter	<i>Etheostoma blennioides</i>	SC					1 2
Hornyhead Chub	<i>Nocomis biguttatus</i>	NAR					2
Iowa Darter	<i>Etheostoma exile</i>						1
Johnny Darter	<i>Etheostoma nigrum</i>		1	1		1	1 2
Largemouth Bass	<i>Micropterus salmoides</i>			1		1	1 2
Least Darter	<i>Etheostoma microperca</i>	NAR	1				1 2
Log Perch	<i>Percina caprodes</i>						1 2
Longear Sunfish	<i>Lepomis megalotis</i>	NAR					1 2
Longnose Gar	<i>Lepisosteus osseus</i>						1 2
Mimic Shiner	<i>Notropis volucellus</i>		1				1 2

Common Name	Scientific Name	COSEWIC Status*	Watersheds				
			Lake Huron Tributaries	Lake St. Clair Tributaries	Lambton Shore	St. Clair River Tributaries	Sydenham River
Mottled Sculpin	<i>Cottus bairdi</i>						1 2
Northern Hog Sucker	<i>Hypentelium nigricans</i>						1 2
Northern Pike	<i>Esox lucius</i>		1				1 2
Northern Redbelly Dace	<i>Phoxinus eos</i>	Candidate	1				1 2
Pearl Dace	<i>Margariscus margarita</i>						1
Pugnose Minnow	<i>Opsopoeodus emiliae</i>	SC				3	
Pugnose Shiner	<i>Notropis anogenus</i>	END		3		3	
Pumpkinseed	<i>Lepomis gibbosus</i>		1	1		1	1 2
Quillback	<i>Carpionodes cyprinus</i>						1 2
Rainbow Darter	<i>Etheostoma caeruleum</i>		1				1
Rainbow Trout	<i>Oncorhynchus mykiss</i>						1
Redfin Shiner	<i>Lythrurus umbratilis</i>	NAR		1			1 2
Rock Bass	<i>Ambloplites rupestris</i>		1			1	1 2
Rosyface Shiner	<i>Notropis rubellus</i>	NAR					1
Round Goby	<i>Neogobius melanostomus</i>		1	1			
Shorthead Redhorse	<i>Moxostoma macrolepidotum</i>						1 2
Silver Redhorse	<i>Moxostoma anisurum</i>						2
Smallmouth Bass	<i>Micropterus dolomieu</i>		1				1 2
Spotfin Shiner	<i>Cyprinella spiloptera</i>		1			1	1 2
Spottail Shiner	<i>Notropis hudsonius</i>		1				2
Spotted Sucker	<i>Minytrema melanops</i>	SC				3	2
Stonecat	<i>Noturus flavus</i>	Candidate					1 2
Striped Shiner	<i>Luxilus chrysocephalus</i>	NAR	1				1 2
Tadpole Madtom	<i>Noturus gyrinus</i>			1			1 2
Trout-Perch	<i>Percopsis omiscomaycus</i>						1 2
Walleye	<i>Stizostedion vitreum</i>						1 2
White Bass	<i>Morone chrysops</i>						2
White Crappie	<i>Pomoxis annularis</i>						1 2
White Perch	<i>Morone americana</i>	Candidate					1 2
White Sucker	<i>Catostomus commersoni</i>		1	1		1	1 2
Yellow Bullhead	<i>Ameiurus natalis</i>	Candidate					1 2
Yellow Perch	<i>Perca flavescens</i>		1			1	1 2

Source 1: SCRC Electro-fishing Results 1999 - 2004

2: Mark Poos MSc Sampling 2002 - 2003

3: Shawn Staton, DFO Species at Risk biologist. 2004 Pers. com.

\* October 2005

The most common fish species in the Sydenham are Johnny Darter, Bluntnose Minnow, Spotfin Shiner, Logperch and White Sucker. Other species that were found by Poos in more than half of his field sites were Redfin Shiner, Mimic Shiner, Rock Bass, Green Sunfish and Greenside Darter. Although Greenside Darter is common in the Sydenham watershed, at a federal scale it is sufficiently rare to be designated as "Special Concern."

Katie Stammler is currently completing a graduate thesis at the University of Guelph, that involves an analysis of the fish found in natural watercourses and classified municipal drains within southwestern Ontario. This research may provide further fisheries information on watercourses in the St. Clair region.

Additional species probably occur in the subwatersheds that have not received close scrutiny. This is suggested by the recent discovery of the endangered Pugnose Shiner during the DFO survey in the Whitebread Drain, which is a St. Clair River tributary. More intensive surveys in the future may reveal more species of significance in this region.

A number of the fish have been identified as being sensitive to habitat disturbance in a list provided by DFO<sup>109</sup>. This list was generated to help prioritize watercourses where disturbance would require site-specific authorization under the federal Fisheries Act. As indicated on **Table 2.5.1-1**, there are 13 sensitive species found in the SCRCA.

Nine sensitive species (Eastern Sand Darter, Greater Redhorse, Longear Sunfish, Mottled Sculpin, Northern Pike, Pearl Dace, Rainbow Trout, Shorthead Redhorse and Smallmouth Bass) are found in the headwater areas of the East Branch of the Sydenham River. The Pearl Dace and Rainbow Trout are found on the small tributaries of the upper watershed but not in the main (East Sydenham) river.

On the north branch of the Sydenham, Bear Creek has seven sensitive species (Walleye, Northern Pike, Longear Sunfish, Spotted Sucker, Smallmouth Bass, Shorthead Sucker and Bigmouth Buffalo) and Black Creek has five (Northern Pike, Longear Sunfish, Spotted Sucker, Shorthead Sucker and Bigmouth Buffalo). Northern Pike is the most widely distributed sensitive species.

The sensitive species are not specific to the headwaters of the watercourses. Pike in particular were found in all subwatershed areas of the St. Clair region except for Brown Creek. None of the sensitive species have been recorded recently in Brown Creek.

Temperature studies related to fisheries have been limited to applying the Stoneman protocol<sup>110</sup> for the municipal drain classification process. Based on these temperature measurements, cool watercourses are limited to tributaries in the upper third of the East Sydenham coming from geographic Strathroy-Caradoc and Middlesex Centre (Lobo) Townships.

The thermal regime rating for fish species as listed in **Table 2.5.1-1** is based on published information<sup>111</sup>. This literature indicates that 34 of the 82 species recorded for the region actually prefer cool or cold water. However, many of these species were found to be living in habitats in the St. Clair region that appear to be warm water habitats. It may be that the habitat requirements of these species are very broad so they can survive in warm water, or that local habitat conditions provide better conditions. Most surveys were conducted at bridge crossings and well-vegetated reaches between the bridges may be providing a cooler thermal regime for these fish. If this is the case, habitat enhancement at more reaches may provide significant benefits to the water. It is not known whether this may be of significance for source protection.

A Fisheries Habitat Management Plan has been written for the Upper East Sydenham.<sup>112</sup> This plan included a comparison between recent fisheries information (1999 to 2004) and OMNR data and

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<sup>109</sup> Brunette, Peter. May 2005. Pers. comm. Unpublished list. 5pp.

<sup>110</sup> Stoneman, C.L. and M.J. Jones. 1996. A Simple Methodology to Evaluate the Thermal Stability of Trout Streams. *North American Journal of Fisheries Management*. 16:72-737.

<sup>111</sup> Coker, G.A., C.B. Portt, and C.K. Minns. 2001. Morphological and Ecological Characteristics of Canadian Freshwater Fishes, *Can. MS.Rpt. Fish. Aquat. Sci.* 2554:iv + 89pp.

<sup>112</sup> Seidler, A. and M. Andreae. June 2004. Upper East Sydenham Fisheries Management Plan. Unpublished report. 84 pp.

classification from 1975 stream survey field notes<sup>113</sup>. A number of watercourses that were classified as cool water in 1975 are now lacking this characteristic.

Several stressors of fish habitat were identified in the Upper East Sydenham in this report including:

- Permits To Take Water are significant, in both their number and in the volume of water approved for removal
- Insufficient riparian vegetation
- Presence of dams or impoundments
- High percentage of area has tiled drains
- Low percentage of area is wetland complexes
- Low percentage of watercourses are natural watercourses
- Potential for urban runoff

The report also identified some knowledge gaps in temperature records and fish surveys. The additional work done in the summer of 2004 addressed these issues. These more detailed surveys found species such as Pearl Dace and Rainbow Trout at several previously-unknown locations.

The discussion in this management plan indicates:

*“As a general recommendation for projects that will benefit aquatic habitat for native fish species, the focus should be placed on reducing sediment deposition, stabilizing temperature regimes and preserving stream hydrology”.*<sup>112</sup>

General application of this recommendation would be of benefit to the water quality and water quantity throughout the region.

### **Fisheries Data Gaps**

- Fisheries data for the Lambton Shores Area is not available.
- Fisheries data for the last 30 years has not been analyzed with respect to each subwatershed area.
- The distribution of fish species has not been analyzed with respect to groundwater discharge areas.
- The distribution of fish species has not been analyzed with respect to their sensitivity to turbidity, siltation, thermal fluctuations or increases in chemical concentrations.
- The current thermal status of watercourses has not been compared with the classifications of the Chatham region OMNR Stream Survey data from 1975.
- Review of the Aylmer District Fisheries Management Plan and the Chatham District Fisheries Management Plan has not been completed.
- The Ontario Ministry of the Environment Sport Fish Contaminant Monitoring Program is a source of fisheries information that has not been examined to date.

## **2.5.2 Mussels**

Freshwater mussels are valuable indicators of environmental degradation because they are affected by many kinds of habitat alteration and pollution. They are useful for bio-monitoring environmental contamination because they are long-lived, sedentary bottom-dwellers and accumulate many toxic substances.<sup>114</sup>

The biodiversity of freshwater mussels has declined across the whole lower Great Lakes drainage basin. Janice Metcalfe-Smith et al. conclude “River systems that once supported numerous species characteristic of a wide variety of habitats are now dominated by fewer siltation- and pollution-tolerant species of the

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<sup>113</sup> Ontario Ministry of Natural Resources Aylmer. 1975. Unpublished Stream Survey Data by Scott and Payne.

<sup>114</sup> Metcalfe-Smith, J., A. MacKenzie, I. Carmichael and D. McGoldrick. 2005. Photo Field Guide to the Freshwater Mussels of Ontario. St. Thomas Field Naturalist Club Incorporated, St. Thomas, Ontario. 60 pp. (in press).

Anodontinae”<sup>115</sup>. The major rivers in southwestern Ontario such as the Grand, Thames and Sydenham historically supported a greater diversity of species, and now have species losses of 24% for the Grand, 30% for the Thames and 15% for the Sydenham.

The Sydenham River supports the richest freshwater mussel community of any river in Canada. Based on the composition of the mussel community, the calculation of Conservation Status Scores for sites on the Grand, Thames, Sydenham, Ausable and Maitland Rivers, revealed the eight highest-scoring sites were on the Sydenham River. More than 50 km of the Sydenham have high scoring sites. Also, when compared to drainage basins of similar size in the State of Ohio, the Sydenham River had greater than average mussel and fish diversity, with over 30% more species of mussels than the average watercourse of this size<sup>116</sup>.

Historically, 33 native mussel species were recorded for the Sydenham. Extensive sampling by Janice Metcalfe-Smith, Environment Canada, and co-workers from 1997 to 1999 found 30 live species, including the Threehorn Wartyback, which was a new species of record for the river. However, the work in the late 1990s indicated that in general, conditions were deteriorating. Four species (Wavy-rayed Lampmussel, Slippershell, Paper Pondshell and Lilliput) were represented only by empty shells. A number of sensitive species were declining in both branches of the river (Round Hickorynut, Fat Mucket, Plain Pocketbook, Creeper and Rainbow on the east branch, and Deertoe and Fragile Papershell on the north branch). Also, several pollution-tolerant species (Pink Heelsplitter, Mapleleaf, White Heelsplitter and Fluted Shell) were found to be expanding their range<sup>117</sup>.

**Table 2.5.2-1: Unionid Mussel Species** provides a list of the 34 species that have been found within the main branches of the Sydenham River and includes the COSEWIC status. The distribution for the two main branches of the Sydenham is shown to highlight the difference in dispersal. The East Sydenham, in particular the middle reaches, support the majority of the endangered mussels and the greatest mussel diversity. The presence of abundant riffles, clean gravel and sand substrates and adequate summer flow in the east branch are presumed to be the reasons for this greater diversity. One of the mussel SAR is found on the north branch above Petrolia, so it is plausible that the historic discharges associated with oil extraction near Petrolia and downstream have limited the mussels.

This table indicates that 23 species are endangered, under review by COSEWIC or are candidate species for review. Overall, 68% of the mussel species known in the Sydenham River are in need of conservation actions. This is consistent with mussel status throughout North America.

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<sup>115</sup> Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie and N.M. Lane. 1998. Changes in the Biodiversity of Freshwater Mussels in the Canadian Waters of the Lower Great Lakes Drainage Basin Over the Past 140 Years. *J. Great Lakes Res.* 24(4):845-858.

<sup>116</sup> Metcalfe-Smith, J. L. 1999. Sydenham River Mussel Communities. Unpublished report from National Water Research Institute. 12 pp.

<sup>117</sup> Metcalfe-Smith, J., J. Di Maio, S.K. Staton and S.R. De Solla. 2003. Status of the Freshwater Mussel Communities of the Sydenham River, Ontario, Canada. *American Midland Naturalist* 150:37-50.

Table 2.5.2-1:

**Unionid Mussel Species found within the main branches of the  
Sydenham River, 1997 to 1999**

			East Sydenham	Bear Creek, Black Creek, North Sydenham
Common Name	Scientific Name	COSEWIC Status	Subwatersheds	
Black Sandshell	<i>Ligumia recta</i>	Candidate	+	
Creek Heelsplitter	<i>Lasmigona compressa</i>			+
Creeper	<i>Strophitus undulatus</i>		+	+
Cylindrical Papershell	<i>Anodontoides ferussacianus</i>			+
Deertoe	<i>Truncilla truncata</i>	Candidate	+	+
Elktoe	<i>Alasmidonta marginata</i>	Candidate	+	+
Fatmucket	<i>Lampsilis siliquoidea</i>		+	+
Fawnsfoot	<i>Truncilla donaciformis</i>	Candidate	+	
Flutedshell	<i>Lasmigona costata</i>		+	+
Fragile Papershell	<i>Leptodea fragilis</i>		+	+
Giant Floater	<i>Pyganodon grandis</i>		+	+
Kidneyshell	<i>Ptychobranthus fasciolaris</i>	END	+	
Lilliput	<i>Toxolasma parvus</i>	Candidate		
Mapleleaf	<i>Quadrula quadrula</i>	Under Review	+	+
Mucket	<i>Actinonaias ligamentina</i>	Candidate	+	
Mudpuppy Mussel	<i>Simpsonaias ambigua</i>	END	+	+
Northern Riffleshell	<i>Epioblasma torulosa rangiana</i>	END	+	
Paper Pondshell	<i>Utterbackia imbecillis</i>	Candidate	+	
Pimpleback	<i>Quadrula pustulosa pustulosa</i>	Candidate	+	
Pink Heelsplitter	<i>Potamilus alatus</i>	Candidate	+	+
Plain pocketbook	<i>Lampsilis cardium</i>		+	
Purple Wartyback	<i>Cyclonaias tuberculata</i>	Candidate	+	
Rainbow	<i>Villosa iris</i>	Under Review	+	+
Rayed Bean	<i>Villosa fabalis</i>	END	+	
Round Hickorynut	<i>Obovaria subrotunda</i>	END	+	
Round Pigtoe	<i>Pleurobema sintoxia</i>	END	+	+
Slippershell Mussel	<i>Alasmidonta viridis</i>	Candidate	+	
Snuffbox	<i>Epioblasma triquetra</i>	END	+	
Spike	<i>Elliptio dilatata</i>		+	+
Threeridge	<i>Amblema plicata plicata</i>		+	+
Threehorn Wartyback	<i>Obliquaria reflexa</i>	Candidate	+	
Wabash Pigtoe	<i>Fusconaia flava</i>	Candidate	+	+
Wavy-rayed Lampmussel	<i>Lampsilis fasciola</i>	END	+	
White Heelsplitter	<i>Lasmigona complanata complanata</i>		+	+

Source: Metcalfe-Smith et al., 2003

Janice Metcalfe-Smith has designed a monitoring program to track the endangered mussels of southwestern Ontario<sup>118</sup>. She has implemented this program in the Sydenham, with 15 monitoring sites distributed across the Sydenham watershed.

Following implementation of the monitoring program from 1999 to 2003, Janice Metcalfe-Smith said “the Rayed Bean and Northern Riffleshell appear to be ‘holding their own’ in the Sydenham River, whereas populations of the Kidneyshell, Snuffbox, and Round Pigtoe may be declining. The Wavy-rayed Lampmussel is believed to be extirpated from the system and the Round Hickorynut nearly so. There are too few data available on the Mudpuppy Mussel to determine its status.”

As long-lived, sediment dwelling filter feeders, mussels are a valuable indicator of water quality. They have been recommended for use as biomonitors for both heavy metals and organic industrial contaminants<sup>119 120</sup>. They have been used as biomonitors during implementation of Remedial Action Plans on the St. Clair River, Detroit River and Niagara River. They are threatened by silt, drought, toxic chemicals and heavy metals such as copper<sup>121</sup>. As their immature life stage as glochidia is particularly sensitive to water quality, they are used in the development of aquatic life guidelines and can provide an early warning system of contamination.

### Mussel Data Gaps

- Mussel species distribution in the St. Clair region outside of the Sydenham River is an information gap.

## 2.5.3 Aquatic (Benthic) Macroinvertebrates

Aquatic macroinvertebrates have been used effectively to evaluate the quality of water in rivers, streams and lakes. Benthic, or bottom-dwelling, macroinvertebrates live on or in the substrate of water bodies and include organisms such as mayflies, stoneflies, aquatic worms and snails. Benthic macroinvertebrates provide an excellent tool for water quality assessment because different species have different tolerances to pollution.

The presence of many pollution-intolerant species, such as caddisflies and mayflies, in a certain reach of a stream indicates good quality water with no major disturbances in recent years. If pollution-tolerant species such as aquatic worms and midge larvae dominate the substrate, the water quality is poor. This would indicate that chronic contamination, a spill or major habitat disturbance has removed the pollution-intolerant species.<sup>122</sup> Usually, additional sampling is needed to determine the cause of the water quality problem.

The SCRCA has been monitoring the benthic macroinvertebrate community beginning in 1999 when 20 sites were sampled. Since then, between 34 and 68 sites are sampled per year at locations distributed across the region. Samples are collected in spring or early summer and preserved for analysis over the winter. This program has been carried out in cooperation with the Biology Department of the University of Western Ontario. The Rapid Bioassessment protocol of the United States Environmental Protection

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<sup>118</sup> Metcalfe-Smith, J.L., D.J. McGoldrick and D.T. Zanatta. 2004. Implementation of a Monitoring Program to Track the Recovery of Endangered Freshwater Mussels in the Sydenham River, Ontario *in* Proceedings of the Species at Risk 2004 Pathways to Recovery Conference. March 2004, Victoria, BC.

<sup>119</sup> Metcalfe-Smith, J.L., R.H. Green and L.C. Grapentine. 1996. Influence of biological factors on concentrations of metals in the tissues of freshwater mussels (*Elliptio complanata* and *Lampsilis radiata radiata*) from the St. Lawrence River. *Can. J. Fish. Aquat. Sci.* 53:205-219.

<sup>120</sup> Comba, M.E., J.L. Metcalfe-Smith and K.L.E. Kaiser. 1996. Zebra mussels as biomonitors for organic contaminants in the lower Great Lakes. *Water Qual. Res. J. Canada* 31(2):411-430.

<sup>121</sup> Species at Risk Public Registry. [www.sararegistry.gc.ca/species/speciesDetails\\_e.cfm?sid=583](http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=583).

<sup>122</sup> Mackenzie, H. and M. Andreae. 2005. Benthic Macroinvertebrate Field Study 2004. St. Clair Region Conservation Authority report.

Agency<sup>123</sup>, as modified by Dr. Robert Bailey of the University of Western Ontario (Bailey pers. comm.), is used to assess the samples.

For environmental monitoring and reporting, the St. Clair region has been divided into 10 subwatershed areas. The Sydenham River, which represents almost 70% of the region, has been subdivided into seven areas. The Lake Huron, St. Clair River and Lake St. Clair watersheds are the other three areas. The sites of the current sampling program are indicated on **Map 23: Benthic Sampling Sites**. A small portion of the Lake Huron tributaries area in Lambton Shores became part of the St. Clair Region Conservation Authority in 2005. There were no sampling locations in this area. Also, there were no sampling locations on First Nation lands.

Since 2003, the SCRCA's program has been associated with the Ontario Benthic Biomonitoring Network (OBBN). This program was developed by Environment Canada and the Ontario Ministry of the Environment to provide a consistent benthic biomonitoring protocol<sup>124</sup>. The sampling protocol for this program is slightly different from the Rapid Bioassessment protocol. Samples have been collected at between eight and 10 of the sites using the OBBN protocol across the St. Clair region since 2003. In 2006, all samples were done using the OBBN protocol. The data has not yet been entered into the OBBN database.

On-line data analysis software is also being developed, so that site data can be entered into the OBBN database and analyzed with a large suite of benthic macroinvertebrate indices. In the future, use of the OBBN on-line data analysis should allow calculation of more benthic indices, so that our watersheds can be compared with regional reference sites and with abutting watersheds.

Results for the SCRCA benthic monitoring program from 1999 to 2005 have been summarized in annual reports.<sup>122 125 126 127 128</sup> The most recent analysis used four indices of water quality including:

- Hilsenhoff's Family Biotic Index (FBI),
- Simpson's Diversity Index,
- Ephemeroptera, Plecoptera, Trichoptera Index, and
- Percent Model Affinity Index.

For comparison purposes with the neighbouring Thames watershed, the Hilsenhoff's Family Biotic Index (FBI) values will be considered in this report. The Index is a calculated value based on the organisms found in a study site. Hilsenhoff examined 53 Wisconsin streams and their pollution levels in order to assign a numeric value to specific macroinvertebrate families, as indicators of pollution.<sup>129 130</sup> An average FBI value is calculated from the 200 organisms randomly selected from the sample to give a biotic index for that site.

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<sup>123</sup> Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, 2<sup>nd</sup> edition, EPA 841-B-99-002. U.S. EPA, Washington, D.C.

<sup>124</sup> Jones, C., K.M. Somers, B. Craig and T. Reynoldson, 2004. Ontario Benthos Biomonitoring Network Protocol Manual, Version 1. Ontario Ministry of the Environment.

<sup>125</sup> Wilson, R. 2001. Benthic Macroinvertebrate Field Study 1999 and 2000. St. Clair Region Conservation Authority report.

<sup>126</sup> Dietrich, L. 2002. Benthic Macroinvertebrate Field Study 2001. St. Clair Region Conservation Authority report.

<sup>127</sup> MacKenzie, H. and M. Andreae. 2003. Benthic Macroinvertebrate Field Study 2002. St. Clair Region Conservation Authority report.

<sup>128</sup> Mackenzie, H. and M. Andreae. 2004. Benthic Macroinvertebrate Field Study 2003. St. Clair Region Conservation Authority report.

<sup>129</sup> Hilsenhoff, W.L. 1987. An Improved Biotic Index of Organic Stream Pollution. The Great Lakes Entomologist 10(1): 31-39.

<sup>130</sup> Hilsenhoff, W.L. 1988. Rapid Field Assessment of Organic Pollution with a Family Level Biotic Index. Journal of North American Benthological Society 7:65-68.

The FBI has four water quality categories:

< 5.00	Good
5.01 – 5.75	Fair
5.76-6.50	Fairly Poor
> 6.51	Poor

The number of sites sampled each year has varied due to available staff time, budget and weather. The number of sites sampled and analyzed are as follows: 1999 - 20, 2000 - 54, 2001 - 41, 2002 - 68, 2003 - 38, 2004 - 34, and 2005 - 38. SCRCA sampled 30 sites in 2006, with analyses to follow in the winter of 2006/2007. There are five or more years of data for 18 sites. These sites are representative of all 10 subwatershed areas within the SCRCA watershed boundary. These data sets are summarized in **Table 2.5.3-1: Benthic Macroinvertebrate Index Values.**

**Table 2.5.3-1: Benthic Macroinvertebrate Index Values for sites in the St. Clair Region, 1999 to 2004**

Subwatershed	Site Code	Watercourse Name	Hilsenhoff's Family Biotic Index (FBI)						Totals
			1999	2000	2001	2002	2003	2004	
Upper East Sydenham	uesa01	Buttery Creek	-	6.15	5.54	5.87	-	-	
Upper East Sydenham	uesa02	McDonald Drain	-	6.24	-	-	-	-	
Upper East Sydenham	uesb05	Gold Creek	4.74	5.78	4.99	4.72	4.71	4.62	
Upper East Sydenham	uesb09	Sydenham River	4.49	5.89	4.79	6.94	5.53	5.38	
Upper East Sydenham	uesb10	Sydenham River	4.92	-	-	-	-	-	
Upper East Sydenham	uesc01	Trout Creek	-	6.24	5.46	5.82	-	-	
Upper East Sydenham	uesc02	Spring Creek	-	6.76	5.03	6.27	-	-	
Upper East Sydenham	uesca1	Humphrey Drain	-	-	-	-	-	6.39	
Upper East Sydenham	uesf02	O'Neil Drain	-	7.43	-	7.83	-	-	
Upper East Sydenham	ueslo2	Sydenham River	5.93	6.77	5.64	6.46	5.81	6.31	
Upper East Sydenham	uesmo2	Bear Creek Drain	-	6.56	5.52	5.66	-	-	
<b>AVERAGE</b>			5.02	6.42	5.28	6.20	5.35	5.68	5.81
<b>Sample Sizes</b>			4	9	7	8	3	4	35

Brown Creek	brca5hsp	Hair Creek	-	-	-	7.1	-	-	
Brown Creek	brca02	Hardy Creek	-	-	-	6.53	-	-	
Brown Creek	brcbr1	Brown Creek	-	-	-	-	-	6.14	
Brown Creek	brcf01	Hardy Creek	-	7.43	-	6.48	-	-	
Brown Creek	brcl09	Brown Creek	5.68	5.27	4.84	7.4	3.88	5.64	
Brown Creek	brcw05	Brown Creek	-	-	-	5.51	4.66	5.66	
<b>AVERAGE</b>			5.68	6.35	4.84	6.60	4.27	5.81	5.87
<b>Sample Sizes</b>			1	2	1	5	2	3	14

Subwatershed	Site Code	Watercourse Name	Hilsenhoff's Family Biotic Index (FBI)						Totals
			1999	2000	2001	2002	2003	2004	

Middle East Sydenham	mesa01	Morrow Drain	-	-	-	6.87	-	-	
Middle East Sydenham	mesa04	Fansher Creek	-	-	-	7.17	-	-	
Middle East Sydenham	mesa05	Sydenham River	-	-	-	6.71	7.37	6.49	
Middle East Sydenham	mesb02	Pray Drain	-	5.43	4.65	7.02	-	-	
Middle East Sydenham	mese01	Morrogh Creek	-	7.02	-	-	-	-	
Middle East Sydenham	mese02	Unknown	-	6.04	5.95	3.15	3.99	5.51	
Middle East Sydenham	mesj03	Fansher Creek	5.98	6.57	4.78	5.4	6.01	-	
Middle East Sydenham	mesl10	Sydenham River	5.07	6.16	4.31	6.67	-	-	
Middle East Sydenham	mesm01	Sydenham River	5.14	-	-	-	-	5.00	
Middle East Sydenham	meso03	Haggerty Creek	-	6.69	6.10	7.41	-	-	
Middle East Sydenham	meso04	Haggerty Creek	-	5.77	-	-	-	-	
Middle East Sydenham	meso06	Sydenham Tributary	5.31	6.27	5.91	6.04	-	-	
Middle East Sydenham	mesu03	Annett Drain	-	6.41	7.59	-	-	-	
<b>AVERAGE</b>			5.38	6.26	5.61	6.27	5.79	5.67	5.94
<b>Sample Sizes</b>			4	9	7	9	3	3	35

Lower East Sydenham	lesa01	Drummond Creek Drain	-	-	-	7.47	-	-	
Lower East Sydenham	lesd01	Long Creek	-	6.33	5.79	7.98	-	-	
Lower East Sydenham	lesd02	Molly's Creek	-	7.89	-	7.16	-	-	
Lower East Sydenham	lesh02	Sydenham River	5.20	-	4.43	6.32	6.41	5.12	
Lower East Sydenham	lesn01	Little Bear Creek	-	6.18	5.32	6.10	3.68	6.36	
Lower East Sydenham	lesn02	Long Creek	-	-	-	6.34	6.02	6.19	
Lower East Sydenham	lesz03	Crowell Creek	-	7.50	-	6.10	-	-	
Lower East Sydenham	lesz05	Donkey Creek Drain	-	7.57	-	5.46	-	-	
<b>AVERAGE</b>			5.20	7.09	5.18	6.62	5.37	5.89	6.21
<b>Sample Sizes</b>			1	5	3	8	3	3	23

Lower North Sydenham	Insa01	Annett Drain	-	-	-	6.79	5.99	6.95	
Lower North Sydenham	Insa02	Heyland Drain	-	-	-	7.69	7.38	7.50	
Lower North Sydenham	Insc09	Otter Creek	-	-	5.81	6.06	6.98	-	
Lower North Sydenham	Inss07	West Otter Creek Drain	-	7.90	-	6.76	6.26	6.93	
Lower North Sydenham	Inss08	East Otter Creek Drain	-	7.48	-	6.5	-	-	
<b>AVERAGE</b>			-	7.69	5.81	6.76	6.65	7.13	6.87
<b>Sample Sizes</b>			0	2	1	5	4	3	15

Subwatershed	Site Code	Watercourse Name	Hilsenhoff's Family Biotic Index (FBI)						Totals
			1999	2000	2001	2002	2003	2004	
Black Creek	blca01	Black Creek Tributary	-	-	-	6.1	5.54	4.47	
Black Creek	blca02	Curry Creek Drain	-	-	-	6.45	-	-	
Black Creek	blca03	Plum Creek	-	-	-	6.34	-	-	
Black Creek	blca04	Black Creek	-	-	-	-	6.54	-	
Black Creek	blcd03	Crooked Creek	-	-	-	5.85	-	-	
Black Creek	blce03	Black Creek	-	6.27	6.08	5.53	7.26	6.73	
Black Creek	blce04	Fox Creek	-	6.74	7.51	6.35	-	-	
Black Creek	blcs04	Booth Creek	-	5.18	5.00	5.89	5.89	-	
<b>AVERAGE</b>			-	6.06	6.20	6.07	6.31	5.60	6.09
<b>Sample Sizes</b>			0	3	3	7	4	2	19

Bear Creek	becd17	Bear Creek	5.82	6.80	4.74	5.19	6.75	-	
Bear Creek	becd21	Bear Creek	5.48	-	-	-	-	-	
Bear Creek	bece06	Stonehouse Drain	-	6.73	5.50	6.60	6.94	5.88	
Bear Creek	bece07	Durham Creek	-	-	-	6.35	6.89	6.77	
Bear Creek	bece08	Bear Creek Tributary	-	-	-	6.86	-	-	
Bear Creek	becen1	Bear Creek	-	-	-	-	-	6.42	
Bear Creek	beck31	Bear Creek	5.96	6.28	5.30	5.93	6.24	-	
Bear Creek	beck40	Bear Creek	6.15	-	-	-	-	-	
Bear Creek	becm04	Burton Creek	-	5.23	5.41	-	-	-	
Bear Creek	becm05	Nickel Creek	-	7.90	-	6.11	5.51	7.72	
Bear Creek	becw01	Bear Creek	-	6.67	5.76	6.15	5.86	-	
Bear Creek	becw02	Auld Redmond Drain	-	7.36	-	-	-	-	
Bear Creek	becw03	Gilliand-Gerts Drain	-	6.52	5.54	6.15	-	-	
Bear Creek	becw04	Unknown	-	7.36	-	-	-	-	
<b>AVERAGE</b>			5.85	6.76	5.38	6.17	6.37	6.70	6.24
<b>Sample Sizes</b>			4	9	6	8	6	4	37

Lake Huron Tributaries	lhtp01	Cow Creek	-	5.63	6.06	6.27	4.29	6.16	
Lake Huron Tributaries	lhtp03	Aberarder Creek	-	7.30	-	7.53	-	-	
Lake Huron Tributaries	lhtp04	Highland Creek	-	7.05	6.20	6.60	-	-	
Lake Huron Tributaries	lhtp05	McDonald Gillatly Drain	-	7.40	-	7.15	-	-	
Lake Huron Tributaries	lhtp15	Highland Creek	5.87	6.86	6.12	7.14	6.34	6.08	
Lake Huron Tributaries	lhtp16	Aberarder Creek	5.89	-	-	-	-	-	
Lake Huron Tributaries	lhtp1	Bonnie Doon Creek	-	-	-	-	-	6.06	
Lake Huron Tributaries	lhts01	Ferguson Drain	-	7.46	-	-	-	-	
Lake Huron Tributaries	lhts02	Perch Creek	-	6.62	6.42	6.67	5.77	6.39	
Lake Huron Tributaries	lhts03	Porter Creek Drain	-	-	-	-	-	-	
Lake Huron Tributaries	lhzt01	Hickory Creek	6.01	-	5.26	6.17	5.47	6.17	
<b>AVERAGE</b>			5.92	6.90	6.01	6.79	5.47	6.17	6.34
<b>Sample Sizes</b>			3	7	5	7	4	5	31

Subwatershed	Site Code	Watercourse Name	Hilsenhoff's Family Biotic Index (FBI)						Totals
			1999	2000	2001	2002	2003	2004	
St. Clair River Tributaries	scra01	Clay Creek	-	-	-	7.47	5.76	7.47	
St. Clair River Tributaries	scra02	Grape Run Drain	-	-	-	6.49	7.49	7.51	
St. Clair River Tributaries	scra03	Clay Creek	-	-	-	-	6.27	7.34	
St. Clair River Tributaries	scra04	Talford Creek	5.59	-	-	-	6.87	7.21	
St. Clair River Tributaries	scrm03	Gray Drain	-	7.28	-	-			
St. Clair River Tributaries	scrm07	Baby Creek	-	6.28	4.96	6.63	6.29	-	
St. Clair River Tributaries	scrm08	Talford Creek	-	-	-	6.9	6.24	6.06	
St. Clair River Tributaries	scrs06	Marshy Creek	-	7.96	-	-	-	-	
<b>AVERAGE</b>			5.59	7.17	4.96	6.87	6.49	7.12	6.70
<b>Sample Sizes</b>			1	3	1	4	6	5	20

Lake St. Clair Tributaries	Isca01	Big Creek Drain	-	-	-	7.54	-	-	
Lake St. Clair Tributaries	Iscc03	Danforth Creek Drain	-	5.98	-	6.67	-	-	
Lake St. Clair Tributaries	Iscc05	Maxwell Creek	-	5.80	5.07	6.8	6.67	7.69	
Lake St. Clair Tributaries	Iscc04	Rankin Creek	-	6.30	7.71	7.51	6.92	6.48	
Lake St. Clair Tributaries	Iscc27	Big Creek	6.55	-	7.59	6.29	-	-	
Lake St. Clair Tributaries	Iscc30	Little Bear Creek	5.38	-	5.00	6.61	6.90	-	
<b>AVERAGE</b>			5.97	6.03	6.34	6.90	6.83	7.09	6.57
<b>Sample Sizes</b>			2	3	4	6	3	2	20

With six years of sampling, it is now possible to combine data sets and obtain a sample size, of between 14 and 37 samples per watershed area. It must be recognized that variations in the weather and stream flow impacted site selection over this time period. Thus, there is a bias toward sites with a consistent flow.

Based on the six years of benthic monitoring, all of the watershed areas have 'Poor' to 'Fairly Poor' aquatic health. These results are presented figuratively on **Map 24: Benthic Sampling Analysis Results by Subwatershed**.

This broad overview of the data indicates that the Upper East Sydenham has the best quality of aquatic habitat, based on achieving the lowest average FBI of 5.81 (**Table 2.5.3-1**) which still places it in the 'Fairly Poor' category. In increasing order of impact, Brown Creek, Middle East Sydenham, Black Creek, Lower East Sydenham, Bear Creek and the Lake Huron Tributaries are in the same category of 'Fairly Poor'. The most impacted watershed areas are the Lake St. Clair Tributaries, St. Clair River Tributaries and Lower North Sydenham, in the 'Poor' category. It is also of note that the majority of the 'Good' sites were found in the East Sydenham watersheds.

In order to analyze results for each calendar year, the annual reports have averaged the results for each watershed area. These averages and categories are summarized in **Table 2.5.3-2: Summary of Family Biotic Index (FBI) Values for the years 2000 to 2004**.

Table 2.5.3-2:

## Summary of Family Biotic Index (FBI) Values for the St. Clair Region

Subwatershed	FBI	Years				
		2000	2001	2002	2003	2004
Upper East Sydenham	Average	6.42	5.28	6.20	5.35	5.68
	Category	Fairly Poor	Fair	Fairly Poor	Fair	Fair
	Sample Size	9	7	8	3	4
Brown Creek	Average	6.35	4.84	6.60	4.27	5.81
	Category	Fairly Poor	Good	Poor	Good	Fairly Poor
	Sample Size	2	1	5	2	3
Middle East Sydenham	Average	6.26	5.61	6.27	5.79	5.67
	Category	Fairly Poor	Fairly Poor	Fairly Poor	Fairly Poor	Fair
	Sample Size	10	8	10	3	3
Lower East Sydenham	Average	7.09	5.18	6.62	5.37	5.89
	Category	Poor	Fair	Poor	Fair	Fairly Poor
	Sample Size	5	3	8	3	3
Lower North Sydenham	Average	7.69	5.81	6.76	6.65	7.13
	Category	Poor	Fairly Poor	Poor	Poor	Poor
	Sample Size	2	1	5	4	3
Black Creek	Average	6.06	6.20	6.07	6.31	5.60
	Category	Fairly Poor	Fairly Poor	Fairly Poor	Fairly Poor	Fair
	Sample Size	3	3	7	4	2
Bear Creek	Average	6.76	5.38	6.17	6.37	6.70
	Category	Poor	Fair	Fairly Poor	Fairly Poor	Poor
	Sample Size	9	6	8	6	4
Lake Huron Tributaries	Average	6.90	6.01	6.79	5.47	6.17
	Category	Poor	Fairly Poor	Poor	Fair	Fairly Poor
	Sample Size	7	5	7	4	5
St. Clair River Tributaries	Average	7.17	4.69	6.87	6.49	7.12
	Category	Poor	Good	Poor	Fairly Poor	Poor
	Sample Size	3	1	4	6	5
Lake St. Clair Tributaries	Average	6.03	6.34	6.90	6.83	7.09
	Category	Fairly Poor	Fairly Poor	Poor	Poor	Poor
	Sample Size	3	4	6	3	2

Other research papers on the benthic organisms in the region include work by Ian Harris<sup>131</sup> and a thesis by Simon Geoghegan. Ian Harris carried out a five year study to examine major variables and correlate the invertebrate communities and habitat characteristics of the North Sydenham River. He also compared them to the tributary systems of the St. Clair River. He found higher values of density (number of

<sup>131</sup> Harris, I.W. E., C.F. Drury, R.R. Simard and T.Q. Zhang. 2003. Density and richness of benthic invertebrate populations in the North Sydenham River of Southwestern Ontario (1996-2000) compared with those of the St. Clair River (1990-1995). Canadian Field-Naturalist 117(2):267-277.

invertebrates/sq m) and richness (number of invertebrate families/sample site) in the downstream reach of the North Sydenham River compared to the tributary systems of the St. Clair River.

Simon Geoghegan completed a thesis on the effects of natural oil seepage on the benthic ecosystem in a 3.5 km reach of Bear Creek upstream of the “Petrolia Discovery” site in Petrolia.<sup>132</sup> Geoghegan found the benthic macroinvertebrate abundance and the invertebrate community diversity was reduced at the oil seep sites.

Biomonitoring of the St. Clair River itself has occurred since at least 1957<sup>133</sup>, when contaminants were identified in the river sediments. The St. Clair River Area of Concern was identified in 1987, and the development of a Remedial Action Plan (RAP) was initiated. Degradation of the benthos in the St. Clair River was identified as a major environmental issue.

The Sarnia-Lambton Industrial Society (now the Sarnia Lambton Environmental Association) contracted Pollutech EnviroQuatics in 1999 to develop reference conditions for benthic communities in the St. Clair River. They were to use these reference areas to complete a detailed study comparing the communities in the reference areas with those in the areas that had contaminated sediment. This RAP program is continuing. (Scott Munro 2005 pers. comm.) However, the sampling methods and the benthic communities in this Great Lakes connecting channel are not readily compared to those of the smaller interior watercourses in the St. Clair region.

The St. Clair RAP area includes several small watercourses that are tributaries to the St. Clair River between Sarnia and Chatham-Kent. These watercourses have been examined as part of the St. Clair RAP program. Danuta Zaranko<sup>134</sup> processed samples collected in 1998 on many of the St. Clair River tributaries using the BioMAP protocol<sup>135</sup>. She concluded that the water quality was impaired at all sites evaluated on Clay Creek, Baby Creek, Talfourd Creek, Bowens Creek and Grape Run. The upstream sites on Baby and Clay Creeks were the least impaired sites.

The SCRCA has completed benthic macroinvertebrate field sampling for the St. Clair River tributaries as part of the RAP program since 2001. The benthic samples have been taken using the Rapid Bioassessment protocol, and the results analyzed with the FBI and Simpson’s Diversity Index<sup>126 127 128</sup>. The average FBI of the St. Clair tributaries has not improved over this time period, with readings averaging ‘Poor.’

### **Aquatic Macroinvertebrate Information Gaps**

- There is no information on macroinvertebrates for the Lambton Shores portion of the Lake Huron tributaries watershed area.
- It is not known whether the distribution and diversity of the identified benthic specimens correlate with groundwater discharge.
- Identification has been done at a family species level and it has not been possible to analyze the specific species found here for their pollution tolerance, functional feeding group, or preferred thermal regime.

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<sup>132</sup> Geoghegan, S.A. 2001. The effects of natural oil seepage on the structure and function of a freshwater benthic ecosystem in Southwestern Ontario. M.Sc. thesis in Zoology (Environmental Science), University of Western Ontario, London, Ontario. 39pp.+

<sup>133</sup> Sarnia-Lambton Environmental Association. <http://lis.sarnia.com/pdf%20files/Water2Biomonitoring.pdf> (retrieved November 6, 2005).

<sup>134</sup> Zaranko Environmental Assessment Services. 1998. Benthic Macroinvertebrate Survey of Selected Tributaries of the St. Clair River, Detroit River and Wheatley Harbour. Report for Friends of the St. Clair River and Ministry of the Environment. 31pp.+appendices.

<sup>135</sup> Griffiths, R.W. 1993. BioMAP: Concepts, protocols and procedures for the southwestern region of Ontario. Ontario Ministry of Environment and Energy, London. 28 pp.

## 2.5.4 Species at Risk

Within the St. Clair region, the Sydenham River watershed has received the most intensive examination for Species at Risk (SAR). 45 aquatic species of mussels, fish and reptiles have been designated by the federal COSEWIC as Endangered, Threatened or of Special Concern or are candidate species for assessment.

Species at Risk classifications are defined as follows:

- Endangered - A species facing imminent extirpation or extinction.
- Threatened - A species that is likely to become endangered if limiting factors are not reversed.
- Special Concern - A species whose characteristics make it particularly sensitive to human activities or natural events.

A summary is provided in **Table 2.5.4-1: Species at Risk and provincially rare aquatic based species within the Sydenham River Subwatershed**. This table also includes information on the provincial ranking for species together with the Global and Regional ranking by The Nature Conservancy of Arlington, Virginia, U.S.A. **Table 2.5.4-2** (St. Clair River), **Table 2.5.4-3** (Lake St. Clair) and **Table 2.5.4-4** (Lake Huron) provide information for the other subwatersheds in the St. Clair Region Conservation Authority watershed.

The provincial ranking categories of Endangered, Threatened, Special Concern and Not at Risk, are derived from the federal standards but refer solely to the species' status within Ontario. Fifty-four provincially rare species live in or use the Sydenham River for all or part of their life cycle (S1, S2 or S3 ranking on **Table 2.5.4.1**).

- S1 is extremely rare in Ontario; usually 5 or fewer occurrences or very few individuals.
- S2 is very rare in Ontario; usually between 5 and 20 occurrences or with many individuals in fewer occurrences.
- S3 is rare to uncommon in Ontario; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations.

The table includes freshwater mussels, fish, reptiles, dragonflies and damselflies. Neither MNR nor Environment Canada has status ranking for these insects as yet. However, Odonate species (dragonflies and damselflies) are tracked by the Natural Heritage Information Centre and The Nature Conservancy.

**Table 2.5.4-1: Species at Risk and provincially rare aquatic based species within the Sydenham River Subwatershed**

	Common Name	Scientific Name	COSEWIC Status	MNR Status	G RANK	S RANK
Unionids	Black Sandshell	<i>Ligumia recta</i>	Candidate		G5	S3
	Deertoe	<i>Truncilla truncata</i>	Candidate		G5	S3
	Elktoe	<i>Alasmidonta marginata</i>	Candidate		G4	S3
	Fawnsfoot	<i>Truncilla donaciformis</i>	Candidate		G5	S2
	Kidneyshell	<i>Ptychobranhus fasciolaris</i>	END	END	G4G5	S1
	Lilliput	<i>Toxolasma parvus</i>	Candidate		G5	S1
	Mapleleaf	<i>Quadrula quadrula</i>	THR		G5	S2
	Mucket	<i>Actinonaias ligamentina</i>	Candidate		G5	S3
	Mudpuppy Mussel*	<i>Simpsonaias ambigua</i>	END	END	G3	S1
	Northern Riffleshell*	<i>Epioblasma torulosa rangiana</i>	END	END	G2T2	S1
	Paper Pondshell	<i>Utterbackia imbecillis</i>	Candidate		G5	S2

	Common Name	Scientific Name	COSEWIC Status	MNR Status	G RANK	S RANK
	Pimpleback	<i>Quadrula pustulosa pustulosa</i>	Candidate		G5	S3
	Pink Heelsplitter	<i>Potamilus alatus</i>	Candidate		G5	S3
	Purple Wartyback	<i>Cyclonaias tuberculata</i>	Candidate		G5	S3
	Rainbow	<i>Villosa iris</i>	END		G5	S2S3
	Rayed Bean*	<i>Villosa fabalis</i>	END	END	G1G2	S1
	Round Hickorynut	<i>Obovaria subrotunda</i>	END	END	G4	S1
	Round Pigtoe	<i>Pleurobema sintoxia</i>	END		G4	S1
	Slippershell Mussel	<i>Alasmidonta viridis</i>	Candidate		G4G5	S3
	Snuffbox*	<i>Epioblasma triquerta</i>	END	END	G3	S1
	Threehorn Wartyback	<i>Obliquaria reflexa</i>	Candidate		G5	S1
	Wabash Pigtoe	<i>Fusconaia flava</i>	Candidate		G5	S2S3
	Wavy-rayed Lampmussel*	<i>Lampsilis fasciola</i>	END	END	G4	S1

Fish	Bigmouth Buffalo	<i>Ictiobus cyprinellus</i>	SC	SC	G5	SU
	Blackstripe Topminnow	<i>Fundulus notatus</i>	SC	SC	G5	S2
	Brassy Minnow	<i>Hybognathus hankinsoni</i>	Candidate		G5	S5
	Brindled Madtom	<i>Noturus miurus</i>	NAR	NAR	G5	S2
	Eastern Sand Darter*	<i>Ammocrypta pellucida</i>	THR	THR	G3	S2
	Ghost Shiner	<i>Notropis buchmanii</i>	NAR	NAR	G5	S2
	Grass Pickerel	<i>Esox americanus vermiculatus</i>	SC		G5	S3
	Greater Redhorse	<i>Moxostoma valenciennesi</i>	Candidate		G4	S3
	Greenside Darter	<i>Etheostoma blennioides</i>	SC	SC	G5	S4
	Mottled Sculpin	<i>Cottus bairdi</i>	Candidate		G5	S5
	Northern Madtom*	<i>Noturus stigmosus</i>	END	END	G3	S1S2
	Pugnose Minnow	<i>Opsopoeodus emiliae</i>	SC	SC	G5	S2
	Spotted Gar*	<i>Lepisosteus oculatus</i>	THR	THR	G5	S2
	Spotted Sucker	<i>Minytrema melanops</i>	SC	SC	G5	S2
	Stonecat	<i>Noturus flavus</i>	Candidate		G5	S4
	White Perch	<i>Morone americana</i>	Candidate		G5	SE
Yellow Bullhead	<i>Ameiurus natalis</i>	Candidate		G5	S4	

Reptiles	Butler's Garter Snake	<i>Thamnophis butleri</i>	THR	THR	G4	S2
	Eastern Fox Snake	<i>Elaphe gloydi</i>	THR	THR	G3	S3
	Eastern Hognosed Snake	<i>Heterodon platirhinos</i>	THR	THR	G5	S3
	Eastern Massasauga Rattlesnake	<i>Sistrurus catenatus</i>	THR	THR	G3G4	S3
	Eastern Milksnake	<i>Lampropeltis triangulum</i>	SC	SC	G5	S3
	Northern Map Turtle	<i>Graptemys geographica</i>	SC	SC	G5	S3
	Spiny Softshell Turtle*	<i>Apalone spinifera</i>	THR	THR	G5	S3

	Common Name	Scientific Name	COSEWIC Status	MNR Status	G RANK	S RANK
Odonata	Arrow Clubtail	<i>Stylurus spiniceps</i>			G5	S1S2
	Blue-ringed Dancer	<i>Argia sedula</i>			G5	S2
	Blue-tipped Dancer	<i>Argia tibialis</i>			G5	S3
	Double-striped Bluet	<i>Enallagma basidens</i>			G5	S3
	Dusky Dancer	<i>Argia translata</i>			G5	S2
	Eastern Amberwing	<i>Perithemis tenera</i>			G5	S3
	Flag-tailed Spinyleg	<i>Dromogomphus spoliatus</i>			G4G5	S1
	Midland Clubtail	<i>Gomphus fraternus</i>			G5	S3
	Mocha Emerald	<i>Somatochlora linearis</i>			G5	S1
	Pronghorn Clubtail	<i>Gomphus graslinellus</i>			G5	S2
	Royal River Cruiser	<i>Macromia taeniolata</i>			G5	S1
	Rusty Snaketail	<i>Ophiogomphus rupinsulensis</i>			G5	S3
	Smoky Rubyspot	<i>Hetaerina titia</i>			G5	S2
	Swamp Darner	<i>Epiaeschna heros</i>			G5	S2S3

\* Assessed by the Recovery Team as having a high conservation priority (see Dextrase *et al.* 2003)

**Table 2.5.4-2: Species at Risk and provincially rare aquatic based species within the St. Clair River Subwatershed**

	Common Name	Scientific Name	COSEWIC Status	MNR Status	G RANK	S RANK
Fish	Blackstripe Topminnow	<i>Fundulus notatus</i>	SC	SC	G5	S2
	Grass Pickerel	<i>Esox americanus vermiculatus</i>	SC		G5	S3
	Pugnose Minnow	<i>Opsopoeodus emiliae</i>	SC	SC	G5	S2
	Pugnose Shiner	<i>Notropis anogenus</i>	END	END	G3	S2
	Spotted Sucker	<i>Minytrema melanops</i>	SC	SC	G5	S2

Reptiles	Butler's Garter Snake	<i>Thamnophis butleri</i>	THR	THR	G4	S2
	Eastern Fox Snake	<i>Elaphe gloydi</i>	THR	THR	G3	S3
	Eastern Hognosed Snake	<i>Heterodon platirhinos</i>	THR	THR	G5	S3
	Eastern Milksnake	<i>Lampropeltis triangulum</i>	SC	SC	G5	S3
	Spiny Softshell Turtle*	<i>Apalone spinifera</i>	THR	THR	G5	S3

Odonata	Elusive Clubtail*	<i>Stylurus notatus</i>			G3	S2
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\* Historical record only 1935-08-14, St. Clair River, *pers. comm.* Colin Jones June 30, 2006

**Table 2.5.4-3: Species at Risk and provincially rare aquatic based species within the Lake St. Clair Subwatershed**

	Common Name	Scientific Name	COSEWIC Status	MNR Status	G RANK	S RANK
Fish	Grass Pickerel	<i>Esox americanus vermiculatus</i>	SC		G5	S3
	Pugnose Shiner	<i>Notropis anogenus</i>	END	END	G3	S2
Reptiles	Butler's Garter Snake	<i>Thamnophis butleri</i>	THR	THR	G4	S2
	Eastern Fox Snake	<i>Elaphe gloydi</i>	THR	THR	G3	S3
	Northern Map Turtle	<i>Graptemys geographica</i>	SC	SC	G5	S3
	Queen Snake	<i>Regina septemvittata</i>	THR	THR	G5	S2
	Spotted Turtle	<i>Clemmys guttata</i>	END	SC	G5	S3
Odonata	Ashy Clubtail*	<i>Gomphus lividus</i>			G5	S4
	Painted Skimmer**	<i>Libellula semifasciata</i>			G5	S2

\*Historical record only on Walpole Island, *pers. comm.* Colin Jones June 30, 2006

\*\*Historical record only (pre-1941) from Mitchell's Bay, Lake St. Clair, *pers. comm.* Colin Jones June 30, 2006

**Table 2.5.4-4: Species at Risk and provincially rare aquatic based species within the Lake Huron Subwatershed**

	Common Name	Scientific Name	COSEWIC Status	MNR Status	G RANK	S RANK
Reptiles	Butler's Garter Snake	<i>Thamnophis butleri</i>	THR	THR	G4	S2
	Eastern Fox Snake	<i>Elaphe gloydi</i>	THR	THR	G3	S3
	Eastern Hognosed Snake	<i>Heterodon platirhinos</i>	THR	THR	G5	S3
	Eastern Milksnake	<i>Lampropeltis triangulum</i>	SC	SC	G5	S3
	Northern Map Turtle	<i>Graptemys geographica</i>	SC	SC	G5	S3
	Spotted Turtle	<i>Clemmys guttata</i>	END	SC	G5	S3

Information obtained from NHIC website [http://nhic.mnr.gov.on.ca/nhic\\_.cfm](http://nhic.mnr.gov.on.ca/nhic_.cfm)

### ***Mussels***

The Sydenham River is globally and nationally significant for its population of rare freshwater mussels. Four of the mussels are designated as globally rare by The Nature Conservancy from Arlington, Virginia. The Mudpuppy Mussel and Snuffbox are rare to uncommon (G3); the Northern riffleshell subspecies is very rare (G2T2); and the Rayed Bean is very rare to extremely rare (G1G2). Nine of the mussels that are found in the Sydenham have been designated by COSEWIC as Endangered and one has been designated as Threatened. An additional 13 mussel species are candidates for review by COSEWIC for nationally rare status. In total, 23 species or 68% of the mussel species known from the Sydenham River are in need of conservation action.

The Wavy-rayed Lampmussel may actually be extirpated from the Sydenham since in recent years it has been identified only from fresh shells found in a 5 km reach of the river.<sup>136</sup>

The Sydenham population of the globally-rare Mudpuppy Mussel is believed to be the only remaining population in Canada (Ibid.).

The only significant Canadian population of the globally-rare Rayed Bean appears to be in one 45 km reach of the Sydenham, where it appears to be successfully reproducing (Ibid.).

The Canadian distribution of the globally-rare Northern Riffleshell is limited mainly to a 50 km reach of the Sydenham. This is estimated to be 25% of the global population of the Northern Riffleshell (Ibid.).

The Sydenham population of the globally-rare Snuffbox is believed to be one of two remaining populations in Canada (Ibid.).

As the Sydenham River is nationally significant for its mussel populations, it is clear that the mussel populations are the most endangered group of organisms in the Sydenham.

Some species of freshwater mussels including the Mapleleaf (Threatened) have been found in Clay Creek which is a St. Clair River tributary, but it has not been surveyed in detail.

### ***Fish***

Eight fish species are identified as Species at Risk including Northern Madtom (Endangered), Eastern Sand Darter and Spotted Gar (Threatened), and Bigmouth Buffalo, Blackstripe Topminnow, Grass Pickerel, Greenside Darter and Pugnose Minnow (Special Concern). Ten fish species from the Sydenham are considered provincially rare (S1, S2 or S3 ranking on **Table 2.5.4.1**).

The Eastern Sand Darter has persisted in the Sydenham, but its range has decreased (Ibid.).

The Sydenham was reported to be the only river in Canada for the Blackstripe Topminnow, as of 2001 (Ibid.) and its distribution has expanded up the East Sydenham River since the 1980s.<sup>137</sup> In 2003, it was also found in a tributary of the St. Clair River. (Staton 2004 pers. com.)

Spotted Gar is known from the Sydenham only from two specimens obtained in 1975, and the identification of both specimens has been questioned.

Northern Madtom has been identified only once in the Sydenham, in 1975.

Only nine individuals of the Spotted Sucker have been found in the Sydenham, so it may be a year-round resident or may only spawn in the Sydenham.

The Pugnose Minnow is still found in the Sydenham, but its population is difficult to estimate.

Bigmouth Buffalo and Greenside Darter are thriving in the Sydenham and elsewhere.

Much of the SAR fish study work has focused on the Sydenham River but other areas in the region have also been identified as having SAR.

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<sup>136</sup> Dextrase, A.J., S.K. Staton, and J.L. Metcalfe-Smith. 2003. National Recovery Strategy for Species at Risk in the Sydenham River: An Ecosystem Approach. National Recovery Plan No. 25. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, Ontario. 73 pp.

<sup>137</sup> McAllister, D.E. 1987. Status of the Blackstripe Topminnow, *Fundulus notatus*, in Canada. Canadian Field-Naturalist 101(2):219-225.

Four Species at Risk were recently found in Whitebread Drain which is a tributary of the lower St. Clair River. These species included Spotted Sucker (Special Concern), Pugnose Shiner (Endangered), Pugnose Minnow (Special Concern) and Blackstripe Topminnow (Special Concern) (Staton 2004 pers.com.).

Little Bear Creek in Dover Township has Pugnose Shiner (Endangered).

Grass Pickerel (Special Concern) was found in both Whitebread Drain and Little Bear Creek.

### ***Reptiles***

Nine reptiles from the St. Clair region are provincially rare and are identified by COSEWIC as Species At Risk. The Spotted Turtle is Endangered. The Butler's Garter Snake, Eastern Fox Snake, Eastern Hognosed Snake, Spiny Softshell Turtle, Eastern Massasauga Rattlesnake, and Queen Snake are Threatened. The Eastern Milksnake and Northern Map Turtle are Special Concern.

Recent surveys for the Spiny Softshell Turtle have included incidental sightings of Map Turtles. Fletcher and Gillingwater observed 87 softshell individuals in 1994<sup>138</sup> during a canoe survey from Napier to Croton. SCRCA staff observed 45 softshell individuals in 2005 during a canoe survey from Napier to Florence<sup>139</sup>. In 2006, the richest reaches of the Sydenham were surveyed twice, and the best results were 34 Spiny Softshells and four Map Turtles<sup>140</sup>.

### ***Dragonflies and Damselflies***

Neither MNR nor Environment Canada has status ranking for these insects. However, Odonate species (dragonflies and damselflies) are tracked by the Natural Heritage Information Centre (NHIC) and The Nature Conservancy. Twenty-two Odonates from the region are provincially rare (S3, S3 or S1) with 14 of those species found in the Sydenham watershed. Surveys for rare Odonata by NHIC staff in 2003 identified 50 species of Odonata and resulted in the discovery of a new species for Canada when the Mocha Emerald dragonfly was found in the Black Creek watershed of the Sydenham<sup>141</sup>.

### ***Summary***

It is important to monitor Species at Risk as they are sensitive to environmental change and may provide warning signs of deteriorating environmental health. The distribution and abundance of Species at Risk in the St. Clair region may be valuable indicators of a change in the environmental health of the region. Toxicology work at the University of Guelph using the Biotic Ligand Model indicates major differences between glochidia of a common mussel and glochidia of an Endangered mussel species in their sensitivity to aluminum in the water.<sup>142</sup> Dextrase et al. indicated that "the principal stresses affecting populations of species at risk in the Sydenham River watershed are sediment loadings causing turbidity and siltation, nutrient loads, toxic compounds, thermal effects, and exotic species."<sup>136</sup>

### **Species at Risk Information Gaps**

- The current distribution and abundance of reptiles and amphibians in the St. Clair region is incomplete.
- Identification of Species at Risk, including mussels and fish, in the St. Clair Region outside of the Sydenham River watershed is incomplete.
- Identification of the stresses on aquatic systems is also an information gap.

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<sup>138</sup> Fletcher, M. and S. Gillingwater. 1994. A Survey of the Eastern Spiny Softshell Turtle along the Thames and Sydenham Rivers 1994. Report for the UTRCA, SCRCA, LTVCA and Eastern Spiny Softshell Recovery Team.

<sup>139</sup> Tran, P.H. MacKenzie and M. Andreae. 2005. Turtle Survey 2005. Unpublished report for the SCRCA.

<sup>140</sup> Dow, J., H. MacKenzie and M. Andreae. 2006. Turtle Survey 2006. Unpublished report for the SCRCA.

<sup>141</sup> Jones, C.D. 2004. NHIC Coordinates Odonata and Reptile Surveys on Sydenham and Ausable Rivers. Natural Heritage Information Centre Science and Information Newsletter, 9(1):10-11.

<sup>142</sup> Gillis, P.L., A.N. Schwalb, K.A. McNichols, G.L. Mackie, and J.D. Ackerman. In prep. The effect of water composition on the acute toxicity of copper to glochidia of freshwater mussels.

## 2.5.5 Invasive Species

An invasive species is defined as “a species that has been transported by human activities, intentional or accidental, into a region where it does not naturally occur or a species occurring in an area outside of its historically known natural range as a result of intentional or accidental dispersal by human activities.”<sup>143</sup>

Invasive species are known by many names such as non-native, alien, exotic, non-indigenous, or introduced species. Acronyms have been used to more accurately describe these species. NIS is short for non-native invasive species<sup>144</sup>, while IAS denotes invasive alien species<sup>145</sup>.

For purposes of this report, invasive species shall be considered to be “a non-native species whose introduction and/or spread threaten biological diversity.”<sup>145</sup>

Due to the 200 year history of European settlement in this region, invasive species are abundant. Human migration has long served as a source of species introductions as people tend to bring familiar plants and animals with them to their new homes and unintentionally, also bring diseases and pest species.<sup>145</sup> In addition to imported species, many species indigenous to North America, but not the local area, have taken advantage of dispersion mechanisms such as canals and other human transport systems to expand their original range.

Invasive species have had a significant negative impact on the ecosystem by out competing native species, carrying pathogens, disrupting communities, causing extinction, altering the food chain, disturbing habitat, affecting environmental/ecosystem health, and impacting water quality.<sup>145</sup> They can also impact industries such as fisheries, tourism, water production and water removal. Some impacts of invasive species may not be distinguishable from other stressors such as a change in hydrology, loss of habitat, or pollution.<sup>145</sup>

### ***Fish***

Introduced fish species found in the St. Clair Region include the Common Carp, Goldfish, Alewife, Round Goby and Sea Lamprey. Species such as the sea lamprey have had devastating impacts on fish populations in the Great Lakes. The presence of Goldfish indicates the release of ‘pets’ as a potential source of invasive species. Most invasive fish species threaten native fish through their ability to out-compete for food and habitat and to pass on disease. Some species, such as the Common Carp, can have a direct impact on water quality and aquatic habitat. Species such as the goby can be considered to be contributing to the fish community since many species forage on the gobies, but they have reduced the abundance of other bottom-dwelling species such as mottled sculpin and logperch.

Common Carp (*Cyprinus carpio*) are widespread throughout the Sydenham River and other streams in the St. Clair region. Members of the minnow family, carp grow to very large sizes. Carp feed on aquatic vegetation and aquatic invertebrates. They have significant impacts on aquatic habitats through their feeding and spawning behaviour. When carp feed, they suck up sediments and organisms from the bottom, uprooting and destroying vegetation. They create a very turbid environment by disturbing the

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<sup>143</sup> European Community Biodiversity Clearing House Mechanism, Supporting the Convention on Biological Diversity. 2005 (may be downloaded at [http://biodiversity-chm.eea.eu.int/glossary/A/alien\\_species](http://biodiversity-chm.eea.eu.int/glossary/A/alien_species)); Royal Botanical Gardens. 2005. Science and Conservation: A fisheries management plan for Hamilton Harbour. ([www.rbg.ca/pages\\_sci\\_conserv/sci\\_fmpe exotic.html](http://www.rbg.ca/pages_sci_conserv/sci_fmpe exotic.html))

<sup>144</sup> Environment Canada. 2005. Aquatic Non-Native Invasive Species: Invaders Pose Major Threat to the Great Lakes. ([www.on.ec.gc.ca/coa/invaders-e.html](http://www.on.ec.gc.ca/coa/invaders-e.html))

<sup>145</sup> Cinura, K.A., L.A. Meyerson, and A. Gutierrez. 2004. The ecological and socio-economic impacts of invasive alien species in inland water ecosystems. Report to the Conservation on Biological Diversity on behalf of the Global Invasive Species Programme, Washington, D.C. p 34. ([www.biodiv.org/doc/ref/alien/ias-inland-waters-en.pdf](http://www.biodiv.org/doc/ref/alien/ias-inland-waters-en.pdf))

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sediment, which is then carried downstream to settle.<sup>146</sup> Carp can also drastically modify nearshore habitats and increase turbidity through their spawning behaviour.<sup>147</sup>

Anecdotal records indicate carp have been here since at least the 1960s, although the earliest record in the ROM database is 1982. Community surveys may provide reports from much earlier in the 1900s. The activity of carp in shallow warm pools has resulted in increased turbidity in the watercourses according to local residents. However, it is important to realize that the First Nation name for the Sydenham was Jonquakamik, which translates as “Milky River”<sup>148</sup>. Consequently we can assume the Sydenham has always appeared turbid.

Round goby are reported from the Great Lakes shoreline (Purdy fishery in Sarnia in particular) and Talfourd Creek, but are not known from other interior watersheds.

### ***Mussels***

As the Sydenham River is nationally significant for its native mussel fauna, the most serious invasive species for this region is the zebra mussel. This European species has already decimated the native mussels of the Great Lakes. It is found throughout the Trent-Severn River and canal system and has now appeared in the Thames River. Fortunately, it has not been seen in the interior watersheds of this region, except for one report from the lower North Sydenham River at County Road 1, west of Becher<sup>149</sup>.

These mussels are tolerant of a wide range of environmental conditions.<sup>150</sup> They reproduce more readily than native mussels and compete with them for food supply. They also can have a severe effect on water intakes by reducing pipe diameter.

### ***Plants***

Most non-native invasive plant species that invade wetlands and other wet areas displace the diverse native plant populations with very dense monocultures. These species may affect water quality if they displace plants such as cattails which are good water-purifiers.

Invasive terrestrial species include purple loosestrife which is found in many locations in the region. It usually occurs as scattered plants rather than dense stands. When the University of Guelph selected sites to release the *Galerucella* beetles in 1994, the only extensive stands known to be located on publicly-owned properties were at Wawanosh Wetlands Conservation Area and the Oil Discovery site in Petrolia. Both stands were less than half a hectare. There has not been a noticeable change in the abundance of this species in the last decade.

Common Reed/Giant Reed (*Phragmites australis*) is probably the most aggressive wetland species in this region. This species also forms dense monocultures and displaces native fish and wildlife habitat.<sup>151</sup> <sup>152</sup> It occurs in many locations in the watershed, including wetlands such as Wawanosh Wetlands Conservation

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<sup>146</sup> Ontario Federation of Anglers and Hunters. 2005. Invasive Carp. [www.invadingspecies.com/Invaders.cfm?A=Page&PID=20](http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=20)

<sup>147</sup> Gillingwater, S. and J. Schwindt. 2005. UTRCA. Pers. comm.

<sup>148</sup> “The Diaries of Christian Denke on the Sydenham River 1804–1805.” Retrieved July 12, 2001 from [www.denke.org/CDDiaries.htm](http://www.denke.org/CDDiaries.htm)

<sup>149</sup> Jeremy Vanderwaal, UWO Master’s student in zoology, July 27 1999. Pers. comm.

<sup>150</sup> Ontario Federation of Anglers and Hunters. 2005. Zebra Mussel. [www.invadingspecies.com/Invaders.cfm?A=Page&PID=1](http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=1)

<sup>151</sup> Marks, M. et al. 2005. Element Stewardship Abstract for *Phragmites australis*. Prepared for the Nature Conservancy (<http://tncweeds.ucdavis.edu/esadocs/documnts/phraaus.html>)

<sup>152</sup> Wilcox, K.L. and S.A. Petrie. 1999. Monitoring *Phragmites australis* at Long Point, Ontario: Past, Present, and Future. Prepared for the Long Point Waterfowl and Wetlands Research Fund. [www.escarpment.org/leading\\_edge/LE99/LE99\\_S1/Wilcox.pdf](http://www.escarpment.org/leading_edge/LE99/LE99_S1/Wilcox.pdf)

Area, Marthaville Management Area and McDonald Park on the St. Clair River. It is also found along many municipal drains and roadside ditches. The invasive ecotype of this native species is encroaching on wet meadow areas in heavy clay soils, such as the Fairbank oil field properties south of Oil Springs.

## 2.6 Human Characterization

The St. Clair Region Conservation Authority (SCRCA) includes most of Lambton County, part of Middlesex County and part of the Municipality of Chatham-Kent. The SCRCA watershed covers approximately 4,100 square kilometres. Under the Clean Water Act, it will form the St. Clair Region Source Protection Area in the Thames-Sydenham and Region Source Protection Region.

The total area of each census region and the proportion within the St. Clair Region area are summarized in **Table 2.6-1: Census Regions - St. Clair Region Source Protection Area**.

**Table 2.6-1: Census Regions - St. Clair Region Source Protection Area**

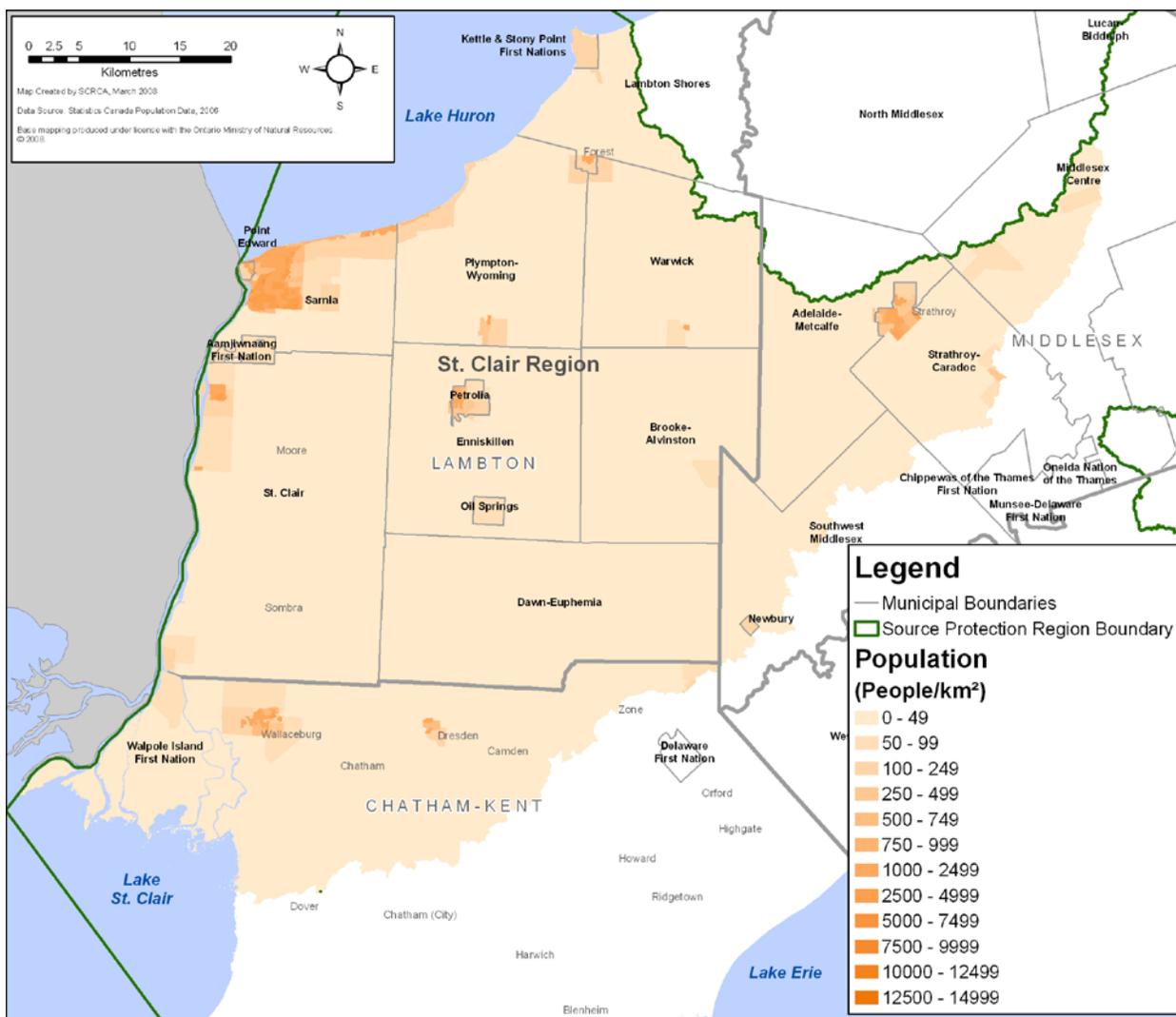
Census Region	Total Area (sq. km)	Area within St. Clair Region		
		Square km	Percentage of Municipality	Percentage of SCR Watershed
Lambton	3,002	2,780	93	67
Middlesex	3,333	697	21	17
Chatham-Kent	2,490	652	26	16
Total	8,825	4,129		

The total population in the St. Clair Region Source Protection Area is about 167,000 based on the 2001 census. Most of the population is concentrated in urban communities surrounded by agricultural land as illustrated by the urban/industrial areas shown on **Map 25: Generalized Land Cover**.

Lambton County makes up two thirds of the watershed in the St. Clair Region Source Protection Area and the remaining watershed is divided almost equally between Chatham-Kent and Middlesex County.

### 2.6.1 Population Distribution and Density

**Figure 2.6.1-1: Generalized Population Density – St. Clair Region** has been produced using 2006 Census information obtained from Census Canada. This figure helps to illustrate the variations in population density across the Source Protection Area.



**Figure 2.6.1-1: Generalized Population Density - St. Clair Region**

### ***Lambton County***

Over 92% of Lambton County is in the St. Clair Region Conservation Authority (SCRCA) watershed. Lambton Shores is the only local municipality with a portion that is outside the watershed. **Table 2.6.1-1: Lambton Population Distribution** provides a summary of the 2001 populations for the communities based on census data. This table also provides information on the land area and population density together with the percentage of the geographic areas within the Source Protection Area.

The City of Sarnia has the largest population (70,876) which represents about 56% of the total population (126,971) in Lambton County. As shown in **Figure 2.6.1-1**, most of the Sarnia population is concentrated in the northwestern part of the city and in a strip of urban development along the Lake Huron shoreline. The city has a large rural land base as a result of the amalgamation of the City and the adjacent township. This lowers the overall population density for the city reported in **Table 2.6.1-1**. In the urban areas of the city, the population density would be similar to those shown for Point Edward and Petrolia in **Table 2.6.1-1**.

As a result of the amalgamation of rural townships with villages and towns, several other Lambton municipalities have a similar population pattern of more concentrated urban/residential areas surrounded by agricultural land as shown on **Map 25** and **Figure 2.6.1-1**.

**Table 2.6.1-1: Lambton Population Distribution<sup>153</sup>**

	Population 2001	Land Area in sq km	Population Density per sq km	% of Area within St. Clair SP Area
Lambton County	126,971	3,001	42	92.6%
- City of Sarnia	70,876	800	88	100%
- St. Clair	14,659	620	23	100%
- Lambton Shores	10,571	340	31	37.3%
- Plympton-Wyoming	7,359	320	23	100%
- Petrolia	4,849	13	373	100%
- Warwick	4,025	290	13	100%
- Enniskillen	3,259	340	10	100%
- Brooke-Alvinston	2,785	310	9	100%
- Dawn-Euphemia	2,369	450	5	100%
- Point Edward	2,101	3	700	100%
- Oil Springs	758	8	95	100%
- Bkejwanong Territory (Walpole Island First Nation)	1,843			100%
- Chippewas of Kettle & Stony Point First Nation	822			100%
- Aamjiwnaang First Nation	695			100%

### ***Chatham-Kent***

The municipality of Chatham-Kent is the result of the restructuring that transformed 22 local municipalities into one. The population is generally located in urban centres surrounded by agricultural land. All of the former Town of Wallaceburg with a population of 11,772 (about 11% Chatham-Kent) is in the SCRCA watershed. The Dresden and Bothwell communities also have higher local population densities. Most (about 40%) of the population of Chatham-Kent is in the former City of Chatham which is in the Lower Thames Valley Conservation Authority watershed.

**Table 2.6.1-2: Chatham-Kent Population Distribution** provides a population summary for the Chatham-Kent communities in the St. Clair Source Protection Area. **Map 25: Generalized Land Cover** and **Figure 2.6.1-1: Generalized Population Density – St. Clair Region** show the urban areas in Chatham-Kent.

**Table 2.6.1-2 : Chatham-Kent Population Distribution<sup>154</sup>**

	Population 2001	Land Area in sq km	Population Density Per sq km	% area within St. Clair SP Area
Chatham-Kent	107,341	2,470	43	26.2%
- Wallaceburg	11,114	11	1,010	100%
- Dresden	2,572	3	847	100%
- Bothwell	981	2	490	50%
- Camden (Township)	2,161	174	12	86.2%
- Chatham (Township)	6,002	356	17	85%

<sup>153</sup> City of Sarnia web site, August 2006, city.sarnia.on.ca

<sup>154</sup> Chatham-Kent web site, August 2006, www.chatham-kent.ca

- Dover (Township)	3,923	280	14	42.4%
- Zone	1,002	114	9	49%

### ***Middlesex County***

About 21% of Middlesex County is in the St. Clair Region Source Protection Area. Most of the land is rural agricultural with low population density. Approximately 83% of the Middlesex Census Region population is in the City of London and none of the city is in the SCRCA watershed.

The most significant urban area in the St. Clair Region watershed is the former Town of Strathroy which is now part of the Municipality of Strathroy-Caradoc. As shown in **Figure 2.6.1-1: Generalized Population Density – St. Clair Region**, the population density in the former town is higher than the surrounding parts of the former Caradoc Township. Other smaller urban areas in Middlesex include Newbury and Mount Brydges.

**Table 2.6.1-3: Middlesex Population Distribution** provides an outline of populations of local municipalities in the Source Protection Region. **Map 25: Generalized Land Cover** shows the urban areas associated with these municipalities.

**Table 2.6.1-3: Middlesex Population Distribution** <sup>155</sup>

	Population 2001	Land Area in sq km	Population Density per sq km	% area within St. Clair SP Area
Middlesex County (incl. City of London)	403,185	3,317	122	20.9%
City of London	336,539	422	798	0%
Middlesex County (excluding London)	66,635	2,895	23	23.9%
- Strathroy-Caradoc	19,105	274	70	53.5%
- Middlesex Centre	14,250	587	24	26.5%
- Adelaide-Metcalf	3,155	332	10	67.9%
- Southwest Middlesex	6,135	428	14	41.6%
- Newbury	395	2	197	100%

## **2.6.2 Population Projections**

**Table 2.6.2-1: Historic Populations - St. Clair Region Source Protection Area** gives the populations for 2001 and 1996 with the percent change for the communities. Both Lambton County and Chatham-Kent experienced a decline in population over the five year period from 1996 to 2001. Middlesex County (excluding the City of London) experienced a population increase of about 4.2%.

<sup>155</sup> County of Middlesex web site, August 2006, [www.county.middlesex.on.ca](http://www.county.middlesex.on.ca)  
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**Table 2.6.2-1: Historic Populations - St. Clair Region Source Protection Area**

<b>Municipality</b>	<b>2001 Population</b>	<b>1996 Population</b>	<b>1996 to 2001 Population Change %</b>
Lambton County	126,971	128,975	-1.6%
- City of Sarnia	70,876	72,738	
- St. Clair	14,659	15,081	
- Lambton Shores	10,571	10,874	
- Plympton-Wyoming	7,359	7,344	
- Petrolia	4,849	4,908	
- Warwick	4,025	4,095	
- Enniskillen	3,259	3,288	
- Brooke-Alvinston	2,785	2,894	
- Dawn-Euphemia	2,369	2,577	
- Point Edward	2,101	2,257	
- Oil Springs	758	773	
- Bkejwanong Territory (Walpole Island FN)	1,843	1,525	
Middlesex County (incl. City of London)	403,165	389,616	3.5%
Middlesex County (excl. City of London)	66,635	63,947	4.2%
- Strathroy-Caradoc	19,114	17,930	
- Middlesex Centre	14,242	12,985	
- Adelaide-Metcalf	3,149	3,128	
- Southwest Middlesex	6,144	6,204	
- Newbury	422	430	
Chatham-Kent	107,341	109,350	-1.8%
- Wallaceburg Centre	11,114	11,772	
- Dresden Centre	2,572	2,589	
- Bothwell	981	990	
- Camden	2,161	2,142	
- Chatham (Township)	6,022	6,321	
- Dover	3,923	4,040	
- Zone	1,002	1,039	

The growth of Middlesex County's economy can be primarily attributed to the municipality's close proximity to large urban markets. Lambton and Chatham-Kent have experienced a decline in their traditional industrial sectors (petrochemical and automotive). They have also had a general decrease in the 'farm' population. These factors help to explain the population changes in the three municipalities and the continuing differences in the future population projections.

The Ontario Ministry of Finance indicates that the population of Southwestern Ontario is projected to grow by about 18% from 1,579,000 in 2006 to 1,857,700 in 2031. This is lower than the projected growth rate of approximately 30% for the whole province. The information on projections for Chatham-Kent, Lambton and Middlesex Census Divisions has been extracted from the Ministry's report and is

summarized in **Table 2.6.2-2: Population Projections Census Divisions - Ontario Ministry of Finance**.

**Table 2.6.2-2: Population Projections Census Divisions - Ontario Ministry of Finance**

	2001	2006	2011	2016	2021	2026	2031
Chatham-Kent*	111,900	111,000	108,600	108,300	108,300	108,600	108,700
Lambton	131,800	132,300	132,200	133,100	134,400	135,9100	137,000
Middlesex	422,000	436,200	453,700	473,800	493,700	512,800	530,100

\* The difference between the Ministry of Finance Projections and the Municipality's Official Plan are discussed in the accompanying text.

Based on Ontario Ministry of Finance predictions, significant differences in the growth rates across the region are predicted over the next 25 years. Middlesex is projected to have growth of about 22% which is slightly above the provincial projection for southwestern Ontario. Lambton with 4% will see some growth<sup>156</sup> over the 27 year period of the projections. Chatham-Kent (-1%) is expected to continue to see a population decline.

It should be noted that the Municipality of Chatham-Kent feels that the Ontario Ministry of Finance population projections do not take into account the proactive development strategy being implemented by Chatham-Kent. The Chatham-Kent Official Plan<sup>157</sup> projects a higher growth rate of approximately 6% and a population of 122,600 in 2021 based on a medium growth scenario.

## 2.6.3 Land Use and Settlement Areas

For this report, the discussion on land use and settlement areas has been divided into six categories: residential, industrial/commercial, transportation, agricultural, landfills and recreation. As shown on **Map 25: Generalized Land Cover**, agriculture is the dominant land use in the St. Clair Region Source Protection Area. However, many significant industrial and commercial land uses provide employment for the population. Water transportation, oil, railways, roads and recreational opportunities had major influences on the development and location of urban, industrial, commercial and recreational land use in the region.

### 2.6.3.1 Existing Urban Residential Development

#### *Lambton County*

The City of Sarnia is the largest municipality with a population of about 71,000. The City and the adjacent Village of Point Edward contain the largest area of existing residential development.

There is residential development along the Lake Huron shoreline in the city. To the east of the city boundary, smaller residential areas have also been built along the lakeshore in Plympton-Wyoming and Lambton Shores.

In a similar manner, there is residential development along the St. Clair River in a string of small communities (Corunna, Mooretown, Sombra and Courtright) that are part of the Township of St. Clair.

Other urban centres located in Lambton include the Town of Petrolia with a population of about 5,000, the Village of Oil Springs, and the communities of Alvinston, Forest, Wyoming and Watford.

<sup>156</sup> Ontario Ministry of Finance, Ontario Population Projections, 2004-2031.

<sup>157</sup> Chatham-Kent Official Plan, Adopted January 2005.

### ***Chatham-Kent***

The communities of Wallaceburg and Dresden are the two significant urban areas located in the Chatham-Kent part of the St. Clair Region Source Protection Area. Wallaceburg has a population of approximately 11,500 and Dresden has about 2,500. Wallaceburg is built at the confluence of the North and East Branches of the Sydenham River. The community of Dresden is built on both sides of the Sydenham River with a larger portion of the town on the south side of the river.

### ***Middlesex County***

The former Town of Strathroy, now part of the Municipality of Strathroy-Caradoc, is the major urban centre in the part of Middlesex that is in the St. Clair Region Source Protection Area. The Strathroy settlement of approximately 13,500 is the only area in the township that is serviced by both a municipal water supply and a sanitary sewage system<sup>158</sup>.

The Village of Newbury with a current population of about 400 and the community of Mount Brydges are small urban residential areas in the St. Clair area.

## **2.6.3.2. New and Projected Urban Residential Development**

### ***Lambton County***

The Lambton Official Plan<sup>159</sup> indicates that the development strategy will direct the majority of growth to urban centres and urban settlements on full municipal sewage and water services. It anticipates a limited amount of growth in the rural area serviced by private sewage and/or water systems. Four growth areas have been identified: West Lambton, North Lambton, Central Lambton and East Lambton. The Plan indicates that there are adequate quantities of land designated to accommodate residential growth.

West Lambton, consisting of the City of Sarnia, Village of Point Edward and the Township of St. Clair, has been allocated approximately 56% of the total anticipated new dwelling units. Residential areas in the Township of St. Clair (Moore and Sombra) have historically been developed in a linear form along the river. The Official Plan will permit residential development in the areas connecting the existing communities on the basis of infilling locally designated lands.

Central Lambton consisting of Petrolia, Oil Springs, Plympton-Wyoming, Enniskillen and the Dawn portion of Dawn-Euphemia, has been allocated about 16% of the future dwelling units.

East Lambton, comprised of Brooke-Alvinston, Warwick (includes the former Village of Watford) and the Euphemia portion of Dawn-Euphemia, has been allocated about 7% of the new units.

North Lambton has been allocated approximately 21% of the anticipated dwelling units. It consists of Lambton Shores (formerly Bosanquet, Forest and Grand Bend). Most of the area is in the Ausable Bayfield Source Protection Area. North Lambton is expected to continue to be a prime location for development due to the attraction for retirees and individuals from the London market. The aging population will reinforce this continued trend.

Due to the considerable tourism potential and the desirable residential location, the Lake Huron, Plympton-Wyoming and West Lambton Shores areas have been specifically identified as requiring a comprehensive planning approach to development in this area. The area requiring more detailed study has been identified as “Lakeshore Policy Areas” in the County Official Plan.

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<sup>158</sup> Township of Strathroy-Caradoc, Draft Official Plan, August 2006, [www.strathroy-caradoc.ca](http://www.strathroy-caradoc.ca)

<sup>159</sup> Lambton County Official Plan, August 2006, [www.lambtononline.com](http://www.lambtononline.com)

## ***Middlesex County***

The Middlesex County Official Plan<sup>160</sup> provides a growth management hierarchy for urban growth. In 1996, it was determined that sufficient vacant land for residential and commercial development was designated in local official plans to accommodate anticipated growth. Based on an overall permanent population increase of 21,070 people to the year 2016, a total of approximately 7,531 additional residential units will be required throughout the County to house the increased population.

Under the County of Middlesex Official Plan, Strathroy, Mount Brydges and Melbourne are the areas in the Township of Strathroy-Caradoc designated as ‘settlement areas’. The growth management strategy<sup>161</sup> for the Township of Strathroy-Caradoc is designed to direct the majority of future growth to the Strathroy settlement area. This is the only area in the township that has both municipal water supply and sanitary sewage system.

The Village of Newbury population is also predicted to increase due to sewer and water services.<sup>162</sup>

## ***Chatham-Kent***

The municipality of Chatham-Kent feels that the Ontario Ministry of Finance prepared population projections presented in **Table 2.6.1.2-2** do not take into account the proactive development strategy being implemented by Chatham-Kent<sup>163</sup>. The Chatham-Kent Official Plan projects a higher growth rate.

Primary urban centres with full municipal services are the focal points for growth. Both Wallaceburg and Dresden are identified as primary urban centres. Low, steady population growth is expected and the existing housing supply is sufficient.

### **2.6.3.3 Rural Residential**

The population of the rural area of the watershed is experiencing a decline. Changes in farm practices are resulting in farm consolidation and larger landholdings for viable operations. There seems to be a decreasing interest in farming from younger generations as this demographic segment moves toward more urban centres in search of employment. The search for appropriate retirement housing has also contributed to an emigration of seniors from the rural area.

Generally, municipalities recognize the importance of agriculture to their areas and have discouraged conflicts between rural residential landowners and farm operations by imposing policies that restrict the creation of new rural non-farm residential lots.

Piped water to rural residential and rural/agricultural areas is supported by a number of the local municipalities because of historic potable water quality and quantity concerns. Providing a good water supply to rural residents and the agricultural sector is a priority in maintaining the rural community viability. The provision of rural piped water is not meant to encourage scattered development in the rural/agricultural area.

### **2.6.3.4 Cottage Development**

Seasonal residences are located in the Mitchell’s Bay area on Lake St. Clair, on Fawn and Stag Islands in the St. Clair River, and along the lakeshore area in Plympton-Wyoming and Lambton Shores (formerly West Bosanquet).

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<sup>160</sup> Middlesex County Official Plan, August 2006, [www.county.middlesex.on.ca](http://www.county.middlesex.on.ca)

<sup>161</sup> Draft Official Plan Township of Strathroy-Caradoc, August, 2006, [www.strathroy-caradoc.ca](http://www.strathroy-caradoc.ca)

<sup>162</sup> Village of Newbury, [www.newbury.ca](http://www.newbury.ca)

<sup>163</sup> Chatham-Kent Official Plan, Adopted January 2005.

### ***Lake Huron***

In Sarnia, most of the housing that may have originated as seasonal cottages has been converted to permanent dwellings. Along the Plympton-Wyoming shore of Lake Huron, most dwellings are fully serviced by municipal sewerage collection and piped water supply. Therefore, the municipality does not distinguish between seasonal and non-seasonal residences in planning documents. There are numerous lakeshore areas within Lambton Shores (formerly Bosanquet Township) that are not fully serviced.

There are a number of tent and trailer parks which are seasonal and are provided a special designation and policies in the municipal official plans.

### ***St. Clair River***

There are two significant seasonal cottage developments located on Fawn Island and Stag Island. Large seasonal trailer parks are also located along the river.

### ***Lake St. Clair***

Seasonal cottages, cabins and trailer parks are located at Mitchell's Bay on Lake St. Clair.

## **2.6.3.5 Commercial Development**

### ***Existing Commercial Development***

All of the existing urban residential areas have commercial development that is relative to their size and location. The London Road/Lambton Mall and the Exmouth Street (Northgate) commercial areas of Sarnia are recognized as high order commercial centres in Lambton County.

### ***Future Commercial***

Low density business parks along the 402 and major roads are encouraged in the Lambton Official Plan. Potential Highway 402 service centre areas have been identified in the Lambton County Official Plan. Similarly, future growth in the Strathroy settlement area and proximity to Highway 402 will probably lead to more commercial development in this area of Middlesex County.

### ***Trends in Commercial Development***

In general, most urban areas are struggling with an effort to retain or revitalize the downtown core while accommodating the trend to outlying shopping hubs with plenty of parking.

## **2.6.3.6 Industrial**

### ***Existing Industrial***

The largest concentration of petroleum and chemical industry in Ontario stretches along the St. Clair River from Sarnia to the former Village of Sombra in St. Clair Township. The evolution and expansion of the "Chemical Valley" is an interesting one and had a profound effect on land use changes in Lambton County.

In 1851, a Geological Survey of Canada report of gum beds in Enniskillen Township led to the start of the chemical industry. Utilizing the gum beds as a source of asphalt, a local early industrialist discovered oil while digging a well for water. Following a succession of oil discoveries, a railroad finally reached Petrolia in 1866 to assist with transportation to refineries in Hamilton. Refineries eventually were constructed in Petrolia and Oil Springs to process the oil.

Imperial Oil eventually constructed a refinery in Sarnia which processed the oil more efficiently. The refinery utilized the St. Clair River as a source of water and for transportation. Dominion Salt Co., now

Sifto Salt, was established in Sarnia in the early 1900s. The salt company exploited a huge salt bed about 450-600 metres underground in Sarnia. The need for rubber during the Second World War led to the construction of a large rubber plant in 1942.

The St. Clair River provided a cheap means of transportation and cooling water for various industrial processes. Other industrial companies soon followed suit and situated on the St. Clair River for its favourable supply of water and area amenities. The industrial construction boom lasted from the 1950s to the 1970s<sup>164</sup>.

The strong agricultural nature of the area results in food processing plants. For example, Cuddy Farms, which processes poultry products, is the third largest employer<sup>165</sup> in Strathroy-Caradoc. Cangro Foods Inc. processes locally grown tomatoes at a Dresden facility<sup>166</sup>. Chatham-Kent is home of Commercial Alcohols, the largest supplier of industrial fuel and beverage grade alcohols in Canada using corn for ethanol production.

The automotive industry is another significant part of the industrial base in southwestern Ontario with a number of plants located across the St. Clair area. Wallaceburg is a major centre for machine, tool, die and mould makers. Thyssen Krupp Fabco is a tier one automotive supplier in Dresden.

### ***Industrial Trends***

The Lambton Official Plan indicates that a good supply of lands in Western Lambton has been set aside to accommodate the demand for industrial land by petrochemical companies. The benefit of the St. Clair River for water supplies and transportation is recognized as important for these industries. It is also recognized that locating large scale industrial uses elsewhere would be inappropriate and incompatible.

After a 1990s decline in the petrochemical employment sector, it is the general opinion that economic stability has now been achieved in this sector. Transportation, warehousing, manufacturing and heavy industrial are all considered to have stabilized in terms of growth.

Due to Ontario's high consumption of power, numerous industrial developments are currently being examined that involve alternative energy sources and conversions. These proposals are situated within St. Clair Township south of the City of Sarnia. Wind powered electrical supplies are also being considered along the Lake Huron shoreline.

Overall, 42% or 4,021 hectares of industrially designated lands in Lambton County have been developed to date. Most (3,680 ha) of the vacant industrial land is located in the Geographic Township of Moore, now part of St. Clair Township. About 1,111 ha of vacant industrial land are in the City of Sarnia.

In terms of vacant industrial lands available, the existing supply in Lambton is adequate to meet future need.

In Chatham-Kent, Wallaceburg has seen a serious reduction in the industrial base over the past decades with the loss of food processing, glass manufacturing and other plants. Former industrial sites are available in the community. In Chatham-Kent, Highway 401 tends to focus possible industrial development south of the St. Clair Region Source Protection Area watershed.

Strathroy-Caradoc in Middlesex County is a convenient location with good road transportation. Highway 402 provides access to local, national and international markets. This has attracted several industries to the area and will probably continue.

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<sup>164</sup> Ford, R.W. September 2000. A History of the Chemical Industry in Lambton County.

<sup>165</sup> London Regional Analysis, Final Working Report, March 2002.

<sup>166</sup> Chatham-Kent Community Profile, June 2007, [www.chatham-kent.ca](http://www.chatham-kent.ca)



brownfields that result from urban activity, as do most municipal strategies, and also address brownfields that are a legacy of agriculture and agi-business.

## 2.6.5 Landfills

There are a number of closed, active and proposed landfills in the St. Clair Region Source Protection Area including a hazardous waste disposal site.

### 2.6.5.1 Existing (Active)

In the St. Clair Region Source Protection Area, all active landfill sites are located in Lambton County. **Table 2.6.5-1: Active Landfills in the St. Clair Region Source Protection Area** provides a summary of active landfills.

Waste management (disposal) within the County of Lambton is a responsibility of the County government. Waste collection is a local responsibility. In January of 1991, the County of Lambton, under the Sarnia-Lambton Act, assumed ownership of six existing waste disposal facilities that were previously operated by the lower tier municipalities of Brooke, Dawn, Grand Bend, Moore, Sarnia and Sombra. Four facilities (Brooke, Grand Bend, Sarnia and Sombra) have been closed by the County; however, environmental monitoring and post-closure care continues on an ongoing basis. Two facilities, Dawn and Moore, continue to accept waste. The county also utilizes privately owned landfills for its disposal needs.

The Dawn landfill site is located approximately 2.5 km west of County Road 21 (Oil Heritage Road) at 4084 Langbank Line in the Township of Dawn-Euphemia. The 36 acre site, encompassing a landfill area of 14 acres, was opened in 1972. Currently, this site continues to receive and dispose of household and commercial waste. The site is only open on Saturdays.

The Moore landfill site is located approximately 1 km north of County Road 80 (Courtright Line) at 3198 Ladysmith Rd. in the Township of St. Clair. The 143 acre site, encompassing a landfill area of 21 acres, was opened in 1970. Currently, this site continues to receive and dispose of household and commercial waste. The site is open between the hours of 8:00 am and 4:00 pm, Monday through Friday and Saturdays from 8:00 am to 12:00 noon.

Other licensed landfills that presently receive household waste are the Warwick Landfill, and the Petrolia Landfill, which are owned by Waste Management Ltd<sup>169</sup>.

A hazardous waste disposal site including a secure landfill and liquids incinerator is operated by Clean Harbors Canada Inc. in St. Clair Township.

The Ontario Power Generation Lambton site in St. Clair Township has a private landfill at the generating station to dispose of off-specification gypsum from the gas scrubbing system on their coal fired units.

Inter Recycling operates a solid non-hazardous landfill in Sarnia.

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<sup>169</sup> Lambton County website, November 2005, [www.lambtononline.com](http://www.lambtononline.com)  
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**Table 2.6.5-1: Active Landfills in the St. Clair Region Source Protection Area**

<b>Landfill Owner/Operator</b>	<b>Location</b>	<b>Municipality</b>
Dawn (LC) Lambton County	Tramway Road/Langbank Line Lot 21, Conc. 5	Dawn-Euphemia Twp
Moore (LC) Lambton County	Ladysmith Road, Lot 21, Conc. 5 & 6	St. Clair Twp
Moore (OPG) Ontario Power Generation	Greenfield Road, Lot 28, Conc. 3	St. Clair Twp
Warwick (WM) Waste Management	Zion Line, Lot 19-21, Conc. 3	Warwick Twp
Petrolia (WM) Waste Management	Oil Heritage Road, Lot 16-17, Conc. 10	Petrolia
Secure/Hazardous Waste (CH) Clean Harbors	Telfer Road, Lot 8-9, Conc. 10	St. Clair Twp
Inter Recycling		Sarnia

### **2.6.5.2 Proposed Landfills**

There is a proposal by Waste Management of Canada Corporation for a major expansion of their landfill site in Warwick Township. An Environmental Assessment has been completed and approved by the Minister of Environment. The proposal would expand the landfill from 55,000 tonnes/annum to 750,000 tonnes/annum of solid, non-hazardous municipal, industrial, commercial and institutional waste generated in Ontario for a period of approximately 25 years.

### **2.6.5.3 Closed Landfills**

Numerous former landfill sites are located across the Source Protection Area. **Table 2.6.5.3-1: Closed Landfills within the St. Clair Region** lists the known closed sites within the St. Clair Region Source Protection Area. This information is based on the Ministry of the Environment Waste Disposal Site Inventory (Waste Management Branch, June 1991), local municipal official plans and zoning bylaws, and other available sources.

**Table 2.6.5.3-1: Closed Landfills within the St. Clair Region Source Protection Area**

Year Closed	Location	Geographic Township	Municipality
<b>Middlesex County</b>			
1973	Metcalfe St. E.	Strathroy	Strathroy-Caradoc
1941	Mill Pond Cres.	Strathroy	Strathroy-Caradoc
1964	Carroll & Park St.	Strathroy	Strathroy-Caradoc
1955	Pt. Lot 5, Conc. 9	Caradoc	Strathroy-Caradoc
1959	Pt. Lot 8, Conc. 8	Ekfrid	Southwest Middlesex
1954	Pt. Lot 8, Conc. 1	Ekfrid	Southwest Middlesex
1967	Lot 21, Conc. 3	Mosa	Southwest Middlesex
<b>Lambton County</b>			
1979	Lot 17, River Road	Sarnia	Sarnia
1973	Lot 19, River Road	Sarnia	Sarnia
1975	Scott Road	Sarnia	Sarnia
1974	Vidal St.	Sarnia	Sarnia
unknown	Hwy 40 S. of Confederation, Lot 15, Conc. 4	Sarnia	Sarnia
unknown	Blackwell Rd, N. of Churchill, Lot 12, Conc. 3	Sarnia	Sarnia
1979	Lot 19, Conc. 6	Warwick	Warwick
1976	Pt. Lot 18-19, Plan 3	Oil Springs	Enniskillen
1975	Pt. Lot 22(W1/2), Conc. 14, Mawlam Rd	Dawn	Dawn-Euphemia
1974	Lot 31, Conc. 5	Enniskillen	Enniskillen
1980	Lot 26-27, Conc. 2	Moore	St. Clair
1965	Pt. Lot 26 (W1/2), Conc. 11	Moore	St. Clair
unknown	Lot 22-23, Conc. 12, LaSalle Line	Moore	St. Clair
unknown	Lot 3, Conc. 9, Waterworks Rd	Moore	St. Clair
unknown	Lot 29, Conc. 6, Smith Falls Rd	Euphemia	Dawn-Euphemia
unknown	Lot 11, Conc. 11, Indian Creek Rd	Sombra	St. Clair
unknown	Lot 1, Conc. 5, Pointe Line	Sombra	St. Clair
unknown	Lot 2-3, Conc. 15	Sombra	St. Clair
(1997 –2000)	Lot 15, Conc. 11 (Old Walnut Rd)	Brooke	Brooke-Alvinston
<b>Chatham-Kent</b>			
1974	Baldoon Rd S. of Libby St.	Wallaceburg	Chatham-Kent
1974	Lot 4, Conc. 3	Camden	Chatham-Kent
1972	Lot 4, Conc. 3	Camden	Chatham-Kent
1971	Lot 1, Conc. 7	Camden	Chatham-Kent
1955	Lot 4, Conc. 4	Camden	Chatham-Kent
1965	Lot 3, Conc. 4	Camden	Chatham-Kent
unknown	Lot 23, Conc. 3	Chatham	Chatham-Kent

## 2.6.6 Mining/Aggregates

In general, the St. Clair Region Source Protection Area is considered to be aggregate poor since most of the deposits are small and have been largely depleted. These small deposits are situated within lacustrine beach deposits in the form of low relief ridges. There are sand deposits in Lambton Shores (formerly

Bosanquet), Enniskillen, Plympton, Sarnia and Warwick. Middlesex Centre has some aggregate resource areas identified in the Official Plan.

While there may be a limited supply of aggregate left in a few isolated pockets, the actual future extraction is dependent on nearby demand and access to transportation routes. Extraction is strongly discouraged in natural environment features with greater priority placed on retention of woodlands/natural areas versus aggregate extraction.

Salt mining operations have taken place in the Sarnia-Lambton area for over a century. The Empire Salt Company began salt mining operations in 1904 at the present Centennial Park in Sarnia. Solution mining for salt extracts high-purity brine used for human consumption and for the production of sodium and chlorine based chemicals. Most local brine production is now in connection with the construction and operation of subterranean caverns used for the storage of hydrocarbons.

### 2.6.7 Oil and Gas

Lambton County and southwestern Ontario have a long history related to the oil and gas industry as discussed earlier in the section on existing industries. **Map 26: Oil and Gas Wells** shows the concentration of wells across the SCRCA area. According to a 1996 study, Lambton County produced approximately 6-10% of the Province's total natural gas and 13-17% of its oil.<sup>170</sup> Chatham-Kent is the second largest producer of oil and gas in Ontario. As shown on **Map 26**, oil and gas production also extends into the Middlesex County portion of the SCRCA area.

Many of the historic oil wells obtained crude oil from a depth of less than 200 metres from rock formations of Devonian age. These oil wells were not subject to current regulations and standards which deal with exploration, operations and environmental concerns. The existence of improperly plugged abandoned oil wells and tanks in Enniskillen, Petrolia and Oil Springs is an environmental threat to surface water and groundwater resources. These abandoned wells are subject to current decommissioning requirements when they are found.

Salt caverns located approximately 600 metres below the surface are used by the petrochemical industries for the safe storage of hydrocarbons. While rock salt is soluble in water, it is quite insoluble in hydrocarbons.

Lambton County is also the location of important natural gas facilities, including subterranean gas storage pools and compressor stations along with pipeline distribution networks. Storage pools enable more economical pipeline shipping of gas from Western Canada during the summer months. In Ontario, there are 22 designated natural gas storage pools, 20 of which are active and these are situated in Lambton County. The total working storage capacity is approximately 5.9 billion cubic metres, comprising more than 60% of the total storage capacity in Canada.

### 2.6.8 Forestry

While forestry is often considered a Northern Ontario operation, the high values of some hard wood species have made woodlots in southwestern Ontario very valuable. Most private land forestry in southern Ontario uses a selective logging approach<sup>171</sup>. Sound silvicultural practices can ensure the long-term health of the woodlot while providing a source of income for the landowner. The reforestation of marginal farmland helps prevent erosion, filters run-off and retains soil moisture.

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<sup>170</sup> Manocha, J. and T. Carter. 1996. Underground Hydrocarbon Storage in Ontario. Petroleum Resources Centre, OMNR.

<sup>171</sup> Norri, Tod. To Cut or Not to Cut. OMNR, S & W Report Winter/Spring 2000 (Volume 18).  
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SCRCA staff members provide woodlot management and marking service to landowners. In 2006, 17 timber marks were completed for selective harvest and management plans were completed for 13 woodlots<sup>172</sup>. SCRCA has also completed a forestry survey of properties owned by the Authority and the St. Clair Region Conservation Foundation.

## **2.6.9 Transportation, Services, & Utilities**

### **2.6.9.1 Water, Rail, Road and Airports**

Southwestern Ontario has an excellent transportation network that provides connections across Canada, North America and the world. Much of the development, urban and industrial, can be traced to the availability of water transportation which was followed by rail and road. These continue to support industrial and commercial activities across the region. **Map 27: Transportation** provides an overview of the major rail and road transportation network for the Source Protection Area together with the significant port or docking facilities.

#### ***Water***

Water was the most important means of initial transportation for the municipalities along the St. Clair River. The gradual gradient in the Sydenham River also allowed accesses to both Wallaceburg and Dresden. Water transportation continues to be important for local industries providing connections to other ports on the Great Lakes and links to the world via the Seaway. The Sarnia harbour provides winter dockage for lake freighters.

There are a number of deep water ports or docking facilities along the St. Clair River in Lambton County. Shipping via the river is beneficial to local industries, particularly the agricultural sector shipping grain (Sarnia elevators) and the petrochemical industries. The petrochemical industries ship product, fuel freighters and receive large pieces of equipment. Industrial dock facilities are located along the river include Imperial Oil, Shell, Dow, Suncor and Lanxess.

The Ontario Power Generating Lambton Station has a coal receiving dock. Port facilities also exist at Courtright, Sombra and Mooretown. These are utilized for off-loading of aggregates from Manitoulin Island, Michigan and Ohio.

Ferry services at Sombra and Walpole Island offer international crossings. They primarily serve the recreational traveller.

#### ***Rail***

While passenger service is still provided, service has declined due to lower demand. Industries utilize the railway for transportation of materials, with the agricultural sector using the railway for farm product shipping from the Sarnia harbour elevators.

The Canadian National Railways mainline runs east-west across Lambton County through Strathroy-Caradoc to London and points east. It is a strategic route for CN as it includes the St. Clair River tunnel, which provides a direct link to Port Huron in the United States. This provides a direct link for the rail route leading to Chicago which is an important hub of the American railroad system.

Another important line, Canadian Pacific Railway line from London to Windsor, passes through the southeast portion of the Township of Dawn-Euphemia. Chesapeake and Ohio Railway operates a line that runs from Chatham to Sarnia, parallel to the St. Clair River. This provides rail transportation for petrochemical plants located along this corridor.

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<sup>172</sup> St. Clair Region Conservation Authority. 2006 Annual Report.  
Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

## ***Road***

Aside from Highway 402, which has four lanes, traffic volumes are generally handled by a system of two lane roads. A network of roads provides connections to all parts of the region.

Highway 402 is a very significant road in the St. Clair Source Protection Area. This multi-lane controlled access provincial highway runs from Highway 401 at London to the international crossing at Bluewater Bridge in Sarnia/Point Edward. It carries traffic east and west across the middle of Middlesex County and northern Lambton County.

The Bluewater Bridge at Sarnia is one of the busiest Canada-US border crossings. The bridge has recently been twinned, as the existing bridge had reached its design capacity. The Bluewater Bridge is actively promoted as one of the Canada-US links in the “NAFTA (North American Free Trade Agreement) Superhighway” system of a series of designated highways from Canada to Mexico.

**Table 2.6.9.1-1 Transportation Routes – St. Clair Region** provides a summary of major railways and roads in the region.

**Table 2.6.9.1-1:                    Transportation Routes - St. Clair Region**

<b>Provincial Highways</b>	<b>Location</b>
402	Sarnia to London
40	Sarnia to Chatham through Wallaceburg
21	Forest to Owen Sound through Grand Bend
<b>Former Highways</b>	<b>Location</b>
81	Mt Brydges to Grand Bend through Strathroy
80	Glencoe to Courtright through Brigden
21	Wyoming to Dresden
22 & 7	London to Sarnia through Warwick
79	Watford to Bothwell
<b>Railways</b>	<b>Location</b>
CNR	Sarnia tunnel to Toronto through London
C & O	Sarnia to Windsor through Chatham
CPR	London to Windsor through Chatham

## ***Airports***

There is one public airport in the City of Sarnia. The Sarnia Airport (Chris Hadfield airport) offers commuter flights to London and Toronto. The facility is seen as having significant capability for accommodating future expansions in activity and services. There are a number of private airstrips within the County.

### **2.6.9.2 Services & Utilities**

#### ***Electric***

A major thermal electric power generating station (Lambton Generating Station) is located in St. Clair Township. Ontario Power Generation owns the coal-fired station which has four units capable of producing 1,972 megawatts of power. A number of high voltage electric transmission corridors branch out from this station.

There are two proposals for natural gas-fuelled generating stations to be located in St. Clair Township. These projects are expected to supply 775 and 570 megawatts and to be in operation in 2008.

### ***Water***

Most of the population in the SCRCA area is supplied with piped potable water from municipal systems. Expansion of the water pipeline system throughout the rural area is continuing. A brief summary of the major water supplies is provided below. More information on drinking water sources is provided in Section 2.7 Water Uses.

The Lambton Area Water System supplies Lake Huron water to Point Edward, Sarnia, Aamjiwnaang First Nation, St. Clair, Pymptom-Wyoming, Warwick and Brook-Alvinston. Potable water is pumped through a network of over 250 km of pipeline that extends throughout much of Lambton County.

The Petrolia Water System supplies Lake Huron water to Petrolia, Enniskillen, Oil Springs, Dawn-Euphemia and Brook-Alvinston.

Several Chatham-Kent communities including Mitchell's Bay, Tuppersville and Dresden receive Lake Erie water via the Chatham Water Treatment Plant. Wallaceburg and area have a supply from a local plant taking water from the Chenal Ecarte. Bothwell receives potable water from the West Elgin (Tri-County) Water Supply System.

Strathroy receives Lake Huron water from a pipeline connection from the Grand Bend Water Plant.

Newbury obtains Lake Erie water from the West Elgin (Tri-County) Water Supply System.

The Bkejwanong Territory (Walpole Island First Nation) and the Chippewas of Kettle & Stony Point First Nation have water treatment plants taking water from the St. Clair River and Lake Huron.

### ***Oil & Natural Gas***

According to a 1996 study, Lambton County produced approximately 6-10% of the Province's total natural gas and 13-17% of its oil<sup>170</sup>. As well, large pipelines for the shipping of petroleum and petroleum products and natural gas pass through the county. Most of Lambton County is served by piped natural gas through local systems.

## **2.6.10 Wastewater Treatment**

### ***Sewage Treatment***

The larger urban centres in the St. Clair Region are serviced by municipal collection and wastewater treatment systems. Rural residents and people in smaller communities have private sewage disposal systems (septic tanks). **Table 2.6.10-1: Municipal Wastewater Treatment Facilities – St. Clair Region** lists the communities that are serviced by wastewater treatment facilities. Most of the population is included in the urban areas serviced by these wastewater treatment facilities.

**Table 2.6.10-1: Municipal Wastewater Treatment Facilities - St. Clair Region**

Municipality	Community	WWTP, Lagoons or Septic
City of Sarnia	Sarnia	WWTP (Wastewater Treatment Plant)
	Bright's Grove	Lagoons
Town of Petrolia	Petrolia	WWTP
Town of Plympton-Wyoming	Wyoming	WWTP
	Plympton- Lakeshore	WWTP
Village of Point Edward	Point Edward	WWTP
Township of St. Clair	Corunna	WWTP
	Mooretown	Serviced by Courtright WWTP
	Courtright	WWTP
	Sombra	Lagoons
	Port Lambton	Lagoons
	Brigden	Lagoons
Municipality of Lambton Shores	Forest	Lagoons
Township of Enniskillen	Oil City	Lagoons
Village of Oil Springs	Oil Springs	Lagoons
Township of Brooke-Alvinston	Alvinston	WWTP
Township of Warwick	Watford	Lagoons
Municipality of Chatham-Kent	Wallaceburg	WWTP
	Dresden	WWTP
	Mitchell's Bay	Lagoons
	Bothwell	Septic
Township of Strathroy-Caradoc	Strathroy	Lagoons
Village of Newbury	Newbury	WWTP
Township of Adelaide-Metcalf	Kerwood	Septic/sewer construction 2006

The locations of the municipal treatment facilities are shown on **Map 31: Wastewater Treatment**. Where there is a wastewater treatment facility, the boundaries of the municipally serviced areas approximate the urban/industrial lands.

The serviced lands along the Lake Huron shoreline and the St. Clair River shorelines are more extensive than the areas shown as urban/industrial lands on the map. Municipal sanitary sewers have been installed along the Lake Huron shoreline in Plympton-Wyoming and along most of the St. Clair River shoreline in St. Clair Township. These sewers service both the urban/industrial areas shown on the map and development between these areas.

In addition to municipal services, the major industrial plants that are located along the St. Clair River in the City of Sarnia and St. Clair Township have their own specialized wastewater treatment facilities to process industrial sewage prior to discharge to the river.

The areas that are not shown as urban/industrial land are serviced by private sewage systems.

***Stormwater Management***

Water that flows across impervious surfaces such as paved areas and enters surface water courses untreated is considered stormwater. It can be contaminated with various pollutants and the Ministry of the Environment issued a Stormwater Management Planning and Design Manual (March 2003). In general,

stormwater management is the responsibility of the lower tier government in a multi-tier municipal system and is a more significant concern in larger urban centres.

The City of Sarnia is the largest municipality in the SCRCA watershed. As part of their Official Plan<sup>173</sup>, the city has established several management principles to reduce the rate of stormwater runoff and to improve the quality of stormwater conveyed to watercourses. All new development will be required to provide site grading and outlet facilities for storm drainage in order to achieve no overall increase in the peak level and volume of stormwater runoff. This can include processes such as man-made wetlands. The construction of a stormwater management pond to serve a new subdivision in Sarnia has an additional conservation aspect with the support of a \$100,000 donation from the Suncor Energy Foundation. Soil excavated from the kilometre-long pond was contoured and vegetated to establish diverse habitats including tallgrass prairie and wetland. These habitats are more ecologically diverse than the monoculture turf grass normally planted around stormwater management ponds<sup>174</sup>.

## 2.6.11 Agriculture

Agriculture is the dominant land use in the SCRCA as shown in **Map 25: Generalized Land Cover**. With a growing season that averages 203 to 207 days in length, the region’s climate is very favourable and is considered part of the “breadbasket” area of Canada. Market conditions and soils have led to cash crop cultivation becoming the dominant land use. However, there is a wide range of specialty crops of tomatoes, fruits and vegetables as well as a variety of livestock operations from beef and dairy cattle to poultry and eggs. As shown on **Map 28: Land Capability for Agriculture**, most of the soils in the region are Class 1, 2 or 3 soils that are suitable for the sustained production of common field crops.

### 2.6.11.1 Agricultural Sector Distribution

Agricultural land use in the St. Clair Region Source Protection Area will be examined using Census Canada information<sup>175</sup>. There are three (Lambton, Middlesex and Chatham-Kent) Census Canada regions within the SCRCA watershed. Lambton County represents the largest area within the watershed, and is almost wholly (93%) contained within the region. The remaining watershed area consists of approximately 26% of the area of Chatham-Kent and 21% of Middlesex. The proportions of those regions that are within the watershed region are identified in **Table 2.6.11.1-1: Lands in SCRCA Census Regions**. Agricultural land use will be discussed based on the census regions only.

**Table 2.6.11.1-1: Lands in SCRCA Census Regions**

Census Region	Total area of Region (sq. km)	Area within SCRCA (sq. km)	% of total area within SCRCA
Lambton	3,002	2,780	93
Middlesex	3,333	679	21
Chatham-Kent	2,490	652	26
Total	8,825	4,129	

The amount and percentage of farmland for each of the census regions is shown in **Table 2.6.11.1-2 Farmland in SCRCA Census Regions**. Approximately 81% of the land in the Source Protection Region is farmland.

<sup>173</sup> City of Sarnia Official Plan, January 12, 2001, Office Consolidation as Amended July, 2006.

<sup>174</sup> Evergreen. [www.evergreen.ca/en/cg/sarnia-steward.html](http://www.evergreen.ca/en/cg/sarnia-steward.html).

<sup>175</sup> Ontario Ministry of Agriculture and Food. 2001 Census of Agriculture and Policy and Programs Branch.

**Table 2.6.11.1-2: Farmland in SCRCA Census Regions**

Census Region	Total area in Region (sq. km)	Farmland in Region (sq. km)	% Farmland in Region
Lambton	3,002	2,447	81
Middlesex	3,333	2,510	75
Chatham-Kent	2,490	2,235	90
Total	8,825	7,192	81

As shown in **Table 2.6.11.1-3: Agricultural Land Use in the SCRCA Census Regions**, cropland is the dominant use of farmland in the watershed.

**Table 2.6.11.1-3: Agricultural Land Use in the SCRCA Census Regions**

Land Use (hectares)	Lambton	Chatham-Kent	Middlesex	Total	% of Total Area of Farmland
Cropland	208,990	208,433	207,556	624,979	86.9
Summer fallow	197	114	249	560	.08
Improved pasture	5,453	2,646	8,472	16,571	2.3
Unimproved pasture	5,465	1,874	7,471	14,810	2.0
Other land	24,558	10,483	27,287	62,328	8.8
Total area of farms (ha)	244,663	223,549	251,035	719,247	100.0
Total area of Region (ha)	300,200	249,000	333,300	882,500	
Farmland as a % of total area	81.5	89.8	75.3		

**Table 2.6.11.1-4: Major Field Crops in SCRCA Census Regions** indicates that the majority of farmland is used for the cultivation of soybeans, corn and wheat. According to Kevin Mariott, Director of Ontario Soybean Growers, Lambton was one of the first counties to grow soybeans in Ontario in the 1930s and 1940s. Most of the soybeans are sold for commercial use; however approximately 10-20% are organically grown and processed into soy foods.

Most of the corn grown is also sold for commercial purposes. Two of the major customers are NewLife Feeds which makes livestock feed in Wyoming, and Casco which makes corn starch and sweeteners in Middlesex County. Recent construction of ethanol plants in Chatham-Kent and Lambton County also provide a market for local corn production.

Wheat is still a major crop that is commonly used as a rotation crop.

**Table 2.6.11.1-4: Major Field Crops in the SCRCA Census Regions**

Major Field Crops (ha)	Lambton	Chatham-Kent	Middlesex	Total	% of total area of farmland
Winter wheat	30,353	21,132	19,656	71,141	9.9
Oats for grain	931	255	1,092	2,278	0.3
Barley for grain	648	94	1,131	1,873	0.2
Mixed grains	121	8	1,018	1,147	0.2
Corn for grain	40,632	66,729	69,500	176,861	24.6
Corn for silage	3,116	1,686	5,333	10,135	1.4
Hay	9,106	2,241	17,764	29,111	4.0
Soybeans	112,709	99,272	72,586	284,567	39.6
Dry white beans	526	913	2,015	3,454	0.5
Flue cured tobacco	81	979	0	1,060	0.1
Potatoes	0	110	57	167	0.02
Total area of major field crops	198,223	193,419	190,152	581,794	100.0

### 2.6.11.2 Livestock Density

In addition to crop cultivation, a proportion of farmland is allocated to the raising of livestock. **Table 2.6.11.2-1: Livestock in SCRCA Census Regions** outlines the livestock population in the three SCRCA census regions. These three regions have over 20% of the Ontario turkey and swine production. Hog production is cost-efficient due to the reliable supply of locally-grown feed grain. Transportation costs are also reduced due to proximity to the U.S. border where half of the hogs are exported<sup>176</sup>.

**Table 2.6.11.2-1: Livestock in the SCRCA Census Regions**

Livestock	Lambton	Chatham-Kent	Middlesex	Total	% of total Ontario population
Dairy cows	6,650	611	11,766	19,027	5.2
Beef cows	8,100	1,744	11,568	21,412	5.7
Steers	12,700	5,604	20,063	38,367	11.5
Total cattle and calves	47,950	15,364	91,446	154,760	7.2
Total pigs	254,400	182,699	281,677	718,776	20.8
Total sheep and lambs	8,100	1,001	13,046	22,147	6.5
Total hens and chickens	1,226,924	254,042	2,021,175	3,502,141	8.0
Total turkeys	208,784	58,263	491,520	758,567	22.3

### 2.6.11.3 Trends in Agriculture

Over the last 50 years, a significant trend in the agriculture industry has been the conversion from a mixed land use (livestock pasture and crop cultivation) to crop cultivation land use. **Table 2.6.11.3-1: Land Use** shows this trend.

<sup>176</sup> Sarnia-Lambton Economic Partnership website, Agriculture Profile, August 2006, [www.sarnialambton.on.ca](http://www.sarnialambton.on.ca)  
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**Table 2.6.11.3-1: Land Use**

<b>Land Use</b>	<b>Percentage of total in 1960</b>	<b>Percentage of total in 2001</b>
Cropland	47%	85%
Pasture	52%	5%
Miscellaneous	1%	10%

Also, in more recent years, agricultural land use activity has focused on farm acreage consolidation. Larger acreage is needed in order to render farms viable from a crop cultivation standpoint. In some instances, more land is acquired for the purposes of waste management practices and policies associated with livestock production. To prevent conflicts between non-farm rural residents and agricultural activity on prime agricultural lands, most municipalities have adopted policies preventing the severance of agricultural lands.

## **2.6.12 Recreation**

There is a wide range of recreational opportunities in the area. In particular, the clean, blue waters of Lake Huron, the St. Clair River and Lake St. Clair together provide a focus for summer activities. Travel guides and brochures display examples of the blue waters typical of Lake Huron and other local beaches. The shallow waters of Lake St. Clair in Chatham-Kent also provide swimming, fishing and boating activities.

The extensive beach development along Lake Huron in the Grand Bend area attracts many tourists. Although Pinery Provincial Park, Port Franks and Grand Bend are outside the SCRCA, this major tourism anchor creates fringe/spin-off tourism opportunities along the more southern Lambton shoreline communities (e.g. trailer parks, cottages, smaller public beach areas, golf courses, etc.).

Recreational boating is continuing to grow in popularity. There are over 1,500 boat slips in public and private marinas along the Lake Huron, St. Clair River and Lake St. Clair shorelines. The State of Michigan has one of the highest concentrations of boat owners in the United States and boaters from Michigan utilize Canadian marinas and services. Good sport fishing opportunities are provided by Lake Huron, the St. Clair River and Lake St. Clair. Motorized boats can travel the Sydenham River to Tupperville most of the year.

Many of the municipal parks along the St. Clair River were established as part of the former St. Clair Parks Commission's network of parks. These parks are day use green areas that provide vistas to the St. Clair River. There are several other waterfront parks along the lake and river. Riverfront festivals are held throughout the year in some of these waterfront parks. A list of waterfront parks is provided in **Table 2.6.12-1: Waterfront Parks in SCRCA**.

**Table 2.6.12-1: Waterfront Parks in SCRCA**

<b>Park</b>	<b>River or Lake</b>
Sarnia Bay Marina	St. Clair River
Sarnia Centennial Park	St. Clair River
Alexander Mackenzie Park	St. Clair River
Seaway Centre	St. Clair River
Guthrie Park	St. Clair River
Mooretown Centennial Park	St. Clair River
Courtright Waterfront Park	St. Clair River
Willow Park	St. Clair River
Seager Park	St. Clair River
Cathcart Park	St. Clair River
Lambton-Cundick Park	St. Clair River
Sombra Park	St. Clair River
Reagan Park	St. Clair River
Marshy Creek Park	St. Clair River
Port Lambton Park	St. Clair River
Brander Park	St. Clair River
Highland Glen Conservation Area	Lake Huron
C. J. McEwen Conservation Area	Lake Huron
Mitchell's Bay Beach	Lake St. Clair

Scuba diving is a recreation activity popular under the Bluewater Bridge, where sunken boats are situated and the water clarity is good. Pleasure cruises are offered by a number of boat operators. The international ferry service at Sombra and Walpole Island provides tourism opportunities for West Lambton.

In addition to the water related activities, there is a wide range of other recreation opportunities including bird watching, hiking, golfing, cross country skiing, and other sports.

## **2.6.13 Protected Areas**

Specific areas are protected from developmental changes that could alter the natural character. This protection is designated through federal, provincial and local initiatives. Depending on the degree of protection, “protected” areas are not likely to change over time and will encounter minimal human disturbance.

### **2.6.13.1 Municipal Official Plans - Protection of Natural Environmental Features**

In general, municipal official plans provide an initial source of information on significant natural environmental features and the level of protection provided to these areas. Information from the Official Plans for Lambton, Chatham-Kent and Middlesex is summarized below.

#### ***Lambton***

The Lambton County Official Plan identifies a Natural Heritage System that includes a combination of significant natural areas, their functions, and the corridors that connect them. The system is portrayed in **Figure 2.6.13-1: Natural Heritage System - Lambton County** and the features are divided into three groups:

- Group A – No development is permitted
  - Provincially significant wetlands
  - Significant portions of the habitat of threatened and endangered species

- Group B – Development may be permitted if it can be demonstrated that no negative impacts on the features or their associated ecological functions will result
  - Lands adjacent to Group A features
  - Primary corridors, including anchors
  - Fish habitat
  - Significant woodlands
  - Significant valley lands
  - Significant wildlife habitat
  - Areas of Natural and Scientific Interest (ANSIs)
  - Locally significant wetlands
  - Other significant natural areas
- Group C – local official plans will address controls on development
  - Linkage areas
  - Secondary corridors

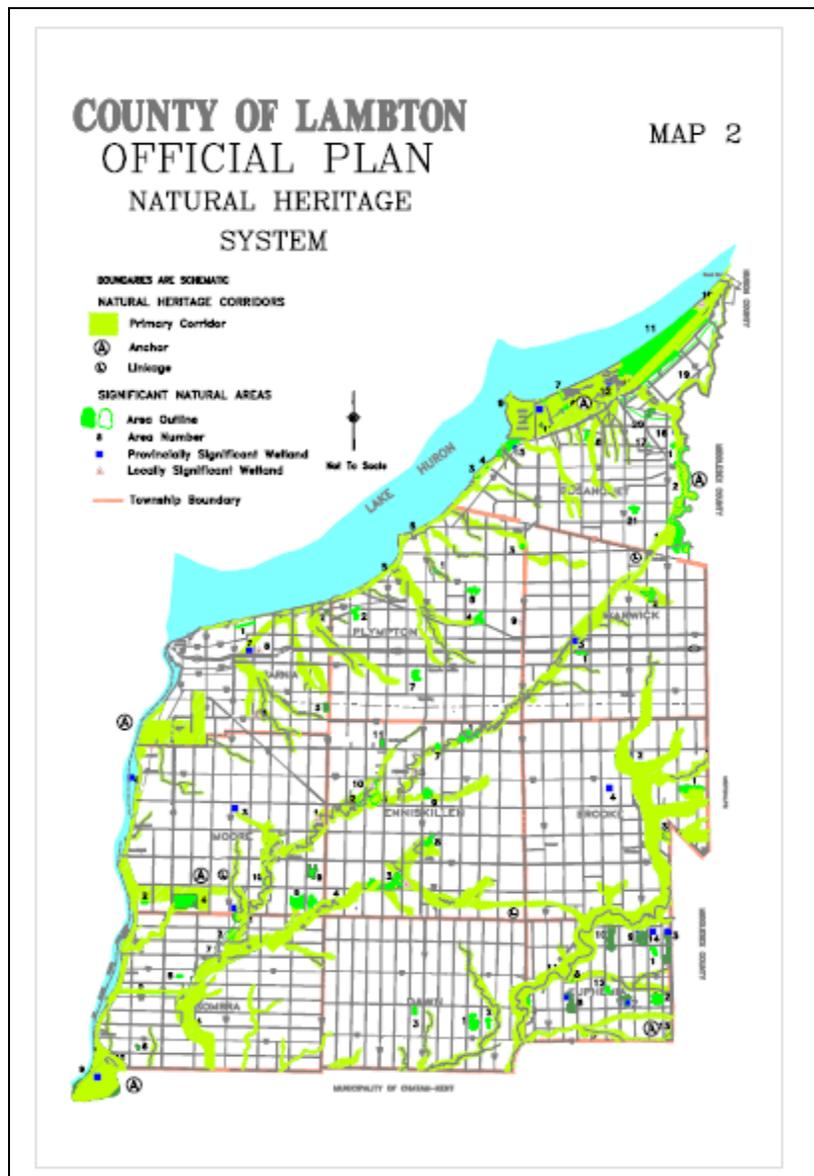


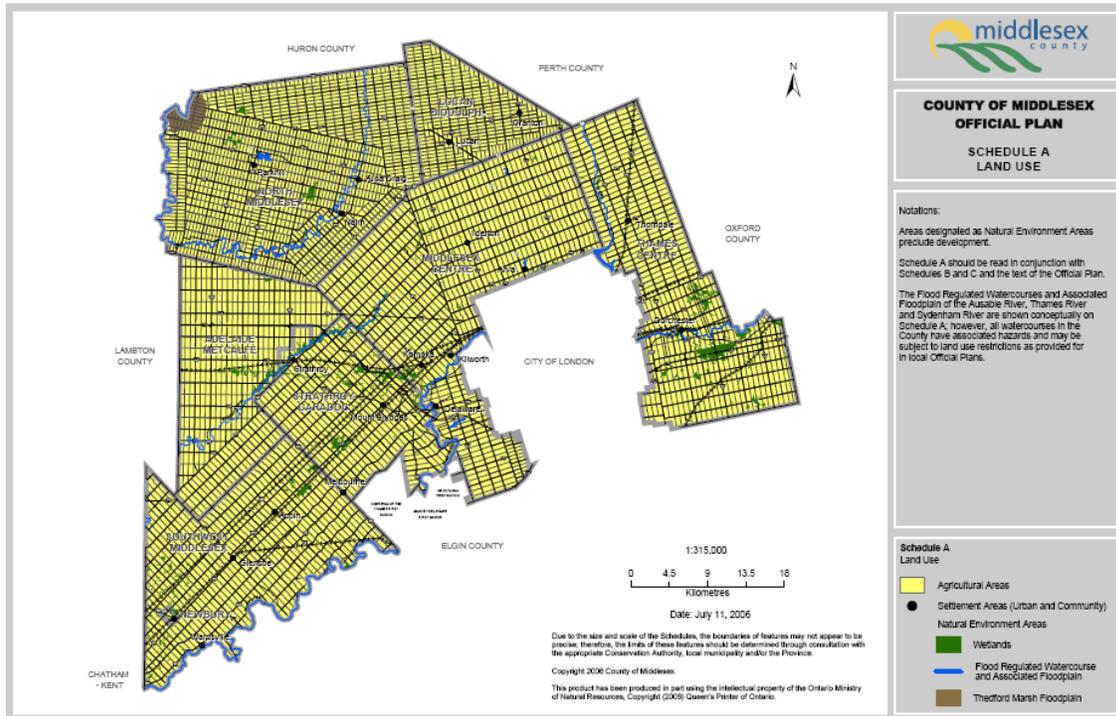
Figure 2.6.13-1: Natural Heritage System - Lambton County<sup>177</sup>

### *Middlesex*

The County of Middlesex Official Plan<sup>178</sup> identifies features that are important parts of the ecosystem. The features identified as part of the Natural Environmental Areas designation on **Figure 2.6.13-2: Schedule A Land Use – Middlesex County** preclude development. As such, these features have restrictive Official Plan policies associated with them. This designation includes wetlands, flood regulated watercourses and associated flood plains.

<sup>177</sup> Lambton County Official Plan.

<sup>178</sup> Middlesex County Official Plan, Adopted by County Council September 9, 1997, Amended by Official Plan Amendment No. 2, July 11, 2006.

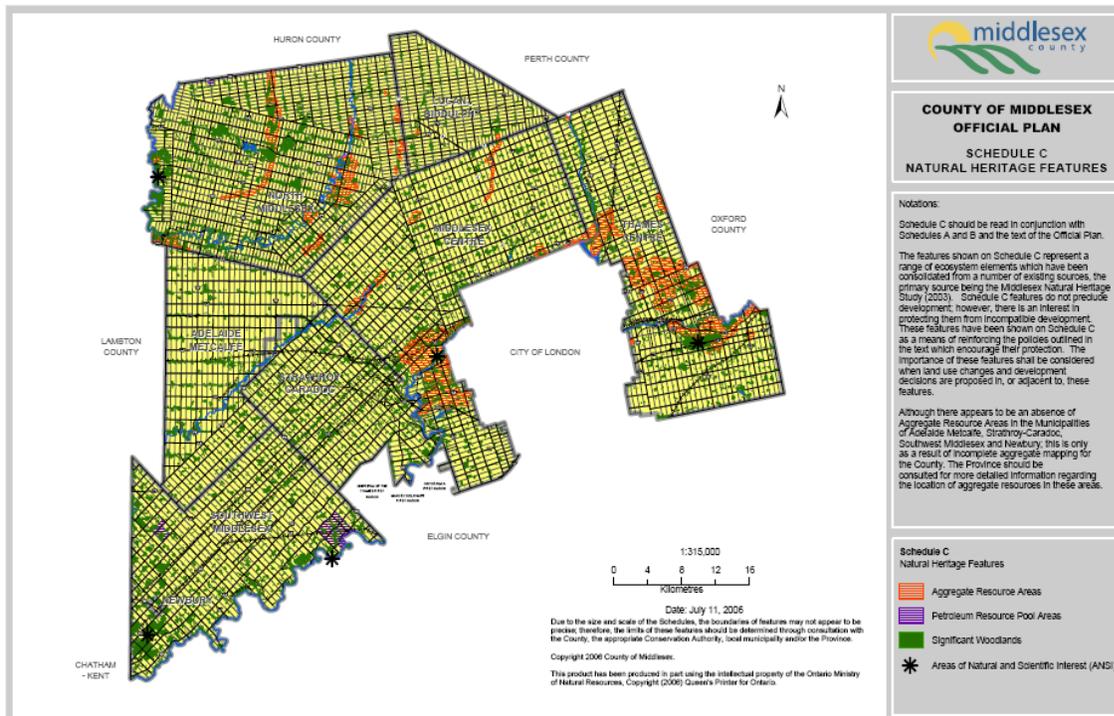


**Figure 2.6.13-2: Schedule A Land Use - Middlesex County**

In addition to the features identified in Schedule A, a wide range of ecosystem elements are identified in **Figure 2.6.13-3: Schedule C Natural Heritage Features – Middlesex County**. While Schedule C features do not preclude development, there is an interest in protecting them from incompatible development. A Development Assessment Report (DAR) is required when there is an application for development within a Natural Heritage Feature or within the adjacent lands of the elements as identified in **Table 2.6.13-1: Areas Subject to Development Assessment Report – Middlesex County**.

Natural heritage features include:

- Significant woodlands
- Wildlife habitat
- Endangered and threatened species habitat
- Aquatic ecosystems including fish habitat
- River, stream, ravine and upland corridors
- Areas of Natural & Scientific Interest (ANSIs)



**Figure 2.6.13-3: Schedule C Natural Heritage Features - Middlesex County**

**Table 2.6.13-1: Areas Subject to Development Assessment Report (DAR) - Middlesex County**

Natural System Element	Development Adjacent to Natural System Element	Development Within Natural System Element
Wetlands and adjacent lands within 120 m of an individual wetland or land connecting individual wetlands within a wetland complex	DAR required within 120 m	Not Permitted
Significant habitat of endangered or threatened species	DAR required within 100 m	Not Permitted
Flood plains and flood prone areas mapped and/or regulated by a Conservation Authority	DAR required within 50 m	Not Permitted
Significant woodlands and ANSI's as identified on Schedule 'C'	DAR required within 50 m	DAR Required
Significant wildlife habitat	DAR required within 50 m	DAR Required
Significant valley lands	DAR required within 50 m	DAR Required
Fish habitat	DAR required within 30 m	DAR Required

### **Chatham-Kent**

The Chatham-Kent Official Plan<sup>179</sup> includes a Natural Heritage System that is based on the Community Strategic Plan Objective of Sustaining and Enhancing Environmental Assets. The System identifies:

- Lands where natural heritage features will be protected from development and site alteration through an “Open Space and Conservation” designation

<sup>179</sup> Chatham-Kent Official Plan, Adopted January 10, 2005.

- Lands and natural heritage features where an Environmental Impact Statement (EIS) is needed before any development or site alteration can proceed
- Policies for lands adjacent to natural heritage lands to ensure that negative impacts do not occur
- Natural corridors and linkages to be considered in any future development or site alteration

No development or site alteration is permitted in natural heritage features such as Provincially Significant Wetlands and Significant Portions of the Habitat of Endangered, Threatened and Vulnerable Species. An Environmental Impact Statement is required for development on land adjacent to these areas. Chatham-Kent is host to 11,500 hectares of Provincially Significant Wetlands along Lake St. Clair including the St. Clair National Wildlife Area, which has been identified as a Globally Important Bird Area.

Natural Heritage Features where an Environmental Impact Statement is required include Fish Habitat, Significant Woodlands, Significant Areas of Natural and Scientific Interest and Features of Local Significance.

### **2.6.13.2 Significant Protected Areas**

There are a number of nationally, provincially and locally significant environmental areas in the SCRCA watershed. The control or ownership of these properties often provides an additional degree of protection.

A small part of the St. Clair National Wildlife Area (the 41 hectare Bear Creek property) is in the SCRCA watershed. It is owned by Environment Canada and is a part of the Eastern Lake St. Clair Important Bird Area. The St. Clair National Wildlife Area is also included in the International Ramer Convention on Wetlands. This treaty is intended to conserve wetlands and the resources in them.

The Bkejwanong Territory (Walpole Island First Nation) is the home of a rich mosaic of areas with one of the largest wetland systems in the Great Lakes basin. Rare tallgrass prairie, oak savannah and Carolinian forest are also part of the natural areas remaining as part of the St. Clair delta. Over 50 nationally rare and endangered wildlife species make the Bkejwanong (where the waters divide) their home.

The Aamjiwnaang First Nation on the St. Clair River retains approximately 70% of its natural forest cover and thus, has one of highest percentages of woodland cover in the St. Clair Region.

The Bickford Oak Woods is a 308 hectare property located in St. Clair Township in Lambton County. It was acquired through funds raised by the Ontario Government, Nature Conservancy of Canada, Rural Lambton Stewardship Network and the Sydenham Field Naturalists. Title was transferred to the Ontario Ministry of Natural Resources shortly after acquisition to be regulated as a conservation reserve. It is the largest inland clay forest in the Carolinian life zone outside of First Nation lands<sup>180</sup>.

The St. Clair Region Conservation Authority and the St. Clair Region Conservation Foundation own more than 1,800 hectares of land including wetlands, forests, campgrounds, day use parks and beaches along Lake Huron. Upstream of the McKeough Floodway, SCRCA owns 746 hectares of land. Over the years, erosion prone and other lands have been planted with trees, shrubs and tallgrass prairie. Today, 343 hectares are forested.

SCRCA also manages properties on behalf of the County of Lambton including the Perch Creek Habitat Management Area which includes the buffer lands for the former Sarnia landfill site.

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<sup>180</sup> Carolinian Canada. The Big Picture: Cores and Connections in Carolinian Canada.  
[www.carolinian.org/ConservationPrograms\\_BigPicture.htm](http://www.carolinian.org/ConservationPrograms_BigPicture.htm)

## 2.6.14 Data Gaps Human Characterization

The current information base does not allow for detailed mapping of settlement areas, designated growth areas, rural areas, urban residential development, rural residential, cottage and camp development, industrial/commercial sectors distribution. **Map 25** only shows four general land use categories: agriculture, urban/industrial, recreational and woodlands.

Future land use and development cannot be easily mapped although it is discussed in Section 2.6.3.

## 2.7 Water Uses

Within the St. Clair Region Source Protection Area, numerous human activities benefit from a substantial supply of water. Ecosystems also rely on water to support habitats that contain a variety of aquatic and non-aquatic species.

Municipalities draw from surface water and groundwater sources to supply treated water to the public, businesses and industries. Individuals and businesses in rural communities may rely on groundwater wells for drinking water. Large industries take water directly from a source for cooling, washing and other plant operations. Agricultural businesses use water to irrigate crops and nourish livestock. Golf courses, a component of the commercial business sector, are dependent upon a reliable supply of water for irrigation. The water bodies also support other important recreational activities and a variety of ecological systems throughout the watershed.

### 2.7.1 Drinking Water Sources

In general, treated surface water delivered via pipeline is the main source of drinking water for the residents within the watershed. Groundwater serves as an important source for the region's rural residents that use private wells but it is only used as a source by one municipal piped water supply.

#### 2.7.1.1 Groundwater - Municipal, Private and Regulation 252 Wells

##### *Municipal*

In the St. Clair Region Conservation Authority watershed, only the community of Mount Brydges in the Municipality of Strathroy-Caradoc still has a municipal water supply system that uses a groundwater source.

The wells supplying Mount Brydges are located outside the St. Clair Region watershed as shown in **Map 33: Wellhead Protection Areas**. The map also shows the wellhead capture zones for the wells that previously supplied Strathroy. The capture zones are based on a groundwater study<sup>181</sup> completed in 2001.

Until recently, municipal wells also serviced the former Town of Strathroy and the Village of Newbury. However, these systems changed to surface water supplied via pipelines. Strathroy now receives water from Lake Huron and Newbury has a supply from Lake Erie.

##### *Private*

Private wells are found across the watershed in rural areas and in small hamlets. These wells are individually owned and maintained. The wells supply untreated groundwater or groundwater that receives limited treatment through residential water treatment systems to local residents. **Map 29: Water Wells** shows the locations of wells based on Ministry of the Environment water well records. Most of these wells would supply individual homes, farms or rural businesses.

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<sup>181</sup> International Water Consultants. June 2001. Strathroy-Caradoc Groundwater Management Study. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

The Ministry of the Environment provided funding for basic groundwater studies. These groundwater studies were completed on a county basis and provide good information resources for the region. However, watersheds cross county borders and the data needs to be re-calculated on a subwatershed basis for the region.

In Middlesex County, groundwater remains a significant drinking water source for rural residents in the northeastern portion of the St. Clair Region. The breakdown of drinking water sources by population on a watershed basis is undetermined but percentage of the population on private groundwater wells is shown in **Table 2.7.1.1-1 Summary of Potable Water Source by Municipality for Middlesex County**.

**Table 2.7.1.1-1: Summary of Potable Water Source by Municipality for Middlesex County**

Municipality	Percent of Population on Municipal Surface Water	Percent of Population on Municipal Groundwater Wells	Percent of Population on Private Groundwater Wells
Middlesex Centre	20%	22%	58%
Adelaide-Metcalf	0%	0%	100%
Southwest Middlesex	41%	0%	59%
Strathroy-Caradoc	76%	0%	24%
Newbury	100%	%	0%

The Middlesex-Elgin Groundwater Study<sup>182</sup> ranked the Strathroy-Caradoc aquifer as highly susceptible and vulnerable to contamination. A Class Environmental Assessment (EA) for Long Term Water Supply Screening Report for Strathroy was completed by BM Ross and Associates in 2004. The problem statement described in the Class EA identifying the issues related to the groundwater supply in Strathroy is as follows:

*The capacity of the Strathroy Water Works will soon be fully utilized. Existing supplies are also experiencing problems related to increasing nitrate concentrations, decreasing water table levels and iron and manganese associated aesthetic issues which have been aggravated by the need to increase chlorine residual concentrations. These factors all increase the risk of losing part of the source of supply. Further, there is the need to make substantial improvements to the system to meet the requirements of O. Reg. 170/03.*

Due to the issues discussed in the problem statement, in 2006 the Township of Strathroy-Caradoc changed the supply of their drinking water from local groundwater to surface water from Lake Huron at Grand Bend.

In the Municipality of Chatham-Kent and the County of Lambton, many rural residents obtain their domestic water supplies from municipal water systems that have extended service into the rural parts of the community. The remaining rural residents have private wells.

In Lambton County, a history of poor quality brackish groundwater as well as low well yield resulted in the development of extensive (municipal) pipelines serving rural residents. The historical evolution of water use in Lambton County is summarized by Husain<sup>183</sup>. Due to the extensive water pipeline network in Lambton County, it was reported that water well drilling in Lambton County almost ceased in the 1990s.

<sup>182</sup> Dillon Consulting and Golder Associates. July 2004. Middlesex-Elgin Groundwater Study, Final Report.

<sup>183</sup> Husain, M.M. 1996. Origin and Persistence of Pleistocene and Holocene Water in a Regional Clayey Aquitard and Underlying Aquifer in Part of Southwestern Ontario.

For Lambton County, the distribution of the different types of wells utilized is summarized in **Table 2.7.1.1-2: Distribution of Wells by Municipality for Lambton County**. Bedrock wells tend to dominate in most municipalities. Most overburden wells are located in Lambton Shores. **Map 29: Water Wells** shows the distribution of the water wells.

**Table 2.7.1.1-2: Distribution of Wells by Municipality for Lambton County<sup>1</sup>**

Municipality	Number of Wells	
	<i>Overburden</i>	<i>Bedrock</i>
Township of Brooke-Alvinston	169	396
Township of Dawn-Euphemia	168	598
Township of Enniskillen <sup>2</sup>	69	425
Municipality of Lambton Shores	485	340
Town of Plympton-Wyoming	88	576
City of Sarnia <sup>3</sup>	50	282
Township of St. Clair	193	616
Township of Warwick <sup>4</sup>	180	518

<sup>1</sup> This table includes population outside of the region

<sup>2</sup> Includes the Village of Oil Springs and Town of Petrolia

<sup>3</sup> Includes the Village of Point Edward

<sup>4</sup> Includes wells on the north side of County Road 12, now in Lambton Shores, previously in Warwick Township

The Essex/Chatham-Kent Regional Groundwater Study<sup>184</sup> completed in 2004 indicates that 24% of the residents of Chatham-Kent have self water supply. It also estimates that volume of groundwater use is approximately 18% of the overall water use while surface water use is 82%. Pipelines being installed by the municipality are probably reducing the number of people using private wells.

### ***Regulation 252/05***

Ontario Regulation 252/05 came into effect on June 30, 2005 and applies to water systems serving facilities that have non-residential or seasonal uses. Under an intended transfer of responsibility from the Ministry of the Environment to the Ministry of Health and Long-Term Care, it is anticipated that public health units will oversee these small drinking-water systems.

The categories of drinking water systems being transferred include:

- Large municipal non-residential, such as municipally owned airports, industrial parks, sports facilities and recreation complexes
- Small municipal non-residential, such as small community centres, libraries, sports and recreation facilities
- Non-municipal seasonal residential, such as private cottages on communal drinking water systems
- Large non-municipal, non-residential, such as large motels and resorts
- Small non-municipal, non-residential, such as motels, restaurants, gas stations, churches, bed and breakfasts

Systems serving designated facilities, such as schools, day care facilities, children's camps, etc., would not be affected by this bill and would remain regulated by the Ministry of the Environment.

At the time this report was being prepared, the transfer was in transition and exact information on the number and location of Reg. 252/05 facilities in the St. Clair Region Source Protection Area was not

<sup>184</sup> Dillon Consulting and Golder Associates. December 2004. Essex Region/Chatham-Kent Region Groundwater Study Volume I: Geologic/Hydrogeologic Evaluation. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

available. However, the location of these facilities would be similar to the private water wells discussed previously.

It is estimated that there would be less than 300 of the Reg. 252/05 systems in the St. Clair Region Source Protection Area. This estimate is based on information from local health units and the percentage of each municipality in the St. Clair Region. Most of these would be in the Middlesex County part of the watershed. The groundwater sources for the systems would follow the pattern of overburden and bedrock wells shown in **Map 29: Water Wells**.

### **2.7.1.2 Surface Water Intakes**

Surface water is the primary source of drinking water for residents within the St. Clair Region Source Protection Area. **Map 30: Drinking Water Supplies/Intakes** shows the locations of surface water intakes for the St. Clair Region. Raw water from lakes and rivers is treated in water treatment plants and passed on through pipelines to residents throughout the region. The water is taken from Lake Huron, the St. Clair River and Lake Erie. There are six municipal water treatment plants that supply water to communities in the Source Protection Area. Three of these plants are located outside the watershed. There are also two water treatment plants in the watershed that supply First Nation residents.

**Table 2.7.1.2-1: Municipal Drinking Water Sources in the St. Clair Region** shows a breakdown of the drinking water supplies for the local municipalities in the Source Protection Area. Water from the Great Lakes has replaced sources of surface water taken from smaller local watercourses. The inland communities of Dresden in Chatham-Kent and Alvinston in Lambton have recently replaced their Sydenham River water supply with piped water from Lake Erie (Dresden) and Lake Huron (Alvinston).

**Table 2.7.1.2-1: Municipal Drinking Water Sources in the St. Clair Region**

County	Municipality	Water Source	Water Supply System	Population** serviced by Public Water
Lambton <sup>185</sup>	City of Sarnia	Lake Huron	Lambton Area Water Supply System (LAWSS)	95%
	Town of Petrolia	Lake Huron	Petrolia Water Treatment Plant	100%
	Town of Plympton-Wyoming	Lake Huron	LAWSS	83%
	Village of Point Edward	Lake Huron	LAWSS	100%
	Township of St. Clair	Lake Huron	LAWSS	100%
	Municipality of Lambton Shores*	Lake Huron	LAWSS (& Lake Huron Primary Water Supply System*)	70%
	Township of Enniskillen	Lake Huron	Petrolia	71%
	Township of Dawn-Euphemia	Lake Huron	Petrolia	31%
	Village of Oil Springs	Lake Huron	Petrolia	99%
	Township of Brooke-Alvinston	Lake Huron	LAWSS	41%
Township of Warwick	Lake Huron	LAWSS	49%	
Chatham-Kent <sup>186</sup>	Municipality of Chatham-Kent*	Chenal Ecarte	Wallaceburg Water Distribution System	76%
		Lake Erie	Chatham Water Treatment Plant West Elgin WTP	
Middlesex <sup>187</sup>	Township of Strathroy-Caradoc*	Lake Huron	Lake Huron Primary Water Supply System (LHPWSS)	76%
		Groundwater	Mount Brydges wells	
	Municipality of Southwest Middlesex*	Lake Erie	West Elgin WTP	41%
	Village of Newbury	Lake Erie	Elgin Water Treatment Plant	100%
	Township of Adelaide-Metcalf*	Groundwater	Private wells	0%
	Municipality of Middlesex Centre*	Groundwater	Municipal and private wells	42%
Lake Huron		LHPWSS		
Lake Huron		LHPWSS		

\* This table includes municipal population outside the St. Clair Region Watershed

\*\* People that do not have piped public water obtain drinking water from private groundwater wells.

The majority (88%) of residents in Lambton County obtain their domestic water supplies from municipal water systems. Piped surface water usage ranges from 100% in some municipalities to 31% in the Township of Dawn-Euphemia. The Lambton Area Water Supply System and the Petrolia Water Treatment Plant both take water from Lake Huron and distribute treated water across the county.

<sup>185</sup> Figures taken from Dillon Consulting and Golder Associates. 2004. Lambton County Groundwater Study.

<sup>186</sup> Figures taken from Dillon Consulting and Golder Associates. 2004. Essex/Chatham-Kent Regional Groundwater Study Vol. 1.

<sup>187</sup> Figures taken from Dillon Consulting and Golder Associates. Middlesex - Elgin County Groundwater Study.

All three First Nations have piped treated surface water supplies as summarized in **Table 2.7.1.2-2: First Nation Drinking Water Sources**. The Aamjiwnaang First Nation utilizes Lake Huron water from the Lambton Area Water Supply System. The Chippewas of Kettle & Stony Point First Nation water treatment plant takes water from Lake Huron. The Bkejwanong Territory (Walpole Island First Nation) WTP draws water from the South Channel of the St. Clair River.

**Table 2.7.1.2-2: First Nation Drinking Water Sources in the St. Clair Region**

First Nation	Water Source	Water Supply System	Population Served
Aamjiwnaang First Nation	Lake Huron	LAWSS	100%
Chippewas of Kettle & Stony Point First Nation	Lake Huron	Chippewas of Kettle & Stony Point FN WTP	100%
Bkejwanong Territory (Walpole Island First Nation)	South Channel (St. Clair River)	Bkejwanong Territory (Walpole Island FN) WTP	100%

In Chatham-Kent, it is estimated that about 76% of the population is supplied with municipal water. In the St. Clair Region part of Chatham-Kent, the community of Wallaceburg uses treated surface water taken from the Chenal Ecarte (St. Clair River). The communities of Dresden, Mitchell’s Bay, and Tupperville are supplied with water taken from Lake Erie via the Chatham Water Treatment Plant. Bothwell is supplied with water taken from Lake Erie from the West Elgin Water Treatment Plant via the Tri-County Water System.

In Middlesex County, urban areas such as the former town of Strathroy are supplied with piped municipal water from a recently installed connection to the pipeline from Lake Huron Primary Water Supply System. The Village of Newbury and the Municipality of Southwest Middlesex obtain Lake Erie water from the Tri-County Water Supply System.

The Lambton Area Water Supply System (LAWSS) located in Sarnia/Point Edward treats Lake Huron water and supplies the majority of residents in Lambton County with drinking water. Treated water from LAWSS is distributed to the Village of Point Edward, City of Sarnia, Aamjiwnaang First Nation, Municipality of Lambton Shores and the Townships of St. Clair, Plympton-Wyoming, Warwick, Enniskillen and Brooke-Alvinston.

The Petrolia Water Treatment Plant (WTP), which was established in 1896, has its intake located in Lake Huron at Bright’s Grove in the City of Sarnia. The Petrolia WTP supplies potable water to the Town of Petrolia and other Lambton area municipalities including the Township of Enniskillen, Village of Oil Springs and Township of Dawn-Euphemia and portions of Brooke-Alvinston, Sarnia, St. Clair and Plympton-Wyoming.<sup>188</sup>

The Wallaceburg Water Treatment Plant has an intake located in the Chenal Ecarte channel of the St. Clair River near Wallaceburg. This plant supplies water to the residents in the community of Wallaceburg in Chatham-Kent.

The Bkejwanong Territory (Walpole Island First Nation) Water Treatment Plant takes water from the South Channel of the St. Clair River. This plant supplies water to Bkejwanong Territory (Walpole Island First Nation) residents and community buildings.

The Chippewas of Kettle & Stony Point First Nation Water Treatment Plant takes water from Lake Huron at Kettle Point.

<sup>188</sup> Town of Petrolia. 2004. Town of Petrolia Bright’s Grove Water Treatment Plant Annual Report, 2004. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

In Chatham-Kent, raw water is pumped from an intake in Lake Erie to the Chatham WTP which treats the water and distributes the treated water across the municipality. This system supplies water to the communities of Dresden, Mitchell's Bay, and Tupperville.

The Lake Huron Primary Water Supply System (LHPWSS) is another significant source of treated surface water for municipalities in the region. The LHPWSS water intake and treatment plant are located just north of Grand Bend on the shore of Lake Huron. Drinking water is supplied to Strathroy-Caradoc, Middlesex Centre, and Lambton Shores.

The Village of Newbury has piped water from Lake Erie supplied by the Tri-County Water Supply System which receives water from the Elgin Water Treatment Plant with an intake from Lake Erie south of Eagle in Elgin County.

## 2.7.2 Ecological Water Use

The St. Clair Region has a wide variety of water bodies and watercourses ranging from Lake Huron to small intermittent streams. The region also covers a transitional area between the Carolinian and the Lower Great Lakes-St. Lawrence forest zones. As a result there are many different types of habitat and ecological systems including open water communities, wetlands, river channel communities, abandoned river channel communities, upland forests, residual tall grass prairie and transitional zones of scrub, savannah, meadows, marshes and beaches. The different habitats, combined with a climate moderated by the Great Lakes, results in biodiversity of native flora and fauna.

The Sydenham River supports an astonishing diversity of aquatic species. At least 34 species of mussels and 80 species of fish have been found there. Many of these are rare and were discussed at greater length in Section 2.5 Aquatic Ecology.

The amount of water necessary to meet ecological requirements in the St. Clair Region is undetermined. An assessment of the ecological needs will be undertaken as part of the Water Budget.

## 2.7.3 Permit To Take Water (PTTW) Uses

Water takers have the responsibility to ensure that the amount of water they use does not threaten the environment or existing water users. To enforce this principle, water takings in Ontario are governed by the Ontario Water Resources Act (OWRA) and the Water Taking and Transfer Regulation (O. Reg. 387/04) a regulation under the OWRA Act. Section 34 of the OWRA requires any one taking more than a total of 50,000 litres of water per day to acquire a Permit to Take Water (PTTW).<sup>189</sup>

*“The purpose of the PTTW program is to ensure the conservation, protection and wise use and management of waters of the province. Permits are controlled and not issued if the taking of more water in a given area would adversely affect existing users or the environment.”*

Permit holders draw water for a variety of applications from both groundwater and surface water sources. **Map 15: Permit to Take Water Locations by Type** shows the locations of water takers that have water taking permits in the St. Clair Region watershed and **Map 16: Permit to Take Water Locations by Usage** shows the various types of water takers.

On the eastern side of the region, there are a concentrated number of permits (most of which derive their water from the ground) in the headwaters of the East Sydenham River near Strathroy for a variety of agricultural irrigation uses. The same is true for the North Sydenham River where several groundwater water taking permits are located near the headwaters of Bear Creek.

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<sup>189</sup> Ontario Ministry of the Environment. Guide to Permit to Take Water Manual. April 2005.  
Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

In the lower southwestern portion of the region, water takers draw their water from surface water (rivers and streams). Many agricultural and commercial (golf course) water users store runoff water during the spring in ponds for application later in the summer. Along the shores of Lake Huron, Lake St. Clair and the St. Clair River, the permits are mainly surface water taking permits with few groundwater usages.

Some water takings that are exempt from the requirement to obtain a permit include takings by an individual for ordinary household purposes, water takings for the direct watering of livestock or poultry, or for firefighting purposes.

A Ministry of the Environment Director issues a permit that establishes the maximum amount of litres permitted per day and the number of takings allowed per year. Other aspects of the permit may include seasonal restrictions and the time of day in which takings may occur. The permit may also require a monitoring program. Generally, for surface water takings, the user must not take more than 10% of the total flow at the point of taking. Thus, a requirement to know the value of the stream flow at the time of taking is usually included for new and renewed permits.

The Ministry collects water taking permit information and stores the information in a database. The number of permits for various water taking purposes (as listed in the MOE database) in the watershed is summarized in **Table 2.7.3-1: Number of Water Taking Permits**. A total of 524 PTTWs were listed in the database for the St. Clair Region in 2003. Past permits only set limits for the maximum water taking per day. Therefore, it is difficult to determine how much water each sector actually uses.

As of January 1, 2005, new requirements have been introduced that require permit holders to collect, record and submit daily taking volumes to the Ministry on an annual basis. Permit holders, such as large consumptive water users, covered under Phase 1<sup>190</sup> must begin collecting and recording the data starting on July 1, 2005. Phase 2 and 3 permit holders will also eventually be required to measure, record and submit takings. These phases combined will cover all permit holders.

Many of the permits that are still listed in the database have expired dates beside them and it is unclear if these permits have been renewed. As water taking data is recorded, more representative water use values for the various sectors in the watershed will be available.

The quantity of water used by each sector has not been estimated as part of the Watershed Characterization Report as the assessment work will be part of the Water Budget Report.

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<sup>190</sup> Ontario Ministry of the Environment. October 2005. Technical Bulletin: Permit to Take Water – Phase 1 Monitoring and Reporting. Phase 1 permit holders are outlined in this bulletin, and generally include large consumptive takings such as drinking water, beverage manufacturing, certain aggregate processing plus others. Watershed Characterization Report - St. Clair Region Source Protection Area - Volume 1

**Table 2.7.3-1: Number of Water Taking Permits by Sector in the St. Clair Region<sup>191</sup>**

Water Taking Sector	Water Use	Number of Permits	Percent of Total Permits
Agricultural	Field and Pasture Crops, Fruit Orchards, Market Gardens/ Flowers, Nursery, Other - Agricultural, Sod Farm, Tender Fruit, Tobacco	264	57%
Commercial	Aquaculture, Bottled Water, Golf Course Irrigation, Mall/ Business, Other - Commercial, Snowmaking	27	6%
Construction	Other - Construction, Road Building	33	7%
Dewatering	Construction, Other - Dewatering, Pits and Quarries	16	4%
Industrial	Aggregate Washing, Cooling Water, Food Processing, Other - Industrial, Pipeline Testing, Power Production	26	6%
Miscellaneous	Dams and Reservoirs, Heat Pumps, Other - Miscellaneous, Pumping Test, Wildlife Conservation	40	9%
Recreational	Aesthetics, Other - Recreational, Wetlands	8	2%
Water Supply	Campgrounds, Communal, Municipal, Other - Water Supply	47	10%

A brief discussion of the recreational, agricultural and industrial/commercial uses is provided in the following sections.

## 2.7.4 Recreation

Recreational activities across the St. Clair Region include: fishing, boating, swimming, and aesthetic appreciation.

Fishing occurs in Lake Huron, Lake St. Clair and the St. Clair River as well as virtually all other watercourses in the region. There are two impediments (dams) to fish passage on the Sydenham River at Strathroy and at Coldstream but fishing activities continue upstream of both structures.

Both commercial and recreational vessels move through the region primarily along the St. Clair River, Lake St. Clair and Lake Huron. There are several marinas and boat launches in the region. In addition to the marinas and public docks, numerous private facilities and docks located along the shoreline give cottage and homeowners the ability to use the waterways in the watershed.<sup>192</sup> On the Sydenham River, the municipal docks at Wallaceburg have facilities to accommodate over 150 transient boats. The upper portions of the Sydenham River are limited to non-motorized use.

In general, there are good swimming opportunities in the region but in certain areas, swimming may be limited due to water quality. Lake Huron provides the majority of beach areas for the region. Additional swimming opportunities exist along the St. Clair River and Lake St. Clair.

Open water viewing areas such as parklands and watercourse road crossings maintain a recreation quality from the aesthetic viewpoint.

Tourism is the third largest economic sector in Sarnia-Lambton and the second largest sector in terms of jobs<sup>193</sup>. It is estimated that in 2002, over 7,000 jobs could be attributed to tourism and annual revenues are approximately \$250 million. More than 3.5 million person-visits were made to Sarnia-Lambton in 2002.

<sup>191</sup> Ontario Ministry of the Environment. Permit to Take Water database.

<sup>192</sup> Lake St. Clair Canadian Watershed Coordination Council. 2005. Lake St. Clair Canadian Watershed Draft Technical Report: An examination of current conditions.

<sup>193</sup> Sarnia Lambton Training Board. Profile 2006-2007 – Life in Sarnia-Lambton Summary.

While the exact amount of revenue and number of jobs directly related to water-based activities is not available, the area's abundant waters and variety of recreation help to attract tourists to the region.

Chatham-Kent is a premier fishing destination and Mitchell's Bay in Chatham-Kent is one of the few musky lakes in existence<sup>194</sup>. It is a popular choice for professional and recreational anglers from around the world. The sport is year-round with an excellent supply of perch during winter providing good ice fishing on Mitchell's Bay. Several marina facilities have ramps that accommodate boats of various sizes. As well, there are boat repair centres and sporting goods stores. Experienced charter companies and guide services are also available to take anglers to areas where fish are abundant.

The amount of water required for recreational water use has not been estimated for the region.

## 2.7.5 Agricultural

In general, irrigation of cash crops, such as corn and soybeans, is not practiced in the region. However, two noteworthy agricultural areas are the sand plains near Strathroy in Middlesex County and a muck deposit in the southwestern portion of the region in the former Dover Township part of Chatham-Kent.

The majority of Middlesex County within the St. Clair Region is comprised of sand plains that promote the production of tobacco, ginseng, and a variety of farm market vegetables. Most of these farms undertake some form of irrigation. The significant muck deposit in former Dover Township is suitable for growing fruits and vegetables which are also irrigated using surface water and groundwater.<sup>195</sup>

Surface and ground sources of water are critical to the viability of specialized farming operations in the St. Clair Region. Crops such as tobacco, ginseng and market crops including potatoes, beets, carrots and tomatoes are irrigated. Water sources for this irrigation include groundwater and surface water taken directly from watercourses or from storage ponds. A substantial percentage of the water permits are used for market crops. In addition, livestock and poultry operations, which do not require a permit, also use significant amounts of water.

Agricultural water used for irrigation and in livestock and poultry operations has not been monitored in the region and as a result, the amount of water use required by agriculture is undetermined for the St. Clair Region Source Protection Area. However, groundwater studies provide some estimates for agricultural water usage in Lambton County, Middlesex County and the Municipality of Chatham-Kent as summarized in **Table 2.7.5-1: Agricultural Water Use**. While the table includes areas that are outside the St. Clair Region, it helps to show the differences in agricultural water usage across the region.

**Table 2.7.5-1: Agricultural Water Use (m<sup>3</sup>/yr)\***

Municipality	Number of Farms	Livestock Watering	Field Crops	Fruit Crops	Vegetable Crops	Specialty Crops	Total
Chatham-Kent	2,299	840,754	927,806	315,456	1,257,748	355,611	3,697,375
Lambton	2,346	1,625,661	79,143	243,621	918,217	172,566	3,039,208
Middlesex	2,515	2,551,461	856,073	347,628	82,723	2,013,392	5,851,278

\*Figures taken from the Essex/Chatham-Kent Region Groundwater Study, the Lambton County Groundwater Study and the Middlesex-Elgin Groundwater Study.

<sup>194</sup> Chatham-Kent website, Explore Fishing in Chatham-Kent, [www.chatham-kent.ca/recreation](http://www.chatham-kent.ca/recreation)

<sup>195</sup> Ridgetown College, University of Guelph, Economics Research Group, August 2002. Agricultural Economic Impact and Development Study for Chatham-Kent.

## 2.7.6 Industrial/Commercial

The focus of industrial activities in the St. Clair Region is found in Sarnia's 'Chemical Valley'; an area located along the St. Clair River. A large number of petrochemical and refinery facilities are located in the City of Sarnia and St. Clair Township. These and other industrial facilities within the watershed use (surface) water for industrial cooling as well as in other plant processes.<sup>196</sup>

In the commercial sector, water for irrigation of golf courses is a significant water usage. Water sources for this golf course irrigation in the St. Clair Region include groundwater, surface water from ponds and directly from watercourses.

Industrial and commercial water uses for the St. Clair Region Source Protection Area have not been determined.

## 2.7.7 Water Use Comparison

The Draft Conceptual Water Budget for the Thames-Sydenham and Region provides some comparisons of estimates for municipal, agricultural and unserved domestic annual water uses. For the Conceptual Water Budget, the St. Clair Region was split into two subwatershed catchments. The 'Sydenham' subwatershed catchment area consisting of the Main Sydenham, the East Sydenham and the Lake St. Clair drainage areas. The 'Bear Creek' subwatershed catchment consists of the North Sydenham drainage plus the watercourses flowing into Lake Huron and the St. Clair River.

The estimated water use is summarized in **Table 2.7.7-1: Estimated Annual Water Use** based on information taken from the June 7, 2007 Version 2.0 of the Draft Conceptual Water Budget<sup>197</sup>.

**Table 2.7.7-1: Estimated Annual Water Use in mm/Watershed Area**

Sub Watershed	Water Use Sector					Total
	Municipal Surface Water	Municipal Groundwater	Private Groundwater	Livestock Watering	Crop Irrigation	
Bear Creek	11	0	0.3	2	3	16.3
Sydenham	3	0	0.5	2	4	9.5

The estimates provided in **Table 2.7.7-1** are based on a number of assumptions provided in the Draft Conceptual Water Budget. A more detailed review of water use is underway as part of the Tier 1 Water Budget which is being prepared for the St. Clair Region.

<sup>196</sup> Dillon Consulting and Golder Associates. 2004. Lambton County Groundwater Study.

<sup>197</sup> Thames-Sydenham and Region Source Protection Region. June 7, 2007. Thames-Sydenham and Region Draft Conceptual Water Budget, Version 2.0 Final Draft.