WATERSHED CHARACTERIZATION REPORT

Niagara Peninsula Source Protection Area

Made possible with support by the Government of Ontario

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Table of Contents

TABLES

Tables - continued

FIGURES

Figures – continued

APPENDICES

1.0 INTRODUCTION

In 2002, Justice Dennis O'Connor released his report on the results of the Walkerton Public Inquiry, which probed the causes of the Walkerton contaminated water tragedy. The report outlined several recommendations related to the protection of drinking water in Ontario. One important recommendation was to use a multi-barrier approach, where source (water) protection (SP) is considered the first barrier in ensuring safe drinking water. With respect to SP, the report stated that the protection and enhancement of natural systems is one of the most effective ways of ensuring the safety of Ontario's drinking water. Consequently, in October 2006, the Ontario provincial government passed the Clean Water Act (CWA). The purpose of the legislation is to protect existing and future sources of drinking water throughout the province. The Clean Water Act is just one of a number of major steps that the government has taken to ensure drinking water in Ontario is safe.

The Clean Water Act provides a process for achieving protection of drinking water sources, which is watershed based, uses a science-based approach, and is locally administered. This Watershed Characterization report is one of several technical studies and reports required under the process outlined in the CWA. Initially the Ontario Minister of the Environment (MOE) provided a set of draft guidance modules (MOE 2006b) to provide direction on how the technical studies should be completed. These draft guidance modules were superseded by the Assessment Report Technical Rules and Ontario Regulation 385/08, which were released in November and December 2008. Although the guidance modules were superseded, they still offer a good deal of detailed information and discussion not shown in the AR Rules and Regulation, and thus are useful background information. A list of the technical guidance modules and associated reports is provided in Table 1.1.

1.1 Background on the SWP Program

Under the CWA, the area of jurisdiction for each Conservation Authority (CA) is generally designated the drinking water source protection area and the CA acts as drinking water Source Protection Authority. Where it was deemed advisable by the province, several Source Protection Authorities in a given area have been combined to form a Source Protection Region. For example the Hamilton and Halton Conservation Authorities have been combined to form the Hamilton-Halton SP Region with Halton as the lead Authority. The designated Source Protection Regions in Ontario as outlined in the Clean Water Act are shown in Appendix E (Item 1).

The Niagara Peninsula Conservation Authority has not been combined with any other CAs to form a Source Protection Region. Figure 1.1 shows the jurisdiction of the Niagara Peninsula Source Protection Area.

Each Source Protection Authority (SPA) was required to establish a Source Protection Committee (SPC), which is ultimately responsible for the preparation of an Assessment

Report, Terms of Reference, and the Source Protection Plan as prescribed in the Clean Water Act. These documents will ultimately be submitted to the province for review and approval by the MOE.

Conservation Authorities as the SPAs are expected to play a key role in the preparation of the Assessment report which will include a number of technical studies and reports. For example, in the NPSP Area the Watershed Characterization and the Water Budget analysis has been largely completed by the Source Protection staff at the Conservation Authority, while the municipalities were responsible for municipal drinking water supply studies, such as the delineation of Intake Protection Zones (IPZs) and Well Head Protection Areas (WHPAs).

The purpose of the Watershed Characterization report is to provide an overview description of the watershed. In preparation of this report, currently available information was collected, organized, and summarized, and an analysis of the data and knowledge gaps was undertaken. The work undertaken for this report has been funded by the Ministry of Environment (MOE) and Ministry of Natural Resources (MNR), under the Source Water Protection program. The Watershed Characterization report is one of several reports/studies that have been completed as part of the development of the 'Assessment Report'.

The Watershed Characterization Report provides a base level of information that was used in several subsequent source protection studies, such as the Conceptual Water Budget Study, and the Surface Water Vulnerability Studies.

1.2 Niagara Peninsula Source Protection Authority

The Niagara Peninsula Source Protection Area (NPSP Area) is located between Lake Ontario and Lake Erie, and consists of the same jurisdiction as the Niagara Peninsula Conservation Authority (NPCA). The NPCA jurisdiction is 2,424 square kilometres in size (km^2), and contains an estimated population in 2006 of about 465,000[1]. The NPCA jurisdiction covers all of the Regional Municipality of Niagara (Regional Niagara) and approximately 20% of the City of Hamilton and 25% of Haldimand County. There are also 12 second tier municipalities located within Regional Niagara (Figure 1.1).

1.2.1 Surface Water

The NPSP Area watersheds can be divided into three main drainage areas, which are;

- Lake Ontario Drainage area;
- Niagara River (and Welland River) Drainage area; and
- Lake Erie Drainage area.

[1] This current population was prorated from the 2001 Census Canada data and rounded to nearest 5,000. The NPCA Groundwater Study (WHI 2005) indicated NPCA population was 448,231 in 2001.

Each of these major drainage areas contains several subwatersheds. Significant watersheds in the Ontario drainage system include Forty Mile Creek, Twelve Mile Creek, and Twenty Mile Creek. The Welland River watershed as well as several smaller watersheds are included in the Niagara River drainage area, while the Lake Erie drainage area contains several small watersheds. The NPSP Area also encompasses 117 km of Great Lakes shoreline, of which 67 km are located on Lake Erie and 50 km are located on Lake Ontario.

Surface waters in the NPSP Area have the following primary functions:

- Provide fish habitat and other ecosystem functions;
- Municipal drinking water supplies via Lake Ontario, Lake Erie, Welland Canal, Welland River, and Niagara River;
- Recreational uses such as rowing, canoeing, fishing and swimming;
- Irrigation water for agricultural operations and golf courses;
- Industrial/commercial uses; and
- Water for hydroelectric power generation via Great Lakes waters (i.e. Adam Beck, DeCew Falls, and Port Dalhousie generating stations).

1.2.2 Groundwater

Within the NPSP Area groundwater resources have two distinct functions (NPCA, 2002):

- to serve as a significant supply of rural residential and agricultural water; and
- to augment dry weather river flows and sustain wetland ecosystems

While there are no operational municipal groundwater wells supplying municipalities within the NPSP Area, it is estimated that about 15% of residents rely on private wells or as a source of drinking water. Many of these residents depend on highly sensitive groundwater systems such as the Fonthill Kame-Delta Complex and the Onondaga Escarpment, which are susceptible to impacts from development (NPCA, 2002).

Some of the groundwater concerns in the NPSP Area include (NPCA, 2002):

- Increasing demand from fruit and vegetable growers for irrigation water;
- Potential impact on groundwater quantity and quality due to large scale aggregate extractions and oil/gas exploration in some parts of the watershed;
- Potential risks from improperly constructed, maintained and abandoned wells;
- Potential contamination and security of aquifers and individual wells;
- Contamination problems with wells tapping vulnerable shallow bedrock and overburden aquifers; and
- Potential contamination from sources such as septic systems, agricultural applications (e.g. fertilizer, herbicides, pesticides), road salts, and landfill sites.

1.2.3 Human Activities

Anthropogenic (or human/man-made) activities have shaped and impacted the NPSP Area in significant ways. At the time of European settlement, the Niagara Peninsula is assumed to have been mostly covered by forests, until the land was cleared by settlers for agricultural purposes. There were significant impacts as a result of the changes in vegetative cover report (Section 4.0). Since 1829, the construction of the four Welland Canals has also impacted the peninsula's surface water systems. Each new route contained improvements to the canal system resulting in increased shipping capacity while maintaining land transport. Another major man-made impact resulted from the construction of the Adam Beck Generating Station and the construction of the power canals, which transport water from the mouth of the Welland River to the generating station.

Notable man-made structures that have had an impact on the water resources within the Niagara Peninsula include:

- The Welland Canal, which begins in Port Colborne on Lake Erie and ends in Port Weller, St. Catharines on Lake Ontario. The canal contains 7 locks and three tunnels (having dewatering operations). The fourth canal (also called the *new canal*) is the one currently used for shipping;
    1. Townline (road and rail) tunnel under the Welland Canal;
    2. East Main Street (road) tunnel under the Welland Canal; and
    3. Thorold (road) tunnel under the Welland Canal.
- The 'Old' Welland Canal (also called the third canal or Welland Recreational Canal) passes through downtown Welland, and is now used only for recreation;
- The Welland River siphons at the old and new Welland Canals;
- Binbrook Dam;
- Virgil Dam;
- Oil and Gas Wells (that are mostly located in the southwest portion of the NPSP Area and are potential conduits for vertical contaminant movement, Figure 5.5);
- Hydroelectric water supply tunnels, channels, and intake structures on the Niagara River and the mouth of the Welland River used for the Adam Beck Hydro Electric Generating Station;
- DeCew Hydro Electric Station;
- Lake Gibson system, including the associated intake channels and retaining dykes and Lake Moodie; and
- Port Dalhousie Hydroelectric Dam on Twelve Mile Creek.

1.2.4 Niagara Peninsula Conservation Authority (NPCA) History

The NPCA was established in 1959, under The Conservation Authorities Act, through the efforts of local conservation clubs and local county councils. At the time, the population in the Niagara Region was slightly more than 300,000 and has currently increased to approximately 465,000. Involvement in water management was not a key concern for the

Authority initially but became so several years after its foundation. Today the NPCA maintains and manages 34 conservation areas in addition to 4 active conservation areas that host special events and offer educational and recreational activities. The NPCA has jurisdiction over one of the most complex watersheds in the Province, an area whose general land use is considered primarily agriculture.

The following list denotes historical dates and significant events for the NPCA:

- In 1969 the Niagara Peninsula Conservation Foundation, a registered charity, was established with the goal of assisting the NPCA through fundraising efforts for conservation projects and programs.
- Niagara River Remedial Action Plan (RAP) came into existence in 1987 in an effort to restore and protect the environmental integrity of the Niagara River. The long-term project began after the Niagara River was designated as an Area of Concern (AOC) in the Great Lakes basin by the International Joint Commission (IJC).
- In 2002 the Authority acquired Morgan's Point Conservation Area in Wainfleet.
- 2004 marked the beginning of the Provincial Groundwater Monitoring Network (PGMN) which set forth to determine current and historic surface and groundwater trends.
- 2 significant properties were obtained in 2004. The first was the "Smith-Ness Forest" in Niagara Falls consisting of 72 acres of environmentally significant property. The second property comprises a 12 kilometre stretch along the former Grand Trunk Railway corridor and Lake Erie shoreline in the Town of Wainfleet. In 2007 the trail was renamed the "Gord Harry Conservation Trail" in honour of the NPCA's former Chairman Gord Harry.
- Ontario introduced the Clean Water Act in 2005 and appointed the Conservation Authority the agency responsible for coordinating Source Protection Plans.
- In 2005, 23 acres of environmentally significant land adjacent to the E.C. Brown Conservation Area was purchased. The floodplain property was developed into a meadow and wetland habitat, complete with trails, signs, and parking, and opened in 2008.
- 2006 launched the 3 year long Natural Areas Inventory (NAI) Study.
- In 2008 the Memorandum of Understanding (MOU) between the Region, the local municipalities and the NPCA was fully implemented.
- The Centre for Conservation was constructed at Balls Falls and opened in May of 2008.

The mandate of the NPCA is to establish and undertake programs designed to further the conservation, restoration, development and management of natural resources. The NPCA fulfills this mandate by advocating and implementing programs that:

- Improve the quality of lands and waters within its jurisdiction;
- Contribute to public safety through flooding and erosion protection programs;
- Provide for the acquisition of conservation and hazard lands; and

- Enhance the quality of life in its watershed by using its lands for regional recreation, heritage preservation and conservation education.

The NPCA aims to accomplish this through promoting an ecosystem approach to watershed management activities, and partnering with local communities to further the work of conservation. The key areas for NPCA involvement include Watershed and Land Management.

Watershed Management programs include:

- Floodplain and hazard land management by means of regulations to control development in flood and erosion hazard areas;
- Flood forecasting and warning, and the operation of a number of dams and weirs for low flow augmentation and flood control, and water recreation purposes[2];
- Input and review on plans for subdivisions, property severances, official plans and zoning by-laws, and additional planning services with the Regional Niagara, the City of Hamilton and the Haldimand County;
- Stormwater management;
- Watershed restoration programs;
- Water quality monitoring; and
- Coordination of the implementation of the Niagara River Remedial Action Plan.

With respect to Land Management, NPCA owns approximately 2,833 hectares (7,000 acres) of natural and environmentally significant land including portions of the Niagara escarpment lands, provincially significant wetlands and woodlots. These lands are managed for recreation, heritage preservation and conservation education opportunities.

Key studies and initiatives undertaken in whole or in part by NPCA that directly relate to Source Water Protection include:

- Niagara Water Quality Protection Strategy (NWQPS) now called Niagara Water Strategy (NWS), which is a joint initiative by the NPCA and the Regional Municipality of Niagara (Regional Niagara);
- 12 Mile Creek and 20 Mile Creek Watershed Management Plans under an initiative to prepare management plans for all the watersheds in the NPCA jurisdiction;
- Watershed Restoration program and Water Quality Monitoring program;
- Niagara River Remedial Action Plan (a joint initiative by the Canadian federal and Ontario provincial governments); and
- NPCA Groundwater Study.

Further descriptions of these studies and others are provided in Appendix A.

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[2] NPCA operates the Binbrook dam, and the Upper and Lower Virgil dams, as well as maintains about a dozen weirs and dykes.

1.2.5 Natural Areas Inventory (NAI)

The Natural Areas Inventory (NAI) Project involved creating an up-to-date data base and mapping of natural areas through field collection of natural vegetation data within the NPCA watershed. The 3 year project was a cooperative effort supported by Government, local Non-Governmental Organisation's (NGOs) and community landowners, clubs, and volunteers. Field work was completed according to Ecological Land Classification (ELC) as well as Ontario Wetland Evaluation System (OWES) protocols. Presently, field work is complete and analyses and interpretation of the data is being conducted by the contribution writers. The results of the study will provide a scientifically defensible baseline for use in planning decisions and policy development and also as baseline knowledge for future inventory work. Furthermore, this solid resource of information will aid in the development of greater environmental awareness within the community and the prioritization of restoration opportunities. This study began in April of 2006 and will be complete by December of 2009.

1.3 Stakeholders

NPCA has several watershed network partners that will likely participate in the SP program. These partners include:

- Local municipalities (listed in Section 1.3.1);
- Provincial Government;
- Federal Government; and
- Interested stakeholders, engaged public and non-governmental organizations (NGOs).

1.3.1 Municipalities

NPCA has endeavoured to form close relationships and project partnerships with regional and local municipalities. The three "Tier 1" municipalities that are located in the NPCA jurisdiction are:

1. Regional (Municipality of) Niagara: Regional Niagara covers an area of approximately 1,850 km^2, and has a population of 434,347[3]. It makes up 75 % of the NPCA area of jurisdiction, and is the most densely populated of the upper tier municipalities in the NPCA. All of Regional Niagara is located within the NPCA watershed. Twelve lower tier municipalities are located within Regional Niagara. Major urban population centres in Regional Niagara include St. Catharines, Niagara Falls and Welland. Municipal drinking water in Regional Niagara is obtained entirely from surface water sources, which include the Niagara River, Welland Canals, Lake Ontario and Lake Erie.

[3] Based on 2001 Census Canada data prorated to 2006 by Niagara Economic Development Corporation

NPCA has partnered with Regional Niagara on several conservation initiatives. The Niagara Water Quality Protection Strategy (NWQPS) is an example of a project where NPCA worked with Regional Niagara and Ontario Ministry of Environment in a major long-term water quality protection strategy.

2. City of Hamilton: The City of Hamilton is approximately 1,146 km^2 in size, of which an estimated 237 km^2 (21%) is located in the NPCA area of jurisdiction. The population located in this portion of City of Hamilton is estimated to be 19,422 of which 7,769 are estimated to be located in a rural setting (WHI, 2005, Table 4.1, pg 4-2). There are no Tier 2 municipalities within City of Hamilton.

3. Haldimand County: Haldimand County contains an estimated 301 km^2 of land within the NPCA, and a population of 5,625 within the NPCA boundaries (WHI, 2005, Table 4.1, pg 4-2). No Haldimand County urban areas are situated within the NPCA boundaries. There are no tier 2 municipalities in this county.

The NPCA contains twelve lower tier municipalities, all of which are located in Regional Niagara (Figure 1.1). They include:

The Town of Grimsby is located between the Niagara Escarpment and Lake Ontario and has a population of 21,297 (WHI, 2005, Table 4.1, pg. 4-2). Urban areas account for 18% (MacViro Consultants, 2003b) of the land use and include the village of Grimsby. Municipal water is supplied by the Grimsby Water Treatment Plant (WTP).

The Town of Lincoln is located along Lake Ontario and has a population of 20,612. Urban areas include the villages of Beamsville, Vineland and Jordan. Land use is primarily agricultural, and north of the escarpment the main agricultural crops include tender fruit and grapes for wine due to the unique climate and soil conditions. Vineland and Jordan receive municipal water supplied from the St. Catharines DeCew Falls WTP, while Beamsville is supplied by the Grimsby WTP.

The City of St. Catharines is the most urbanized municipality in the NPCA and over 63% of its area is urban (MacViro Consultants, 2003b). It is also considered the financial hub of the Niagara Peninsula and has an estimated population of 129,170. Municipal water is supplied from the DeCew Falls WTP which is supplied with raw water from the Welland Canal.

The City of Thorold is located immediately south of St. Catharines and has a population of 18,048. The urban areas in the municipality are located adjacent to the St. Catharines boundaries. Significant future residential development is expected to occur in Thorold in the next 20 years. Municipal water is supplied from the DeCew Falls WTP.

The Town of Niagara-on-the-Lake (NOTL) is located at the mouth of the Niagara River and contains the villages of St. Davids, Virgil, NOTL, and Queenston. It has a population of 13,839. Municipal water is supplied by watermain from the St. Catharines DeCew Falls WTP.

The City of Niagara Falls is located along the Niagara River above the Niagara Escarpment. It has a population of 78,815 and is one of the more urbanized municipalities with about 38% of the city being urban land. Niagara Falls municipal water is supplied from a WTP located on the Niagara River at the mouth of the Welland River.

The Town of Fort Erie is located on Lake Erie at the Niagara River. Fort Erie has a population of 28,143 of which approximately 23,806 are located in urban areas (WHI, 2005, Table 4.1, pg 4-2). Fort Erie contains the villages of Crystal Beach, Fort Erie, Stevensville, and Ridgeway. Municipal water is supplied by the Rosehill Water Treatment Plant which is located along the Lake Erie shoreline in Fort Erie.

The City of Welland is mostly urbanized with 94% of the 48,402 (WHI, 2005, Table 4.1, pg 4-2) population residing in urban areas. Approximately 55% of the land in Welland is urban. Welland municipal water is supplied from the WTP located on the Welland Recreational Canal near downtown Welland (MacViro, 2003b).

The City of Port Colborne is located on Lake Erie at the start of the Welland Canal, and contains significant areas designated for future development. It has a population of 18,450. A WTP located at the start of the Welland Canal supplies municipal water to the urban area. A Wastewater Treatment Plant (WWTP) is located along the Welland Canal downstream of the Port Colborne urban area.

The Town of Pelham is located near the centre of the peninsula and has a population of 15,272. The largest urban area in Pelham is the village of Fonthill. Municipal water for Fonthill is currently supplied from the Welland WTP. (Two Fonthill municipal groundwater wells are no longer used for water supply).

The Township of Wainfleet is located west of Port Colborne, between the Welland River and Lake Erie. It is primarily a rural/agricultural community and has a population of just 6,258. There are no significant urban areas in Wainfleet.

The Township of West Lincoln is the largest of the Tier 2 municipalities in terms of land area (383 km^2), and is mostly rural/agricultural. West Lincoln has a population of 12,268. Smithville, the only urban area located in West Lincoln, is supplied with municipal water via a watermain from the Grimsby WTP.

1.3.2 Provincial Agencies

Ontario Ministry of Environment (MOE)

The MOE is currently committed through a signed agreement with the NPCA for the coordination of the Niagara River Remedial Action Plan (RAP). The MOE provides project coordination and financial contributions to the RAP. MOE representatives are part of a technical committee which reviews projects of similar interest. MOE staff also participate in several steering committees associated with the RAP.

NPCA also works with MOE on water quality programs in the watershed. MOE provided financial and technical support for the NPCAs groundwater study, and also supports the Provincial Water Quality Monitoring Network (water quality sampling & analysis), Provincial Groundwater Monitoring Network and the Richardson Creek Track Down Project.

Ontario Ministry of Natural Resources (MNR)
MNR representatives are part of a technical committee which reviews projects of similar interest. MNR staff also participate in several NPCA steering committees for project implementation (Restoration, Water Quality) and watershed plans. Example projects include the Drapers Creek Restoration and Twelve Mile Creek Watershed Plan.

The NPCA is also involved with the MNR through the Low Water Response Program. Through this program, decisions are made about water use when stream flows and/or precipitation are below average. The MNR provides the NPCA with provincial flood forecasting information. As well, the NPCA, MNR, and Environment Canada participate in maintaining and operating a series of gauge stations within the NPSP area.

Finally NPCA works with MNR on a number of Ontario Stewardship Program initiatives.

Ontario Ministry of Agriculture and Food (OMAFRA)
OMAFRA Representatives sit on the project review committee for several NPCA restoration and water quality programs. OMAFRA Representatives provide technical advice and support for best management practice (BMP) projects.

Ministry of Municipal Affairs and Housing
An agreement is in-place with NPCA for the implementation of Natural Hazards policies.

Conservation Ontario (CO)
Conservation Ontario is the umbrella organization for the conservation authorities in Ontario. NPCA is involved with various Conservation Ontario initiatives including the coordination between all CAs of the Stewardship program.

Niagara Parks Commission (NPC)
NPCA is involved in an ecosystem management plan for the NPC jurisdiction. This is a Niagara River RAP related project, as the NPC owns the entire river corridor on the Canadian side. Projects include a riparian management strategy, Old Growth Oak Savannah restoration and various other naturalization projects. NPC staff also participate in several steering committees as part of the Niagara River RAP (i.e. Riparian Management Plan, and Paradise Grove Restoration Project).

1.3.3 Federal Government

Environment Canada (EC)
Environment Canada is currently committed through a signed agreement with the NPCA for the coordination of the Niagara River RAP. Environment Canada provides project coordination and financial contributions to the RAP.

Through Environment Canada's Great Lakes Sustainability Fund, NPCA currently receives significant grants towards restoration efforts in the Niagara River RAP.

Department of Fisheries and Oceans (DFO)
NPCA currently administers Level 2 fisheries screenings under the *Fisheries Act* for the Department of Fisheries and Oceans. NPCA and DFO staff are part of a joint technical committee which review proposed projects that may affect fish habitat.

Parks Canada (PC)
Parks Canada is involved as a landowner in a NPCA project to restore an Old Growth Oak Savannah in Niagara-On-The-Lake.

1.3.4 First Nations

There are no First Nations Reserves in the NPCA jurisdiction.

1.3.5 Interested Stakeholders, Engaged Public and NGO's

NPCA consults with a variety of local non-government organizations and stakeholder groups. The following is an example list of stakeholders that have provided advice and guidance on a number of NPCA projects such as the Niagara River RAP, and Twenty and Twelve Mile Creek Watershed plans.

- Welland River Keepers
- Friends of Fort Erie's Creeks
- Friends of One Mile Creek
- Friends of Twelve Mile Creek
- Fort Erie Conservation Club
- Walkers Creek Neighbourhood Association
- Niagara Restoration Council
- Landcare Niagara
- Haldimand Stewardship Council
- Niagara College
- Ontario Soil and Crop, North & South Improvement Association
- Niagara Falls Nature Club
- Peninsula Field Naturalists
- Bert Miller Nature Club

- Ontario Federation of Agriculture
- Ducks Unlimited
- Wetland Habitat Fund
- Port Colborne & District Conservation Club
- Glanbrook Conservation Committee
- Niagara South Federation of Agriculture
- Niagara North Federation of Agriculture

2.0 PHYSICAL AND GEOLOGICAL DESCRIPTION

2.1 Topography

The topography in the Niagara Peninsula ranges from the highest elevation of 260 metres above sea level (masl) on the Fonthill Kame-Delta Complex (Fonthill Kame) (Bedrock Topography, 2002) near the middle of the peninsula, to a low elevation of 75 masl at Lake Ontario (WHI, 2005, pg 2-6, 2-7). Figure 2.1 shows the ground elevation and topography for the NPSP Area.

The Niagara River forms the eastern boundary of the NPSP Area, and the Grand River watershed lies along the western boundary. Lake Ontario and several smaller watersheds of the Hamilton Conservation Authority (i.e. Red Hill Creek, and Stoney Creek) form the northern boundary, while Lake Erie forms the southern boundary of the Niagara Peninsula SWP Area (Figure 1.1).

There are three main drainage basins in the NPSP Area; Lake Ontario, Niagara River, and Lake Erie as described below (Figure 2.2):

- Lands along the north side of the Niagara Peninsula drain into Lake Ontario. This area contains the steep slopes of the Niagara Escarpment, as well as the gently sloped lands north of the escarpment, known as the Iroquois Plain, and portions of the Niagara moraine above the Escarpment;
- The relatively flat central portion of the peninsula drains into the Niagara River. By far the largest watershed in this drainage basin is the Welland River that extends from the western boundary of the NPSP Area to the eastern boundary where it drains into the Niagara River.
- The topography along the Lake Erie shoreline slopes down from the Onondaga Escarpment toward the lake, to form the third major drainage area in the peninsula.

2.2 Physiography

The NPSP Area contains a number of key physiographic areas (Figure 2.3), including the Iroquois Plain, Niagara Escarpment, and Haldimand Clay Plain. Other landforms and physiographic features found within the Niagara Peninsula include moraines, eskers, drumlins, sand plains, the Fonthill Kame-Delta Complex, and the Onondaga Escarpment (Chapman & Putman, 1984). The main physiographic areas and features are described below.

The Iroquois Plain is located between the Niagara Escarpment and Lake Ontario, and consists of lacustrine deposits of sand, silt, and clay associated with the glacial Lake Iroquois (Figure 2.3). The Iroquois Plain deposits overlie Halton Till.

The Niagara Escarpment extends east-west across the Niagara Peninsula, and rises up to 120 m above ground surface of the Iroquois Plain, which is located north of the escarpment. The escarpment contains a relatively hard dolostone bedrock cap, which is underlain by softer shales and sandstones of the Clinton, Cataract and Queenston bedrock groups. The escarpment was formed by erosion of the softer bedrock materials below the dolostone cap. The escarpment has a significant impact on the local climate and ecosystems, and as a key topographical feature in the Niagara Peninsula, it influences drainage patterns, as well as wildlife (i.e. waterfalls along the escarpment create fish barriers). The escarpment contains a number of Areas of Natural and Scientific Interest (ANSIs).

The relatively flat lands of the Haldimand Clay Plain are located above the Niagara Escarpment in the central part of the peninsula. The Haldimand Clay Plain covers the major portion of the NPSP Area and includes within it the Welland River watershed.

Key physiographic features located in the Haldimand Clay Plain include the Onondaga Escarpment, Fonthill Kame-Delta Complex, and several moraines. The Onondaga Escarpment is of relatively low topographical relief, and rises only a few metres above the surrounding lands. Overburden soils overlie portions of the Onondaga Escarpment near the NPSP Area's western boundary. It is east-west trending, and is located just north of Lake Erie.

The Fonthill Kame-Delta Complex rises 80 m above the surrounding land and covers an area approximately 6 km in diameter (WHI, 2005, pg 2-11). Groundwater from the Fonthill Kame-Delta Complex discharges to the north and into Twelve Mile Creek, to produce one of the only cold water streams and cold water fish habitats in Niagara Peninsula.

A number of end moraines were also formed on the Haldimand Clay Plain (WHI, 2005, Table 2.4, pg 2-10, NPCA). They include the Fort Erie, Wainfleet, Vinemount, Crystal Beach, and Niagara Falls moraines. Additional details about these moraines are provided in Figure 2.3 (Physiography) and Table 2.1.

2.2.1 Effect of Physiographic Features on Development

Four physiographic features have had a significant effect upon development within the Niagara Peninsula: (i) Niagara Falls, (ii) the Niagara Escarpment, (iii) the Haldimand Clay Plain and (iv) the Fonthill Kame-Delta Complex.

The strong effect of Niagara Falls on the character of the watershed for economic development cannot be understated as both:

- A source of tourism and electric power; and
- An engineering challenge to transportation resulting in the construction of the Welland Canals, and currently six bridges spanning the Niagara River[4].

The Niagara Escarpment has also served as a barrier to transportation with limited natural passage over the escarpment, (e.g. Four Mile Creek). This barrier to transportation has influenced the development patterns in Niagara, and has for example resulted in pressures to develop within the fruit belt area below the escarpment rather than extend transportation routes above the escarpment.

The heavy clay soils of the Haldimand Clay Plain challenge agricultural use as a result of poor drainage and deficiencies in lime, phosphorus and organic matter. The Fonthill Kame-Delta Complex however forms a horticultural island within the clay plain.

2.3 Soils

A soils map for the Niagara Peninsula is provided in Figure 2.4. The soils mapping in Figure 2.4 is derived from three different former county soil surveys. (These three former counties now make up City of Hamilton, Haldimand County, and Niagara Region). Consequently, differences exist in mapping and categorizing of soils between these three upper tier municipalities.

The soils in the large central portion of the peninsula (occupied by the Niagara River/Welland River watersheds) are dominated by clays, silty clays, and silty clay loams, characteristic of the Haldimand Clay Plain. The dominant land use occupying this area is agricultural and open space incorporating residential and industrial land uses neighbouring the Niagara River.

Loamy sands are encountered in the southwest portion of the Niagara Peninsula, near Dunnville. Here, the land cover is mainly agricultural and open space with non-systematic, sporadic residential areas. Sands and sandy loams are found extensively along the Lake Ontario shoreline, generating a mix of agriculture and residential land uses. Clay soils are often observed above the Niagara Escarpment which is characterized by agricultural, residential, and environmental conservation/protection areas.

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[4] Lewiston-Queenston, Whirlpool Rapids, Rainbow, and Peace (vehicular traffic) Bridges, and Michagan Central Railway Bridge and International Railway Bridge.

When comparing Figures 2.4 of the general soils to Figure 5.1 of the SOARIS SIL land cover, patterns in the Source Protection Area are revealed. For example, organic soils which are predominantly organic matter overlie the Wainfleet bog and parts of the Onondaga Escarpment. Organic soils are commonly found in fens and bogs, areas which are designated for conservation and protection in the NPSP Area. Mixed Sand/Loam soils occupy the North shore of Lake Ontario and the Southwest portion of Haldimand County, areas which are largely agricultural due to the presence of this highly productive soil type. Sandy soils found on the Iroquois Plain between Lake Ontario and the Niagara Escarpment have allowed for the development of a prime fruit and grape growing area in Ontario (Chapman & Putman, 1984, pg. 190). Fruits and vegetables have been grown on the well drained loam soils found in the soils between Grimsby and Hamilton. The Fonthill Delta-Kame with its better draining soils shows an emphasis towards fruit growing. (Chapman & Putman, 1984, pg. 156).

Clay loams have a high water holding capacity and are the principal soil type in the SP Area, coinciding with mainly agricultural and open space types of land use. There is an emphasis on livestock as well as a higher portion of idle land in areas with this type of soil, reflecting the poorer growing conditions. (Chapman & Putman, 1984).

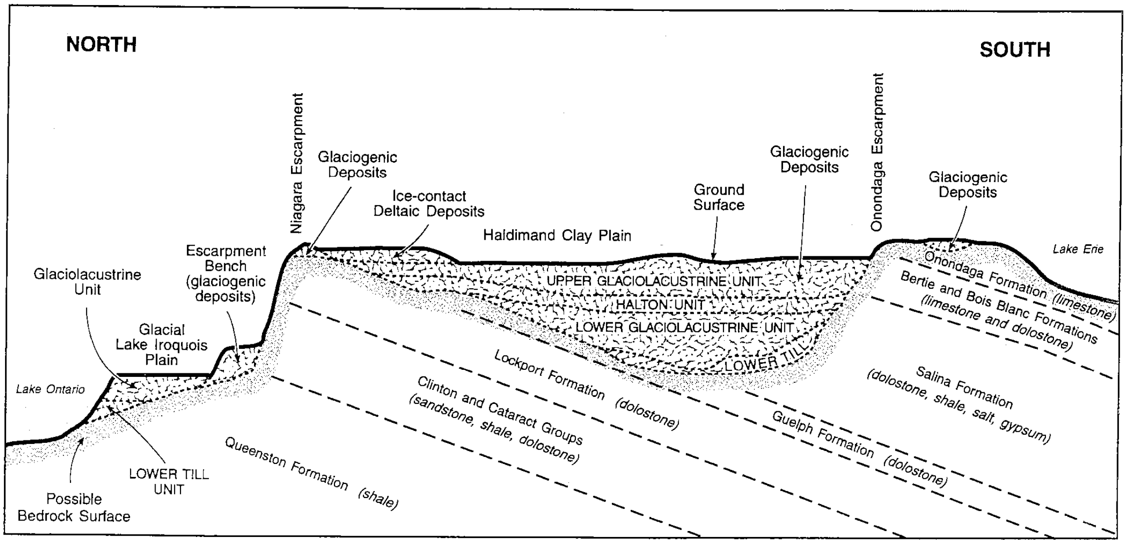
2.4 Bedrock Geology

Paleozoic Era[5] bedrock, associated with Appalachian Basin marine sediments, underlies the study area. This sedimentary bedrock consists mainly of interbedded limestone and dolostone carbonate materials, and shale. Bedrock units of the Ordovician Period (oldest) to the Devonian Period (newest) are present. The bedrock contains a slight dip to the south (to southwest) of about 4 to 6 m/km (i.e. <1degree).

The bedrock units in the Niagara Peninsula are east-west trending with the oldest bedrock units found along Lake Ontario (i.e. Queenston Formation), and the youngest units found in the south along Lake Erie (i.e. Onondaga Formation) (Figure 2.5). Bedrock outcrops are found in various areas of the Niagara Peninsula, but most significantly along the Niagara Escarpment, and on the Onondaga Escarpment which is located north of the Lake Erie shoreline. Table 2.2 provides a chronological summary of the Paleozoic bedrock geology found in the Niagara Peninsula. Figure 2.6 shows the bedrock surface topography and Figure 2.7 presents the overburden thickness in the Niagara Peninsula. The overburden thickness was determined by calculating the difference between the bedrock surface and ground surface elevations (WHI, 2005). However, the bedrock topographic surface is now considered a work-in-progress, as previous investigations,

[5] Estimated to be deposited over 300 million years.

highlighting features such as the Erigan Channel (e.g. Flint and Locama, 1988) remain to be incorporated into the dataset.



<u>Insert 1: Cross-section of the sub-surface geology along the Welland Canal.</u>

The insert above shows a generalized cross-section of the sub-surface geology from north to south along the Welland Canal (Menzies and Taylor, 1998, as modified by Gartner Lee, 1987). Additional cross-sectional conceptual models of the sub-surface geology for the Niagara Peninsula were completed in the NPCA Groundwater Study and are shown in the Appendix E (Items 2, 3, and 4)[6].

A description of major bedrock units in the NPSP Area is presented below**.**

The <u>Queenston Formation</u>, which is the oldest of the Paleozoic bedrock units immediately below overburden or at surface, consists of shale interbedded with limestone and siltstone, and ranges in thickness from 45 m to 335 m. It is commonly known as the Queenston Shale. Outcropping of this formation is present in the northern extent of the NPSP Area along Lake Ontario.

Overlying the Queenston Formation is the <u>Cataract Group</u> which consists primarily of shale, and sandstone (MacViro Consultants Inc., 2003b pg 3-2). Above the Cataract Group is the <u>Clinton Group</u> consisting mainly of interbedded shale and dolostone. The Cataract and Clinton bedrock is exposed along the face of the Niagara Escarpment. Overlying the Clinton Group is the <u>Lockport Group,</u> consisting of the Guelph-Lockport Bedrock Formations, which are comprised mostly of limestone and dolostone. The Lockport Group Formations are located on the top of the Niagara Escarpment, and are much harder than the underlying shales and sandstones of the Cataract and Clinton groups. The Niagara Escarpment was formed by the gradual erosion of the softer exposed

[6] Please refer to the NPCA Groundwater Study report for a detailed description of how these conceptual models were determined.

surfaces of the shales and sandstones that were underlying the relatively hard Lockport Group bedrock.

Terra-Dynamics Consulting Inc. (2006) recently completed an initial assessment of potential karst topography areas within the NPSP Area (Terra-Dynamics Consulting Inc., 2006). Karst features within the NPSP Area are primarily associated with the Eramosa Formation of the Lockport Formation. Notable karst areas identified included: (i) The Stoney Creek "Mountain" Area, (ii) The Smithville Area and (iii) Gavora Drain and Balls Falls, Vineland.

The Salina Formation overlies the Lockport formations, and consists of evaporates (salts, gypsum), shales, and carbonates (dolostone). Groundwater associated with this formation is generally poor in quality due to the salts/sulphur content. The Salina Formation underlies much of the clay plains in the central portion of the peninsula, south of the Niagara Escarpment, but does not extend north of the Niagara Escarpment.

The Bertie, Bois Blanc, and Onondaga Formations overlie the Salina unit. The Bertie Formation (the oldest of these three formations) consists of a grey and brown dolostone. The Bois Blanc bedrock overlies the Bertie Formation and consists of mostly limestone, and forms the cap of the Onondaga Escarpment while the Onondaga Formation is found between the Onondaga Escarpment and Lake Erie shoreline.

Main bedrock geological areas of interest in the Niagara Peninsula are described below.

Niagara Escarpment: As outlined previously (Section 2.2), the Niagara Escarpment trends east-west across the peninsula and reaches up to 120 m above the adjacent Iroquois Plain to the north. The escarpment result from the differential erosion between the harder bedrock cap, and the softer underlying bedrock units.

Onondaga Escarpment: The Onondaga Escarpment runs along the north side of Lake Erie and only rises a few metres above the surrounding landscape. It is also the result of differential erosion between the harder bedrock cap, and the softer underlying bedrock to the north.

Erigan Channel: The main channel runs from the village of Lowbanks, located on the Lake Erie shoreline, through the Village of Fonthill, and beyond to the Niagara Escarpment. The bedrock channel is estimated to be 400 m wide and up to 50 m deep, and is in-filled with sediment.

St. Davids Buried Gorge: This bedrock valley runs from the Whirlpool area of the Niagara River northwest to the Village of St. Davids at the base of the Niagara Escarpment, and is estimated to be up to 130 m deep and 630 m wide. It is infilled with fine sands interbedded with thin clay and silt layers.

Relief within the bedrock topography is focused along the Niagara Escarpment, and along the Erigan Channel and the St. Davids Buried Gorge. There is a bedrock depression associated with the sub-crop of the Salina Formation, which was historically more-easily eroded. Corresponding to this, a low area within the bedrock topography is located north-west of the Wainfleet Bog (see Figure 2.6.). This area also shows up as one of the thickest areas of overburden in Figure 2.7.

2.5 Surficial Geology

Most of the Niagara Peninsula is covered by up to 30 m of unconsolidated sediment. These overburden sediments mainly resulted from glacial advances and retreats that occurred during the last glaciation period in southern Ontario. The glacial movements were responsible for eroding bedrock and creating moraines and till deposits, as well as glaciolacustrine deposits. The last glaciation period is estimated to have occurred between 23,000 and 10,000 years ago (MacViro Consultants Inc., 2003b, pg 2-7) during the Wisconsinan Substage of the Pleistocene Epoch, and created the following four primary Quaternary geological units that are found in the NPSP Area:

- Wentworth Till
- Deeper water glaciolacustrine deposits
- Halton Till
- Beach and near-shore glaciolacustrine deposits (including the Fonthill Kame-Delta Complex)

Other noteworthy quaternary units include the (i) St. Davids Gorge infill, which is considered to contain some of the oldest soils in the Niagara Peninsula; and (ii) post-glacial deposits of the Recent Age (such as coastal dunes and modern floodplains). Man-made deposits include excavation materials from the construction of the Welland Canal. Table 2.3 provides a summary the various quaternary sediments that were deposited in the Niagara Peninsula. Figure 2.8 provides locations of the quaternary deposits and Figure 2.7 depicts the overburden thickness across the peninsula. A description of the main quaternary units from oldest to youngest is provided below.

The Wentworth Till was deposited during the Late Wisconsinan period[7], during the advance of the Ontario-Erie glacial lobe. The Wentworth Till is a gravelly, sandy silt till, that occasionally contains sand and gravel derived from the underlying Silurian and Devonian bedrock (MacViro Consultants, 2003b).

The deeper water glaciolacustrine unit was created during the retreat of the Ontario-Erie glacial lobe. A pro-glacial lake was formed which produced the glaciolacustrine unit deposits of clay and silt overlying the Wentworth Till. This unit covers the Niagara Peninsula extensively.

The Halton Till was created during the re-advancement of the Ontario-Erie glacial lobe. In some areas, the Halton Till directly overlies the Wentworth Till, but in other areas it

[7] Estimated age of the Late Wisconsinan period is approximately 22,000 to 14,000 years ago. This theoretical age is interpreted using carbon dating techniques and assumptions.

overlies the clays and silts of the deeper water glaciolacustrine unit. The Halton Till is a clayey silt till which ranges up to 30 m thick in bedrock valleys and is visible at ground surface in areas north of the Niagara Escarpment and near Lake Erie.

During the retreat of the Two Creeks Interstadial, several moraines were created such as the Wainfleet, Fort Erie, and Niagara Falls moraines. The upper glaciolacustrine unit was deposited during this period, and includes deposits such as the Haldimand Clay Plain and the Fonthill Kame-Delta Complex.

2.6 Land Cover

Land cover information was provided by the Ministry of Natural Resources as part of its Southern Ontario Land Resource Information System (SOLRIS) and Southern Ontario Interim Landcover (SIL) mapping exercises. The SOLRIS dataset is a regional, ecologically based, land cover inventory current to 2000-2002. SOLRIS included thirty (30) categories of ecological land classification (ELC). The SIL dataset is an integration of best available vintage land cover datasets in 2000-2002 including eighteen (18) categories.

SOLRIS Version 2 (2007) was used as the primary land cover data. This dataset was further improved through the addition of specific agricultural categories from version 1 and SIL. SOLRIS version 1 (2006) included additional mapping of Greenbelt agriculture including orchards, vineyards, perennial crop, annual crop, mixed crop and idle land. SIL (2006) included additional mapping of monoculture, mixed agriculture and rural land use. This SIL information was proportioned to the SOLRIS version 1 agricultural categories using Statistics Canada field crop data.

Land cover information was important for the Water Availability Studies as the surface water flow models required runoff curve numbers and soil water holding capacities based upon the land cover classification and the hydrologic soil group per individual catchment. The compiled land cover dataset used for the Water Availability Study is shown on Figure 5.1.

The highest percentage of land cover categories per WSPA are shown below:

- Rural land use: UWR (32%), TWEN (19%) and CWR (25%);
- Built-up areas: TWEL (19%);
- Monoculture: SNF (30%), LWR (29%), LENS (23%), FEC (22%), BDSC (18%), BFC (37%);
- Vineyards / Orchards: NOTL (24%,15%), LIN (18%, 16%), respectively; and
- Mixed Crop: GR (30%), FSEM (19%).

Rural Land use is defined by SIL as ‘forage’, determined through the use of medium resolution satellite imagery (30 m LANDSAT) in early spring where annual crops are represented as bare ground and forage as foliated ground. Monoculture areas were classified where a farm field was left continuously in annual crop from three observed sequential time periods, i.e. no rotation with hay or pasture. Mixed crop were rotated annual/forage areas using the same methodology of change detection.

2.7 Data and Knowledge Gaps

A number of data and knowledge gaps exist with respect to our understanding of the physical and geological description of the study area. These include:

- The bedrock topographic surface has been contoured historically by Flint and Locama (1986) and as part of the recent NPCA Groundwater Study (2005). These surfaces need to be reconciled with each other and additional information incorporated (i.e. recent borehole data and oil/gas well records).
- Delineation of sub-surface geologic units. This gap is discussed with respect to hydrostratigraphy in Section 4.7 but would largely involve correlation of published geologic borehole data (i.e. geotechnical boreholes) available from the MOE technical support section, and public works departments at Regional Niagara, City of Hamilton and Haldimand County within a database structure that allows for creation of geologic cross-sections and geologic surfaces.

Appendix F lists the data gaps in accordance with Guidance Module 1 protocols, and also provides a summary of the data gaps cited at the end of each report section/chapter.

3.0 ENVIRONMENTAL LANDSCAPE AND AQUATIC ECOLOGY

Wetlands and forest-woodlands have been inventoried on a GIS database for the NPSP Area (MacViro, 2003b pg 3-49-50) (Figure 3.1 and Figure 5.1). Other types of natural areas encountered within the NPSP Area include:

- Fish habitat areas;
- Natural heritage corridors;
- Aquifer recharge areas;
- Creek and river headwaters;
- Scrub lands/ meadows (not extensively inventoried);
- Niagara Escarpment lands; and
- ANSI lands.

The natural areas in the Niagara Peninsula provide a number of useful environmental functions. Natural areas can reduce turbidity in stream flows by protecting against soil erosion, and can trap sediment carried by surface water before it reaches a stream. Figure 3.2 outlines erosion areas of concern in the NPSP Area. Riparian areas can provide shading along streams, which improves stream habitat and raises dissolved oxygen content thus reducing oxygen-depleting eutrophication.

3.1 Wetlands

Wetlands in the NPSP Area include bogs, fens, swamps, and marshes. Wetlands make up a total of 3.8% of the watershed (NPCA Stewardship program). The majority of the wetlands in the watershed are classified as swamp, and cover about 2.8% of the watershed (versus marshes at 0.8%, bogs at 0.1%, and fens and open water at <0.1%) (NPCA Stewardship program). The largest and most significant wetlands include the Wainfleet Bog, and the Humberstone Marsh (Figure 3.1). Many wetlands are also located along the shorelines of Lake Ontario and Lake Erie. Table 3.1 lists some of these larger wetlands that are considered to be Environmentally Sensitive Areas (ESAs). ESAs support a rich diversity of natural features including major marshes throughout the region, important plant and wildlife habitats, major forested areas and major landforms such as the Niagara Escarpment (Niagara Region, 2007). Additional wetland inventory work is underway and the percentage of wetland is expected to increase once Natural Heritage Resource Mapping Project is completed by the NPCA.

Wetlands provide a number of important benefits to the NPSP Area. Wetlands can accommodate moderate nutrient loadings in the water versus dammed reservoirs which would exhibit eutrophication problems (MacViro Consultants, 2003b, pg 3-49-50). Wetlands also tend to reduce contaminant loadings in stream flows by allowing sediments to settle out of the water, and this also provides time for plants to take in the nutrients, etc.

Wetlands and sloughs (naturally vegetated surface depressions) reduce peak stream flows from storm water runoff by adding storage capacity. For example, surface depressions (or sloughs), which are common as natural areas in the Haldimand Clay Plain, have been estimated to create a storage capacity of about 312 m^3/hectare (RMON NWQPS, Phase 2 Report, Section 3.4.3.1, pg 3-54). To-date no inventory of the sloughs has been completed for the NPSP Area. The advantage of the sloughs is that they have no maintenance cost (compared to man-made structures such as the Binbrook dam). Sloughs also have faster storage recovery times before the next storm, and as a result of their broad distribution throughout the watershed they reduce or "de-synchronize" storm peak river flows.

3.2 Forest and Woodlands

Forested areas in the Niagara Peninsula (Figure 3.1 Natural Heritage System) have been divided into categories of wet forest, moist forest, and upland forest. All three types are found throughout the jurisdiction's natural communities. The categories were determined using soil drainage information based on soil maps, which was then intersected with a woodlot layer. Upland forest type have a very rapid to rapid soil drainage class, moist forest types have well to moderately well soil drainage class, and wet forest type is considered to have imperfect, saturated or organic soil drainage class. Tree cover (forest, orchards, vineyards) makes up only about 15% of the watershed's total land cover

Forested areas in the Niagara Peninsula (Figure 5.1 SOLRIS – SIL Land Cover) include deciduous, coniferous, and mixed forest. Of the Natural Areas within the jurisdiction, 3.34% is coniferous (forested and plantation), 44.3% is deciduous (Hedgerows, deciduous forest and forest), while 2.2% is mixed. Wetlands (Bog, marsh, and swamp) make up the other half (50.16%) of the inventoried Natural Areas. These statistics were compiled from the SOLRIS data of natural layers. The greatest abundance of forest cover in the Niagara Peninsula is generally located along the Niagara Escarpment and in the south east part of the peninsula (such as the Municipality of Fort Erie).

Forest areas have beneficial effects on the environment. Forests can reduce weather extremes by cooling summertime temperatures and warming winter temperatures. Forest cover increases storm water infiltration to groundwater systems, and generally produces slower melting of snow pack in springtime thus reducing peak spring flows in creeks and rivers.

3.3 Aquatic Ecology

3.3.1 Fisheries

Fish communities have long been used as barometers of ecosystem health in watersheds, with fish community diversity, and population health, widely used as surrogate measures of habitat quality, including water quality. As a result of the recreational, commercial, aboriginal and cultural importance of fish, a healthy fishery is vital to the overall well being of many residents within the watershed.

Due to the geographic location in the province and proximity to Lake Ontario, Lake Erie and the Niagara River, the fish community in the NPSP Area is very diverse. Aiding in this diversity is the influence of the Welland Canals, which act as the main fish dispersal routes between Lake Erie and Lake Ontario (MacViro, 2003b) (Figure 3.3). As a result of these factors, the fish community in the NPSP Authority is comprised of approximately 98 fish species. Of these species, several are considered as sensitive or species-at-risk and will be discussed further within this section.

Although groundwater inputs have been identified in the headwaters of many watercourses throughout the NPSP Area, the upper reaches of Twelve Mile Creek are the only remaining watercourses in Niagara that is cool enough to support brook trout (*Salvelinus fontinalis*). As a result, the abundance of this species is of particular interest in the Niagara Peninsula (OMNR 1989, pg. 21). Brook trout are typically found in clear, cold, well oxygenated streams and lakes (Scott and Crossman, 1973). Despite being the last remaining population of brook trout in the Niagara Peninsula, brook trout in upper Twelve Mile Creek are threatened by sources of thermal pollution, such as online ponds, interruptions to groundwater inputs, sediment deposition and habitat alterations. The NPCA is currently conducting a detailed temperature study of Twelve Mile Creek to determine the extent of thermal pollution within the upper reaches of this watercourse, however preliminary results are unavailable at this time. It is anticipated this data will be invaluable in the restoration and plan review process, where efforts are being made to restrict and mitigate sources of thermal pollution in the creek.

A second fish species of particular concern in Niagara is muskellunge (*Esox masquinongy*). Muskellunge are concentrated mainly in the upper Niagara River, and have been reduced in numbers in the Niagara waters of Lake Erie (OMNR, 1989, pg 21), however this reduction in population size is likely attributed to habitat alterations and fishing pressures and not directly related to water quality. Native stock has been successfully transplanted into numerous lakes, and is currently considered a secure species with the MNR.

The NPCA is currently systematically conducting watershed studies on watersheds within the NPSP Area. Part of the intent of these studies is to provide updates to the status of fish communities and sensitive species, in hopes of protecting these species by directing restoration and management decisions. The NPCA is also currently investigating the feasibility of creating fisheries management plans for the individual watersheds within the NPSP Area in order to update and build upon the current Niagara District Fisheries Management Plan.

3.3.2 Species at Risk

Several fish species-at-risk have been identified in the Niagara Peninsula, of which, the most widely distributed species is the grass pickerel (*Esox americanus vermiculatus*). Grass pickerel are present in most watercourses and municipal drains emptying into the upper Niagara River and Lake Erie. Recent fish community sampling conducted by the

NPCA also indicated that grass pickerel continue to persist in Upper Twenty Mile Creek, a tributary of Lake Ontario. Grass pickerel are generally found in sluggish streams with abundant vegetation and are tolerant of high water temperatures (25-29^{o}C) and turbidity (Scott and Crossman 1973), making this species well suited to habitat conditions in the Niagara Peninsula. Grass pickerel is currently listed by COSEWIC (Committee on the Status of Endangered Wildlife) as a 'Special Concern'.

Lake chubsucker (*Erimyzon sucetta*) has a much more confined distribution in the Niagara Peninsula. Currently, lake chubsucker have been found exclusively in Lyons Creek, a tributary to the Welland River, although this species is likely also present in low numbers in other tributaries to the Niagara River. Lake chubsucker are typically found in clear, sluggish streams, lakes and wetlands with abundant vegetation (Scott and Crossman, 1973). The lake chubsucker is tolerant of warmwater conditions, having a preferred water temperature of between 28^{o}C and 34^{o}C (Coker et al. 2001). Lake chubsucker are currently listed federally as a Schedule 1 species-at-risk and are therefore afforded protection under the *Species at Risk Act*. The recovery strategy for the lake chubsucker is scheduled to be initiated in 2006 by Fisheries and Oceans Canada.

Several other fish species at risk and sensitive species are present or have recently been captured within the Niagara Peninsula. These species include northern brook lamprey (*Ichthyomyzon fossor*), lake sturgeon (*Acipenser fulvescens*), American eel (Anguilla rostrata), bigmouth buffalo (*Ictiobus cyprinellus*) and greater redhorse (*Moxostoma valenciennesi*). These species are present primarily in the Niagara River and tributaries.

There are several freshwater mussels found in the SP Area that are on the MNRs Natural Heritage Inventory Centre (NHIC) and are on the Species at Risk list in Ontario. These include the Round Pigtoe *(Pleurobema sintoxia)* mussel and the Kidneyshell *(Ptychobranchus fasciolaris*) mussel. According to NPCA NAI staff, the Mapleleaf (*Quadrula quadrula)* mussel was found during the Natural Area Inventory of 2007 and 2008, a remarkable discovery since it had not been recorded since the 1970s.

The majority of the Species on Ontario's Species at Risk List (MNR) depend on the NPCA watersheds for varied durations in their life-cycles and are vulnerable to changes in water quantity and quality. Studies which would relate species distribution to water quantity and quality conditions do not exist. The following charts display the 66 Species in the MNR's NHIC inventory for the SP Area that are found on the Ontario Species at Risk List.

The Ontario Species at Risk List includes any native plant or animal that is at risk of extinction or of disappearing from the province. The list contains species that are Extirpated (EXP), Endangered (END), Threatened (THR) and Special Concern (SC). Extirpated species no longer exist in the wild in Ontario but still occur elsewhere. Endangered species face imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's ESA. Threatened species are at risk of becoming endangered in Ontario if limiting factors are not reversed. Special Concern Species have characteristics that make it sensitive to human activities.

3.3.3 *Herpetofaunal Study*

Many populations of amphibian and reptile species are in decline on a global basis due to a combination of factors such as water pollution and habitat loss. Unfortunately the same assumption cannot be made in confidence regarding the NPCA jurisdiction as these species have not been studied in enough detail. However, in 2007 and 2008 certain hotspots were examined by the MNR/NPCA in a Partnership for the Herpetofaunal Study under the Natural Heritage Areas Inventory. The following "Areas of Interest" within the Peninsula were selected and assessed in 2007:

- Caistor-Canborough Slough Forest
- Onondaga Escarpment
- St. David's Buried Gorge
- River Mouths in Niagara-on-the-Lake
- McCullen Swamp – Lowbanks
- Wainfleet Wetland

The 2008 field season focused on the following municipalities:

- West Lincoln
- Lincoln
- Pelham
- Thorold
- Welland
- North Niagara Falls

These studies will determine the presence/absence of both herpetofaunal species and Species at Risk in the Niagara and Haldimand areas. It must be noted that this study is not comprehensive to the entire Peninsula and is only looking at certain areas of interest.

3.3.4 Invasive Species

Several non-native and invasive species have colonized watersheds in the Niagara Peninsula (Table 3.2), with several others, such as grass carp (*Ctenopharyngodon idella*) and Asian carps (*Hypophthalmichthys* spp.) anticipated in the near future. Non-native species are most successful at colonizing new areas when invading species are well adapted to local environmental conditions and lack competitors or predators. By far, the most successful non-native fish species to colonize the Niagara Peninsula has been the common carp (*Cyprinus carpio*), which are present in all watersheds in the area. It is well documented that common carp are responsible for uprooting aquatic vegetation and increasing turbidity, potentially limiting the extent of submerged macrophytes. Efforts are currently underway to exclude adult carp from various watercourses within the Niagara Peninsula. Goldfish (*Carassius auratus*), a close relative of common carp, are also well established in many watercourses, ponds and municipal drains in the Niagara

Peninsula, however this species is less widespread than common carp.

Round goby (*Neogobius melonostomus*) is a species of particular concern in Niagara, due to the documented impacts on recreationally important fish species such as smallmouth bass (*Micropterus dolomieu*). Round goby are typically found in rivers and lakes in association with rock and gravel substrates (Lane et al.1996). Currently, round gobies are found in all watercourses draining into Lake Ontario, Lake Erie and the Niagara River that provide suitable substrates. Due to the round gobies' preference for rock and gravel, this species has not been found in most watercourses that are dominated by silt and clay substrates. Round gobies have not been reported in the Welland River upstream of the new siphon or in watercourses above the escarpment.

Other documented invasive species of interest in the Niagara Peninsula include rudd (*Scardinius erythrophthalmus*), ruffe (*Gymnocephalus cernuus*) and sea lamprey (*Petromyzon marinus*), however these species do not pose a significant threat to water quality in the NPSP Area.

3.4 Data and Knowledge Gaps

A number of data and knowledge gaps exist with respect to our understanding of the environmental landscape and aquatic ecology of the study area these include:

- Distribution of wetlands following completion of the Ministry of Natural Resources recent wetlands inventory.

4.0 HYDROLOGY

The Hydrologic Cycle describes the processes and movement of water on the earth's surface and through subsurface soils and bedrock. These processes include precipitation, evaporation and transpiration, infiltration, runoff, storage, groundwater flow and discharge.

4.1 Climate Data and Monitoring Stations

Climate monitoring stations are commonly used to collect information on one or more of the following parameters; temperature, precipitation (rain and/or snowfall), rate of precipitation, evaporation, wind speed and direction, relative humidity and dew point. Since climate stations cover only a small point of the area they are considered to represent, the climate data from these stations can be highly variable on a geographical basis as well as across the seasons. Geographic variations can be due to factors such as topography, land cover, and effects of the Great Lakes.

Several government agencies operate climate monitoring stations within the NPSP Area. These stations are summarized in Table 4.1 and their locations are shown in Figure 4.1, and include stations operated by the following government agencies:

- Environment Canada - Meterological Services of Canada (MSC), formerly called Atmospheric Environment Services (AES), currently publishes climate data on its internet site (Environment Canada, National Climate Data and Information Archive). The MSC operates twelve (12) stations within the NPSP Area and 2 stations within 10 km of the NPSP Area's boundary. The MSC has operated an additional 13, currently inactive, stations within the NPSP Area with at least 15 years of data. MSC has produced climate normals for twelve (12) stations in the NPSP Area (Appendix C);
- Agriculture and Agri-Food Canada has produced climate normals and potential evapotranspiration values for three (3) ecodistricts (Figure 4.2) that cover the NPSP Area for the 1961-1990 period. Ecodistrict boundaries were derived from version 2.2 of the Soil Landscapes of Canada. The climate normal information originated from point-based weather station data obtained from Environment Canada (1994). These ecodistricts were used in the NPCA Groundwater Study, groundwater use assessment. The information is available as a GIS database for ecodistricts in Canada with monthly climatic normals (Agriculture and Agrifood Canada);
- Regional Niagara currently operates 20 precipitation monitoring stations, 9 of which are also climate stations (personal communication Glenn Fulton);
- The Niagara Agricultural Weather Network (NAWN) also operates 13 solar powered weather stations during the growing season. Data is recorded at 15 minute intervals and is aimed at providing information to the agricultural community;
- Local municipalities also operate weather and precipitation stations, however this data is usually unavailable for external purposes. As an example St. Catharines operates five stations; one weather and four precipitation stations.

The U.S.A. National Oceanic & Atmospheric Administration (NOAA) operates a (NEXRAD) Weather Service radar station in Buffalo, New York State, U.S.A. The service also has weather radar data coverage for the Area. The NEXRAD measures weather information (precipitation and wind) based on radar technology.

The radar emits a burst of energy. If the energy strikes an object (rain drop, bug, bird, etc), the energy is scattered in all directions. A small fraction of that scattered energy is directed back toward the radar, where the information is processed and interpreted to record rainfall events. Spatial coverage as well as the intensity, time and duration of the rainfall event are identified by NEXRAD. The data is revised and recorded about once every six minutes.

The NPCA is currently processing, reformatting, calibrating, and normalizing NEXRAD precipitation data for use in applications such as floodplain mapping (as well as potentially Tier 1 water budget analyses). NEXRAD is considered more accurate than point source data obtained from climate stations, since it can better depict the spatial coverage of a given rainfall event. (Scientists often use Thiessen polygons to interpolate between climate stations). However the dataset is to be used only for the period of May to November as the angle/height of the radar reduces its effectiveness in measuring lake effect snow.

NPCA also operates two (2) snow courses where snowpack depth and water equivalent measurements are recorded normally at the middle and end of each month. These snow courses include Mount Hope and Chippawa Creek Conservation Area. This information is transmitted to the MNR Flood Forecast Centre shortly after measurement for analysis of runoff potential (Figure 4.1).

The Ministry of Transportation operates some Road Weather Information System (RWIS) stations in the NPSP Area, however the data collected does not include precipitation.

There is a wide variety of climate data within the NPSP Area, however this data is scattered amongst agencies, and data is not collected to a common standard. It is hoped that the 2006 updating of the Environment Canada program ICONO (Inventory of Climate Observing Networks in Ontario) will help to address this. However as Environment Canada (EC) operates a number of long term stations that are maintained to a federal standard (both with respect to gauge operation, and data collection) these are considered to be the most accurate and reliable data available. However, these twelve (12) EC stations are not evenly distributed throughout the Area. Eleven (11) are located in the eastern portion of the watershed, with only one station in the extreme western portion. As a result, upcoming projects should attempt to incorporate other data sources such as Regional Niagara and Haldimand County results to improve accuracy.

It is noted that the effect of the Niagara Escarpment on climate can be surmised from Agriculture Canada's ecodistrict data shown below (WHI, 2005).

Ecodistrict	Annual Precipitation (mm)	Annual Potential Evapotranspiration (mm)	Annual Average Temperature (°C)
District No. 564 (City of Hamilton)	865	662	7.9
District No. 566 (North of Niagara Escarpment)	859	689	8.8
District No. 569 (South of Niagara Escarpment)	927	637	8.1

From these generalized results it can be observed that:

- precipitation below (north of) the escarpment can be expected to be about 8% less than above the escarpment; and
- evapotranspiration below the escarpment can be expected to be about 8% greater than above the escarpment.

Consequently, due to less precipitation and greater evapotranspiration below the escarpment the water deficit is likely to be greater.

4.2 Climate Summary

Precipitation across the Niagara Peninsula varies considerably (Figure 4.3). The average annual precipitation at climate stations in the peninsula ranges from 875 mm to over 1030 mm (Franz Environmental, 2006). The southeast portion of the peninsula has the highest annual precipitation, and this is believed to be due to lake-effect precipitation. As the winds pass over Lake Erie during late fall and early winter, they pick up water and then deposit it as rain or snow when they reach land (e.g. Fort Erie). The lake-effect does not appear to extend very far inland. The Niagara Escarpment is also expected to affect precipitation patterns as suggested by the ecodistrict normal results of the above section.

There is a lack of climate stations and climate data in the western portion of the Niagara Peninsula (Environment Canada website, climate normals), and as a result, the calculated annual precipitation rates appear to be fairly uniform in the section.

Snowfall can represent a significant proportion of the annual precipitation. The southeast areas of the Niagara Peninsula show the highest snowfall at over 180 cm per year due to lake-effects, compared to some inland areas which receive only 115 cm per year. Further details are provided in the NPCA *Draft* Conceptual Water Budget report dated May 2006.

A plot of the mean monthly precipitation for the 12 climate stations (where climate normals have been determined by MSC) indicates that the wettest months are September, followed by June, and November. The winter months of January through March have the least precipitation. [See Appendix C for more detailed information on monthly precipitation values and graphs (MacViro Consultants Inc, 2003b, Table 3.2.1, pg 3-5)].

Mean air temperature tends to have less local variation and is therefore more regional in character than precipitation. Consequently the temperature tends to be fairly uniform across the peninsula, compared to the variation in precipitation (Franz, May 2006). The Niagara Peninsula is generally about 1 degree C warmer than inland areas to the west, likely because of the moderating effects of Lakes Erie and Ontario. The warming effects of urban areas are evident in Hamilton and St. Catharines.

Historical climate trends, groundwater levels and stream flow records have not been analysed to identify future meteorological trends for the watershed. This may be completed in future in order to identify climatic trends affecting water resources where sufficient data is available and where warranted. However, the source protection staff have reviewed reports and discussion papers on this topic, and the findings are presented below.

J.P. Hamilton and G.S. Whitelaw (Climate Change Trends Along the Niagara Escarpment, Niagara Escarpment Commission 1999) examined long-term climate trends from stations along or near the Niagara Escarpment. Stations (including homogeneity adjusted) within the Niagara Peninsula included Niagara Falls, St. Catharines and Welland. These stations (at the time of the analyses) had records of 93, 94 and 103 years, respectively.

Notable observations included:

- Long-term increases in mean annual temperature of 0.6^{o}C at St. Catharines and 0.7^{o}C at Welland. Generally these increases were highest in winter and spring and lower in summer and fall. <u>Most of the increase in mean temperature was due to rising minimum values</u> and as a result daily temperature ranges declined about 1.0^{o}C.
- At Welland precipitation analyses included: (i) a significant increase in precipitation of 13%, (ii) a 23% increase in annual rainfall and (iii) a decline in annual snowfall of 20%. The highest increase in precipitation occurred in the fall with stable or declining precipitation in the winter and spring periods. An increasing trend in annual precipitation was also noted over the period 1950-1998.

The NWQPS Phase 2 Report referenced Bruce (2002) (Bruce, J.P., 2002) with respect to predicted climate change effects for the study area:

- Increased flash flooding as patterns shift from longer low intensity storms to shorter more severe ones and subsequent increased erosion from the intense storms;
- Increased snow melt floods as shortened lake ice seasons encourage more lake-effect snow deposition;
- A possible shorter snow protection season;
- Decreased soil moisture levels through higher evaporation and faster runoff;
- Lower groundwater levels; and

- Lower Lake Levels; it is expected that by 2050 average levels in Lake Erie will be reduced 0.8 m and in Lake Ontario by 0.5 m. This may have the effect of increasing the profile of water quality issues such as rotting algae and exotic species contamination.

According to the NWQPS (MacViro Consultants, 2003b, pgs3-55 &56), "*The impacts on natural areas will include more severe stress in floodplains and marshes, both from extra sediment and from extra scour. On tablelands, the changing soil moisture regimes could combine with the warming temperatures to impose so much stress that whole ecosystems could be altered. In general the shifts would be towards drier, more southern communities but will require many decades of stressed transition phases before more stable, mature southern communities are established.*"

4.3 Surface Water Gauges

A summary of surface water gauges (i.e. flow and/or level) within the NPSP Area is presented in Table 4.2 and Figure 4.4. Twelve (12) stations within the NPSP Area are currently operated by Environment Canada (EC), or by the NPCA under a joint agreement between EC, MNR and NPCA. The NPCA also operates five (5) surface water gauges on their own initiative.

Data is however available for twelve (12) historical EC stations which are not in operation. The datasets for these stations appear to range from two to fifteen years.

A number of subwatersheds in the NPSP Area are not currently monitored, especially in the eastern portion, as can be seen in Figure 4.4. In order to address this, the NPCA initiated five new stations from 2004 to 2006 on priority watercourses lacking information such as Twelve Mile Creek.

4.4 Surface Water Hydrology and Watershed Descriptions

The surface water hydrology can be divided into three main drainage areas; Lake Ontario, the Niagara River, and Lake Erie and each of the drainage areas contain several creek and river watersheds (Figure 2.2).

Within the NPSP Area watersheds, peak flows occur during the spring snow melt (Franz, May 2006), while low flows generally occur in the summer months of July and August. As determined from the analysis of the streamflow data, the Niagara Peninsula contains watersheds that are dominated by runoff processes. Stream response is flashy, with flows quickly receding to pre-event conditions. There are no, or very low, sustained baseflows during the summer months, with significant streamflows only observed in response to a rainfall event. From the available gauge data, there is very little evidence for any substantial surface/groundwater interactions (no stations from Twelve Mile Creek were available for this assessment). It is assumed that these conditions exist for most areas above the Escarpment, however enhanced recharge and baseflow conditions can be expected where permeable local geologic features such as the Fonthill Kame-Delta

Complex and Dunnville Sand Plain exist. Due to the lack of data on watersheds below the Escarpment, it cannot be determined at this time if there is a significant difference between watercourses above and below the Escarpment (Franz, May 2006).

4.4.1 Lake Ontario Drainage Area

Larger watersheds in the *Lake Ontario* drainage basin generally start above (or south) of the Niagara Escarpment and flow easterly before turning north and flowing down the escarpment and into Lake Ontario. Smaller watersheds in this drainage basin start below the escarpment and flow north into Lake Ontario. The Lake Ontario Drainage Area covers about 40% of the NPSP Area. (NPCA Stewardship program). The most significant Lake Ontario basin watersheds are described below.

<u>Forty Mile Creek</u>
Forty Mile Creek watershed covers an area of approximately 64.8 km^2. A significant portion of the Forty Mile Creek watershed is located above the Niagara Escarpment. The creek and its tributaries span three municipalities with the headwaters located in West Lincoln and the City of Hamilton, while the mouth of the creek is located at Lake Ontario in the Town of Grimsby. The NPCA is unaware of any stream flow gauges located on the creek, however precipitation gauges (operated locally for snow and rain) are located in the watershed.

<u>Twenty Mile Creek</u>
Twenty Mile Creek watershed covers an area of 291 km^2 (NPCA, 2005c, April 2005) and is about 79 km in length (NWQPS Phase 2 Report, pg 3-20). The creek begins at the headwaters above the Niagara escarpment in the City of Hamilton and travels in an easterly direction above the escarpment, before turning north and crossing the escarpment at Balls Falls (where it drops 26 m). The creek eventually enters Lake Ontario at Jordan Harbour, after passing through the Jordan Marsh, which was created by lake waters flooding the lower reaches of the river valley. The Twenty Mile Creek watershed contains five (5) sub-watersheds including the main channel of Twenty Mile Creek, Gavora Ditch, Spring Creek, North Creek and Sinkhole Creek. The NPCA completed a Master Watershed Plan for Twenty Mile Creek in 2006.

The Twenty Mile Creek watershed contains several ANSIs, ESAs and regionally significant wetlands. The upper reaches of the Twenty Mile Creek watershed are characterized by rolling topography with fairly steep slopes in the headwaters. Further downstream, the watershed contains gently rolling to flat topography before the creek flows over the Niagara Escarpment.

Base flow in Twenty Mile Creek drops to zero during the summer months, although some water is retained in the channel pools. The low to non-existent summer flows may be due to a number of land use factors primarily resulting from agricultural expansion. These factors include a loss of water storage resulting from a decrease in the amount of forested areas, soil compaction, soil loss, and tile drainage. There may also be natural surface water losses via bedrock fractures and karst features.

The Fifteen, Sixteen and Eighteen Mile Creeks

Fifteen Mile Creek starts above the Niagara Escarpment, then flows over the escarpment at Rockway Falls, and crosses the relatively flat Iroquois Plain before entering into a drowned creek mouth that is separated from Lake Ontario by a vegetated sand bar. Fifteen Mile Creek has a drainage area of 42.5 km^2. The Fifteen Mile Creek Drain system and Keenan Drain are the only municipal drains in the watershed.

Sixteen Mile Creek and Eighteen Mile Creek follow similar patterns beginning above the escarpment, crossing the escarpment and flat plains below, to eventually discharge into Lake Ontario.

Aquatic habitat is considered good in these watershed. Agricultural water use is high and is typically used for irrigation, greenhouse production and livestock (MacViro Consultants, 2003b).

Twelve Mile Creek

Twelve Mile Creek starts above the Niagara Escarpment in the Town of Pelham and flows north through Thorold and St. Catharines before discharging into Lake Ontario. The total drainage area of the watershed is 178 km^2 (NPCA, 2005b), and the length of the creek is about 20 km. The Twelve Mile Creek watershed contains 6 sub-watersheds including the Upper Twelve Mile Creek, Lake Gibson System, Richardson Creek, Francis Creek, Dick's Creek and the Lower Twelve Mile Creek. The NPCA completed a Master Watershed Plan for Twelve Mile Creek in 2006.

The headwaters of the main branch of Twelve Mile Creek begin at the Fonthill Kame-Delta Complex. This is the only watershed in the Niagara Peninsula that supports naturally reproducing cold water fish species (identified in the St. John's and Effingham branches). The topography of the watershed above the escarpment is very irregular due to the deeply eroded gullies and multi-branched nature of the headwater tributaries. The upper Twelve Mile Creek contains Environmentally Sensitive Areas, ANSIs, and Short Hills Provincial Park. The abundance of forested natural areas in this sub-watershed has attracted several provincially and regionally rare bird species to the area.

Twelve Mile Creek flows north and passes over the escarpment at DeCew Falls. Below the escarpment, the creek follows the route of a former Welland Canal before it eventually reaches Lake Ontario at Port Dalhousie. Discharge water from the DeCew Hydro-Electric Generating Station enters the creek at the base of the escarpment, thereby significantly increasing the creek flows. It is estimated that the natural flows in the creek would be only one to two percent of current flows if water was not diverted by the generating station from the Welland Canal. Without these additional flows the natural conditions of Twelve Mile Creek below DeCew Falls would be a slow moving, meandering stream contained within a larger valley (Public Works and Government Services Canada, 1996).

The Lake Gibson System is a constructed system of reservoirs owned by Ontario Power Generation (OPG). This system was created to supply water to the DeCew Power Station in 1898. Originally, water was diverted from Lake Erie via the Welland Canal by the construction of a 7.6 kilometre canal to the Niagara Escarpment just east of DeCew Falls. This canal is called the Power Canal and is now used to supply water for the DeCew Falls Water Treatment Plant (WTP). The DeCew Power Station was expanded in 1904 leading to the creation of Lakes Moodie and Gibson, and was then expanded again in 1947 with the enlargement of Lakes Moodie and Gibson, and the excavation of three channels. These included an intake channel from the Third Welland Canal north of Allanburg, an equalization channel between the two arms of Lake Gibson, and an outflow channel from Lake Moodie to the new penstocks. (See also Appendix B, containing DeCew Falls WTP information and the aerial photograph of the Lake Gibson System).

Several underground connections supply water to the Lake Gibson System. The Davis culvert takes water under the Welland Canal and under the Third Welland Canal to Lake Gibson. In addition, some of the water from Beaverdams Creek is diverted into the Welland Canal and into Lake Gibson. A third connection, Shriner's culvert, does not empty into Lake Gibson. This water originates from the Abitibi-Consolidated Incorporated paper mill in Thorold, and flows into the 'Third Welland Canal' and eventually outlets into the Twelve Mile Creek.

The other contributors to Twelve Mile Creek, Richardson Creek, Francis Creek, Dick's Creek and the Lower Twelve Mile Creek, are all primarily located in St. Catharines below the escarpment.

Four Mile Creek

The Four Mile Creek headwaters are located along the Niagara Escarpment. The creek passes through agricultural lands and the village of Virgil in NOTL before discharging into Lake Ontario. The Virgil Dam and Reservoir are located about 5 km from the mouth of the river. Summer baseflow is essentially non-existent.

4.4.2 Niagara River Drainage Area

The Niagara River flows from Lake Erie north to Lake Ontario, and essentially drains the water from the four upstream Great Lakes (Erie, Huron, Michigan, and Superior). It has an annual average flow of 5,700 cubic metres per second (m^3/s). However the *Niagara River Drainage Area* that is discussed in this report concerns only that portion of the drainage area between Lake Erie and Lake Ontario (and represents only 0.1% of the total Niagara River flow). The Welland River and several smaller creeks, including Black Creek, Beaver Creek and Frenchman Creek, flow into the Niagara River. The Niagara River drainage area (via Welland River watershed) stretches across the entire central portion of the NPSP Area, and covers about 55% of the NPSP Area.

Welland River

The Welland River is the largest watershed in the Niagara Peninsula, and has a watershed area of approximately 1,050 km^2 (Niagara River AOC, Sept, 1993, pg 2-9). The main river channel extends from the headwaters at the western NPSP Area boundary to the eastern NPSP Area boundary, where it connects to the Niagara River, just above Niagara Falls. The river drops about 78 m in the upper portion (above Port Davidson) but only 4 m in the lower portion below Port Davidson (MacViro Consultants, 2003b, pg 3-17).

The Welland River watershed is located primarily on the Haldimand Clay Plain, (consisting of fine-textured glaciolacustrine deposits that cover most of the NPSP Area) and as a consequence the amount of precipitation infiltrating to groundwater is relatively low, as is also the discharge of groundwater to the river. Because of the relatively minor interaction between groundwater and surface water, the Welland River experiences accentuated peak river flows. The watershed contains one major dam, Binbrook Dam on Lake Niapenco located in City of Hamilton, as well as a number of smaller dams, which help to mitigate the variance in flows. There is an ongoing restoration program to eliminate most of the dams and other fish barriers in the river's watershed.

The lower portion of the Welland River has been significantly modified by man-made structures. The river passes beneath the old and new Welland Canals via two siphons. The flow is reversed in the lower reaches of the river as water is drawn from the Niagara River to the Queenston-Chippawa Power Canal via the Welland River. The Queenston-Chippawa Power Canal supplies water for the Adam Beck Hydro Electric Generating Station. This problem is accentuated by the regulation of flow in the Niagara River to increase power generation. This results in diurnal fluctuations in flow that extend many kilometres upstream from the river mouth (MacViro Consultants, 2003b, pg 3-18).

Oswego Creek covers an area over 195 km^2, is oblong in shape, and stretches a distance of approximately 40 km in an east-west direction. From Canboro, to its confluence with the Welland River, flow is sluggish and large meanders characterize this downstream reach of the system. Upstream of Canboro the creek gradient is about 0.9 m/km. Land use within the watershed is predominantly agricultural with scattered development Cuming Cockburn Limited, 1988).

Lyons Creek begins in the City of Welland and discharges into the Welland River in the City of Niagara Falls. The creek is located on relatively flat lands covered with clay soils and is about 47.5 km^2 (Niagara River AOC, Sept, 1993, pg 3-3).

Black Creek is located in Town of Fort Erie and contains a watershed of approximately 70.3 km^2 (Niagara River AOC, Sept, 1993, pg 2-9). The creek starts at Humberstone Marsh, and flows in a north easterly direction before discharging into the Niagara River upstream of the Welland River and Niagara Falls Water Treatment Plant. The creek is located on relatively flat lands covered with mostly silty clay soils. A main tributary of Black Creek is Beaver Creek.

4.4.3 Lake Erie Drainage Area

The Lake Erie drainage area covers about 5% of the NPSP Area and contains several small creek watersheds and tile drained areas which flow generally south and discharge into Lake Erie. The largest watersheds in this drainage area include Six Mile Creek, Wignell Drain, and Lowbanks Drain. All the watersheds in this drainage area are less than 20 km^2 in size, and are generally located between the Onondaga Escarpment and Lake Erie. The Welland Canal passes through the Eagle Marsh Drain and Lake Erie watersheds in this drainage area.

4.5 Surface Water Modeling

The NPCA uses HEC-HMS hydrologic modeling and HEC-RAS hydraulic modeling software to simulate single-event 100 year design storms to forecast stream flows for the purposes of floodplain mapping. Stream cross-sections for the hydraulic modeling are determined using a 1:2,000 scale GIS database. The single-event storm simulations are currently not calibrated to actual stream flow data. (See also Appendix D GIS Information)

4.6 Groundwater and Hydrogeology

Groundwater refers to water found beneath the water table, in soil and geological formations that are fully saturated (i.e. aquifers and aquitards). Hydrogeology is the study of the movement and interactions of groundwater.

In October 2005, a regional Groundwater Study was completed for the whole NPCA jurisdiction. The study was completed according to the MOE Municipal Groundwater Studies Terms of Reference, and provides a regional characterization of the groundwater, groundwater intrinsic susceptibility analysis, groundwater use assessment, and limited flow modeling of the Fonthill Kame-Delta Complex. Information for the study was derived mainly from the Water Well Information System (WWIS), a database maintained by the MOE. Only about 7,600 wells (or approximately 50% of the total number of wells) were used in the study, and the remainder were discarded for quality control reasons, (i.e. location accuracy) Figure 4.5 shows locations of the wells used in the study. Information in the following hydrogeology section was largely obtained from the NPCA Groundwater Study.

Singer et al (2003) indicate that 8,916 overburden wells have been identified within the NPCA as compared to 1,663 bedrock wells. This may indicate that overburden is the main source of non-municipal groundwater supply. However the NPCA groundwater study indicates that of the MOE WWIS records filtered for the study 6,241 are completed in bedrock and 1,370 in overburden. This would indicate that bedrock aquifers are the main source of non-municipal groundwater supply. These two major studies disagree on this significant characterization component and as such, future hydrostratigraphic work is required to resolve this conflict. The reason for this disagreement is unknown (possibilities may include different location accuracy filtering methodologies and/or differing interpretations of aquifers at the overburden/bedrock interface).

4.6.1 Bedrock Hydrogeologic Units

The bedrock hydrogeologic units with the highest water yields in the Niagara Peninsula are typically those shallower units containing limestones and dolostones such as the Onondaga, Bois Blanc, Salina, Guelph, and Lockport Formations (MOE, 2003 pg 33). These younger, shallower bedrock units are much more permeable and are considered a more significant higher quality groundwater source than the older deeper shale formations. Table 4.3 identifies some hydraulic conductivities associated with the bedrock hydrogeologic formations. Specific capacity ranges are shown in Figure 4.6. A short description of the bedrock hydrogeological units is provided below.

The Queenston Formation, is the oldest of the Paleozoic bedrock formations in Niagara and is generally not considered a significant source of groundwater. The top three to five metres of the formation are weathered and may yield enough water for domestic wells but not for municipal supplies. This formation typically has naturally poor water quality.

Overlying the Queenston Formation in the Niagara Peninsula, is the Cataract Group. This group is not considered to be a significant groundwater source for drinking water as it is buried under thick layers of younger bedrock and has naturally poor water quality (MOE, 2003, pg 33).

The Clinton Group overlies the Cataract Group, and contains a number of formations including the DeCew, Rochester, Irondeiquiot, Reynales, and Thorold Formations. These formations of the Clinton Group, below the Rochester Formation, are not considered to be a significant groundwater source for drinking water.

Within the Clinton Group, the Rochester Formation (consisting of interbedded shale and limestone), is characterized by a much lower permeability than the overlying DeCew Formation, and therefore acts as a barrier (aquitard) restricting groundwater flow vertically below the DeCew Formation. The dolostones of the DeCew Formation are often assessed as part of the overlying Lockport hydrogeologic unit.

The Lockport and Guelph Formations overlie the Clinton Group and are made of mostly limestone and dolostone. They are estimated to have a high permeability, particularly in the upper few metres of the formations where fracturing and chemical dissolution are most prevalent. Most domestic wells are installed into this upper portion of these formations, and as a result the well capacities are usually high. Groundwater from the Lockport Formation is also known to have naturally poor quality especially for sulphur-type compounds. The Lockport and Guelph Formations are often treated as one hydrogeologic unit due to their similar specific capacity and transmissivity distributions (MOE, 2003, pg 34). The hydraulic conductivity of the Lockport and DeCew Formations was estimated to be between $2x10^{-5}$ and $1x10^{-8}$ m/s, from packer testing data in one site-specific hydrogeologic study (Jagger Hims Limited July 1999, pg 17). Hydraulic conductivity of the Rochester Formation was estimated to be between 10^{-7} to 10^{-9} m/s in the same study (Jagger Hims Limited July 1999, pg 17).

The Salina Formation consists mostly of dolostones, evaporates, evaporitic carbonates, and shales. The formation is estimated to have a high permeability and good water-yielding capability. However water quality from this formation is often not suitable for drinking water.

The Bertie Formation is expected to exhibit good water-yielding capability, due to its similarity to the Bass Island Formation which has a good water-yielding capability. However, more information and analysis is required to confirm this estimate (MOE, 2003. pg 37-38).

The Bois Blanc Formation consists of cherty limestone, with a high water-yielding capability.

There is very little data available at this time on the Onondaga Formation and consequently no generalizations on this hydrogeologic unit have been identified.

4.6.2 Overburden Aquifers

Overburden aquifers in Niagara Peninsula generally consist of near surface coarse-grained deposits that are primarily observed in the following locations (WHI, 2005, pg 2-20).

- Sand and gravel along the floodplain of Twenty Mile Creek and the Welland River at the western end of the watershed;
- A thick sequence of sand and gravel in the headwaters of the Welland River directly south of Ancaster;
- Dunnville Sand Plain;
- Wainfleet Moraine, just west of the Wainfleet Bog;
- Shoreline deposits along Lake Erie;
- Fonthill Kame-Delta Complex;
- Glaciolacustrine and deltaic sand deposits along Lake Ontario between Grimsby and St. Catharines;
- Sand deposits in St. Catharines and NOTL that are associated with glacial Lake Iroquois; and
- St. Davids Buried Gorge.

These areas and physiographic features are depicted in Figures 2.3, 2.4, 2.6 and 2.8.

Well records show that water well yields in the thicker, near surface deposits of coarse textured soils are sufficient for domestic water supply purposes and natural water quality is usually satisfactory (WHI, 2005, pg 2-21,22). Table 4.4 identifies hydraulic conductivities for various soil types in the Niagara Peninsula.

The following is a description of the main overburden aquifers from Singer et al, (2003). These aquifers were primarily determined based upon high specific capacity results in the overburden and a review of water well records. However their aerial extent has not been published.

The Fonthill Kame-Delta Complex aquifer contains sand and gravel up to 60 m in depth. The central area of this unit is considered unconfined despite occasional deposits of clay. The outer edges of the Kame are confined by a covering of glaciolacustrine clay. Well yields are reported to range from 15 to 1335 L/min.

The Lincoln Aquifer is located within the western half of the NPSP Area and has been identified in the former townships of Ancaster, Glandford, Binbrook, Canborough, and West Lincoln. It is covered by thick deposits of glaciolacustrine clay and some till. The aquifer consists mainly of gravel with minor sand ranging in thickness from a few metres to up to 10 metres. The aquifer is confined, and static water levels range from 1 to 17 m below ground surface. Well yields are between 15 and 300 L/min.

The Wainfleet Aquifer, consists of medium sand and gravel deposits a few metres thick, which is overlain by up to 10 m of blue clay and a thin layer of sand that is present at the surface in this area. Well yields for this confined aquifer range from 25 to 180 L/min. Water levels range from 2 m to 7 m below ground surface.

The Port Colborne Aquifer consists of gravel with some medium sand up to a few metres thick. This confined aquifer is overlain by a deposit of glaciolacustrine clay up to 25 m in thickness. The well yields range from 15 to 65 L/min.

The St. Catharines Aquifer consists of medium sand and gravel up to a few metres thick. The aquifer is confined and is covered by up to 22 m of clay. The land surface where this aquifer occurs is covered with till and glaciolacustrine sand. Well yields range from 35 to 890 L/min (MOE, 2003 pg 165-167).

The Niagara-on-the-Lake (NOTL) Aquifer consists of fine to medium sand (and/or gravel) in deposits up to a few metres thick. The aquifer is overlain by up to 25 m of clay and till deposits. The land surface where this aquifer occurs in NOTL is covered with till and glaciolacustrine sand. The well yields range from 15 to 175 L/min.

4.6.3 Overburden Aquitards

A large portion of the Niagara Peninsula is covered with fine-texture glaciolacustrine deposits associated with the Haldimand Clay Plain. These deposits form an aquitard layer above the bedrock that restricts the vertical movement of groundwater down into the bedrock aquifer. These silts and clays are subject to drying and cracking near the surface during the dry summer months, but the weathering is assumed to not significantly affect the overall hydraulic conductivity of the aquitard, which is estimated to be less than 10^{-7}m/s (Niagara River AOC, Sept 1993, pg 2-12).

4.6.4 Surface-Groundwater Interaction

The impermeable near-surface soils of the Haldimand Clay Plain limit the interactions between surface water and groundwater in much of the NPSP Area. However interactions between surface water and groundwater do occur in areas such as the Niagara Escarpment (particularly in karst locations) as diffused seeps. There is also groundwater discharge to numerous creeks and streams that originate at the foot of the escarpment (both seasonal and perennial).

Significant groundwater discharge, on a local scale, occurs where various streams and creeks cut into more permeable overburden and fractured shallow bedrock. Twelve Mile Creek is a significant coldwater stream being fed primarily by the Fonthill Kame-Delta Complex. Groundwater discharge is also known to occur in large quantities in the vicinity of the St. Davids Buried Gorge.

4.6.5 Groundwater Flow, Recharge Areas, and Discharge Areas

Shallow groundwater flow is expected to generally follow the ground surface topography. Regional groundwater flow is generally expected to be directed towards either Lake Ontario with an elevation of approximately 75 metres above sea level (masl), or Lake Erie (with an elevation of about 176 masl) from typically the mid-section of the peninsula (i.e. Fonthill Kame-Delta Complex which has an elevation of over 250 masl). See Figure 4.7 for groundwater table elevations, and Figure 4.8 for the depth to the water table (from ground surface). The estimated groundwater potentiometric surface is also presented in Figure 4.9.

Groundwater recharge areas in the Niagara Peninsula are generally associated with coarse grained relatively permeable soil deposits, as well as bedrock outcrops. Figure 4.10 shows the potential recharge areas identified in the NPCA Groundwater Study (WHI, 2005). The potential recharge areas in the NPCA Groundwater Study were identified where permeable soil deposits were located in areas where the water table was significantly lower than the ground surface. The most significant of these groundwater recharge areas include:

- Fonthill Kame-Delta Complex;
- Dunnville Sand Plain;
- Iroquois Plain sand deposits located between the Niagara Escarpment and Lake Ontario;
- Bedrock outcrops of the Onondaga and Niagara Escarpments; and
- Wainfleet, Crystal Beach and Fort Erie moraines.

The high potential recharge mapped along the escarpment is likely due to generalized water table mapping (Figure 4.7) and may not be realistic. However, karstification due to chemical weathering may occur along the escarpment and enhance local recharge conditions. In general, throughout NPCA there is a low recharge potential.

The potential for upward groundwater flow is greatest where the potentiometric surface elevation is greater than the water table elevation. Differences between the potentiometric and water table surfaces are minimal across most of the Niagara Peninsula; however, areas of increased potential upward gradients are noted, e.g. below the Niagara Escarpment in the Town of Lincoln. The upward gradient shown in the Fonthill Kame-Delta Complex is surmised to be an error due to inaccurate mapping of the water table within that unit, as there is a lack of water level points within the upper 15m and as such the water table at this location is not well represented in Figure 4.7 (Franz, May 2006).

Discharge areas are typically located where the water table potentially extends above (or meets) the ground surface (Figure 4.11). Discharge areas tend to be situated in wetlands, and low lying areas such as valleys, and at the base of the Niagara Escarpment. Other discharge areas include the base of the Fonthill Delta-Kame Complex, part of the Twelve Mile Creek headwaters, and the area south of Pelham where the sands of the Fonthill Kame-Delta Complex meet the Welland River. Discharge from above the escarpment is also expected to occur beneath (north of) the escarpment, but not to the degree indicated on Figure 4.11. A high discharge area indicated below the escarpment north-northwest of Grimsby, (where the water table is indicated to be greater than 100 m above ground surface) is likely a function of the water table interpolation procedure used in the NPCA Groundwater Study. Artesian (or flowing) wells are reported in the St Davids area near the base of the Niagara Escarpment, south of the Onondaga Escarpment, and northwest of Fonthill (and the Kame-Delta's highpoint) (WHI, 2005).

The NPCA Groundwater Study identified shallow intrinsic susceptibility areas for groundwater, based on calculations and protocols prescribed by the MOE. The key parameters included depth to water table, and the permeability of the soils overlying the groundwater table. Figure 4.12 shows the areas of shallow intrinsic susceptibility in the Niagara Peninsula.

4.7 Data and Knowledge Gaps

A number of data and knowledge gaps exist with respect to our understanding of the hydrology and hydrostratigraphy of the Niagara Peninsula are identified below. It should be noted that not all of these 'gaps' are required to satisfy the requirements of the SP Guidance Modules.

- Climate normals that sufficiently cover the breadth and contrasting regions of the NPSP Area, in addition to those already produced by the MSC. This would likely be addressed through the production of climate normals for Regional Niagara Stations (and would require digital compilation of pre-1992 weather station data) as well as information from outside the NPSP, e.g. Haldimand County and City of Hamilton.
- Review of Provincial Groundwater Monitoring Network water level data for baseline evaluation of water level trends.
- Groundwater divides and subwatersheds. The NPCA Groundwater Study provided a coarse estimation of the water table and potentiometric surface. However,

differentiation of groundwater subwatersheds are difficult to observe due to the scale of assessment combined with low hydraulic gradients. As a result, delineation of site-scale groundwater flow contours is required for water resource protection and planning. This could be accomplished through subwatershed-scale hydrogeologic studies completed in tandem with the NPCA watershed plan program.

- Delineation of overburden and bedrock aquifers (i.e. hydrostratigraphy) and compilation of their physical properties. This could also be accomplished through subwatershed-scale hydrogeologic studies completed in tandem with the NPCA watershed plan program building upon existing public studies and datasets (e.g. Ontario Waste Management Corporation hydrogeologic assessments).
- Determination of water well completion units (i.e. overburden or bedrock). This would resolve the significant disagreement between the NPCA Groundwater Study and The Hydrogeology of Southern Ontario with respect to the number of water wells in overburden or bedrock.
- Identification of an aquifer specific subwatershed-scale, intrinsic susceptibility index, rather than the bulk indices currently presented. This could be completed following delineation of aquifer units but would require the use of geotechnical and environmental geologic logs where available. It would also be recommended to incorporate a measure of confidence based upon the data source and density of reliable information as per existing SP Guidance Module- Groundwater Vulnerability Assessment.
- Delineation of significant recharge areas. This will be completed as part of the Tier 1 Water Budget program.
- Data with respect to existing surface water flow monitoring completed by the St.Lawrence Seaway Management Corporation, Ontario Power Generation, the City of St.Catharines and other agencies.
- Surface water gauge stations that adequately cover ungauged portions of the NPSP Area. Approaches to address this could include:
    - Evaluation of restarting some older stations;
    - Use of data/stations from development applications and permit to take water holders; and
    - Completion of a Gaps Study to determine where stations are needed, although this depends upon the specific data need.

5.0 HUMAN CHARACTERIZATION

5.1 Population Distribution and Density

Population distributions and projections up to the year 2026 were obtained for the NPSP Area,[8] and are shown in Tables 5.1 and 5.2. Current population estimates use the 2001 Census Canada survey. Densities have been calculated based on these populations and the known jurisdictional areas of the municipalities.

An approximate population of 465,000 currently resides within the NPSP Area, (projected to 2006 from 2001 Census data showing a population of about 435,620), and the population is expected to increase by about 28% to 559,947 by the year 2026[9].

The largest percentage increases in population are expected to occur in NOTL (62%) and Thorold (48%) by the year 2026. However Niagara Falls and Welland are expected to contain the greatest total population increases (at approximately 19,070 and 11,380 people respectively). St. Catharines, the largest population centre in 2006, is expected to grow by about 7,450 people by the year 2026. The Regional Niagara population is expected to increase by 22% (or 89,000 people) by 2026, with most of the rural municipalities increasing by 20 to 30%.

According to the NPCA Groundwater Study, the portion of population in 2001 living in urban areas with full water and sewer servicing is estimated at about 85% of the total population (Table 5.3). The largest urban centre in the NPSP Area is St. Catharines with an urban population of approximately 127,000 (NPCA Groundwater Study Final, 2005). Other large urban centres include the cities of Niagara Falls and Welland, with urban populations of about 76,170 and 46,460, respectively.

The major urban centres in the NPSP Area are clustered along the Lake Ontario/Lake Erie shorelines, the Niagara River and the Welland Canal. Drinking water sources for these urban centres are essentially supplied from the Great Lakes. Consequently, adequate long-term supply of source water for these municipally serviced urban centres is not considered a significant issue (from a quantity perspective).

As stated by 2001 Census Canada Results, the City of St. Catharines has the largest population (129,170) and maintains the highest density in the NPSP Area of 1368 Persons/ km^2. In terms of Density, the City of Welland follows St. Catharines (48,402)

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[8] Current and projected populations were obtained from Haldimand County Planning & Development Dept., the Regional Niagara Planning Dept., and the City of Hamilton, Manager of the GRIDS program. As indicated, some data is also referenced from the NPCA Groundwater Study Final report dated October 2005.

[9] 2001/2026 Hamilton population estimates/projections that are shown in this report were obtained in 2006 from City of Hamilton after it completed its GRIDS planning and forecasting model. Consequently, the estimates/projections are different to the NPCA Groundwater Study data, which is now considered outdated.

with 596 Persons/ km^2, which is followed by the City of Niagara Falls (78,815) with 372 Persons/ km^2 and the Town of Grimsby (21, 297) with 313 Persons/ km^2. The Township of Wainfleet has the smallest population (6,258) and also the lowest density of 29 Persons/ km^2. The Township of West Lincoln has the second smallest population (12,268) and corresponding density of 32 Persons/ km^2. Niagara-on-the-Lake comes in third for the fewest population of (13,839) and density of 106 Persons/ km^2. The remaining populations and densities can be found in Table 5.1 and in Figure 5.9.

The rural population uses either private groundwater wells, or cisterns supplied with either rainfall or purchased drinking water. Inland streams and rivers (such as the Welland River and Twenty Mile Creek) are not known to be used for drinking water sources.

5.2 Land Uses

Land uses can have a significant impact on drinking water supplies in terms of quality and quantity. Land uses are primarily governed by council-approved municipal planning documents such as the Official Plan (OP). The Official Plan is a policy that describes a municipality's strategic vision for community development and land use. Official Plans specify present and future uses for lands (residential, agricultural, industrial and commercial, etc), and may also require special policies for areas such as wetlands, and environmentally sensitive areas. Land uses have a direct impact on the type of ground cover.

Approximately 70% of the NPSP Area is agricultural, and about 15% is rural wooded or natural. The remaining 15% is considered urban. The urban areas are defined as the lands within the urban boundaries as shown on Municipal Official Plans. A land-cover and land-use inventory of the NPSP Area is shown in Figure 5.1. The inventory uses the Southern Ontario Land Resource Information System (SOLRIS) database. Table 5.4 provides a break-down of the urban areas as a percentage of the total for each municipality. The municipalities with the highest proportion of urban lands are St. Catharines (63%), Welland (55%), and Niagara Falls (39%), while the Townships of Wainfleet and West Lincoln contain the lowest percentage of urban land (at 0% and 1% respectively). Figure 5.2 shows the current urban areas.

There are several major transportation corridors in the NPSP Area. The major road arterials described below:

- The Queen Elizabeth Way (QEW) is a major freeway that runs parallel to the Lake Ontario shoreline and then turns southward to cross the peninsula just west of the Niagara River and ends in Fort Erie at the Peace Bridge to the U.S.A.. The QEW is the main transportation route from Toronto to Fort Erie;
- Highway 406 runs between St. Catharines (at QEW) and Welland and is currently undergoing major expansion and improvements to accommodate the increased traffic flows between these two cities. It is an important link in the development and growth plans in the Niagara Peninsula;

- Highway 3 is a two-lane highway that runs roughly parallel to the Lake Erie shoreline connecting smaller urban centres such as Fort Erie, Crystal Beach, Port Colborne, and Dunnville;
- Highway 20 runs east-west through the centre of the peninsula connecting villages such as Fonthill and Smithville;
- Regional Road No. 24 runs north-south from Lake Ontario at Vineland to Lake Erie (at Morgans Point).
- Old No. 8 Hwy is a popular scenic route that runs east-west along the northern edge of the Niagara Escarpment.

The two main railway corridors traverse east-west across the NPSP Area. One is located north of the Niagara Escarpment and the other is located south of Welland River.

The Welland Canal, which is operated by the St. Lawrence Seaway Management Corporation, runs north-south from Lake Erie to Lake Ontario (between Port Colborne and St. Catharines). The Canal is a major seaway shipping corridor and has historically been a significant economic driver in the Niagara Peninsula. However, the Welland Canal also creates a barrier to east-west land-based transportation, since there is a limited number of bridges and tunnels crossing the canal.

Another historic barrier to transportation has been the Niagara Escarpment. The cost to construct transportation arteries across this physiographic feature with its steep drop in elevation has often been prohibitive. Consequently, only a handful of major transportation routes actually cross the Escarpment, namely the QEW, Hwy 406 and the Welland Canal.

The Niagara Peninsula is also serviced by the John C. Munro Hamilton International Airport, the Niagara Airport (NOTL) and the Welland Airport. The Hamilton airport serves as an alternate and reliever airport for nearby Toronto-Pearson International Airport. The Niagara Airport has no regular passenger service but does accommodate a significant number of charter flights.

5.2.1 Designated Growth Areas

Growth areas in the Niagara Peninsula are expected to be primarily located along the north-south Welland Canal corridor linking the urban centres of St. Catharines/Thorold, Welland/Fonthill, and Port Colborne. The improvements to Hwy 406, which connects St. Catharines to Welland, is an important link in this strategy to push economic development south across the peninsula. A mid-peninsula freeway is also being considered by the province to improve economic development south of the Niagara Escarpment. While the specific route has not yet been selected by the provincial government, the mid-peninsula freeway is expected to connect to the QEW in the west, cross the Niagara Escarpment and then travel west to east across the Niagara Peninsula, eventually connecting to Welland and Fort Erie.

5.2.2 Urban Residential Development

Planning with respect to urban development, including residential, has been given significant consideration as part of the province's Growth Plan for the Greater Golden Horseshoe. Municipalities maintain data with respect to existing and remaining urban residential areas and will be required to formally report this to the province using a common standard in the near future.

5.2.3 Industrial / Commercial Areas and Trends

The primary industrial areas are located in the cities of St. Catharines, Thorold, Welland, and Niagara Falls, and include industrial sectors such as manufacturing of automotive parts, steel products, pulp and paper mills and recycling centres, and chemical products. The key commercial-financial districts are located in St. Catharines, and Niagara Falls.

Regional Niagara

Minimal data appears to exist with respect to trends in industrial and commercial land use patterns within the Niagara Region. Data exists with respect 1970 and 2000 on occupied industrial and commercial lands, however this data has not been evaluated and may not be comparable (Miller, Rick).

City of Hamilton

No information with respect to industrial trends is currently available however it is hoped that the new Official Plan for the City of Hamilton, which is expected before the end of 2006, may address this topic (Plosz, Cathy).

Haldimand County

No information is available for Haldimand County with respect to this deliverable. However within the Haldimand County portion of the NPSP Area, there are limited industrial and commercial lands (Vandezande, Rich).

5.2.4 Agriculture

Agricultural land uses are typically oriented to operations that are most effective for the soil and climate conditions in that locality. Vineyards and tender fruit orchards are as such, primarily encountered below (north of) the Niagara Escarpment where the climate is more moderate and soil conditions are more conducive to those crops. On top of the Niagara Escarpment, livestock operations and specialty crops make up the main agricultural land uses. Specialty crops include greenhouses for flowers and vegetables, sod farms, and mushroom farms. Livestock operations are primarily found in the Town of Fort Erie and the Townships of Wainfleet and West Lincoln, which are located on the Haldimand Clay Plain (WHI, 2005, pg 2-4, Section 4).

Based on data analysed for the Niagara River AOC between 1941 and 1991, there has been a trend toward fewer, larger, farms. There has also been a decline in the number of farms and the amount of land used for agricultural purposes in Niagara. Market gardens, orchards, and field crops have declined in total acreage, while grape growing, greenhouse operations, and feedlot operations have increased. Intensive livestock operations make up the largest portion of the farming economy.

Agriculture Operations and Water Use

The types of agriculture operations in an area are influenced by the availability of water, as some types of operations consume more water than others. NPCA has investigated demand from agricultural water use sectors using the de Loe methodology (de Loe, 2001 and 2005) during the development of the Tier 1 Water Budget. Using this methodology and agricultural census data (for 1991, 1996, 2001 and 2006), demand estimates were determined for the following five main categories;

- Livestock (i.e. hens and chickens)
- Field crops (i.e. winter wheat)
- Fruit crops (i.e. apples)
- Vegetable crops (i.e. sweet corn)
- Specialty crops (i.e. sod)

In the NPSP Area, the majority of agricultural water demand is primarily for greenhouse flowers (within the specialty crops category) followed closely by peaches (within the fruit crops category). These types of farming operations are typically located north of the Niagara Escarpment where water can be supplied from Lake Ontario, municipal water supply, or other sources. Estimates show a decreasing trend between 1991 and 2006 for livestock watering, while crop water use shows an overall increasing trend in the same time frame. Calculated agricultural consumptive water demands (NPCA, 2009d, Table 5.12) with respect to groundwater and in-land surface water sources indicate monthly volumes were greatest in either July, August or both. Further information is presented in the Tier 1 Water Budget prepared by NPCA in 2009.

Livestock effects on water quality will vary between animals because of size differences between species. Therefore, the amount of nutrient derived from manure production was used as a surrogate for livestock density to allow meaningful comparisons of livestock operations between municipalities. Figure 5.10 exhibits livestock density in Nutrient Units/Hectare.

5.2.5 Protected and Recreational Areas

Protected land areas are shown in Figure 5.3, and include NPCA-owned lands such as Ball's Falls Conservation Area and Wainfleet Bog. Other areas that are marginally protected include the lands under the jurisdiction of the Niagara Escarpment Commission, and the Green Belt Act, 2005.

Recreational land-use areas in the Niagara Peninsula include Conservation Areas, municipal parks, golf courses, campgrounds, bicycling and walking paths, and the Welland Recreational Canal (which is also known as the Old Welland Canal). Recreational areas are presented in Figure 5.4.

5.2.6 Landfills and Brownfields

Landfills and Brownfield sites are potential sources of groundwater contamination in the NPSP Area. According to the NPCA Groundwater Study, there are 112 landfill sites in the study area, of which 21 are active and 91 are closed. Older landfills that were developed prior to provincial standards that required leachate collection and liners, and groundwater monitoring are potentially a major source of groundwater contamination (WHI, 2005, pg 5-5). Consequently, landfills are presented in more detail in Section 8.0 of this report.

Brownfield sites are properties that have historically contained contaminated soil and/or groundwater at the site. Typically these are former industrial facilities. These sites can pose a significant environmental problem and can be a significant threat to drinking water sources. Discussion of a brownfields inventory is described in more detail in Section 8 of this report.

5.2.7 Oil and Gas Fields, and Aggregate Extractions

According to the NPCA Groundwater Study, there are approximately 53 quarries (where bedrock is extracted), and 34 gravel pits (where sand and gravel is extracted near the ground surface from granular overburden deposits) in the NPSP Area. Aggregate extraction operations usually result in the protective overburden being removed and this may increase the risk of groundwater contamination. Locations of major aggregate extraction operations are shown in Figure 2.8 (Surficial Geology).

Natural gas has historically been extracted from deep bedrock wells in the Niagara Peninsula. Oil and Gas wells are primarily located in the southern portion of the peninsula, as shown in Figure 5.5. The Ontario Oil, Gas and Salt Library (OGSRL) provided this dataset and the data are being verified (i.e. geo-referenced) as detailed on the figure. The OGSRL dataset included six (6) well types: (i) natural gas storage wells, (ii) natural gas wells, (iii) observation wells, (iv) oil and gas wells, (v) private gas wells and (vi) stratigraphic test wells.

5.2.8 Municipally Serviced Areas

Municipally serviced areas in the Niagara Peninsula are generally restricted to the larger developed urban centres. The areas serviced by municipal water are shown in Figure 5.6. A number of villages are also serviced by municipal water. These include Smithville, Jordan, Vineland, Binbrook, Virgil, and Stevensville.

In terms of municipal wastewater treatment facilities, there are currently ten (10) waste water treatment plants (WWTPs) and one (1) sewage lagoon system in operation in the NPSP Area (Table 8.3 and Figure 5.7). Discharges from WPCPs and sewage lagoon are considered a Threat to the water quality. Typical concerns related to these facilities include nitrogen, phosphorous, bacteria, and pathogens. Pharmaceuticals are also now being researched for their potential adverse effects on the water quality. Further details of the municipal wastewater treatment facilities are described in this report in Chapter 8; Threats Inventory.

5.2.9 Private Sewage Systems

Many rural areas and villages in the NPSP Area are serviced by private sewage systems. These sewage systems are known to adversely affect the water quality at several locations in the Niagara Peninsula. Some key locations where this issue needs to be addressed include the Lake Erie shoreline developments in Wainfleet, Port Colborne and Fort Erie. The responsibility for inspection and approval of sewage systems having capacity less than 10,000 L/day depends on the municipality's implementation of the Ontario Building Code, i.e. some conduct their own approvals while some utilize the services of the Regional Niagara Health Unit. The MOE Environmental Assessment and Approvals Branch is however responsible for approval of large sewage systems (i.e. discharges greater than 10,000 L/day). Table 5.5 provides information on the municipal approvals process. Additional details on septic systems are found in the "Threats and Issues" Section of this report.

5.3 Drinking Water Sources

5.3.1 Municipal Drinking Water Supplies and Distribution Systems

City of Hamilton

A portion of the City of Hamilton municipal drinking water distribution system extends into the NPSP Area. These municipally serviced areas are primarily located in the former Town of Stoney Creek and in the southern portion of Hamilton. This portion of the City of Hamilton water distribution system is supplied by the Hamilton-Woodward WTP, which is located west of Centennial Parkway and obtains its source water from Lake Ontario (Figure 5.7).

Haldimand County

Haldimand County has no urban areas with municipal water services that are located in the NPSP Area. There are no municipal water supplies (WTP Intake Protection Zones or Wellhead Protection Areas) located in the Haldimand County portion of the NPSP Area.

Regional Niagara

Municipal drinking water in the Regional Niagara is derived exclusively from surface water sources. They include the following Water Treatment Plants (WTPs):

1. Grimsby WTP
2. St. Catharines DeCew Falls WTP
3. Niagara Falls WTP
4. Welland WTP
5. Fort Erie (Rosehill) WTP
6. Port Colbourne WTP

WTP locations are shown in Figure 5.7. Table 5.6 provides a summary of the municipal WTPs that are located in the NPSP Area. More detailed information on the WTPs is provided in Appendix B.

The St.Catharines DeCew Falls WTP is essentially supplied water from Lake Erie, via the (new) Welland Canal. The water travels from the (fourth or current) Welland Canal, along the Power Canal, which is located south of Gibson Lake, to a storage pond at the western end of Lake Gibson, where the intake to DeCew Water Treatment Plant is located. Consequently the intake water for the DeCew Falls WTP is susceptible to potential threats along the Welland Canal such as ship bilge/waste water releases to the canal, and sewer discharges to the Welland Canal. Contaminated soils are also known to be present at the east end of Lake Gibson.

Port Colborne WTP obtains its water directly from the Welland Canal, and is therefore susceptible to similar potential threats along the canal. The Welland WTP obtains its water from the Welland Recreational Canal which is fed from the *new* Welland Canal, and consequently is also susceptible (albeit to a lesser degree) to potential threats along the canal.

The current intake for the Niagara Falls WTP is located at the easternmost end of the Welland River but receives inflow from the Niagara River due to hydroelectric diversion of river flow. Plans are underway to construct a new intake within the Niagara River in the near future. Discharges to the Niagara River as well as Lake Erie water quality are potential concerns. However remedial actions have significantly decreased the amount of contaminants of concern discharging to the Niagara River in recent years (Section 8.7).

The Fort Erie WTP is located in Lake Erie about four km west of the intake to the Niagara River on Rosehill Road. The pipe intake is approximately 500 m from the shoreline and is about six m deep under water.

The Grimsby WTP is located beside Lake Ontario, approximately three km west of the mouth of Forty Mile Creek. The raw water intake is approximately 2 km from the shoreline and in water about 10 m deep.

The last two municipal wells operated by Regional Niagara were decommissioned around 2002 in the Town of Pelham. The municipal water system in Pelham is now supplied by the Welland WTP.

Municipal Drinking Water Distribution Systems
The municipal drinking water distribution systems located in Regional Niagara include the urban areas of Grimsby, Lincoln, St. Catharines, NOTL, Niagara Falls, Welland, Fort Erie, and Port Colborne. (See Figure 5.6, Municipally Serviced Areas and Appendix B).

5.3.2 Communal Wells

Information on communal water supplies (e.g. campgrounds and trailer parks) is incomplete, primarily due to data release restrictions at the provincial level. The Niagara Regional Health Department prior to Ontario Regulation 170/03 (Drinking Water Systems) provided monthly testing as a general rule to these communal systems (Wolf, Alphie). It is expected that monitoring of some non-municipal systems will be downloaded and therefore become the responsibility of the local health units in early 2008. Information on communal water supplies may also be available from the MOE Certificate of Approval (C of A) database once it is released to the NPCA from the MOE.

5.3.3 Private Wells

There are over 14,000 wells registered in the MOE Water Well Information System (WWIS) database for the NPSP Area. The NPCA Groundwater Study estimated that most of the rural population uses private wells for their domestic water supply. This represents about 67,000 people, or 15% to 20% of the total population in the NPSP Area. Based upon 175 L/person/day, the groundwater study estimated that groundwater use totals about 11,760 m^3/day for Area rural population domestic water use (Table 5.7). However this estimate may be higher than the actual consumption, since not all the rural population uses groundwater for domestic water. The actual groundwater used for domestic water is expected to vary across the region, based on availability of aquifers that can produce sufficient groundwater supplies of satisfactory water quality. For example, it is known that in Haldimand County, where the groundwater quality is often not appropriate for domestic consumption (due to naturally occurring salts, etc.), upwards to 90% of the rural population are likely using some other domestic water source (i.e. cisterns).

Cisterns are commonly used in areas where the groundwater is of poor quality, such as in the Salina Formation, and municipal water is the common source of water to supply the cisterns (NWQPS, Phase 2 Report, Section 3.3.4.1). Table 5.7 provides estimates of the domestic groundwater consumption for each of the three major drainage basins (Lake Ontario, Niagara River, and Lake Erie)[10]. Domestic groundwater use is expected to

[10] The domestic groundwater consumption value is not corrected to account for the residents' use of other sources of rural drinking water such as purchased municipal drinking water.

increase by 10% by the year 2026 (NPCA Groundwater Study, 2005, pg. 4-15). Figure 4.5 shows the locations of water wells that were used in the NPCA Groundwater Study[11].

5.4 Other Water Uses

5.4.1 Groundwater Takings

Other water uses besides drinking water include agriculture, irrigation, industrial, commercial, dewatering, recreation, miscellaneous, and remediation. The NPCA Groundwater Study (2005) performed an analysis of the large groundwater PTTW's (>200,000 L/day) for the NPCA jurisdiction (WHI, 2005, Tables 4.5,6 and 7, pg 4-6 to 4-7). NPCA completed further analyses of the PTTW database during development of the Tier 1 Water Budget and the results are showin in Figure 5.8 (NPCA, 2009d). Dewatering represented the largest amount of groundwater use based on the PTTW Maximum Permitted Rates. The dewatering quantities include groundwater extracted from the transportation tunnels that pass under the Welland Canal, as well as dewatering for aggregate mineral extraction. The second highest type of PTTW purpose/use was industrial with commercial third.[12]

The NPCA Groundwater Study (2005) estimated total groundwater use to be about 55,774 m^3/year. The estimate was derived through summing the large and small PTTWs, and estimated rural domestic and agricultural water uses (Table 5.8; Analysis of Groundwater Uses). The actual water takings of the PTTWs were estimated/prorated for the calculations in the NPCA Groundwater Study[13]. According to the Groundwater Study, the large PTTWs represent 88% of the groundwater use in the NPCA jurisdiction, and the total groundwater use is about 25% of the anticipated annual groundwater recharge, which is considered significant.

<u>*Dewatering*</u>

The dewatering of groundwater is believed to occur actively at two crossings of the Welland Canal; the East Main Tunnel operated by the Ministry of Transportation (MTO), and the Townline Tunnel operated by The St. Lawrence Seaway Corporation. The Thorold Road Tunnel is also actively dewatered but the MTO believes infiltration is from the above canal waters (Kozina, Joe).

Two studies were published in 1970 (Farvolden and Nunan, and Frind, Canadian Geotechnical Journal Volume 7) investigating the temporary and permanent regional depressurization of the shallow bedrock aquifer to facilitate realignment of the Welland Canal between Port Robinson and Port Colborne. A re-assessment of the zone of

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[11] The MOE Water Well Information System (WWIS) database was utilized in the NPCA Groundwater Study. The WWIS contained data for 14,140 wells, but only 7,611 wells were considered to have information that met the quality control requirements of the study, and these are the wells plotted.
[12] Water uses/requirements for ecological purposes were not analysed in the groundwater study.
[13] Actual water used/extracted is expected to be much less than the maximum allowed water takings noted in the PTTW permits.

interference has not been conducted on the East Main or Townline Tunnels since. However an outline of the regional 3 m (10 foot) zone of interference based upon the historical work by Frind (1970) and the principle of superposition is shown on Figure 4.7 as a possible current zone.

5.4.2 Surface Water Takings

No detailed studies are available that provide information on surface water takings occurring in the Niagara Peninsula. However some limited analysis has been performed using the MOE PTTW database, which provides information on water takings of more than 50,000 L/day[14]. Prior to analysis the data was filtered to remove temporary or cancelled permits, as well as permits that expired before 2002, permits for wetlands construction and great lakes water takings.

The two largest categories of inland surface water takings in the Niagara Peninsula, based on the PTTW database, are agricultural uses and commercial uses. Even when the PTTW volumes are reduced to reflect actual takings[15], the two largest categories are still agriculture and commercial. Other water uses across the peninsula include water takings for industrial, recreational and miscellaneous purposes. A more detailed analysis of the surface water takings is provided in the *Draft* Conceptual Water Budget report, dated May 2006.

5.4.3 Recreational Water Use

Some general comments with respect to the connection between local economic prosperity and water-based recreational activities (primarily tourism) in Niagara Peninsula are described below:

- The Niagara Economic Development Corporation (NEDC) website reports that Niagara is the #1 tourism destination in Ontario and accounts for 40% of the Canadian tourism industry. It is expected that by 2016, 30 million visitors will spend over $2.3 billion in Niagara.
- Tourism is a major sector of the Niagara Peninsula's commerce. A number of water features are considered very important to the tourism industry including Niagara Falls, the Niagara River, Lake Ontario, Lake Erie, Welland Canal, Twelve Mile Creek and Port Dalhousie. Examples of large employers or events tied to these water features include:
    - Niagara Fallsview Casino Resort (4,279 employees), Casino Niagara (1,820 employees), Niagara 21st Group Inc. (1,600 employees), Canadian Niagara Hotels (1,400 employees), fishing tournaments, 53 beaches, boating, rowing clubs and the Royal Canadian Henley Regatta

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[14] Exceptions to this reporting requirement are agricultural uses and firefighting.

[15] For example; Actual water takings were estimated from golf course PTTWs by adjusting to reflect the seasonality of the golfing season. Agricultural water takings were also adjusted in a similar manner.

A number of recreational uses are also indirectly related to water such as (NWQPS, 2003):

- Nature watching (e.g. Shorthills Provincial Park, Port Weller, Queenston Sand Docks, Wainfleet Bog, Rock Point, Morgan's Point and Beamer Conservation Area);
- Trail Use (e.g. the Waterfront Trail, Welland Canal Trail System and the Niagara River Parkway);
- Hunting;
- Lakeside Cottages;
- Golfing; and
- Parks (e.g. Beaverdams Park, Mel Stewart Lake Gibson Conservation Park, Charles Daley Park, Dufferin Islands, and Lakeside Park).

5.4.4 Stormwater Management Requirements in Niagara

Storm water management is currently a municipal responsibility. However, many municipalities in Ontario have chosen to delegate this task to the Conservation Authorities, through separate agreements. In the Niagara Peninsula, these responsibilities are shared between the NPCA and the Tier 1 and 2 municipalities. Table 5.9 provides a summary describing how the storm water management responsibilities are divided between the Tier 1 and 2 municipalities and the NPCA. Table 5.9 also outlines the stormwater management policies as outlined in the Official Plans of the Tier 1 and 2 municipalities. The following is a brief description of the storm water management policies. Figure 5.11 shows locations of inventoried Surface Water Control Structures in the NPSP Area.

Regional Niagara

Approved stormwater management facilities within Regional Niagara are to comply with the MOE's Stormwater Management Practices Planning and Design Manual (2003). Under an agreement with Regional Niagara (signed in 2000), the NPCA reviews new development proposals to confirm that they comply with these storm water management policies and practises. The Tier 2 (local) municipalities may also perform a review of storm water management practises.

Current guidelines with respect to Stormwater Management Facilities in Regional Niagara are discussed in Model Urban Design Guidelines (Brook McIlroy Planning + Urban Design, 2005). These include direction with respect to design principles, water quality and runoff management.

Stormwater Guidelines are however being prepared (by an external consultant in cooperation with the NPCA) for Regional Niagara to provide a detailed stormwater management framework for existing and proposed development in the NPCA watershed. The policy will assist in creating a more consistent approach to stormwater management planning in the NPSP Area. Adoption of the guidelines by municipalities is currently optional.

Haldimand County

Haldimand County, as a single tier municipality, is responsible for review of servicing approvals through its Engineering and Infrastructure Division. Haldimand County's "Design Criteria" document (revision 2.0 June 2005) provides a concise description of the County's engineering design standards and review process.

The Haldimand County Official Plan (Haldimand County, June, 2006) requires that all new development be subject to stormwater management practices that are adequate to control storm water run-off in an efficient and environmentally sound manner and where required, stormwater management facilities shall be provided. Stormwater management facilities, that are required as part of any development proposal, shall include provisions and methods to ensure that the quantity and quality of run-off will not exceed pre-development levels or appropriate levels as determined by the County. These provisions include controls on stormwater run-off, sediment and erosion during construction, maintenance of base flows and water quality of streams, preservation of forest cover and riparian vegetation in headwaters. Comprehensive storm water management studies are required. New construction of combined storm and sanitary sewers is prohibited.

Haldimand County has a significant amount of municipal drainage infrastructure, particularly in the eastern portion of the County. As part of the establishment and maintenance of the municipal drainage infrastructure, the County acts according to the procedures set out in the *Drainage Act* and other applicable provincial and federal legislation. Impacts on municipal drainage infrastructure may be assessed when proposing new land uses.

City of Hamilton

In the City of Hamilton, the document "Storm Drainage Criteria and Guidelines for Stormwater Infrastructure" provides the specific details on how to implement the companion document "Storm Drainage Policy". The 'infrastructure' document provides the standards, including desired attributes, of stormwater infrastructure. The policy document, establishes the planning and design process for land development and redevelopment.

The regional level plan (former Region of Hamilton-Wentworth) identified stormwater management policies (Section 9 Watershed/Subwatershed Planning) requiring determination of the need for subwatershed planning. Subwatershed planning and implementation program would be required where it is determined that this will benefit the formulation of new neighbourhood and/or secondary plans, in terms of protecting and enhancing environmental features.

Such a plan/program would identify priority areas, terms of reference for specific plans, and methods to finance preparation of such plans including imposition of development charges. Prior to the establishment of such programs, through development review and approval authority, subwatershed plans may be required for major site specific development proposals, with the preparation of such plans at the expense of the proponent. Before a decision is made by the municipality to have such a plan approved, they will consult with the Conservation Authority.

5.5 Data and Knowledge Gaps

A number of data and knowledge gaps exist with respect to our understanding of the Human Characterization of the study area. These include:

- The Water Well Information System (WWIS) contains approximately 6,500 water well records in the NPSP Area that cannot accurately be located on a map. Field reconnaissance of these wells would be required to identify their locations.
- Abandoned wells located within municipally serviced areas that have not been decommissioned, cannot been identified using only the WWIS.
- Locations and other information on non-municipal regulated water systems have not yet been provided from the MOE. This could include water systems in communities such as Binbrook, Empire Corners, Canborough, Welland River West, Caistor, Bismark, Chambers Corners, Long Beach and Lowbanks, as well as local airports, conservation areas and campgrounds/trailer parks.
- The locations and details of tile-drained fields in areas not identified by the province.
- Very little information has been provided by MOE to-date on the locations of existing Brownfields (i.e. contaminated) sites.

6.0 WATER QUALITY

This section provides a general assessment of the surface and groundwater quality conditions and trends, using data from existing sources. The overall objectives are:

- Describe the current state of surface and groundwater quality;
- Identify long-term trends to see if water quality is improving, deteriorating or staying the same; and
- Assess information gaps.

There are several water quality monitoring programs that are carried out in Niagara Peninsula. These programs are listed in Table 6.1 and include programs such as DWIS, DWSP, NPCA surface water monitoring, NPCA groundwater monitoring, and monitoring of lake water at Niagara's beaches. Indicator parameters that were analysed in these monitoring programs were selected to measure the influence of land use activities on water quality and include water quality criteria (e.g. Ontario Drinking Water Quality Standards - ODWQS). The programs are described in more detail below under the surface water or groundwater sections.

In addition to the above-mentioned programs, NPCA conducted an Ambient Groundwater Quality Study in 2008 to assess the general quality of groundwater in Niagara. Information from this study is provided in Section 6.2.3.

Finally in this section a high level characterization of the surface water and groundwater quantity is provided as required by the Clean Water Act.

6.1 Surface Water Quality

Surface water quality is monitored under a number of programs in Niagara. The Niagara Region administers the Drinking Water Information System (DWIS) which is a mandatory water quality testing program at its water treatment plants (WTPs). Niagara Region also participates in the Drinking Water Surveillance Program (DWSP), which is a voluntary monitoring program, at its WTPs.

The purpose of the NPCA Surface Water Quality Monitoring program is to gather long-term water quality data across the NPCA jurisdiction and assess water quality in local watersheds using a network of chemical and biological monitoring stations. The NPCA Surface Water Quality Monitoring program is comprised of several component programs including;

- Provincial Water Quality Monitoring Network (PWQMN) funded by the province
- General Water Quality Monitoring program funded by City of Hamilton, Niagara Region and NPCA.
- Ontario Benthos Biomonitoring Network
- Hamilton Airport Biomonitoring; and

- Niagara River AOC Tributary Monitoring

Other surface water quality monitoring programs include Beach Monitoring and Private Well Water Quality Monitoring both operated by Niagara Region, and Niagara River Monitoring, conducted under the Niagara River Toxics Management Plan.

A description of these programs and their findings is provided below.

6.1.1 Drinking Water Information System (DWIS)

6.1.1.1 Regional Niagara 2005 Annual Reports

Annual drinking-water system reports are produced by the Niagara Region under Ontario Regulation 170/03 for each municipal water system and posted on the internet. The 2005 annual reports were reviewed to obtain a snapshot perspective of the current state of municipal water quality in Niagara.

Upon review, no exceedances of drinking water criteria were identified for any of the Regional Niagara systems in 2005. In some instances, parameters requiring notification as exceedances were identified, but upon resampling these parameters were not detected. The instances included single occurrences of:

- Cryptosporidum and *giardia* detection at Niagara Falls;
- Bacteriological detection (*Escherichia coli*, fecal coliforms and total coliforms) at Grimsby; and
- Medical Officer of Health sodium criterion exceedance at Grimsby.

The chlorine dosage was also increased after single instances of low free chlorine residuals in the Port Colborne and St. Catharines (DeCew) systems. Also a single occurrence at the Niagara Falls water treatment plant of turbidity exceeding 1 NTU as a result of a process change with no corrective action required. However these are largely operational matters.

6.1.1.2 City of Hamilton 2005 Annual Report

The City of Hamilton services municipal water to areas within the NPSP Area not serviced by Regional Niagara (Figure 5.6). The source of this water is the Woodward Avenue water treatment plant on Lake Ontario (Figure 5.7). The 2005 annual drinking-water system report reviewed for the City of Hamilton is posted on the internet.

Upon review, no exceedances of drinking water criteria were identified for the Woodward Avenue treatment plant in 2005. In some instances parameters requiring notification as exceedances were identified, but upon resampling these parameters were either immediately or eventually not detected. The instances included a number of occurrences of total coliform background, total coliform and *E.coli* detections within the treatment and/or distribution system including a boil water advisory between August 27 and September 2, 2006. It is unknown from the annual report if the boil water advisory was for a portion of the distribution system located within our NPSP Area. The chlorine dosage was also increased, at times, after occurrences of low free chlorine residuals in the distribution system. As in the case of the Regional Niagara systems these are largely operational matters.

6.1.1.3 Regional Niagara Long-term Surface Water Trends

Under the Safe Drinking Water Act (2002), Regional Niagara conducts microbiological and chemical monitoring at its municipal water treatment plants. Monitoring is conducted according to prescribed schedules in Ontario Regulation 170/03. This required monitoring includes raw water analyses of *Escherichia coli* or fecal coliforms and total coliforms, on a weekly frequency at a minimum. Additional monitoring is also completed on treated and distribution samples (e.g. inorganic analyses, lead, and organic analyses) and for some parameters, these analyzed concentrations of treated water are expected to be representative of raw water quality (e.g. chloride).

Data was provided for analysis by the MOE, from the Drinking Water Information System (DWIS) for the Regional Niagara water treatment plants. The dataset included raw results for the time period between May 2003 and September 2006. Treated and distribution results for a similar time period were also included although not analyzed at this time in favour of the Drinking Water Surveillance Program (DWSP) data (discussed in the next section) as it has a longer temporal database. However the DWSP does not contain microbiological results, and as a result the DWIS is most relevant for microbiological review and is discussed below.

Coliform bacteria are the most commonly used indicator of water quality, of which fecal coliforms are a part. The presence of fecal coliforms in water is expected to be an indication of sewage contamination (however some false positives have been identified as a result of the analysis method, personal communication, Dr. aqPierre Payment Institut Armand-Frappier). Escherichia coli (E.coli) is the fecal coliform most frequently associated with recent fecal pollution. Contamination with sewage as shown by positive E.coli tests strongly suggests the presence of pathogenic bacteria and viruses, as well as more chlorine resistant pathogens such as Giardia and Cryptosporidium, which are much more difficult to detect. (Ministry of the Environment, 2006, Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines).

According to the DWIS dataset provided, Regional Niagara analysed raw water samples between May 2003 and September 2006 on a minimum weekly basis for total coliform, fecal coliform and *E.coli*. This effort exceeds the minimum requirements for testing as outlined by the MOE. Limited raw water testing of *Giardia* and *Cryptosporidium* was also completed in 2004 at Port Colborne, Welland, St. Catharines and Grimsby with all values reported as non-detect. The method detection limit (MDL) for coliforms analysis was 2 CFU/100ml and, for values of total coliforms above 400 CFU/100 ml, results were reported as >400 CFU/100 ml. Graphs of raw water microbiological data over time for the Regional Niagara water treatment plants are presented in Appendix D, for the period of 2004, 2005 and 2006 and are discussed below. Additional data for portions of 2003 were also received but not included for this preliminary analysis. Please note that these graphs utilize logarithmic vertical scales and non-detects were plotted at their MDL of 2 CFU/100 ml

A preliminary review of the raw microbiological data suggests, as would be expected, that total coliforms, fecal coliforms and *E.coli* followed similar concentration over time trends, such that where fecal coliforms or *E.coli* were detected they mimicked the total coliform trend. No immediate seasonal trends were observed, however an overall increasing trend in detections is noted at most stations in the latter half of 2005. Of all the water treatment intakes, for the 2004-2006 period reviewed, Grimsby reported the lowest number of detections of total and fecal coliforms and *E.coli* (i.e. Grimsby on average exhibited the lowest microbiological detections).

The St. Catharines and Fort Erie results show the most improvement in microbiological quality when comparing *E.coli* detections in 2006 to 2004 and 2005 results. This improvement in water quality is also seen at Niagara Falls to a lesser degree. However it is unknown to the authors at this time, the cause for this improvement, e.g. weather influences, combined sewer overflow (CSO) remedial activities, etc.

Three water treatment plants are located along the Welland Canal which receives primary inflow from Lake Erie; Port Colborne, Welland and St.Catharines (DeCew). Graphs of the *E.coli* raw water counts from these Welland Canal water treatment plants for 2004, 2005 and 2006 were prepared (Appendix D). It is expected that *E.coli* counts would decrease with distance downstream from Port Colborne unless additional *E.coli* inputs were located along the canal (e.g. CSOs). Although this is not always the case, a review of the graphs suggests that raw water counts of *E.coli* generally decrease from Port Colborne to Welland to St. Catharines. For those instances where this relationship did not occur it may be valuable to investigate the correlation with large precipitation events as this may confirm inlets to the canal of less desirable water quality downstream of Port Colborne during wet weather. Also, the Welland Canal water may be affected by a number of dischargers of poorly treated sewage effluent.

6.1.2 Drinking Water Surveillance Program (DWSP)

The Drinking Water Surveillance Program (DWSP) is a voluntary program operated by the MOE in cooperation with municipalities to gather scientific data on drinking water quality in Ontario. The six (6) Regional Niagara water treatment plants and the City of Hamilton Woodward Avenue water treatment plant have been participants in this program since 1990. It should be noted that the DWSP analyses are conducted to extremely low method detection limits employed at the MOE laboratory.

DWSP results are compared to Ontario Drinking Water Quality Standards (ODWQS) by the MOE. These are the provincial standards for drinking water quality, most of which have been adopted from the Canadian drinking water quality guidelines established by the Federal-Provincial-Territorial Committee on Drinking Water. The guidelines are derived from risk assessment based exposure limits as modified by a risk management process incorporating review of the geographic scope and prevalence of the contaminant, available technology to remove it and associated costs.

6.1.2.1 DWSP Parameters

Physical parameters are important to the efficient operation of a treatment plant. Five physical parameters are measured at the time of sampling and reported to the DWSP as field results. They include turbidity, chloramines, chlorine residual, free chlorine residual and combined chlorine residual. Of these five (5) parameters, two (2) have health-related ODWQS and one (1) is an indicator of adverse water quality.

Some chemical parameters are naturally occurring in source water and the water treatment process can be designed to reduce or increase the levels of some of these parameters. There are 31 parameters included in this group (e.g. fluoride), of which five (5) have health-related ODWQS.

Metals are naturally present in source water, or are the result of industrial activity. Some metals, such as copper, zinc, nickel and lead, may leach into the drinking water from the distribution system and from domestic plumbing. There are 23 parameters included in this group of which six (6) have health-related ODWQS.

Organic chemicals make up 83% of the total number of parameters tested by the DWSP. Organic chemical parameters are grouped accordingly and listed below.

- Parameters classified as *chloroaromatics* are present in surface water as a result of industrial activity. They are by-products of certain industrial processes of chlorination of hydrocarbons. There are 15 parameters included in this group, of which none currently have health-related ODWQS.
- There are seven (7) specific *chlorophenols* reported in this group, of which four (4) have health-related ODWQS.
- *Dioxins and furans* are chlorinated hydrocarbons that occur as by-products and are formed in very small amounts in combustion processes, particularly of chlorinated materials, and in some poorly controlled industrial processes such as bleached paper manufacturing. Dioxins and furans are not routinely tested in drinking water.
- *N-nitrosodimethylamine* (NDMA) or precursors that cause the formation of NDMA may be present in the source water as a result of industrial discharge or from sewage/animal waste effluents combined with nitrite from anaerobic decay of organic waste matter. NDMA has been detected as a by-product in certain blends of coagulant and polymer used in the treatment process. Three additional N-nitroso-amine compounds, N-nitrosodibutylamine, N–nitrosodiethylamine and N-nitrosomorpholine are included in this group. The NDMA ODWQS is 9 nanograms per litre (parts per trillion).
- The presence of Polynuclear Aromatic Hydrocarbons (PAH) in the environment is principally associated with the combustion of organic matter, including fossil fuels. There are 15 parameters included in this group, of which one (1) has a health-related ODWQS - benzo(a)pyrene.

- Polychlorinated Biphenyls (PCBs), in the past, have been marketed extensively for a wide variety of purposes but are no longer manufactured or used. The interim health-related ODWQS is 0.003 mg/L.
- There are 93 parameters included in the Pesticides/Herbicides group, of which 53 have health-related ODWQS. Atrazine is the pesticide most commonly detected in Ontario's municipal drinking water. The presence of atrazine and other pesticides at trace levels indicates that the raw water source is affected by agricultural activity. The ODWQS for atrazine is 5,000 nanograms per litre ((ng/L) or parts per trillion).
- Taste and odour episodes in drinking water have become more prevalent in Ontario over the past several years. They are caused by the decomposition of blue-green algae and generally occur after the algae blooms in the late summer. The compounds most frequently associated with taste and odour are Geosmin and 2-methylisoborneol (2-MIB). Although geosmin and 2-MIB can impart nuisance taste and odour at very low levels, no health-related or aesthetic guidelines have been established. There are six (6) parameters included in this group, of which none have health-related ODWQS. Geosmin and 2-MIB are now monitored routinely under the DWSP.
- Volatile organic compounds are generally present in source water as a result of recreational or industrial activity. There are 28 parameters included in this group, of which 11 have health-related ODWQS.

There are more than 200 radionuclides, some which occur naturally and others which originate from the activities of society. The radionuclide of concern in Ontario drinking water supplies is tritium. Surrogate measurements, such as gross alpha emission and gross beta emission, are preliminary screens for all radionuclides. Tritium, a gross beta emitter, must be measured separately because the screening process is not sufficiently sensitive to detect low levels of tritium. ODWQS screening levels for gross alpha and gross beta are 0.1 Bq/L and 1 Bq/L, respectively.

6.1.2.2 Regional Niagara DWSP Reports

The most recent Regional Niagara MOE DWSP summary reports posted cover the period 2000 -2002. The DWSP program collected and analyzed between seven to ten samples per water treatment plant from a dedicated raw water sample line. The DWSP data were compared by the MOE to the ODWQS which contain health-related standards as well as non-health related aesthetic objectives and guidelines. In the future the more recent results should be compared to the ODWQS.

There were no ODWQS exceedances of health-related criteria noted in the DWSP 2000-2002 Regional Niagara reports. However some non-health related criteria were exceeded. For example the guideline for hardness (80-100 mg/L) was slightly exceeded at all six (6) water treatment plants.

Other DWSP 2000-2002 ODWQS exceedances of non-health aesthetic objectives (AO) or operational guidelines criteria (OG) included:

WATER TREATMENT PLANT	PARAMETER (NUMBER OF EXCEEDANCES)
Fort Erie – Rosehill	Temperature (2 of 7)
Niagara Falls	Temperature (5 of 9) Turbidity (2 of 9)
Port Colborne	Temperature (3 of 7) Turbidity (3 of 7) Aluminum (1 of 7)
Welland	Temperature (4 of 9) Aluminum (1 of 9)
St. Catharines – DeCew	Temperature (3 of 10) Colour (3 of 10) Aluminum (2 of 10) Turbidity (2 of 10) pH (1 of 10)

A number of parameters were below regulatory criteria, but detected. These included:

- Grimsby:
  - Hexachlorocyclopentadiene, haloacetic acids and atrazine; detected only in treated but raw not always tested
- Fort Erie – Rosehill:
  - Hexachlorocyclopentadiene, haloacetic acids, 2,4-D; detected in treated but not raw
  - NDMA; detected once in raw and treated
  - Atrazine; detected once in raw only
- Niagara Falls:
  - Hexachlorocyclopentadiene, haloacetic acids; detected in treated but not raw
  - Toluene, xylenes and styrene; detected in raw only
- Port Colborne:
  - Hexachlorocyclopentadiene; detected in raw and treated at different times
  - Haloacetic acids; detected in treated only
  - NDMA; detected in raw and treated
  - Atrazine, styrene, tetrachloroethylene; detected in raw only
- Welland:
  - Hexachlorocyclopentadiene, haloacetic acids, PCBs, 2,4-D, Dicamba; detected only in treated but raw not always tested
  - NDMA; detected in raw and treated
  - Atrazine, benzene, toluene, ethylbenzene and xylenes (BTEX); detected only in raw
- St. Catharines:
  - Hexachlorocyclopentadiene, haloacetic acids, NDMA, toluene; detected only in treated however not raw not always tested
  - Atrazine, ethylbenzene; detected only in raw
  - Xylene and styrene; detected in raw and treated

6.1.2.3 DWSP Surface Water Long-term Trends

Long-term trends were evaluated for Regional Niagara and the City of Hamilton Woodward Avenue water treatment plant using DWSP data provided for the period 1990 to 2005. The dataset was pre-processed prior to delivery and as such, the dataset did not contain each individual sampling event but rather per year and per parameter, the minimum, average, maximum concentrations and the number of samples. Where values were non-detect it appears averages were calculated using the value of the MDL.

Concentration-versus-time graphs are presented in Appendix D with ODWQS criteria. The non-detect results were plotted at their MDL. The parameters were selected for graphing based on: ODWQS exceedances, known threats (e.g. road salting), historical issues (e.g. Geosmin) and/or other lake area and Niagara River concerns (e.g. atrazine). These graphs are a preliminary assessment of water quality as they use annual averages. In addition, the results are not yet statistically corrected for bias, as in some cases the number of samples per year per parameter per location is not consistent. A refined analysis of a combined DWSP and DWIS dataset should be completed in the future as part of the Intake Protection Zone studies, being undertaken by Regional Niagara. The City of Hamilton Woodward Avenue treatment plant data was included primarily to show Grimsby water quality results with respect to another Lake Ontario drinking water source. As a general observation these two water sources were more similar to each other per parameter (e.g. chloride) than the other water treatment plants.

Raw water average concentration ODWQS exceedances included only non-health related aesthetic objectives and operational guidelines. These included aluminum, turbidity, pH, temperature, colour and iron.

General observations from the **average** total (i.e. unfiltered) concentrations over time graphs include:

- Aluminum:
    - Historic concentrations at or above the ODWQS Operation Guideline (OG);
    - Results have shown less overall variability during the last five years; and
    - Concentrations show some recent increasing trends within the historical range, e.g. Welland.
- There is an overall fifteen year increasing trend in chloride concentrations for Lake Erie water sources while an increasing trend for Lake Ontario sources is present for about the past five years;
- Copper concentrations were generally low with isolated averaged peaks measured at Port Colborne and St.Catharines;
- Turbidity values are variable but generally below the ODWQS Aesthetic Objective (AO);
- pH values have at times exceeded the ODWQS OG at Port Colborne and have been decreasing recently at Grimsby;
- Average temperature values exceeded the ODWQS AO at all locations except Grimsby, and values show a great deal of variability;
- Colour results show generally elevated values at the St. Catharines intake since 1998;

- Iron concentrations and variability has generally been decreasing;
- Organic nitrogen concentrations exceeded the OG at all locations but may be decreasing. Results at Rosehill appear to show the greatest variability.
- Phosphorus concentrations generally exceeded both Provincial Water Quality Objectives for the Great Lakes. These objectives are for control of algae which can be a source of toxins.
- Decreases in 2-MIB and geosmin at Fort Erie and St. Catharines since 1998;
- Arsenic concentrations are slowly increasing at most stations, although concentrations are well below the ODWQS interim maximum acceptable concentration (IMAC);
- Lead concentrations were generally low; and
- Atrazine concentrations are slowly decreasing.

Parameters such as total PCBs, mirex, dieldrin, hexachlorobenzene, chlordane, octachlorostyrene and mercury were non-detect or practically non-detect for the DWSP data provided. However not all parameters were consistently monitored, e.g. mercury.

Emerging chemicals of concern that were not tested included: pathogens, (polybrominated diphenyl ethers - PBDEs, hexabromocyclododecane - HCBD), perfluorinated compounds (PFOS, PFOA), polychlorinated naphthalenes (PCNs), and other emerging chemicals included endocrine disrupting compounds, pharmaceuticals and personal care products and harmful algal blooms.

6.1.3 NPCA Surface Water Quality Monitoring Programs

The NPCA Water Quality Monitoring Program was initiated in the summer of 2001. Previous to 2001, the NPCA was involved in numerous water quality related initiatives but did not have a dedicated monitoring program. The NPCA has since established an extensive network of monitoring stations located throughout the watershed with the purpose of gathering long-term water quality data for both surface and groundwater sources. The monitoring network is operated in partnership with the MOE, Regional Niagara, and the City of Hamilton. The main objective of the NPCA Water Quality Monitoring Program (Table 6.1) is to assess water quality in local watersheds using a network of chemical and biological monitoring stations. More detailed information can be obtained from the NPCA Water Quality Monitoring Program 2005 Annual Report (Michaud, A. and Diamond, J., 2006) which summarizes the water quality data collected from these monitoring stations and provides recommendations for future monitoring and restoration efforts.

The NPCA monitors surface water quality at 40 stations covering 22 watersheds. Grab samples are collected monthly throughout the ice-free season and analyzed for several parameters including nutrients, metals, bacteria, suspended solids, and general chemistry. Descriptions of the various monitoring programs that are administered by NPCA are provided below.

Niagara River AOC Tributary Monitoring Program

The Niagara River Remedial Action Plan (RAP) Stage 2 Report, released in 1995 by Environment Canada and the MOE, outlines 37 recommended remedial actions to restore the health of the watershed. Recommendation #29 is to develop and implement a Welland River and Niagara River tributaries monitoring program to monitor rural non-point sources of pollution and track the effectiveness of restoration efforts. In order to fulfill this recommendation, a Niagara River Area of Concern (AOC) Tributary Monitoring Program was implemented in 2003 through a partnership between the NPCA and the MOE (Table 6.2). The objectives of the program are to establish baseline water quality conditions at selected tributaries and track changes in water quality over time. Monitoring stations for the Niagara River AOC Tributary Monitoring Program were selected as specified in the funding agreement and sampling was initiated in 2003. Stations were selected to both overlap with historic stations and fill data gaps where required. Annual monitoring reports for this program were completed by NPCA in both 2004 and 2005.

Provincial Water Quality Monitoring Network

In 2003 a partnership was established with the MOE through the Provincial Water Quality Monitoring Network (PWQMN) whereby NPCA staff collect monthly water samples at six stations (Table 6.3) located within the NPCA watershed and the MOE provides laboratory services. Analysis for bacteria is currently not included in the PWQMN. The PWQMN was established in 1964 to collect surface water quality information from rivers and streams at strategic locations throughout Ontario. Over time, stations have been added and discontinued in response to changing MOE and program-specific needs. The six NPCA PWQMN stations are located on the Welland River, Twenty Mile Creek, Four Mile Creek, and upper Twelve Mile Creek.

Other NPCA Water Quality Monitoring Stations

Several watersheds are monitored through other water quality monitoring programs. In 2002 a monitoring agreement was established with the City of Hamilton whereby NPCA staff collect monthly water samples at eleven stations located within the City of Hamilton's municipal boundaries (Table 6.4) and the City of Hamilton provides laboratory services. Monitoring stations were selected based on existing water quality information and local landuse issues. The headwaters of the Welland River and Twenty Mile Creek are located in the former Township of Glanbrook in the City of Hamilton. The Welland River and Twenty Mile Creek are the largest watersheds in the NPCA jurisdiction, covering a total drainage area of 1171 km^2. In 2003 a monitoring agreement was established with the Regional Niagara whereby NPCA staff collect water samples at ten stations located within the NPCA watershed (Table 6.5) and the Region provides laboratory services. In 2004 the NPCA began monitoring tributaries of Twenty Mile Creek as part of the Twenty Mile Creek Watershed Plan (NPCA 2006).

Biological Monitoring

The NPCA also monitors surface water quality using benthic invertebrates as indicators of stream health. Water quality monitoring has historically relied heavily upon chemical testing as a means of measuring the quality of water but the advantages of biological monitoring using benthic invertebrates as indicators of water quality are well documented. Due to their restricted mobility and habitat preferences, benthic invertebrates usually remain in a localized area. As a result, they are continuously subjected to the effects of all pollutants and environmental stream conditions over time, and as such can provide a broad overview of water quality related problems. They are abundant in all types of aquatic systems, and can be easily collected and identified using inexpensive equipment. Benthic invertebrates are the larger organisms that inhabit the bottom portion or substrate of waterways for at least part of their life cycle. Some typical benthic invertebrate species commonly found in the NPCA watershed include clams, snails, leeches, worms, the larval stages of dragonflies, stoneflies, caddisflies, mayflies, beetles, and a wide variety of other insects.

The NPCA has been using benthic invertebrates as indicators of water quality since 1995. The NPCA is a leader in the field of biological monitoring in the Niagara Peninsula, and benthic invertebrate sampling is a core component of the Water Quality Monitoring Program. Samples are collected during the spring and fall seasons using the Biological Monitoring and Assessment Protocol (BioMAP) developed by Dr. Ron Griffiths. BioMAP water quality assessments have been completed at over 100 sites located throughout the NPCA watershed (Figure 6.1). Specific biomonitoring projects are also completed annually and biennially by the NPCA for Hamilton International Airport and the City of Hamilton's Glanbrook Landfill to evaluate environmental management practices.

The NPCA is also involved in the development of the Ontario Benthos Biomonitoring Network (OBBN). The OBBN is a biomonitoring research initiative that was launched in 2002 and is jointly led by the MOE and Environment Canada. The goal of the OBBN is to provide a standardized benthic invertebrate sampling protocol for the province of Ontario. A secondary goal of the OBBN is to provide a biological complement to the chemistry-based PWQMN. The NPCA is an active participant in the development of the OBBN, and is providing on-going research support in the Twelve Mile Creek watershed. It is anticipated that the NPCA will use the OBBN protocol to collect benthic invertebrate samples once the network has been firmly established and the protocol can be applied to warm water clay-based watercourses such as the Welland River.

NPCA Surface Water Quality Summary

The NPCA Water Quality Program was implemented in 2001 and is operated in partnership with the Ministry of the Environment, Regional Niagara, and City of Hamilton. Through these partnerships NPCA staff collect water quality samples and the supporting agencies provide laboratory analyses. Surface water quality samples are collected monthly at 40 monitoring stations located throughout the NPCA watershed and analyzed using several indicator parameters which include: chloride, nitrate, total phosphorus, suspended solids, copper, lead, zinc, and *E. coli*. These indicator parameters are used to calculate the CCME Water Quality Index (WQI), which provides a descriptive water quality rating for each station. Benthic invertebrate samples are collected annually throughout the watershed during the spring and fall seasons to assess stream health using the BioMAP protocol.

In general, water quality monitoring data collected between 2001 and 2005 is summarized as follows:

- Based on the results of the 2005 WQI 35 of 40 stations are rated as having *poor* water quality, two stations are rated as having *marginal* water quality, and two stations are rated as having *fair* water quality. There was insufficient data at one station to calculate the WQI.
- *Marginal* water quality is found in the upper Welland River and St. John's tributary of upper Twelve Mile Creek.
- *Fair* water quality is found in the lower Welland River where there is mixing with the Niagara River, and in the Effingham tributary of upper Twelve Mile Creek.
- Minor exceedances of nitrate and chloride are observed at some stations; however, they are relatively infrequent.
- Exceedances of copper and lead are observed at some stations; however, they are relatively infrequent.
- Exceedances of zinc are frequently observed at several stations, most notably the upper Welland River in the vicinity of Hamilton International Airport.
- Exceedances of suspended solids and *E. coli* are frequently observed at several stations throughout the watershed.
- Total phosphorous concentrations exceed the provincial water quality objective at all 40 monitoring stations. Based on the data collected to date, elevated concentrations of total phosphorus are the most frequent and widespread cause of water quality impairment in the NPCA watershed. The relative high frequency and magnitude of these exceedances was a driving factor in lowering the WQI at all stations.
- Results from BioMAP assessments indicate that water quality is *impaired* at all monitoring stations sampled except for the Effingham tributary of upper Twelve Mile Creek.
- WQI and BioMAP results generally match up well at most stations (i.e. where the WQI is *poor* the BioMAP result is *impaired*) indicating that the benthic invertebrate data supports the chemical data. For example, TW006 is the only station to obtain a WQI rating of *fair* and a BioMAP rating of *unimpaired*.

Based on the surface water quality monitoring data collected to date, upper Twelve Mile Creek represents the best water quality conditions in the NPCA watershed. Nutrient inputs from surrounding urban, rural and agricultural land-use continue to be a source of water quality degradation in the NPCA watershed. Figure 6.2 indicates the general surface water quality conditions in the watershed. Surface and groundwater monitoring is expected to continue in order to track changes in water quality over time throughout the watershed, target restoration activities, provide information for the Watershed Report Card, and assist in the development of source water protection plans.

6.1.4 Niagara River Monitoring

The 2005 Niagara River Toxics Management Plan (NRTMP) Progress report, summarized the progress made in dealing with eighteen "Priority Toxics" of the Niagara River, by reviewing fifteen years of results (1986/87-2000/01) from the Niagara River Upstream/Downstream Program.

The Upstream/Downstream (U/D) Program measures about fifty (50) organic chemicals in the dissolved and particulate phases at Fort Erie and Niagara-on-the-Lake and about 25 metals in whole water. The concentrations of suspended sediment at each station are also measured so that loads can be calculated for the particulate fraction. The U/D Program enables calculation of: (i) re-combined whole water concentrations, (ii) trends over time and (iii) the load of chemical presumed to be entering from sources along the Niagara River.

The report indicates that some "Priority Toxics" exceed their strictest agency criterion and may have Niagara River sources contributing to these exceedances, i.e. mirex, hexachlorobenzene (HCB) and PAHs. However of the 18 parameter data summaries presented, none exceeded their Ontario Drinking Water Quality Standard, if existing. According to the Niaraga River RAP, a detailed NRTMP progress report is expected in early 2007. It is recommended that this report be reviewed to assist with source protection of the Niagara Falls water treatment plant.

The eighteen priority toxics are:

Chlordane	Mercury	Tetrachloroethylene
Mirex/ Photomirex	Arsenic	Benz(a)anthrancene
Dieldrin	Lead	Benzo(a)pyrene B(a)P
Hexachlorobenzene (HCB)	PCBs	Benzo(b)fluoranthene
DDT and metabolites	Dioxin (2,3,7,8-TCDD)	Benzo(k)fluoranthene
Toxaphene	Octachlorostyrene (OCS)	Chrysene/Triphenylene

6.1.5 Beach Monitoring

Nearshore water quality is measured as part of the beach monitoring program by the Regional Niagara Public Health Department. Each year, from June to the end of August, weekly water samples are collected from: 10 beach locations along Lake Ontario and the northern part of the Niagara River, and 22 beach locations along Lake Erie and the southern part of the Niagara River. Also, there is a beach on the Welland River that is routinely sampled. Based on the data reviewed for the NWQPS, the nearshore areas of

St. Catharines, Grimsby, Wainfleet and Port Colborne exhibited high levels of *E.coli*. Examples of beaches historically closed for long periods of time include Jones Beach and Port Dalhousie (St. Catharines) and Nickel beach (Port Colborne). This contamination could be due to CSO, urban or agricultural runoff.

6.1.6 MOE Near Shore Intake Monitoring Program

The Ministry of the Environment has completed weekly monitoring of parameters associated with algae function and eutrophication for over thirty (30) years at Niagara WTPs. Data has been collected from the Rosehill (Lake Erie) WTP since 1978 and the Grimsby (Lake Ontario) WTP since 1980. However it should be noted that the Grimsby WTP intake position and depth was changed to be further out in Lake Ontario and deeper in 1994.

6.1.6.1 Great Lakes Organic Nitrogen

The water quality monitoring includes concentrations of TKN and ammonia. Organic nitrogen concentrations were calculated for the period 1978 to 2008. Organic nitrogen concentrations were generally above the ODWQS OG of 0.15 mg/L throughout the thirty (30) year period. During the last five years (2003-2008) concentrations at Rosehill were generally higher and more subject to peaks than those at Grimsby. On average Grimsby organic nitrogen concentrations have decreased somewhat since commissioning of the new intake in 1994.

The Technical Support Document for ODWQS (MOE, 2003) indicates that "high levels *(of organic nitrogen)* may be caused by septic tank or sewage effluent contamination. This form of contamination is often associated with some types of chlorine-worsened taste problems."

6.1.6.2 Great Lakes Phosphorus, Algae and Toxins

Algal blooms occur when cell concentrations are high enough to be visible to the naked eye. Many types of algae form blooms, however not all algal blooms are toxic. Some, such as the blooms of diatoms in the early spring, are very important to the health of the ecosystem. When algal blooms contain organisms having toxins, other noxious chemicals or pathogens, the bloom is known as a harmful algal bloom (HAB). HABs can cause the death of nearby fish, and foul up nearby coastlines, and produce harmful conditions to marine life as well as humans.

The most common group of algae to form HABs are cyanobacteria, or blue-green algae. They are able to photosynthesize and grow in water, either terrestrial, fresh, brackish or marine. Cyanobacteria have been linked to human and animal illnesses around the world. A cyanobacteria bloom may look like foam, scum, or mats on the surface of fresh water lakes and ponds. The blooms can be blue, bright green, brown, or red and may look like paint floating on the water. As algae in a cyanobacteria bloom die, unpleasant odours may result. Microscopic identification is required to confirm its presence.

Algal blooms are caused by a combination of factors, such as the presence of elevated nutrients (e.g. phosphorus), warm temperatures and sunlight. Increased nutrients may be as a result of urban and rural sources such as fertilizer runoff and sewage overflows. Cyanobacterial blooms may occur within a few days of normal conditions. Blooms can occur at any time, but most often occur in late summer or early fall. Zebra mussels may promote the formation of HABs by the removal of natural competitors, altering water chemistry and increasing the amount of light reaching the bottom of the lake.
(Source - Great Lakes Environmental Research Lab, Sea Grant Lakes Network, Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration http://www.glerl.noaa.gov/seagrant/GLWL/Algae/HAB/HABFAQ.html)

Water affected by cyanobacterial toxins needs to be filtered through activated carbon to be safe for drinking. All NPSP Area water treatment plants have activated carbon filters available for use. Activated carbon also adsorbs taste and odour causing compounds such as geosmin and MIB (2-methylisoborneol). Geosmin and MIB are also produced in aquatic environments by cyanobacteria and mould-like, filamentous bacteria called actinomycetes.

In Ontario the maximum acceptable concentration (MAC) for the cyanobacterial toxin microcystin-LR in drinking water is 0.0015 mg/L. This guideline is believed to be protective of human health against exposure to other microcystins that may also be presented. However, there are no available microcystin-LR results in the water quality datasets available for the NPSP Area WTPs.

This lack of data may be because the MOE approach to cyanobacteria monitoring first recommends: (i) visually monitoring water bodies that have historically exhibited algal blooms during the peak season (usually late May to early October) and (ii) then sampling for the toxin (MOE ODWQS, 2006).

Long-term weekly measurements (28 to 30 years) of phosphorus and filtered reactive phosphorus concentrations are available for the Rosehill (Lake Erie) and Grimsby (Lake Ontario) water treatment plants. Filtered reactive phosphorus, the phosphorus available for plant growth and often considered the most limiting nutrient in freshwater systems, is also called dissolved inorganic phosphorus.

The Ontario Provincial Water Quality Objectives (PWQOs, 1999) provide two (2) total phosphorus criteria as general guidelines for control of algae in lakes:

- "*To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 0.02 mg/L*"
- "*A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 0.01 mg/L or less. This should apply to all lakes naturally below this value.*"

Some observations of the long-term weekly total phosphorus data (Figures D-39 and D-40) to these criteria include:

- Rosehill (Lake Erie) – on average, concentrations were generally elevated above the 0.02 mg/L guideline during the 1981 to1983 period, decreasing to between 0.01-0.02 mg/L between 1990 to 1996 and subsequently steadily increasing above the 0.02 mg/L criterion for 2006 to 2008. On average, total phosphorus concentrations were above the 0.01 mg/L criterion for the entire period of record, thirty (30) years.
- Grimsby (Lake Ontario) – on average, concentrations were generally elevated above the 0.02 mg/L guideline between 1980 and 1993 and then dropped close to the 0.01 mg/L guideline from 1994 to 2008. However a new intake was commissioned in 1994 which was much further from shore and obviously subject to lower phosphorus concentrations.
- On average, 1994-2008 concentrations are higher at Rosehill than Grimsby:
  - Rosehill mean 0.019 mg/L, median 0.012 mg/L
  - Grimsby mean 0.011 mg/L, median 0.008 mg/L

6.2 Groundwater Quality

6.2.1 Groundwater Quality Historical Studies

General information from textbooks and various studies has been published on the groundwater quality associated with particular bedrock formations in southern Ontario, and some of these formations are found in the Niagara Peninsula. The following is a brief overview of the water quality known to be associated with some of these geologic formations.

Groundwater from the Queenston formation can range from poor to good. The groundwater is generally hard to very hard. Many water samples collected from this unit have been reported to be high in sodium, chloride, or sulphates, and exceeding the Aesthetic Objectives for these parameters.

The Clinton and Cataract Group is identified as hard to very hard, occasionally with elevated iron levels.

The Lockport-Guelph Units have been identified as generally yielding groundwater of suitable quality for domestic use. However, reported analyses of some groundwater samples from this formation have indicated poor water quality. Elevated iron levels have also been reported in a large number of groundwater samples taken from this unit.

The Salina Formation is known to generally produce poor groundwater quality with high sulphur and mineral content. The water is reported to range from hard to very hard with high total dissolved solids content.

The Bois Blanc Unit has also been identified as containing groundwater of poor quality. For example elevated levels of iron and total dissolved solids are commonly identified in the water.

<u>*2005 NPCA Groundwater Study*</u>

In 2005, NPCA completed a regional groundwater study encompassing its whole watershed area (Waterloo Hydrogeologic Inc., October 2005). Part of the study focussed on groundwater quality. The 2005 Groundwater Study was a significant undertaking aimed at improving the general knowledge of groundwater and hydrogeologic systems in Niagara. The study report covered the following topics:

- <u>Regional Groundwater and Aquifer Characterization</u>, using primarily the Water Well Information System (WWIS) database from the MOE. The aim was to develop a conceptual understanding of the groundwater resources in Niagara, with respect to water quantity and movement, water quality, important geological areas/features, etc.
- <u>Groundwater Intrinsic Susceptibility Analysis</u>. The study assessed the vulnerability groundwater to impact from land activities. The groundwater vulnerability was assessed throughout the NPCA jurisdiction using the Intrinsic Susceptibility Index (ISI) method combined with a practical review of the geology in the area. Areas were classified as high, moderate, or low susceptibility. The information from the 2005 Study was used in the assessment of Aquifer Areas of High Vulnerability, which is discussed in this report in Chapter 7 (Vulnerable Areas Description).
- <u>Groundwater Use Assessment</u>. Groundwater use was estimated for rural domestic, large Permit-To-Take-Water (PTTW) users, small PTTW users, and agricultural uses. A preliminary estimate was also made of the total groundwater consumption. These groundwater quantity estimates have been improved upon with completion of the Conceptual and Tier 1 Water Budget studies.
- <u>Potential Contaminant Source Inventory</u>. Using a number of provincial and municipal data bases the study developed an inventory of potential contaminant sources from land use activities. These results are described in further detail in this report in Chapter 8 (Existing Threats Inventory).
- A <u>Groundwater Management and Protection Strategy</u> was also developed as part of the study.

Figures 6.3 and 6.4 show the locations where the 2005 NPCA Study identified natural water quality problems in the overburden and bedrock respectively. The overburden groundwater quality was estimated in the 2005 NPCA Study by using the water well drillers' descriptions of the water quality noted on the water well records. These water quality descriptors are quite limited and only include the choices; fresh, salty, minerals, sulphur, gas and other. Anything besides 'fresh water' was plotted in the study and is summarized in Figure 6.3. A similar process was used to plot the groundwater quality problems in bedrock. Natural groundwater quality problems in the bedrock appear more abundant, likely due to the longer residence time spent in the bedrock and the fact that 80% of all water wells were installed in bedrock (Waterloo Hydrogeologic Inc., October 2005).

6.2.2 NPCA Groundwater Monitoring Program

The Provincial Groundwater Monitoring Network (PGMN) is a province-wide groundwater monitoring initiative designed to collect long-term baseline data on groundwater quantity and quality in special areas of concern. Groundwater is monitored using a network of monitoring wells located throughout the NPCA watershed. NPCA currently operates 15 monitoring wells as part of the PGMN (Figure 6.5). Monitoring wells are instrumented with data-logging and telemetry equipment which enable NPCA staff to access groundwater level data remotely. Groundwater levels are recorded hourly at all of the monitoring wells and corrected for barometric pressure. The first round of water quality samples were collected from the monitoring wells between 2002 and 2004 and analysed by the MOE laboratory for a wide range of parameters.

Preliminary PGMN data indicated that groundwater quality generally meets the ODWS. Exceedances for boron, selenium and fluoride were detected; however, these are likely attributed to natural bedrock conditions. An exceedance for nitrate was detected and is likely attributed to agricultural land-use or septic systems. These exceedances have been reported to the appropriate agencies. Additional analysis has been completed on the PGWN data and is presented in the Ambient Groundwater Quality Study, which is described in the following report section.

6.2.3 Ambient Groundwater Quality Study

An Ambient Groundwater Quality Assessment was conducted within the Niagara Peninsula Source Protection Area (NPSPA) by Jagger Hims Limited in 2008 (Jagger Hims Limited, 2008). The report was prepared for the NPCA to satisfy requirements under the MOE Assessment Report Draft Guidance Module 1 (MOE Draft Guidance Module 1: Watershed Characterization) for the purpose of addressing water quality in the NPSP Area. The report utilized available data sets from:

- Groundwater monitoring wells in the Provincial Groundwater Monitoring Network (PGMN); and
- Background monitoring wells located at Regional Municipality of Niagara landfills. (Background wells are considered to be not impacted by the landfill and thus represent the ambient or background conditions.)

The data set included 671 sampling events at 49 wells that were analyzed to characterize the ambient groundwater quality within the NPSPA.

The Ambient Groundwater Quality Study should be considered as an initial assessment phase. Further assessment is recommended if funding is available. Groundwater quality monitoring data from other sources such as Permits-to-take-water (PTTW) were not readily available for use in this report. It is recommended that future phases of this study include additional monitoring sources where possible.

The data sets were collected from the established wells, sorted by parameter and location, and parameters that exceeded the applicable Ontario Drinking Water Quality Standards (ODWQS) were identified. The Piper Trilinear Diagram and Stiff Diagrams were two tools used to evaluate and visualize the groundwater quality. In order to identify potentially increasing or decreasing trends in the parameter concentrations, selected parameters were also plotted on a concentration versus time plot. The following parameters were chosen for study analyses as they represent common inorganic contaminants and groundwater quality indicators:

- Chloride
- Sodium
- Nitrate
- Lead
- Fluoride
- Alkalinity
- Sulphate; and
- Electrical Conductivity

Groundwater Quality Results

Of the 34 locations for which a full suite of metals data was available, only nine (9) were observed to have parameter concentrations that were consistently less than the Maximum Acceptable Concentration (MAC) of the ODWQS. *Groundwater that contains parameter concentrations greater than the MAC is not suitable for use as a drinking water source unless appropriate treatment is utilized.*

Lead was the most common parameter observed in concentrations greater than the MAC. Lead exceeded the MAC for at least one test result in 16 of the 34 wells where trace metal analysis were completed. A significant number of wells that contained lead exceedances were within the Lockport Bedrock Formation or were located in overburden units that overlie the Lockport Formation.

Other parameters that exceeded the MAC values in at least one well were selenium (10 wells), cadmium (7 wells), fluoride (5 wells), chromium (4 wells), nitrate (3 wells), boron (3 wells), arsenic (2 wells), benzene (2 wells), Mercury (1 well), and 1,2 dichlorobenzene (1 well).

The following parameters were observed, on at least one occasion, in concentrations that were greater than the Aesthetic Objective or Operation Guideline of the ODWQS:

- Iron (34 wells);
- Manganese (33 wells);
- Total Dissolved Solids (TDS) (27 wells);
- Sulphate (27 wells);
- Hardness (22 wells);
- Aluminum (19 wells);

- Sodium (18 wells > 200 mg/L; 16 additional wells > 20 mg/L);
- Dissolved Organic Carbon (DOC) (14 wells);
- Alkalinity (11 wells);
- Organic nitrogen (6 wells);
- Chloride (5 wells);
- Sulphide (3 wells);
- Xylenes (3 wells);
- Toluene (1 well); and
- Ethylbenzene (1 well).

Hardness, TDS, iron and manganese are commonly found in elevated concentrations in groundwater in Southern Ontario, but their concentrations can be reduced by readily available treatment technologies to render water acceptable for drinking.

Elevated sulphate concentrations are expected in the bedrock formations, due to the presence of naturally occurring gypsum. Naturally occurring sodium and chloride are also identified in the study particularly when associated with shaley bedrock formations. However some elevated concentrations of sodium and chloride may be due to human activities.

Xylenes, toluene, and ethylbenzene are parameters associated with petroliferous bedrock units within bedrock formations in the Niagara area.

Results of the analyses suggest that the water infiltrating into the groundwater system is typically dominated by calcium and bicarbonate. With increased residence time, the amount of dissolved minerals tends to increase due to soluble minerals in the bedrock and soil. Groundwater quality in the overburden was observed to generally reflect the groundwater quality in the underlying bedrock.

Overall, the groundwater quality data is likely to underestimate that actual number of exceedances of the MAC due to detection limits close to or greater than the MAC or due to the absence of testing for trace metals parameters.

Groundwater Quality Trends
To identify parameter concentration trends, the data for each well in the study was plotted on graphs against time. The outcome of the study indicated the following results in trend analysis:

- No obvious "ambient trends"
- Landfill monitors show "spikes" and recoveries
- Many wells show very poor water quality due to aesthetic conditions (naturally high sulphate, sodium, and/or chloride).

There are several limitations to identifying long term trends of the groundwater quality data. First, several wells have only a few available data points. Second, often a data set is not available for the entire sampling record for the set of indicator parameters used. The third limitation is the variability of method detection limits across the study sites. Overall, there are some potentially increasing and decreasing trends but no clear picture of persistently deteriorating groundwater quality at any location (Jagger Hims Limited, 2008).

Conclusions of the Ambient Groundwater Study

The JHL report made the following conclusions about the ambient groundwater quality in the Niagara Peninsula. It is noted that these are preliminary findings since further study is needed to confirm the findings.

- Groundwater quality is variable and related to the soil/bedrock composition, flowpaths, and residence time.
- At least 75% of the groundwater samples tested for trace metals contained at least one chemical parameter with concentrations higher than the MAC established in the ODWQS. Thus, all groundwater to be used as drinking water should be tested for ODWQS Parameters.
- Mercury was not consistently tested but may be present in groundwater. Based on the reported occurrence of mercury concentrations greater than the MAC of the ODWQS in the two samples tested, it is appropriate to conduct additional testing to confirm that dissolved mercury is not widely present in the groundwater systems.
- Infiltrating groundwater is dominated by calcium-carbonate rich ions and evolves to magnesium-sulphate rich.
- Infiltrating groundwater typically is dominated by calcium and carbonate ions. With increased residence time the groundwater becomes progressively enriched in magnesium and sulphate. This is observed within individual formations, but is most extreme in formations where there is abundant gypsum as either a primary (Salina Formation) or secondary (Guelph Formation) mineral.
- Groundwater from the Overburden units is variable in quality and the dissolved minerals typically reflect the composition of the underlying bedrock. Groundwater types vary from Calcium-Carbonate to Magnesium-Sulphate. The suitability of the groundwater from the overburden for drinking water purposes is locally variable.
- Groundwater from the Onondaga/Bois Blanc Formation varies in type between Calcium-Magnesium-Bicarbonate-Sulphate to Magnesium-Calcium-Sulphate-Bicarbonate. The groundwater from the Onondaga/Bois Blanc Formation may contain low concentrations of soluble petroleum hydrocarbon constituents including benzene in concentrations greater than the MAC of the ODWQS.
- Groundwater from the Bertie Formation is classified as Magnesium-Calcium-Bicarbonate-Sulphate type. Groundwater quality results for trace metals content were not available.
- Groundwater from the Salina Formation is classified as either Sodium-Sulphate, Sodium-Chloride, or Sodium-Magnesium-Sulphate. The groundwater quality of the Salina Formation is distinct from the other units in the bedrock sequence due to very high concentrations of sulphate, total dissolved solids, hardness and

electrical conductivity. The average measured concentrations of arsenic, boron, and selenium were greater than the MAC of the ODWQS.

- Groundwater from the Guelph Formation is classified as Magnesium-Sulphate type. The Guelph Formation has very high concentrations of sulphate, total dissolved solids, hardness and electrical conductivity. These components likely reflect the presence of evaporitic gypsum and salt deposits within this stratigraphic unit or adjacent units. The average measured concentrations of cadmium and lead are greater than the MAC of the ODWQS.
- Groundwater from the Lockport Formation is observed to vary between Calcium-Bicarbonate and Magnesium-Sulphate in composition and the data reflects most positions between these two end points. The average concentration of lead is greater than the MAC of the ODWQS.
- Groundwater from the Irondequoit/Reynales Formation is classified as Magnesium-Sodium-Chloride, which reflects bedrock groundwater conditions below the Rochester Formation shale. The Irondequoit/Reynales Formation has very high concentrations of sodium, chloride, sulphate, hardness, total dissolved solids, and electrical conductivity. The average measured concentrations of nitrate, boron, and cadmium are greater than the MAC of the ODWQS. The average lead and arsenic concentrations are sufficiently high to be a concern if this groundwater was to be used as a drinking water source.

6.3 Water Quantity

The NPSP Area is characterized by abundant surface water sources from Lake Erie, Lake Ontario, The Niagara River and the Welland Canal. The sources are available mainly for municipal and in some cases agricultural supply. Typically groundwater systems are the dominant water resource however due to the location of the NPSP Area, dependence is largely municipal. Groundwater is still used for rural residents and some agricultural operations and is an important component of the water budget.

Please refer to the Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment Report for maps of water use by watershed and also water takings in the study area.

6.4 Data and Knowledge Gaps

A number of data and knowledge gaps exist which can be addressed, where pertinent, within the Threats Inventory and Issues Evaluation report. These include but are not limited to evaluations of:

- Evaluation of surface water/groundwater quality using DWIS data for non-municipal drinking water systems – however not yet provided by MOE;

- Correlation between large precipitation events and unusual microbiological detections (e.g. *E.coli* counts at Welland or St. Catharines at higher levels than at the Port Colborne water treatment plant);
- Long-term trends from a combined DWSP/DWIS database including individual DWSP samples and comparison to ODWQS;
- Regional Niagara Health Unit microbiologic database (private water supplies and beaches);
- The Municipal/Industrial Strategy for Abatement (MISA) water quality discharge database;
- Wastewater treatment plant discharge database;
- Regional Niagara Wainfleet/Lake Erie shore hydrogeologic investigations with respect to private well and septic sewage use;
- Long-term groundwater quality in order to determine (i) trends, and (ii) to provide information for discerning the cause of poor water quality (i.e. naturally versus anthropogenic(human) affects). Data may be available through existing monitoring programs such as landfill monitoring (i.e. background wells) and quarry operations;
- Review of detailed NRTMP progress report expected in early 2007; and
- Synergy/opportunities between expansion of NPCA water quality monitoring programs (e.g. PGMN) and municipal source water protection, e.g. addition of flow monitoring to water quality sampling to enable mass balance modelling of contaminant loading.
- Source of elevated organic nitrogen concentrations and potential associated un-monitored parameters, e.g. pharmaceutical products
- Concentrations of microcytin-LR in Niagara Region raw water quality

The Ambient Groundwater Quality Report identified a number of data gaps that should be considered to improve the groundwater quality knowledge in Niagara as well as improve the assessment of groundwater for use as drinking water.

- The ambient groundwater quality has been compared to the ODWQS to evaluate the suitability of the ambient groundwater as a drinking water source. Comparison to the Provincial Water Quality Objectives would be required to evaluate the potential effects of groundwater quality on surface water systems.

- The overall study results do not necessarily reflect the overburden groundwater quality in local water supply aquifers. Consideration should be given to perform mapping and testing of the local aquifers used for private groundwater-based water supplies.

- The analytical parameter lists and the method detection limits from the contributing landfill monitoring programs are not consistent. Where possible, coordination of groundwater sampling events with Niagara Region would help to ensure that the parameters of interest are included and reported detection limits are consistent.

- The analysis of water quality evolution in the groundwater flow system would benefit from the availability of representative groundwater samples that describe the typical flow path from the recharge point to the discharge point of local watersheds and subwatersheds. This would help to describe conditions where impaired water quality from deeper aquifer formations may flow toward other aquifers and cause an eventual impairment of the source water.

- Background groundwater quality data from landfill monitoring programs at closed landfill sites, or at active or closed landfill sites in the City of Hamilton or in Haldimand County could be incorporated into the Ambient Groundwater Quality evaluation.

- Several other groundwater monitoring programs in place throughout the NPSP Area could be incorporated into the Ambient Groundwater Study.

- Expansion of the private water supply testing to include concentrations of trace metals, particularly lead and mercury should be considered.

7.0 VULNERABLE AREAS DESCRIPTION

7.1 Source Protection Areas

Source water protection areas that may be vulnerable from a water quality and/or quantity perspective are divided into the following classifications:

- Wellhead (groundwater) Protection Areas (WHPAs);
- Surface Water Intake Protection Zones (IPZs);
- Other Vulnerable Areas - Areas of high aquifer vulnerability (susceptible to groundwater contamination);
- Other Vulnerable Areas - Significant Recharge Areas; and
- Potential Future Drinking Water Sources.

These source water protection areas are described in more detail below, as they relate to the NPSP Area.

7.2 Wellhead Protection Areas (WHPAs)

Wellhead protection areas (WHPAs) encompass the land area that provides recharge to a well, or well field. There are a number of different methods that can be used to delineate a WHPA. These methods range from simply delineating an area by establishing an arbitrary distance from the wellhead, to more complex methods that use numerical groundwater flow and particle tracking computer models.

There are no municipal WHPAs in the NPSP Area, since there are no municipal wells currently in operation. However, there is a possibility that a hamlet containing several private wells in close proximity could be designated as a WHPA in future, through a resolution of one of the local municipal councils. At this time no hamlets have been designated in the NPSP Area.

7.3 Surface Water Intake Protection Zones (IPZs)

Surface water IPZs are the designated protection areas around the raw water intakes of the Water Treatment Plants (WTPs). Surface drinking water intakes ultimately draw water that comes from upstream lands and tributaries. As such, the upstream watershed boundary would normally be considered the appropriate source water catchment area for a drinking water intake. However, intakes that are located on the Great Lakes or Great Lakes Interconnecting Channels and Rivers, receive source water that is not as susceptible to local or near-field sources of contamination. For this reason the MOE has divided intake protection zones (IPZs), around municipal drinking water intakes, into four categories, and suggested different methods for delineating each IPZ category. The four types of IPZs are:

1. Great Lakes;
2. Great Lakes Connecting Channel and Rivers;
3. Small (Inland) River and Streams; and
4. Inland Lakes.

Currently there are six (6) municipal surface water intakes in the NPSP Area. These are described in Section 5.3 of this report, with additional details provided in Table 5.6 and Appendix B. Surface water intake locations are shown in Figure 5.7 (Water Treatment Plant Locations). Great Lakes intakes include Grimsby WTP and Fort Erie (Rosehill). Great Lakes Interconnecting Channel intakes include the remaining four WTPs (which are DeCew, Niagara Falls, Welland and Port Colborne). There are no municipal inland river or (small) inland lake water intakes in the NPSP Area.

Studies to delineate the IPZs for each municipal surface water intake are presented in separate reports.

7.3 Other Vulnerable Areas

'Other Vulnerable Areas' as referred to in the Clean Water Act include *Aquifer Recharge Areas*, and *Highly Vulnerable Aquifer Areas*.

<u>Aquifer Recharge Areas</u>
Aquifer and groundwater recharge areas were identified during the completion of the NPCA Groundwater Study. However, 'significant recharge areas' are considered to be vulnerable areas that require identification in the watershed for source water protection purposes.

In the NPCA Groundwater Study (2005), the potential recharge areas were derived from a comparison of the calculated water table surface, to ground elevation. Recharge areas were identified where the calculated water table was below the ground surface. However this area was then further refined to only include areas of granular deposits at the ground surface. The NPCA Groundwater Study report did not indicate if bedrock outcrops were also *always* classified as recharge areas but in many cases, they were classified as recharge areas.

Some prominent overburden recharge areas that were delineated included the Fonthill Kame-Delta complex and the Dunnville Sandplain, areas below the crest of the Niagara Escarpment, areas around Niagara Falls and in NOTL. Bedrock recharge potential was considered significant where fractured bedrock was at or near surface, such as along the Niagara Escarpment and the Onondaga Escarpment.

Significant Recharge Areas have not yet been delineated using the method outlined in the April 10, 2006 MOE SWP Guidance Module 2 "Water Budgets". However a preliminary identification of significant recharge areas was calculated using a comparable simple procedure outlined in the NPCA Groundwater Study (2005). These preliminary areas will be confirmed or recalculated during completion of the Tier 1 Water Budget. It is believed that using the simple approach outlined in Water Budget Guidance Module, recharge areas will likely increase (over those determined using the groundwater study information) because of the incorporation of flat-lying cohesive soils.

Highly Vulnerable Aquifer Areas

Aquifer vulnerability refers to the groundwater areas outside municipal wellhead protection areas. These areas are predominantly in rural locations and may contain water uses such as private wells, and also ecological uses (MOE, Assessment Guidance Module 1, Dec 12, 2005, pg 56). A preliminary delineation of the highly vulnerable aquifer areas was determined using information available from the NPCA Groundwater Study (WHI, 2005).

The NPCA Groundwater Study used a standard methodology prescribed by the MOE, known as the *Intrinsic Susceptibility Index (ISI)*[16] to identify aquifer areas that are susceptible to impacts from contaminants at the ground surface.

In the NPCA Groundwater Study (2005), Intrinsic Susceptibility Index (ISI) values, were calculated at individual wells based on ISI calculations to the first (or shallowest) significant aquifer. These aquifers were determined from the geology and the calculated water table and bedrock potentiometric surface maps. Point ISI values across the study area were then interpolated and classed (<30 High susceptibility, 30 to 80 medium susceptibility and >80 low susceptibility). All areas mapped at surface as "coarse-textured deposits" from Quaternary Geology mapping were also classed as having a high susceptibility. All areas mapped as bedrock at ground surface/outcrop, including karst areas, were also classed as high susceptibility.

These areas of high intrinsic susceptibility have been equated, on a preliminary basis, with areas of high aquifer vulnerability.

Calculation of the 'Other Vulnerable Areas'

Figure 7.1 "Preliminary Vulnerable Areas" was created using the intersection of three NPCA Groundwater Study datasets: (i) high intrinsic susceptibility (ii) recharge areas and (iii) non-discharge areas[17]. The vulnerable areas in this figure were prioritized as follows:

- Highest priority: intersection of High Intrinsic Susceptibility and Recharge (295 km^2)

[16] The Aquifer Vulnerability Index (AVI) is another methodology that could be used to determine aquifer vulnerability.

[17] Potential discharge areas were derived from a comparison of the calculated surface of water table to ground elevation. Discharge areas were identified where the calculated water table was above the ground surface. Delineated potential discharge areas included areas along the base of the Niagara Escarpment, along Twelve Mile Creek from the headwaters near Pelham to St. Catharines, and areas south of Pelham where sands associated with the Fonthill Kame-Delta Complex meet the Welland River.

- Secondary priority: (i) Recharge Only (98 km^2) and (ii) High Intrinsic Susceptibility Only (200 km^2)

A number of areas mapped as High Intrinsic Susceptibility were also mapped as Discharge areas (164 km^2). These areas were not prioritized as they are surmised to be protected by water levels that are the above ground surface.

The top priority vulnerable areas are primarily located:

- Along the shore of Lake Erie;
- The Dunnville Sand Plain;
- The Fonthill Kame-Delta Complex;
- The Niagara Escarpment (western portion of NPSP Area);
- Niagara Falls; and
- Along the Lake Ontario shore (eastern portion of the NPSP Area).

7.4 Potential Future Drinking Water Sources

The Tier 1 municipalities in the NPSP Area were contacted for information on future potential drinking water sources. The information that was provided by each Tier 1 municipality is outlined below.

Regional Niagara
Regional Niagara does not currently have a Municipal Long Term Water Supply Strategy prepared in response to the MOE Assessment Report Guidance Module 2. However, part of the required information is provided in *The Regional Niagara Water and Wastewater Master Servicing Plan Update (2003).* This update report does not propose any new municipal drinking water sources. It is noted that areas not municipally serviced may be developed with new, individual or communal, drinking water sources. (Figure 5.6).

It is expected that the existing Niagara Falls Water Treatment Plant intake pipe will be relocated in 2007, from the north side of the Welland River to the Niagara River (upstream of the mouth of the Welland River)[18]. However, the actual WTP location will not change.

City of Hamilton
A Municipal Long Term Water Supply Strategy has not yet been received from the City of Hamilton. However, according to City of Hamilton Public Works Department staff, the City of Hamilton is not expected to locate any new municipal water sources within the NPSP Area.

Haldimand County
A Municipal Long Term Water Supply Strategy has not yet been received from Haldimand County. No new municipal sources of drinking water are proposed at this

[18] Proposals were received in June 2006 for the relocation of the Niagara Falls WTP water intake pipe.

time within the portion of Haldimand County located within the NPSP Area. This is based on conversations with Haldimand County staff. Haldimand County has no areas that are serviced by municipal water systems which are located in the NPSP Area.

7.5 Data and Knowledge Gaps

A number of data and knowledge gaps exist; these include, but are not limited to:

- Identification of communal water systems providing potable water to more than five residences (groundwater or surface water).

8.0 EXISTING THREATS INVENTORIES

According to the MOE SWP Guidance Modules, a *Threat* is a land use activity (existing or future) that affects or has the potential to negatively affect the quality or quantity of a drinking water source (MOE Guidance Module 6, April 10, 2006, section 1.0). Threats can be determined from tools such as land use maps, windshield surveys and questionnaires.

The objective of the *Threats* analysis is to identify activities known to, or that may, pose a threat to the quality of drinking water. Only *Threats* information identified through past work is presented in the Watershed Characterization report.

Drinking water threats considered to be of provincial concern are discussed below. This list was used as a guide in preparation of the existing threats inventory. However, where existing data sources were incomplete or unavailable to address a given threat type, a recommendation had been included in Section 8.8, Data and Knowledge Gaps for Threats Inventory/Assessment, to address this.

Direct introduction threats include activities that result in direct loadings of drinking water contaminants into source water such as sewage treatment plant effluent and plant by-passes, and industrial effluents.

Current and/or historical landscape activities can also introduce loadings of drinking water contaminants. Landscape activities include: (i) road salting and associated de-icing activities and snow storage, (ii) stormwater management systems, (iii) cemeteries, (iv) landfills and hazardous waste disposal, (v) land applications such as septage, biosolids, manure, fertilizer and pesticide/herbicide, (vi) sewage systems and (vii) brownfields and contaminated lands.

Another threat type is the storage of commercial quantities of potential drinking water contaminants such as fuels/hydrocarbons, dense non-aqueous phase liquids (DNAPLs), organic solvents, pesticides, fertilizers and manure.

Constructed preferential pathways of provincial concern are discussed below. Similar to the threats list, this was used as a guide for summarizing existing threats and to derive items for the data and knowledge gaps section.

Constructed groundwater pathways that may transmit drinking water contaminants into the subsurface include: (i) existing and abandoned wells (water, monitoring, oil and gas), (ii) aggregate quarry operations (operational and orphaned), (iii) construction activities (e.g. dewatering and foundation drains), (iv) storm water facilities (e.g. infiltration galleries), (v) sewage systems and (vi) sanitary sewer infrastructure.

Constructed surface water pathways that may transmit drinking water contaminants into surface water sources include: (i) storm water sewers, (ii) storm water ditches, (iii) combined storm/sanitary sewers, (iv) irrigation ditches and subsurface tiling and (v) hard-surfacing.

A number of publications have been reviewed for this initial assessment report, however due to the breadth of reporting available, this review should not be considered exhaustive. Listed below are the publications reviewed and a summary of information considered directly relevant to the threats inventory.

8.1 Source Protection Area-Wide Threat Inventories

A Potential Contaminant Sources Inventory (PCSI) was completed as part of the NPCA Groundwater Study (completed by Waterloo Hydrogeologic, Inc., October 2005). Data for the PCSI was obtained primarily from the MOE with additional potential contaminant sources provided by NPCA and Regional Niagara. However due to lack of positioning coordinates for many sources, one third of the MOE data points could not be regionally mapped.

The NPCA Groundwater study PCSI dataset is tabulated (Table 8.1) and mapped on Figures 8.1 and 8.2 for those records which could be geo-referenced. Brief descriptions are presented below for a number of the PCSI datasets including some not mapped:

- Fuel storage sites are locations of underground storage tanks (USTs) from the Technical Standards and Safety Association (TSSA) database. However this does not include private fuel tanks such as residential heating oil tanks.
- PCB Storage Sites are areas where PCBs are believed to exist within a transformer, or in areas designed as PCB storage facilities.
- Contaminant Spill Sites database (1988 to 2002) included MOE recorded spills to both air and ground/sewers/water, however the 592 releases to air were not plotted.
- Hazardous Waste Generating Stations are facilities/operations involved in the production, collection, handling or storage of regulated wastes (e.g. pharmacies, hospitals, laboratories, factories/manufacturing plants and dry cleaners).
- Hazardous Waste Receiving Stations are sites to which waste is transferred to via a waste carrier.
- Active/Closed Landfill Sites were identified based upon multiple sources including the 1991 MOE Waste Disposal Inventory, MOE Technical Support Section reports and Regional Niagara and Ministry of Environment staff information.
- Waste Sites are waste transfer stations and other types of temporary waste storage sites.
- Biosolids application locations are for the period 1999 to 2003 within Regional Niagara only. The MOE has not provided locations of biosolids application sites within the City of Hamilton or Haldimand County.
- Automotive/ Machinery Sites included recycling yards, and some sales yards locations, where automobiles and various types of machinery are stored, or parked in sales yards.

- Lumber yards are plants or operations that preserve, dress, plane, and store wood products prior to distribution to the consumer.
- The "Pipelines" dataset consists of oil and gas pipelines and petroleum product transfer locations.
- Septic System "Hot Spots" were mapped in two shoreline areas; Onondaga and Niagara-on-the-Lake. These areas were classified as hydrogeologically sensitive and having inadequately designed/malfunctioning septic systems as shown by contaminated groundwater results.
- Large Sub-Surface Sewage Disposal systems were mapped using two datasets: (i) those sewage works with a design capacity over 10,000 L/day and in operation under a Certificate of Approval from the MOE Environmental Assessment and Approvals Branch and (ii) those systems previously approved (pre-1998) for design capacities over 4,500 L/day by the Region of Niagara Public Health Department under, now repealed, Part VIII of the Environmental Protection Act.
- A preliminary listing of abandoned water wells was identified using the MOE Water Well Information System (176 wells). Abandoned water wells in this case means those wells that were drilled but are unused for supply or monitoring, and have not been properly decommissioned.
- There remain many abandoned oil and gas wells within Regional Niagara. These wells were drilled for oil and gas exploration and / or production, but are no longer in use and they have not been properly decommissioned. These numerous abandoned wells pose an additional risk due to their depth/gas/water quality.
- Agricultural land use is 70% of the study area. Below the escarpment, vineyards, tender fruit farms and orchard crops are generally important while above/south of the escarpment speciality crops including greenhouse flowers and vegetables, sod farms, nursery products, and mushroom farms are more dominant. Specialty crops account for the greatest quantity except where livestock operations are the dominant land use (i.e. Town of Fort Erie, City of Port Colborne and Township of West Lincoln). Specific threats that require identification include storage and use of fertilizer, pesticide and herbicide.
- Salt Storage Domes were located for Regional Niagara however additional storage facilities and snow dumps should be located for local municipalities, the City of Hamilton, Haldimand County and the Ministry of Transportation.

<u>Focussed Contaminant Source Assessment</u>

A focussed contaminant source assessment (windshield survey) was also conducted in selected hydrogeologically sensitive areas to identify additional potential contaminant sources and verify, where possible, the locations of inventory sources. This field survey was conducted in three areas considered hydrogeologically sensitve (the Onondaga Escarpment, Niagara-on-the-Lake and the Fonthill Kame-Delta Complex). The survey results are presented with the previously described databases on Figures 8.3, 8.4, 8.5 and 8.6. However additional information (e.g. sewage disposal systems, abandoned wells, etc.) could still be gathered through door-to-door surveys and meeting with local industries. A number of new additional source locations were determined through the windshield survey including : (i) 47 fuel storage (ii) 1 PCB storage (iii) 32 hazardous waste generating (iv) 20 cemeteries (v) 30 automotive/machinery (vi) 1 lumber yards and (vii) 3 pipeline transfer stations.

Groundwater Sustainability

Historical water budget estimates for Regional Niagara area estimated that Permit To Take Water (PTTW) usage was about 15% of the recharge and overall groundwater availability was not an issue (NWQPS, 2003). However the NPCA Groundwater Study (October 2005) indicated the current annual groundwater use across the study area is about 25% of the annual groundwater recharge. The study authors considered this significant enough to possibly have a negative effect on groundwater discharge. However, with the exception of Twelve Mile Creek, most creeks and rivers within the study area do not receive an appreciable amount of groundwater discharge. The Source Water Protection Tier 1 Water Budget should better assist in defining stressed areas as a result of groundwater withdrawals and reduced recharge. A potential threat of reduced recharge to the groundwater system is degradation of groundwater quality through a combination of less meteoric dilution and increased upward contribution from deeper bedrock units, as well as stress to sensitive groundwater features, e.g. marshes.

8.2 Municipal/Industrial Discharges

In 1986 the Ministry of Environment and Energy initiated the Municipal/Industrial Strategy for Abatement (MISA). In Ontario most industrial point source discharges fall under the MISA program. The main features of the MISA industrial regulations include monitoring and reporting requirements such as:

- Compliance for every chemical parameter in the MISA regulations for which there are two limits: daily and monthly average;
- A required monitoring frequency to demonstrate compliance with the limits;
- Non-toxic effluent to fish and water fleas;
- Annual reporting for each plant available to the public;
- Summary quarterly reports to the province; and
- Incidents of non-compliance reported directly to the province followed by a letter.

According to the MOE website, (www.ene.gov.on.ca), ten (10) facilities are located within the NPSP Area or immediately adjacent (Table 8.2).

8.3 City of Hamilton Threat Inventory

A regional contaminant source inventory was completed for the City of Hamilton which contained a portion of the NPSP Area (Charlesworth, 2006). The inventory consisted of a series of database searches, supplemented by a review of "hard copy" files from the local MOE offices, including various hydrogeological studies and reports. The survey was conducted for the portion of the Hamilton study area above the Niagara Escarpment

(See Appendix E, Item 5). The justification for this was "because there is very little use of groundwater for drinking water below the escarpment". The report states that it is their understanding that the City is undertaking a review of potential contaminant sources within the urban area under another project.

The database search was conducted using an ECOLOG-ERIS search of their private and government databases. The additionally searched databases that were not already covered by the NPCA Groundwater Study (2005) included the following:

1. **National PCB Database (NPCB):** Environment Canada's National PCB inventory includes information on in-use PCB containing equipment in Canada including federal, provincial and private facilities. All federal out-of-service PCB containing equipment and all PCB waste owned by the federal government or by federally regulated industries such as airlines, railway companies, broadcasting companies, telephone and telecommunications companies, pipeline companies, etc. are also listed. Although it is not Environment Canada's mandate to collect data on non-federal PCB waste, the National PCB inventory includes some information on provincial and private PCB waste and storage sites.
2. **National Pollutant Release Inventory (NPRI):** Environment Canada has defined the National Pollutant Release Inventory ("NPRI") as a federal government initiative designed to collect comprehensive national data regarding releases to air, water, or land, and waste transfers of 178 specified substances.
3. **Ontario Certificates of Approval (CA)**: This database contains the following types of approvals: Certificates of Approval (Air) issued under Section 9 of the Ontario EPA; Certificates of Approval (Industrial Wastewater) issued under Section 53 of the Ontario Water Resources Act ("OWRA"); and Certificates of Approval (Municipal/Provincial Sewage and Waterworks) issued under Sections 52 and 53 of the OWRA.
4. **Ontario Pesticide Register (PES)**: The Ontario Ministry of the Environment maintains a database of all manufacturers and vendors of registered pesticides.
5. **Anderson's Waste Disposal Sites (ANDR)**: The Anderson database uses historical documentation to locate and characterize the likely positions of former waste disposal sites in Ontario. It aims to identify those sites that are missing from the Ontario Ministry of the Environment's *Waste Disposal Site Inventory*. The Anderson database provides revisions and corrections to the positions and descriptions for sites listed in the MOE database. In addition to historic waste disposal facilities, the database also identifies certain auto wreckers and scrap yards that have been extrapolated from documentary sources.
6. **Scott's Manufacturing Directory (SCT) (Industries by the NAICS Codes)** Scott's Directories is a data bank containing information on over 56,000 manufacturers in Ontario. Even though Scott's listings are voluntary, it is the most comprehensive database of Ontario manufacturers available. Information concerning a company's address, plant size, and main products are included in this database. This database begins with 1992 information and is updated annually.

In addition, the following were searched, however there were no locations that could be attributed to the results from these database searches:

- National Contaminated Sites Remediation Program;
- Ontario Compliance and Convictions; and
- Ontario Chemical Register.

8.4 Regional Niagara Threat Inventories

8.4.1 Road Salt

The total volume of salt used by Regional Niagara and the area municipalities for winter de-icing over the years 1998-2001 averaged about 50,000 tonnes per year. Regional Niagara salt is stored in domes but other potential road salt sources exist through activities such as the wash water from the washing of salt spreaders (e.g. Fort Erie, Jordan and Smithville) (MacViro, 2003a-d).

Within Regional Niagara the vulnerability to road salt was estimated for a number of different category vulnerabilities (land use, groundwater and surface water) (Ecoplans Limited, February 2005). In order to summarize those areas in which alternative management practices should be considered, the vulnerabilities were combined with the road network. Each segment of the road network was assigned an environmental vulnerability rank based on the predominant area it crossed and a calculation completed to assign an overall vulnerability rank.

The highest ranked areas (most vulnerable) were found along the south shore of Lake Ontario and the west side of the Niagara River and in areas in the southwest and south central area of Regional Niagara (Appendix E, Item 6). The lowest ranking roads were in the urban areas of St. Catharines and Niagara Falls. This is because there was little surficial soil (not quaternary) mapping available in the urban areas with which to categorize the vulnerability (vulnerability was calculated based upon surficial soil and quaternary soil classifications). Higher vulnerability in the north and northeast parts of the Region was due mainly to land use, while in the south and east it was due mainly to surface water constraints. The areas ranked as most vulnerable to road salt contamination were recommended for further study to confirm, refine, and prioritize the areas for development of protection measures.

8.4.2 Water Pollution Control Plants (WPCP)

There are nine (9) municipal water pollution control plants (WPCPs) and five (5) municipal wastewater lagoons located within the NPSP Area (MacViro, 2003a-d). A summary of the WPCPs is presented in Table 8.3.

Overflows at various WPCP facilities indicate this has been an on-going problem. Frequencies of overflows have been the largest for the Niagara Falls WPCP and the Port Weller WPCP. The release of untreated sewage from WPCPs can have similar impact to receiving waters as CSO/storm sewer discharges discussed below.

Biosolids generated from the WPCP treatment process are also a potential threat as they are often applied to agricultural fields and contain heavy metals and other contaminants which can be absorbed by food sources or can get washed into receiving watercourses or infiltrated into groundwater.

Violations to the sewer-use bylaw may also exist, whereby the WPCP receives inflow concentrations in excess of plant design.

Average annual by-pass frequencies (1995-2000) from pumping stations and WPCP were about six (6) events for Fort Erie, three (3) events for Grimbsy, 46 events for Niagara Falls, one (1) event for Niagara-on-the-Lake, three events for Port Colborne, 28 events for St.Catharines and two (2) events for Welland.

There are data and knowledge gaps concerning the locations of municipal and communal wastewater facilities and their outfall locations and therefore the specified map could not be produced.

8.4.3 Municipal Sewers, Drains and Nutrient Management

The information presented in Section 8.4.3 on municipal sewers and drains, and storm runoff was referenced from the Niagara Water Quality Protection Strategy (NWQPS) Technical Reports (Oct 2003).

- Municipal drains and storm sewer outlets are potential pathways for contaminants. The NWQPS reports identify a number of municipal storm sewers and drains. However the list appears to be incomplete. More detailed information on storm sewers which are located in the vicinities of the Water Treatment Plant intakes has been requested from the Tier 2 municipalities as part of the Intake Protection Zone studies.

<u>Storm Runoff</u>
Storm runoff via outfalls to various receiving water bodies is a significant problem contributing to water quality degradation. The municipalities with the highest volume of runoff and associated loadings are (in descending order) St. Catharines, Niagara Falls, Welland, Port Colborne. Storm runoff and associated loadings from agricultural areas are the highest for the following Local Management Areas (LMAs)[19] 1.1, 2.3, 2.7, 1.5, 1.10, 2.8, 1.4 and 2.06 (Appendix E, Items 7 and 8). The discharge of urban runoff also contains various levels of contaminants such as suspended solids, *E.coli*/fecal coliforms, heavy metals (copper, lead, zinc), oil and grease, pesticides and nutrients such as phosphorus, nitrate/nitrite and TKN. As an example, Lorraine Bay (immediately east of Port Colborne) discharges silt from municipal drains and may be responsible for water quality degradation in the bay (MacViro, 2003, NWQPS Technical Reports).

[19] LMA are defined and used in the Niagara Water Quality Protection Strategy reports, dated 2003.

The number of storm outfalls in Regional Niagara to Lake Ontario, the Niagara River and Lake Erie are 191, 89 and 35, respectively. The NWQPS reports did not provide locations of these storm outfalls. The seasonal volume of water discharged is in excess of 3,278,380 m^3 to Lake Ontario and 804,123 m^3 to the Niagara River, while the volume of overflows to Lake Erie is not available.

Combined Sewer Overflows

Combined Sewer Overflows (CSOs) are significant sources of contamination in some of the municipalities such as St. Catharines, Welland, Niagara Falls, Port Colborne and Fort Erie. It is noted that the Town of Lincoln and Town of Pelham systems are fully separated systems (i.e. do not have combined sewers). CSO discharge often has high levels of contaminants such as phosphorus, suspended solids, bacteria/pathogens, PCBs, radioactivity, toxins, endocrine inhibitors, hormones, copper, Total Kjeldahl Nitrogen (TKN), nitrate/nitrite, zinc, lead, oil and grease.

The number of CSO outfalls in Regional Niagara to Lake Ontario, the Niagara River and Lake Erie are 52, 42 and 9, respectively. The seasonal (April to November) total volume of overflow is in excess of 640,083 m^3 to Lake Ontario and 1,540,164 m^3 to Niagara River (volume of overflows to Lake Erie is not available).

Sediment/Nutrient Loading

Average storm runoff from urban areas is about 56.4 million m^3/year and the total suspended solids loading is estimated at 8.8 million kg/year according to the NWQPS report (Oct 2003). The average annual runoff from agricultural areas is estimated at 274 million m^3/year and the total suspended solids loading 107 million kg/year. It is estimated that agriculture produces more total nitrogen (nitrate/nitrite/ammonia) and phosphorus, but less bacteria and copper compared to the urban areas.

Livestock numbers for cattle are relatively low and also for hogs with the exception of West Lincoln. The number of poultry is quite significant in the overall agriculture of the area both above and below the escarpment.

8.4.4 Contaminated Sites

Industrial sites/brownfields exist in Regional Niagara that could be leaching chemicals into receiving bodies of water. Some of the contaminated sites being investigated within the watershed include eastern Lake Gibson (contaminant source), 12 Mile Creek (PCB trackdown), Lyons Creek (sediment PCBs remediation program) and Port Colborne area (INCO risk assessment of contaminants such as arsenic, cobalt, nickel and copper). The NWQPS report (Oct 2003) also mentioned the existence of historic coal gasification plants including one at Lake Gibson (MacViro, 2003, NWQPS Technical Reports).

The NWQPS presented a summary of non-regional waste disposal sites: active – four (4), closed - sixty-five (65), and industrial (non-hazardous) – six (6). These summaries were based upon the June 1991 MOE publication "Waste Disposal Site Inventory" which does not contain detailed or current information (such as identification of potential off-site contamination and water quality monitoring results). The NWQPS report indicates that "Various old dump/fill sites are (also) in existence throughout the area which are not being monitored and could be leaching contaminants to surface and groundwater". The NWQPS report identified a priority listing of sites to investigate based upon MOE waste disposal site classification criteria and includes the following sites: PT24-24 (Port Colborne), Feeder Rd. North of Town Line Rd. (Welland), 36 Cushman Rd (St.Catharines), Lot 27 (Port Colborne), Beaverdams Rd. (Thorold), Ontario Paper (Thorold) and PT 21-22 PT 223 (Welland).

The NWQPS report also indicated that based upon recent work there were no concerns for the Binbrook Landfill site (City of Hamilton). The Walker Industries landfill was also mentioned but no comment given with respect to any off-site contamination. The City of Hamilton provided information on the Stoney Creek Landfill indicating that waste probably extends off property to the north, onto the road allowance, and that leachate migration from the landfill exceeds allowable criteria for groundwater quality. Further investigations were undertaken in 2001 for remediation of the problem but results were not available for the NWQPS report (2003).

Despite the concerns noted above, existing monitoring programs and MOE regulatory reviews currently conclude that the Regional Niagara municipal landfills (six operating and eight closed) are not having adverse affects on off-site groundwater resources. Monitoring programs under MOE review will continue to document any impacts as they occur (Krisjanson, Jamie).

8.4.5 Direct Industrial Discharges

The following information on direct industrial discharges was referenced from the NWQPS (MacViro, 2003, NWQPS Technical Reports). . Major industrial discharges and contaminant sources to receiving water within the St.Catharines - Thorold area were summarized and presented in a drawing (St. Catharines Area Pollution Control Plan, Urban and Industrial Discharges Study, Nov. 1989). Over the past several years, the number of direct discharges have been decreasing with plant closures. At this time, it appears that there are about three (3) dischargers left in St. Catharines but this was not confirmed.

The MOE has identified that some non-MISA Certificates of Approvals are old and in need of updating.

MOE records indicate that there are approximately 36 industrial discharges in Regional Niagara. Some of these are based on water receiver or old technologies and the previous Certificates of Approvals that were issued need to be reviewed. The NWQPS report included a list of industrial site discharges from the Canadian side; however, the list only included facility names.

8.4.6 Septic Systems

Several studies have been completed that indicate potential water resources impacts due to septic systems. In 2001, Regional Niagara's Public Health Department conducted a sanitary survey of the Long Beach Area along Lake Erie and found many existing/potential malfunctioning sewage disposal systems leading to Lake Erie and contributing to negative environmental impacts. In 2002, MacViro Consultants Inc. conducted a Groundwater Impact Assessment and water well /septic system survey along the lakeshore area of Wainfleet. The study reported that groundwater resources are at a high risk of contamination from nitrate and other sewage effluent contaminants, including bacteria and other pathogens. In addition, it was reported that phosphate loading and pathogen contamination from septic systems are a potential threat to the natural environment of Lake Erie. Previous investigations have also highlighted potential septic system problems in the Upper Welland River (.MacViro, 2003, NWQPS Technical Reports).

The NWQPS authors stated that "septic systems are not generally in proper working order. Wineries generally own their own septic systems, which are often not kept up with the expansion of their operations".

A boil water advisory was issued by the Regional Niagara Public Health Department in April 2006 for all properties in the Township of Wainfleet located in the area south of the Trans Canada Trail (former CN railway), extending to the Lake Erie shoreline. Significant bacterial contamination continues to exist in groundwater tested from private and communal wells in the area (Regional Niagara Website).

8.4.7 Spills

A review of spill locations within Regional Niagara indicated the largest number of spills have occurred in St. Catharines, Niagara Falls, Fort Erie, Welland, Thorold and Port Colborne. There was an average of 3.5 incidences of water-related and 8 land-related reported spills per year in the Regional Niagara.

8.5 Lake Erie

The Lake Erie (Lakewide Management Plan) LaMP (LaMP, 2004) is a comprehensive management plan to restore and protect the waters of Lake Erie as part of the Great Lakes Water Quality Agreement. The Lake Erie LaMP has designated drinking water from Lake Erie to be unimpaired (accounting for current municipal water treatment technology) but an area to protect. However critical pollutants and chemical pollutants of concern remain, which include organochlorines and metals that are known to cause adverse health effects in animals and humans. Potential negative water quality impairments mentioned included: taste and odour, endocrine disruptors, lowered water levels, persistent toxic chemicals (in water and sediment) and eutrophication. The Lake Erie LaMP includes a technical Sources and Loads subcommittee, charged with the task of identifying key chemical sources of identified water quality problems. Their published research to-date has primarily focussed on the distribution of mercury, PCBs, dioxin, chlordane and PAHs in sediment within Lake Erie.

8.6 Lake Ontario

The Lake Ontario LaMP (LaMP, 2006) is a comprehensive management plan to restore and protect the waters of Lake Ontario as part of the Great Lakes Water Quality Agreement.

The Lake Ontario LaMP Stage 1 beneficial use assessment determined that on a lakewide basis only, drinking water restrictions or taste and odour problems were unimpaired. This was based upon monitoring from municipal water supplies drawn from Lake Ontario that met public health standards for drinking supplies. However local consumers within the western portion of Lake Ontario report occasional taste and odour problems related to naturally occurring chemicals such as geosmin and methylisoborneol (MIB), produced by blue-green algae and bacteria. These taste and odour problems can be alleviated at water treatment plants by the use of powdered activated carbon or potassium permanganate. There have not been any severe episodes of taste and odour on the Canadian shores of western Lake Ontario since 1999; however, a late summer pulse in geosmin production has been detected annually in western Lake Ontario since 2000. This is thought to be due to cyanobacteria in lake plankton during late summer, however zebra mussel controls may also be a contributing factor as well.

The designated Lake Ontario LaMP lakewide critical pollutants are polychlorinated biphenyls (PCBs), DDT (and its metabolites), mirex, dieldrin, mercury and dioxins/furans. LaMP critical pollutants are those substances “responsible, either singly or in synergistic or additive combination, for beneficial use impairments in the …lake waters…as well as those substances that exceed criteria and are therefore likely to impair such uses, which require…actions for resolution” (LaMP, 2006, Section 2.4 pg 2-10). These substances are the focus of LaMP source reduction activities. Based on current, although limited loadings data available, it appears that the upstream Great Lakes are still a significant source of critical pollutants and are now equalled in magnitude by atmospheric deposition from emissions both within and outside the Lake Ontario basin. As an example the only measurable mirex that enters Lake Ontario originates in the Niagara River basin. However the Niagara River Upstream/Downstream water sampling program operated by Environment Canada shows substantial decreases in the concentrations of mirex. Historically chemically manufacturing sources in the Niagara River basin were also significant sources of dioxins/furans to Lake Ontario. These sources have been effectively controlled, although low-level releases to water from one Ontario site to the Niagara River Basin are reported to Canada’s National Pollutant Release Inventory.

Emerging issues include emerging chemicals of concern: flame retardants (polybrominated diphenyl ethers - PBDEs, hexabromocyclododecane - HCBD), perfluorinated compounds (PFOS, PFOA), polychlorinated naphthalenes (PCNs), and other emerging chemicals including endocrine disrupting compounds, pharmaceuticals and personal care products and harmful algal blooms. Notably, previous Lake Ontario Toxics Management Plan reports have also identified three other contaminants as potentially exceeding water quality standards and critieria: octachlorostyrene (OCS), chlordane and hexachlorobenzene (HCB). It was reported that none of these contaminants persist as a lakewide issue and concentrations are well below applicable water quality criteria.

It was also mentioned that the Great Lakes Binational Toxics Strategy (www.binational.net) Level 1 substances include all the Lake Ontario critical pollutants as well as benzo(a)pyrene, alkyl-lead and toxaphene. This is a strategy for virtual elimination of persistent toxic substances.

8.7 Connecting Channel - Niagara River

The Niagara River has been designated by the International Joint Commission (IJC) as one of forty-three Areas of Concern in the Great Lakes Basin. This designation is due to degraded water quality which impairs complete use of the river's resources. The Remedial Action Plan (RAP) is a plan to restore and protect water quality in the Niagara River (Ontario) Area of Concern which extends from Lake Erie to Lake Ontario at Niagara-on-the-Lake and includes several small tributaries to the upper sections of the Niagara River, and the entire drainage basin of the Welland River. The Stage 1 report and update described the current environmental conditions, sources of contamination and beneficial uses which are impaired and the extent of impairment (MOE, September 1993, Remedial Action Plan – Stage 1; and Remedial Action Plan, Stage 1 – Update, March 1995).

Sources of contamination discussed within the Niagara River – Ontario Area of Concern (AOC) included: water pollution control plants, industrial point sources, combined sewer overflows, urban non-point runoff, rural non-point sources/runoff (e.g. sewage systems), waste disposal sites and spills. However it has been recognized that the majority of the contamination in the Niagara River comes from sources on the U.S. side of the river. Contamination from sources in the four upstream Great Lakes also contribute to background levels in the Niagara River, e.g. airborne pollutants.

Sediments are both a source and a sink for contaminants. Sediments become sources when fine particles (to which contaminants adhere) are resuspended in the water through disruptive activities such as dredging or natural processes such as high flows or wave action. Sediment-bound contaminants may re-enter the water column through chemical diffusion or be consumed by bottom-dwelling organisms. Sediments act as a sink in areas of slow moving water where deposition occurs and contaminants may accumulate and be buried.

In support of the Niagara River Remedial Action Plan, a review of sediment conditions in twelve (12) sites within the Ontario AOC was undertaken as a move towards delisting the area. Concerns at each of the 12 sites were assessed through a review of the processes and operations at each site, the potential contaminants of concern (COCs) produced, and the history of monitoring at the sites (Golder Associates, February 2005).

Based on the outcome of the initial investigation, three areas were identified where risks to biota indicated the need for more detailed assessment under Phase III (Lyon's Creek West, Welland River and Frenchman's Creek). The study indicated the only site where risks to biota were present was Lyon's Creek West. Additionally a remediation plan is in development for Lyon's Creek East, a contaminated site also being investigated within the Welland River watershed.

Ontario Power Generation (OPG) is planning a shut-down of the Sir Adam Beck No. 1 Generating Station Canal, which has its starting point on the Welland River, upstream (west) of its historic connection to the Niagara River. During this period when the canal is off line, the current "normal" back flow of Niagara River water into the Welland River will stop, and the Welland River water could then flow all the way to the Niagara River as it did prior to construction of the Power Generating Station Canal. The existing intake for the Niagara Falls Water Treatment Plant would then receive raw water from the Welland River (R.V. Anderson Associates Limited, 2002).

This condition for the Niagara Falls WTP intake is considered undesirable because:

1. The Welland River can be considerably more polluted than the Niagara River (i.e. higher suspended solids), therefore requiring a higher degree of treatment. Under some conditions, this could have a negative impact on treated water quality; and
2. Water quantity in the Welland River can be extremely variable, making it difficult to control and optimize treatment chemistry at the plant.

As a result the Region completed a feasibility study to consider various alternatives for development of an intake in the Niagara River. It is our understanding the design for this new intake is underway for completion fall 2006.

Of the 26 U.S. hazardous waste sites responsible for 99% of the estimated toxic chemical inputs to the Niagara River, the EPA estimates that remediations to date have reduced the potential inputs into the river by approximately 93% (USEPA and NYSDEC, 2004).

8.8 Data and Knowledge Gaps

A number of data and knowledge gaps. They include but are not limited to:

- Existing St. Lawrence Seaway information, e.g. Welland Canal – sediment deposition quality
- Off-site contamination status/monitoring of non-Regional Niagara landfills, e.g. local municipal closed landfills, off-site contamination from Stoney Creek Landfill (City of Hamilton)
- Lyon's Creek West Remediation Action Plan report – in draft preparation stage
- Atmospheric deposition of contaminants to raw water sources (e.g. Great Lakes)
- Location of tile drained agricultural areas

- Biosolids mapping for City of Hamilton and Haldimand County
- Constructed pathways - abandoned non-decommissioned water/monitoring/gas wells
- City of Hamilton Contaminant Source Assessment database.
- Map of stormwater management facilities, storm sewer outlets and combined sewer overflows.
- Septic system inventory/overview – number, locations, functioning/failures,
- Road salt studies/management plans for City of Hamilton and Haldimand County
- Road salt storage areas and snow dumps for local Niagara municipalities, City of Hamilton, Haldimand County, MTO and road maintenance contractors.
- Identification of large confined animal feeding operations
- Current industrial dischargers.

9.0 SUMMARY OF IDENTIFIED ISSUES AND CONCERNS

9.1 Identified Issues

An **identified issue** is the realization of a threat within a drinking water source. It is a condition of the drinking water source, related to its quality (or quantity), represented by an exceedance of a water quality standard or an increasing trend, in an undesirable water quality parameter. Parameter detections may in some cases be considered issues where no water quality standards exist.

Issues can be identified from: (i) the water quality review, (ii) previous watershed plans/studies, (iii) land use information, (iv) information overlays and (v) correspondence.

Only a limited number of issues were identified concerning the Regional Niagara municipal water supplies. These issues included:

- Increasing chloride concentrations at all water treatment plant intakes;
- Increasing arsenic concentrations at all water treatment plant intakes.;
- Elevated organic nitrogen concentration at all water treatment plant intakes; and
- Elevated phosphorus concentrations in Lake Erie and Lake Ontario.

A more detailed analysis of the above noted parameters is presented in Section 6.0 of this report. Known issues also exist with respect to private water supplies, however, a discussion of private well issues is not currently within the scope of this report.

9.2 Identified Concerns

A "Concern" is a purported drinking water issue that has not been substantiated by monitoring or other verification methods.

A summary of identified concerns is provided below. The aim of the source protection program is to, where possible, eventually identify the source of the concerns that exist in the watershed.

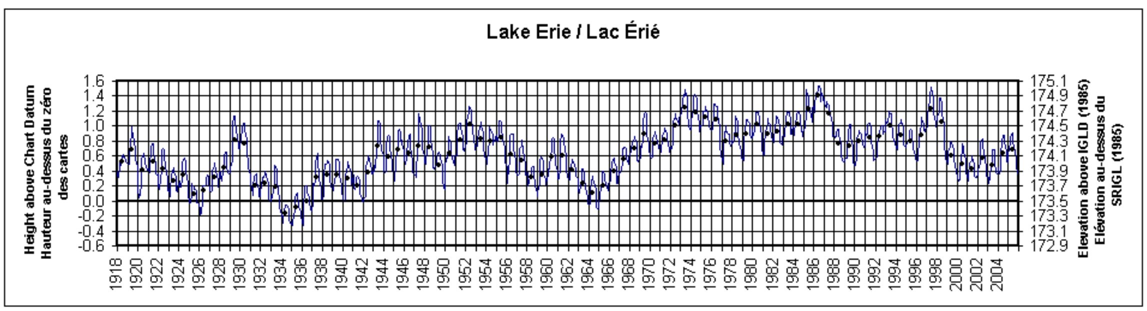
Identified concerns are expected to cover a broad range of topics and be identified through: (i) media reports and (ii) resident reports.

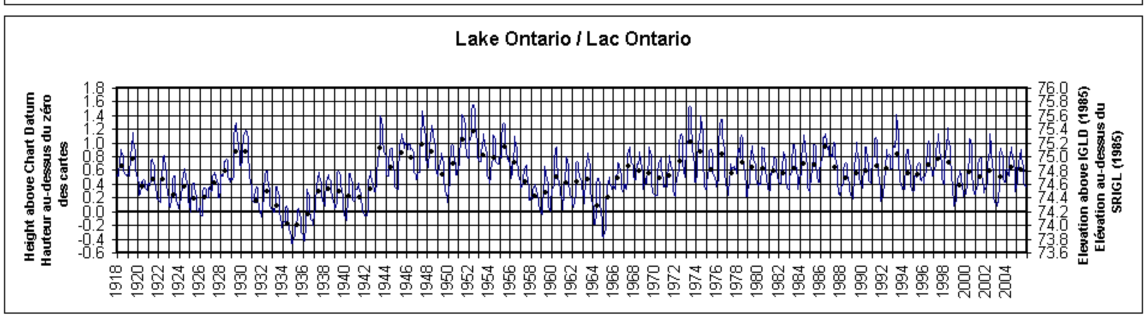
Recent local media reports have included the following source water protection concerns:

1. Toxic drugs found in St. Lawrence samples (Moore, Dean, 2006): Detections of drugs in the St. Lawrence River ranging from caffeine, over-the-counter ibuprofen to prescription antibiotic oxytetracycline and carbamazepine (prescribed to treat epilepsy and Alzheimer's). Drugs, birth control hormones, Prozac and perfume have all turned up in similar studies in the United Kingdom and the United States

in recent years. These parameters are often identified as 'emerging chemicals of concern' (e.g. endocrine disrupting compounds and pharmaceuticals).

2. Test well water for lead city (McGuiness, Eric, 2006): Hamilton advised owners of drilled wells above the escarpment to have their wells tested for the presence of naturally occurring lead.
3. War over waste; Paper fibre biosolids are safe, says Abitibi Consolidated (Van Dongen, Matthew, 2006): Biosolids from paper recycling at Abitibi Consolidated in Thorold have been mixed with sand and used to build berms in Ontario (e.g. Sound-Sorb berm in Pelham). Concerns have been raised that the material exhibits unpleasant odours, leaks chemicals (e.g. ammonia) and bacteria (e.g. *E.coli*). The producer has indicated that it is benign and non-toxic. However, a number of organizations have requested stricter regulation as the paper biosolids are exempted from the waste regulation to promote recycling. An expert panel report has been completed and is being reviewed by the MOE.
4. Erie – the incredible shrinking lake (Associated Press, 2006): The newest update to the Lake Erie Management Plan (2006) predicts global warming will lead to a drop in water levels over the next 64 years, a change that could cause the lake's surface area to shrink by up to 15 % and expose 5,700 km^2 of land. The report says the water temperature has increased by 0.55 degrees Celsius since 1988 and predicts the lake's level could fall about 85 centimetres.
   a. In the last century water levels in Lake Erie and Lake Ontario have fluctuated between 173.2 and 175.0 m and 73.7 and 75.6 m, respectively. The Canadian Hydrographic Central and Arctic Region (Fisheries and Oceans Canada) presents the following water level data in Lake Erie and Lake Ontario for consideration:





5. Life's not a beach (Van Dongen, 2006): St. Catharines beaches were posted as unsafe 61 % and 76 % of the time in June and July 2006, respectively. Two of these beaches were classified by Water keepers (a beach monitoring advocacy

group) as part of a top five list of the most frequently unsafe beaches (they monitored seven Ontario regions). During 2005, Regional Niagara beaches were posted unsafe 117 times but by August 16, 2006 beaches had already been posted unsafe 166 times. However, for the first time in decades, St. Catharines was able to open Jones Beach in Port Weller east during summer 2006.

6. Private Well Users affected by Storm Encouraged to Sample Water (Regional Niagara, 2006): Fort Erie and Port Colborne residents who relied on private wells as their source of drinking water were advised to have their water tested immediately as their wells may have undergone potential flooding and treatment systems may have malfunctioned due to a lack of power.
7. An anonymous survey was completed by NPCA (NPCA, 2006d) to uncover issues of importance and concerns in the agricultural community to be addressed by watershed planning. Two top identified concerns were, water quality and quantity; including wells drying up, low surface water conditions, drinking water quality, nitrogen/phosphorus/bacteria/pesticides in groundwater/surface water and seepage from septic tanks.
8. Algae build-up, that was identified by NWQPS, has been noted as an area of public concern along the Great Lakes requiring further monitoring and reporting to quantify the issue.
9. Avoiding “the big pipe” in Wainfleet; Panel is examining alternative – and cheaper – solutions to community’s tainted water problem (Van Dongen, 2007). Old septic beds leaking sewage into area groundwater prompted the public health department to issue a boil water advisory that was in effect for over a year. Niagara received Ministry of the Environment approval to fix the problem with water and sewer pipes, but residents balked at the huge price tag and threat of development.
10. Road salt can have damaging impact on environment (Niagara Falls Review, 2007). Niagara Region spreads more than 40,000 tonnes of road salt every winter to battle icy road conditions. The most susceptible areas include tenderfruit lands, the Fonthill Kame and wetlands.
11. E.coli contamination closes Fort Erie beaches (Staff, Niagara Falls Review, 2008). Three Fort Erie Beaches were posted as unsafe for swimming due to excessively high levels of bacteria in June of 2008. The presence of E.coli in water means that other bacteria, viruses and parasites may also be present.
12. Clear Waters (Van Dongen, 2009). Every year 1.3 billion litres of untreated sewage enters Niagara’s waterways and two Great Lakes via storm-swamped sewers and treatment plants. This amount of dirty water and sewage is equivalent to 520 Olympic-sized swimming pools. Rectifying the problem is priced at $200 million over 15 years.
13. Clean Harbors makes first court appearance (Sun Media, 2009). Clean Harbors Canada is a hazardous materials plant located in Thorold, and was recently charged by Ontario’s Ministry of Environment due to a series of explosions in 2007. Charges include discharging a contaminant into the environment, improper storage of waste materials and failing to follow standard operating procedures for the handling and processing of waste lithium batteries.

14. RCCAO study finds Ontario consumers paying $700 million a year for water that never reaches their taps (RCCAO, 2009). The Residential and Civil Construction Alliance of Ontario (RCCAO) found in a study that municipal water systems in Ontario experience leakage rates ranging form 10 to 50 percent, costing taxpayers millions. Aside from cost, the chlorinated water from leaking pipes impacts sensitive water bodies and leaking sewer lines discharge effluent into the environment. There can also be increased risks to human health.

9.3 Issues Raised by the Public in Response to the Terms of Reference

1. How will agriculture business continue their practice of drawing water from the Great Lakes?
2. Because water is taken from bodies of water in Niagara, are the sewage treatment plants Certificate of Approvals going to be modified to eliminate sewer overflows or by-passes?
3. For south Niagara, our main source of water is Lake Erie, and much of the quality of Lake Erie is affected by the USA states of New York, Pennsylvania, and Ohio. Also, other westerly regions of Ontario down to the Kingsville area/Pelee Island would affect our water. Will this be addressed on a provincial and international platform?
4. Should the drinking water system issues downstream also be included, as water treatment plants and distribution systems also affect the total drinking water scenario?
5. The focus of the SWP Plan is two fold; managing water quantity and improving municipal drinking water supplies. Through the terms of reference, will the scope of the work be limited to municipal drinking water?

9.4 Data and Knowledge Gaps for Identified Issues and Concerns

A number of data and knowledge gaps exist which may include but are not limited to:

- Evaluation of water level trends for municipal water sources i.e. Lake Ontario and Lake Erie ;
- Monitoring programs of emerging chemicals of concern (e.g. pharmaceuticals);

10.0 STUDY LIMITATIONS

The findings, opinions and recommendations presented in this report are based on available information that was collected during the preparation of this report. Information provided by others has not been independently verified for accuracy. Professional judgement was exercised in organizing and assessing the information obtained and utilized. However, the Niagara Peninsula Conservation Authority cannot verify the accuracy of third party information that was reviewed or included in this report. This report was prepared using the direction and comments outlined in the MOE Assessment Report technical Rules which supercede the former MOE Source Protection Draft Guidance Technical Modules.

This report is to be used in its entirety and no excerpts may be taken to be representative of the findings of this report. This report was completed to satisfy some of the conditions of the MOE Source Protection Program as described under the Clean Water Act. The scope of work performed in completing this document may not be appropriate to satisfy the needs of users other than the MOE or the Niagara Peninsula Conservation Authority. Use or reuse of this document, or the findings, conclusions or recommendations presented herein are at the sole risk of the said user.

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ACRONYMS

ACRONYMS

ACT	-Action Coordination Team (for NWQPS)
AGNPS	-Agricultural Non-Point Source Modeling Results
ANSI	-Area of Natural and Scientific Interest
AOC	-Area of Concern
BMP	-Best Management Practices
CA	-Conservation Authority
CFU	-Coli form Forming Units
CN values	-Curve Number (procedure for estimating storm water runoff)
CO	-Conservation Ontario
CWA	-Clean Water Act
DEM	-Digital Elevation Map
DFO	-Department of Fisheries and Oceans
DNAPL	-Dense Non-Aqueous Phase Liquid
DWIS	-Drinking Water Information System
DWSP	-Drinking Water Surveillance Program
EC	-Environment Canada
EIP	-Electronic Intellectual Property
ESRI	-Environmental Systems Research Institute
GW	-Groundwater
GUDI	-Groundwater Under Direct Influence (of surface water)
HCB	-Hexachlorobenzene
HCBD	-Hexabromocyclododecans
HIS	-Hydrologic Information System
HVA	-Highly Vulnerable Aquifer
IPZ	-Intake Protection Zone
ISI	-Intrinsic Susceptibility Index
LaMP	-Lakewide Management Plan
LIO	-Land Information Ontario (warehouse)
LMA	-Local Management Area (used in the NWQPS)
MASL	-Metres above (mean) sea level
MDL	-Method Detection Limit (of laboratory analysis)
MISA	-Municipal Industrial Strategy for Abatement
MOE	-Ontario Ministry of the Environment
MNDM	-Ministry of Northern Development & Mines
MNR	-Ontario Ministry of Natural Resources
MUD	-Municipal Water Use Database
NAI	-Natural Areas Inventory
NEXRAD	-Next Generation Radar
NHIS	-National Heritage Information System
NOTL	-Niagara-on-the-Lake
NPCA	-Niagara Peninsula Conservation Authority
NPSP Authority	- Niagara Peninsula Source Water Protection Authority
NRCAN	-Natural Resources Canada
NRTMP	-Niagara River Toxics Management Plan

NRVIS	-Natural Resources and Values Information Systems
NWAC	-Niagara Water Advisory Committee
NWQPS	-Niagara Water Quality Protection Strategy
NWS	-Niagara Water Strategy
ODWQS	-Ontario Drinking Water Quality Standards (also known as ODWS)
OGSRL	-Ontario Oil Gas and Salt Library
OMAF	-Ontario Ministry of Agriculture and Food
OBM	-Ontario Base Map
OP	-Official Plan
ORM	-Oak Ridges Moraine
PAH	-Polycyclic Aromatic Hydrocarbon
PC	-Parks Canada
PCB	-Polychlorinated Biphenyl
PCN	-Polychlorinated Naphthalenes
PCSI	-Potential Contaminant Source Inventory
PFOA	-Perfluorinated Compounds
PGMN	-Provincial Groundwater Monitoring Network
PTTW	-Permit To Take Water
RAP	-Remedial Action Plan
SDE	-Spatial Database Engine
SOLRIS	-Southern Ontario Land Resource Information System
SP	-Source Protection
SRA	-Significant Recharge Area
STP	-Sewage Treatment Plant
SWIG	-Source Water Implementation Group – Water Budget Team, etc
SWP	-Source Water Protection
TOT	-Time of Travel
VA	-Vulnerable Area
VOC	-Volatile Organic Compound
WHPA	-Wellhead Protection Area
WMIS	-Watershed Mgmt Information System
WMO	-World Meteorological Organization
WPCP	-Water Pollution Control Plant
WRIP	-Water Resources Information Program
WRIS	-Water Resources Information System
WSIC	-Water Strategy Advisory Committee (for NWQPS)
WTP	-Water Treatment Plant

GLOSSARY

GLOSSARY

Aquifer: A geologic formation, a group of formations or a part of a formation that is water bearing. (2) A geologic formation that stores or transmits water or both such as to springs or wells. (3) An underground layer of porous rock, sand, or gravel containing large amounts of water. *(4) Saturated rock or sediment sufficiently permeable to supply economic quantities of water to wells or springs.*

Aquifer Recharge Area: An area in which water can infiltrate the soil and replenish an aquifer relatively easily. Aquifer recharge areas allow precipitation to reach an aquiger by infiltration. Recharge areas are often much smaller than the actual aquifer area and are important to the aquifer.

Aquifer Susceptibility (or Vulnerability): An intrinsic property of a groundwater system that depends on the sensitivity of that system to human and/or natural impacts. Intrinsic vulnerability depends solely on the hydrogeologic properties of an aquifer.

Aquitard: A geologic formation, group of formations or part of a formation through which almost no water moves. (2) *A low-permeability geologic unit that can store groundwater, but that transmits groundwater slowly*.

Artesian water: Groundwater that is under pressure sufficient to raise it above the level at which it is encountered in a borehole or well.

Artesian Well: A well deriving its water from a confined aquifer in which the water level stands above the top of the aquifer. If the water level stands above the groundwater surface it will be a flowing well.

Background Monitoring Well: A monitoring well located up-gradient of the landfill or facility being monitored. Background monitoring wells are located where the groundwater is expected to be representative of the ambient or background conditions for that area and geological formation.

Barometric pressure: Atmospheric pressure measured by a barometer. Changes in atmospheric pressure are capable of inducing changes in water elevation.

Bedding plane: In sedimentary rocks, the planes or surfaces that separate individual layers, beds, or strata that tend to split more or less horizontally or parallel to ground surface.

Bedrock: Solid rock either exposed at the surface of the earth or overlain by unconsolidated material.

Brownfield: Abandoned, idled, or underused industrial or commercial facilities or land, where expansion or redevelopment is complicated by real or perceived environmental contamination.

Cap Rock: The hard upper strata of a rock formation.

Confining unit: A low-permeability material that lies adjacent to an aquifer and confines groundwater within the aquifer. It may lie above or below the aquifer.

Curve Number: The Soil Conservation Service developed a widely used *curve number procedure* for estimating storm water runoff, based on types of land cover and antecedent conditions.

Discharge: The process by which water is removed from a groundwater system along a discharge area, which may include a spring, seepage from an excavation face, or inflow to a stream.

Dolomite: Mineral (limestone rock) consisting of a mixed magnesium and calcium carbonate, but rich in magnesium carbonate that is not easily weathered or dissolved.

Dolostone: A term used for the sedimentary rock dolomite, in order to avid confusion with the mineral of the same name.

Drift: All unconsolidated mineral material on the bedrock.

End Moraine: A moraine that has been deposited at the lower or outer end of a glacier.

Drinking-water health hazard: Has the same meaning as in the *Safe Drinking Water Act, 2002*;

Drinking-water system: Has the same meaning as in the *Safe Drinking Water Act, 2002*;

Drinking-water threat: An existing activity, possible future activity or existing condition that results from a past activity,

> (a) that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water, or
>
> (b) that results in or has the potential to result in the raw water supply of an existing or planned drinking-water system failing to meet any standards prescribed by the regulations respecting the quality or quantity of water,
>
> and includes an activity or condition that is prescribed by the regulations as a drinking water threat;

Ecosystems: Since the late 1960's, governments, non-government groups, universities and industry have worked to develop a common, hierarchical ecosystem framework and terminology. It gained momentum in the 1970's, especially following the creation of the Canada Committee on Ecological Land Classification.

In 1991 a collaborative project was undertaken by a number of federal agencies in cooperation with provincial and territorial governments, all under the auspices of the Ecological Stratification Working Group, to revise previous work and establish a common ecological framework for Canada. The working group focused on three priority levels of stratification, namely ecozones, ecoregions, and ecodistricts.

The underlying principle for the initiative was the commitment and need to think, plan, and act in terms of ecosystems. The principle required people to move away from an emphasis on individual elements that comprise an ecosystem to a perspective that is more comprehensive - a holistic approach. This required an national ecological framework to provide a consistent, national spatial context within which ecosystems at various levels of generalization can be described, monitored, and reported on. The use of such a framework of standard ecological units provides for common communication and reporting between different jurisdictions and disciplines. In this case, the immediate requirement was to provide a common ground to report on the state of the environment and the sustainability of ecosystems in Canada. The concepts and hierarchy for ecological classification set out by the Canada Committee on Ecological Classification in the 1970s and 1980s (Ecological Stratification Working Group 1996, Ironside 1991) were the overall guide for the revised national framework.

The resulting national report "*A National Ecological Framework for Canada*" released by the Ecological Stratification Working Group in 1996 describes the methodology used to construct the ecological framework maps, the concepts of the hierarchical levels of generalization, narrative descriptions of each ecozone and ecoregion, their linkages to various data sources, examples of applications of the framework, and a list of contributors and collaborating agencies.

Ecodistrict: A Ecodistrict is a subdivision of an ecoregion and is characterized by a distinctive assemblages of relief, landforms, geology, soil, vegetation, water bodies and fauna. For example, the Jeddore Lake ecodistrict (no. 473) is one of five within the Maritime Barrens ecoregion.

Ecoregion: An ecoregion is a subdivision of an ecoprovince and is characterized by distinctive regional ecological factors, including climate, physiography, vegetation, soil, water, and fauna. For example, the Maritime Barrens ecoregion (no. 114) is one of nine ecoregions within the Newfoundland ecoprovince.

Ecoprovince: A subdivision of an ecozone characterized by major assemblages of structural or surface forms, faunal realms, and vegetation, hydrology, soil, and macro climate. For example, the Newfoundland ecoprovince (no. 6.4) is one of six ecoprovinces within the Boreal Shield Ecozone.

Environmentally Sensitive Area (ESA): areas include the major marshes throughout the Region, important plant and wildlife habitats, major forested areas and major landforms such as the Niagara Escarpment and the Short Hills which have an important scenic and natural value

Escarpment: A steep-faced linear ridge frequently presented by the abrupt termination of sedimentary rock layers.

Fractures: Breaks in rock occurring at a variety of possible angles due to intense folding or faulting, or in response to glacial unloading or stress release.

Evapotranspiration: The loss of water from a land area through transpiration or plants and evaporation from the soil.

Groundwater: Water that infiltrates the earth's surface. (2) Subsurface water that occurs beneath the water table in soils and geological formations that are fully saturated.

Groundwater divide: The line of separation between groundwater flow systems. It marks the high point of groundwater elevations, with lower groundwater elevations and flow moving away from this divide

Groundwater recharge area: The area where an aquifer is replenished from (a) natural processes, such as the infiltration of rainfall and snowmelt and the seepage of surface water from lakes, streams and wetlands, (b) from human interventions such as the use of storm water management systems, and (c) whose recharge rate exceeds a threashold specified in the regulations. The Director's rules will spcify the acceptable methologies to determine groundwater recharge rates, i.e. what qualifies as significant.

GUDI Well: A drinking water well that extracts/produces Groundwater Under the Direct Influence of surface water. Further details are provided in the MOE Reference document "Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water" dated October 2001.

Headwater: The upstream end or upper tributaries of a stream or river.

Highly vulnerable aquifer: has the meaning prescribed by the regulations.

Hydraulic conductivity: Rate at which a fluid moves through a given permeable material under a hydraulic gradient (driving force) equal to 1.0 (i.e., rise equals run). Ranges of hydraulic conductivity have been determined for various geological materials.

Hydraulic gradient: The slope of an underground water surface expressed as the change in total head (i.e., groundwater surface elevation) with change in distance in a given direction.

Hydraulic head: The pressure exerted by a fluid upon a unit area (surface) due to the height at which the fluid level stands above the surface. Usually expressed as pounds per square inch, sometimes as actual feet of head or fluid column.

Hydrogeology: The study of geological factors relating to the occurrence and movement of underground water and its relationship to surface water and rainfall.

Infiltration: The flow of water downward from the land surface into and through the underlying soil or rock.

Kame: A geologic unit. An irregularly shaped hill or mound, composed chiefly of poorly sorted sands and gravels deposited by a subglacial stream as an alluvial fan or delta.

Karst: Terrain with special landforms (e.g. closed depressions or sinkholes and caves) and drainage characteristics, due to greater solubility of certain rocks (notably carbonate rocks such as limestone, dolomite or magnesite) in natural waters. Derived from the geographical name "krs" from part of the karst terrain in Slovenia.

Lacustrine: Sediments deposited in a lake, consisting of layers of clay, silt, and fine sand.

Limestone: A bedded, fine-textured sedimentary rock consisting chiefly of calcium carbonate.

Justice: A provincial judge or a justice of the peace;

Kriging: A weighted-moving-average interpolation method where the set of weights assigned to samples minimizes the estimation variance, which is computed as a function of the variogram model and locations of the samples relative to each other, and to the point or block being estimated. (EPA, 1991, GEO-EAS 1.2.1 User's Guide).

Major residential development: has the same meaning as in the *Safe Drinking Water Act, 2002*;

Marl: A soft greyish to white, earthy or powdery usually impure calcium carbonate precipitated on the bottoms of present-day fresh lakes and ponds forming deposits that underlie marches, swamps, and bogs that occupy the sites of former glacial lakes.

Moraine: An accumulation of boulders, stones, or other debris carried by a glacier. Moraines are deposits of glacial Till. Lateral moraines are the ridges of Till that mark the sides of the glacier's path. Terminal moraines are the material left behind by the farthest advance of the glacier's toe.

Municipal drinking-water system: has the same meaning as in the *Safe Drinking Water Act, 2002*;

Municipal planning authority: means a municipal planning authority established under section 14.1 of the *Planning Act*;

Natural Hazards Policy: In 1997, the Province of Ontario released the Provincial Policy Statement under the Planning Act, including the Natural Hazards Policies (Section 3.1), formally recognizing the seriousness of flooding and erosion impacts on public safety and property damage as well as protecting the environment. A combination of the three hazards is used to define hazardous lands. The farthest combined landward extent of flooding hazards, erosion hazards and dynamic beach hazards delineates hazardous lands.

> **Flooding hazards** are based on the combined influence of lake levels, shoreline protection works, wave uprush, and other water related hazards;
> **Erosion hazards** are based on the combined influence of stable slope and shoreline protection works, recession and /or an erosion allowance; and
> **Dynamic beach hazards** are based on the combined influence of flooding and a dynamic beach allowance.

Non-Point Source Pollution: Pollution discharged over a wide land area rather than a specific location.

Overburden: Any loose unconsolidated material which has been deposited upon solid rock (i.e. sand or clay).

Permeability: Capacity of a soil or rock to transmit a fluid. Depends upon the size and shape of the pores and their interconnection. It is measured by the rate of fluid movement in the porous medium.

Piezometric surface: A surface that represents the level to which water will rise in a well. The water table is a piezometric surface for an unconfined aquifer.

Point source: A discrete, identifiable point or area from which a discharge of a fluid or other substance occurs, commonly into air or a water body.

Potentiometric Surface: An imaginary surface representing the total head of groundwater in a confined aquifer that is defined by the level to which the water will rise in a well.

Raw water supply: has the same meaning as in the *Safe Drinking Water Act, 2002*;

Recharge: The addition of water to the groundwater system by natural (precipitation and infiltration) or artificial processes. *The process by which water is added to groundwater, which may include the downward infiltration of precipitation or inflow from streams or other surface water bodies.*

Risk assessment: means an assessment of risks prepared in accordance with the regulations and the rules;

Risk management plan: means a plan for reducing a risk prepared in accordance with the regulations and the rules;

Runoff: Rainwater that does not infiltrate the soil but flows across the earth's surface into a body of water. The proportion of runoff varies greatly depending on a number of factors such as the topography, soil conditions, and vegetative cover.

Sedimentary rock: Rock formed by the accumulation of sediments or chemical precipitates (e.g., gypsum) that forms bedding layers.

Shale: A sedimentary rock made up of clay- and silt-sized particles, hardened into rock.

Significant drinking water threat: means a drinking water threat that, according to a risk assessment, poses or has the potential to pose a significant risk;

Source protection area: means a drinking water source protection area established by subsection 4 (1) or by the regulations of the Clean Water Act;

Source protection authority: means a conservation authority or other person or body that, under subsection 4 (2) or section 5, is required to exercise and perform the powers and duties of a drinking water source protection authority under of the Clean Water Act;

Source protection committee: means a drinking water source protection committee established under section 7 of the Clean Water Act;

Source protection plan: means a drinking water source protection plan prepared under of the Clean Water Act;

Source protection region: means a drinking water source protection region established by the regulations of the Clean Water Act;

Source Water: Water in its natural or raw state, prior to being withdrawn into the drinking water system.

Specific Capacity: The rate of discharge of a water well per unit of drawdown, commonly expressed in m^3/day/m. It varies with duration of discharge and is sometimes used as an approximation of potential aquifer yield.

Surface water intake protection zone: has the meaning prescribed by the regulations of the Clean Water Act;

Stratigraphic Unit: Recognizable unit consisting of stratified, mainly sedimentary, rocks grouped for description and mapping over an area

Till: Sediments deposited by the glacial ice sheet, consisting of a mixture of clays, silt, and sand, with cobbles and boulders. Unstratified drift deposited by a glacier, without reworking by meltwater.

Transmissivity: The rate at which water is transmitted through a unit width of an aquifer, under a unit hydraulic gradient.

Tribunal: means the Environmental Review Tribunal;

Unconfined Aquifer: An aquifer not confined from above by low-permeability material, having a water table surface between unsaturated material above and saturated material below.

Vulnerable area: means,

(a) a groundwater recharge area,
(b) a highly vulnerable aquifer,
(c) a surface water intake protection zone, or
(d) a wellhead protection area;

Watershed: An area that is drained by a river and its tributaries.

Water table: The level of groundwater saturation. The water table is often the upper surface of an unconfined aquifer.

Wellhead protection area: The surface and subsurface area surrounding a water well or well field that supplies a municipal residential water system or other designated system through which contaminants are reasonably likely to move so as to eventually reach the water well or well. The wellhead protection areas are described in the Groundwater Vulnerability Analysis Guidance Module.

Wetlands: Land such as a swamp, marsh, bog or fen (not including land that is being used for agricultural purposes, and longer exhibits wetland characteristics) that, (a) is seasonally or permanently covered by shallow water or has the water table close to or at the surface, (b) has hydric soils and vegetation dominated by hydrophobic or water-tolerant plants, and (c) has been further identified, by the Ministry of Natural Resources or by any other person, according to evaluation procedures established by the MNR as amended from time to time.

TABLES

List of Tables - Watershed Characterization Report

NIAGARA PENINSULA CONSERVATION AUTHORITY

Table 2.1
Moraines and Kames in the Niagara Peninsula
SWP Watershed Characterization Report

Moraine Name	Core Sediments of Moraine	Cap Sediments of Moraine	Approx. Dimensions of Moraine
Wainfleet Moraine	Halton till	gravel, sand, and silt	2.5 km long, by 0.5 km wide, and 8 m high
Vinemount Moraine	Halton till	Halton till, clay, silt, and sand	7 km long, by 1 km wide, and up to 15 m high
Niagara Falls Moraine	Halton till	sand, gravel, and silt	8 km long, by 2 km wide, and up to 30 m high
Fort Erie Moraine	Halton till	Halton till, clay and silt	6.5 km long, by 1.5 km wide, and up to 7 m high
Crystal Beach Moraine	Halton till	Halton till	6.5 km long, by 1 km wide, and 8 m high
Fonthill Kame Delta-Complex	Sand and gravel	sand and gravel	3 km diameter and highest point in Niagara Peninsula

References: 1 NWQPS Final Technical Report, Vol 1, Part 2 (Phase 2 Rrprt), Section 3.3.1 Niagara Physiography, pg 3-28 to 33

Extracted from the -> 2 NPCA Groundwater Study, Draft Report, dated May 5, 2005, Table 2.4, pg 2-9

3 Physiography of Southern Ontario, by Chapman & Putman, 1984.

Table 2.2
Paleozoic Bedrock Geology in the Niagara Peninsula
SWP Watershed Characterization Report

Age	Group	Formation	Description	Approx. Thickness
Middle Devonian		Onondaga	Variably cherty limestone. Grey moderately cherty dolostone, some shale	up to 15 m
Lower Devonian		Bois Blanc	Cherty, brown, limestone,minor shale and dolostone, with sandstone interbeds	3 - 4 m
Upper Silurian		Bertie	Brown dolostone. Brown & cream mottled dolostone	10 m
		Salina	Brown dolomite and grey calcareous shale, with gypsum and anhydrite	90 m
Middle Silurian	Amabel Lockport Guelph	Guelph	Tan or brown, crystalline, thickly bedded dolostone	10 - 40 m
		Lockport	Eramosa Member-Dark grey to black, finely crystalline, laminated dolostone, with gypsum filled vugs, and black chert	3 - 10 m
			Goat Island Member -Grey medium grained dolostone, with medium to thick bedded white chert	5 - 8 m
			Gasport Member -Pink medium to fine grained dolostone and limestone	14 m
	Clinton	DeCew	Grey, finely crystalline, thin to medium bedded dolostone. *Crossed bedded in lower part.*	4 m
		Rochester	Dark bluish to brownish grey calcareous shale, with limestone interbeds	14 m
		Irondequoit	Grey to tan, fine to medium crystalline limestone	3 m
		Reynales	Grey blue, thin to massive bedded dolostone	4 - 6 m
		Thorold	Green, thinly bedded sandstone, with shale partings	2 - 3 m
Lower Silurian	Cataract	Grimsby	Red sandstone, some green and yellow mottling. Red shale interbeds primarily in lower portion of the unit.	12 - 16 m
		Cabot Head (Power Glen)	Grey laminated shales with sandstone interbeds, and occasional limestone interbeds	11 m
		Whirlpool	Grey to light brown weathered sandstone, with shale partings	up to 7 m
Upper Ordovician		Queenston	Red shale, occasionally with interbeds of siltstone, sandstone, and limestone.	>100 m

References: 1 NWQPS Final Technical Report, Vol 1, part 2 (Phase 2 Rrprt) Table 3.3.1, pg 3-36
2 NPCA Groundwater Study, Draft Report, dated May 5, 2005, Table 2.5, pg 2-11
3 Physiography of Southern Ontario, by Chapman & Putman, 1984.

Table 2.3
Quaternary Geology in the Niagara Peninsula
SWP Watershed Characterization Report

Age	Glacial Period	Deposit or Event	Lithology / Description	Geomorphology
Recent	Post-Glacial	Eolian	Sand	Coastal dunes, inland dunes
		Allulvium	Clay, silt, sand, gravel, organic matter in older deposits	Flood plains, beach ridges
		Bog and swamp	Muck, peat, and also clay, sand, and silt	Filled depressions
Late Wisconsin	*Two Creeks Interstadial*	Upper Glaciolacustrine	Sand and gravel, silt and clay	Nearshore, offshore, and delta lake plains, and beach ridges including Fonthill Kame Complex
	Port Huron Stadial	Halton Till	Clayey silt to silty clay till	End moraines, recessional moraines, extensively buried
	Mackinaw Interstadial	Lower Glaciolacustrine	Clay, silt, and sand	Buried lake plain
	Port Huron Stadial	Wentworth Till	Gravelly, sandy, silt till	Buried ground moraine and drumlins
	Port Bruce / Nissour Stadial	Port Stanley Till, Catfish Creek Till	Clayey to silty till	Buried till plain
Early/Middle Wisconsin		Lacustrine	Sand	Buried St David's Gorge fill
		Glacial	Gravel and sand	Buried St David's Gorge fill

References: 1 NWQPS Final Technical Report, Vol 1, Part 2 (Phase 2 Rrprt) Table 3.3.2, pg 3-39
2 NPCA Groundwater Study, Draft Report, dated May 5, 2005, Table 2.3, pg 2-8
3 Physiography of Southern Ontario, by Chapman & Putman, 1984.

NIAGARA PENINSULA CONSERVATION AUTHORITY

Table 3.1
Major Wetlands
SWP Watershed Characterization Report

Major Lake Erie Shoreline Wetlands:	**Location**
Erie Beach (Fort Erie)	Fort Erie
Crescent Estates (Fort Erie)	Fort Erie
Wavecrest Bush (Fort Erie)	Fort Erie
Point Abino (For Erie)	Fort Erie
Shisler Point Woods (Port Colborne)	Port Colbourne
Weaver Road Woodlot (Port Colborne)	Port Colbourne
Nickel Beach Woodlot (Port Colborne)	Port Colbourne
Wainfleet Wetlands Conservation Area (Wainfleet)	Wainfleet
Morgan’s Point (Wainfleet)	Wainfleet
Harold Mitchell Nature Reserve (Wainfleet)	Wainfleet
Major Lake Ontario Shoreline Wetlands:	**Location**
Four Mile Creek Estuary (NOTL)	NOTL
Eight Mile Creek Estuary (NOTL)	NOTL
Fifteen Mile Creek Wetland (St. Catharines)	St Catharines
Martindale and Barnesdale Marsh (St. Catharines)	St Catharines
Terrace Valley (Lincoln)	Lincoln
Jordan Harbour Wetland (Lincoln)	Lincoln
Major Inland Wetlands:	**Location**
Humberstone Marsh (Port Colbourne)	Port Colbourne
Willoughby Marsh (Niagara Falls)	Niagara Falls
Lyons Creek North Wetlands	Niagara Falls
Moulton Wetlands	Haldimand County
Empire Beach Wetland	Port Colbourne
Grimsby Escarpment Wetlands	Grimsby
Wainfleet Bog	Wainfleet
Vinemount Swamp (Stoney Creek)	Hamilton

Reference 1: pg 3-92 of the NWQPS Phase 2 Rprt

Reference 2: Regional Niagara Policy Plan, Office Consolidation, Jan 2004, Regional Strategy for Development and Conservation MOE Map, dated 2001

Reference 3: See also Niagara-Hamilton WastePlan Environmental Assessment Study dated Dec 2005.

Table 3.2
Invasive Species
SWP Watershed Characterization Report

Species (Common)	**Species (Scientific)**	**Distribution**	**Effects on Water Quality**
Common carp	*Cyprinus carpio*	• originally from Asia • one of the most widely distributed fish species in North America • currently ranges from coast to coast from central Canada to central Mexico (OFAH (1), 2005)	• spawn in extremely shallow water and marshy areas • thrashes around in the shallow water, with little of its body submersed • this increases the turbidity of the water • destroys/uproots aquatic vegetation (CBW, 2005)
Zebra mussel	*Dreissena polymorpha*	• originally from Aral, Black and Caspian Sea region of Asia • has spread through all the Great Lakes • showing up in inland waterways and lakes throughout North America (OFAH (2), 2005)	• consume plankton at an extraordinary rate • this increases water clarity, allowing more sunlight to penetrate the water column • and in turn, changes weed growth patterns and forces some light sensitive fish (i.e. walleye) to find new habitats • not all of what the mussel consumes is digested- some combines with mucus as "pseudofeces" and is discharged to the lake bottom where it accumulates (OFAH (2), 2005)
Canada goose	*Branta canadensis*	• native to North America • most widely distributed goose in North America (DWF, 2005)	• can overgraze lawns and crops, leading to erosion (more TDS, TSS in water) • build-up of fecal matter can lead to reduced water quality, by fostering bacteria and adding much nitrogen and phosphorus(Lutz, H. and T. Dewey, 2002)
Round goby	*Neogobius melanostomus*	• native to the Black and Caspian Sea regions of Asia (EATM, 1999) • found throughout much of Lake Erie, Lake Huron, Lake Ontario, southern Lake Michigan, and western Lake Superior (OFAH (3), 2005)	• very aggressive, which impacts/out competes native fish • feed on zebra mussels, which have high contaminant levels in their bodies – this could accumulate in the food chain • die-offs associated with botulism type-E from zebra mussels – outbreaks can travel up the food chain (OFAH (3), 2005)

Table 3.2
Invasive Species
SWP Watershed Characterization Report

Species (Common)	Species (Scientific)	Distribution	Effects on Water Quality
Purple loosestrife	*Lythrum salicaria*	• native of Eurasia • found throughout North America, especially Southern Ontario (OFAH(4), 2005)	• chokes out native vegetation by competing more effectively for light, space and nutrients • clogs waterways • deters wildlife from inhabiting that particular area (diminishes area's ecological value) (FFEC, 2003)
Eurasian watermilfoil	*Myriophyllum spicatum*	• native to Europe, Asia and North Africa • currently found in Ontario, Quebec and British Columbia • one of the most widely distributed non-native aquatic plants in North America (OFAH(5), 2005)	• create a dense mat of vegetation that block sunlight for plants below the surface • out compete native vegetation and a monoculture is created • the thick mats can add more phosphorus and nitrogen to the water column • can alter water quality by raising the pH and temperature and decrease dissolved oxygen (OFAH (5), 2005)

Table 4.1
Climate Stations
SWP Watershed Characterization Report

Station ID	Environment Canada Station Name	Latitude	Longitude	Elevation (mASL)	Monitoring Period (Start/End/Years)			Temperature/ Precipitation	Temperature/ Wind/ Humidity/ Pressure	Snow Depth
Current within NPCA SWP Region										
6132470	FORT ERIE	42.88	-78.97	180	1966	2006	40	X		X
6135657	NIAGARA FALLS NPCSH	43.13	-79.05	175	1980	2006	26	X		X
6136606	PORT COLBORNE	42.88	-79.25	175	1964	2006	42	X		X
613F606	PORT COLBORNE (AUT)	42.87	-79.25	184	1994	2006	12		X	
6136699	PORT WELLER (AUT)	43.25	-79.22	79	2003	2006	3		X	
6137161	RIDGEVILLE	43.05	-79.33	236	1950	2006	56	X		
6137287	ST CATHARINES A (AUT)	43.20	-79.17	97.8	1971	2006	35		X	
6137306	ST CATHARINES POWER GLEN	43.12	-79.25	122	1965	2006	41	X		
6139148	VINELAND STATION RCS (AUT)	43.17	-79.40	79	2002	2006	4		X	
6139445	WELLAND	43.00	-79.27	175	1872	2006	134	X		X
6139449	WELLAND - PELHAM (AUT)	42.97	-79.32	178	2005	2006	1		X	
6153194	HAMILTON A (AUT)	43.17	-79.93	238	1959	2006	47		X	
Current within 10 km of NPCA SWP Region										
6150060	ALBERTON	43.18	-80.05		1994	2006	12	X		X
6153301	HAMILTON RBG CS (AUT)	43.28	-79.90		2002	2006	4		X	
Historic (at least 15 years of data) within NPCA SWP Region										
6139145	VINELAND STATION	43.18	-79.39	79	1924	1988	64	X		X
6139143	VINELAND RITTENHOUSE	43.17	-79.42	95	1965	2001	36	X		
6139142	VINELAND BALLS FALLS	43.13	-79.38	145	1974	1994	20	X		X
6137301	ST CATHARINES CDA	43.18	-79.23	99	1928	1964	36	X		X
6137285	ST CATHARINES	43.20	-79.25	91	1882	1995	113	X		X
6136626	PORT DALHOUSIE	43.18	-79.27	91	1874	1996	122	X		X
6136607	PORT COLBORNE LIGHT	42.87	-79.25	175	1966	1984	18	X		
6135660	NIAGARA FALLS ONT HYDRO	43.08	-79.08	198	1921	1972	51	X		
6135638	NIAGARA FALLS	43.13	-79.08	183	1902	1995	93	X		X
6133057	GRIMSBY ROCK CHAPEL	43.18	-79.58	198	1914	1966	52	X		
6133047	GRIMSBY	43.20	-79.57	91	1910	1985	75	X		X
6132435	FONTHILL	43.03	-79.30	236	1945	1969	24	X		
6131165	CANBORO	42.97	-79.58	183	1946	1971	25	X		

Table 4.1
Climate Stations
SWP Watershed Characterization Report

Station ID /CODE	Regional Niagara Station Name	Easting	Northing	Station Name	Monitoring Period (Start/End/Years)			Precipitation	Temperature/ Wind/ Velocity/ Humidity	-
PRE1/3075	Ontario Road SPS - Welland	644719	4759494	SWEL	1991	2006	15	X		
PRE2/3071	Pelham Municipal Offices	639749	4767184	PELH	1991	2006	15	X		
PRE3/3073	Smithville SPS - West Lincoln	618745	4772310	SMIT	1991	2006	15	X		
PRE4/3076	Victoria SPS - Lincoln	630221	4782700	VICT	1991	2006	15	X		
PRE5/3068	Jordan Yard - Lincoln	632726	4778333	JORD	1991	2002	11	X (INACTIVE)		
PRE6/3064	Port Dalhousie WWTP Station #1	641358	4784695	DALHOUS	1991	2006	15	X (INACTIVE)		
PRE7/3066	Garrison Village SPS - NOTL	654236	4790669	GARR	1994	2006	12	X		
PRE8/3074	Niagara Falls WWTP	655818	4776328	STAN	1991	2006	15	X		
PRE9/3063	Niagara Falls WTP	658512	4769579	CHIP	1991	2006	15	X		
PRE10/3065	DeCew Falls WTP - S.Catharines	641304	4774704	DECE	1991	2006	15	X		
PRE11/3069	Kalar Road SPS - Niagara Falls	651672	4774761	KALA	1991	2006	15	X		
PRE12/3067	Industrial Park - Fort Erie	668102	4754329	INDP	1990	2006	16	X		
PRE14/3080	Seaway - Port Colborne	642722	4751903	PORT/SEAW	1991	2006	15	X		
PRE15/3078	Garner Road - Niagara Falls	650930	4767962	GARN	2001	2006	5	X		
PRE16/3077	Welland WWTP	643649	4763214	WELL	1991	2006	15	X		
PRE17	Humberstone Landfill - Welland	640766	4758039	-	2002	2006	4	X		
PRE18/3070	South Side Highlift - Niagara Falls	653276	4769623	MCLE	1991	2006	15	X		
PRE19	Port Dalhousie WWTP Station #2	641242	4784555	PortD	2006	2006	1	X		
PRE20	Reg. Rd 12 Landfill - West Lincoln	616508	4776894	-	2002	2006	4	X		
PRE21/3061	Baker Road WWTP - Grimsby	618969	4783360	BAKE	1990	2006	16	X		
PRE22/3062	Biggar Lagoon - Grimsby	612540	4785483	BIGG	1994	2001	7	X (INACTIVE)		
CLI1/3067	Industrial Park - Fort Erie	668113	4754335	INDP	1990	2006	16		X	
CLI2/3080	Seaway WWTP - Port Colborne	642702	4751864	SEAW	2002	2006	4		X	
CLI3	Humberstone Landfill - Welland	640766	4758013	-	2002	2006	4		X	
CLI4/3077	Welland WWTP - Welland	643699	4763217	WELL	1991	2006	15		X	
CLI5	Reg. Rd 12 Landfill - West Lincoln	616497	4776895	-	2002	2006	4		X	
CLI6/3061	Baker Road WWTP - Grimsby	618992	4783324	BAKE	1990	2006	16		X	
CLI7/3070	South Side Highlift - Niagara Falls	653308	4769625	MCLE	1991	2006	15		X	
CLI8/3078	Garner Road - Niagara Falls	650930	4767947	GARN	2001	2006	5		X	
CLI9	Port Dalhousie WWTP	641246	4784541	PortD	2006	2006	1		X	

Table 4.1
Climate Stations
SWP Watershed Characterization Report

Station ID /CODE	Regional Niagara Station Name	Easting	Northing	Station Name	Monitoring Period (Start/End/Years)			Precipitation	Temperature/ Wind/ Velocity/ Humidity	-
	Crystal Beach WWTP	658689	4747289	-	2006	2006	1	X		
	Lincoln Town Hall	624750	4782821	-	2006	2006	1	X		
	Douglas Town SPS	661300	4759250	DOUG	1996	1997	1	X (INACTIVE)		
	Nigh Rd SPS	658580	4750660	NIGH	1996	1997	1	X (INACTIVE)		
	Lincoln Ontario Street SPS	623670	4783260	ONTA	1996	1997	1	X (INACTIVE)		

Station ID	Ontario Weather Network Station Name	Latitude	Longitude	Elevation (mASL)	Monitoring Period (Start/End/Years)			Wind Speed/ Direction	Precipitation Rate/ Dew Point/ Temperature
NAWN 1	Niagara Parkway	43.23	-79.07	93	1995	2006	11		X
NAWN 2	NOTL Queenston	43.17	-79.06	108	1995	2006	11		X
NAWN 3	NOTL Virgil	43.20	-79.13	93	1995	2006	11	X	X
NAWN 4	Niagara College	43.15	-79.17	120	2000	2006	6		X
NAWN 5	NOTL Virgil - Lakshore	43.25	-79.14	82	1995	2006	11		X
NAWN 6	West St.Catharines	43.12	-79.28	121	1995	2006	11		X
NAWN 7	Jordan Hwy 8	43.14	-79.36	101	1995	2006	11		X
NAWN 8	Jordan Escarpment	43.12	-79.36	163	1995	2006	11		X
NAWN 9	Vineland Cherry Ave.	43.17	-79.42	-	1995	2006	11		X
NAWN 10	Vineland Escarpment	43.15	-79.91	157	1995	2006	11		X
NAWN 11	Beamsville	43.15	-79.47	154	1995	2006	11		X
NAWN 12	Grimsby	-	-	-	1995	2006	11		X
NAWN 13	Winona	43.21	-79.64	90	1995	2006	11	X	X

Table 4.1
Climate Stations
SWP Watershed Characterization Report

Station ID	Station Name	Latitude	Longitude	Elevation (mASL)	Monitoring Period (Start/End/Years)			Wind/ Dew Point	Precipitation	Temp
-	Pelham - St. Catharines	-	-	-	-	-	>10		X	
-	Merriton - St. Catharines	-	-	-	-	-	>10		X	
-	City Hall - St. Catharines	-	-	-	-	-	>10	X	X	X
-	Linwell - St. Catharines	-	-	-	-	-	>10		X	
-	Greenhouse - St. Catharines	-	-	-	-	-	>10		X	
27011	Allanburg (Hwy58) - MOE	43.07	-79.18	-	1981	2006	25	X		X
-	Thorold - MTO	-	-	-	-	-	-	X	X	X
-	Homer Patrol Yard (QEW) - MTO	-	-	-	-	-	-	X	X (Rate)	X

Station ID	Station Name	Latitude	Longitude	Elevation (mASL)	Monitoring Period (Start/End/Years)			Wind/ Dew Point	Precipitation	Temp
-	Beamsville - LUFFT RWIS	-	-	-	-	-	-	X	X	X
-	Mount Hope Airport - Hamilton City	-	-	220	-	-	-	X	X (Rate)	X

Notes: AUT - Environment Canada 1 hour interval data, except ST CATHARINES a which runs from 5am to 9pm daily
Latitude and Longitude from Environment Canada Website Climate Data on-line
Regional Niagara datasets are as paper reports prior to 1992 and data extents do not account for hiatuses
Easting and Northings in North American Datum 1983
mASL - metres above sea level PRE - Precipitation Station CLI - Climate Station

Table 4.2
Surface Water Gauges
SWP Watershed Characterization Report

Station Name	ID	Agency	Record Start	Record End [1]	Record Length (years) [2]	Easting (mNAD83)	Northing (mNAD83)	Type	Comments
LAKE ERIE									
Port Colborne	02HA017	EC	1911	Current	95	642700	4748359	Water Level	Nat-RC
BIG FORKS CREEK									
Wainfleet	02HA026	EC	1989	1993	4	632064	4756410	Flow	Reg-RC
			1996	1998	2			Flow	Reg-RC-U
OSWEGO CREEK									
Canboro	02HA024	EC/MNR/NPCA	1988	2001	13	607752	4760695	Flow	Nat-RC
			2002	Current	4			Flow/Level	Nat-RC
WELLAND RIVER									
Mount Hope	02HA015	EC	Feb-80	Jun-87	7	585550	4780293	Flow	Nat-RC
Binbrook Dam/Lake Niapenco	02HANPCA01	NPCA	1972	Current	34	595545	4772920	Flow/Level	Reg-MD
Binbrook - Trimble Road	02HA021	EC	1988	1993	5	597754	4771787	Water Level	Nat-RC
Southbrook Golf Course	02HANPCA02	NPCA	2005	Current	1	596734	4772207	Level	RC
Caistor Corners	02HA007	EC/MNR/NPCA	Jul-57	1968	11	612615	4764158	Flow	Reg-MC/S
			1969	2001	32			Flow	Reg-RC
			2002	Current	4			Flow/Level	Reg-RC
Wellandport	02HA028	EC	1991	1993	2	623680	4762487	Flow	RC
			1996	1998	2			Flow	RC-U
Welland Canal (Siphon)	02HA025	EC/MNR/NPCA	1989	1993	4	642480	4761594	Water Level	RC
THREE MILE CREEK									
Mount Hope	02HA016	EC	Feb-80	Jun-87	7	588650	4779839	Flow	Nat-RC
TWENTY MILE CREEK									
Smithville	02HA020	EC/MNR/NPCA	1986	2001	20	616651	4774654	Flow	Nat-RC
			2002	Current	4			Flow/Level	Nat-RC
Balls Falls	02HA006	EC/MNR/NPCA	1957	1966	9	631494	4776905	Flow	Nat-MC
			1967	2001	34			Flow	Nat-RC
			2002	Current	4			Flow/Level	Nat-RC
TWELVE MILE CREEK									
St.Johns Branch	02HANPCA04	NPCA	2004	Current	2	639802	4771002	Level	Nat-RC
Effingham Branch	02HANPCA03	NPCA	2004	Current	2	638305	4771189	Level	Nat-RC
Power Glen	02HA031	EC	2005	Current	1	640353	4775026	Level	-
WALKERS CREEK									
St. Catharines	02HA027	(EC)/NPCA	Jan-91	Apr-95	4	643901	4786307	Flow	Nat-RC
WELLAND CANAL									
Port Colborne	02HA019	EC	1860	Current	146	645476	4756805	Flow	Reg-MC
FOUR MILE CREEK									
Virgil	02HA030	EC/NPCA	2005	Current	1	653285	4784271	Level	RC
LAKE ONTARIO									
Port Weller	02HA018	EC	1929	Current	77	644555	4788660	Water Level	Nat-RC
BLACK CREEK									
Stevensville	02HA029	EC	1991	1993	2	659720	4756567	Flow	Nat-RC
		NPCA	2006	Current	<1			Level	
NIAGARA RIVER									
Below IBM 35	02HA012	EC	1969	1984	15	670212	4752282	Water Level	Reg-RS-U
Above Peace Bridge	02HA011	EC	1967	1977	10	670659	4752540	Water Level	Reg-RC-U
Below Peace Bridge	02HA008	EC	1967	1973	6	670701	4753130	Water Level	Reg-RS-U
			1974	1985	11				Reg-RC-U
			1999	Current	7				Reg-RC
Fort Erie Pumphouse	02HA009	EC	1967	1973	6	670262	4754814	Water Level	Reg-RC-U
			1974	1975	2				Reg-RS-U
Fort Erie Customs Dock	02HA013	EC	1971	1972	2	670208	4755183	Water Level	Reg-RS-U
			1973	1985	12				Reg-RC-U
Bayer's Creek	02HA010	EC	1967	1971	4	660551	4763685	Water Level	Reg-RS-U
Queenston	02HA003	EC	1860	Current	146	658764	4780094	Flow	Reg-PC

Notes:
EC - Environment Canada, MNR - Ministry of Natural Resources, NPCA - Niagara Peninsula Conservation Authority
Nat - Natural Flow, Reg - Regulated Flow, R - Recording Gauge, M - Manual Gauge, C - Continuous Operation, S - Seasonal Operation, P - Power Plant
D - Daily, U - Unpublished
1 - Current implies data collection to end of 2006
2 - Minor data interruptions may not be captured in this summary
NAD83 - North American Datum 1983

<u>Addition stations exist, preliminary information is listed below:</u>
St. Lawrence Seaway Management Corporation operates two water level stations on the Welland Canal
Ontario Power Generation measures flows coming from the Decew Falls Power Generating Station
The City of St.Catharines also measures water level at the Martindale Pond and flows at the Heywood Power Generating Station

Table 4.3
Bedrock Hydraulic Conductivities
SWP Watershed Characterization Report

Bedrock Group	Formation	Description	Groundwater Sources / Comments (R2)	Hydraulic Conductivities (R1)	# of Tests ** (R1)
	Onondaga	Variably cherty limestone. Grey moderately cherty dolostone, some shale	Too little information available	No data	0
	Bois Blanc	Cherty, brown, limestone,minor shale and dolostone, with sandstone interbeds	High water-yielding capacity	6x10-7 to 1x10-6 *	3
	Bertie	Brown dolostone. Brown & cream mottled dolostone	Assumed high water-yielding capacity	9x10-8 to 2x10-7 *	18
	Salina	Brown dolomite and grey calcareous shale, with gypsum and anhydrite	High permeability and good water-yielding capacity	1x10-5 to 6x10-4 *	2
Amabel Lockport Guelph	Guelph	Tan or brown, crystalline, thickly bedded dolostone	The Lockport and Guelph formations exhibit highly variable permeability. Most of the fractures and dissolution are in the upper 3 m, which contributes to the higher hydraulic conductivity values in this portion of the formation. Good water-yielding capacity in all three formations.	3x10-11 to 1x10-5 *	45
	Lockport	Eramosa Member-Dark grey to black, finely crystalline, laminated dolostone, with gypsum filled vugs, and black chert		5x10-9 to 4x10-3 *	52
		Goat Island Member -Grey medium grained dolostone, with medium to thick bedded white chert			
		Gasport Member -Pink medium to fine grained dolostone and limestone			
Clinton	DeCew	Grey, finely crystalline, thin to medium bedded dolostone. *Crossed bedded in lower part.*	Limited use as groundwater source, and primarily by domestis wells.	4x10-11 to 1x10-5 DeCew & Irondequoit Formations (R1 & R3)	88
	Rochester	Dark bluish to brownish grey calcareous shale, with limestone interbeds	Low Permeability	1x10-7 to 1x10-9 (R3)	
	Irondequoit	Grey to tan, fine to medium crystalline limestone	Not a significant source for groundwater	see DeCew Formation	
	Reynales	Grey blue, thin to massive bedded dolostone	Not a significant source for groundwater	No data	
	Thorold	Green, thinly bedded sandstone, with shale partings	Not a significant source for groundwater	No data	
Cataract	Grimsby	Red sandstone, some green and yellow mottling. Red shale interbeds primarily in lower portion of the unit.	Not a significant source for groundwater	7x10-12 to 2x10-7 but higer values for Whilpool Formation	31
	Cabot Head (Power Glen)	Grey laminated shales with sandstone interbeds, and occasional limestone interbeds	Not a significant source for groundwater		
	Whirlpool	Grey to light brown weathered sandstone, with shale partings	Not a significant source for groundwater		
	Queenston	Red shale, occasionally with interbeds of siltstone, sandstone, and limestone.	Not a significant source for groundwater	6x10-12 to 1x10-8	31

References:

R1 Niagara River (Ontario) Area of Concern, Environmental Conditions and Problem Definition, Remedial Action Plan Stage 1, September 1993, by MOE, Environment Canada, MNR, and Fisheries and Oceans Canada, pg2-13, Table 2.2. Data sources used by the report included MOE, Env Cda, and Ont Hydro.

R2 The Hydrogeology of Southern Ontario, Second Edition, by MOE, dated 2003

R3 Detailed Hydrogeologic Study, Vineland Quarries Expansion, pg 17, prepared for Vineland Quarries and Crushed Stone, Limited, by Jagger Hims Limited, dated July 1999

Notes:

* Weathered upper portions of the bedrock is generally more permeable that the deeper rock.

** Hydraulic conductivities based on slug tests, constant head tests, and pump tests.

Table 4.4
Soil Hydraulic Conductivities
SWP Watershed Characterization Report
Quaternary Geology in the Niagara Peninsula

Soil Type	Description	Hydraulic Conductivities (R1)	Groundwater Sources / Comments (R2)	# of Tests ** (R1)
Near Surface Coarse-Textured Soils				
Gravel		1x10-5	Overburden aquifer	1
Sand	St David's Gorge	2x10-5 to 2x10-4	Overburden aquifer	2
Upper Glaciolacustrine Soils				
Silt	Higher values from sandier materials	2x10-9 to 3x10-6	Overburden aquitard	11
Silty Clay		2x10-10 to 7x10-7	Overburden aquitard	10
Clay (weathered)		2x10-9 to 7x10-7		37
Clay (unweathered)		5x10-11 to 1x10-9		57
Silt Till	Halton Till	1x10-10 to 7x10-5		40

References:

R1: Niagara River (Ontario) Area of Concern, Environmental Conditions and Problem Definition, Remedial Action Plan Stage 1, September 1993, by MOE, Environment Canada, MNR, and Fisheries and Oceans Canada, pg2-13, Table 2.2. Data sources used by the report included MOE, Env Cda, and Ont Hydro.

R2: The Hydrogeology of Southern Ontario, Second Edition, by MOE, dated 2003

R3: Detailed Hydrogeologic Study, Vineland Quarries Expansion, pg 17, prepared for Vineland Quarries and Crushed Stone, Limited, by Jagger Hims Limited, dated July 1999

Notes:

***** Weathered upper portions of the bedrock is generally more permeable that the deeper rock.

****** Hydraulic conductivities based on slug tests, constant head tests, and pump tests.

Table 5.1
Current Populations and Densities by Municipality
SWP Watershed Characterization Report

Tier I Municipality	Tier II Municipality	Area (sq.km)	2001 Population *	2001 Density * Persons/sqkm
Regional Municipality of Niagara	Town of Grimsby	68.1	21,297	313
	Town of Lincoln	163.4	20,612	126
	City of St. Catharines	94.4	129,170	1368
	City of Thorold	84.5	18,048	214
	Town of N-O-T-L	131.1	13,839	106
	City of Niagara Falls	212.0	78,815	372
	Town of Fort Erie	168.3	28,143	167
	City of Welland	81.2	48,402	596
	Town of Pelham	124.5	15,272	123
	City of Port Colbourne	122.8	18,450	150
	Township of Wainfleet	217.4	6,258	29
	Township of West Lincoln	382.9	12,268	32
	Regional Niagara Total	1,851	410,574	222
City of Hamilton **	Total	238	19,422	82
Haldimand County ***	Total	310.8	5,625	18
NPCA SWP Region Totals		**2,399**	**435,621**	**181**

* Based on 2001 Census Canada results
** Population estimate provided by City of Hamilton and is based on their GRIDS traffic zone population model for 2001.
** Estimate of the City of Hamilton area located within NPCA was referenced from the GRIDS data provided by City of Hamilton .
*** the 2001 Haldimand County population residing in NPCA was referenced from information provided in a July 14, 2005 email from Haldimand County staff.
Estimated population for 2006 in NPCA is approximately 465,000.
Estimated population of Niagara Region in 2006 is 434,374 according to
Niagara Economic and Development Corporation forecasts using Census Canada 2001 data.

Table 5.2
Projected Populations and Densities by Municipality
SWP Watershed Characterization Report

Tier I Municipality	Tier II Municipality	Area (sq.km)	Projected 2026 Population	Projected 2026 Density	% Population Change from 2001
Regional Municipality of Niagara	Town of Grimsby	68.1	24,669	362	16%
	Town of Lincoln	163.4	29,027	178	41%
	City of St. Catharines	94.4	136,624	1447	6%
	City of Thorold	84.5	26,740	316	48%
	Town of N-O-T-L	131.1	22,407	171	62%
	City of Niagara Falls	212	97,884	462	24%
	Town of Fort Erie	168.3	37,984	226	35%
	City of Welland	81.2	59,780	736	24%
	Town of Pelham	124.5	19,897	160	30%
	City of Port Colbourne	122.8	21,314	174	16%
	Township of Wainfleet	217.4	7,596	35	21%
	Township of West Lincoln	382.9	15,652	41	28%
	Regional Niagara Total	1,851	499,574	270	22%
City of Hamilton *	Total	238	54,103	227	179%
Haldimand County	Total	311	6,270	20	11%
NPCA SWP Region Totals		**2,399**	**559,947**	**233**	**29%**

Notes:

* City of Hamilton population projections were referenced from the GRIDS traffic zone model. Urban expansion area projections that were not within the NPCA jurisdiction were removed by City of Hamilton in their population forecasts.

* Estimate of the City of Hamilton area located within NPCA was referenced from the GRIDS data provided by City of Hamilton .

Table 5.3
Urban Versus Rural Populations in the SWP Authority
SWP Watershed Characterization Report

Tier I Municipality	Tier II Municipality	Urban Population	Non-Urban Population	Total Population
Regional Municipality of Niagara	St. Catharines	127022	2148	129170
	Niagara Falls	76166	2649	78815
	Fort Erie	23806	4337	28143
	Grimsby	17429	3868	21297
	Niagara-on-the-Lake	7882	5957	13839
	Welland	46462	1940	48402
	Thorold	17001	1047	18048
	Lincoln	12717	7895	20612
	West Lincoln	3679	8589	12268
	Port Colborne	15566	2884	18450
	Pelham	10873	4399	15272
	Wainfleet	0	6258	6258
	Total	**358603**	**51971**	**410574**
City of Hamilton				
		11653	**7769**	**19422**
Haldimand County				
		0	**5625**	**5625**
NPCA SWP Region Totals		**370256**	**65365**	**435621**
% of Total		**85%**	**15%**	**100%**

References:
Regional Niagara municipality data referenced from Table 4.1 on pg 4-2,
of NPCA Groundwater Study, May 2005 Draft report.
City of Hamilton data provided from City of Hamilton GRIDS

Table 5.4
Urban Areas
SWP Watershed Characterization Report

Tier I Municipality	Tier II Municipality	Urban Area (Hectares)	Total Area (Hectares)	Urban Area as a % of Total Area
Regional Municipality of Niagara	Town of Grimsby	1257	6885	18%
	Town of Lincoln	968	16544	6%
	City of St. Catharines	6349	10029	63%
	City of Thorold	2525	8853	29%
	Town of N-O-T-L	1389	13452	10%
	City of Niagara Falls	8206	21296	39%
	Town of Fort Erie	4078	16714	24%
	City of Welland	4646	8522	55%
	Town of Pelham	1028	12707	8%
	City of Port Colbourne	2712	12390	22%
	Township of Wainfleet	0	21905	0%
	Township of West Lincoln	513	38886	1%
	Regional Niagara Total	33671	188183	18%
City of Hamilton	Total	1630	23010	7%
Haldimand County	Total	0	29530	0%
NPCA SWP Region Totals		**35,301**	**240,723**	**15%**

Reference:
NWQPS Phase 2 Report, Section 2.2 Population Growth and Urban Area Boundaries, Table 2.3, pg 2-7.

NIAGARA PENINSULA CONSERVATION AUTHORITY

Table 5.5
Sewage Systems Approvals and Inventories
SWP Watershed Characterization Report

Regional Municipality	Area Municipality	Sewage System Approvals Agency	Digital Database	Comments
Regional Niagara	West Lincoln	West Lincoln	No	
Regional Niagara	Welland	Welland	Yes	Digital database since 2003
Regional Niagara	Fort Erie	Fort Erie	Yes	Digital database since 2000
Regional Niagara	Grimsby	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	Lincoln	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	Wainfleet	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	Pelham	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	St.Catharines	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	Thorold	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	Port Colborne	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	Niagara-on-the-Lake	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
Regional Niagara	Niagara Falls	Niagara Region Public Health Department	Yes	Digital database since 1992 to 1994
City of Hamilton	City of Hamilton	Building and Licensing Division	No	Approvals stored as microfiche at central location
Haldimand County	Haldimand County	Building Department	No	County took over approvals from Health Unit in 2004

Notes: Sewage systems having a design capacity of 10,000 litres per day or less

Table 5.6
Water Treatment Plants
SWP Watershed Characterization Report

	WTP Name	Source Water	Capacity ML/D	Ave. Daily Flows ML/D	Ave Daily Flows as % of Capacity	Areas Serviced	Approximate Population Serviced
1	Grimsby WTP	Lake Ontario	44.0	15.3	35%	Grimsby, Smithville, Beamsville	23,788
2	DeCew Falls, St Catharines-Thorold WTP	Lake Erie via Welland Canal and Lake Gibson	227.3	84.5	37%	St Catharines, Thorold, Vineland, Jordan, NOTL	158,264
3	Niagara Falls WTP	Niagara River via Welland River canal	145.5	46.9	32%	Niagara Falls	76,166
4	Rosehill, Fort Erie WTP	Lake Erie	50.0	14.0	28%	Fort Erie, Crystal Beach	23,806
5	Welland WTP	Lake Erie via Welland Canal and Old Welland Canal	109.1	32.7	30%	Welland, Fonthill,	57,335
6	Port Colborne WTP	Lake Erie via Welland Canal	36.4	10.5	29%	Port Colbourne	15,566
	Totals		**612.3**	**203.9**			**354,925**

ML/D = Million Litres/day
WTP Capacity and Ave Daily Flows referenced from Niagara Region IPZ grant application.

Table 5.7
Rural Domestic Groundwater Use by Drainage Basin
SWP Watershed Characterization Report

	Name of Drainage Basin	Area of Drainage Basin sq. km.	Estimated Rural Population	Estimated Rural Groundwater Use cu. m. /day
1	Lake Ontario	961	33,238	5,817
2	Niagara River	1,304	29,738	5,204
3	Lake Erie	155	4,221	739
	Total	**2,420**	**67,197**	**11,760**

cu.m./day = cubic metres per day
Reference: NPCA Groundwater Study, Draft Report, dated November 2004, Table 4.4, pg 4-4

Table 5.8
Analysis of Groundwater Uses
SWP Watershed Characterization Report

Drainage Basin	Rural Domestic Use 1000 cu.m./year	Large PTTW Users 1000 cu.m./year	Small PTTW Users 1000 cu.m./year	Agricultural Uses 1000 cu.m./year	Total 1000 cu.m./year
Lake Ontario	2,123	32,526	236	1,336	36,221
Niagara River	1,900	11,918	261	369	14,447
Lake Erie	270	4,741	78	17	5,106
Total	**4,293**	**49,185**	**575**	**1,722**	**55,774**
% of Total	**8%**	**88%**	**1%**	**3%**	**100%**

cu.m./day = cubic metres per day
Reference: NPCA Groundwater Study, Draft Report, dated November 2004, Table 4.13, pg 4-11
Note: Agricultural yearly uses are adjusted from the daily rates to account for a growing season of 120 days.

Table 5.9
Stormwater Management Policies
SWP Watershed Characterization Report

Municipality	Stormwater Policies/documents	Agency Performing the Review	Comments
Regional Niagara	MOE's Stormwater Management Practices Planning and Design Manual (2003)	NPCA under agreement with Niagara Region	A new document is being prepared for NPCA to consolidate the various Tier 2 municipal storm water policies.
City of Hamilton	1) Storm Drainage Criteria and Guidelines for Stormwater Infrastructure 2) Storm Drainage Policy for Land Development and Redevelopment Infrastructure	City of Hamilton	....recent master drainage plans/subwatershed plan techniques have evolved to address both traditional flooding and drainage issues and broader issues involving pollution control, habitat protection and enhancement, soil erosion, groundwater protection and the identification and preservation of ecologically sensitive landscapes....
Haldimand County	Design Criteria document (revision 2.0 June 2005)	Haldimand County, NPCA	All new development shall be subject to storm water management practices adequate to control storm water run-off in an efficient and environmentally sound manner and where required, storm water management facilities shall be provided ……
Town of Grimsby			
Town of Lincoln	Part 3 Neighbourhood Plans		"…a storm water review will be necessary to determine the method of storm water servicing…incorporate alternative stormwater management design standards into subdivision design, particulary passive stormwater management techniques…All new development shall utilize modern stormwater management techniques to control the quantity and quality of run-off…
City of St. Catharines	OP art 3 Section 12.3.4.2 Development Policy, Servicing, Sewage Disposal	City of St Catharines, NPCA, & Niagara Health Services Department	stormwater and drainage plans must be to satisfaction of review agencies named.

Table 5.9
Stormwater Management Policies
SWP Watershed Characterization Report

Municipality	Stormwater Policies/documents	Agency Performing the Review	Comments
City of Thorold	Section 7.2.5.1 Implmentation, North-east Planning District Secondary Plan Policies, Land Use Related Policies	Reg Niagara Public Health, MOE, MTO,	Approval of stormwater management facilities.
Town of N-O-T-L			
City of Niagara Falls			
Town of Fort Erie	OP Section 10(4) Servicing Policies, Stormwater Management	NPCA, Reg Niagara, MNR	Appropriate storm sewer facilities will be installed and maintained to serve the developed areas, with due regard to the need to protect creek and river areas and adjacent land uses from any possible destructive effects of storm water runoff
City of Welland			
Town of Pelham	Section 1 Land Use, Policies	Regional Planning Department and Niagara Peninsula Conservation Authority	Requires submission of a stormwater management plan which conforms with the Subwatershed Study. The stormwater management plan shall include measures to ensure that all construction sites introduce, directly or indirectly, a minimum of silt and debris to natural watercourses.
City of Port Colbourne	1) OP Section 3.3 Stormwater Mgmt. 2) MOE/MNR Interim Stormwater Quality Control Guidelines for New Development 3) MOE Stormwater Quality Best Management Practices	City of Port Colborne, MOE, MNR, NPCA, Niagara Health Services Department	Storm water management techniques will be employed in all new development to ensure maximum flood protection during periods of high run-off, to control the quantity and quality of run-off and in order to minimize effects on receiving watercourses, groundwater takings or on water supply and sewage disposal systems
Township of Wainfleet	OP Section 6.2.(i) Policies, New Development.		Best management practices and stormwater management techniques will be implemented in accordance with applicable Provincial policies and guidelines. For large-scale development, subwatershed plans should be prepared

Table 5.9
Stormwater Management Policies
SWP Watershed Characterization Report

Municipality	Stormwater Policies/documents	Agency Performing the Review	Comments
Township of West Lincoln	OP Section 10.16 Development Policies, Water Resources Ground and Surface Water		See Township of Wainfleet comments.

OP = (Municipal) Official Plan
MOE = Ontario Ministry of the Environment
MNR = Ontario Ministry of Natural Resources

Table 6.1
Summary of Water Quality Monitoring Programs
SWP Watershed Characterization Report

WQ Program/Name	Program Funded by	Agency Responsible	Purpose of Program	Major Categories of Parameters	# of Monitoring Stations
Drinking Water Information System **DWIS**	Water Treatment Plant owners for residential systems	Water Treatment Plant Owners	Mandated program under Regulation 170/03 (Drinking Water Systems) under the Safe Drinking Water Act 2002.	Microbologic, organic, and inorganic.	6 municipal
Drinking Water Surveillance Program **DWSP**	MOE	MOE in cooperation with municipalities	Gather scientific data on drinking water quality in Ontario	Organic, inorganic and physical. Laboratory analyses are provided by the MOE and the Ministry of Labour	6 municipal
Provincial Water Quality Monitoring Network **PWQMN**	Operated as partnership between MOE and NPCA	NPCA	Collect ambient surface water quality data in Ontario streams and rivers.	Metals, nutrients, ions, solids (total, suspended, dissolved), and general chemistry	6
Provincial Water Quality Monitoring Network **PWQMN**	Operated as partnership between MOE and the City of St. Catharines	City of St.Catharines	Collect ambient surface water quality data in Ontario streams and rivers.	Metals, nutrients, ions, solids (total, suspended, dissolved), BOD, microbiology, pesticides, phenolics, VOCs, PCBs, PAHs, general chemistry	6
Provincial Groundwater Monitoring Network **PGWMN**	Operated as partnership between MOE and NPCA	NPCA	To collect ambient groundwater quantity and quality data in areas of interest across Ontario.	Metals, nutrients, ions, and general chemistry	15
NPCA Water Quality Monitoring Network **General WQ**	NPCA, City of Hamilton, Region of Niagara	NPCA	Collect ambient surface water quality data in NPCA watersheds using chemical and biological indicators.	Metals, nutrients, ions, solids (total, suspended, dissolved), microbiology, benthic invertebrates, and general chemistry	50+
Ontario Benthos Biomonitoring Network	Operated as partnership between MOE and NPCA	NPCA	Assess water quality in Ontario streams, lakes and wetlands using benthic invertebrates as indicators.	Benthic invertebrates and general chemistry	1
Biomonitoring for Glanbrook Landfill	City of Hamilton	NPCA	Assess water quality in Buckhorn Creek and the Welland River in the vicinity of the Glanbrook Landfill using benthic invertebrates as indicators.	Benthic invertebrates and general chemistry	8
Biomonitoring for Hamilton International Airport	Hamilton International Airport	NPCA	Assess water quality in the upper Welland River in the vicinity of Hamilton International Airport using benthic invertebrates as indicators.	Benthic invertebrates and general chemistry	3
Niagara River Toxics Mgmt Plan **NRTMP**	Environment Canada		Great Lakes Water Quality improvement initiative	Organics and inorganics	
Beach Monitoring	Regional Niagara	Regional Niagara Public Health Department	Public Safety of swimmers, beach bathers	Microbologic, (i.e. E.coli)	22 beach locations
Private Water Well Water Quality Monitoring	Regional Niagara	Regional Niagara Public Health Department	Potability of private water supplies (microbiology only)	Microbologic, (i.e. E.coli, total coliforms)	
MOE Near Shore Intake Monitoring Program	Ministry of the Environment	MOE in cooperation with municipalities	Health of Great Lakes with respect to eutrophication	Conductivity, chloride, reactive silicate, total phosphorus, phosphate, total Kjeldahl nitrogen, ammonia+ammonium, nitrite, nitrite+ntirate, chlorophyll a & b, chlorophyll a corrected or acidified, dissolved inorganic and organic carbon	2 - Grimsby and Rosehill (Fort Erie)

Table 6.2
Niagara River AOC Tributary Monitoring Program
SWP Watershed Characterization Report

Station ID	Watershed	Location	Rationale
DR001	Draper's Creek	Site located near the outlet on Colbeck Dr.	Restoration project at this site'
CO001	Coyle Creek	Site located near the outlet on South Pelham Rd.	Historic 1994/96 station
BV001	Beaver Creek	Site located near the outlet at Canborough Rd.	Historic 1994/96 station
MI001	Mill Creek	Site located near the outlet on Smithville Rd.	Large tributary of the Welland River
OS002	Oswego Creek	Site located at Canborough Weir	Historic 1994/96 station
WR006	Welland River	Site located at Port Davidson Weir	Historic 1994/96 station
FR001	Frenchman's Creek	Site located on Pettit Rd. upstream of Fort Erie	Limited data available for this watershed
EL001	Elsie Creek	Site located near the outlet on Regional Road 9	Restoration project at this site
US001	Usshers Creek	Site located near the outlet on Weaver Rd.	Limited data available for this watershed
BL001	Black Creek	Site located upstream of Stevensville	Limited data available for this watershed

References: Information provided by NPCA Technical staff.

NIAGARA PENINSULA CONSERVATION AUTHORITY

Table 6.3
MOE Provincial Water Quality Monitoring Network
SWP Watershed Characterization Report

Station ID	Watershed	Location	Rationale
TW006	Twelve Mile Creek	Effingham headwater tributary on Roland Road	Priority coldwater watershed as identified by NPCA
TW005	Twelve Mile Creek	St. John's headwater tributary on Roland Road	Priority coldwater watershed as identified by NPCA
FU004	Four Mile Creek	Outlet at Lakeshore Road	Priority watershed as identified by MOE and NPCA
TN006	Twenty Mile Creek	Outlet at 21st Street	Priority watershed as identified by NPCA Historic PWQMN station
WR007	Welland River	O'Reilly's Bridge on River Road	Historic 1994/96 station
WR010	Welland River	Welland Canal aqueduct on Biggar Road	Historic 1994/96 station

References: Information provided by NPCA Technical staff.

Table 6.4:
Water Quality Monitoring Stations - in Partnership with the City of Hamilton
SWP Watershed Characterization Report

Station ID	Watershed	Location	Rationale
WR000*	Welland River	Headwater tributary of the Welland River at Butter Road	Biomonitoring station since 1998
WR001	Welland River	West headwater tributary of the Welland River at Airport Road	Biomonitoring station since 1998
WR002	Welland River	East headwater tributary of the Welland River at Airport Road	Biomonitoring station since 1998
WR003	Welland River	Tyneside Road	Niagara River AOC tributary
WR004	Welland River	Hall Road	Historic 1994/96 station
BU000*	Buckhorn Creek	Highway 56	Biomonitoring station since 1996
BU001	Buckhorn Creek	Haldibrook Road	Biomonitoring station since 2002
BU002	Buckhorn Creek	Haldibrook Road	Future restoration project site Biomonitoring station since 2002
TN001	Twenty Mile Creek	Twenty Road at Highway 6	Priority watershed as identified by NPCA
TN002	Twenty Mile Creek	White Church Road	Priority watershed as identified by NPCA
TN003	Twenty Mile Creek	Woodburn Road	Priority watershed as identified by NPCA

***Monitoring stations established in 2004**

References: Information provided by NPCA Technical staff.

Table 6.5
Water Quality Monitoring Stations - in Partnership with Regional Niagara
SWP Watershed Characterization Report

Station ID	Watershed	Location	Rationale
FR003	Frenchman's Creek	Near outlet on Phipps Street	Limited data available
BL003	Black Creek	Near the outlet at Switch Road	Limited data available
LY003	Lyons Creek	Near the outlet at Stanley Avenue	Limited data available
FM001	Forty Mile Creek	Near the outlet at Olive Street	Limited data available
OS001	Oswego Creek	Near the outlet on Diltz Road	Historic 1994/96 station
WR005	Welland River	Abingdon Road	Historic 1994/96 station Upstream of flow reversal effects
FF001	Fifteen Mile Creek	Near the outlet on Fourth Avenue	Limited data available
TM001	Two Mile Creek	Near the outlet on Lakeshore Road	Limited data available
BF001	Big Forks Creek	Near the outlet on Regional Road 24	Historic 1994/96 station
TN004	Twenty Mile Creek	Snyder Road	Priority watershed as identified by NPCA
SP001*	Spring Creek	Tintern Road	Tributary of Twenty Mile Creek
NC001*	North Creek	Patterson Road	Tributary of Twenty Mile Creek
GV001*	Gavora Ditch	Bethesda Road	Tributary of Twenty Mile Creek

*Monitoring stations established in 2004

References: Information provided by NPCA Technical staff.

Table 8.1
Potential Contaminant Source Inventory Data from NPCA Groundwater Study
SWP Watershed Characterization Report

Potential Source	Number of Records		
	Located	Not Located	Total
Fuel Storage Sites	415	110	525
PCB Storage Sites	59	28	87
Contaminant Spill Sites	2,742	686	3,428
Hazardous Waste Receiving Sites	1,195	335	1,530
Hazardous Waste Receiving Sites	47	28	75
Active Landfill sites	21	0	21
Closed Landfill Sites	91	0	91
Waste Sites	11	0	11
Biosolids Locations (Region of	365	0	365
Cemeteries	205	0	205
Automotive/Machinery Sites	50	0	50
Lumber Yards	15	0	15
Pipelines (main)	2	0	2
Golf Courses	49	0	49
Large Sub-Surface Sewage Systems	50	0	50
Salt Storage Domes	17	0	17
Sand and Gravel Pits	34	0	34
Quarries	53	0	53
Total	5,421	1,187	6,608

Table 8.2
Municipal/Industrial Strategy for Abatement (MISA) Facilities Located in or adjacent NPSWP Authority
SWP Watershed Characterization Report

PLANT	CURRENT PLANT NAME	LOCATION
INORGANIC CHEMICALS		
Cytec Canada Inc.		Niagara Falls
Norton Advanced Ceramics of Canada	St. Gobain Ceramic Materials Canada Inc.	Niagara Falls
Washington Mills Electro Minerals		Niagara Falls
IRON AND STEEL		
Dofasco		Hamilton
Stelco Hilton Works		Hamilton
METAL MINING		
Inco Limited - Port Colborne		Port Colborne
ORGANIC CHEMICAL		
Geon Canada Inc.	OxyVinyls Canada Inc.	Thorold
PULP AND PAPER		
Beaver Wood Fibre Company Ltd.	Georgia-Pacific Canada Inc.	Thorold
Kimberly-Clark Canada Inc.	Interlake Acquisition Corporation Inc.	St. Catharines
QUNO Inc.	Abitibi-Consolidated, Thorold Division	Thorold

Table 8.3
Municipal Waste Water Treatment Plants (WWTPs)
SWP Watershed Characterization Report

MUNICIPALITY	PLANT NAME	DETAILS	DISCHARGES TO:
Town of Port Colborne	Seaway WPCP	Receives flows from both the west and east sides of the canal.	Welland Canal
Town of Fort Erie	Anger Avenue WPCP	Currently services the east and southeast part of the Town of Fort Erie.	Niagara River.
	Crystal Beach WPCP	Currently services the communities of Crystal Beach, Ridgeway and Wavecrest in the Town of Fort Erie.	Lake Erie
Town of Niagara-on-the-Lake (NOTL)	NOTL WWTP (and Lagoon System)	Currently services Niagara-on-the-Lake and Virgil.	Lake Ontario
	Queenston WPCP	Currently services Queenston.	Niagara River.
City of Niagara Falls	Stevensville/ Douglastown Lagoon	Currently services Stevensville, Douglastown and a commercial area, discharge is to the Niagara River.	Niagara River.
	Niagara Falls WPCP	Currently services Niagara Falls, discharge is to the Chippawa Power Canal followed by flow to the Niagara River. However during most 2001 rainfall/snow melt events, the hydraulic capacity of the plant was exceeded resulting of bypassing of raw sewage. During year 2001, plant bypassing occurred on 28 occasions, totalling 314.132 megalitres.	Chippawa Power Canal
City of St. Catharines	Port Dalhousie WPCP	Services St. Catharines and portion of Thorold, discharge is to Twelve Mile Creek flowing to Lake Ontario.	Lake Ontario
	Port Weller WPCP	Services St. Catharines, and portions of Thorold and Niagara-on-the-Lake, discharge is to the Welland Canal flowing to Lake Ontario. However since storm water enters the sewer system, bypasses are common in flood conditions.	Welland Canal near Lake Ontario
Town of Grimsby	Baker Road WPCP	Services the Town of Grimsby, and Beamsville, Vineland, Jordan in the Town of Lincoln and Smithville in the Township of West Lincoln. Discharge is to Lake Ontario and bypass events occurred during 2001.	Lake Ontario
City of Welland	Welland WPCP	Services the City of Welland and the Town of Pelham, and Port Robinson, discharge is to the Welland River. According to the Niagara Pollution Control Plan, Feasibility Study, January 1988 there are some twenty overflows from the trunk sewer that discharge combined flow into the Welland River.	Welland River

Note: The Biggar Lagoon in Grimsby, Smithville Lagoon in West Lincoln, and Port Robinson Lagoon in Thorold, were recently removed from operation.

FIGURES

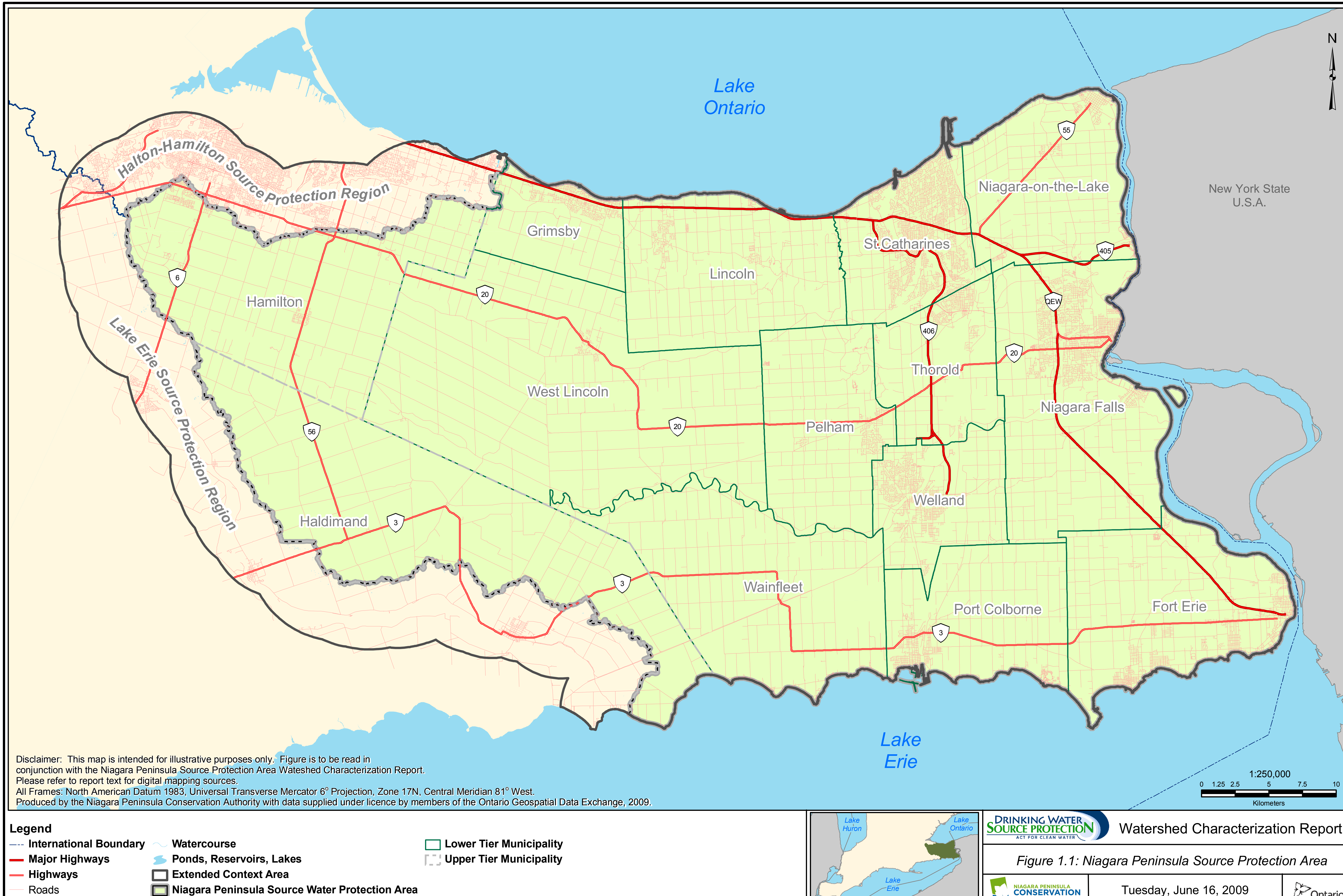
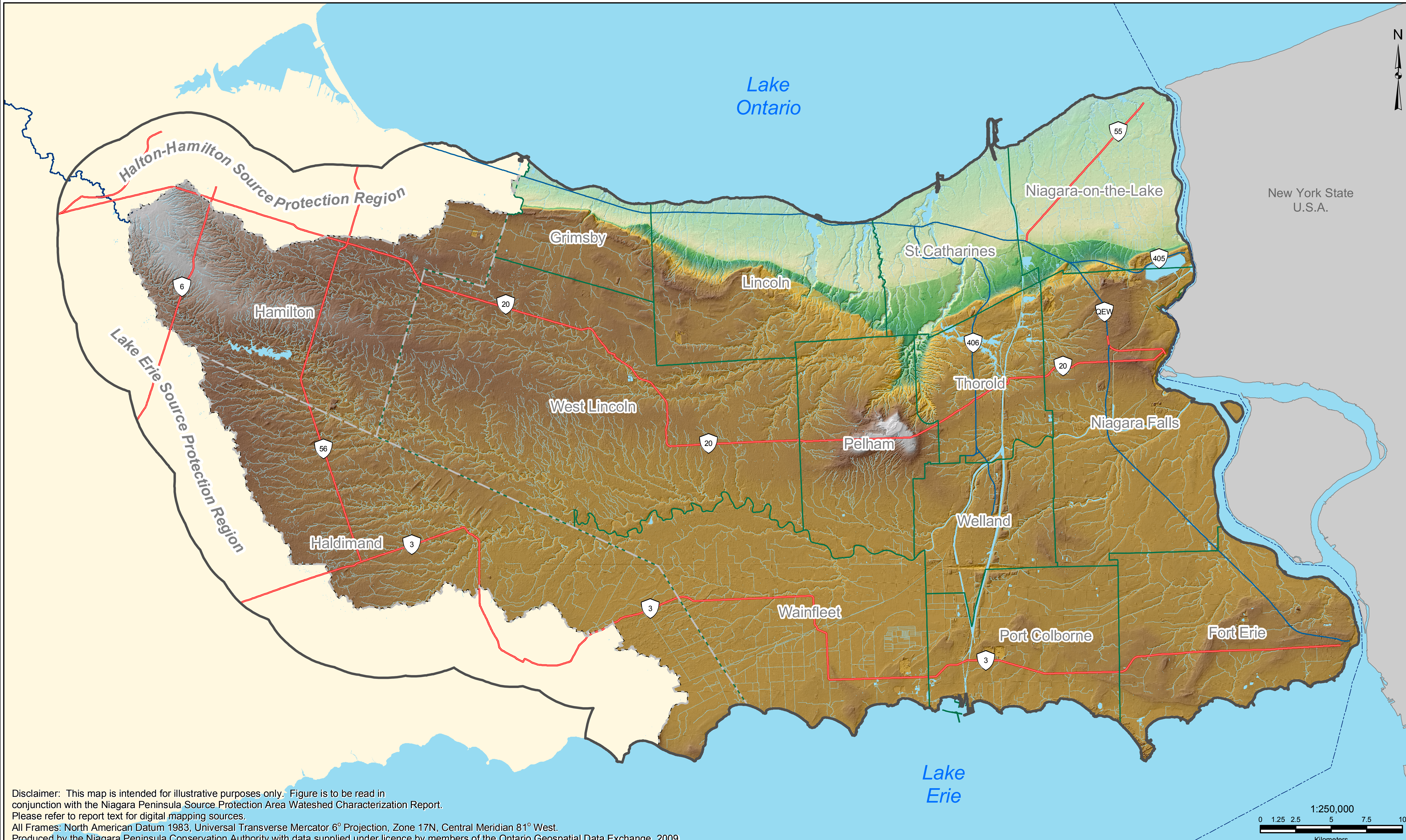


Figure 1.1: Niagara Peninsula Source Protection Area



Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Elevation (m) above sea level
High : 260
Low : 74

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 2.1: Topography

NIAGARA PENINSULA CONSERVATION AUTHORITY

Tuesday, June 16, 2009

Ontario

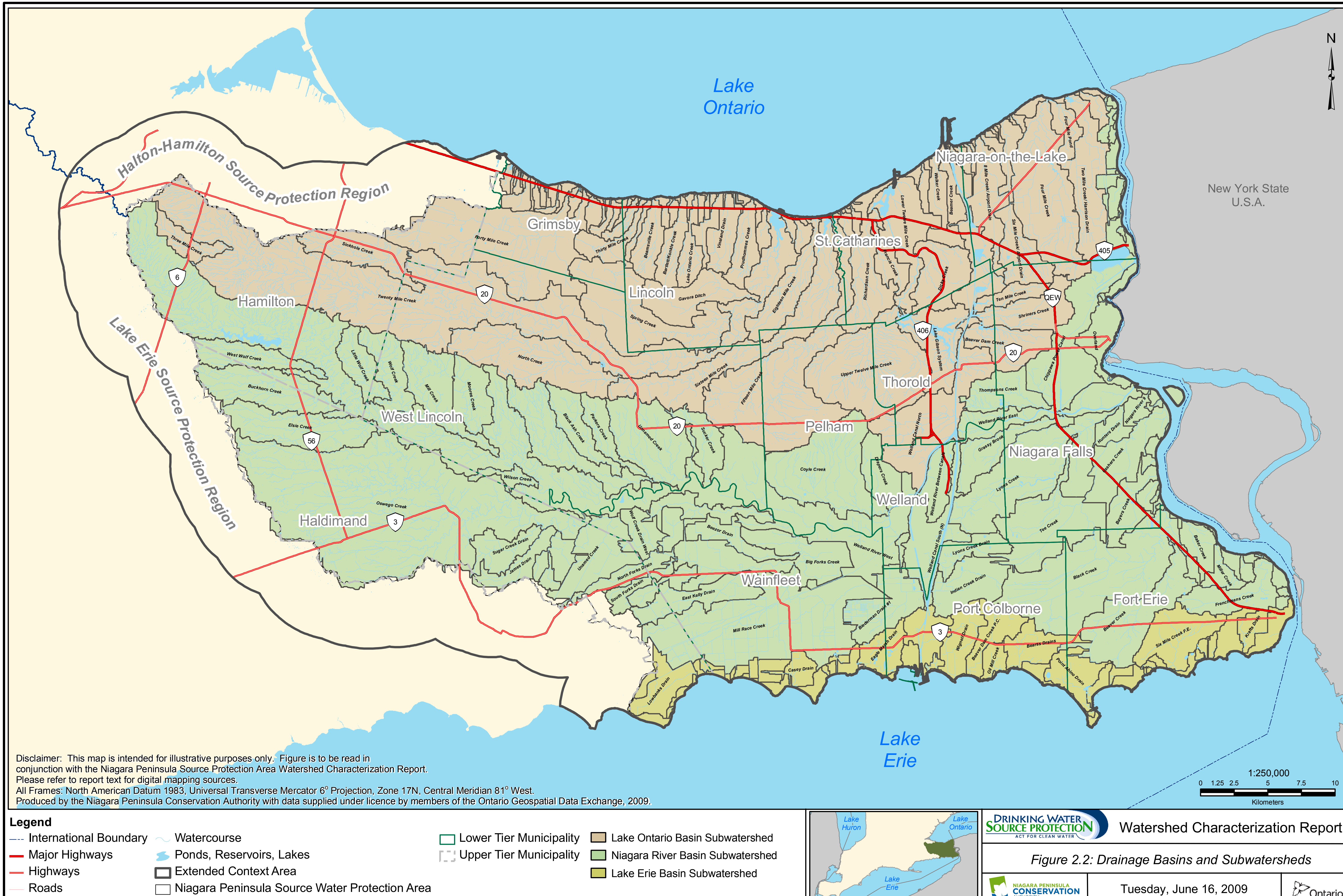


Figure 2.2: Drainage Basins and Subwatersheds

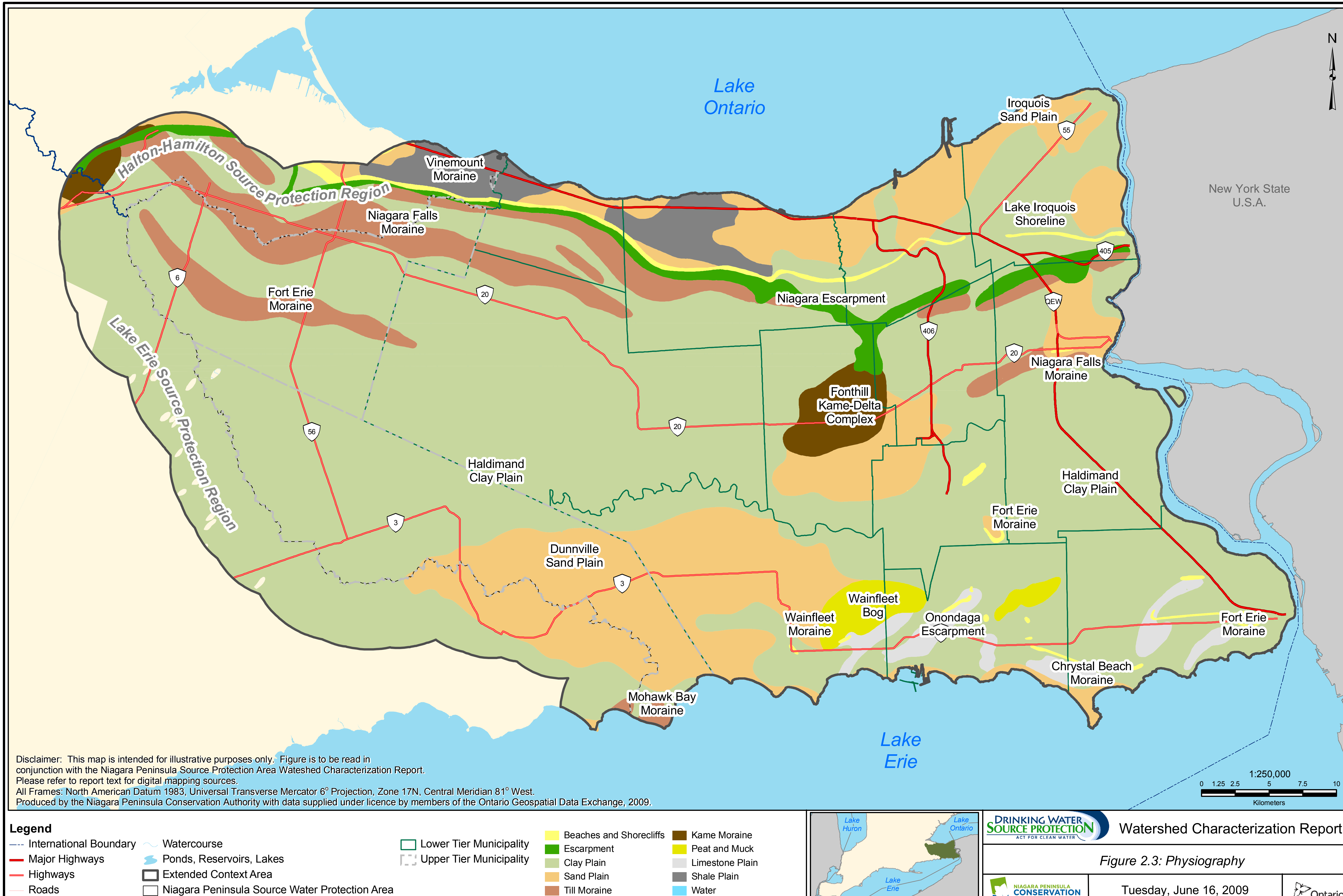
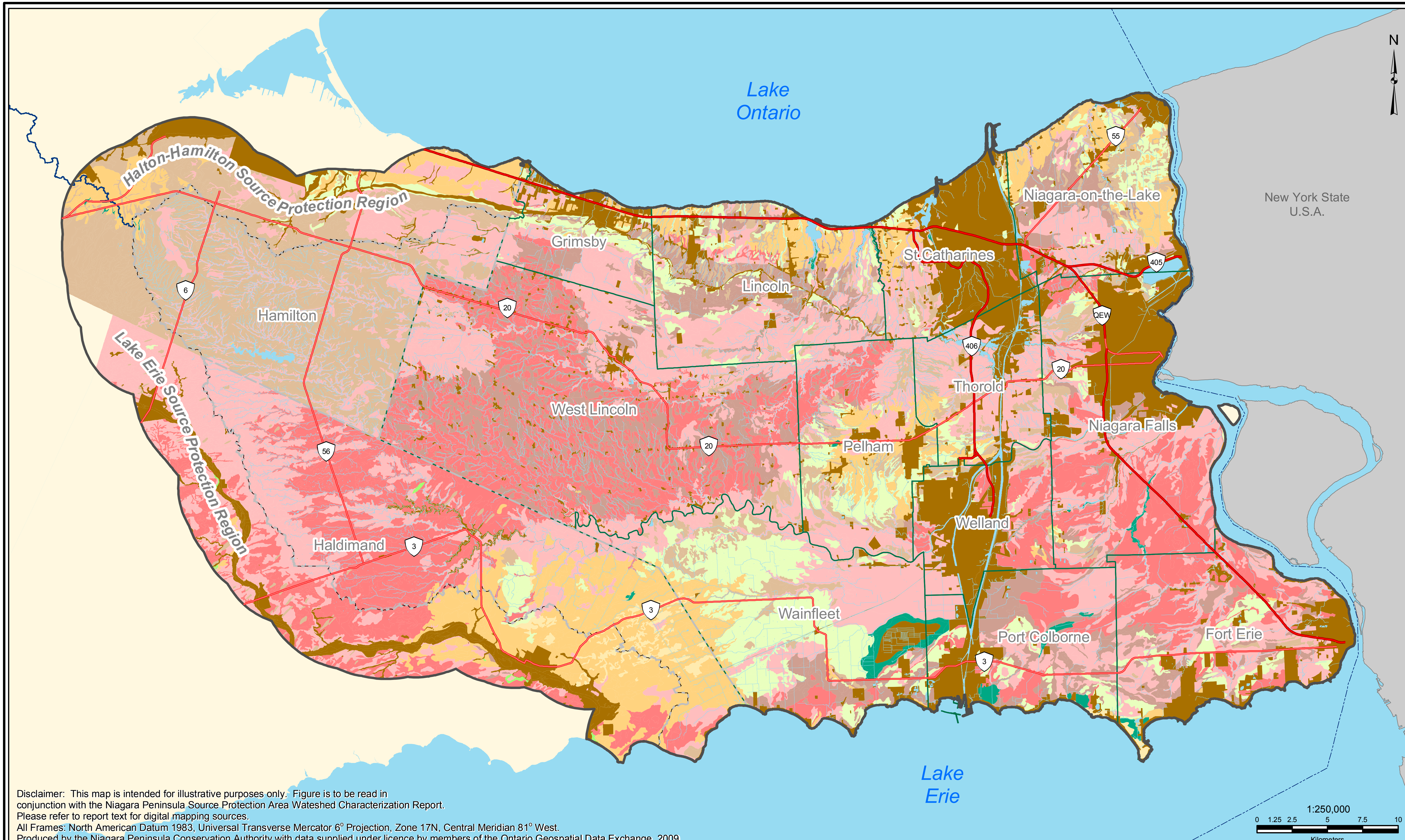


Figure 2.3: Physiography



Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Clay
- Silty Clay Loam
- Sand
- Sandy Loam
- Loam
- Loamy Sand
- Organic Soils
- Silty Clay
- Silty Loam
- Developed / Unclassified

***Please note that soils mapping in this figure is represented by the combination of three different former county soil surveys.**

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

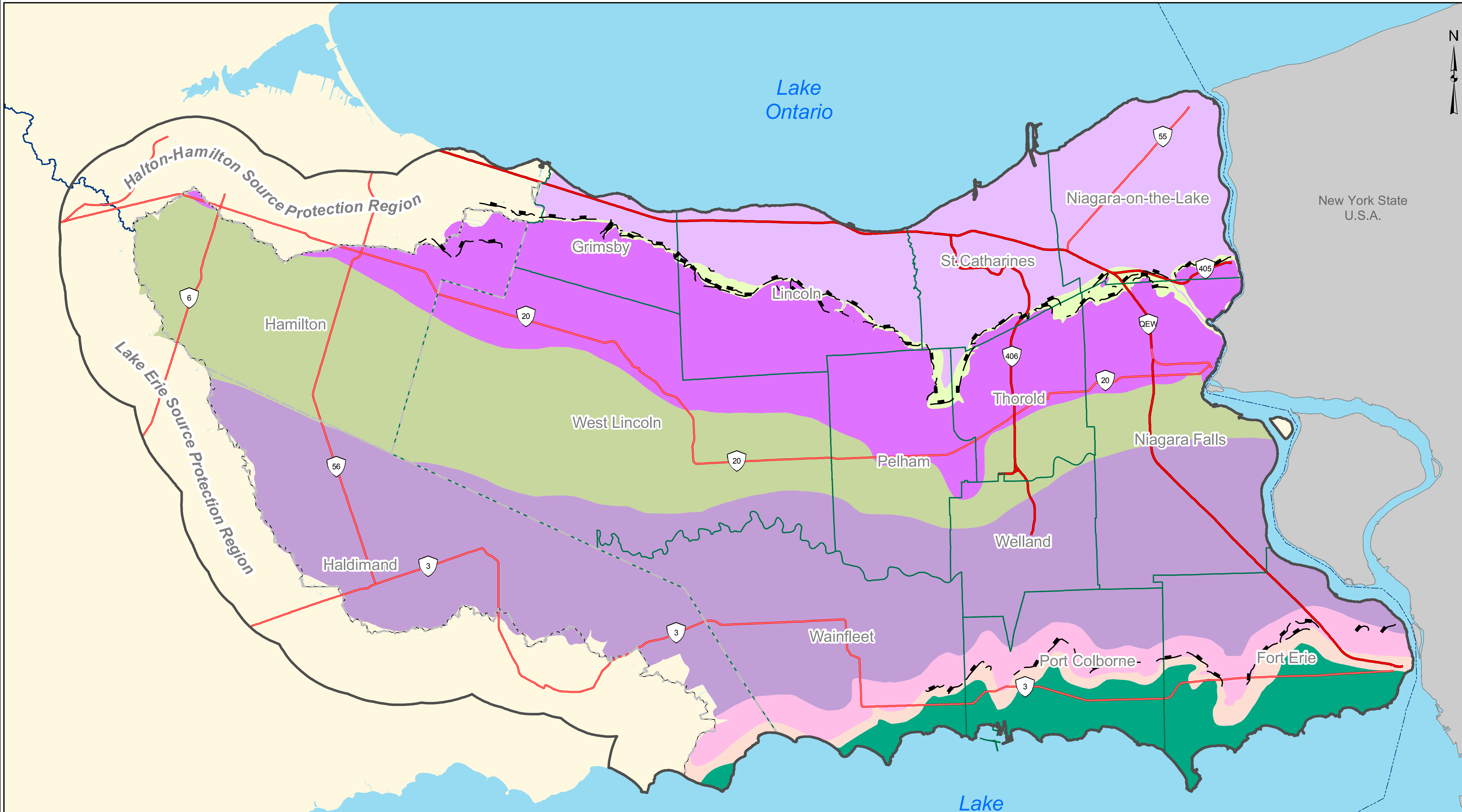
Watershed Characterization Report

Figure 2.4: Soils

NIAGARA PENINSULA CONSERVATION AUTHORITY

Tuesday, June 16, 2009

Ontario



Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Produced by the Niagara Peninsula Conservation Authority with data supplied under licence by members of the Ontario Geospatial Data Exchange, 2009.

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Escarpment

Bedrock Geology

- Bertie Formation
- Bois Blanc Formation
- Clinton - Cataract Group
- Onondaga Formation
- Guelph Formation
- Lockport Group
- Queenston Formation
- Salina Formation

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

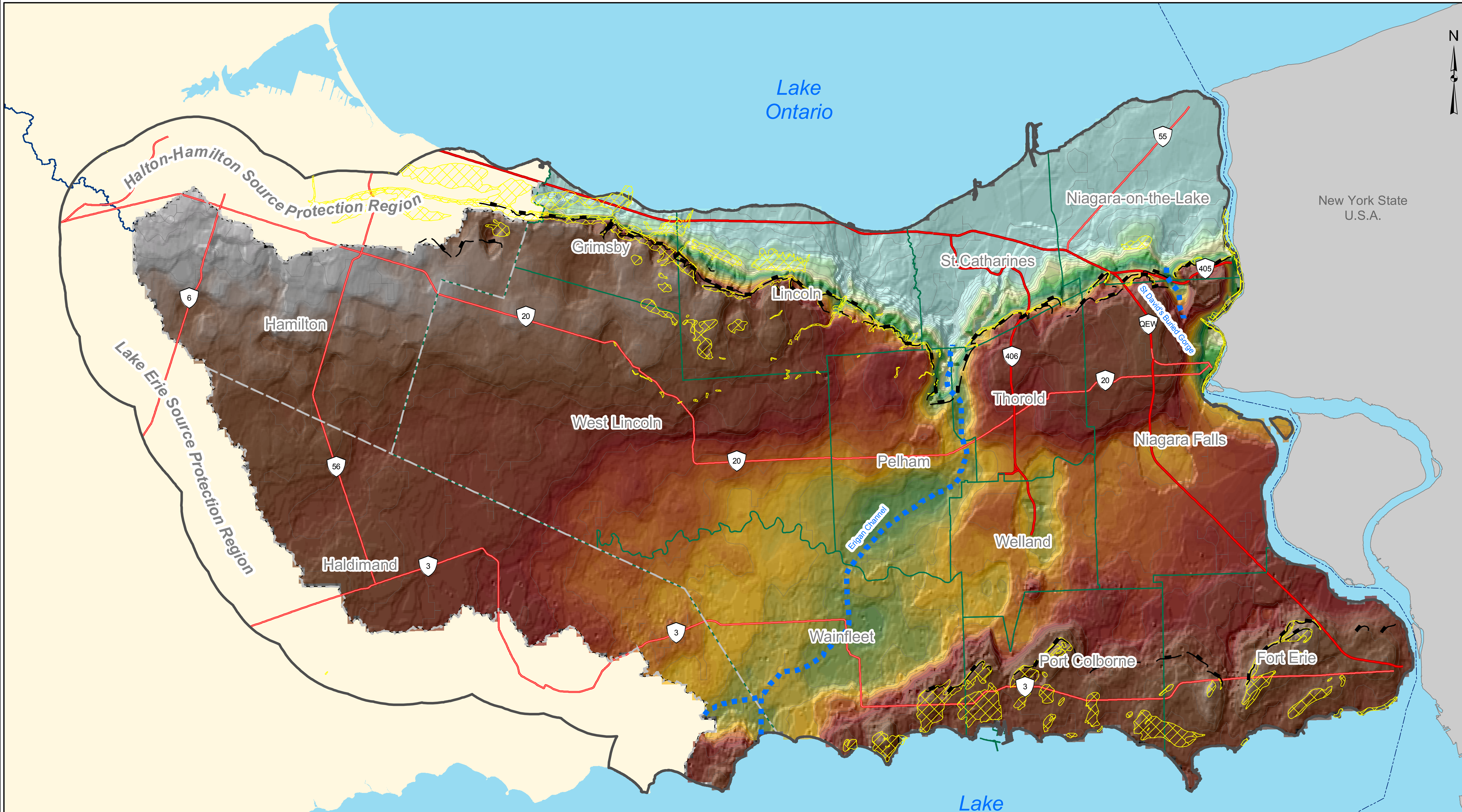
Watershed Characterization Report

Figure 2.5: Bedrock Geology

NIAGARA PENINSULA CONSERVATION AUTHORITY

Tuesday, June 16, 2009

Ontario



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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Bedrock Outcrop
- Escarpment
- 5 m Contours
- Bedrock Valleys

Bedrock topography (m) above sea level

High : 220

Low : 48

Note: 'Bedrock Outcrop' denotes areas where there is less than 1m of overburden.

The bedrock topography depicted in the St. David's Buried Gorge area may not be accurately represented due to a lack of well data. Previous interpretations indicate the gorge cuts approximately 60 to 130 m into the bedrock.

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

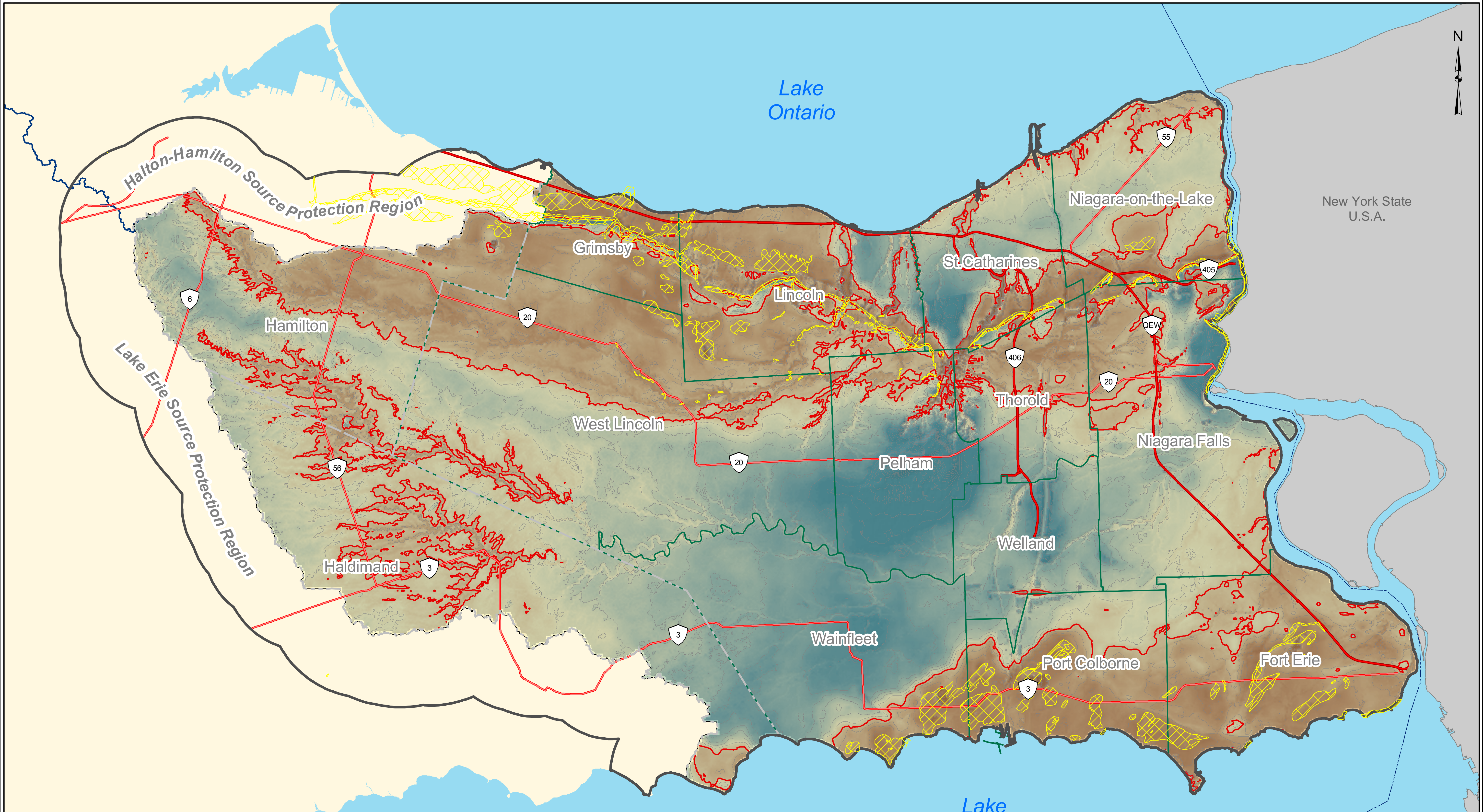
Watershed Characterization Report

Figure 2.6: Bedrock Topography

NIAGARA PENINSULA CONSERVATION AUTHORITY

Tuesday, June 16, 2009

Ontario



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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Bedrock Outcrop
- Contour 5m Interval
- 15 m Thickness

Overburden thickness (m)

High : 106.933

Low : 0

* Bedrock outcrop denotes areas where there is less than 1m of overburden

DRINKING WATER SOURCE PROTECTION — ACT FOR CLEAN WATER

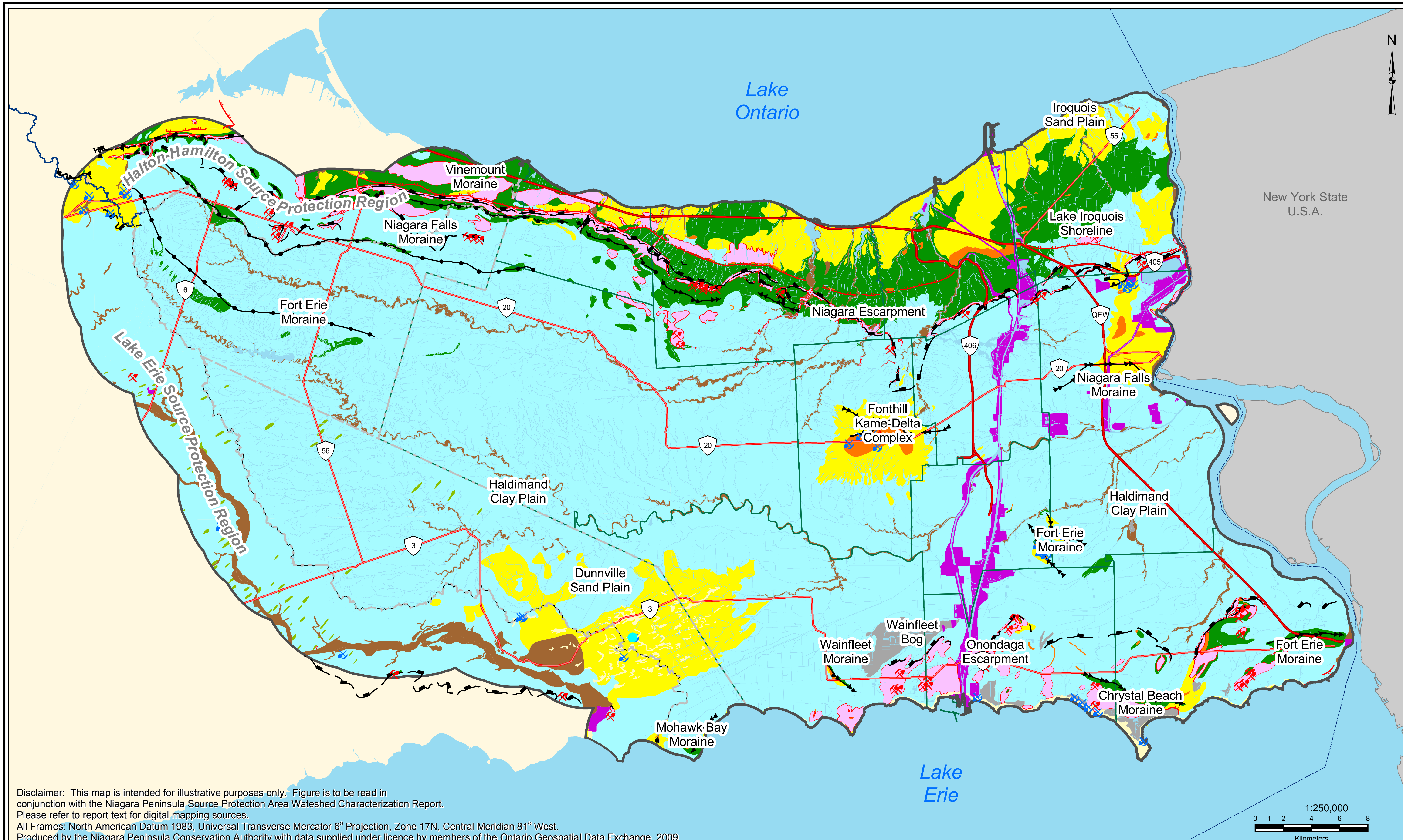
Watershed Characterization Report

Figure 2.7: Overburden Thickness

NIAGARA PENINSULA CONSERVATION AUTHORITY

Tuesday, June 16, 2009

Ontario



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Legend

- International Boundary
- Major Highways
- Highways
- Watercourse
- Ponds, Reservoirs, Lakes
- Lower Tier Municipality
- Upper Tier Municipality
- Extended Context Area
- Abandoned Shore Bluff
- End Moraine
- Escarpment
- Ice Contact Slope
- Moraine Crest
- Sand and Gravel Pit
- Quarry
- Paleozoic bedrock (outcrop)
- Stone-poor, carbonate-derived silty to sandy till
- Glaciolacustrine-derived silty to clayey till
- Ice-contact stratified deposits
- Glaciofluvial deposits
- Fine-textured glaciolacustrine deposits
- Coarse-textured glaciolacustrine deposits
- Older alluvial deposits
- Coarse-textured lacustrine deposits
- Eolian deposits
- Modern alluvial deposits
- Organic deposits
- Man-made deposits

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 2.8: Surficial Geology

NIAGARA PENINSULA CONSERVATION AUTHORITY

Tuesday, June 16, 2009

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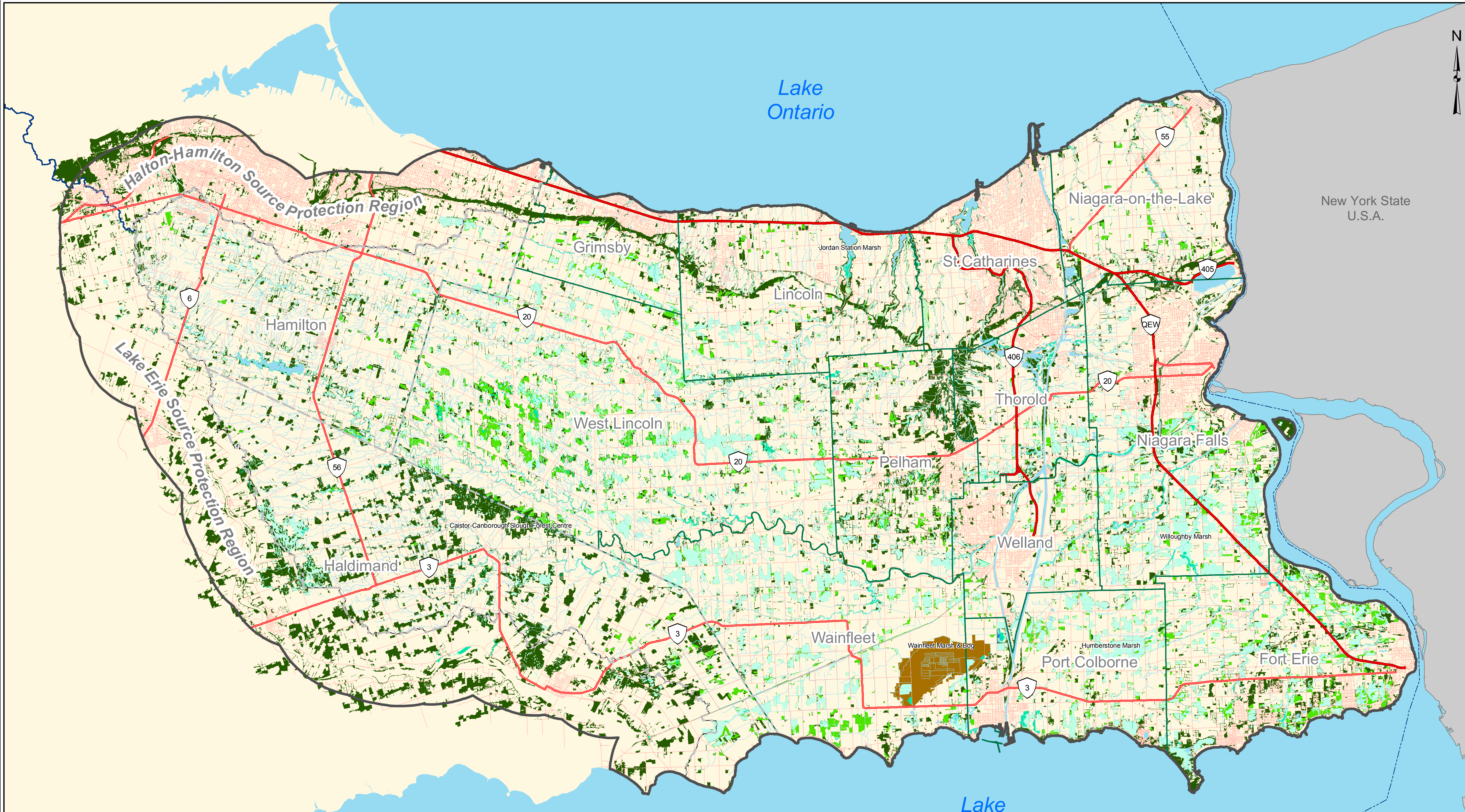

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Please refer to report text for digital mapping sources.
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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Natural Communities

- Bog
- Fen
- Open Water
- Marsh
- Swamp
- Wet Forest
- Moist Forest
- Upland Forest

Drinking Water Source Protection — Act for Clean Water

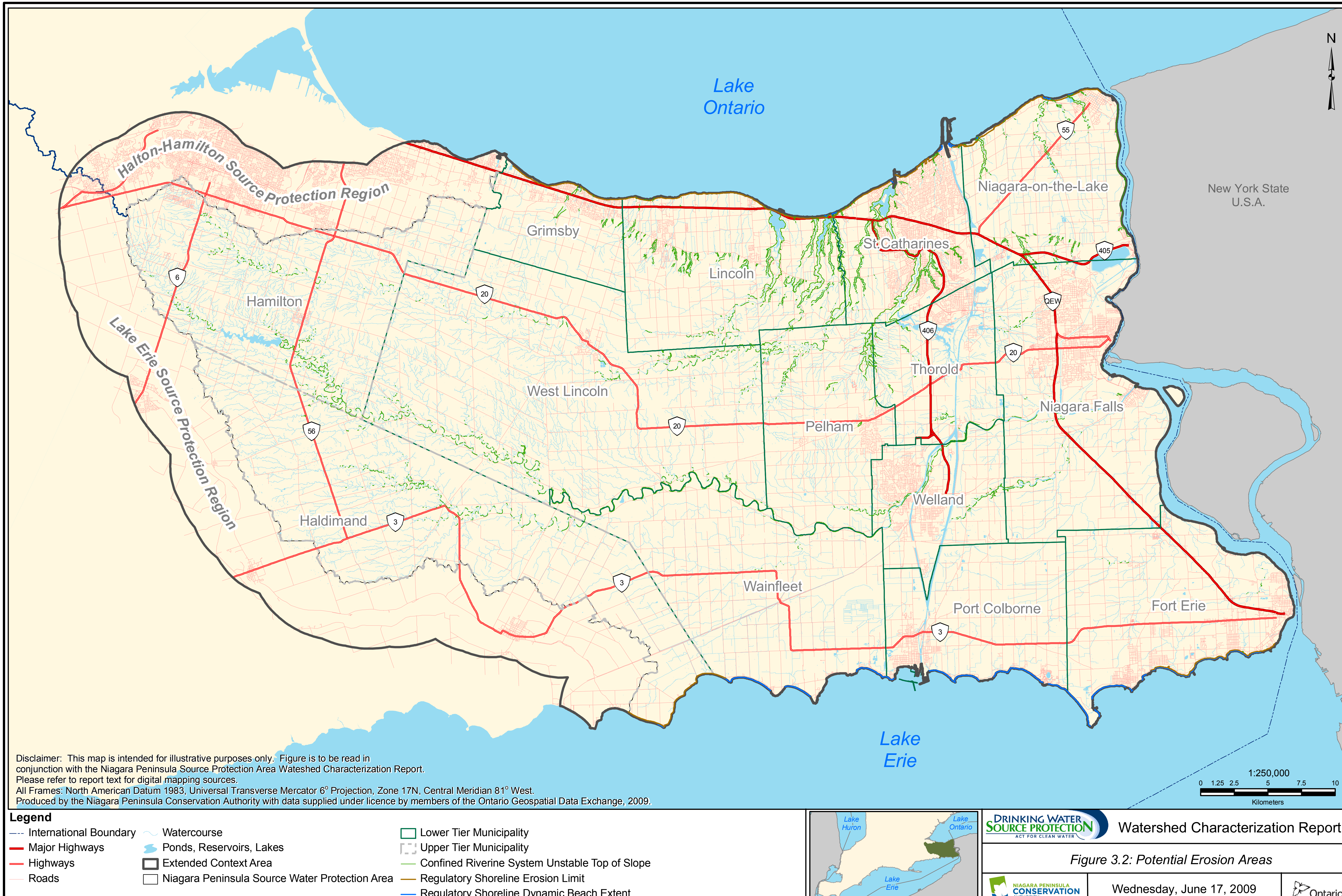
Watershed Characterization Report

Figure 3.1: Natural Heritage Systems

Niagara Peninsula Conservation Authority

Thursday, June 18, 2009

Ontario


Lake Ontario
Lake Erie
N
New York State U.S.A.
Halton-Hamilton Source Protection Region
Lake Erie Source Protection Region
Hamilton
Grimsby
Lincoln
St.Catharines
Niagara-on-the-Lake
Thorold
Niagara Falls
West Lincoln
Pelham
Welland
Haldimand
Wainfleet
Port Colborne
Fort Erie
55
405
QEW
406
20
6
56
3
1:250,000
0 1.25 2.5 5 7.5 10
Kilometers
Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
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All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
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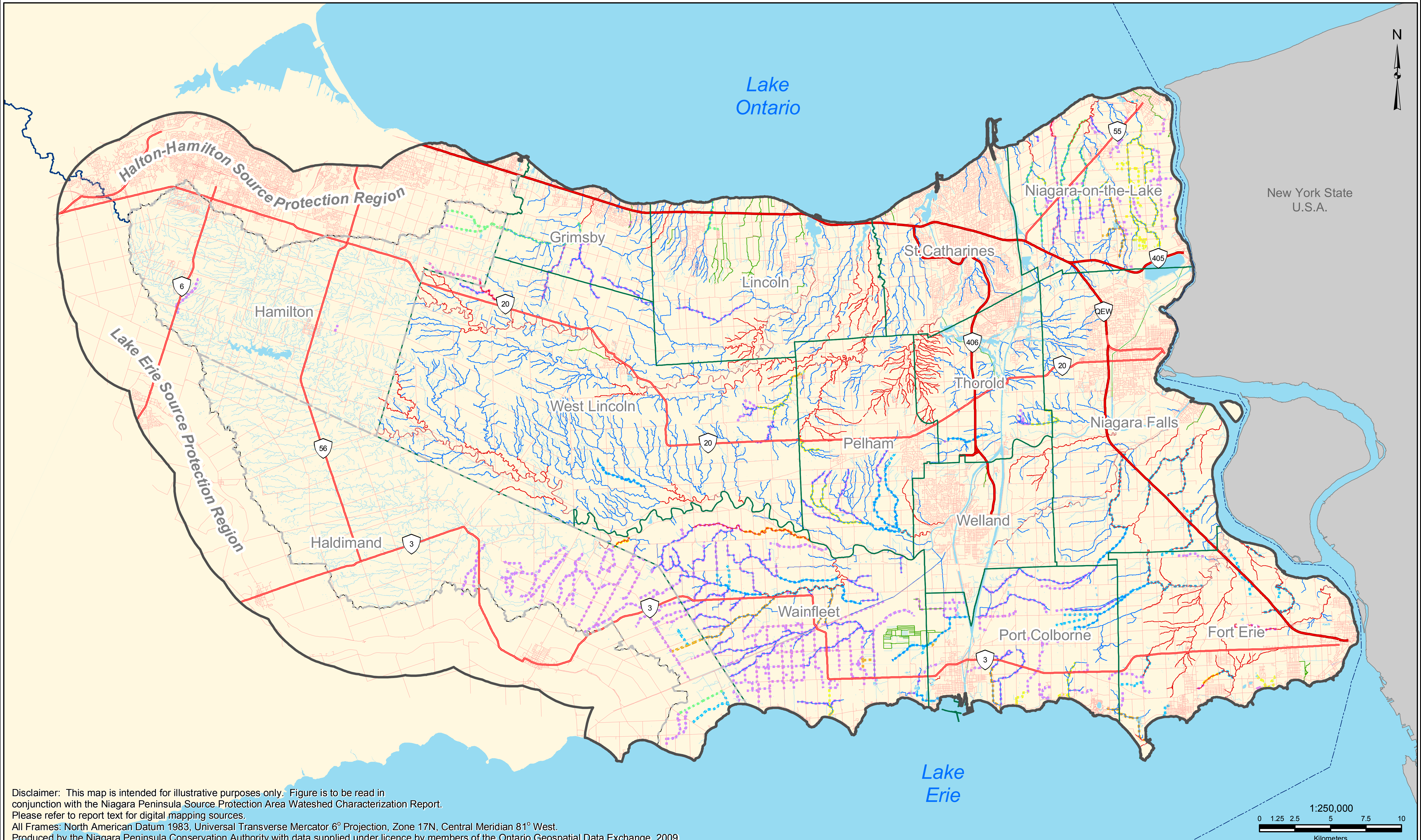
Legend
International Boundary
Major Highways
Highways
Roads
Watercourse
Ponds, Reservoirs, Lakes
Extended Context Area
Niagara Peninsula Source Water Protection Area
Lower Tier Municipality
Upper Tier Municipality
Confined Riverine System Unstable Top of Slope
Regulatory Shoreline Erosion Limit
Regulatory Shoreline Dynamic Beach Extent
Lake Huron
Lake Ontario
Lake Erie
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER
Watershed Characterization Report
Figure 3.2: Potential Erosion Areas
NIAGARA PENINSULA CONSERVATION AUTHORITY
Wednesday, June 17, 2009
Ontario



Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

MNR Classification
- Type 1: Crtical
- Type 2: Important
- Type 3: Marginal

DFO Municipal Drain Class Authorization
- Class A : Permanent, Coldwater or Temperature Unknown
- Class B: Permanent, Warmwater, Top Predators, < 10 yrs since cleanout
- Class C: Warmwater
- Class D: Permanent, Coldwater, Salmonids Persent or Unknown
- Class E: Permanent, Warmwater, Top Predators, > 10 yrs since cleanout
- Class F: Intermittent or Ephemeral

Lake Huron
Lake Ontario
Lake Erie

DRINKING WATER SOURCE PROTECTION — ACT FOR CLEAN WATER

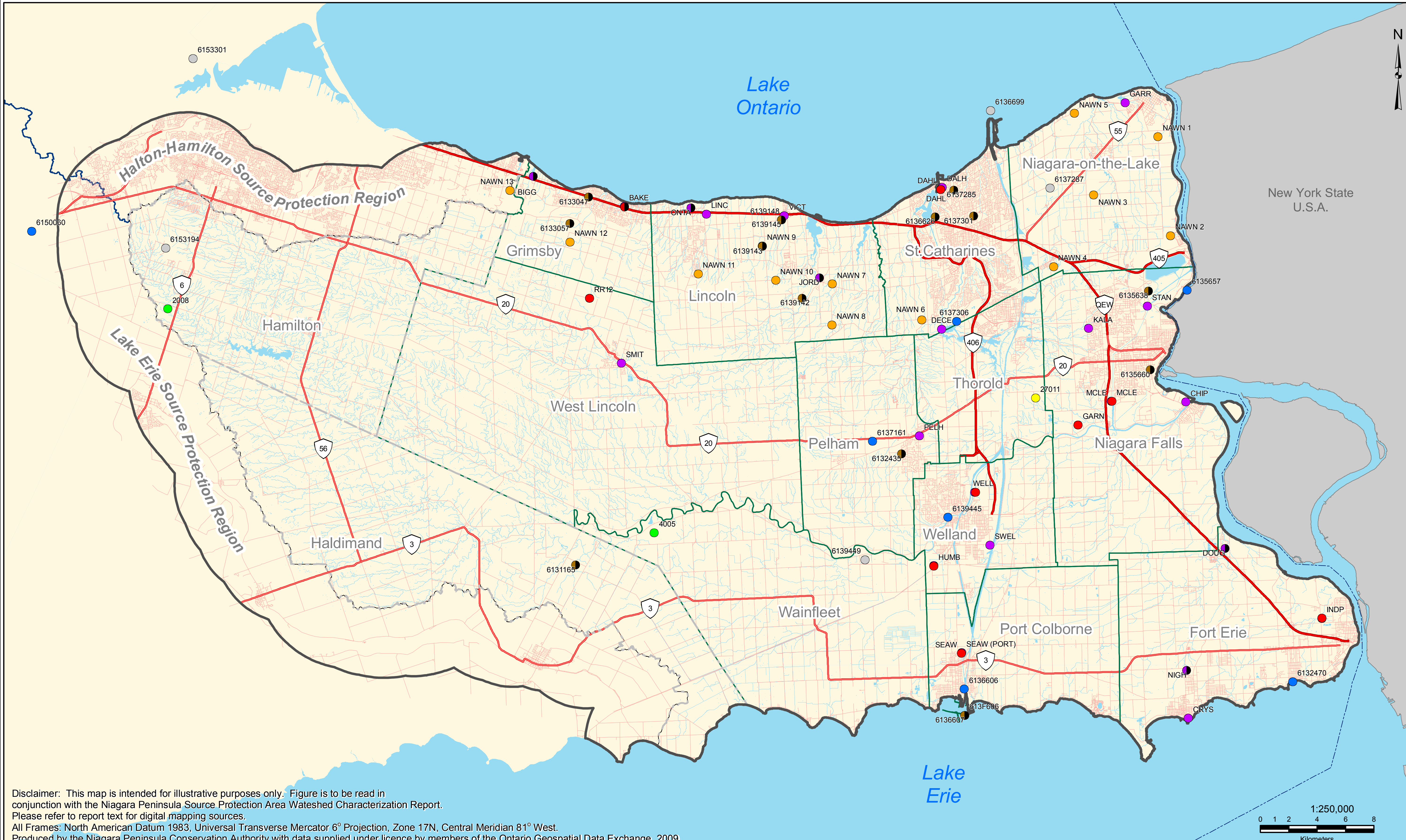
Watershed Characterization Report

Figure 3.3: Fish Habitat Areas

NIAGARA PENINSULA CONSERVATION AUTHORITY

Wednesday, June 17, 2009

Ontario



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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Environment Canada Inactive Precipitation and Climate Station
- Region of Niagara Inactive Climate Station
- Region of Niagara Inactive Precipitation Station
- Environment Canada Active Climate Station
- Environment Canada Active Precipitation and Climate Station
- Region of Niagara Active Climate Station
- Region of Niagara Active Precipitation Station
- Ontario Weather Network Active Precipitation and Climate Station
- NPCA Active Snow Survey Station
- Ontario Ministry of the Environment Active Climate Station

Note: Environment Canada stations within 10 km of SWPA shown.
Inactive Environment Canada stations have at least 15 years of data

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Watershed Characterization Report

Figure 4.1: Weather Monitoring Stations

Niagara Peninsula Conservation Authority

Wednesday, June 17, 2009

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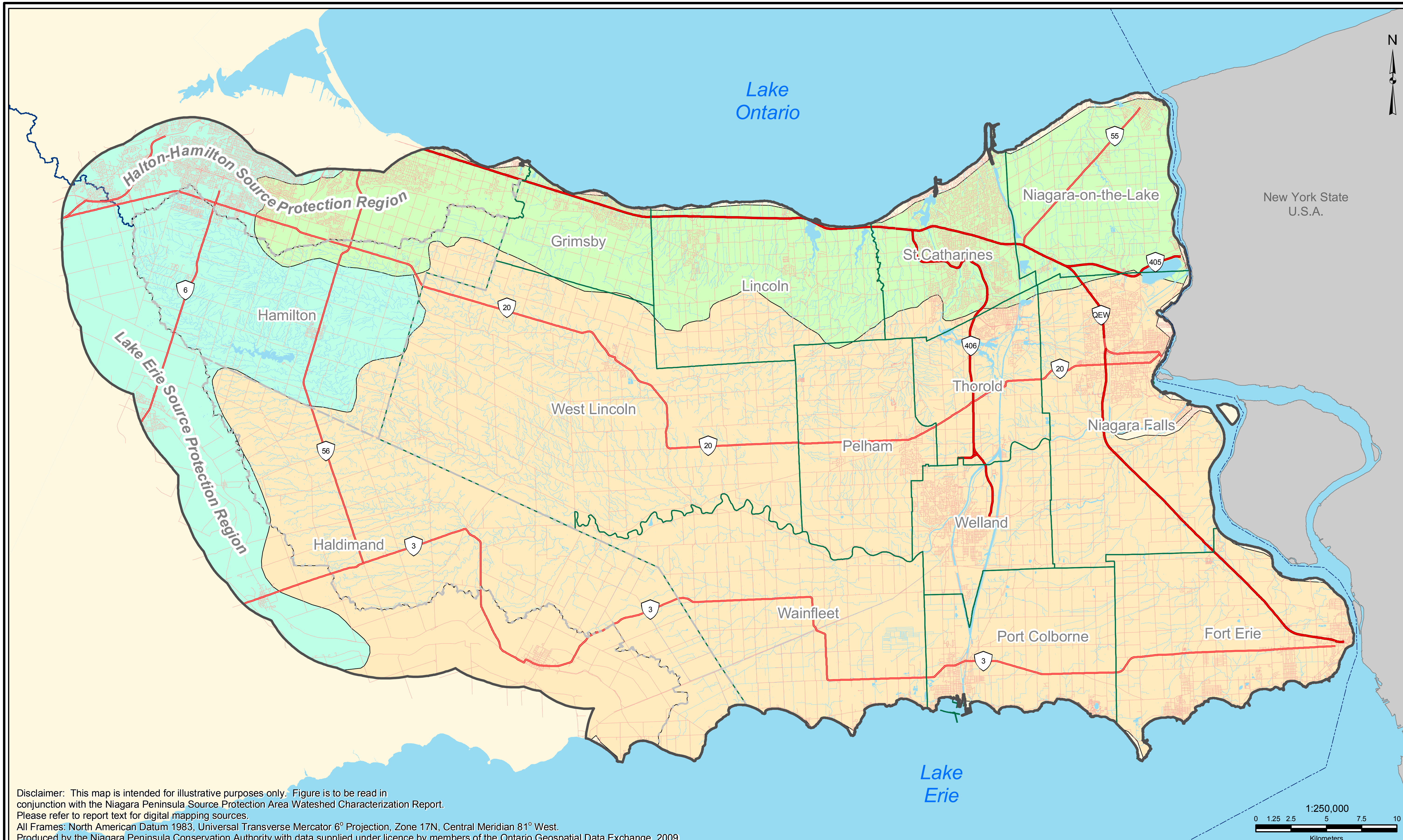

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Ecodistrict 564
- Ecodistrict 566
- Ecodistrict 569

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 4.2: Ecodistricts

NIAGARA PENINSULA CONSERVATION AUTHORITY

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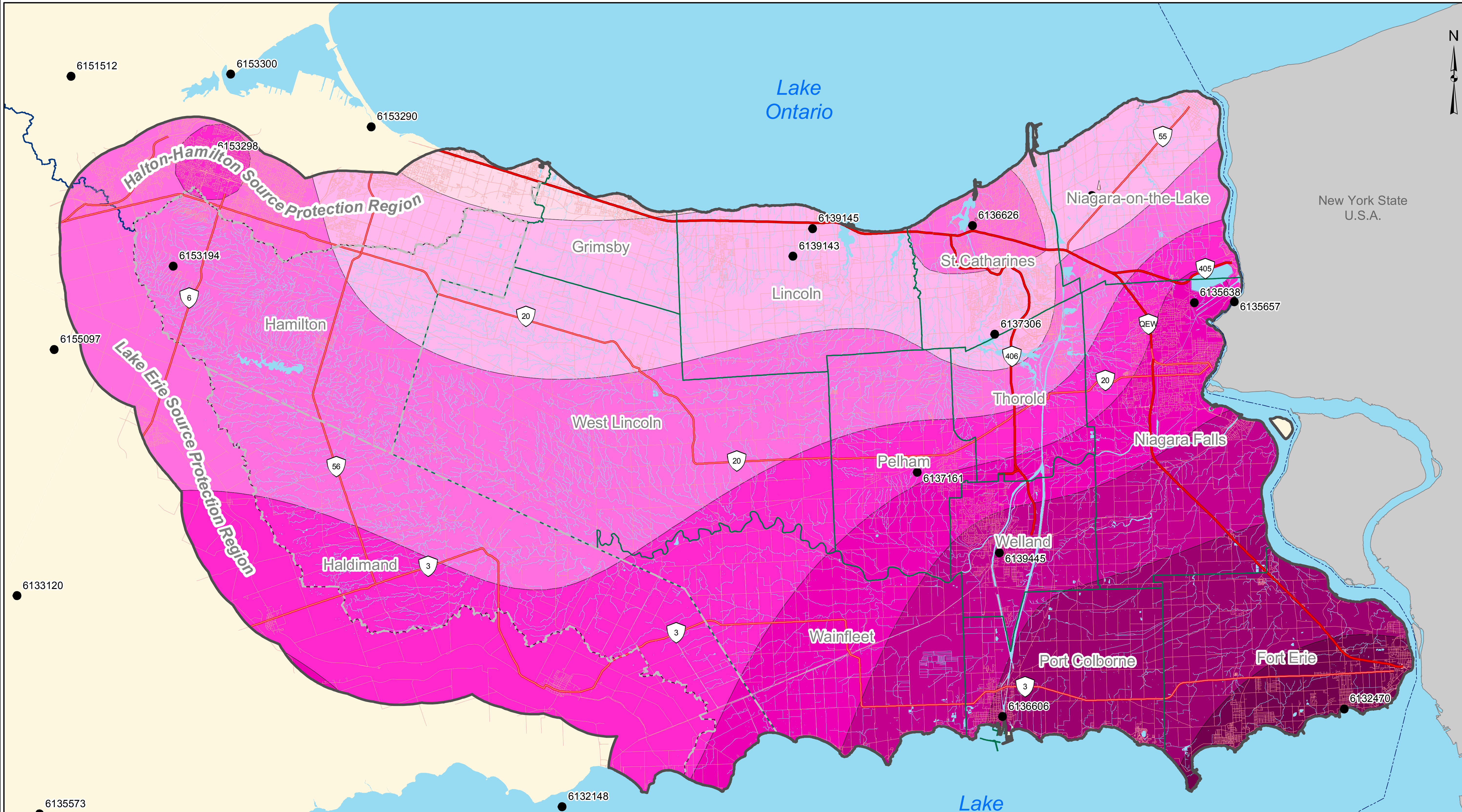

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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Mean Annual Precipitation (mm)

- Environment Canada Climate Stations
- 850.0 - 875.0
- 875.1 - 900.0
- 900.1 - 925.0
- 925.1 - 950.0
- 950.1 - 975.0
- 975.1 - 1000.0
- 1000.1 - 1025.0
- > 1025.0

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Watershed Characterization Report

Figure 4.3: Precipitation Distribution

Niagara Peninsula Conservation Authority

Wednesday, June 17, 2009

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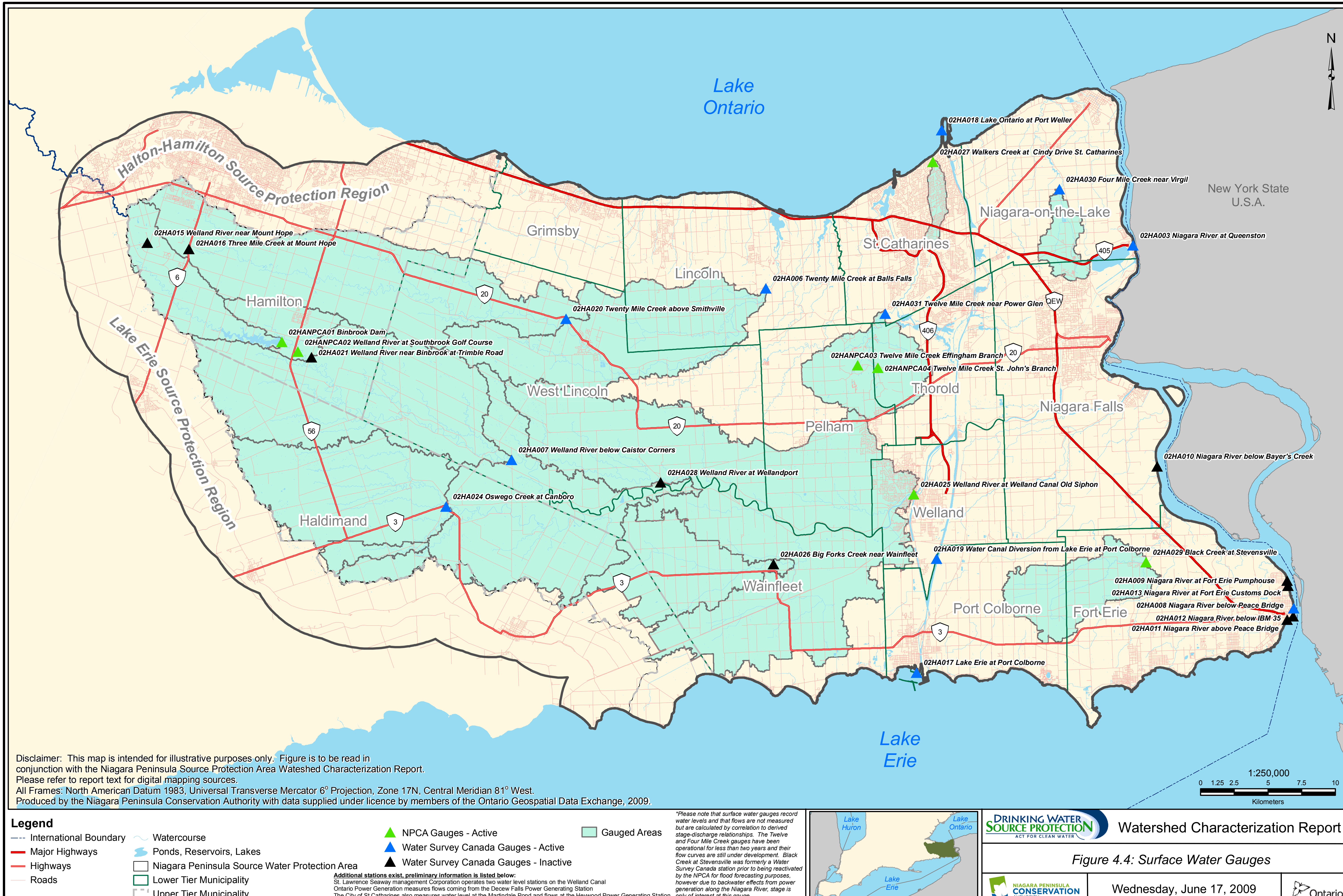

Watershed Characterization Report

Figure 4.4: Surface Water Gauges

Wednesday, June 17, 2009

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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Wells Constructed in Bedrock
- Wells Constructed in Overburden

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Watershed Characterization Report

Figure 4.5: Water Well Locations

Niagara Peninsula Conservation Authority

Wednesday, June 17, 2009

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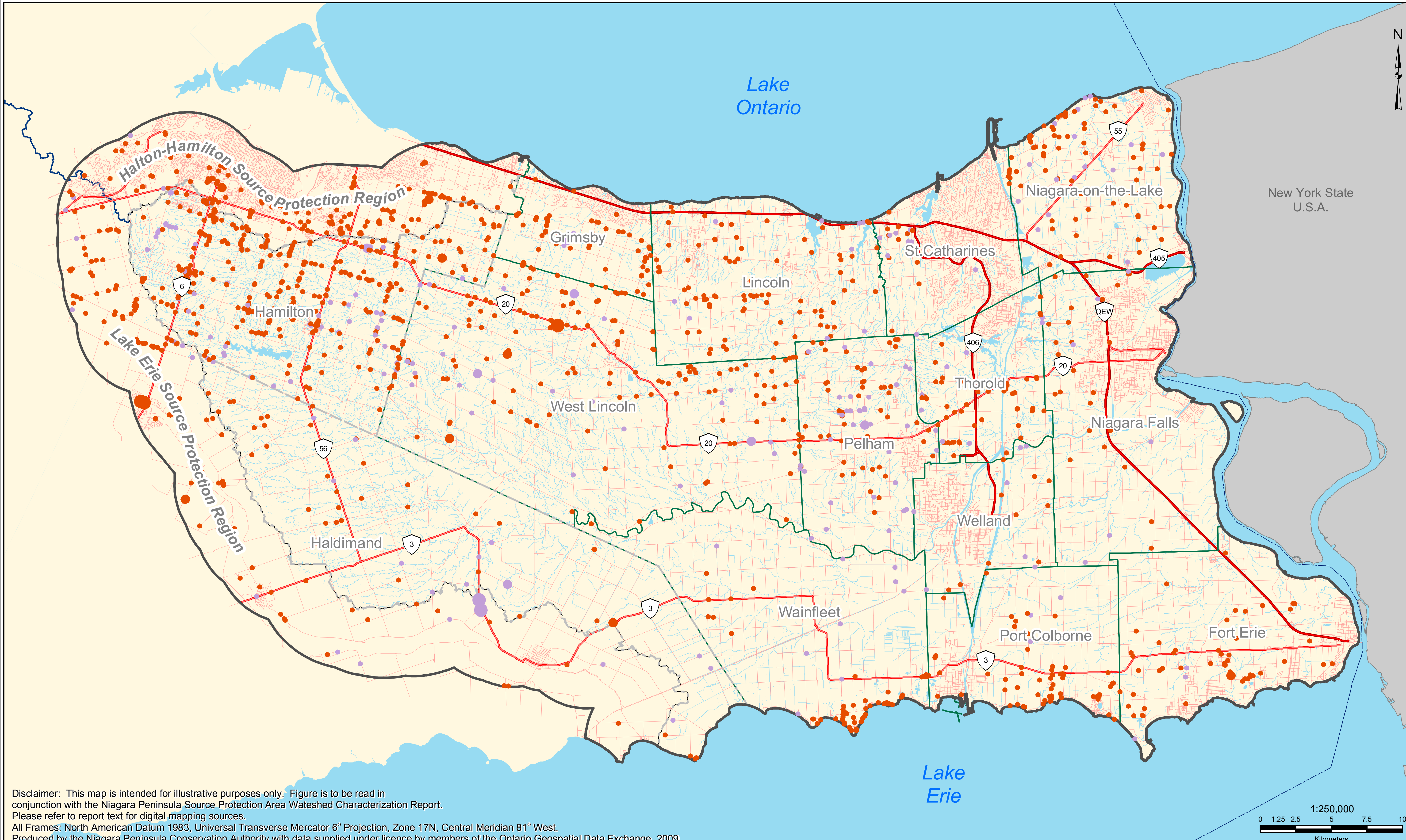

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Bedrock Wells	Overburden Wells
0.0 - 25.0 m^3 / day / m	0.0 - 25.0 m^3 / day / m
25.1 - 50.0 m^3 / day / m	25.1 - 50.0 m^3 / day / m
50.1 - 85.0 m^3 / day / m	50.1 - 85.0 m^3 / day / m

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ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 4.6: Water Well Specific Capacity Ranges

NIAGARA PENINSULA CONSERVATION AUTHORITY

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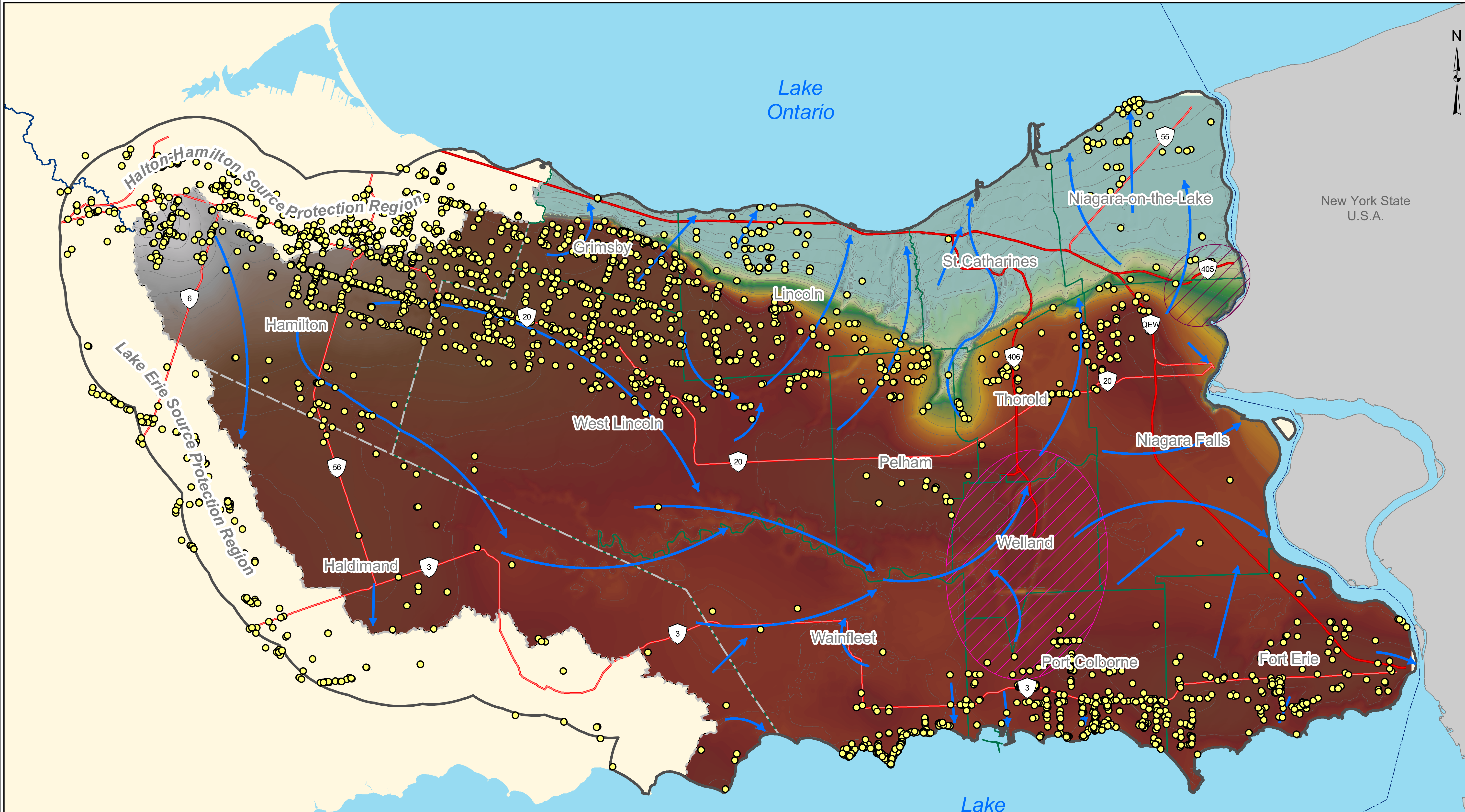

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Legend

- International Boundary
- Major Highways
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Wells Used in Analysis
- Contour 5 m
- Ground Water Flow
- Welland Canal Dewatering
- PGS Reservoir Area*

Elevation (m) above sea level
High : 243.4
Low : 73.2

*Elevation inaccurate due to radial outflow from power generating station reservoir (PGS)

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 4-7: Water Table Elevations

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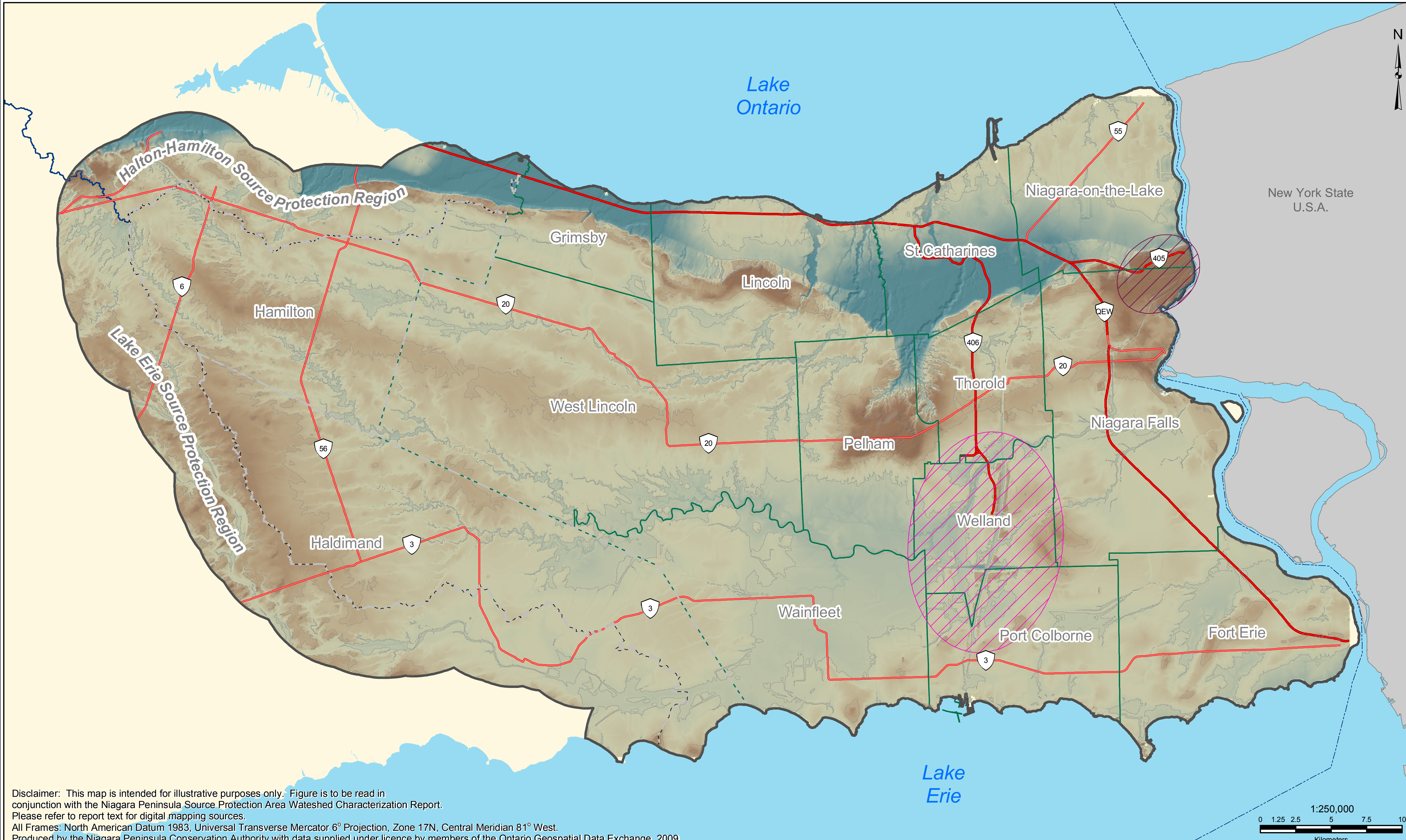

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Legend

- International Boundary
- Major Highways
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Welland Canal Dewatering**
- PGS Reservoir Area*
- Contour 5m

Depth to water table (m)
High : 87.7693
Low : -126.224

**The depth to water table depicted on this map, in the area surrounding the PGS reservoir, do not accurately illustrate the current elevations due to radial outflow from the reservoir and losses to the St. Davids Gorge.*

***The depth to water table depicted on this map, in areas near tunnels that pass under the Welland Canal, may not accurately illustrate current elevations due to dewatering activities associated with tunnels. The water table in these areas is expected to be at a somewhat lower elevation.*

Drinking Water Source Protection — Act for Clean Water

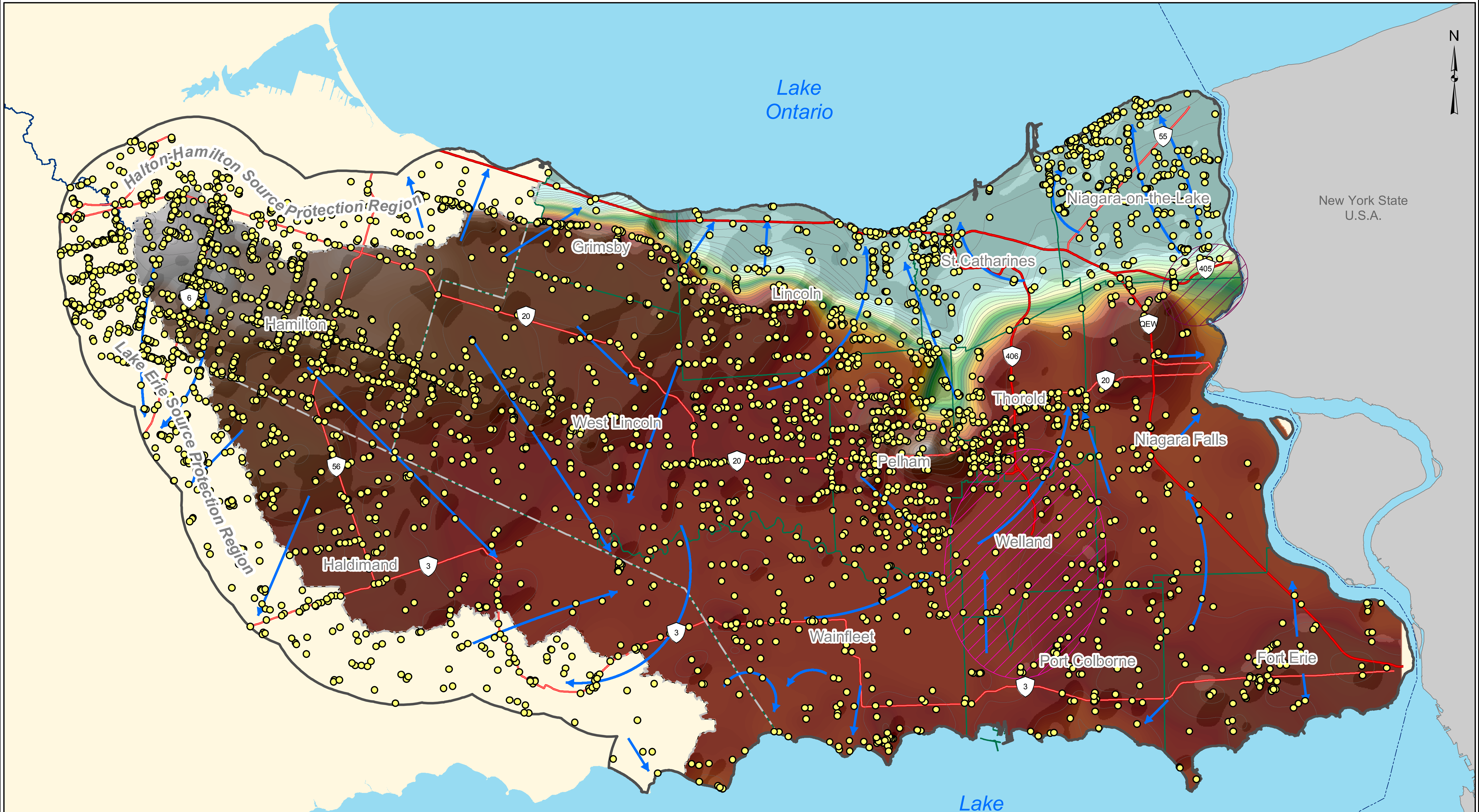
Watershed Characterization Report

Figure 4-8: Depth to Water Table

Niagara Peninsula Conservation Authority

Thursday, June 18, 2009

Ontario



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Legend

- International Boundary
- Major Highways
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Wells Used in Analysis
- Contour 5 m
- Ground Water Flow
- Welland Canal Dewatering
- PGS Reservoir Area*

*Elevation inaccurate due to radial outflow from power generating station reservoir (PGS)

Elevation (m) above sea level
High : 237.5
Low : 69.6

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 4-9: Potentiometric Surface

NIAGARA PENINSULA CONSERVATION AUTHORITY

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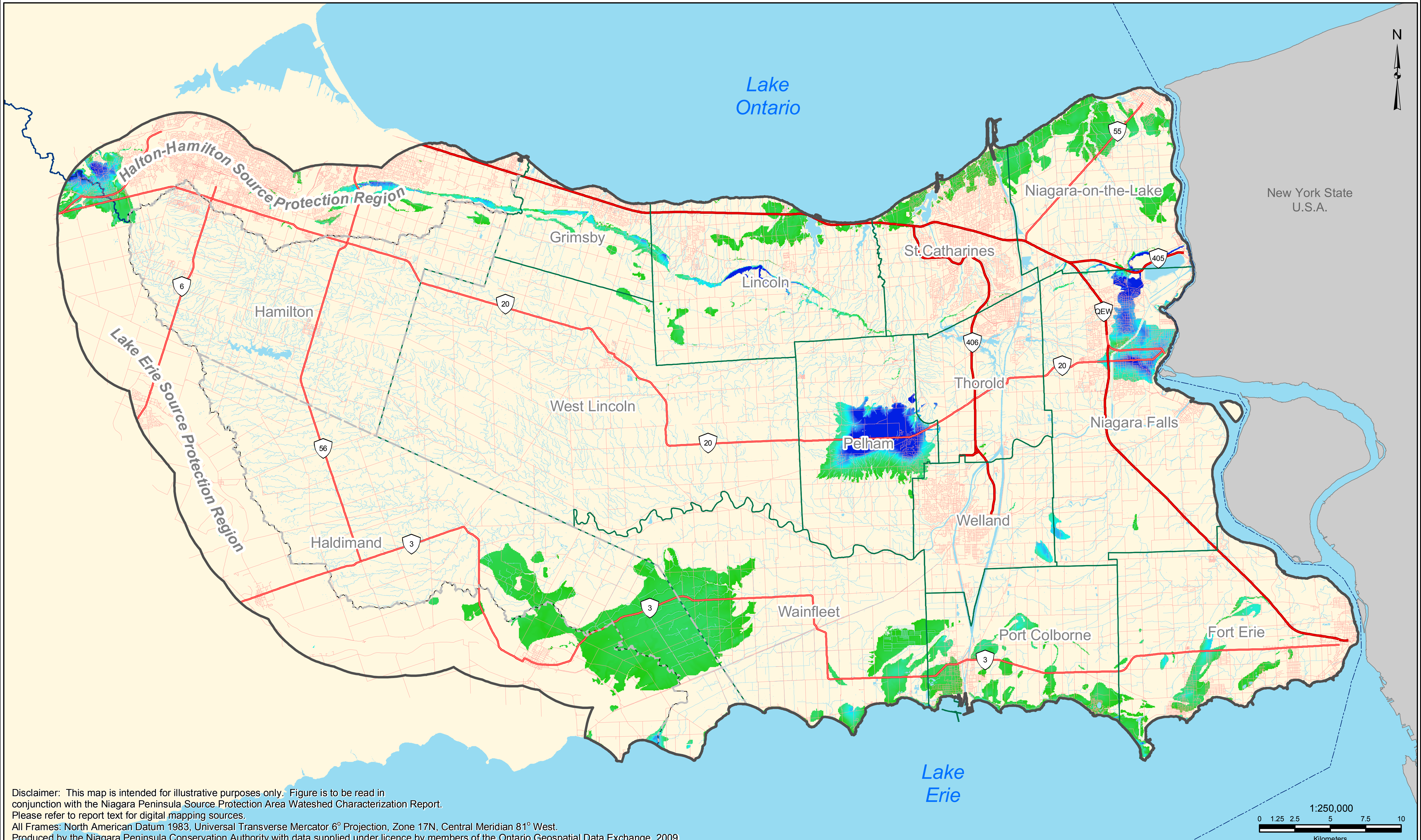

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Ponds, Reservoirs, Lakes
- Watercourse
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Depth to water table (m)
High : 88.0
Low : 0.0

Drinking Water Source Protection — Act for Clean Water

Watershed Characterization Report

Figure 4-10: Potential Groundwater Recharge Areas

Niagara Peninsula Conservation Authority

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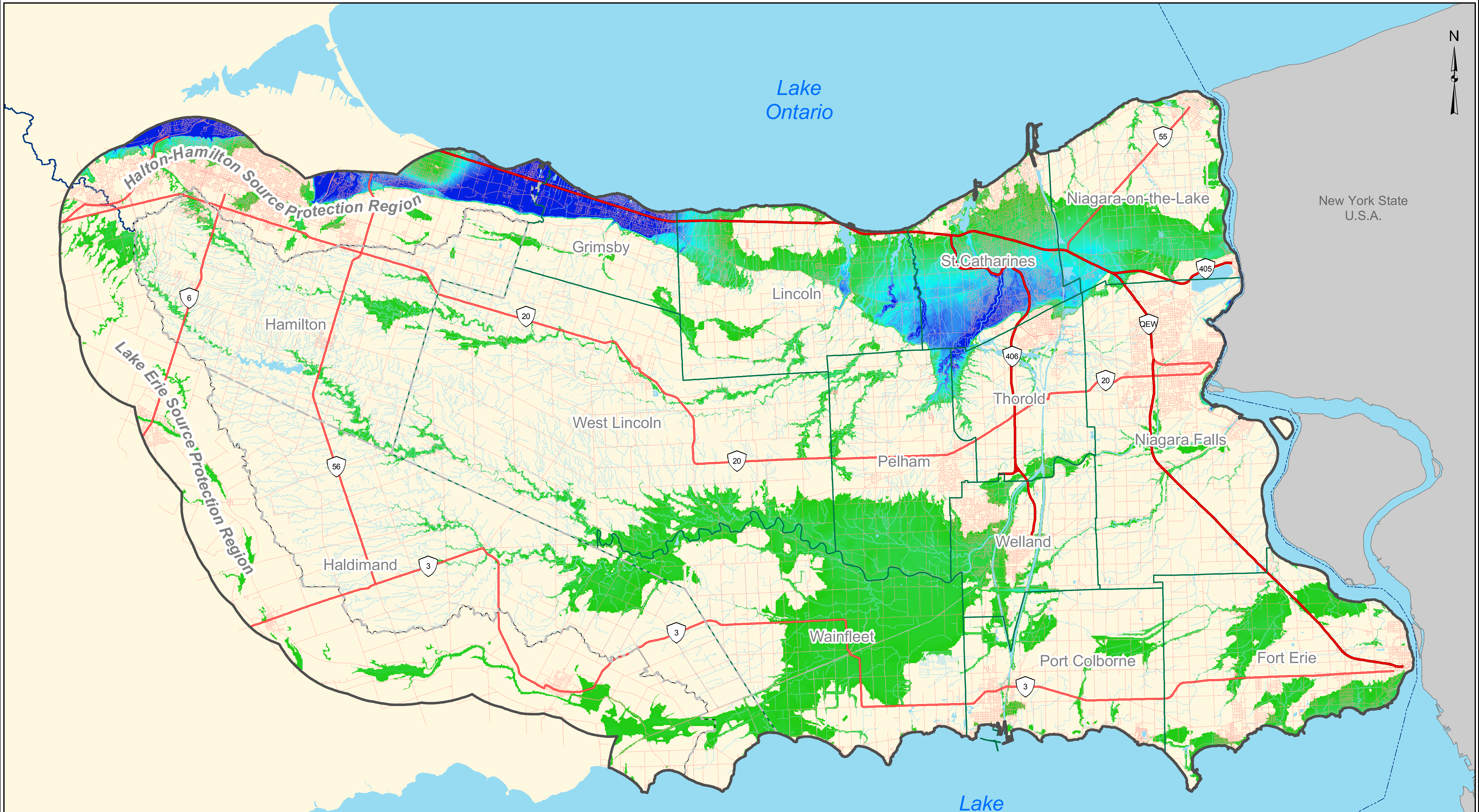

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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Ponds, Reservoirs, Lakes
- Watercourse
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Note: Above ground heads north of the Niagara Escarpment (e.g. Grimsby Area) are generally considered anomalous

Height of water table above ground surface (m)
High : 126.0
Low : 0.0

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 4-11: Potential Groundwater Discharge Areas

NIAGARA PENINSULA CONSERVATION AUTHORITY

Thursday, June 18, 2009

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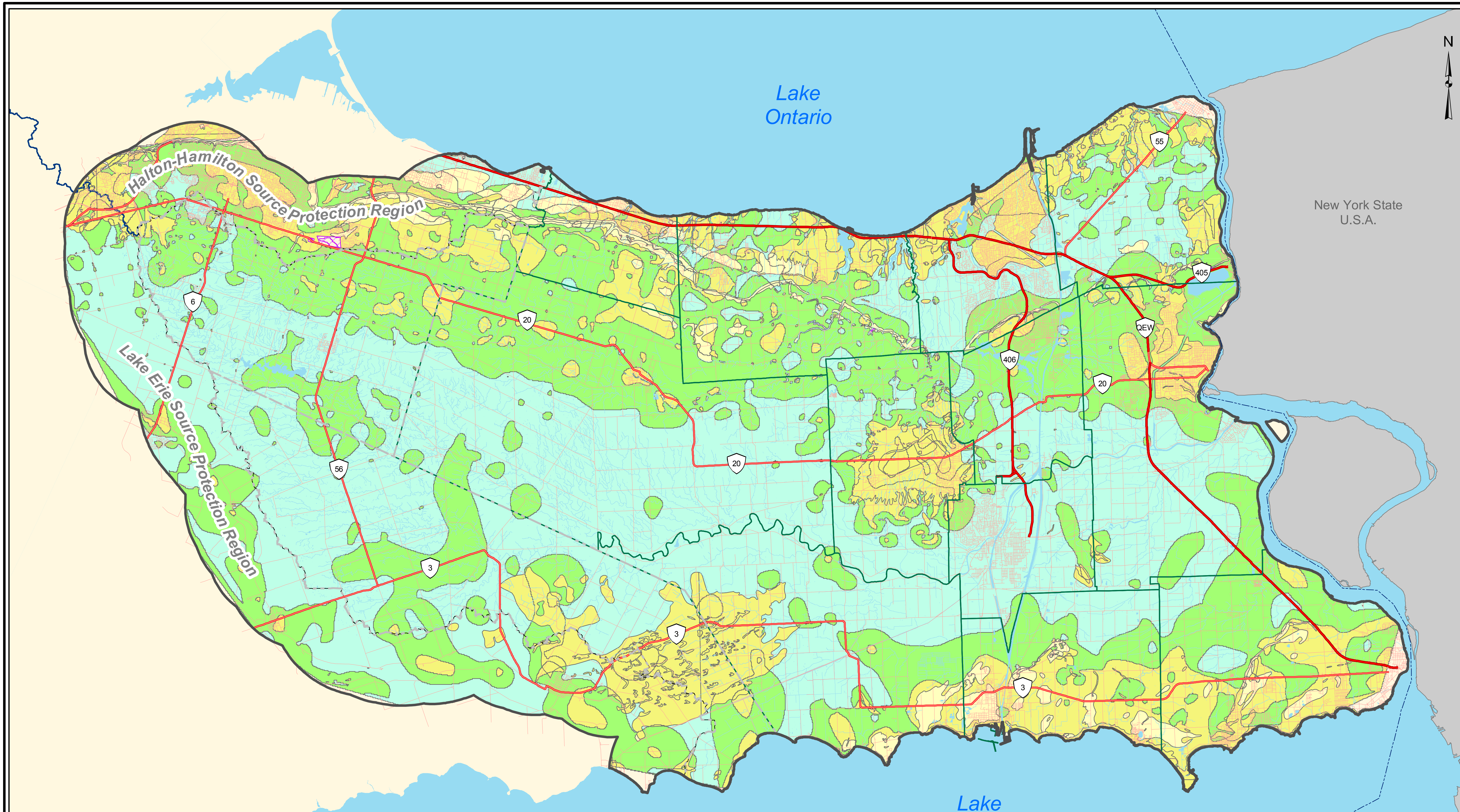

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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Intrinsic Susceptibility

- High (Karst Area)
- High (Bedrock Outcrop)
- High
- Medium
- Low

**Intrinsic Susceptibility Index (ISI) values were calculated at individual wells based on the ISI to the first significant aquifer (determined from well geology and calculated water table and bedrock potentiometric surface maps). Point ISI values across the study area were then interpolated and classed (<30 High susceptibility, 30 to 80 medium susceptibility and >80 low susceptibility). All surficial geology areas mapped as "coarse-textured deposits" (Groundwater Study Figure 2-7 Quaternary Geology) were also classed as high. And all areas mapped as bedrock at surface/outcrop were also classed as high, including karst areas.*

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Watershed Characterization Report

Figure 4.12: Shallow Intrinsic Susceptibility

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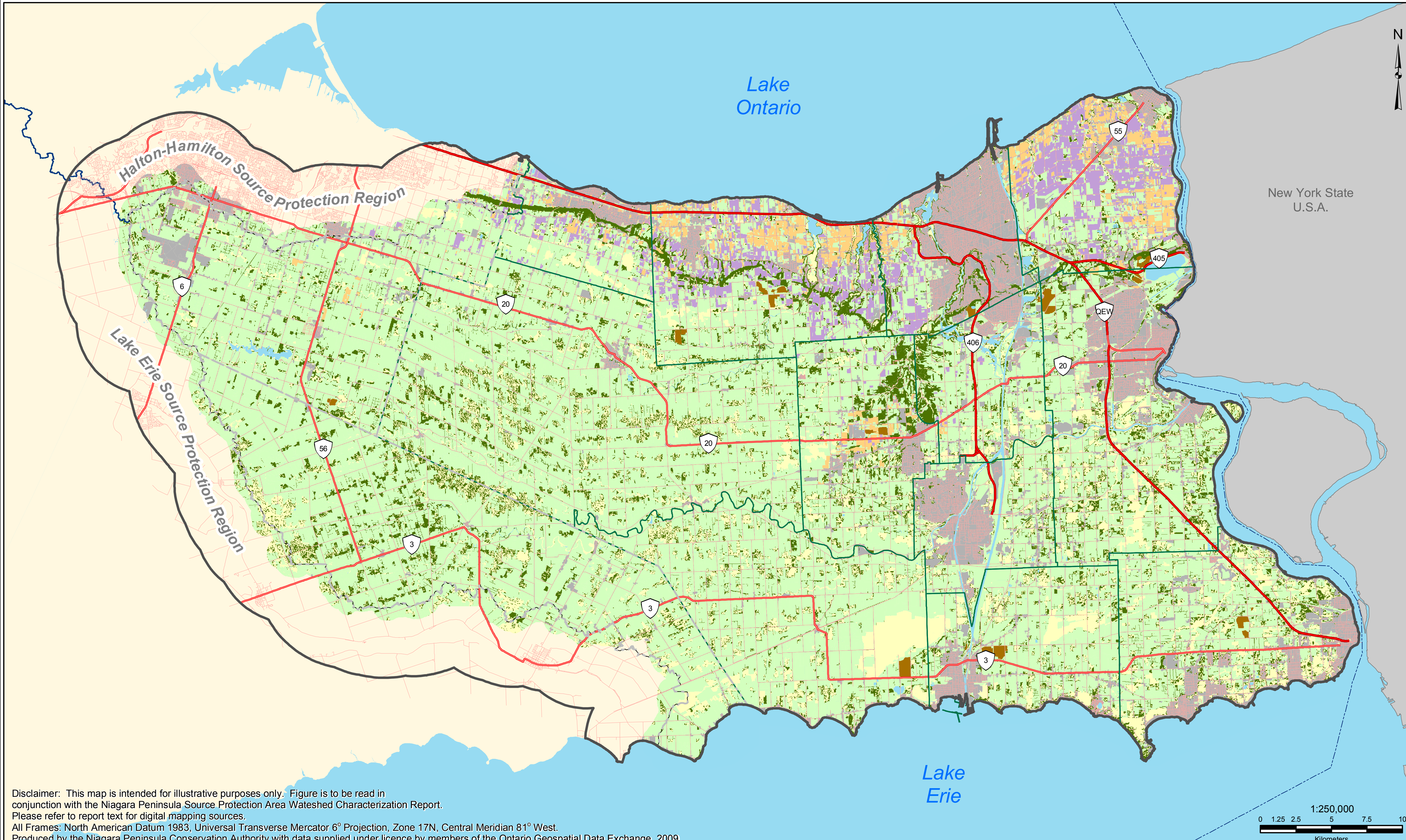

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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

SOLRIS - SIL Land Cover

- Agriculture (58.98 %)
- Wetland (9.70 %)
- Built Up / Transportation (15.00 %)
- Forest (9.64 %)
- Extraction (0.34 %)
- Shoreline (0.01 %)
- Water (1.17 %)
- Orchards (2.10 %)
- Vineyards (3.06 %)

Drinking Water Source Protection
Act for Clean Water

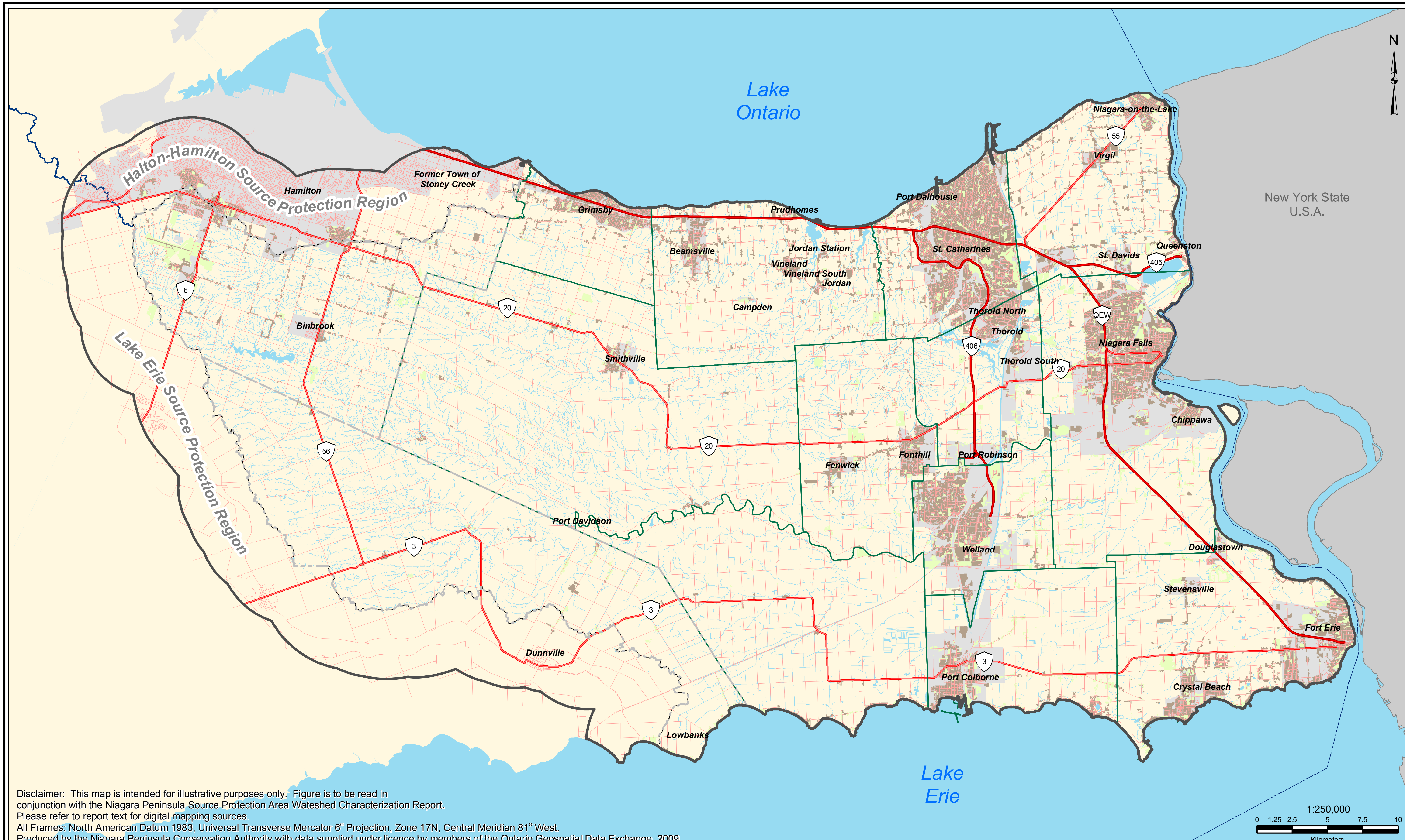
Watershed Characterization Report

Figure 5.1: SOLRIS - SIL Land Cover

Niagara Peninsula Conservation Authority

Tuesday, June 16, 2009

Ontario



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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Built Up Area - Impervious
- Built Up Area - Pervious
- Municipal Urban Area Boundary

Lake Huron, Lake Ontario, Lake Erie

DRINKING WATER SOURCE PROTECTION — ACT FOR CLEAN WATER

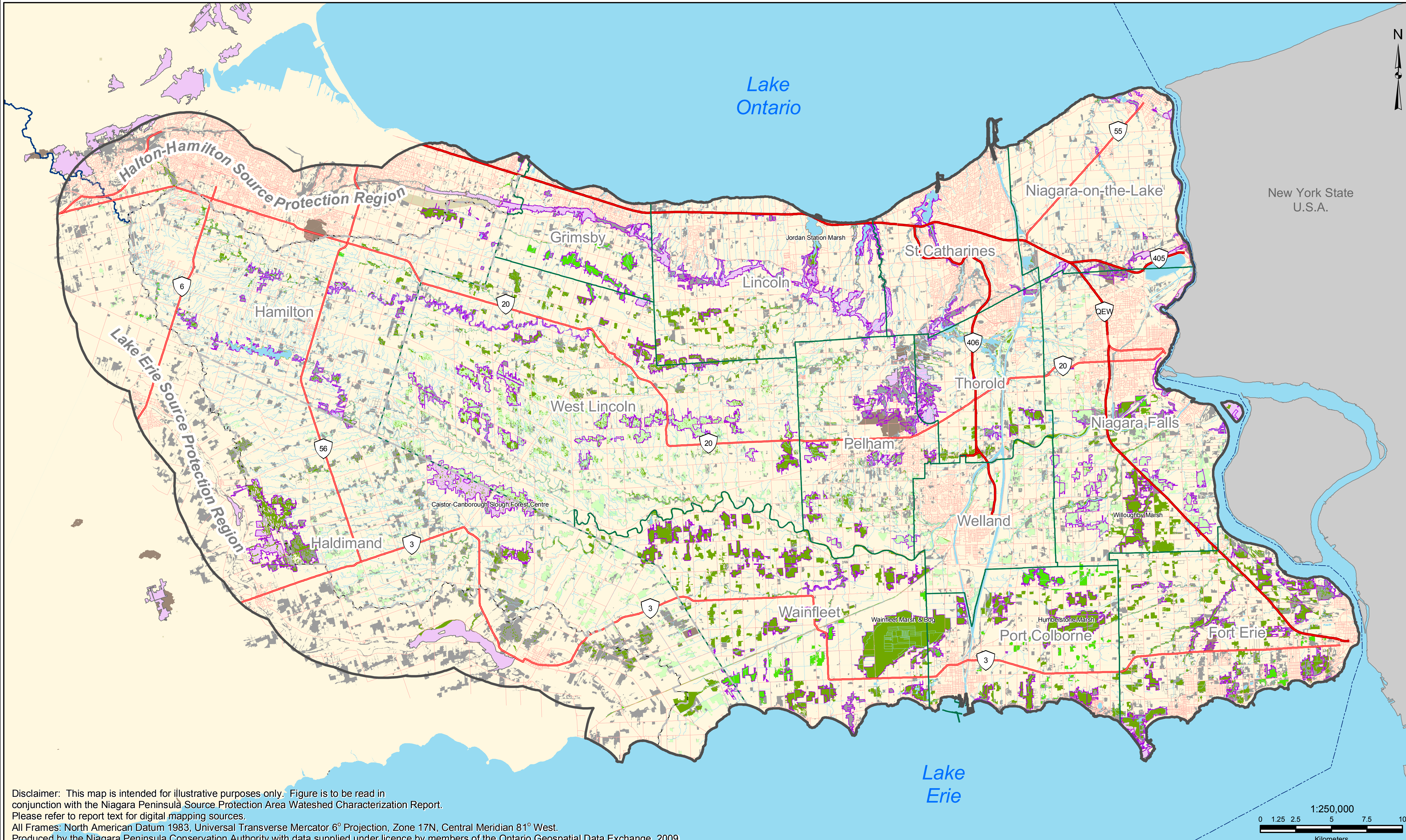
Watershed Characterization Report

Figure 5.2: Current Urban Areas

NIAGARA PENINSULA CONSERVATION AUTHORITY

Tuesday, June 16, 2009

Ontario



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Legend

- International Boundary
- Major Highways
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Environmentally Sensitive Areas
- Unevaluated Wetland
- Locally Significant Wetland
- Provincially Significant Wetland
- npca_gis.GIS_ADMIN.ANSI_LifeScience_030308_LIO
- Regionally Significant Earth Science ANSI
- Provincially Significant Earth Science ANSI
- Unprotected Natural Areas

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 5.3: Protected Natural Areas

NIAGARA PENINSULA CONSERVATION AUTHORITY

Thursday, June 18, 2009

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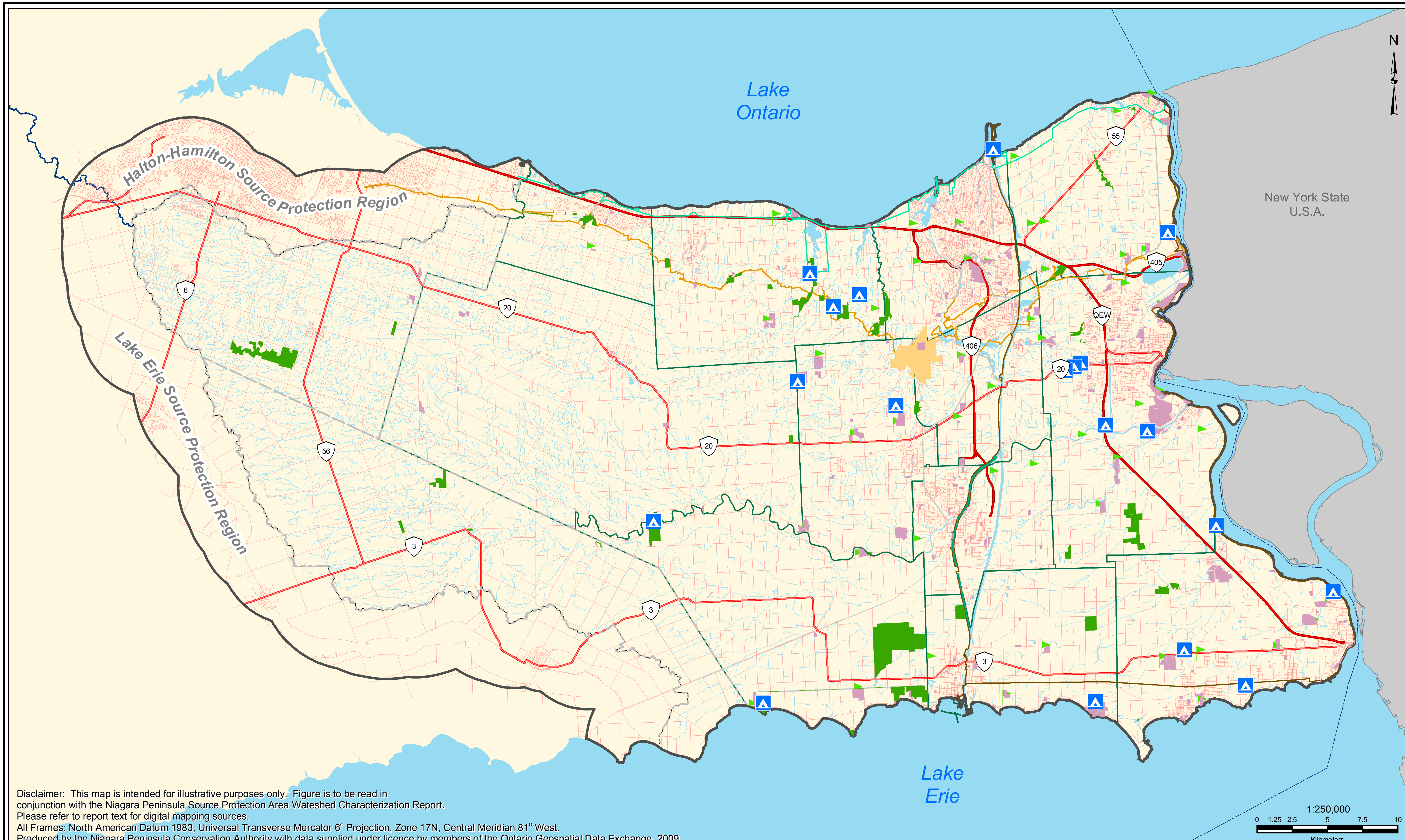

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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Campgrounds
- Conservation Areas
- Short Hills Provincial Park
- Parks and Recreational
- Off Road Biclycle Trails
- Greater Niagara Circle Route
- Lake Ontario Waterfront Trail
- Bruce Trail
- Golf Course
- Welland Recreational Canal

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 5.4: Recreational Areas

NIAGARA PENINSULA CONSERVATION AUTHORITY

Monday, June 22, 2009

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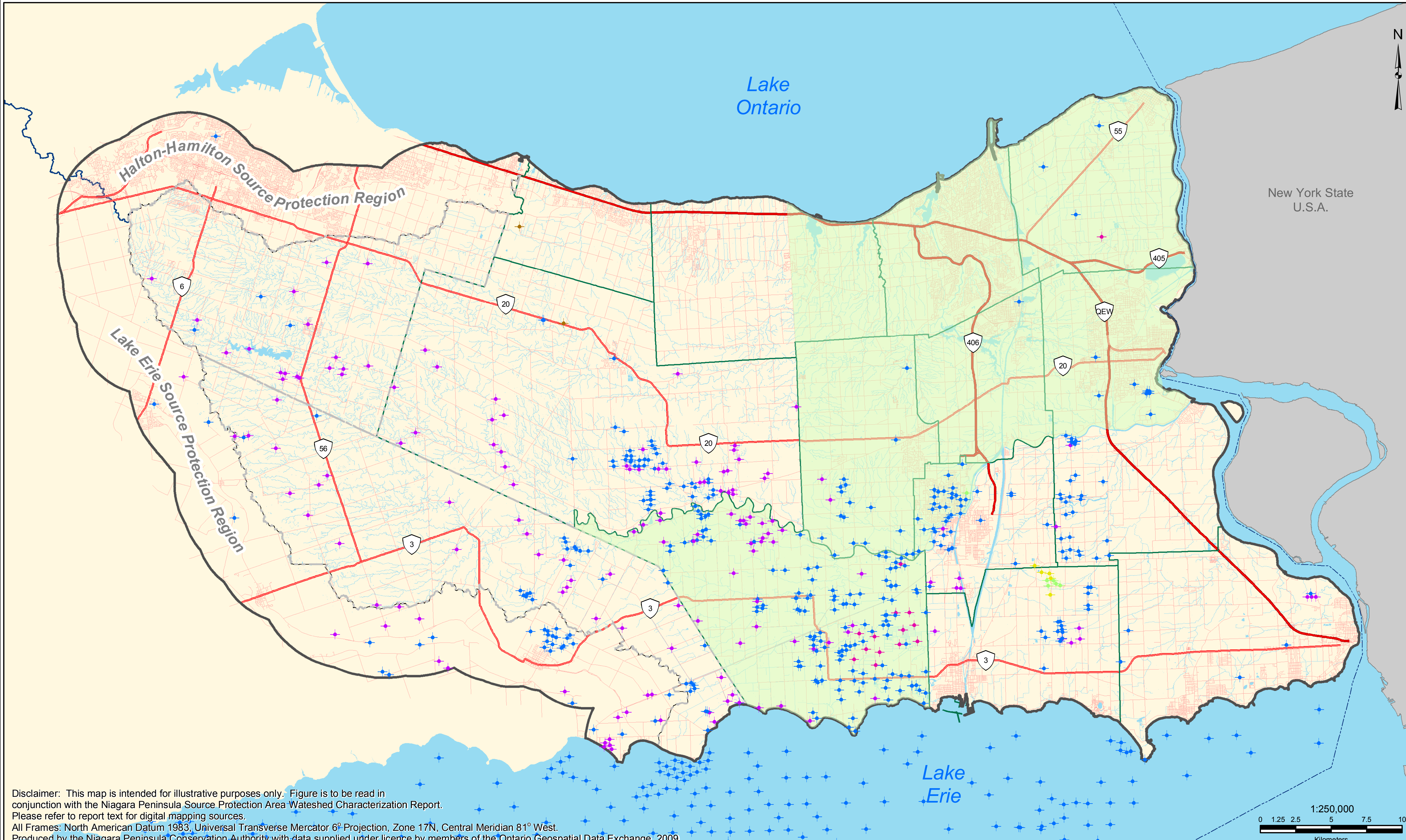


Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- OGSRL Natural Gas Storage Well
- OGSRL Natural Gas Well
- OGSRL Observation Well
- OGSRL Oil and Gas Well
- OGSRL Private Gas Well
- OGSRL Stratigraphic Test
- Current Area of Well Data Verified for OPDS*

**The OGSR Library, in conjunction with MNR, has been populating the Ontario Petroleum Data System (OPDS) with data, and verifying the file data and well co-ordinates. This map depicts the status of this effort as of June 2006. Remaining areas are either in progress or have yet to be initiated.*

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 5.5: Oil and Gas Wells

NIAGARA PENINSULA CONSERVATION AUTHORITY

Monday, June 22, 2009

Ontario

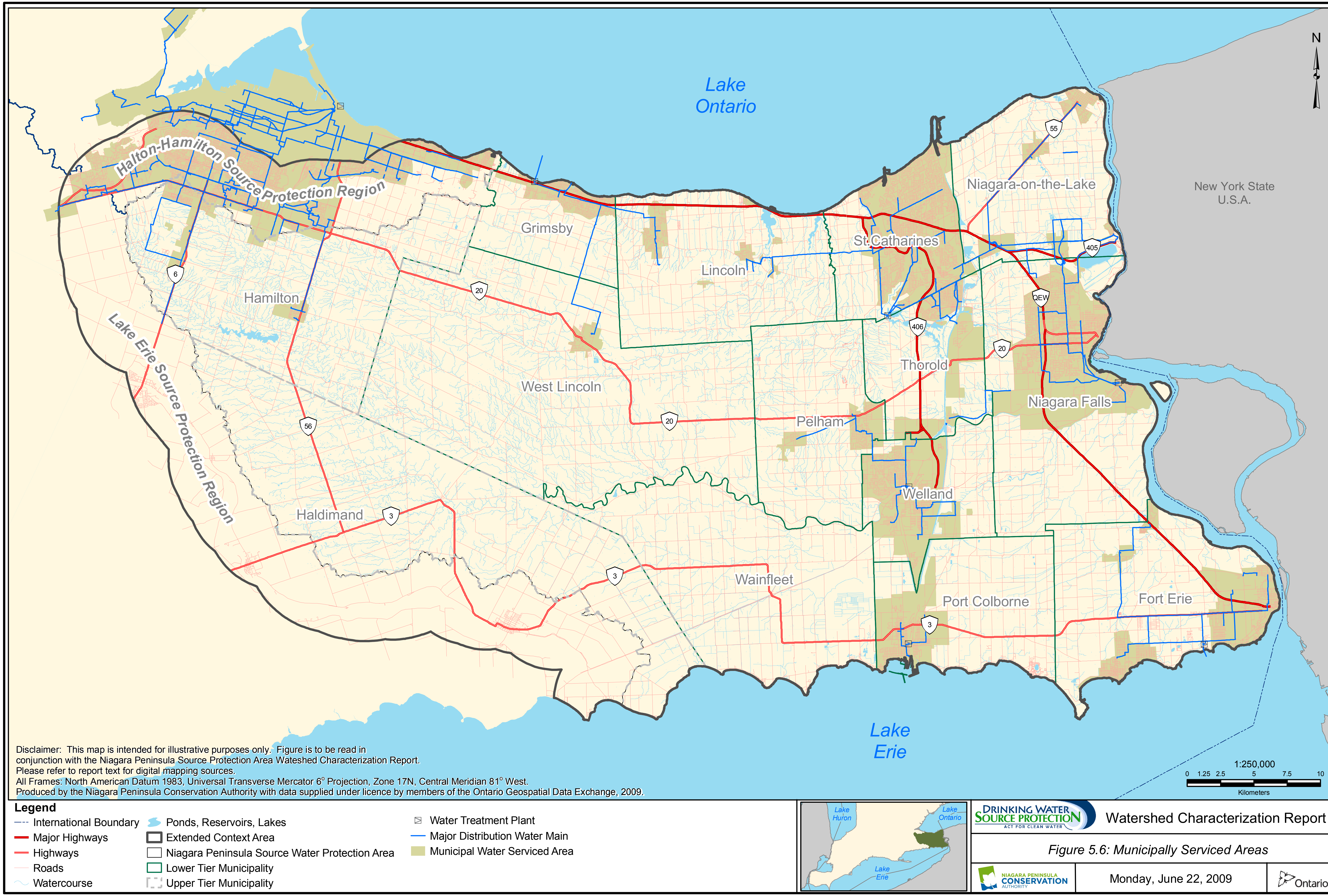
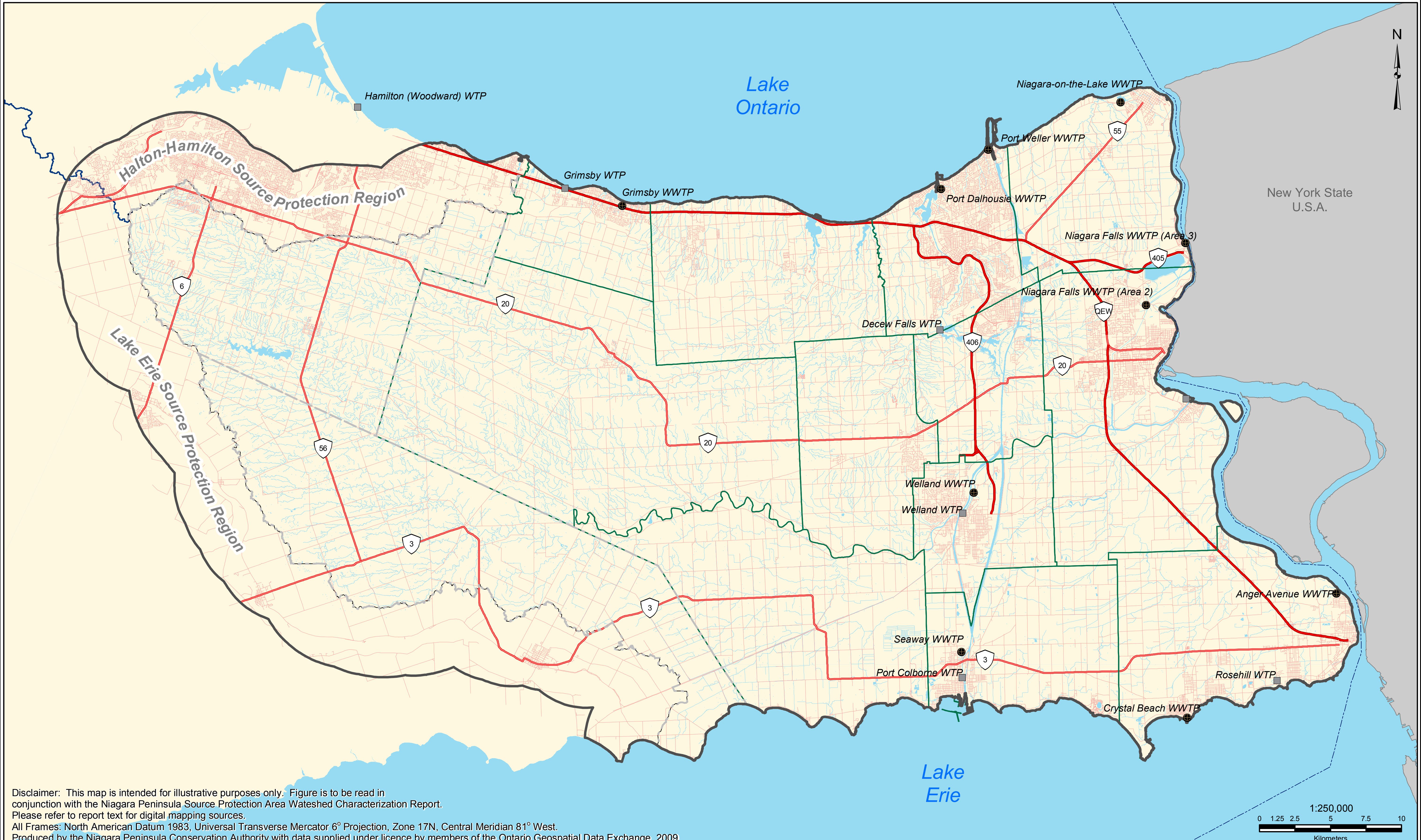


Figure 5.6: Municipally Serviced Areas



Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Municipal Water Treatment Plant (WTP)
- Municipal Waste Water Treatment Plant (WWTP)

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

Watershed Characterization Report

Figure 5.7: Water Treatment Plant Locations

NIAGARA PENINSULA CONSERVATION AUTHORITY

Monday, June 22, 2009

Ontario

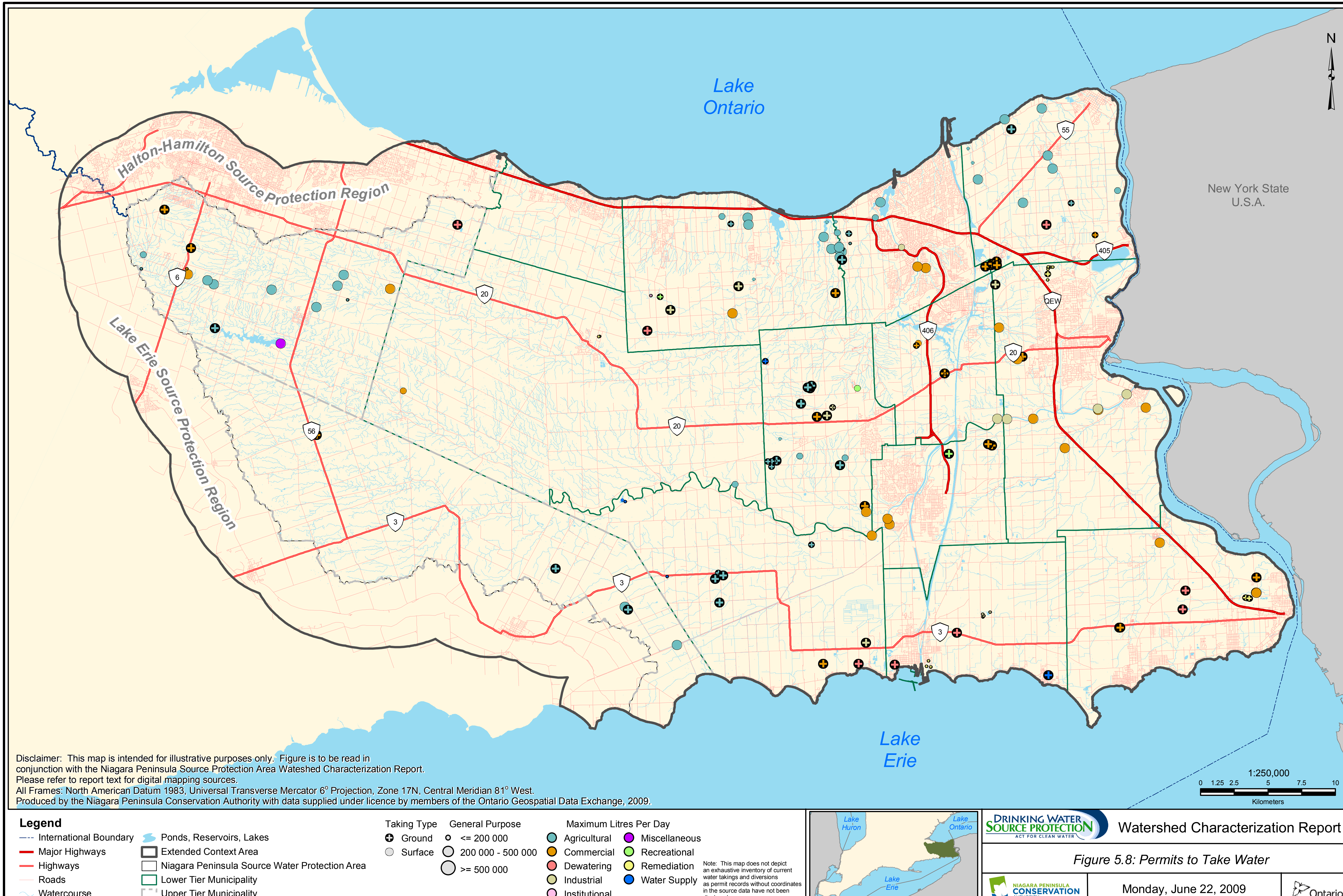
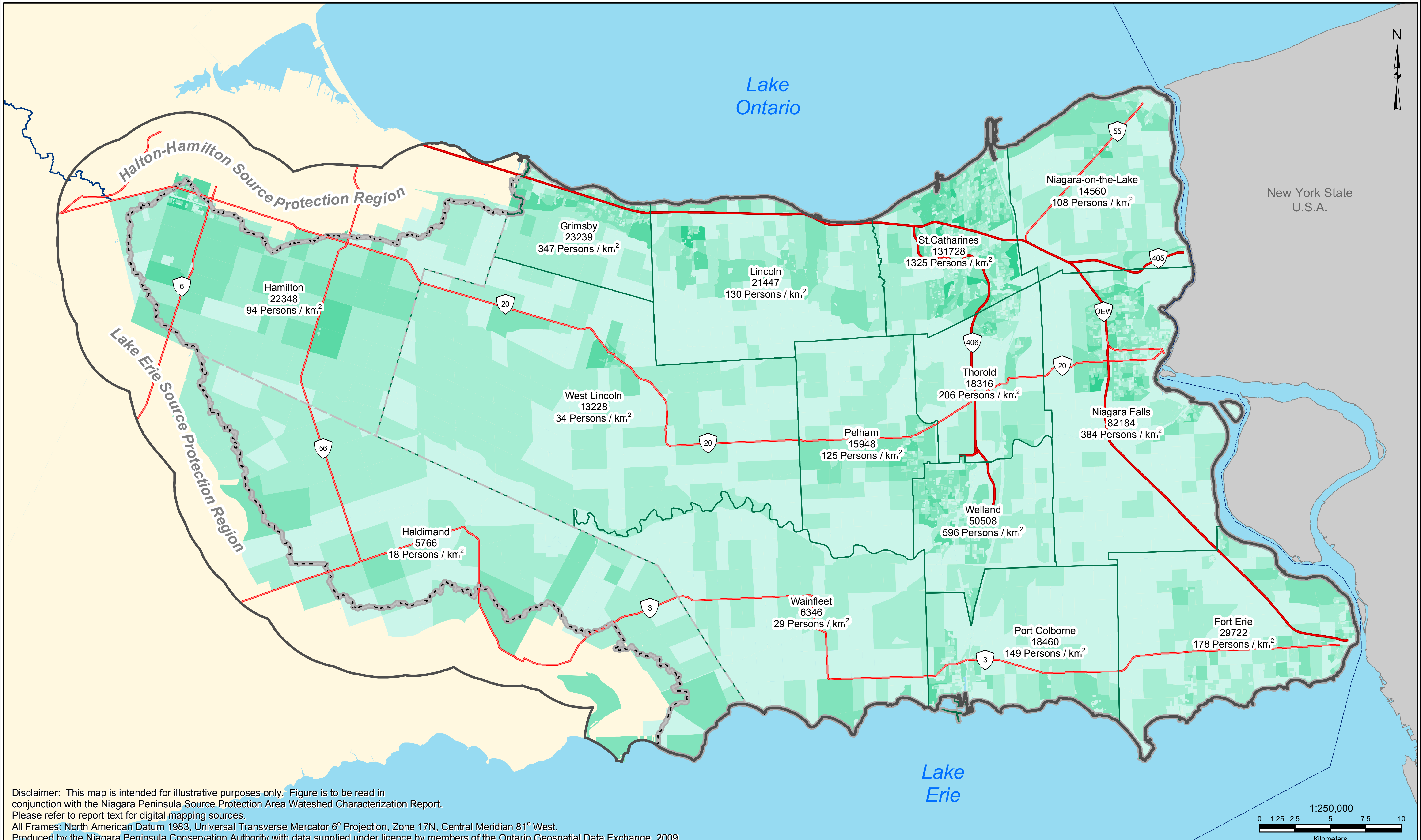


Figure 5.8: Permits to Take Water



Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Population Density (Persons / km^2)

- 0 - 50
- 51 - 150
- 151 - 500
- 501 - 1000
- 1001 - 2000

West Lincoln: Municipality
13228: Population
34: Population Density

Note: Population statistics compiled from Statistics Canada 2006 Dessimination Block Census data

Drinking Water Source Protection — Act for Clean Water

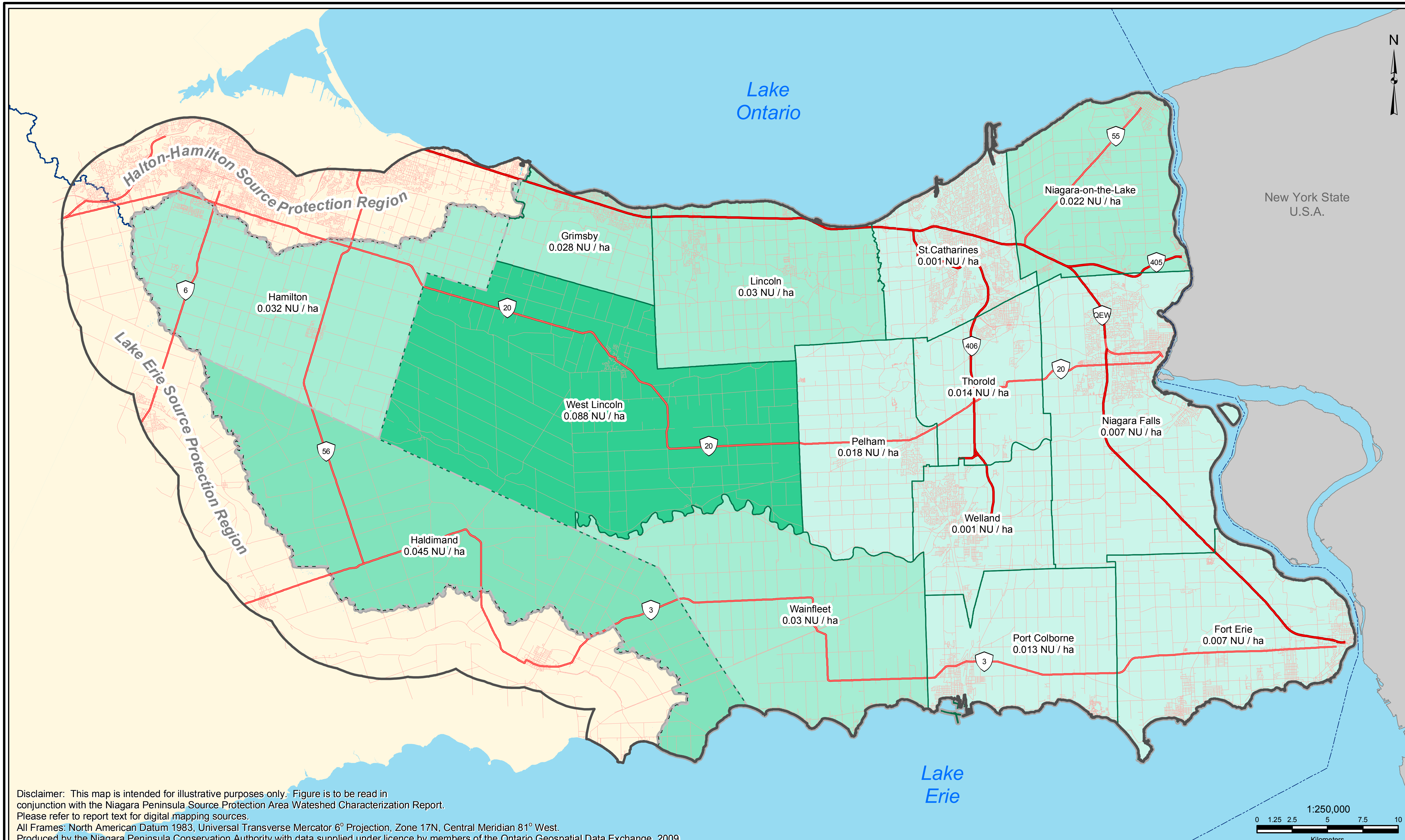
Watershed Characterization Report

Figure 5.9: Municipal Population and Population Density

Niagara Peninsula Conservation Authority

Tuesday, June 16, 2009

Ontario



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Legend

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- Highways
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- Lower Tier Municipality
- Upper Tier Municipality

Livestock Density (Nutrient Units / hectares)

- 0.000 - 0.020
- 0.021 - 0.040
- 0.041 - 0.060
- 0.061 - 0.080
- 0.081 - 0.100

West Lincoln: Municipality
0.217: Nutrient Units / hectares

Note: Livestock density statistics compiled from Statistics Canada 2006 Consolidated Census Subdivision and Ontario Ministry of Agriculture, Food and Rural Affairs data

Drinking Water Source Protection — Act for Clean Water

Watershed Characterization Report

Figure 5.10: Livestock Density

Niagara Peninsula Conservation Authority

Tuesday, June 16, 2009

Ontario

Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Produced by the Niagara Peninsula Conservation Authority with data supplied under licence by members of the Ontario Geospatial Data Exchange, 2009.

1:250,000
0 1.25 2.5 5 7.5 10
Kilometers

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Structure Type
- Dam
- Lock-gate

Lake Huron
Lake Ontario
Lake Erie

DRINKING WATER SOURCE PROTECTION — ACT FOR CLEAN WATER

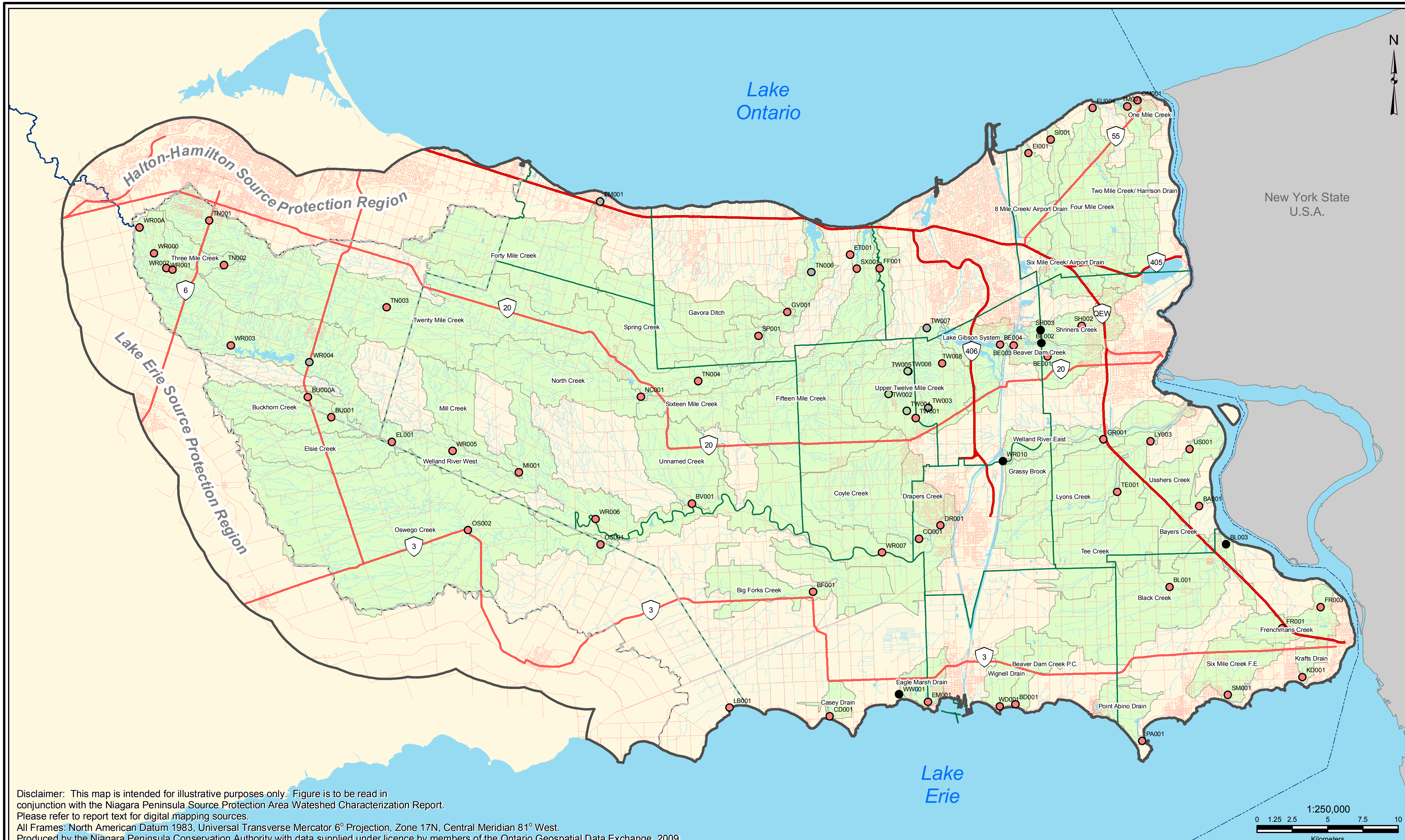
Watershed Characterization Report

Figure 5.11: Surface Water Control Structures

NIAGARA PENINSULA CONSERVATION AUTHORITY

Thursday, July 16, 2009

Ontario



Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

NPCA Sampling Site and Rating*

- Grey Zone
- Impaired
- Insufficient Data
- Unimpaired
- Sampled Subwatersheds

* Ratings are based on Biomap assessment which was calculated using data collected from 2001 - 2009

Lake Huron · Lake Ontario · Lake Erie

DRINKING WATER SOURCE PROTECTION ACT FOR CLEAN WATER

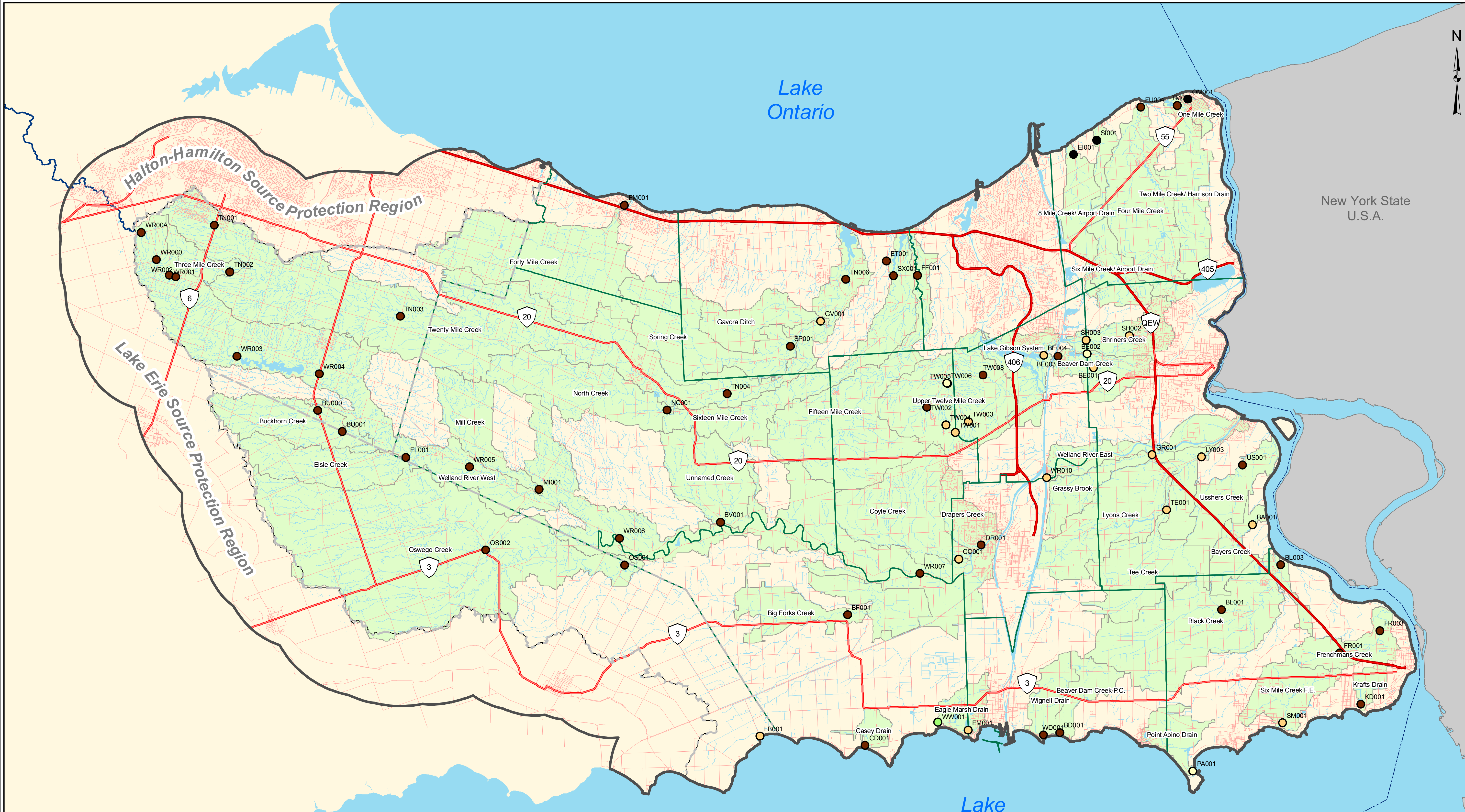
Watershed Characterization Report

Figure 6.1: Biomap Surface Water Quality

NIAGARA PENINSULA CONSERVATION AUTHORITY

Monday, June 22, 2009

Ontario



Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

NPCA Sampling Site and Rating*

- Good
- Fair
- Marginal
- Poor
- Insufficient Data
- Sampled Subwatersheds

* Ratings are based on Biomap assessment which was calculated using data collected from 2001 - 2009

Drinking Water Source Protection — Act for Clean Water

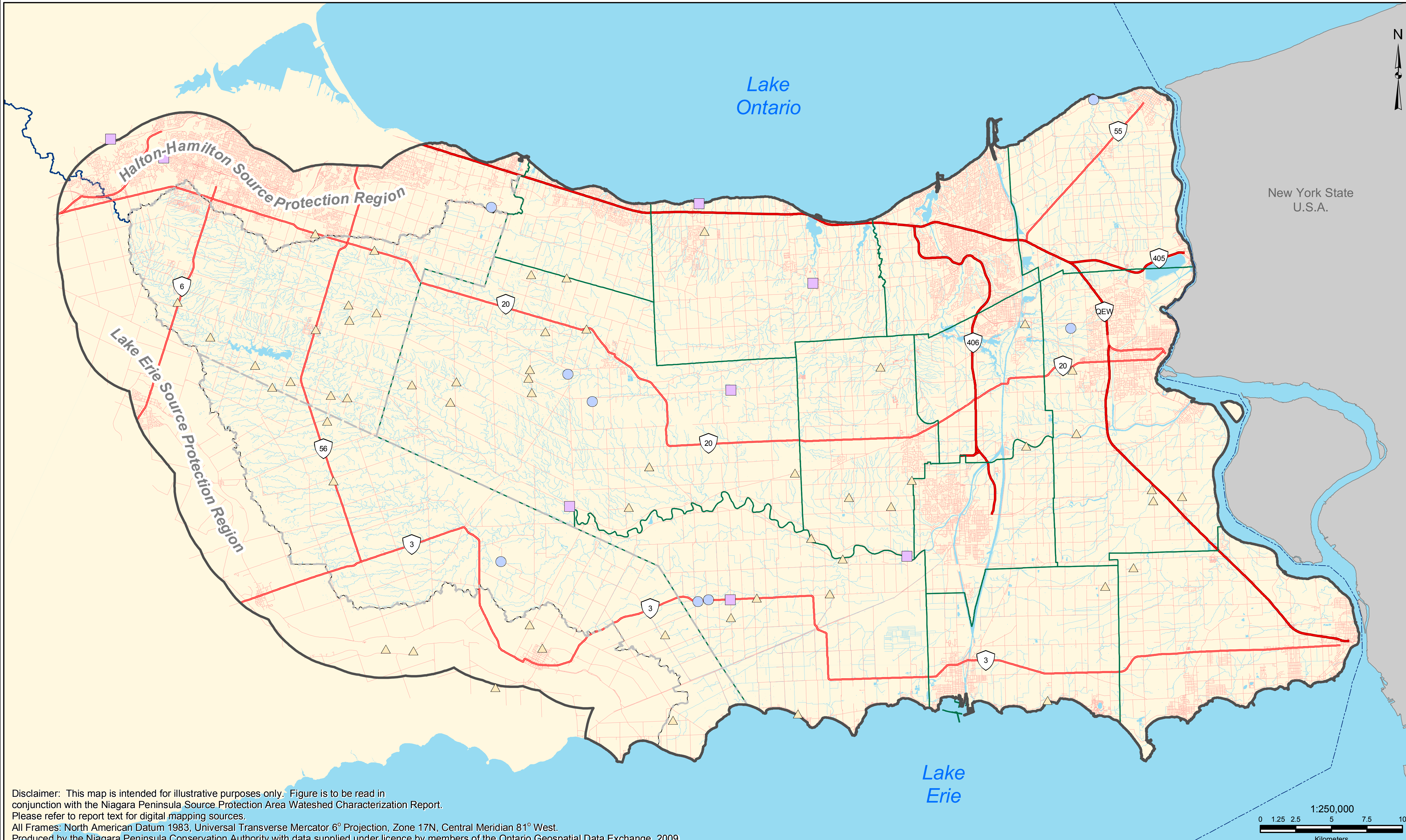
Watershed Characterization Report

Figure 6.2: General Surface Water Quality

Niagara Peninsula Conservation Authority

Monday, June 22, 2009

Ontario



Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Produced by the Niagara Peninsula Conservation Authority with data supplied under licence by members of the Ontario Geospatial Data Exchange, 2009.

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Mineral
- Salty
- Sulphur

Drinking Water Source Protection — Act for Clean Water

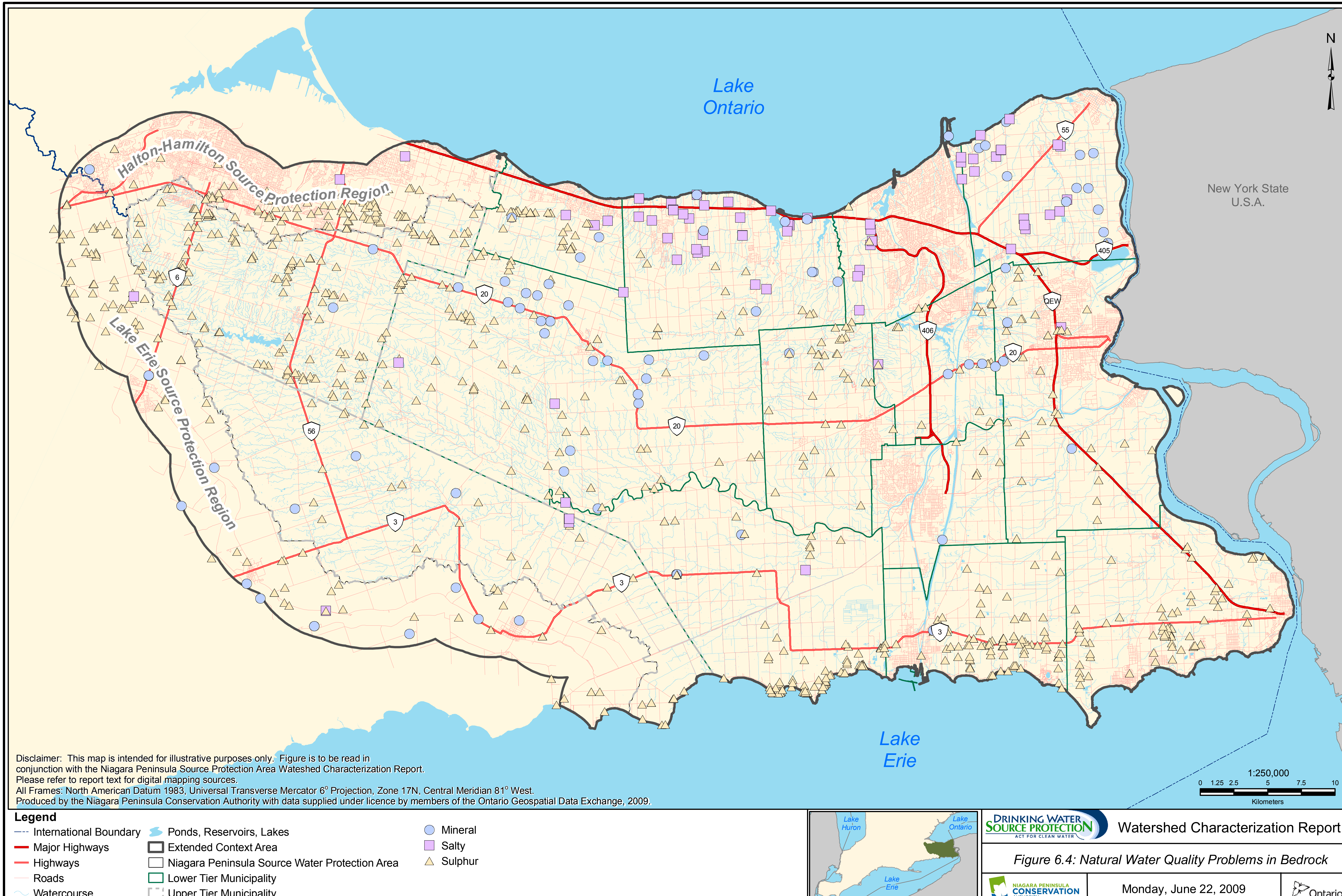
Watershed Characterization Report

Figure 6.3: Natural Water Quality Problems in Overburden

Niagara Peninsula Conservation Authority

Monday, June 22, 2009

Ontario

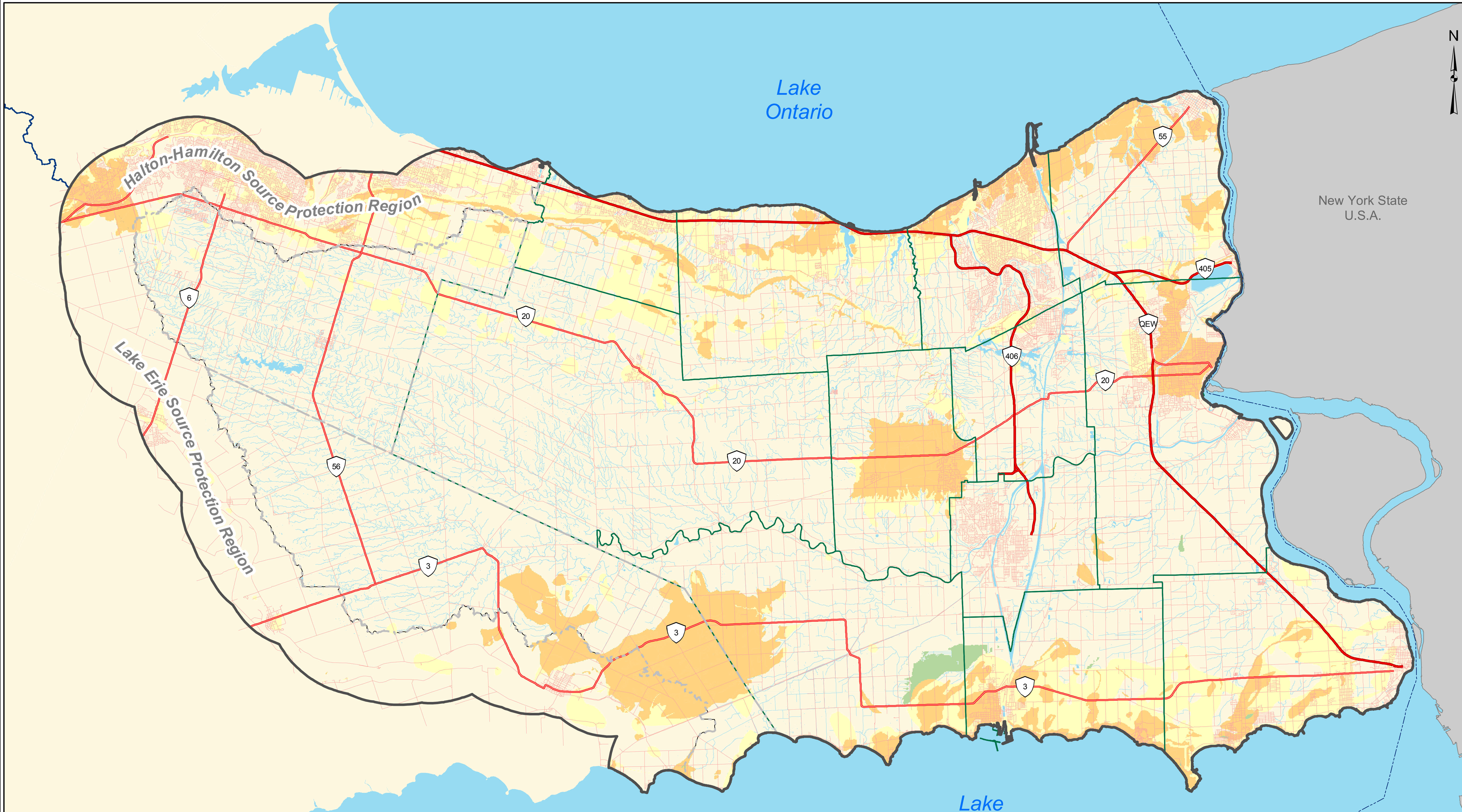


Watershed Characterization Report

Figure 6.4: Natural Water Quality Problems in Bedrock

Monday, June 22, 2009

Lake Ontario
Lake Erie
New York State U.S.A.
Halton-Hamilton Source Protection Region
Lake Erie Source Protection Region
N
GA384
GA288
GA073
GA341
GA356-A
GA080
GA361-A
GA362-A
GA362-B
GA361-B
GA287
GA290
GA289
6
20
56
3
55
405
QEW
406
Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Produced by the Niagara Peninsula Conservation Authority with data supplied under licence by members of the Ontario Geospatial Data Exchange, 2009.
1:250,000
0 1.25 2.5 5 7.5 10
Kilometers
Legend
International Boundary
Major Highways
Highways
Roads
Watercourse
Ponds, Reservoirs, Lakes
Extended Context Area
Niagara Peninsula Source Water Protection Area
Lower Tier Municipality
Upper Tier Municipality
Monitoring Well
Lake Huron
Lake Ontario
Lake Erie
Drinking Water Source Protection
Act for Clean Water
Watershed Characterization Report
Figure 6.5: Provincial Groundwater Monitoring Network
Niagara Peninsula Conservation Authority
Monday, June 22, 2009
Ontario



Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Produced by the Niagara Peninsula Conservation Authority with data supplied under licence by members of the Ontario Geospatial Data Exchange, 2009.

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality

Intrinsic Susceptibility MOE Method 1

- High Intrinsic Susceptibility and Significant Recharge Areas
- High Intrinsic Susceptibility
- Significant Recharge Areas

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

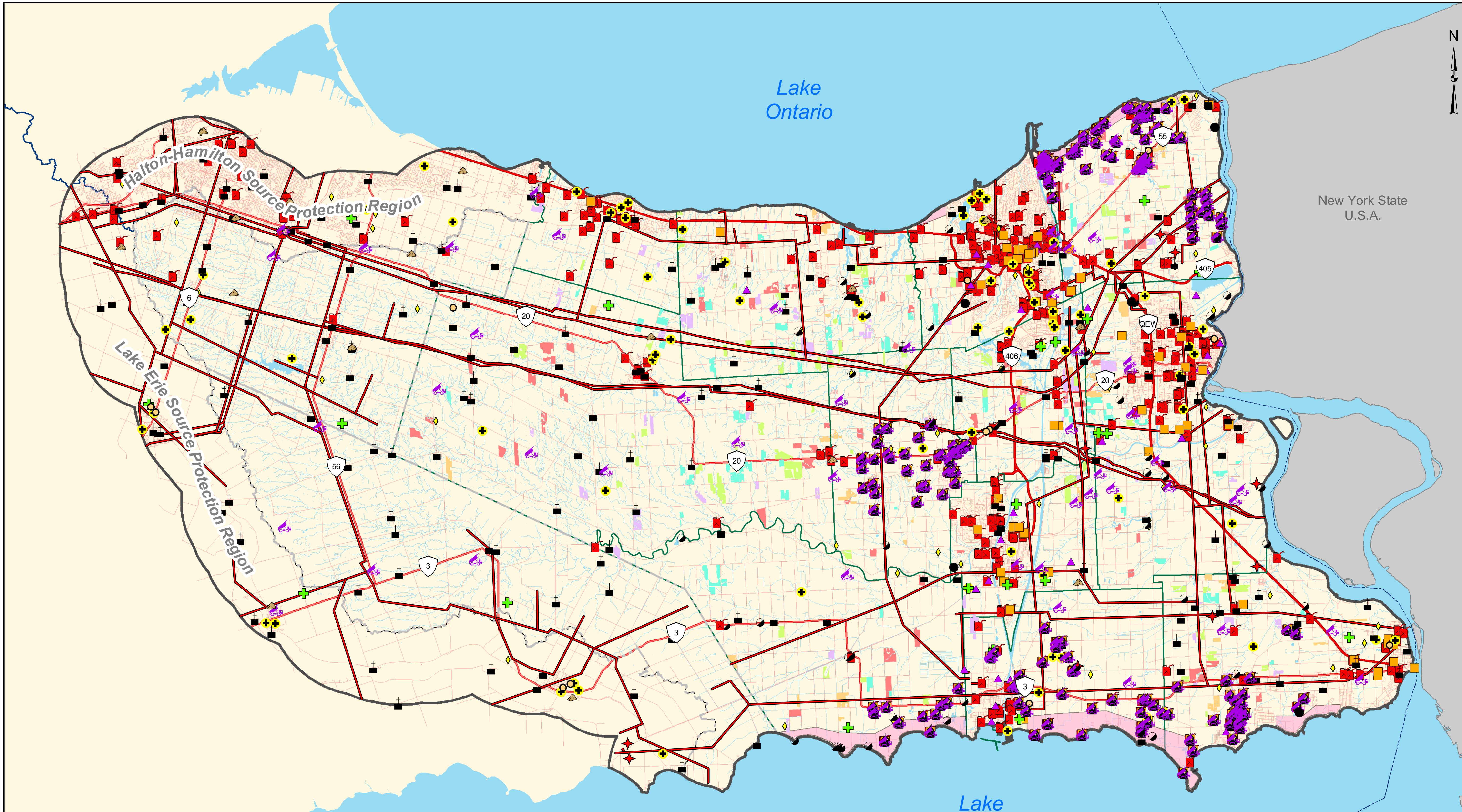
Watershed Characterization Report

Figure 7.1: Aquifer Areas of High Vulnerability

NIAGARA PENINSULA CONSERVATION AUTHORITY

Friday, June 26, 2009

Ontario



Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Produced by the Niagara Peninsula Conservation Authority with data supplied under licence by members of the Ontario Geospatial Data Exchange, 2009.

Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Sand and Gravel Pit
- Quarry
- Active Landfills
- Closed Landfills
- Waste Sites
- PCBs
- Fuel Storage
- Cemeteries
- Hazardous Waste Receiver
- Automotive / Machinery
- Pipeline Transfer Stations
- Pipelines
- Salt Storage Domes
- Lumber Yards
- Golf Courses
- Septic System Problem Areas
- Large Sewage Systems
- Sewage / Septic Systems

Biosolids
'99 '00 '01 '02 '03

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

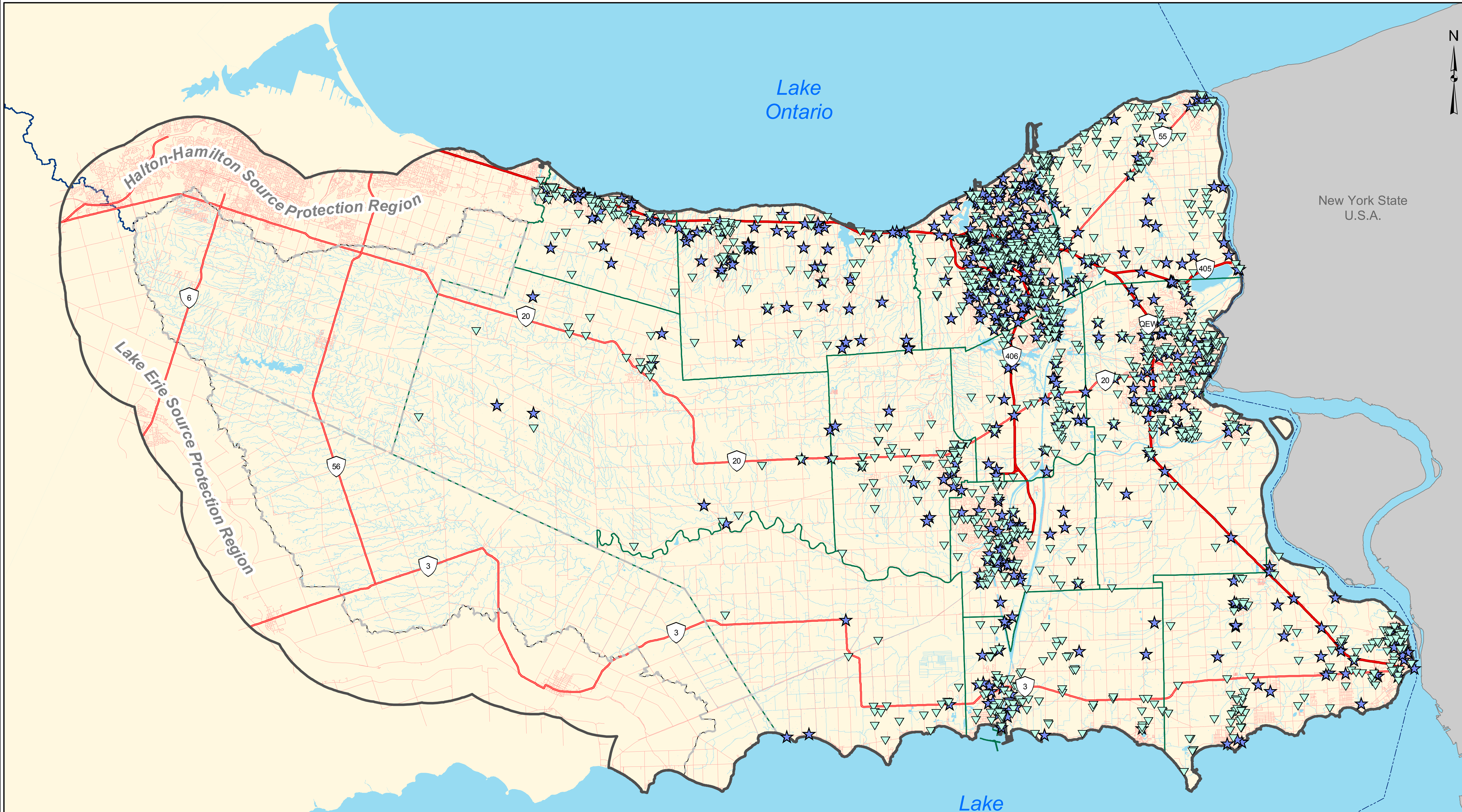
Watershed Characterization Report

Figure 8.1: Potential Contaminant Sources Inventory

NIAGARA PENINSULA CONSERVATION AUTHORITY

Friday, June 26, 2009

Ontario



Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Wateshed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
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Legend

- International Boundary
- Major Highways
- Highways
- Roads
- Watercourse
- Ponds, Reservoirs, Lakes
- Extended Context Area
- Niagara Peninsula Source Water Protection Area
- Lower Tier Municipality
- Upper Tier Municipality
- Hazardous Waste Generator
- Spills

Lake Huron
Lake Ontario
Lake Erie

DRINKING WATER SOURCE PROTECTION — ACT FOR CLEAN WATER

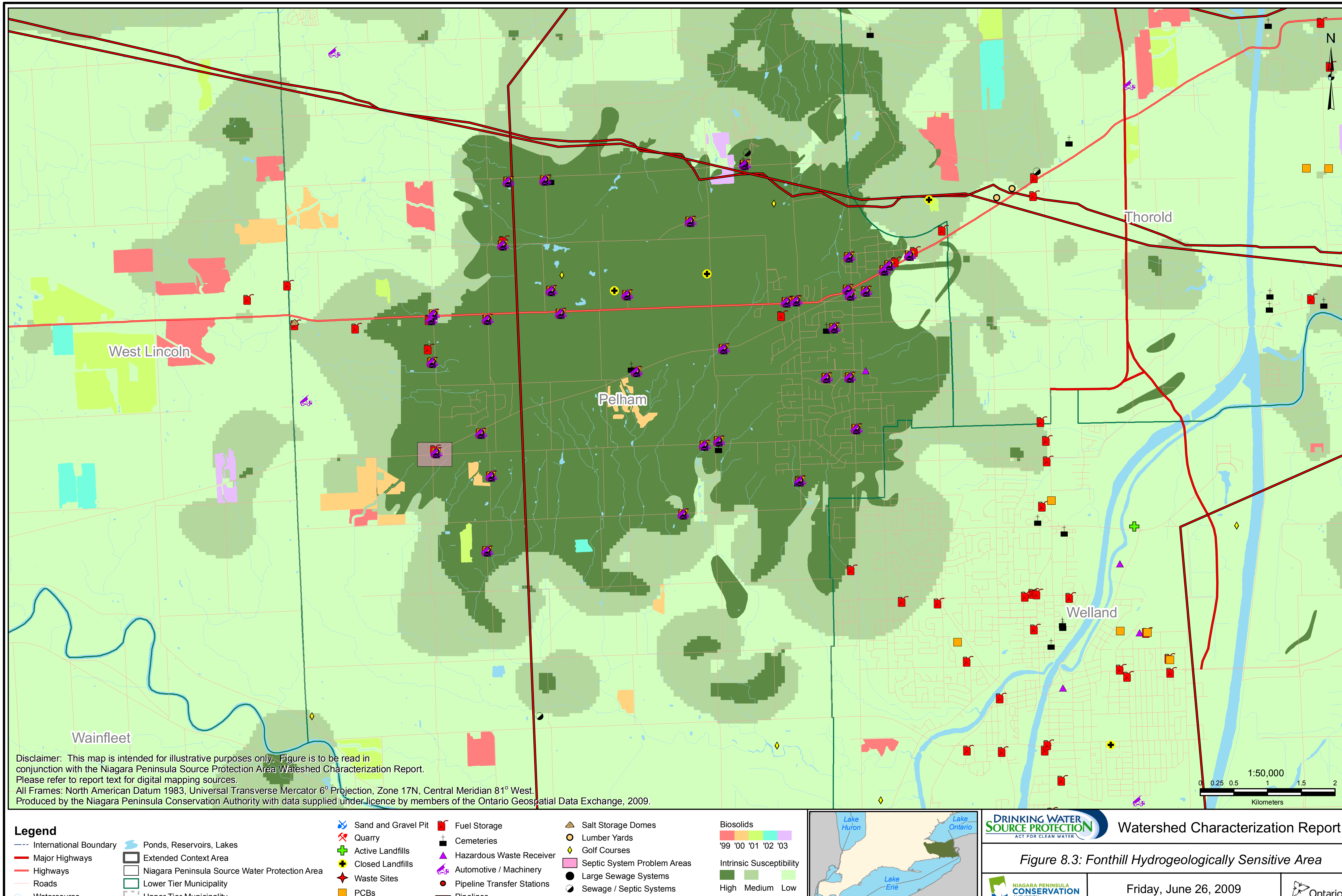
Watershed Characterization Report

Figure 8.2: Spills and Hazardous Waste Generating Sites

NIAGARA PENINSULA CONSERVATION AUTHORITY

Monday, June 29, 2009

Ontario



N
Thorold
West Lincoln
Pelham
Welland
Wainfleet
Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Watershed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Produced by the Niagara Peninsula Conservation Authority with data supplied under licence by members of the Ontario Geospatial Data Exchange, 2009.
1:50,000
0 0.25 0.5 1 1.5 2
Kilometers
Legend
International Boundary
Major Highways
Highways
Roads
Watercourse
Ponds, Reservoirs, Lakes
Extended Context Area
Niagara Peninsula Source Water Protection Area
Lower Tier Municipality
Upper Tier Municipality
Sand and Gravel Pit
Quarry
Active Landfills
Closed Landfills
Waste Sites
PCBs
Fuel Storage
Cemeteries
Hazardous Waste Receiver
Automotive / Machinery
Pipeline Transfer Stations
Pipelines
Salt Storage Domes
Lumber Yards
Golf Courses
Septic System Problem Areas
Large Sewage Systems
Sewage / Septic Systems
Biosolids
'99 '00 '01 '02 '03
Intrinsic Susceptibility
High Medium Low
Lake Huron
Lake Ontario
Lake Erie
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER
Watershed Characterization Report
Figure 8.3: Fonthill Hydrogeologically Sensitive Area
NIAGARA PENINSULA CONSERVATION AUTHORITY
Friday, June 26, 2009
Ontario

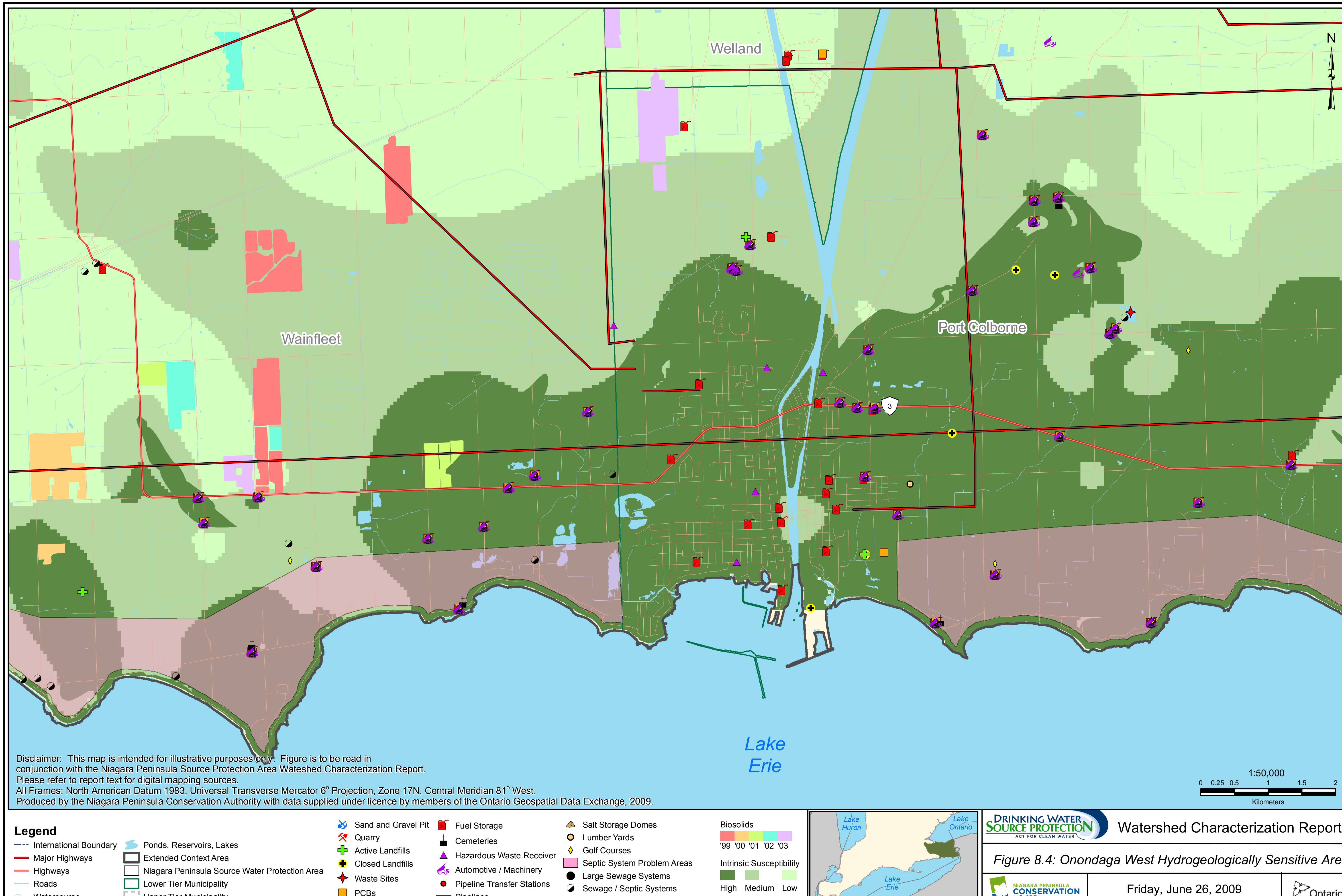
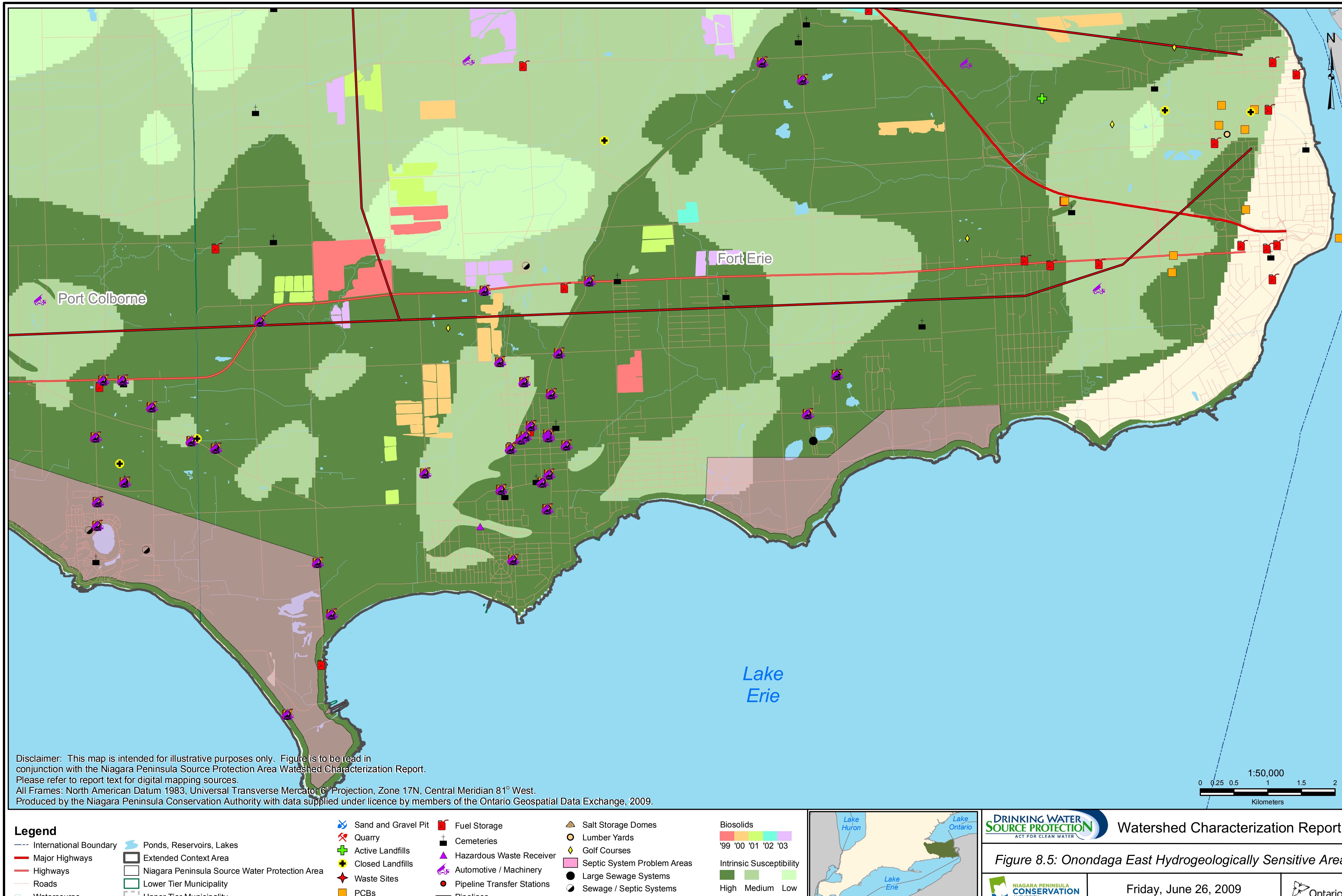


Figure 8.4: Onondaga West Hydrogeologically Sensitive Area


N
Fort Erie
Port Colborne
Lake Erie
Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Area Watershed Characterization Report.
Please refer to report text for digital mapping sources.
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
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1:50,000
0 0.25 0.5 1 1.5 2
Kilometers
Legend
International Boundary
Major Highways
Highways
Roads
Watercourse
Ponds, Reservoirs, Lakes
Extended Context Area
Niagara Peninsula Source Water Protection Area
Lower Tier Municipality
Upper Tier Municipality
Sand and Gravel Pit
Quarry
Active Landfills
Closed Landfills
Waste Sites
PCBs
Fuel Storage
Cemeteries
Hazardous Waste Receiver
Automotive / Machinery
Pipeline Transfer Stations
Pipelines
Salt Storage Domes
Lumber Yards
Golf Courses
Septic System Problem Areas
Large Sewage Systems
Sewage / Septic Systems
Biosolids
'99 '00 '01 '02 '03
Intrinsic Susceptibility
High Medium Low
Lake Huron
Lake Ontario
Lake Erie
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER
Watershed Characterization Report
Figure 8.5: Onondaga East Hydrogeologically Sensitive Area
NIAGARA PENINSULA CONSERVATION AUTHORITY
Friday, June 26, 2009
Ontario

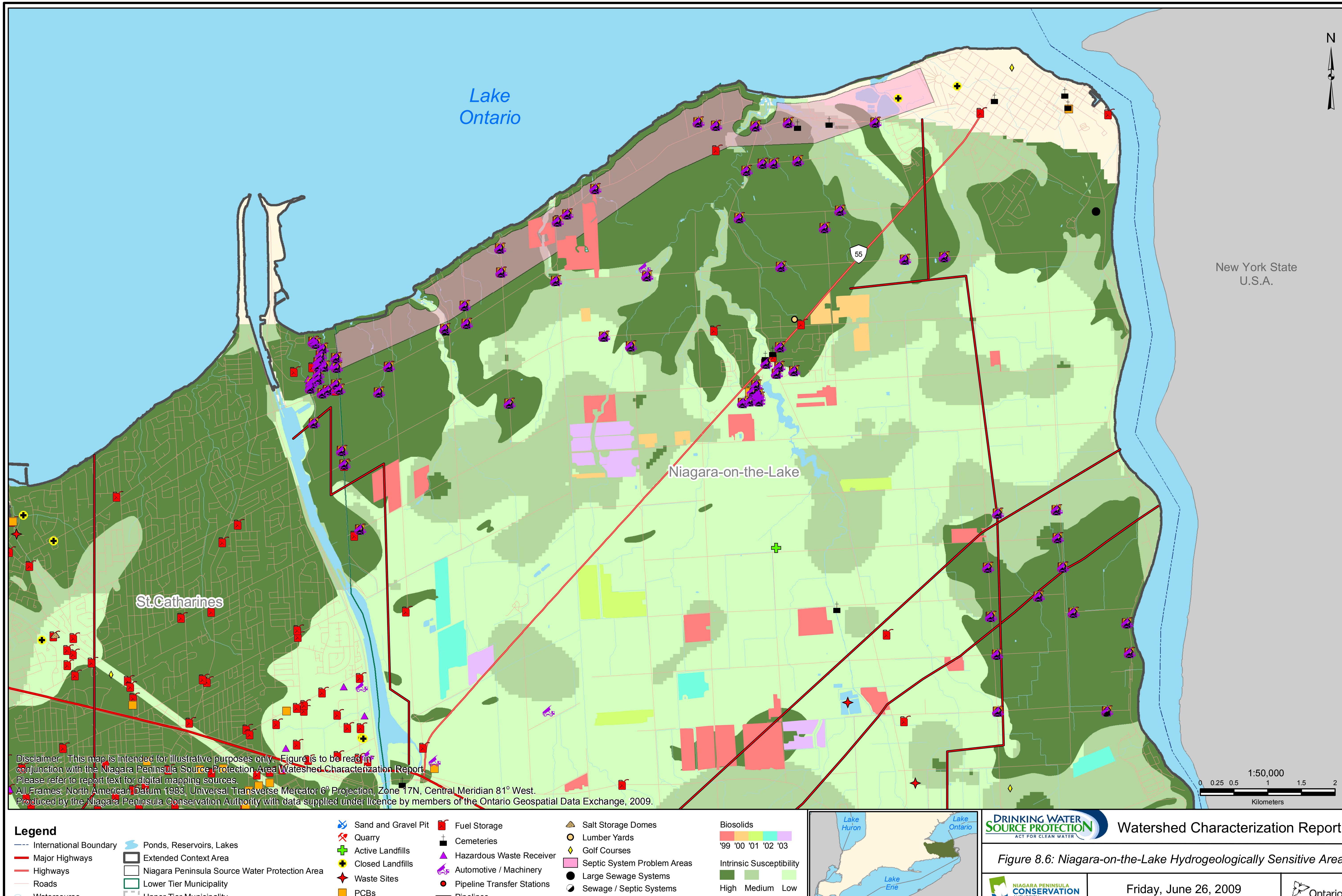


Figure 8.6: Niagara-on-the-Lake Hydrogeologically Sensitive Area

APPENDIX A

Summary of Existing Reports and Projects

List of Reports and Projects Summarized in this Appendix:

1. NPCA Groundwater Study Draft Report, by Waterloo Hydrogeologic Inc. dated Nov 2004.
2. Niagara Water Quality Protection Strategy (NWQPS) Volume 1, Part 1 (Technical Summary Report and Phase 1 Report); and
   Volume 1, Part 2 (Phase 2, 3, and 4 Reports and Appendices)
3. Niagara Water Quality Protection Strategy (NWQPS) Volume 2
   Local Mgmt Areas Summaries.
4. Twelve Mile Creek Watershed Plan; Phase 1 Background Study and Issues Identification by NPCA dated April 2005.
5. Twenty Mile Creek Watershed Plan; Phase 1 Background Study and Issues Identification by NPCA dated April 2005.
6. Warren Creek Watershed Master Plan by Philips Engineering dated September 2000 and commissioned by City of Niagara Falls.
7. Niagara River Remedial Action Plan Reports and Related Projects
    1. Environmental Conditionsand Problem Definition, Remedial Action Plan Stage 1 Report, by MOE, MNR, EC, and FOC.
    2. AOC Water Quality Improvement Program
    3. Welland River Water Level Fluctuation Project
    4. AOC Barrier Removal Project
    5. Niagara River AOC Contaminated Sediment Study
    6. Niagara River Toxic Mgmt Plan
    7. Community Outreach Program
    8. Niagara River AOC Tributary Monitoring Program Annual Reports 2003 and 2004
8. Hamilton International Airport Biological Assessment Annual Reports 1998 to 2004
9. Water Quality Assessment of Buckhorn Creek and the Welland River in the Vicinity of the Glanbrook Landfill Biennial Reports 1996, 1998, 2002, 2004
10. Port Robinson West Subwatershed Study, April 1999.
11. Feasibility Study – Raw Water for Agricultural Irrigation Purposes, Project Report, prepared for Niagara Region, by Stantec Consulting Ltd., dated August 2005.
12. Environmentally Sensitive Areas, for Niagara Region, by Dept of Geography, Brock University, St Catharines, dated September 1980.
13. Gartner Lee Ltd 1987 Report - provides a groundwater budget for the Welland River Watershed.
14. One Mile Creek Watershed Plan.

Report and Project Summaries

1. NPCA Groundwater Study Draft Report, by Waterloo Hydrogeologic Inc. dated Nov 2004

NPCA was the lead for the NPCA Groundwater Study & Fonthill Kame Field Program (completed concurrently by same study team). Final report was issued October 2005. Using technical Terms of Reference from the Ontario Ministry of the Environment, the study provides a regional groundwater and aquifer characterization, and groundwater intrinsic susceptibility analysis, groundwater use assessment, flow modeling around the Fonthill Kame-Delta Complex, and contains a potential contaminant sources inventory. The study report also provided a preliminary groundwater budget for the NPCA jurisdiction.

2. & 3. Niagara Water Quality Protection Strategy Technical Reports Volumes 1, Parts 1 & 2 By NWQPS and dated October 2003.

In late 2001, the Region of Niagara, Niagara Peninsula Conservation Authority (NPCA) and Ontario Ministry of Environment (MOE), consulted to consider ways to more effectively manage Niagara's water resources. All parties agreed that in order to properly protect the area's water, a more integrated approach would be required considering all jurisdictional levels. To this end, the three principals commissioned a study in August 2002 to develop Niagara's Water Quality Protection Strategy (NWQPS).

The consortium of MacViro, CH2MHILL and Philips Engineering Ltd., along with eight specialist firms, worked together with area stakeholders to produce the strategy in fourteen (14) months, releasing it October 2003. The effort included intensive consultation with active stakeholder groups who were organized by specific theme areas.

The strategy involved an intensive data gathering exercise including over 1000 data items, comprising reports, maps, databases and general information from fourteen (14) municipalities and over 30 formal agencies and watershed groups. Based on this data/information, an assessment was conducted of the sensitivity and value of the area's resources, as well as their potential stressors (i.e. sources of contamination, flooding, water taking, etc.).

The understanding gained from the study area characterization was subsequently used as the underpinning to develop the management strategy. This phase of the work involved significant consultation with area stakeholders to develop a prioritized action plan, comprised of over 400 area-wide and locally specific activities organized into eleven (11) focussed Action Programs, to address core issues related to water quantity and quality management.[1]

4. Twelve Mile Creek Watershed Plan; Phase 1 Background Study and Issues Identification by NPCA dated April 2005.

Phase 1 of the Twelve Mile Creek Watershed Plan provided a foundation for understanding the natural character of the watershed, as well as potential and critical issues requiring management. The Phase 1 study provides a synopsis of the physiography, cultural heritage, ecological heritage, and surface water resources of the watershed. The report provides a preliminary description of natural heritage features such as wetlands, ESAs/SNHAs and ANSIs and a description of fish and aquatic habitat.[2]

Several information gaps were revealed in Phase 1, and as a result, a number of studies will continue throughout Phase 2 of the watershed plan, such as flood plain mapping, water quality monitoring, geomorphology studies to establish an erosion restoration program, fish spawning/habitat studies, and an investigation of sources of rural point and non-point pollution.

5. Twenty Mile Creek Watershed Plan; Phase 1 Background Study and Issues Identification by NPCA dated April 2005.

Phase 1 of the Twenty Mile Creek Watershed Plan provided a foundation for understanding the natural character of the watershed, as well as potential and critical issues requiring management. The Phase 1 study provides a synopsis of the physiography, cultural heritage, ecological heritage, and surface and groundwater resources of the watershed. The report provides a preliminary description of natural heritage features such as wetlands, ESAs/SNHAs and ANSIs and a description of fish and aquatic habitat. [3]

Several information gaps were revealed in Phase 1, and as a result, a number of studies will continue throughout Phase 2 of the watershed plan, such as flood plain mapping, Karst Study to better understand surface/groundwater flows, water quality monitoring, and an investigation of sources of rural point and non-point pollution.

6. Warren Creek Watershed Master Plan by Philips Engineering dated September 2000 and commissioned by City of Niagara Falls.

The Warren Creek Study was prepared to determine the stormwater management requirements for the eventual development of lands defined in the City of Niagara Falls Official Plan. The study undertook a baseline inventory for the watershed study area that

[1] Authors; Ronald B. SCHECKENBERGER; Tom MAHOOD; Adel ASHAMALLA; Bob STEELE; Alison SIVERS
[2] Extract from Conclusions Section of the Phase I Study report.
[3] Extracted from the Phase I Study report.

covered the physical setting, hydrogeology, flood plain management, erosion assessment, terrestrial and aquatic resources, cultural conditions, and issues and constraints. Based on this information the study report recommended a preferred solution and implementation strategy for storm water management. The study contains some borehole logs/x-sections which with the plan view drawings.

7. Niagara River Remedial Action Plan (NR-RAP)

In 1987, Canada and the United States signed a joint agreement pledging to restore and protect the environmental integrity of the Niagara River. NPCA, in partnership with the Ontario Ministry of the Environment and Environment Canada, developed a strategic Implementation Work Plan as part of the Niagara River Remedial Action Plan (RAP), which identifies actions to address the remaining environmental Areas of Concern (AOC's) in the Niagara River. Following are some of the specific projects that form part of the Niagara River RAP.

7.1 Niagara River AOC, Environmental Conditions and Problem Definitions, Remedial Action Plan Stage 1, Sept 1993, prepared jointly by :MOE, Environment Canada, MNR, and Fisheries, Oceans Canada.

The Niagar River was designated by Canada and the USA as an Area of Concern (AOC) under the terms of the Great lakes Water Quality Agreement (GLWQA) of 1987. The Stage 1 report provides a description of the environmental conditions and problems based on information available at the time of preparation.

7.2 AOC Water Quality Improvement Program (Part of NR-RAP)

The NPCA has been actively involved in this grass roots program since 1989, assisting local landowners with stewardship projects to improve local water quality problems. More than 310 water quality improvement projects have been completed. Forest cover in the AOC has been increased by 278 hectares, over 22 kilometres of stream-side riparian habitat has been re-established and nearly 8 hectares of wetland has been restored. Substantial pollutant load reductions from livestock fencing and manure storage improvement projects have taken place. Cost-sharing funds are available to qualifying landowners who live in priority areas for the implementation of water quality improvement projects.

7.3 Welland River Water Level Fluctuation Project (Part of NR-RAP)

The NPCA has been working with Ontario Power Generation to develop a solution to the flow reversal and fluctuation problem in the Welland River (which lies within the Niagara River Watershed). A diversion channel has been proposed to provide a separation between the Welland River and the zone of fluctuation influence.

7.4 AOC Barrier Removal Project (Part of NR-RAP)

The Niagara Restoration Council has been working with the NPCA and the Ministry of Natural Resources to identify and remediate obstacles to fish passage in the Niagara River and all of its tributaries, including the Welland River. Over 200 potential barriers to fish migration were identified during an inventory in 2001. Today, over 70 of these have either been removed or modified to allow fish to reach upstream spawning habitat.

7.5 Niagara River AOC Contaminated Sediment Study (Part of NR-RAP)

The NPCA is working with the Ministry of the Environment and Environment Canada to evaluate contaminated sediment sites in the AOC. Twelve potential sites of contamination were assessed in the fall of 2003. Two possible locations, including Frenchman's Creek and Lyon's Creek West, will require further investigation. Another site, the Welland River Reef site was remediated in 1995 and a remediation strategy is under development for Lyons Creek East.

7.6 Niagara River Toxics Management Plan (NRTMP) (Part of NR-RAP)

Since 1987 Environment Canada, the US Environmental Protection Agency, the Ontario Ministry of the Environment and the State of New York Department of Environmental Conservation have worked together to implement a plan to reduce the concentrations of toxic pollutants in the Niagara River. This co-operative effort is ongoing and to date, significant reductions in toxic chemical inputs to the River have been achieved. For example, remediation of hazardous waste sites has resulted in a reduction of potential contaminant inputs to the River from these sites by an estimated 90%.

7.7 Community Outreach Program (Part of NR-RAP)

The NPCA, in partnership with the Ministry of the Environment has developed an educational outreach program to increase environmental knowledge amongst grade school children. Presentations are made throughout the school year about the impacts humans have on the environment and things that can be done to improve local water quality and wildlife habitat. The program also includes information about sport fish consumption and provides information about making informed choices when eating fish from local fisheries.

7.8 Niagara River AOC Tributary Monitoring Program Annual Reports 2003 and 2004

This report provides a summary of the 2003/04 water quality data collected from Niagara River tributaries and gives a comparison between historic 1994/96 and 2003/04 water quality data.

8. Hamilton International Airport Biological Assessment Annual Reports 1998 to 2004

BioMAP water quality assessments were performed downstream of the airport to determine impacts of airport stormwater and de-icing activities on headwater tributaries of the Welland River. The assessments are reported annually.

9. Water Quality Assessment of Buckhorn Creek and the Welland River in the Vicinity of the Glanbrook Landfill - Biennial Reports 1996, 1998, 2002, 2004

BioMAP water quality assessments were performed downstream of the Glanbrook Landfill to determine impacts of landfill activities on Buckhorn Creek and the Welland River. Biennial reports are available for 1996, 1998, 2002, and 2004.

10. Port Robinson West Subwatershed Study
by Totten Sims Hubicki Associates, April 1999. (see electronic pdf file)

The Port Robinson West Subwatershed drains about 14.47 km^2 of land from Fonthill east. to the Welland Canal. Most of the subwatershed is located in Thorold, however the headwaters are located on the east portion of the Fonthill Kame in Pelham, and the southern portion is located in Welland. The subwatershed is drained by Singer's Drain which discharges into the Welland Canal. Much of the drain follows the path of the naturally occurring stream, however there are significant portions that have been rerouted or replaced by storm sewer pipes. The study contains geological cross-sections of the subwatershed.

11. Feasibility Study – Raw Water for Agricultural Irrigation
by Stantec Consulting Ltd, Aug 2005.

The objective of this study was to provide a range of options for providing raw water to the agricultural community in a manner that is technically feasible, financially responsible, environmentally sustainable, and based on a workable and cost effective management. The region currently contains about 23,000 acres (9,308 hectares) of agricultural land that is used for tender fruit, grape, greenhouse, and nursery crops in five municipalities (NOTL, St Catharines, Lincoln, Grimsby, and Pelham). A significant portion of the tender fruit and grape growers use irrigation in their operations. Upwards to 55,000 acres of land could be used for growing these types of high value crops, provided irrigation was available. The study identified sources or irrigation water sources and transportation. Alternative solutions included using water sources such as municipally treated water, Welland Canal, Niagara River, Twelve Mile Creek, Queenston Resevoir, and Lake Ontario. Transportation alternatives suggested included construction of drainage ditches or distribution pipes.

12. Environmentally Sensitive Areas

by Dept of Geography, Brock University, dated Sept 1980.

The objective of this study was to identify remnant natural area in Welland County that qualify as Environmentally Sensitive Areas (ESA's). The report contains hydrographs of Twenty Mile Creek.

13. Gartner Lee Ltd 1987 Report

The report provides a groundwater budget for the Welland River Watershed, and estimates an average recharge rate of 75 mm/year of water, and calculates this amount to about 15 % of PTTW (1989 values). About 2/3 of the NPCA region is covered by the Welland River watershed. The NWQPS Phase 2 study report referenced this report.

14. One Mile Creek Watershed Plan (2005)

The One Mile Creek Watershed is located in the Town of NOTL and drains into Lake Ontario, about 3.5 km west of the mouth of the Niagara River. The watershed is only about 5.2 km^2 in area, and is highly urbanized. A Watershed Flood Damage Assessment Study was completed in 1988 to evaluate flood damages in the NPCA jurisdiction. A portion of the creek flows along the boundary of Parks Canada historic sites such as Fort George. A watershed plan was requested to develop a long term strategy for addressing the issues and concerns associated with the creek, and provide a number of undertakings to restore One Mile Creek and Landsdowne Pond.

File: Appendix A-Existg Rprts-070430.doc

APPENDIX B

Niagara Region WTP Surface Water Intakes

Rosehill Water Treatment Plant

General Treatment Plant Information:
Municipality: Fort Erie
Area Served: Supplies the Town of Fort Erie
Population Served: Approx. 21,698
Year Constructed: 1960
Source of Raw Water: Lake Erie
Total Rated Capacity (ML/d): 50.00

Intake Pipe Location Information:
Longitude: -78.9773360005
Latitude: 42.87544800320

Structural Information:
Intake Pipe Length: 396 metres
Intake Pipe Diameter: 1,050 mm
Pipe Material: Timber/Concrete
Pipe Depth: 2.6 metres
Intake Structure Size: 3960 mm wide at base, 4570 mm high at highest point, at shoreline 1050 mm constant cross section.

Niagara Falls Water Treatment Plant

General Treatment Plant Information:
Municipality: Niagara Falls
Area Served: Supplies the City of Niagara Falls, part of the City of Thorold (Port Robinson) and is an alternate supply for the Town of Nigara-on-the-Lake.
Population Served: Approx. 79,476
Year Constructed: 1930
Source of Raw Water: Niagara River via the Welland River channel
Total Rated Capacity (ML/d): 145.50

Intake Pipe Location Information:
Longitude: -79.05035205950
Latitude: 43.06172540620

Structural Information:
Intake Pipe Length: 139 metres
Intake Pipe Diameter: 1,200 mm
Pipe Material: Timber crib and apron with side sheet steel pilings
Pipe Depth: 5.5 metres
Intake Structure Size: 6.27 m wide at base, 7.13 m high at highest point, cross section constant 1.22 m at shoreline.

Port Colborne Water Treatment Plant

General Treatment Plant Information:
Municipality: Port Colborne
Area Served: Supplies the City of Port Colborne
Population Served: Approx. 15,092
Year Constructed: 1982
Source of Raw Water: Lake Erie via the Welland Canal
Total Rated Capacity (ML/d): 36.37

Intake Pipe Location Information:
Longitude: -79.24995501130
Latitude: 42.88848631010

Structural Information:
Intake Pipe Length: 8 metres
Intake Pipe Diameter: 750 mm
Pipe Material: Concrete
Pipe Depth: 1.2 metres
Intake Structure Size: 750mm diameter concrete pipe located on the west bank of the Welland Canal.

Welland Water Treatment Plant

General Treatment Plant Information:
Municipality: Welland
Area Served: Supplies the City of Welland and parts of the Town of Pelham, Fonthill, and the City of Thorold.
Population Served: Approx. 50,587
Year Constructed: 1925
Source of Raw Water: Lake Erie via the Welland Canal and the Welland Recreational waterway (old Welland canal)
Total Rated Capacity (ML/d): 109.10

Intake Pipe Location Information:
Longitude: -79.24830300280
Latitude: 42.9950161547

Structural Information:
Intake Pipe Length: 79 metres
Intake Pipe Diameter: 2,440 mm
Pipe Material: Concrete channel
Pipe Depth: 4.3 metres
Intake Structure Size: 2.44m x 2.44m submerged concrete conduit, and then a 1.22m x 1.55m sluice gate.

DeCew Falls Water Treatment Plant

General Treatment Plant Information:
Municipality: St. Catharines/Thorold
Area Served: Supplies the City of St. Catharines and parts of the City of Thorold, Town of Lincoln and the Town of Niagara-on-the-Lake.
Population Served: Approx. 178,925
Year Constructed: 1951
Source of Raw Water: Lake Erie via Welland Canal and diversion channel
Alternate Raw Water Source: Lake Erie via Welland Canal and Lake Gibson
Total Rated Capacity (ML/d): 227.30

Main Intake Pipe Location Information:
Longitude: -79.26290081760
Latitude: 43.10957445150

Lake Gibson Intake Location Information
Longitude: -79.24959167960
Latitude: 43.10541104940

Highway 406 Intake Location Information
Longitude: -79.23776615350
Latitude: 43.10219888140

Structural Information:
Intake Pipe Length: 84 metres
Intake Pipe Diameter: 900 (2) mm
Pipe Material: Cast Iron
Pipe Depth: 3.9 to 4.2 metres depending on lake level
Intake Structure Size: No description available at this time.

Grimsby Water Treatment Plant

General Treatment Plant Information:
Municipality: Grimsby
Area Served: Supplies the Town of Grimsby, Lincoln, and West Lincoln
Population Served: Approx. 43,871
Year Constructed: 1993
Source of Raw Water: Lake Ontario
Total Rated Capacity (ML/d): 67.00

Intake Pipe Location Information:
Longitude: -79.579759929
Latitude: 43.2233319707

Structural Information:
Intake Pipe Length: 1950 metres
Intake Pipe Diameter: 1,050 mm
Pipe Material: Concrete
Pipe Depth: 7.3 to 9.7 metres depending on lake level
Intake Structure Size: No description available at this time.

2003 OPERATIONS REPORT ON WTPs

Niagara Region
PUBLIC WORKS

WATER & WASTEWATER SERVICES STATISTICAL REPORT 2003

2003 RATED CAPACITY OF NIAGARA'S WATER SUPPLY SOURCE FACILITIES

Potable Water Facilities	Capacity - ML/d
Niagara Falls System - Plant	145.5
Rosehill System - Plant	50.0
Welland System - Plant	109.1
Port Colborne System - Plant	36.4
DeCew Falls System - Plant	227.3
Grimsby/Lincoln/West Lincoln System	44.0
Total Potable Water	**612.3**

QUANTITY OF WATER PRODUCED BY NIAGARA'S WATER SYSTEMS (cubic metres)

Percent Comparison

Water System	*2003*	*2002*	*2003 to 2002*
Niagara Falls	17,355,378	*19,001,097*	-8.7%
Rosehill	6,306,954	*6,235,821*	+1.1%
Welland	13,079,318	*14,123,695*	-7.4%
Port Colborne	4,840,470	*4,501,593*	+7.5%
Decew Falls	28,172,350	*29,222,550*	-3.6%
Grimsby	5,196,522	*5,672,847*	-8.4%
Totals	***74,950,992***	***78,757,603***	**-4.8%**

QUANTITY OF WATER SUPPLIED

TO AREA MUNICIPALITIES BY NIAGARA

(cubic metres)

Municipality	*2003*	*2002*	*5 Year Average*
Niagara Falls	*15,480,440*	*16,925,600*	*17,777,480*
Port Colborne	*4,525,633*	*4,204,152*	*4,040,631*
St. Catharines	*21,949,430*	*22,533,000*	*25,768,820*
Thorold	*2,885,375*	*3,180,939*	*2,961,984*
Welland	*10,881,260*	*11,804,770*	*11,493,590*
Fort Erie	*5,660,292*	*5,659,908*	*5,198,174*
Grimsby	*2,849,876*	*3,227,963*	*2,955,954*
Lincoln	*2,672,482*	*2,809,761*	*2,755,249*
Niagara-on-the-Lake	*2,872,813*	*3,006,733*	*2,958,513*
Pelham	*1,554,004*	*2,037,490*	*1,664,855*
West Lincoln	*784,652*	*773,199*	*739,827*
Totals	***72,116,257***	***76,163,515***	***77,295,285***

Niagara Falls Water System

Area: This system supplies the City of Niagara Falls, part of the City of Thorold (Port Robinson) and is an alternate supply for the Town of Niagara-on-the-Lake.

Source of Raw Water: Niagara River via the Welland River channel.

Rated Total Capacity: 145.5 ML/d

Treatment:
Screening, coagulation, flocculation, sedimentation, chlorination, and rapid gravity filtration. Granular activated carbon filter-adsorbers for taste and odour control. Powdered activated carbon when required for taste and odour control. Process Wastewater treatment by sedimentation from which the treated water flows to the Niagara River and the sludge waste is removed by tank truck or pumped to the sanitary sewer.

Provincial Utility Classifications: Plant 3, Distribution 4.

Finished Water Storage: Total = 31.323 ML

Location Identification	Type	Capacity (ML)	TWL (metres)
Plant	in-structure storage	7.956	175.72
Lundy's Lane	elevated tank	2.455	249.63
Kent Avenue	reservoir	20.912	196.82

Pumping Station:

Location Identification	Type/Service	Rated Capacity (ML/d)
Kent Avenue reservoir	pump back	90.923

Regional Water Mains: Total length = 42.26 km

Diameter (mm)	Length (km)	Diameter (mm)	Length (km)
1,067	5.71	508	3.62
914	3.27	457	2.43
762	6.02	400	6.54
686	3.60	406	1.86
610	3.33	305	0.01
600	2.35	254	0.02
500	0.43	203	2.03

During the year, 0 m^3 of sludge was trucked out for additional treatment.

The plant staff carried out building and equipment maintenance effectively and no major breakdowns occurred.

Backflow prevention devices were tested and serviced in all locations.

Vibration analysis were carried out on all pumping units.

REGIONAL MUNICIPALITY OF NIAGARA - PUBLIC WORKS DEPARTMENT
WATER AND WASTEWATER DIVISION - WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003

NAME OF WATER SYSTEM: **NIAGARA FALLS**

Rated Total Capacity: 145.475 Megalitres per day (ML/d)

Amount of Water Produced			Quantities of Chemicals Consumed		
January	1,395.289	ML	12% Sodium Hypochlorite	266,166	L
February	1,278.609	ML	Clar+Ion A7	569,443	L
March	1,408.919	ML	Powdered activated carbon	0	Kg
April	1,351.448	ML			
May	1,396.015	ML			
June	1,535.451	ML			
July	1,745.821	ML			
August	1,816.703	ML			
September	1,612.941	ML			
October	1,375.448	ML			
November	1,213.555	ML			
December	1,225.179	ML			
Total	17,355.378	ML	Average Day	45.251	ML

Maximum day this year: Date: July 3, 2003		Amount	73.508	ML
All time Maximum day: Date: July 7, 1988		Amount	143.402	ML
Total amount of water produced the previous year			19,001.097	ML
Difference: this year to previous year (more + or less -)			- 1,645.72	ML
Amount of water supplied to the distribution system:			17,015.075	ML
Peak rate this year:	Date: Aug 21 Time: 0759	Rate:	105.294	ML/d
All time peak rate:	Date: July 4, 1988 Time: 2315	Rate:	195.000	ML/d
Approximate population served:	79,476			
Daily per capita usage (calculated using the sum of the Niagara Falls, Port Robinson and Bevan Heights populations and water usage):			562	L

Water Area served in:	Population	Water used	
(1) Niagara Falls	78,815	16,199.263	ML
(2) Thorold (Port Robinson)	365	96.433	ML
(3) Niagara on the Lake (Bevan Heights)	296	21.056	ML

REGIONAL MUNICIPALITY OF NIAGARA - PUBLIC WORKS DEPARTMENT
WATER AND WASTEWATER DIVISION - WATER SECTION
CHEMICAL ANALYSIS OF TREATED WATER DURING THE YEAR 2003
NAME OF WATER SYSTEM: NIAGARA FALLS

CHEMICAL PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
Alkalinity Total mg/L	92	88	85	84	83	81	82	80	81	81	82	78	83
Aluminum mg/L	<0.02	0.047	0.028	0.066	0.056	0.061	0.064	0.130	0.143	0.037	0.049	0.020	0
Chloride Unfiltered Reactive mg/L	19.0	20.0	18.0	19.0	19.0	19.0	19.0	21.0	22.0	21.0	18.0	20.0	20.0
Colour units True	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	4.0	<3.0	<3.0	<3.0	4.0
Conductivity 25 °C µmhos/cm	285	283	288	279	262	250	271	247	269	254	290	289	272
Fluoride Unfiltered Reactive mg/L	0.09	0.10	0.09	0.13	0.08	0.08	0.09	0.11	0.09	0.07	0.10	0.09	0
Hardness Total mg/L	124	133	132	123	125	117	121	124	114	125	119	118	123
Iron Unfiltered Total mg/L	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	0
Nitrate mg/L	0.268	0.270	0.278	0.214	0.194	0.177	0.196	0.233	0.246	0.267	0.242	0.264	0
Nitrite mg/L	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011
pH	7.49	7078	7.78	7.57	7.21	7.67	7.37	7.43	7.32	7.11	7.04	6.96	7.00
Sodium Unfiltered Reactive mg/L	9.0	10.0	10.3	10.8	10.1	10.1	1.01	11.0	10.0	9.9	10.1	9.8	10.0
Sulphate Unfiltered Reactive mg/L	36.0	34.0	35.0	33.0	33.0	33.0	34.0	31.0	36.0	36.0	32.0	41.0	35.0
Turbidity N.T.U.	<0.2	<0.2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	

Rosehill Water System

Area: This system supplies the Town of Fort Erie**.**

Source of Raw Water: Lake Erie

Rated Total Capacity: 50.0 ML/d

Treatment:
Screening, chlorination, coagulation, flocculation, sedimentation, rapid gravity filtration, pH correction. Granular activated carbon filter-adsorbers for taste and odour control. Process wastewater treatment by sedimentation from which the treated water flows to Lake Erie and the sludge waste is removed by tank truck.

Provincial Utility Classifications: Plant 3, Distribution System 2
Finished Water Storage: Total = 17.847 ML

Location Identification	Type	Capacity (ML)	TWL (metres)
Plant	In-structure storage	2.273	179.68
Plant	Reservoir	11.365	179.68
Ft. Erie South	Elevated tank	1.477	240.94
Crescent Park	Elevated tank	0.909	227.08
Ridgeway	Standpipe	0.800	227.69
Stevensville	Reservoir	1.876	180.25

Pumping Station:

Location Identification	Type/Service	Rated Capacity (ML/d)
Stevensville reservoir	pump back	9.992

Regional Water Mains: Total length = 45.36 km

Diameter (mm)	x Length (km)	Diameter (mm)	x Length (km)
610	4.99	356	4.30
406	10.56	305	16.09
400	6.39	203	0.97

During the year, 837 m^3 of sludge was trucked out for additional treatment.

The Plant Staff carried out building and equipment maintenance effectively and no major problems occurred.

Backflow prevention devices were installed and tested in all locations.

Vibration analysis were carried out on all pumping units.

REGIONAL MUNICIPALITY OF NIAGARA - PUBLIC WORKS DEPARTMENT
WATER AND WASTEWATER DIVISION - WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003
NAME OF WATER SYSTEM: **ROSEHILL**

Rated Total Capacity: 50.0 Megalitres per day (ML/d)

Amount of Water Produced			Quantities of Chemicals Consumed		
January	500.830	ML	12% Sodium Hypochlorite	105,873	L
February	469.717	ML	Liquid Alum	181,655	L
March	498.815	ML	25% Sodium Hydroxide	71,619	L
April	496.004	ML			
May	547.512	ML			
June	567.641	ML			
July	639.602	ML			
August	598.874	ML			
September	564.168	ML			
October	523.962	ML			
November	465.319	ML			
December	434.510	ML			

Total	6,306.954	ML	Average Day	15.836	ML
Maximum day this year: Date:	July 1		Amount	26.418	ML
All time Maximum day: Date:	July 7, 1988		Amount	54.233	ML
Total amount of water produced the previous year				6,235.821	ML
Difference: this year to previous year (more + or less -)				+ 71,133	ML
Amount of water supplied to the distribution system:				6,183.287	ML
Peak rate this year:	Date: Oct 3, 2003	Time: 0815	Rate:	39.481	ML/d
All time peak rate:	Date: July 8, 1988	Time: 1900	Rate:	70.000	ML/d
Approximate population served:	21,698				
Daily per capita usage:				715	L

REGIONAL MUNICIPALITY OF NIAGARA - PUBLIC WORKS DEPARTMENT
WATER AND WASTEWATER DIVISION - WATER SECTION
CHEMICAL ANALYSIS OF TREATED WATER DURING THE YEAR 2003

NAME OF WATER SYSTEM: **ROSEHILL**

CHEMICAL PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
Alkalinity Total mg/L	90	96	98	85	88	90	89	91	89	90	90	93	91
Aluminum Mg/L	<0.2	0.023	0.044	0.046	0.070	0.189	0.191	0.168	0.151	0.053	0.067	<0.02	0.100
Chloride Unfiltered Reactive mg/L	19	19	21	18	19	19	19	22	22	22	19	20	19.9
Colour Units True	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0	3.0
Conductivity 25 °C µmhos/cm	305	305	300	276	274	265	269	260	283	266	306	299	284
Fluoride Unfiltered Reactive mg/L	0.08	0.09	0.09	0.11	0.08	0.08	0.08	0.10	0.09	0.07	0.11	0.10	0.09
Hardness Total mg/L	148	140	134	121	125	122	124	127	116	127	121	122	127
Iron Unfiltered Total mg/l	0.275	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	0.275
Nitrate mg/L	0.299	0.291	0.291	0.206	0.221	0.095	0.178	0.181	0.200	0.235	0.230	0.335	0.230
Nitrite mg/L	<0.011	0.017	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	0.017
pH	7.58	8.01	8.05	7.73	7.29	8.15	8.01	7.64	7.67	7.38	7.24	7.22	7.66
Sodium Unfiltered Reactive mg/L	10.9	12.6	13.8	13.0	10.9	10.8	10.5	13.8	13.0	13.1	13.7	13.7	12.5
Sulphate Unfiltered Reactive mg/L	42.0	35.0	29.0	31.0	31.0	30.0	30.0	29.0	34.0	37.0	32.0	35.0	33.0
Turbidity N.T.U.	<0.2	0.50	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.15	0.33

Welland Water System

Area: This system supplies the City of Welland and parts of the Town of Pelham, Fonthill and the City of Thorold.

Source of Raw Water: Lake Erie via the Welland Canal and the Welland Recreational Waterway (Old Welland Canal).

Rated Total Capacity: 109.1 ML/d

Treatment:

Screening, chlorination, coagulation, flocculation, sedimentation, rapid gravity filtration with granular activated carbon (GAC), fluoridation and powdered activated carbon when required for taste and odour control. Direct filtration may be used when raw water conditions permit. All process wastewater is discharged to a sanitary sewer.

Provincial Utility Classification: Plant 3, Distribution System 3

Finished Water Storage: Total = 42.439 ML

Location Identification	Type	Capacity (ML)	TWL (metres)
Plant	reservoir	6.819	174.95
Plant	in-structure storage	1.982	174.95
Bemis Park	elevated tank	5.683	220.07
Shoalts Drive	reservoir	25.655	220.07
Pelham	elevated tank	2.300	272.80

Pumping Station:

Location Identification	Type/Service	Rated Capacity (ML/d)
Shoalts Drive	reservoir booster	18.343

Regional Watermains: Total length = 27.84 km

Diameter (mm)	x Length (km)	Diameter (mm)	x Length (km)
762	3.95	305	5.30
610	11.91	254	0.24
406	6.44		

Pre-chlorination of the raw water intake as a means of zebra mussel control began May 13 and continued until December 09. During that period, there were no problems encountered.
Taste and odour in the treated water was not a problem this year and Powdered Activated Carbon (PAC) was not required. There were no taste and odour complaints received.

The City of Welland routinely imposes outdoor water restrictions from June to September using the odd/even house number system.

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
ENVIRONMENTAL SERVICES DIVISION – WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003
NAME OF WATER SYSTEM: **WELLAND WATER**
Rated Total Capacity= 109.1 Mega Litres per Day (ML/D)

Amount of Water Produced			Quantities of Chemicals Consumed		
January	1,036,228	ML	Aluminium Sulphate – liquid	224,873	L
February	947,549	ML			
March	1,043,256	ML	Powdered activated carbon	0	Kg
April	1,006,934	ML			
May	1,033,291	ML	Chlorine	0	Kg
June	1,175,173	ML			
July	1,378,703	ML	12% Sodium Hypochlorite	207,573	L
August	1,337,455	ML			
September	1,199,500	ML	Clar+Ion A10	101,685	Kg
October	1,016,726	ML	Hydrofluosilicic Acid 25%	0	ML
November	944,979	ML			
December	959,524	ML			
Total	**13,079,318**	ML	Average Day	35,110	ML

Maximum day this year:				
Date:	July 03	Amount	73,520	ML
All time Maximum day:				
Date:	July 6, 1988	Amount	84.850	ML
Total amount of water produced the previous year			**14,123,695**	ML
Difference: this year to previous year (more+ or less-)			-1,044,377	ML
Amount of water supplied to the distribution system:			**12,822,860**	ML/d
Peak rate this year: Date:	July 01			
Time: 1640		Rate	107,827	ML/d
All time peak rate: Date:	August 01, 2002			
Time: 1900		Rate	113,789	ML/d
Approximate population served:			50,587	
Daily per capita usage:			694	L

(1) Population served in Welland = 44,257 Pelham = 6,330

(2) Per Capita usage is calculated using the population above and of water supplied to Welland and Pelham

REGIONAL MUNICIPALITY OF NIAGARA - PUBLIC WORKS DEPARTMENT
ENVIRONMENTAL SERVICES DIVISION - WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003
NAME OF WATER SYSTEM – **WELLAND**

CHEMICAL PARAMETER	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**	**AVG**
Alkalinity Total mg/L	98	91	90	84	96	86	87	81	82	88	86	90	90.7
Aluminum Mg/L	0.02	0.03	0.02	0.07	0.03	0.05	0.06	0.04	0.29	0.09	0.08	0.035	0.068
Chloride Unfilt., Reactive mg/L	21	20	23	26	21	21	19	20	22	23	19	22	21.4
Colour units Apparent.	3	3	3	3	3	3	3	3	3	3	3	3	3
Conductivity 25^{o} C Umhos/cm	311	299	313	304	287	265	267	263	296	309	315	315	303.6
Fluoride, Unfilt., Reactive mg/L	0.09	0.09	0.09	0.09	0.08	0.1	0.08	0.08	0.08	0.11	0.08	0.105	0.089
Hardness Total mg/L	128	128	137	120	109	123	123	123	112	110	122	129	122
Iron Unfiltered Total mg/L	<0.1	<0.1	0.09	<0.01	0.09	<0.01	<0.03	0.09	<0.03	<0.03	0.09	0.09	<0.1
Nitrates, Total, Filt. Reactive mg/L	0.5	0.4	0.311	0.600	0.5	0.211	0.2	0	0.152	0.2	0.2	0.257	0.321
Nitrite, Filt. Reactive mg/L	0.004	<0.008	<0.005	0.011	<0.02	0.011	<0.02	<0.02	0.011	<0.02	<0.02	0.011	0.0134
PH	7.52	7.84	7.88	7.66	7.95	7.69	7.94	7.49	7.43	7.09	7.04	7.05	7.54
Sodium Unfiltered Reactive mg/L	13.3	12.6	14	15.6	12.9	11.3	12.8	10.7	10.9	10.2	10.7	11.2	12.2
Sulphate, Unfiltered Reactive mg/L	36	34	35	39	36	33	29	33	33	34	33	37	34
Turbidity N.T.U.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Port Colborne Water System

Area: This system supplies the City of Port Colborne.

Source of Raw Water: Lake Erie via the Welland Canal

Rated Total Capacity: 36.369 ML/d

Treatment:

Screening, chlorination, coagulation, flocculation, sedimentation, rapid gravity filtration with granular activated carbon (GAC) media and powdered activated carbon when required for taste and odour control. Direct filtration is used when raw water conditions permit. Process wastewater treatment by sedimentation with settled sludge discharged to a sanitary sewer.

Provincial Utility Classification: Plant 3, Distribution System 3

Finished Water Storage: Total = 11.138 ML

Location Identification	Type	Capacity (ML)	TWL (metres)
Plant	reservoir	3.8	175.75
Plant	in-structure storage	1.655	175.75
King Street	elevated tank	1.137	223.11
Fielden Avenue	reservoir	4.546	179.53

Pumping Stations:

Location Identification	Type/Service	Rated Capacity (ML/d)
Fielden Avenue	reservoir pump back	10.997

Regional Watermains: Total length = 4.76 km

Diameter (mm) x Length (km)		Diameter (mm) x Length (km)	
610	2.75457		0.27
508	0.34406		1.40

Pre-chlorination of the raw water intake as a means of zebra mussel control began June 13 and continued until November 05. During that period there were no problems encountered.

There were no taste and odour complaint during the year, therefore, the additional treatment of Powdered Activated Carbon (PAC) was not required.

The City of Port Colborne routinely imposes outdoor water restrictions between June and September daily, using the odd/even house number system. Water consumers may water at any time, except between the hours of 11:00 a.m. and 3:00 p.m.

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
ENVIRONMENTAL SERVICES DIVISION – WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003
NAME OF WATER SYSTEM: **PORT COLBORNE**

Rated Total Capacity: 36.400 Mega litres per day(ML/d)

Amount of Water Produced			Quantities of Chemicals Consumed		
January	474,642	ML	Aluminium Sulphate - liquid	184,476	L
February	457,546	ML			
March	437,031	ML	Polyelectrolyte	268	Kg
April	393,518	ML			
May	402,807	ML	Chlorine	0	Kg
June	372,760	ML			
July	413,955	ML	12% Sodium Hypochlorite	80,709	L
August	417,789	ML			
September	402,852	ML	Hydrofluosilicic Acid	0	Kg
October	347,510	ML			
November	341,270	ML	Clar+Ion A7	0	Kg
December	378,790	ML			
Total	**4,840,470**	ML	Average Day	**13,279**	ML

Maximum day this year:				
Date:	Jan 18	Amount	16,956	ML
All time Maximum day:				
Date: 1988	July 5,	Amount	29,610	ML
Total amount of water produced the previous year			**4,501,593**	ML
Difference: this year to previous year (more+ or less-)			386,762	ML
Amount of water supplied to the distribution system:			**4,525,633**	ML
Peak rate this year: Date:	Feb 22			
Time	0100	Rate	23.500	ML/d
All time peak rate: Date:	January 15, 1997			
Time:	1900	Rate	44.000	ML/d
Approximate population served:			15,092	
Daily per capita usage:			821	L

(1) Population served in Port Colborne
(2) Per Capita usage is calculated using the population above and of water supplied to Port Colborne

REGIONAL MUNICIPALITY OF NIAGARA - PUBLIC WORKS DEPARTMENT
ENVIRONMENTAL SERVICES DIVISION - WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003

NAME OF WATER SYSTEM - **PORT COLBORNE**

CHEMICAL PARAMETER	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**	**AVG**
Alkalinity Total mg/L	81	88	88	83	77	81	79	77	78	81	81	85	82
Aluminum mg/L	0.02	0.022	0.021	0.11	0.043	0.065	0.076	0.062	0.02	0.033	0.02	0.02	0.04
Chloride Unfilt., Reactive mg/L	19	20	20	19	19	19	19	22	23	22	20	22	20
Colour units Apparent.	3	3	3	3	3	3	3	3	3	3	3	3	3
Conductivity 25°C umhos/cm	290	296	293	294	294	260	265	265	283	272	301	329	287
Fluoride, Unfilt. Reactive mg/L	0.08	0.09	0.1	0.1	0.09	0.09	0.08	0.09	0.08	0.07	0.09	0.08	0.09
Hardness Total mg/L	121	129	134	121	108	123	123	123	113	118	121	138	123
Iron Unfiltered Total mg/L	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Nitrates, Total, Filt. Reactive mg/L	0.29	0.28	0.254	0.256	0.189	0.213	0.15	0.192	0.219	0.243	0.216	0.572	0.256
Nitrite, Filtered Reactive mg/L	0.011	0.015	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
PH	7.39	7.86	7.79	7.69	7.87	7.67	7.9	7.32	7.38	6.99	6.87	7.04	7.48
Sodium Unfiltered Reactive mg/L	10.3	10	10.4	12.2	12.2	10	10.7	9.65	10.1	10.6	11.7	10.8	10.7
Sulphate, Unfiltered Reactive mg/L	40	34	35	35	35	36	33	35	44	41	39	50	36
Turbidity N.T.U.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

DeCew Falls Water System

Area: This system supplies the City of St. Catharines and parts of the City of Thorold, Town of Lincoln and the Town of Niagara-on-the-Lake.

Source of Raw Water: Lake Erie via Welland Canal and diversion Channel.

Rated Total Capacity: 227.3 ML/d surface water

Treatment:
Pre-sedimentation, screening, chlorination, coagulation, flocculation, sedimentation, and rapid gravity filtration using dual media (granular activated carbon and sand) for Filters 1-12 and multi-media (granular activated carbon, sand, and gravel) for Filters 13-15. Process waste sludge collection and disposal of collected sludge by trucking to the Regional lagoon at Garner Road in Niagara Falls.

Provincial Utility Classification: Plant Class 3, Distribution System Class 4.

Finished Water Storage: Total = 90.531 ML

Location/ Identification	Type	Capacity (ML)	TWL (metres)
Plant	in-structure	2.909	163.68
Plant	reservoir	38.000	163.68
Plant	reservoir	18.600	163.68
Carlton Street (Zone 1)	reservoir	13.638	99.52
St. Catharines (Zone 2)	standpipe	4.364	200.25
Thorold South (Zone 3)	elevated tank	2.273	227.08
Victoria Avenue	standpipe	0.455	153.42
Vineland	reservoir	2.273	151.84
Jordan	reservoir	0.568	151.91
St. David's	reservoir	0.682	167.94
St. David's	standpipe	0.591	167.94
Queenston	reservoir	0.682	157.89
John Street	elevated tank	0.946	125.58
Virgil	elevated tank	4.550	144.78

Pumping Stations:

Location/ Identification	Type/Service	Rated Capacity (ML/d)
Carlton Street Reservoir	pump back to Zone 1	31.823
Hillside Drive	booster to Zone 1	100.014
Glendale Avenue	booster to Zone 2	9.092
Brock High	Liftbooster to Zone 3	68.191

Location/ Identification	Type/Service	Rated Capacity (ML/d)
Decew High Lift	booster to Zone 3	68.191
Vineland	booster to Vineland/Jordan	8.638
Progressive Avenue	booster to Queenston	2.182
Artificial recharge	aquifer recharge	19.639
Warner Road	booster to St. David's	6.307

Regional Watermains: Total length = 107.185 km

Diameter (mm)	Length (km)	Diameter (mm)	Length (km)
1,372	1.17	406	18.08
914	12.34	356	1.93
762	4.31	305	17.39
610	19.76	254	7.52
508	5.985	203	5.28
457	10.36	152	3.06

In January, the 18.6ML reservoir was taken out of service for repairs.
The non-mechanical flow meters were calibrated by Procon.

In February Plant #2 filters were taken out of service for a complete rebuild of the underdrain system.

In March, Sirron Systems calibrated online chlorine residual analyzers.

In April, the flow meters were calibrated by Procon. Sirron Systems completed the calibration of the online analyzers. The Vineland Standby Generator was taken out of service for repairs. Horseshoe Carbon installed filter media in Plant #2 filters. The Zone 3 and Smithville Tanks were inspected by Landmark Tank and Tower. North American Construction began construction of the new cell at Hixon Reservoir.

In May, the mechanical flow meters were exchanged and sent out for calibrations. Sirron Systems upgraded the PLC programs and calibrated the turbidmeters in Plant #2. The 18.6ML reservoir was filled, disinfected and placed back in service. Plant #2 Filters placed back in service. Plant #1 was taken out of service for settling basin cleaning and maintenance on valves. Work progressed on the Vineland Booster Pumping Station upgrade. New pumps and associated piping were installed by R.J. Gillespie Enterprises.

In June, new alum feed dosage pumps were installed by Metcon for Plant #1 and Plant #2 plus a standby pump. There were ongoing problems with the pumps throughout the month requiring Plant #2 to be shutdown or filtered to waste. On June 9, pre-chlorine injection was switched to the raw water intake for zebra mussel control. Plant #1 was placed back in service.

In July, Horseshoe Carbon conducted GAC testing on filters #2 and #13. Hach calibrated analyzers throughout the month. The Vineland Booster Pumping Station pumps and rechlorination station were commissioned. There were ongoing problems with the alum dosing system throughout the month. Metcon rebuilt the alum dosing system and Sirron Sytems went through the PLC and

SCADA systems.

In August, Low Lift pump #5 was taken out of service for maintenance. On August 14th there was a major power failure affecting large areas of North Eastern Canada and the United States. The plant and remote stations were not affected.

In September, there were ongoing problems with the alum dosing system. On September 18, ASI inspected the raw water intake. On September 29, the Brock High Lift Pumping Station roof caught fire. The fire department responded resulting in minimal damage to the building.

In October, Plant #3 was taken out of service for settling basin cleaning. Mechanical flow meters were exchanged for calibrated units. Zone #3 elevated tank was taken out of service for scheduled inspection/maintenance by Landmark Tank and Tower. On October 29 there was a watermain break on an 18" line in the City of Thorold resulting in parts of Thorold south being without water while the repair was carried out.

In November, the MOE conducted and unannounced inspection of the facilities. Zone #3 Elevated Tank was placed back in service. The Queenston Reservoir was taken out of service for a scheduled cleaning/inspection. The Jordan reservoir was taken out of service for a scheduled cleaning/inspection. On November 03rd the pre-chlorine injection point was switched back from the intake given that zebra mussel control no longer necessary. The St. Davids chlorine analyzer switched to free chlorine residual reading. Horseshoe carbon conducted GAC sampling. The non-mechanical flow meters were calibrated. A recirculation line was installed at the Queenston Pumping Station. Contractual maintenance work performed on the standby diesel generators.

In December, Plant #3 was taken out of service for settling basin cleaning. Plant #2 was taken out of service for settling basin cleaning. Lightning arrestors were installed at Line 2.

During the year, 18,308 m3 of sludge was hauled by truck to the Garner Road wastewater holding lagoon.

To maintain an acceptable chlorine residual in the Town of Niagara-on-the-Lake distribution system, it was necessary to rechlorinate at Line 2/Highway 55 pressure reducing chamber, and St. David's Control Building #2. Rechlorination was also carried out at the Vineland Pumping Station for the same reason in the Town of Lincoln.

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
WATER & WASTEWATER DIVISION – WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003
NAME OF WATER SYSTEM: **DECEW FALLS**

Rated Total Capacity: 227.305 Mega litres per day(ML/d)

Amount of Water Produced			Quantities of Chemicals Consumed		
January	2,155.870	ML	Aluminum Sulphate – liquid	916,185	L
February	2,105.960	ML	Clar+Ion A7	0	L
March	2,225.810	ML	Clar+Ion A10	0	L
April	2,323.280	ML	Powdered activated carbon	0	Kg
May	2,309.610	ML	Chlorine	75,815	Kg
June	2,496.620	ML	Hydrofluosilicic acid 25% (Thorold)	0	L
July	2,826.940	ML	12% Sodium Hypochlorite	5,198	L
August	2,766.930	ML			
September	2,604.370	ML			
October	2,240.720	ML			
November	2,064.940	ML			
December	2,051.320	ML			
Total	28,172.350	ML	Average Day	77.180	ML

Maximum day this year:				
Date:	July 3, 2003	Amount	116.20	ML
All time Maximum day:				
Date:	July 6, 1988	Amount	206.020	ML
Total amount of water produced the previous year			29222.55	ML
Difference: this year to previous year (more+ or less-)			-1050.20	ML
Amount of water supplied to the distribution system:			28172.35	ML
Peak rate this year: Date: May 26	Time: 1222 hrs		216.54	ML/d
All time peak rate: Date: July 6, 1988	Time: 2100 hrs		206.020	ML/d
Daily per capita usage:			277	L
Population served in:		Rated Capacities Plant:	227.305	ML/d
St. Catharines	134,900			
Lincoln (Vineland)	10,075			
Thorold	19,000			
Niagara-on-the-Lake	14,950			

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
WATER & WASTEWATER DIVISION – WATER SECTION
CHEMICAL ANALYSIS OF TREATED WATER DURING THE YEAR 2003
NAME OF WATER SYSTEM: **DECEW FALLS**

CHEMICAL PARAMETER	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	AVG
Alkalinity Total mg/L	86.0	86.0	86.0	81.0	82.0	80.0	70.0	65.0	71.0	79.0	79.0	84.0	79.1
Aluminum mg/L	0.020	0.021	0.022	0.025	0.067	0.042	0.062	0.056	0.048	0.027	0.030	0.020	0.037
Calcium mg/L	39.0	38.0	38.0	34.0	39.0	36.0	35.0	32.0	32.0	34.0	35.0	36.0	35.7
Chloride Unfilt., Reactive mg/L	22.0	22.0	27.0	29.0	23.0	19.0	19.0	23.0	24.0	24.0	22.0	23.0	22.5
Colour units Apparent	3.0	3.0	3.0	3.0	3.0	3.0	4.0	3.0	3.0	3.0	3.0	3.0	3.1
Conductivity 25o C umhos/cm	316	306	310	311	304	268	253	281	275	254	306	316	292
Fluoride Unfilt., Reactive mg/L	0.10	0.08	0.08	0.12	0.07	0.08	0.07	0.10	0.07	0.08	0.09	0.09	0.09
Hardness Total mg/L	138	138	138	126	136	126	127	117	117	120	124	131	128
Iron Unfiltered Total mg/L	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Magnesium mg/L	10.1	10.5	10.2	9.5	9.3	8.7	9.7	9.2	8.7	8.7	9.1	9.7	9.45
Manganese mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Nitrates Total Filtered Reactive mg/L	0.392	0.300	0.288	0.382	0.138	0.131	0.095	0.116	0.121	0.219	0.200	0.418	0.220
Nitrite, Filtered Reactive mg/L	0.011	0.020	0.011	0.011	0.022	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.012
pH	7.28	7.74	7.66	7.47	7.54	7.51	7.36	6.99	7.14	6.91	6.86	6.85	7.28
Sodium, Unfiltered Reactive mg/L	10.6	10.1	13.1	15.2	10.3	10.5	10.0	10.4	9.70	10.5	10.3	10.8	11.0
Sulphate, Unfiltered Reactive mg/L	37.0	36.0	39.0	48.0	34.0	35.0	38.0	42.0	47.0	40.0	45.0	39.0	40.0
Turbidity N.T.U.	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
WATER & WASTEWATER DIVISION – WATER SECTION

AMOUNT OF WATER PRODUCED, MAXIMUM AND AVERAGE DAY
DURING THE YEAR 2003

Name of Water System: **DECEW FALLS**

MONTH	MAXIMUM DAY		AVERAGE DAY	
JANUARY	73.870	ML	69.540	ML
FEBRUARY	78.590	ML	75.210	ML
MARCH	90.360	ML	71.800	ML
APRIL	83.720	ML	77.440	ML
MAY	89.470	ML	74.500	ML
JUNE	112.200	ML	83.220	ML
JULY	116.200	ML	91.190	ML
AUGUST	105.770	ML	89.260	ML
SEPTEMBER	102.450	ML	86.810	ML
OCTOBER	77.940	ML	72.280	ML
NOVEMBER	76.720	ML	68.830	ML
DECEMBER	69.210	ML	66.170	ML

Grimsby Water System

Area: This system supplies the Town of Grimsby, the Town of Lincoln (Beamsville), and the Community of Smithville in the Township of West Lincoln. The Town of Grimsby, in turn, supplies a small area in the Region of Hamilton-Wentworth.

Source of Raw Water: Lake Ontario

Rated Total Capacity: 44.0 ML/d surface water

Treatment:
Screening, disinfection, coagulation, mechanical mixing, flocculation, sedimentation, filtration, and post disinfection. Powdered activated carbon is added when required for taste and odour control. This facility includes a waste treatment system consisting of wastewater equalizing tanks, sedimentation tanks, and sludge thickening tanks. This system also de-chlorinates the wastewater prior to discharge to the lake.

Provincial Utility Classification: Plant Class 3, Distribution System Class 4.

Finished Water Storage: Total = 26.138 ML

Location/ Identification	Type	Capacity (ML)	TWL (metres)
Plant in-structure	storage	10.000	81.80
Park Road	reservoir	3.410	153.92
London Road	reservoir	0.455	193.93
London Road	elevated tank	2.273	238.60
Hixon Street	reservoirs	5.000	163.71
		5.000	163.71

Pumping Stations:

Location Identification	Type/Service	Rated Capacity (ML/d)
Park Road	booster to Smithville	6.480
London Road	pump back	4.582
Iroquois Trail	booster to Lincoln	19.000

Regional Watermains: Total length = 28.04 km

Diameter (mm) x Length (km)		Diameter (mm) x Length (km)	
900	0.20	406	4.11
750	2.04	305	11.32
508	8.28	254	1.93
457	0.16		

The Grimsby Water Plant was operated by the Senior Operator via modem from the DeCew Falls Water Plant 24 hours a day.

In January, the north sludge thickener was taken out of service for repairs. The non-mechanical flow meters were calibrated by Procon. The Park Road rechlorination system was suspended due to high residuals at Smithville Elevated Tank. Field tests began for the Grimsby coagulation optimization study.

In February, the chlorine contact tank was drained for cleaning and inspection. Black and MacDonald serviced the power transformer. Hixon St. Reservoir booster pump #2 was taken out of service for repairs.

In March, each filter was drained cleaned and inspected. Highlift pump 6410 was placed back in service. Side 'B' was taken out of service for sludge removal. The online analyzers were calibrated by Sirron Systems. North American Construction began construction of the Hixon reservoir expansion on March 28.

In April, TDC sandblasted and waterproofed the concrete in the chlorine contact tank. On April 3, an ice storm caused numerous power outages and communication failures. The Smithville Elevated Tank was taken out of service for inspection by Landmark Tank and Tower Services. Sirron Systems calibrated the chlorine analyzers and the turbidity meters. The non-mechanical flow meters were calibrated by Procon. Work continued on the Park Road pumping station upgrade.

In May, construction continued at Park Road Pumping Station with communication failures ongoing throughout the month. ASI installed the raw water intake diffuser. The alum system piping experienced a blockage. The Park Road Pumping Station rechlorination system returned to May 23. High Lift pump 6460 was taken out of service for repairs. Hypo pump 9408 was taken of service repair of the motor.

In June, the raw water intake chlorine injection line appeared to have a blockage. ASI divers tried unsuccessfully to unplug the restriction. Side 'A' of the alum system experienced a blockage. The new Hixon Reservoir rechlorination system was commissioned on June 30th. The chlorine contact tank was disinfected and returned to service. Romar Electric inspected the transformers at Lincoln Booster Pumping Station and Park Road Pumping Station. The Lincoln Booster Pumping Station rechlorination system was returned to service on June 24th.

In July, the SCADA computer and its backup had their hard drives fail. Consequently, historical data was lost for the days up until the repairs to the system were complete. Hach performed calibrations on the turbidity analyzers and bench equipment. ASI did a camera inspection of the pre-chlorine injection line to the head of the intake. Hypo pump 9408 was returned to service. Canal Electric began construction of the standby alum feed pump installation.

In August, Sirron systems calibrated the online chlorine analyzers. Alum tank 9102 was drained and cleaned. On August 14, there was a major power failure affecting large areas of North Eastern Canada and the United States. The plant and remote stations were not affected. The City of Hamilton requested that the valve at Fifty Road (which supplies water to a small area of Stoney Creek) be opened to assist them during the power failure. There were ongoing problems with the new rechlorination system at Hixon Reservoir. The alum injection point was switched to the flash mixers for the coagulation study.

In September, ASI could not repair the pre-chlorine injection to the intake and therefore it was replaced it with a new line. The alum injection point was switched to the raw water header for the coagulation study. On September 18th the plant was shutdown for an electrical inspection of the switchgear. ASI disinfected the new cell at Hixon Reservoir. Sirron Systems installed repaired flow switch at Hixon Reservoir.

In October, Metcon repaired Hypo pump 9408. Sirron Systems made changes to the SCADA to accommodate the Hixon Reservoir expansion. The MOE conducted an inspection of the facility throughout the month. The overhead lifting devices were inspected. On October 14, an attempt to place the new cell on-line at Hixon. Rechlorination didn't work properly. Low chlorine residual resulted in notification of an adverse. The new cell was isolated immediately and corrective measures were instituted. Hach calibrated the online turbidity analyzers. Sirron Systems calibrated the chlorine analyzers.

The Smithville Elevated Tank was cleaned and inspected by Landmark Tank and Tower Services.

In November, the settling basins on both Side ‘A’ and Side ‘B’ were taken offline, cleaned and placed back in service. The new cell at Hixon Reservoir was placed in service. Coagulation Study Phase II - began feeding Stern Pac 7 as a coagulant to Side ‘B’ at a dosage of 7mg/L. As part of the C of A requirements, Side ‘B’ is set to filter to waste. Powerteam performed scheduled maintenance/inspection of the plant and remote station generators. The alum feed pump modification is complete.

In December, BI&I inspected the plant transformers. Modifications to the plant security gate system were completed.

As per the new mandatory, Ontario Drinking Water Standards, Ontario Regulation 459/00, we complied with the requirement to report the results of the drinking water analysis for all the required parameters for each quarter of the year 2003.

During the year, 7,806 m3 of waste sludge was removed by truck to Garner Road Lagoon.

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
WATER & WASTEWATER DIVISION – WATER SECTION
ANNUAL OPERATING REPORT FOR THE YEAR 2003
NAME OF WATER SYSTEM: **GRIMSBY**
Rated Total Capacity: 44.0 Mega litres per day (ML/d)

Amount of Water Produced			Quantities of Chemicals Consumed		
January	391.262	ML	Aluminum Sulphate – Liquid	198,935	L
February	359.354	ML	Clar+Ion A7	0	L
March	391.364	ML	Clar+Ion A10	0	L
April	403.152	ML	Powdered Activated Carbon	0	Kg
May	421.469	ML	Chlorine	0	Kg
June	494.770	ML	Sodium Bisulphite	897	L
July	551.892	ML	12% Sodium Hypochlorite	102.777	L
August	496.745	ML			
September	514.418	ML			
October	418.351	ML			
November	374.233	ML			
December	378.513	ML			
Total	5,196.522	ML	Average Day	14.237	ML

Maximum day this year:				
Date:	July 4, 2003	Amount	27.740	ML
All time Maximum day:				
Date:	July 16, 2002	Amount	31.976	ML
Total amount of water produced the previous year			5652.428	ML
Difference: this year to previous year (more+ or less-)			-455.906	ML
Amount of water supplied to the distribution system:			5186.928	ML
Peak rate this year: Date:	June 25, 2003			
Time: 23:56 hrs		Rate	41.200	ML/d
All time peak rate: Date:	July 15, 2002			
Time:	2042 hrs	Rate	43.702	ML/d
Approximate population served: 43,871				
Daily per capita usage:			208	L

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
WATER & WASTEWATER DIVISION – WATER SECTION
CHEMICAL ANALYSIS OF TREATED WATER DURING THE YEAR 2003
NAME OF WATER SYSTEM: **GRIMSBY**

CHEMICAL PARAMETER	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	AVG
Alkalinity Total mg/L	83.0	81.0	81.0	81.0	84.0	84.0	80.0	82.0	83.0	85.0	83.0	79.0	82.2
Aluminum mg/L	0.020	0.021	0.023	0.025	0.058	0.057	0.420	0.104	0.062	0.040	0.053	0.027	0.128
Calcium mg/L	34.0	36.0	37.0	33.0	36.0	38.0	37.0	36.0	34.0	37.0	35.0	35.0	35.8
Chloride Unfilt., Reactive mg/L	26.0	25.0	25.0	29.0	26.0	32.0	24.0	27.0	27.0	25.0	27.0	26.0	26.6
Colour units Apparent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Conductivity 25o C umhos/cm	206	301	309	311	295	309	279	282	299	275	309	308	299
Fluoride Unfilt., Reactive mg/L	0.09	0.08	0.08	0.12	0.10	0.12	0.08	0.10	0.08	0.09	0.10	0.10	0.10
Hardness Total mg/L	123	130	132	122	129	133	129	126	120	127	122	124	126
Iron Unfiltered Total mg/L	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Magnesium mg/L	9.10	9.90	9.60	9.90	9.30	9.00	8.80	8.80	8.40	8.70	8.70	9.00	9.10
Manganese mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Nitrates Total Filtered Reactive mg/L	0.446	0.395	0.403	0.549	0.458	0.464	0.418	0.367	0.379	0.424	0.413	0.434	0.429
Nitrite, Filtered Reactive mg/L	0.011	0.012	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
pH	7.45	7.66	7.72	7.37	7.41	7.58	7.71	7.51	7.32	7.06	6.98	6.82	7.38
Sodium, Unfiltered Reactive mg/L	10.3	12.9	13.0	14.8	13.3	16.4	13.6	15.3	12.2	12.3	12.9	12.8	13.3
Sulphate, Unfiltered Reactive mg/L	37.0	35.0	33.0	38.0	36.0	37.0	37.0	35.0	39.0	37.0	35.0	36.0	36.3
Turbidity N.T.U.	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

REGIONAL MUNICIPALITY OF NIAGARA – PUBLIC WORKS DEPARTMENT
WATER & WASTEWATER DIVISION – WATER SECTION
AMOUNT OF WATER PRODUCED, MAXIMUM AND AVERAGE DAY
DURING THE YEAR 2003

Name of Water System: **GRIMSBY**

MONTH	MAXIMUM DAY		AVERAGE DAY	
JANUARY	14.824	ML	12.654	ML
FEBRUARY	14.511	ML	12.834	ML
MARCH	14.472	ML	12.625	ML
APRIL	16.948	ML	13.438	ML
MAY	15.467	ML	13.596	ML
JUNE	25.935	ML	16.492	ML
JULY	27.740	ML	17.803	ML
AUGUST	22.268	ML	16.024	ML
SEPTEMBER	24.094	ML	17.147	ML
OCTOBER	16.602	ML	13,495	ML
NOVEMBER	14.393	ML	12.474	ML
DECEMBER	13,332	ML	12.210	ML

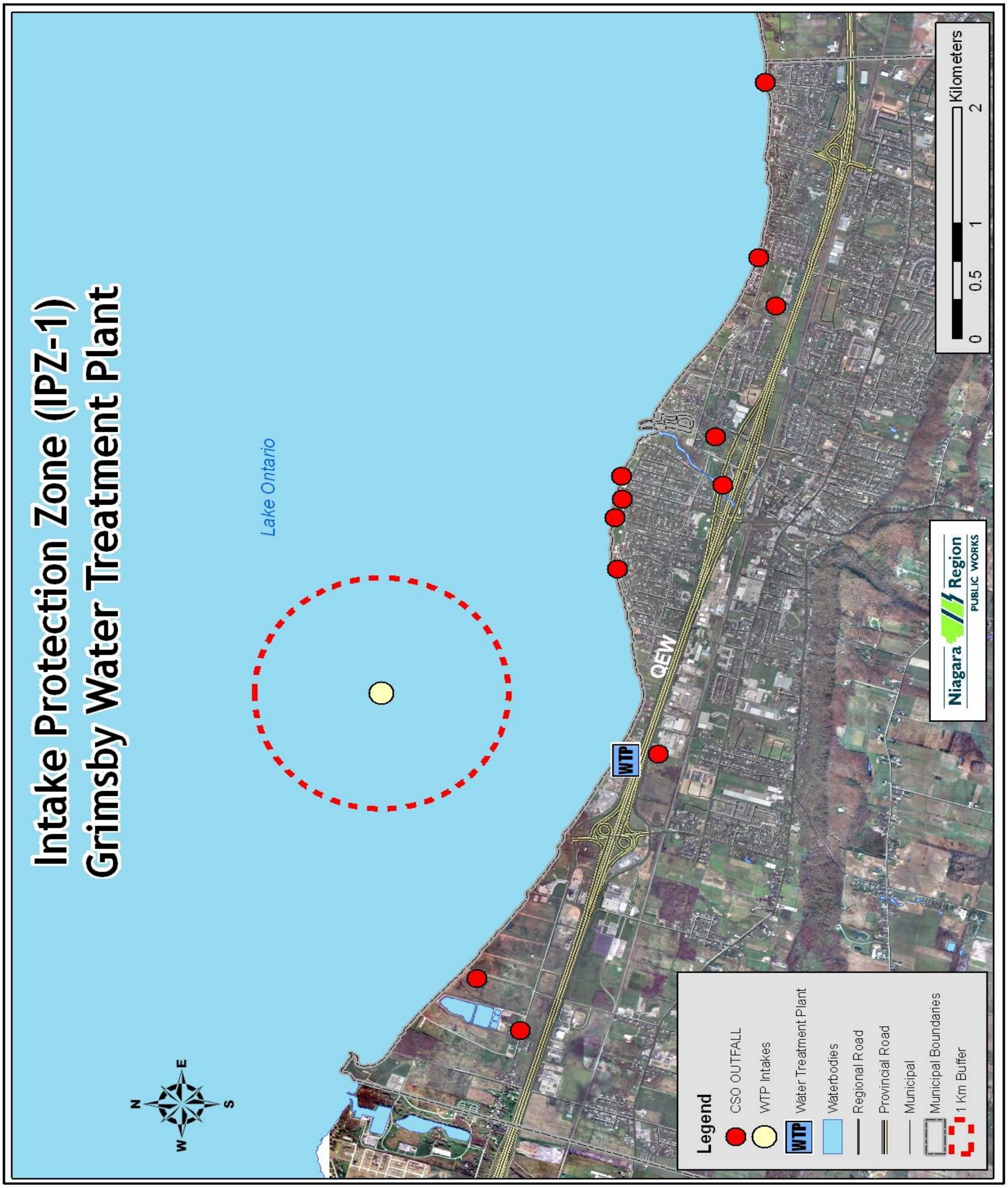
LOCATION OF NIAGARA REGION'S WATER TREATMENT PLANTS


Niagara Region's Water Treatment Plant Intakes
N
E
S
W
Lake Ontario
Lake Erie
WTP
Niagara Region PUBLIC WORKS
0 2 4 8 12 Kilometers
Legend
WTP Intakes
Water Treatment Plant
Waterbodies
Regional Road
Provincial Road
Builtup Areas
Municipal Boundaries

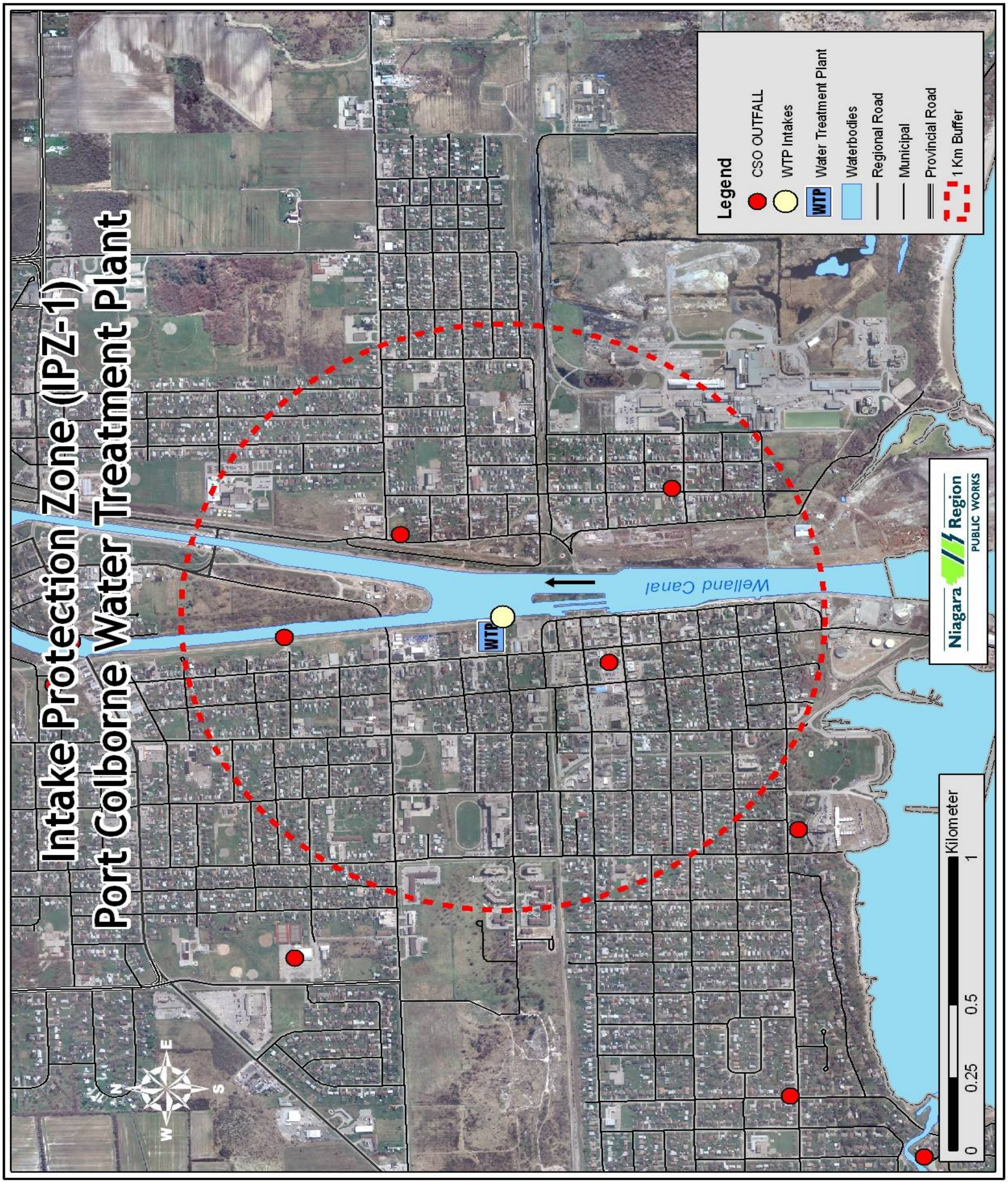
WATER TREATMENT PLANT IPZ-1 MAPS FOR:

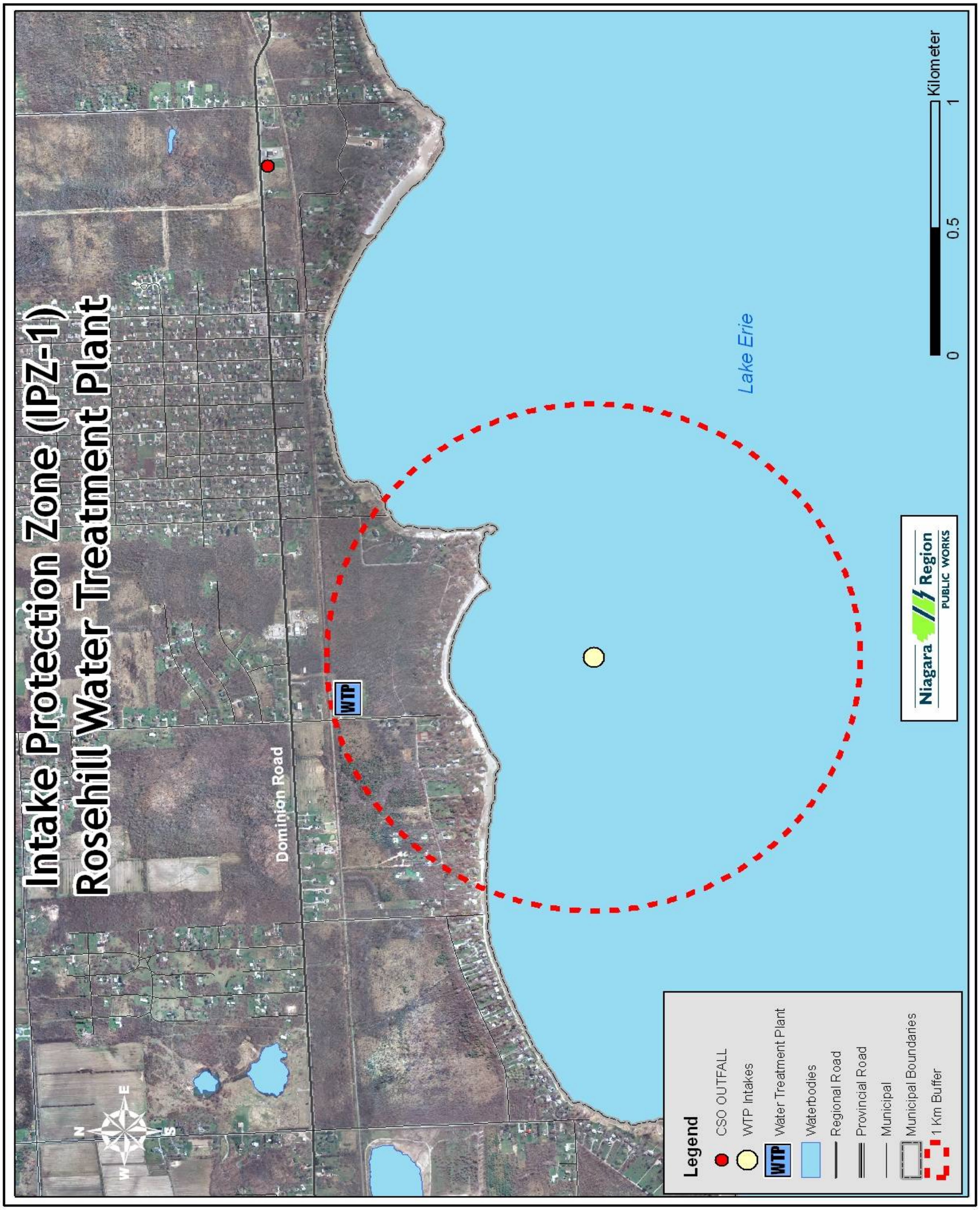
- **DECEW FALLS WATER TREATMENT PLANT**
- **GRIMSBY WATER TREATMENT PLANT**
- **NIAGARA FALLS WATER TREATMENT PLANT**
- **PORT COLBORNE WATER TREATMENT PLANT**
- **ROSEHILL WATER TREATMENT PLANT**
- **WELLAND WATER TREATMENT PLANT**

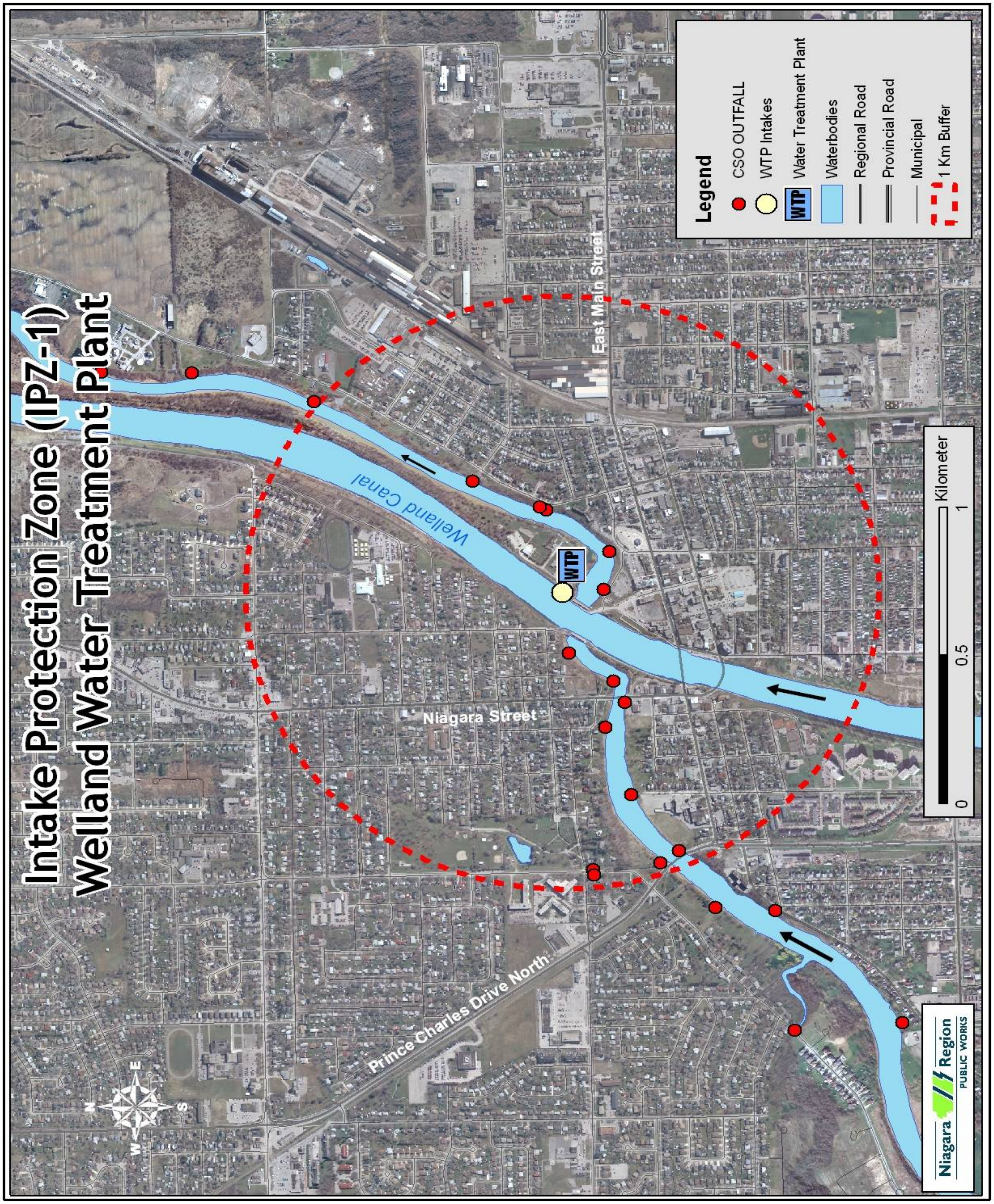

Intake Protection Zone (IPZ-1)
DeCew Falls Water Treatment Plant
Hwy 406
Lake Gibson
Merritville Hwy
Lake Moodie
WTP
Twelve Mile Creek
Pelham Road
First Street Louth
Kilometer
0
0.25
0.5
1
Niagara Region
PUBLIC WORKS
Legend
CSO OUTFALL
WTP Intakes
Water Treatment Plant
Waterbodies
Regional Road
Provincial Road
Municipal
Municipal Boundaries
1 Km Buffer
N
E
S
W


Intake Protection Zone (IPZ-1)
Grimsby Water Treatment Plant
Lake Ontario
QEW
WTP
Legend
CSO OUTFALL
WTP Intakes
Water Treatment Plant
Waterbodies
Regional Road
Provincial Road
Municipal
Municipal Boundaries
1 Km Buffer
0 0.5 1 2 Kilometers
N E S W
Niagara Region PUBLIC WORKS


Intake Protection Zone (IPZ-1)
Niagara Falls Water Treatment Plant
Niagara River
Welland River
WTP
Niagara Region PUBLIC WORKS
0
0.5
1
Kilometer
Legend
CSO OUTFALL
WTP Intakes
Water Treatment Plant
Waterbodies
Regional Road
Provincial Road
Municipal
1 Km Buffer


Intake Protection Zone (IPZ-1)
Port Colborne Water Treatment Plant
Legend
CSO OUTFALL
WTP Intakes
Water Treatment Plant
Waterbodies
Regional Road
Municipal
Provincial Road
1 Km Buffer
Welland Canal
WTP
Niagara Region
PUBLIC WORKS
Kilometer
0
0.25
0.5
1
N
E
S
W


Intake Protection Zone (IPZ-1)
Rosehill Water Treatment Plant
Dominion Road
WTP
Lake Erie
0
0.5
1
Kilometer
Niagara Region
PUBLIC WORKS
Legend
CSO OUTFALL
WTP Intakes
Water Treatment Plant
Waterbodies
Regional Road
Provincial Road
Municipal
Municipal Boundaries
1 Km Buffer


Intake Protection Zone (IPZ-1)
Welland Water Treatment Plant
Legend
CSO OUTFALL
WTP Intakes
WTP Water Treatment Plant
Waterbodies
Regional Road
Provincial Road
Municipal
1 Km Buffer
Welland Canal
East Main Street
Niagara Street
Prince Charles Drive North
WTP
0
0.5
1
Kilometer
N
E
S
W
Niagara Region
PUBLIC WORKS

APPENDIX C

Climate Data

Climate Data

Climate data used in the characterization report was obtained from the Environment Canada website, Meteorological Services of Canada (MSC) links. The analytical results shown below were based on data from the 12 climate stations that are located in the Niagara Peninsula SWP Authority, where climate normals (or averages) have been calculated by MSC. The table below indicates which climate normals meet the World Meteorological Organisation (WMO) standards. Further discussion of the WMO climate normals standards is presented later in this Appendix.

Climate Stations where Climate Normals have been Determined

#	Source	Station Name / Location	Meets WMO Standards	Temp	Precip	Wind Data	Snow
1	EnvCan (MSC)	Vineland Station	No	Yes	Yes	Yes	Yes
2	EnvCan (MSC)	Vineland Rittenhouse	Yes	Yes	Yes	No	Yes
3	EnvCan (MSC)	Port Dalhousie	Yes	Yes	Yes	No	Yes
4	EnvCan (MSC)	St Catharines A	Yes	Yes	Yes	Yes	Yes
5	EnvCan (MSC)	St Catharines Power Glen	No	Yes	Yes	No	Yes
6	EnvCan (MSC)	Niagara Falls	No	Yes	Yes	Yes	Yes
7	EnvCan (MSC)	Niagara Falls NPCSH	No	Yes	Yes	No	Yes
8	EnvCan (MSC)	Ridgeville	Yes	Yes	Yes	No	Yes
9	EnvCan (MSC)	Welland	Yes	Yes	Yes	No	Yes
10	EnvCan (MSC)	Port Colborne	Yes	Yes	Yes	Yes	Yes
11	EnvCan (MSC)	Fort Erie	Yes	Yes	Yes	Yes	Yes
12	EnvCan (MSC)	Hamilton Airport	Yes	Yes	Yes	Yes	Yes

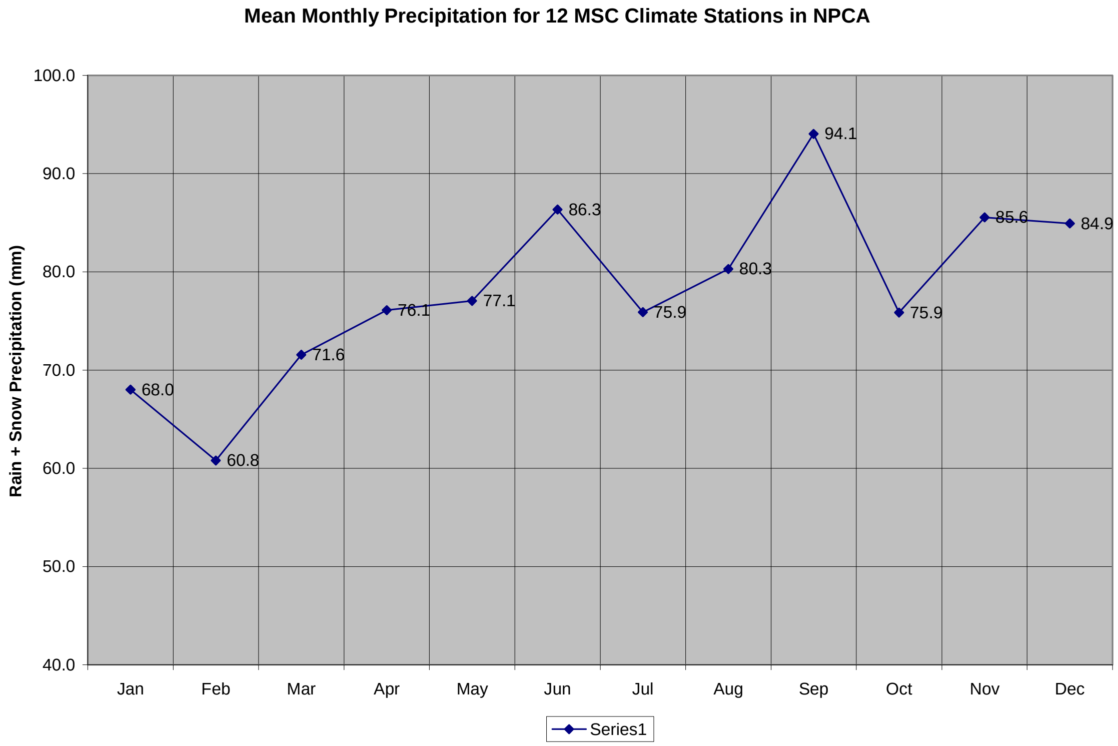
Notes: MSC = Meteorologic Services of Canada
Reference: Environment Canada website - March 2006

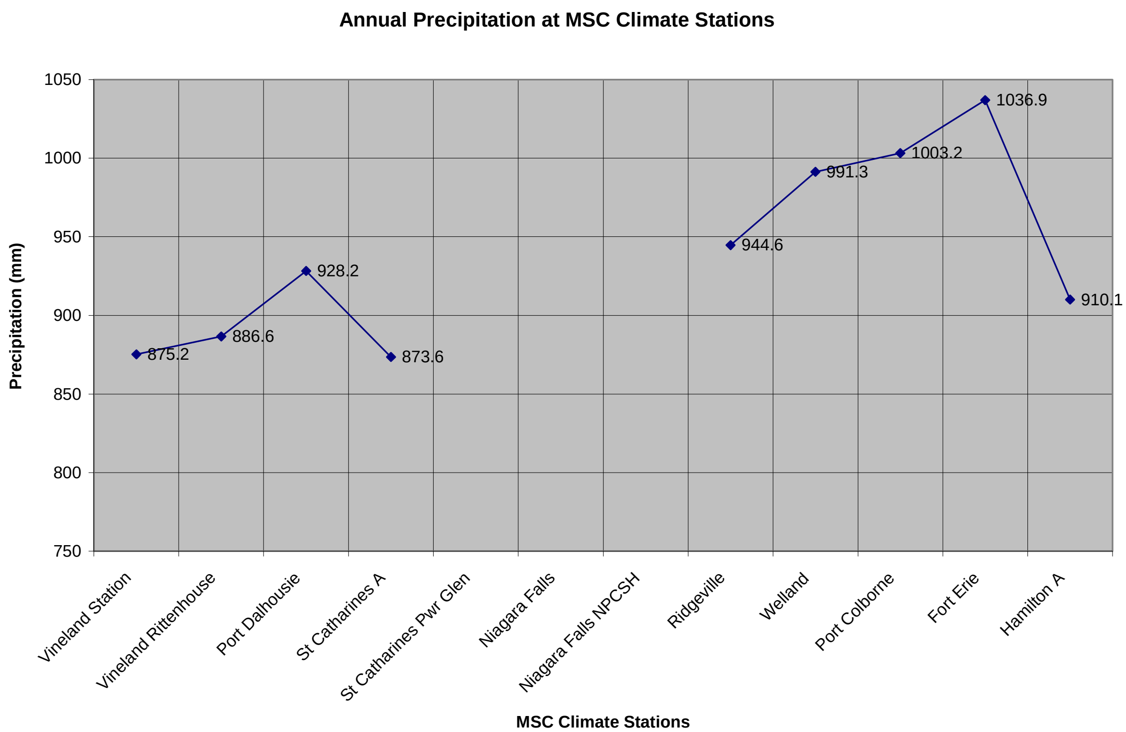
The graph below shows mean monthly precipitation for the 12 climate stations in the SWP Authority where climate normals have been determined. The monthly precipitation values were obtained by calculating a simple arithmetic mean of the monthly data for the 12 climate stations. No attempt was made to provide a weighting based on area represented by each climate station.

Yearly totals of precipitation were obtained from MSC website for comparison between the MSC Climate stations. Where no yearly totals are shown, MSC considered the data to be not of satisfactory quality (i.e. omissions were identified in the data).

A more comprehensive analysis of climate data is presented in the Conceptual Water Budget Report (dated July 2007) and the Tier 1 Water Budget Draft Report (dated May 2009). Additional sources of weather data, such as data from Regional Municipality of

Niagara weather stations and solar radiation data, are referenced in the Conceptual Water Budget Report.





Average Monthly Precipitation per MSC Climate Station

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code		Max Value	Min Value	Std Dev
1	**Vineland Station**	52.2	57.2	77.5	69.6	67.5	81.5	71.8	82.5	92.2	65.2	78.3	79.6	875.2	D		92.2	52.2	11.3
2	**Vineland Rittenhouse**	63.8	55.7	70.7	74.6	74.7	80.6	79.7	74.2	88.8	70.1	79.3	74.5	886.6	A		88.8	55.7	8.5
3	**Port Dalhousie**	62.6	62.4	69.1	82	80.5	83.9	78.8	74.4	92.7	74.5	83.6	83.8	928.2	A		92.7	62.4	9.1
4	**St Catharines A**	63.1	51.9	67.9	77.8	74.9	82.5	73.6	72.1	91.5	68.5	75.5	74.2	873.6	A		91.5	51.9	9.8
5	**St Catharines Pwr Glen**	58.2	52.8	60.7	73.9	72.6	91.5	76.3	77	89.5	70	74.3	76.2		A		91.5	52.8	11.4
6	**Niagara Falls**	69.5	67.4	75.5	75.5	76.5	87.5	75.4	81.6	95.2	84.3	91	90.7		A		95.2	67.4	8.9
7	**Niagara Falls NPCSH**	73.5	62.5	63.8	71.7	85.7	89.2	79	79.7	96.7	75.1	88.4	78.8		C		96.7	62.5	10.2
8	**Ridgeville**	67.5	58.2	70.7	76.4	79.4	89.9	73.3	84.4	96.7	79.1	82.9	86.3	944.6	A		96.7	58.2	10.5
9	**Welland**	76.7	66.3	77.8	76.5	77.7	91.5	70.4	82.7	97.9	84.5	91.6	97.6	991.3	A		97.9	66.3	10.3
10	**Port Colborne**	78.6	65	74.8	78.3	80.9	85.4	75	82.3	101.1	83	101.6	97.2	1003.2	A		101.6	65.0	11.2
11	**Fort Erie**	84.6	74.8	75.5	78.9	78.6	88.7	71	92	104.2	83.5	101.5	103.6	1036.9	A		104.2	71.0	11.7
12	**Hamilton A**	65.8	55.3	74.8	78	75.6	83.9	86.5	80.6	82.1	72.5	78.6	76.6	910.1	A		86.5	55.3	8.5
	Mean of the 12 Stations	68.0	60.8	71.6	76.1	77.1	86.3	75.9	80.3	94.1	75.9	85.6	84.9	938.9			94.05	60.8	9.0

The following is an extract from the Environment Canada website concerning “Climate Normals” and the appropriateness of the climate data that is present on their website.

WMO Standards for "Climate Normals"

"Climate averages", "climate means" or "climate normals" are all interchangeable terms. They refer to arithmetic calculations based on observed climate values for a given location over a specified time period and are used to describe the climatic characteristics of that location. Real-time values, such as daily temperature, are compared to the "climate normal" to determine how unusual or how great the departure from "average" they are.

There are many ways to calculate "climate normals"; the most useful ones adhere to accepted standards. The WMO considers thirty years long enough to eliminate year-to-year variations. Thus the WMO climatological standard period for normals calculations are "averages of climatological data computed for consecutive periods of 30 years as follows: 1 January 1901 to 31 December 1930, 1 January 1931 to 31 December 1960, etc." and should be updated every decade. In addition, the WMO established that normals should be arithmetic means calculated for each month of the year from daily data. To qualify, temperature data, soil temperatures and evaporation must fit the following rule: "If more than 3 consecutive daily values are missing or more than 5 daily values in total in a given month are missing, the monthly mean should not be computed and the year-month mean should be considered missing." This is referred to as the "3/5" rule. For total precipitation, degree-days, and "days with" calculations, no missing days are allowed.

Once the months that qualify are determined, a similar "3/5" rule is also applied to the number of monthly average or total values in the thirty-year period. For instance, to meet this WMO standard, the "normal" value of a monthly element, such as the normal rainfall amount for May, can have no more than 3 consecutive, or 5 in total, missing rainfall values in any month of May between 1971 to 2000.

For the purposes of the Canadian Climate Normals, calculated for 1971 to 2000, locations or climate stations, which meet to these WMO standards, are referred to as Class "A".

Code

Normals for some elements are derived from less than 30 years of record. The minimum number of years used are indicated by a "code" defined as:

- "A": No more than 3 consecutive or 5 total missing years between 1971 to 2000.
- "B": At least 25 years of record between 1971 and 2000.
- "C": At least 20 years of record between 1971 and 2000.
- "D": At least 15 years of record between 1971 and 2000.

Temperature

At most climatological stations the maximum temperature is the highest recorded in a 24-hour period ending in the morning of the next day. The minimum values are for a period of the same length, beginning in the evening of the previous day. Mean temperature is the average of the two. At most principal stations the maximum and minimum temperatures are for a day beginning at 0600 Greenwich (or Universal) Mean Time, which is within a few hours of midnight local standard time in Canada.

Rainfall, Snowfall, and Precipitation

Rain, drizzle, freezing rain, freezing drizzle and hail are usually measured using the standard Canadian rain gauge, a cylindrical container 40 cm high and 11.3 cm in diameter. The precipitation is funnelled into a plastic graduate which serves as the measuring device. Snowfall is the measured depth of newly fallen snow, measured using a snow ruler. Measurements are made at several points which appear representative of the immediate area, and then averaged. "Precipitation" in the tables is the water equivalent of all types of precipitation.

At most ordinary stations the water equivalent of snowfall is computed by dividing the measured amount by ten. At principal stations it is usually determined by melting the snow that falls into Nipher gauges. These are precipitation gauges designed to minimize turbulence around the orifice, and to be high enough above the ground to prevent most blowing snow from entering. The amount of snow determined by this method normally provides a more accurate estimate of precipitation than using the "ten-to-one" rule. Even at ordinary climate stations the normals precipitation values will not always be equal to rainfall plus one tenth of the snowfall. Missing observations is one cause of such discrepancies.

Precipitation measurements are usually made four times daily at principal stations. At ordinary sites they are usually made once or twice per day. Rainfall, snowfall and precipitation amounts given in the tables represent the average accumulation for a given month or year.

Snow Depth

Snow cover is the depth of accumulated snow on the ground, measured at several points which appear representative of the immediate area, and then averaged. End-of-month values are given in the tables.

Wind

The majority of wind measurements are made by anemometers installed at ten metres above the ground. A substantial minority of sites have instruments installed at other heights, usually greater than ten metres. Wind in the first ten's of metres above the ground tends to increase in speed and veer with height.

Winds are normally measured at level, open sites removed as much as possible from obstacles to wind flow such as trees, buildings, or hills.

At the majority of principal stations, wind is measured by taking a one- or (since 1985) two-minute mean at each observation, from a U2A anemometer. At other wind-measuring sites, values are usually obtained from autographic records of U2A or 45B anemometers. Averaging periods may vary from one minute to an hour. Winds measured by U2A's are recorded to the nearest ten degrees, while those from the 45B provide them to eight points of the compass. The extreme gust speed is the instantaneous peak wind observed from the anemometer dials, or abstracted from a continuous chart recording.

Where directions were measured more precisely than eight points, they have been converted to this format. The direction is defined as that from which the wind blows.

Number of Days With Specified Parameters

These tables give the average number of days per month or year on which a specific meteorological event occurs.

In the case of rainfall and precipitation, 0.2 mm or more must occur before a "day with" is counted. The corresponding figure for snowfall is 0.2 cm.

A day with freezing precipitation is counted if there is an occurrence of 0.2 mm or more of rain or drizzle which turns to ice on contact with the underlying surface.

Fog for this purpose is defined as a suspension of very small water droplets reducing the horizontal visibility to less than 1 km.

A day with thunderstorms occurs if thunder is heard.

Degree-Days

Degree-days for a given day represent the number of Celsius degrees that the mean temperature is above or below a given base. For example, heating degree-days are the number of degrees below 18° C. If the temperature is equal to or greater than 18, then the number will be zero. Values above or below the base of 18° C are used primarily to estimate the heating and cooling requirements of buildings. Values above 5° C are frequently called growing degree-days, and are used in agriculture as an index of crop growth. Values in the tables represent the average accumulation for a given month or year.

Soil Temperature

Soil temperature measurements provide a climatology of soil thermal characteristics such as the depth of frost penetration into the soil and the duration that the soil remains frozen. It is of interest to hydrologists because it affects surface runoff, infiltration and snowmelt and to agriculturalists because it affects seed germination. Measurements of soil temperature are made in accordance with the World Meteorological Organization (WMO) recommendations at the standard depths of 5, 10, 20, 50, 100, 150 and 300 cm. They are measured daily as close as possible to 08:00 LST and again at the shallowest depth at 16:00 LST.

Evaporation

Evaporation refers to the calculated lake evaporation occurring from a small natural open water-body having negligible heat storage and very little heat transfer at its bottom and sides. It represents the water loss from ponds and small reservoirs but not from lakes that have large heat storage capacities. Lake evaporation is calculated using the observed daily values of pan evaporative water loss, the mean temperatures of the water in the pan and of the nearby air, and the total wind run over the pan.

Lake Evaporation normals for the 1971 to 2000 period were calculated as means of daily means for a given station. This in effect is a measure of the rate of evaporation rather than a measure of total evaporation as was calculated in previous normals. To make the 1971 to 2000 lake evaporation normal values comparable to previous normals calculations, multiply the 1971 to 2000 value by the number of days for a given month.

APPENDIX D

Water Quality:

- **Drinking Water Information System (DWIS)**
- **Drinking Water Surveillance Program (DWSP)**

FIGURES

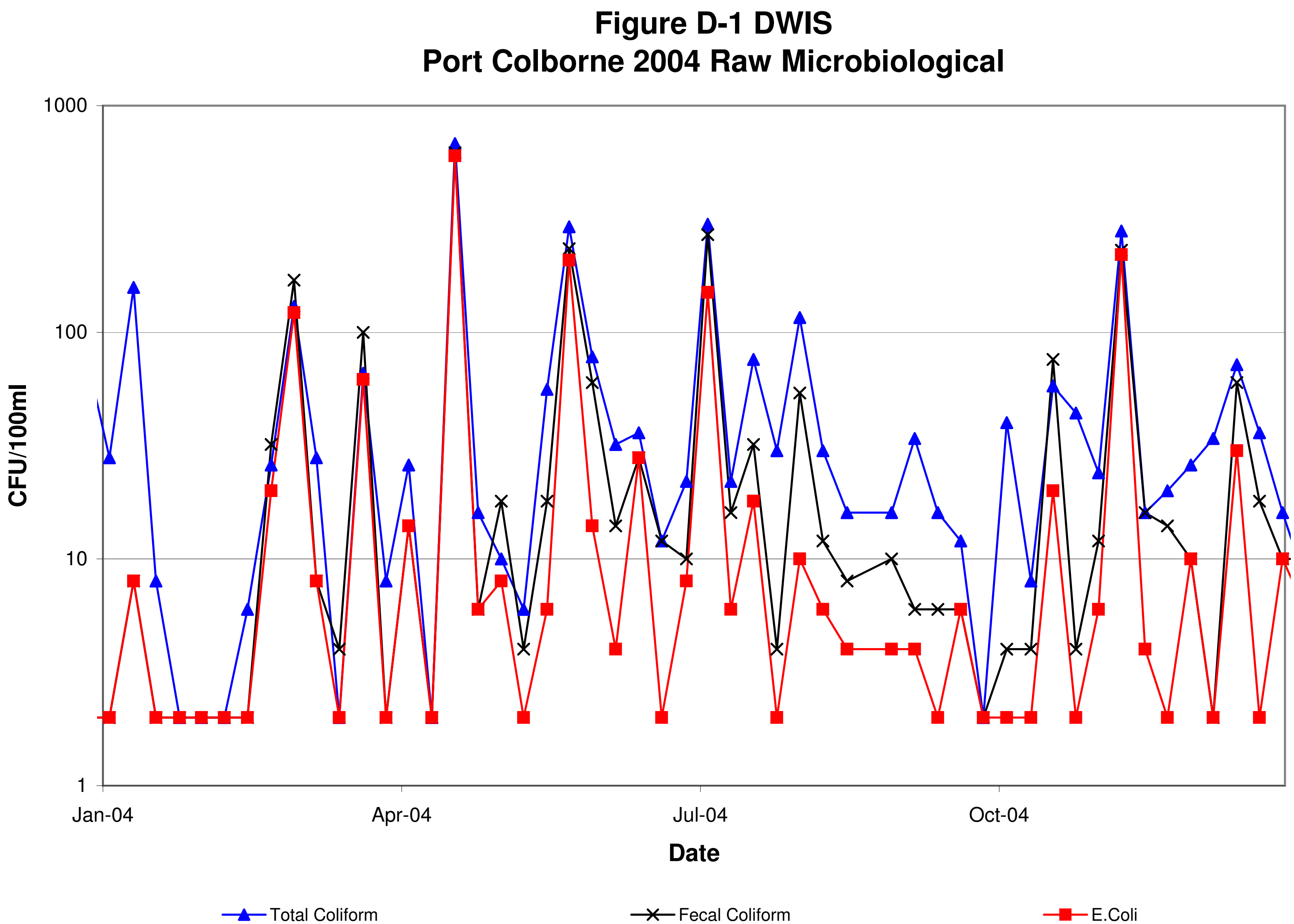


Figure D-1 DWIS
Port Colborne 2004 Raw Microbiological
1000
100
10
1
CFU/100ml
Jan-04
Apr-04
Jul-04
Oct-04
Date
Total Coliform
Fecal Coliform
E.Coli

Figure D-2 DWIS
Port Colborne 2005 Raw Microbiological

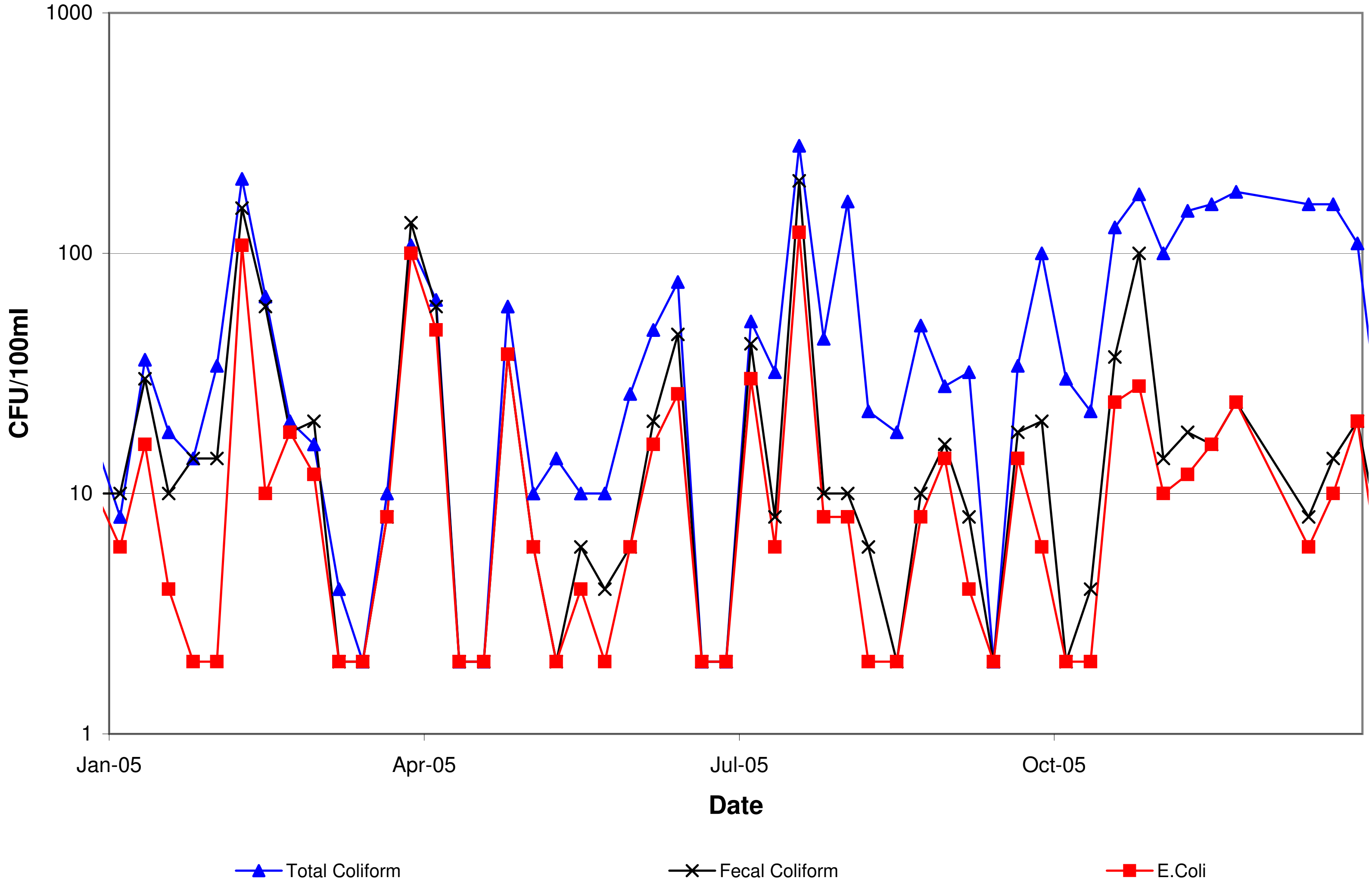


Figure D-3 DWIS
Port Colborne 2006 Raw Microbiological

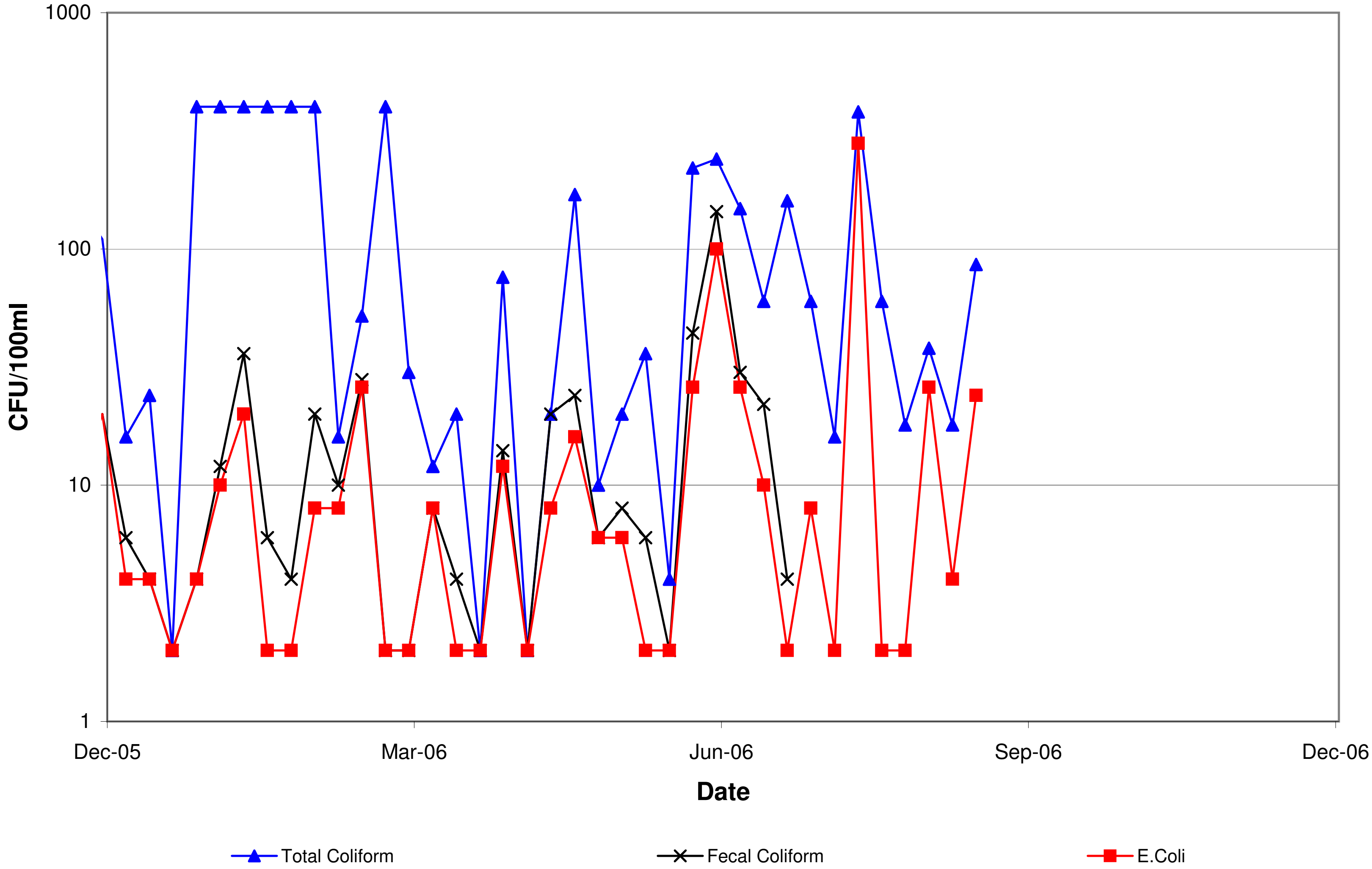


Figure D-4 DWIS
Welland 2004 Raw Microbiological

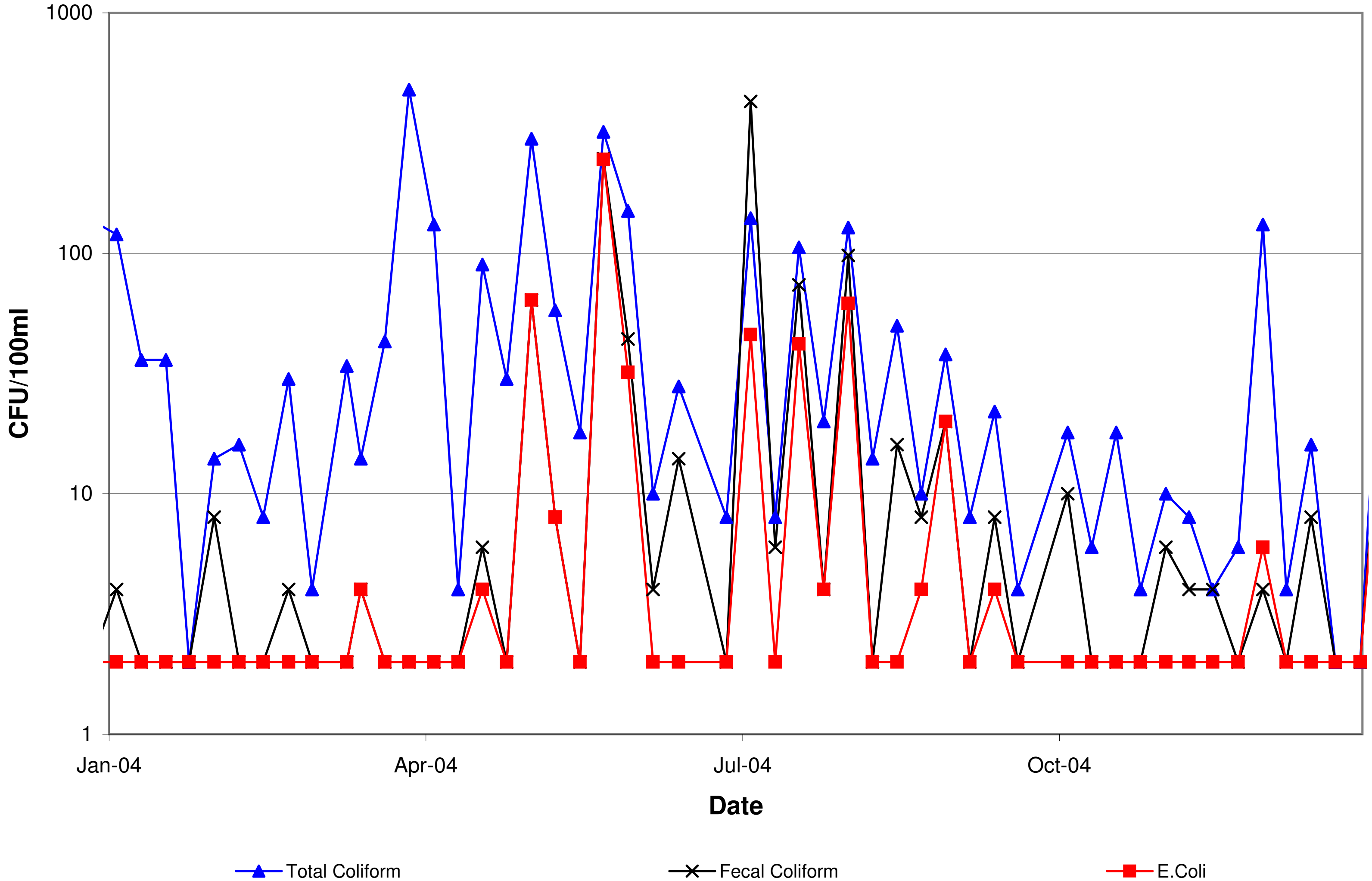


Figure D-5 DWIS
Welland 2005 Raw Microbiological

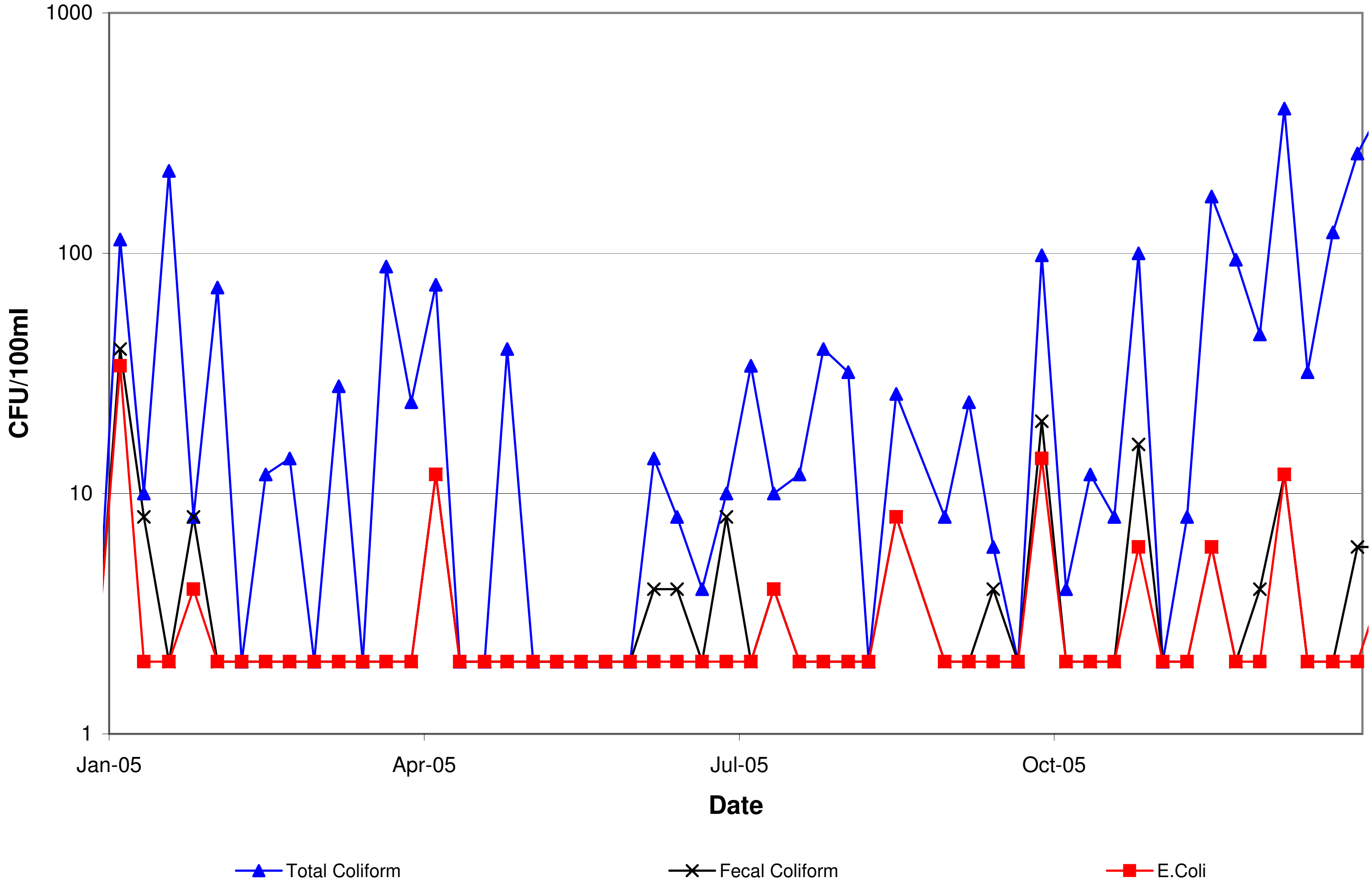
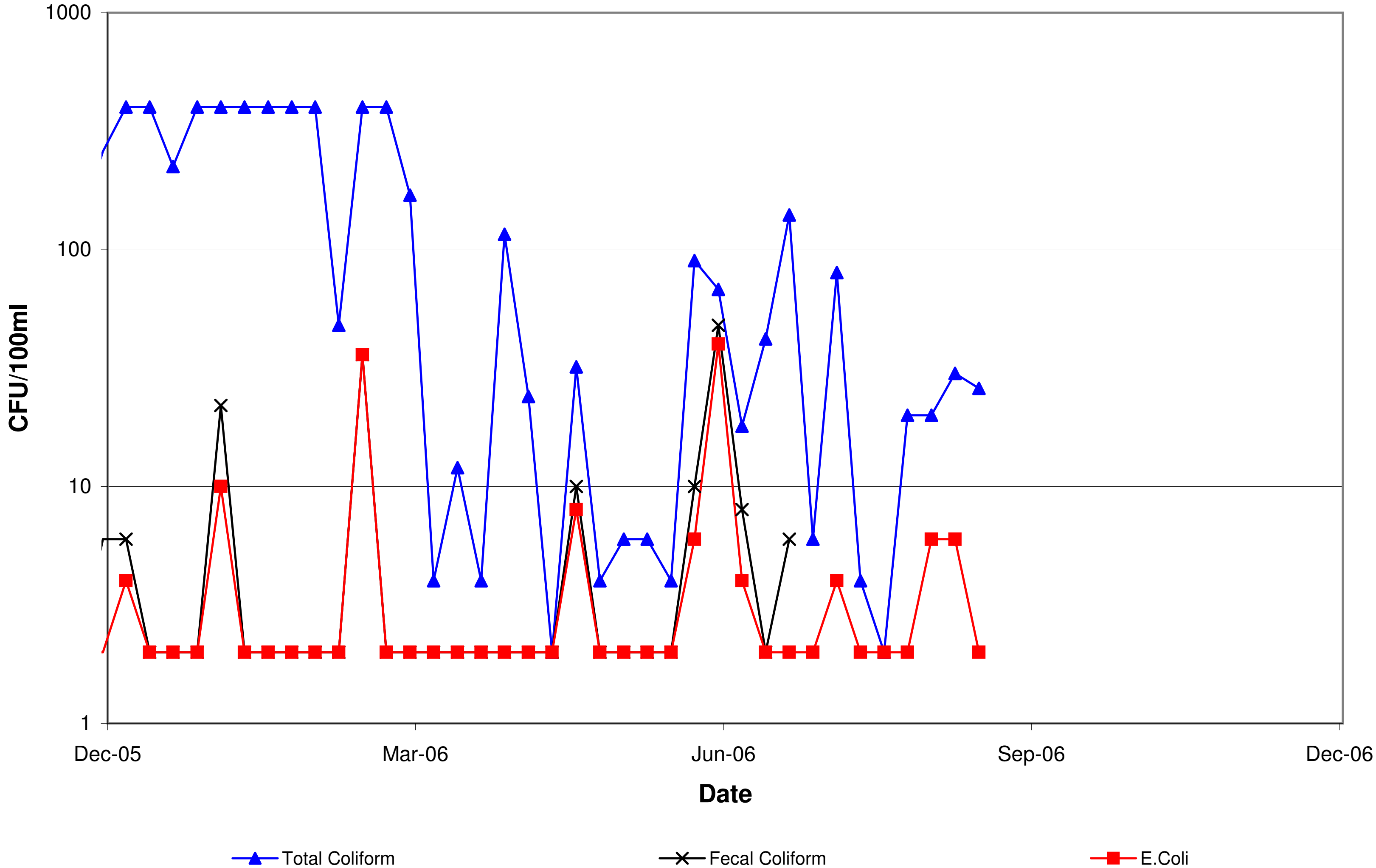


Figure D-6 DWIS
Welland 2006 Raw Microbiological



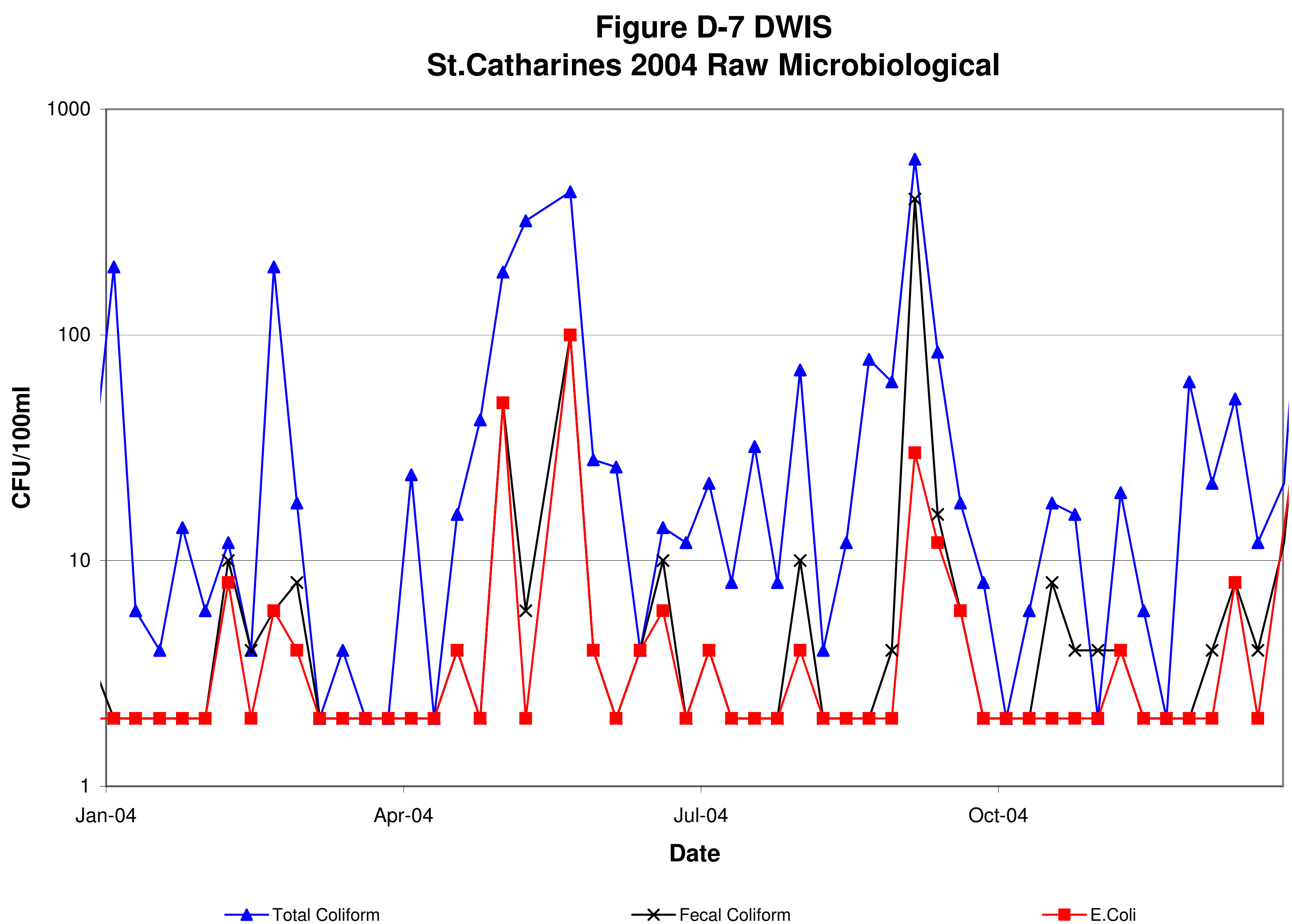


Figure D-7 DWIS
St.Catharines 2004 Raw Microbiological
1000
100
10
1
CFU/100ml
Jan-04
Apr-04
Jul-04
Oct-04
Date
Total Coliform
Fecal Coliform
E.Coli

Figure D-8 DWIS
St.Catharines 2005 Raw Microbiological

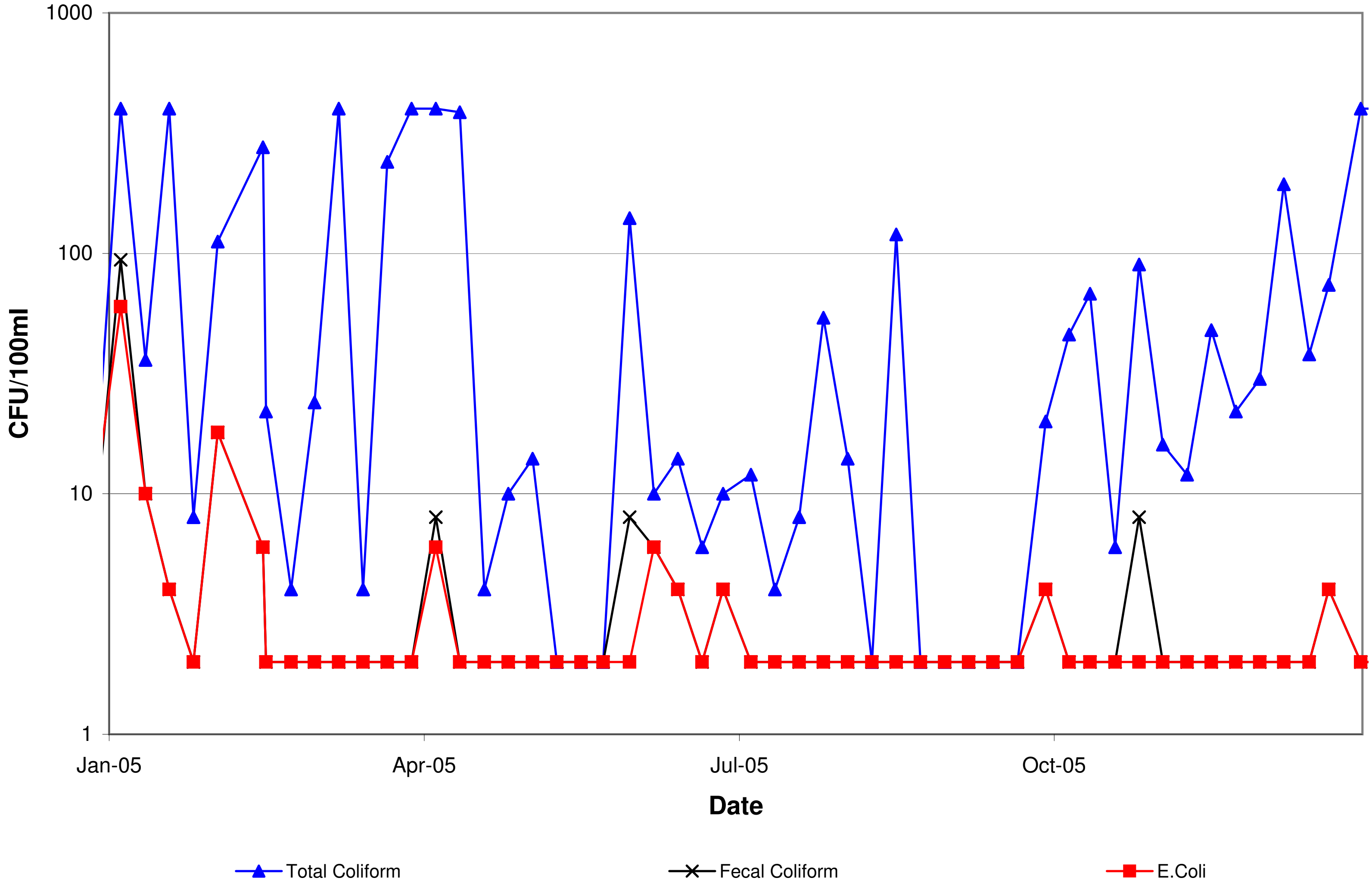
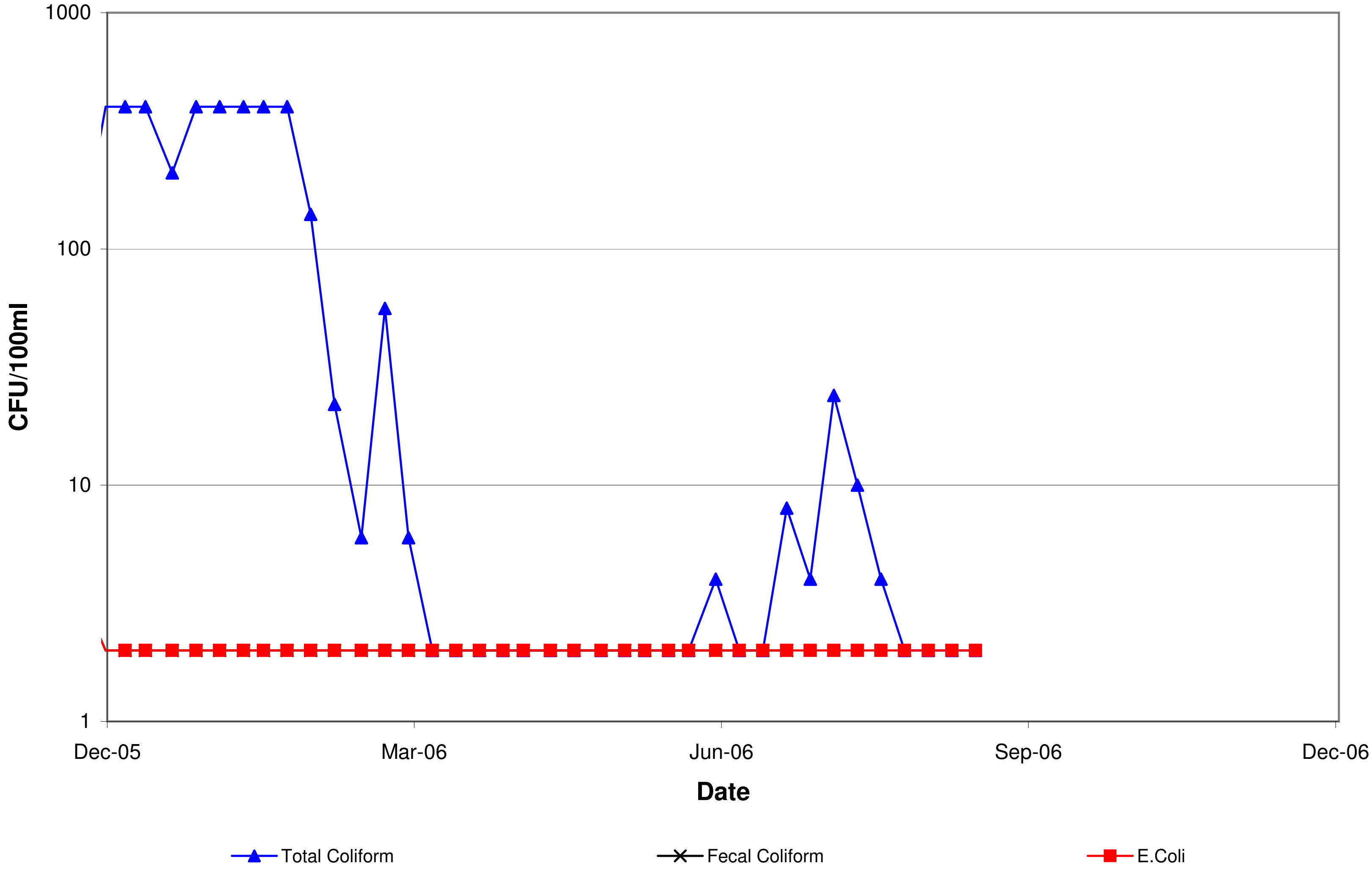


Figure D-9 DWIS
St.Catharines 2006 Raw Microbiological



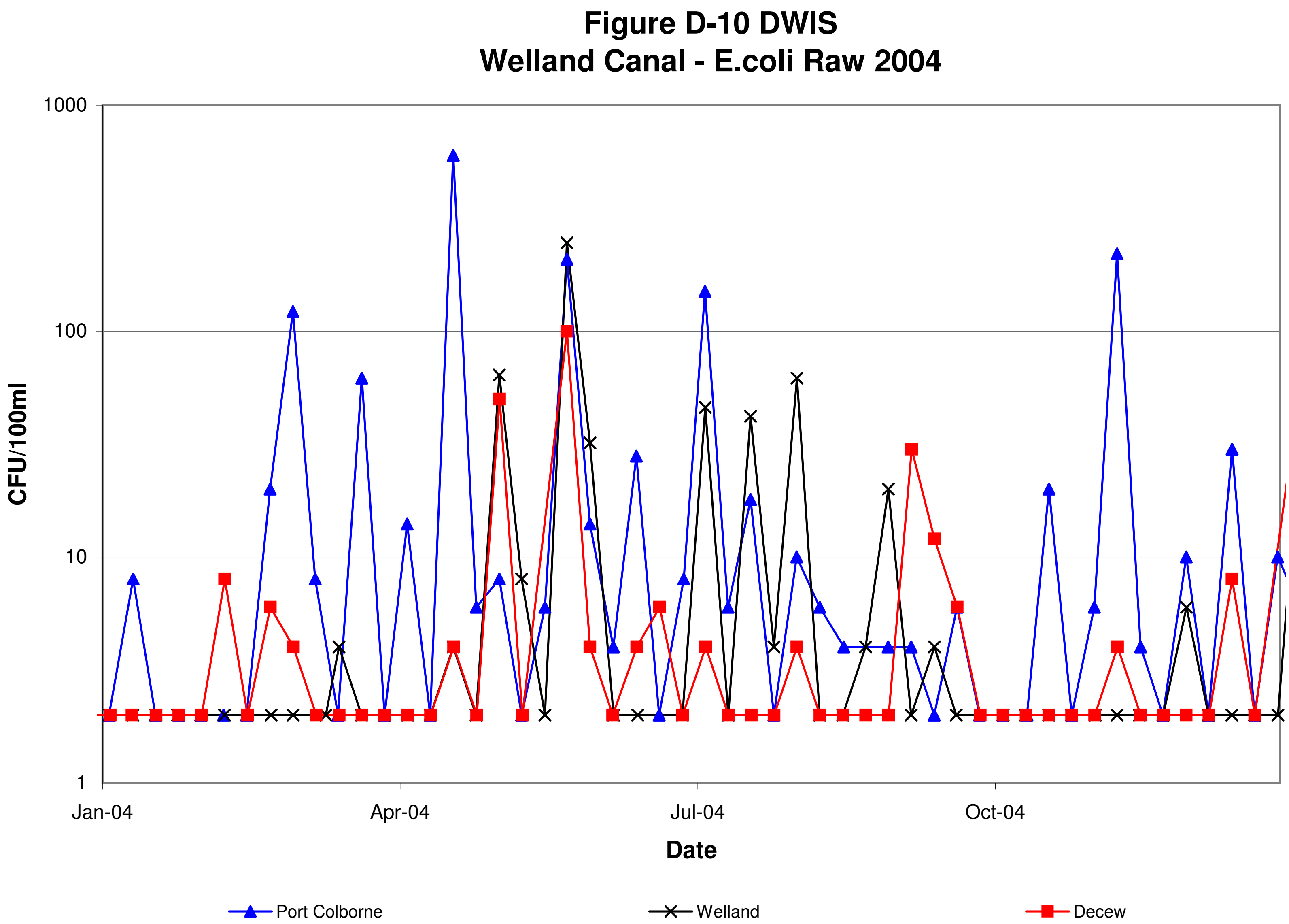


Figure D-10 DWIS
Welland Canal - E.coli Raw 2004
1000
100
10
1
CFU/100ml
Jan-04
Apr-04
Jul-04
Oct-04
Date
Port Colborne
Welland
Decew

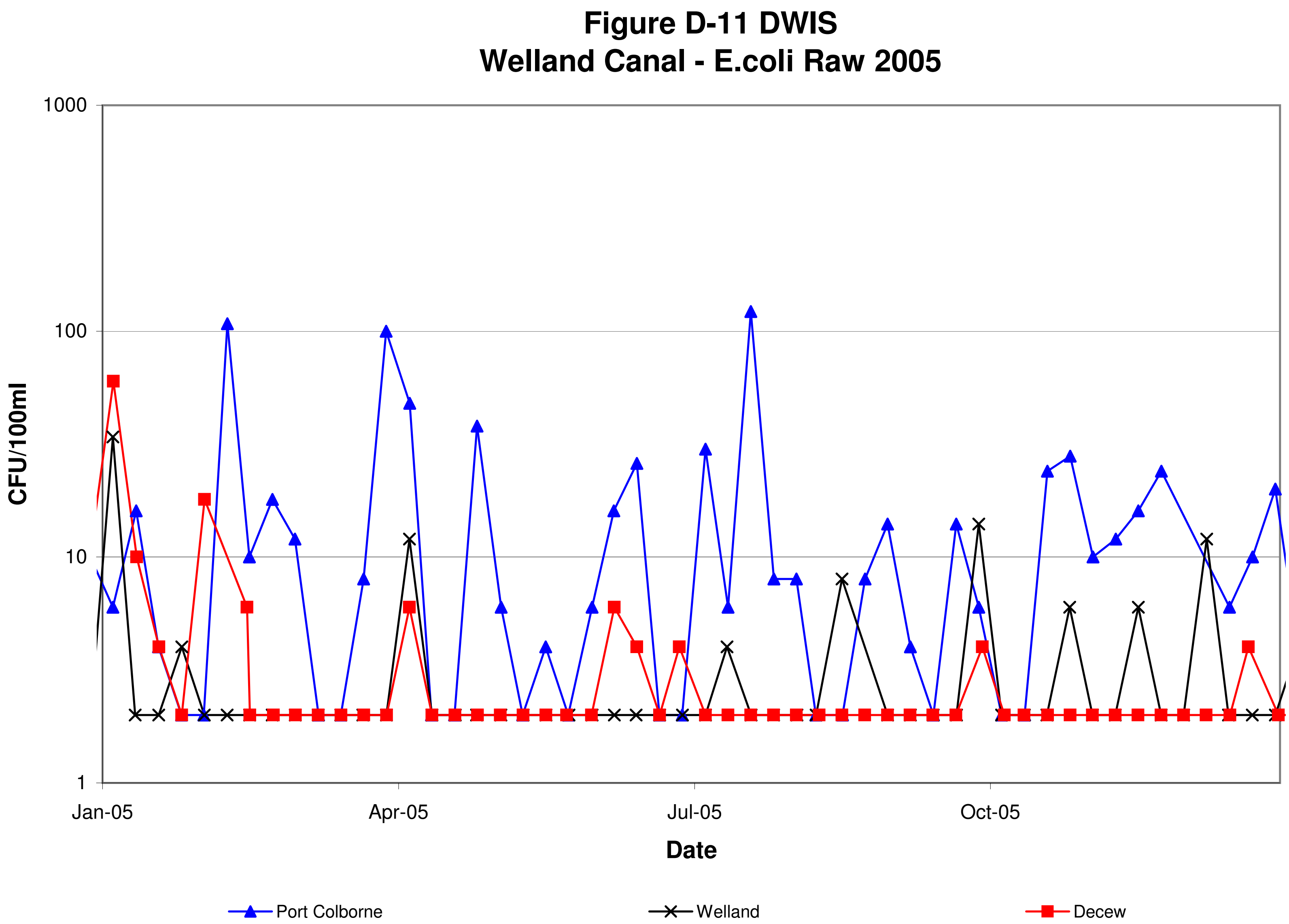


Figure D-11 DWIS
Welland Canal - E.coli Raw 2005
1000
100
10
1
CFU/100ml
Jan-05
Apr-05
Jul-05
Oct-05
Date
Port Colborne
Welland
Decew

Figure D-12 DWIS
Welland Canal - E.coli Raw 2006

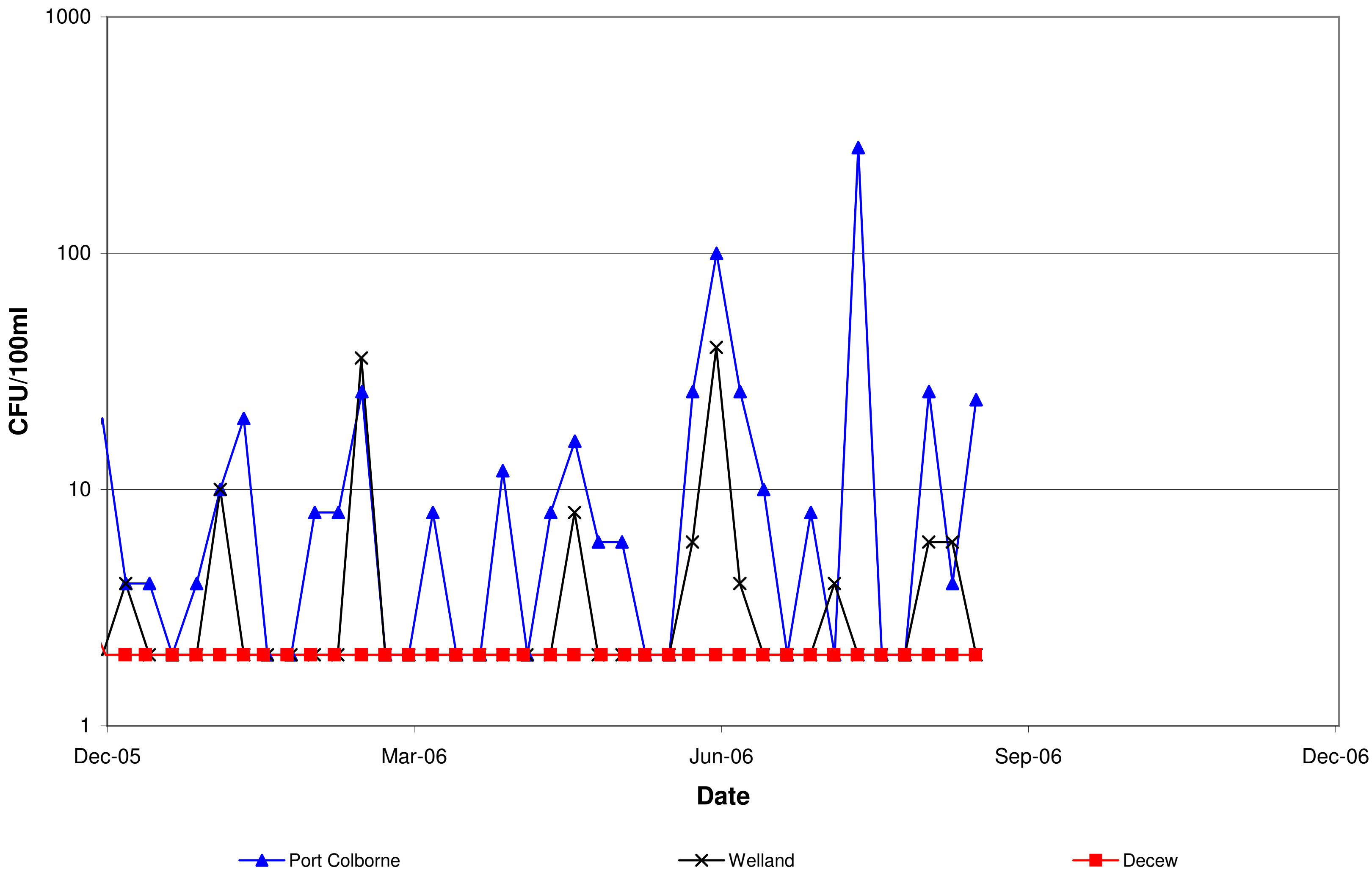
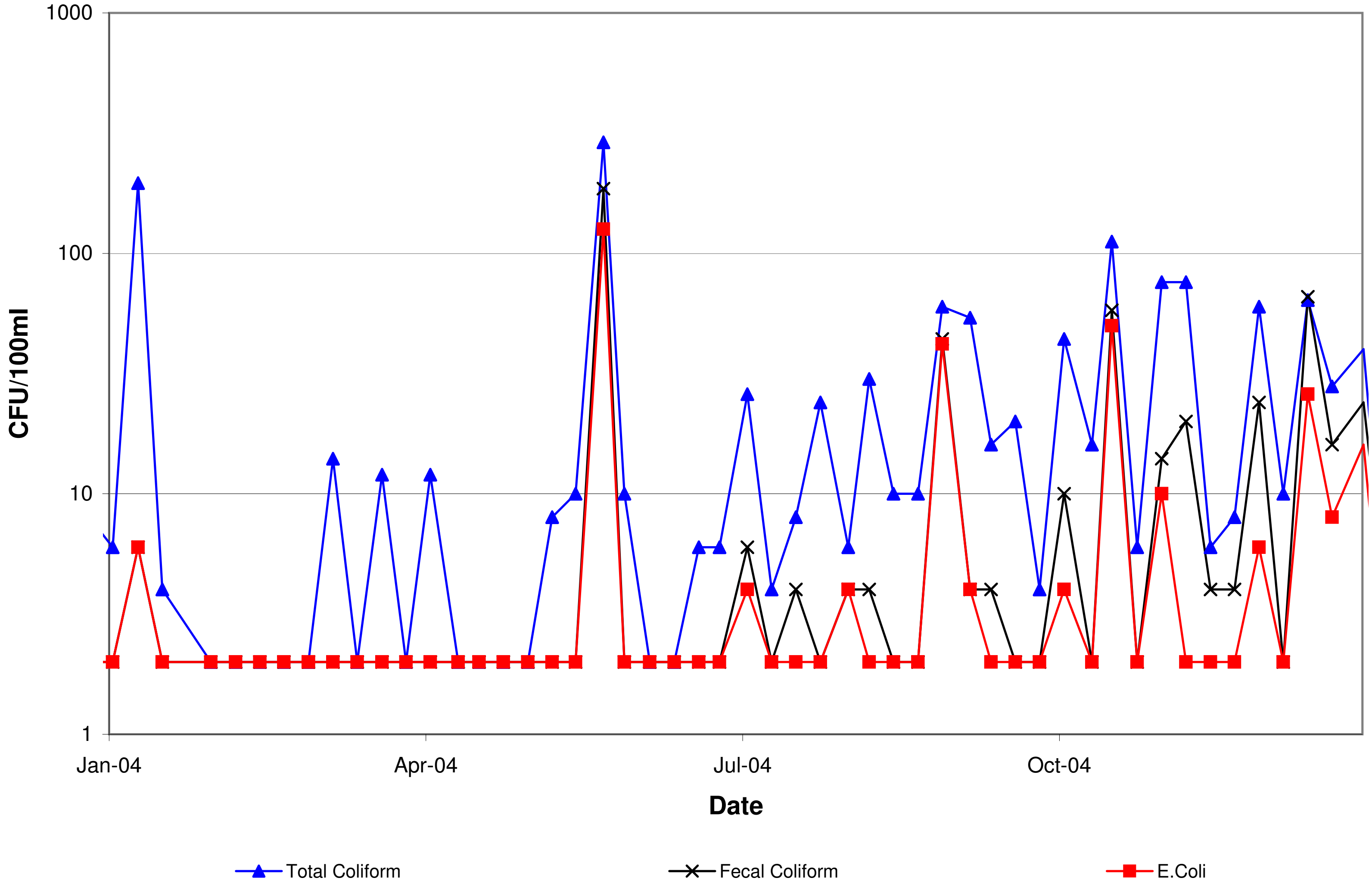


Figure D-13 DWIS
Fort Erie 2004 Raw Microbiological



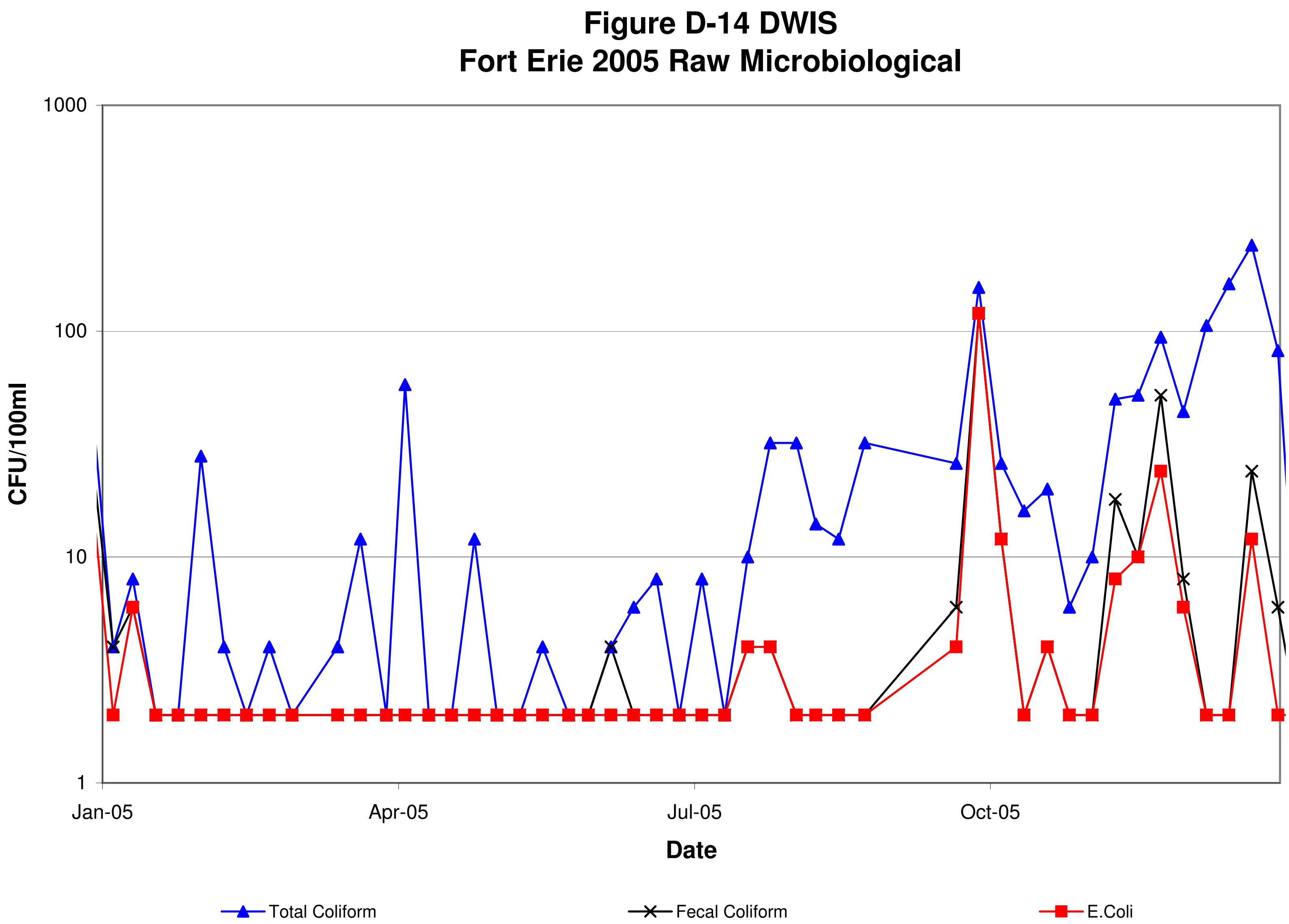


Figure D-14 DWIS
Fort Erie 2005 Raw Microbiological
1000
100
10
1
CFU/100ml
Jan-05
Apr-05
Jul-05
Oct-05
Date
Total Coliform
Fecal Coliform
E.Coli

Figure D-15 DWIS
Fort Erie 2006 Raw Microbiological

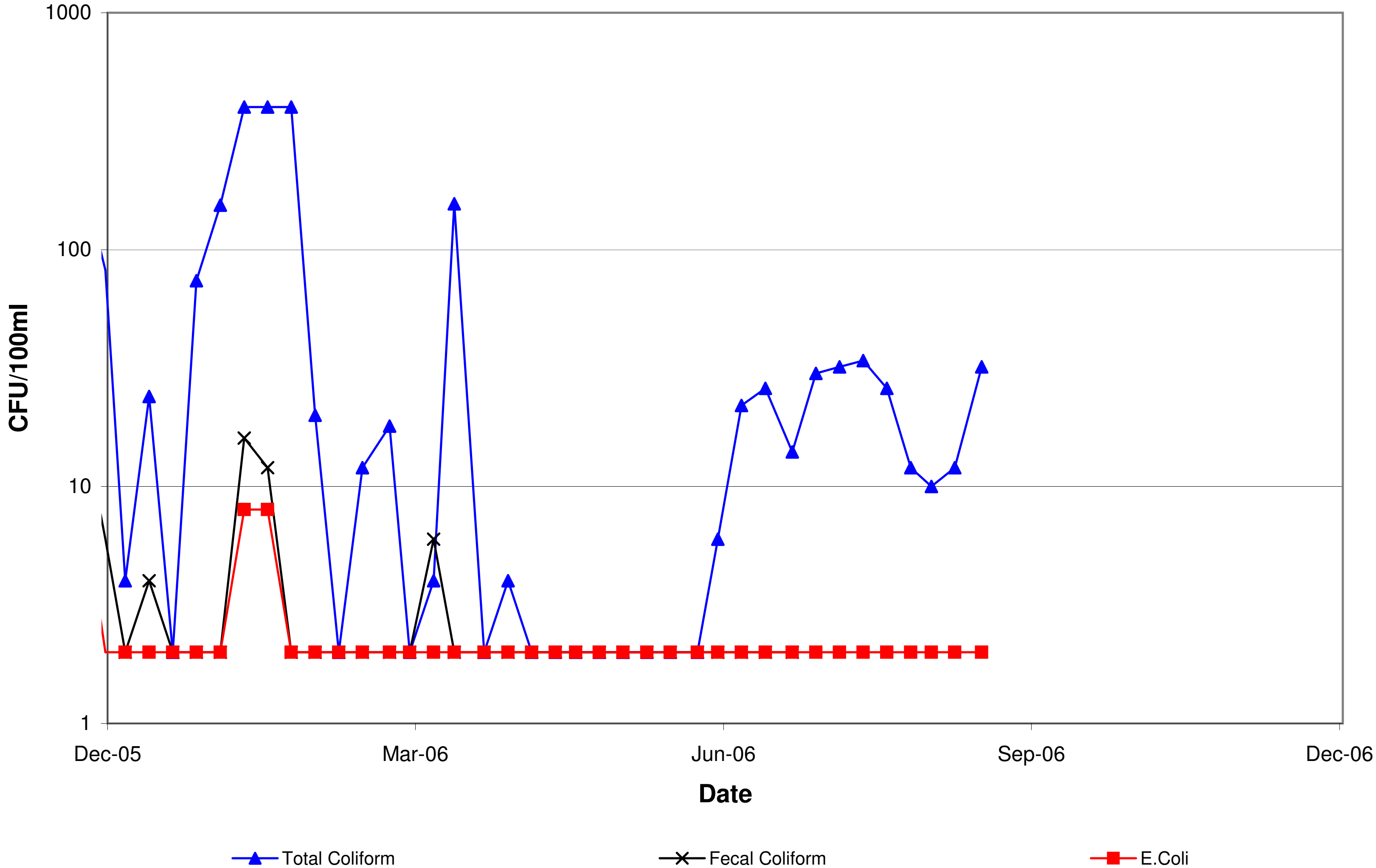
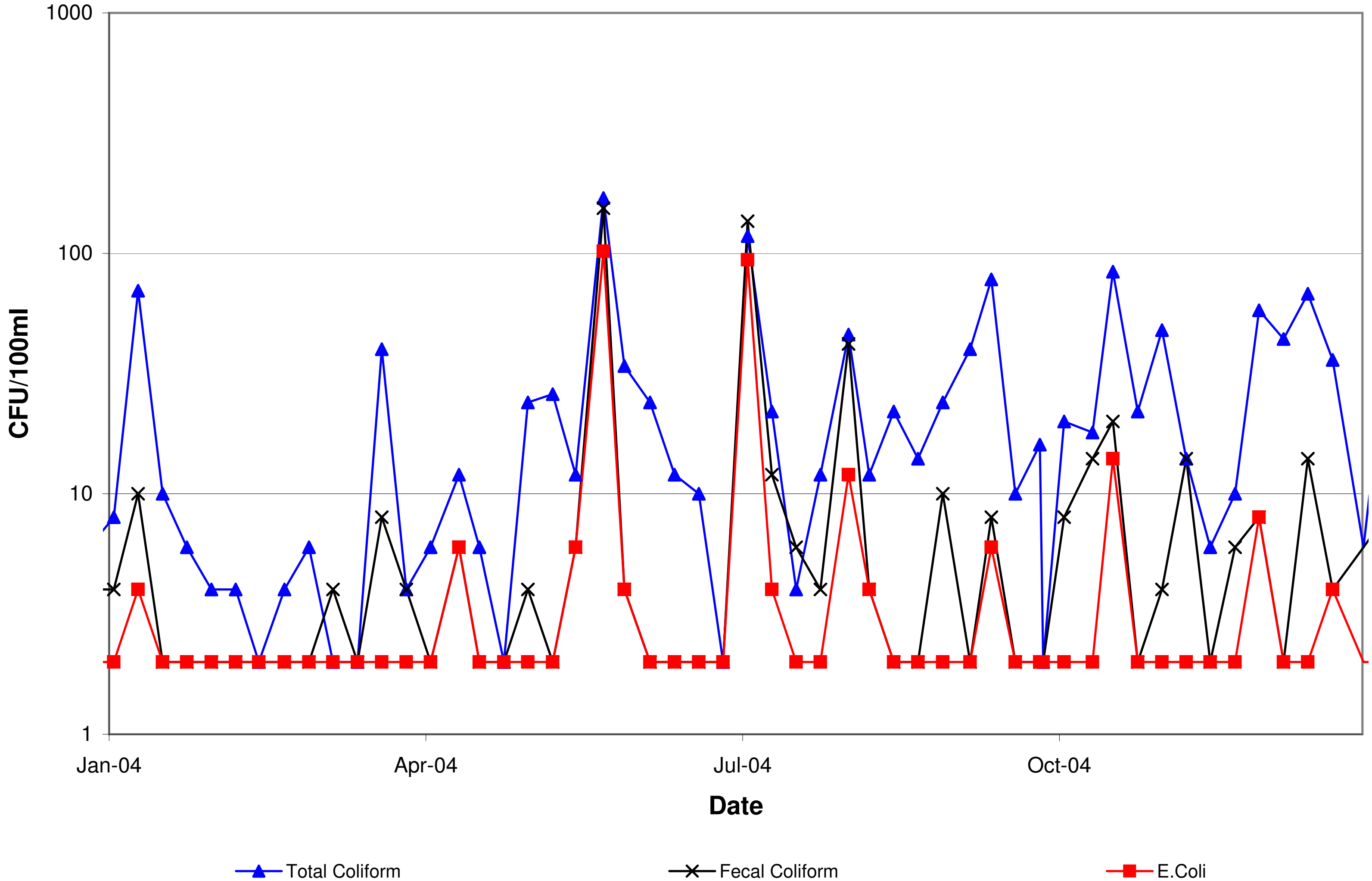


Figure D-16 DWIS
Niagara Falls 2004 Raw Microbiological



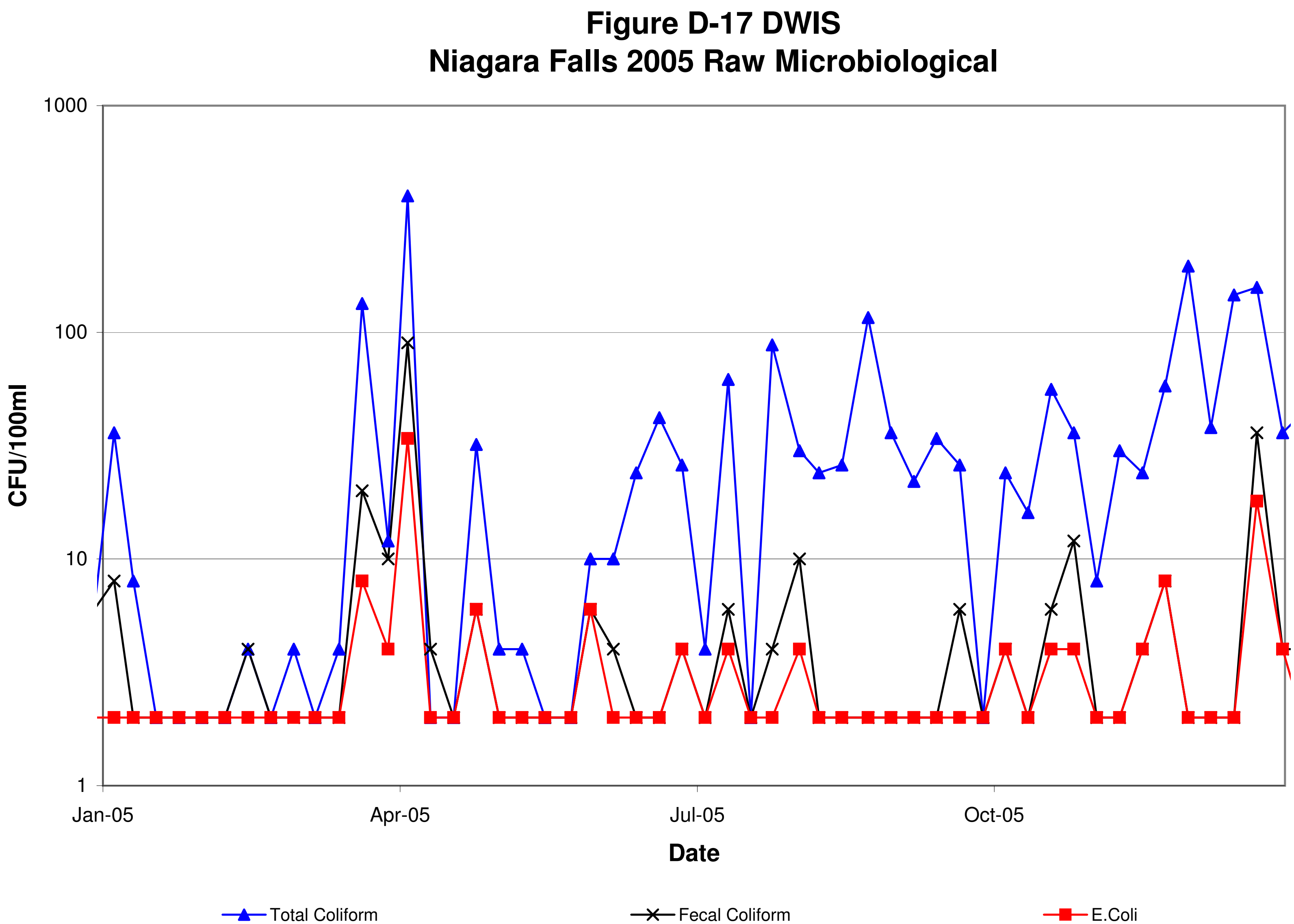


Figure D-17 DWIS
Niagara Falls 2005 Raw Microbiological
1000
100
10
1
CFU/100ml
Jan-05
Apr-05
Jul-05
Oct-05
Date
Total Coliform
Fecal Coliform
E.Coli

Figure D-18 DWIS
Niagara Falls 2006 Raw Microbiological

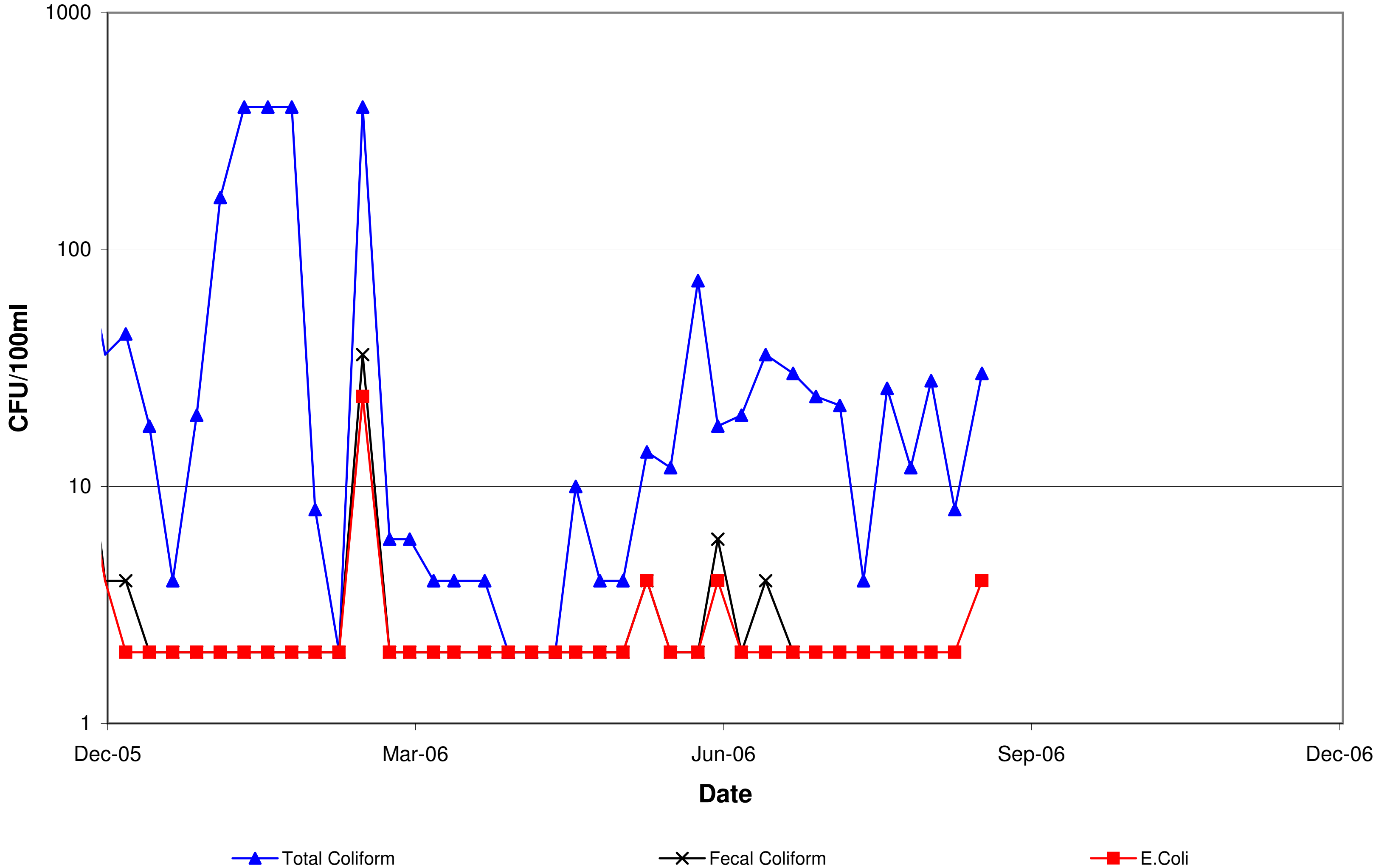
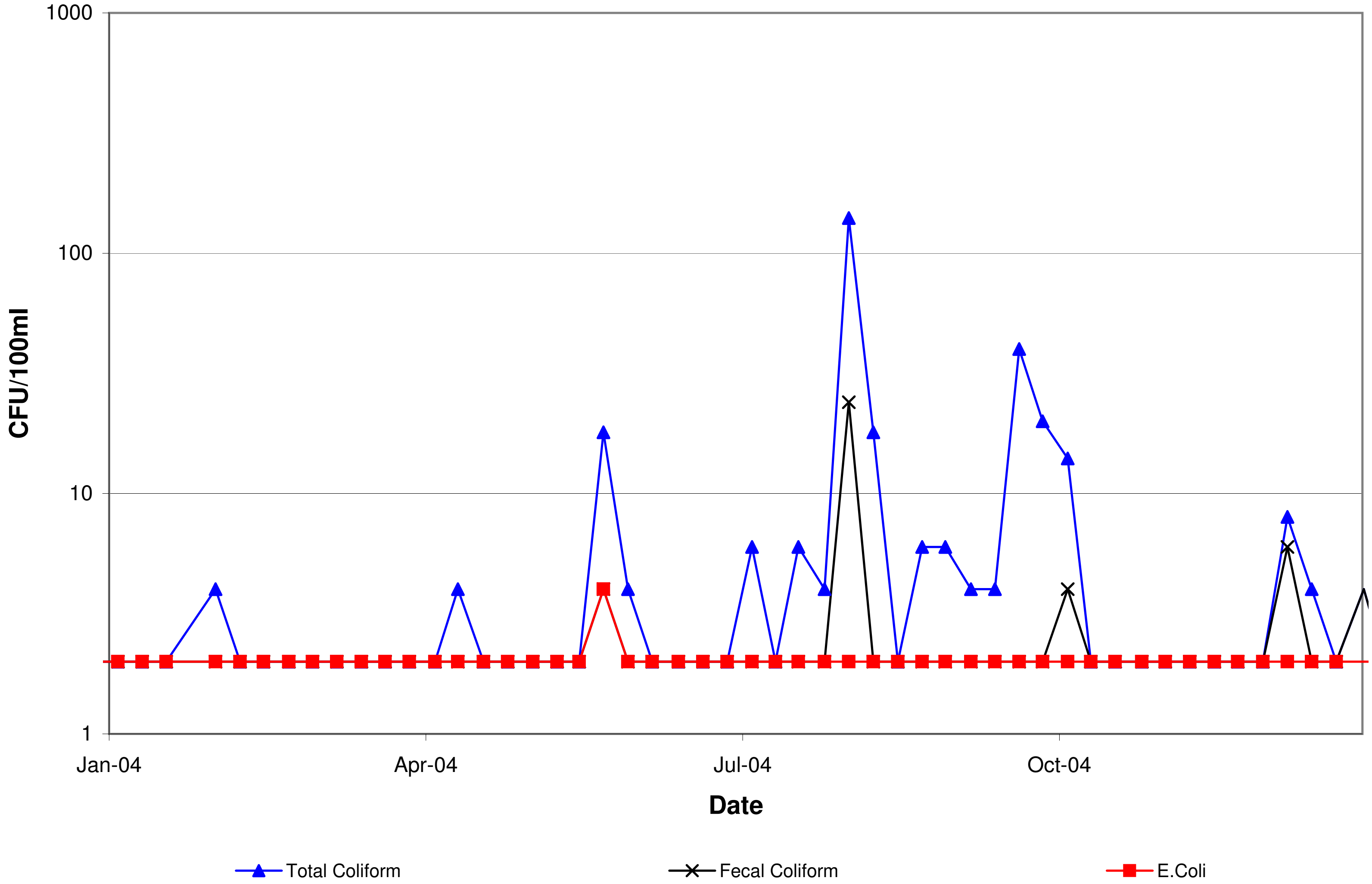


Figure D-19 DWIS
Grimsby 2004 Raw Microbiological



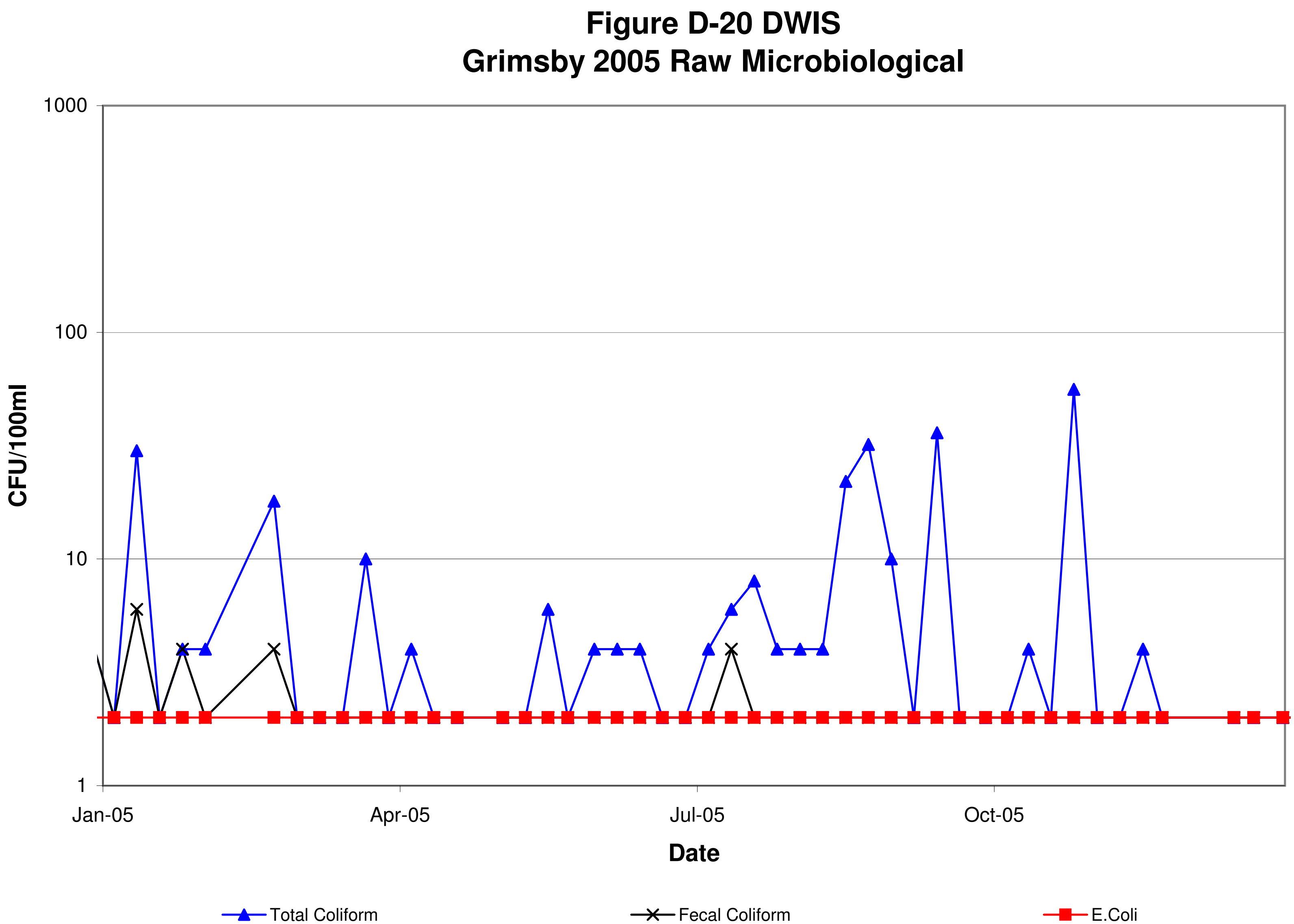


Figure D-20 DWIS
Grimsby 2005 Raw Microbiological
1000
100
10
1
CFU/100ml
Jan-05
Apr-05
Jul-05
Oct-05
Date
Total Coliform
Fecal Coliform
E.Coli

Figure D-21 DWIS
Grimsby 2006 Raw Microbiological

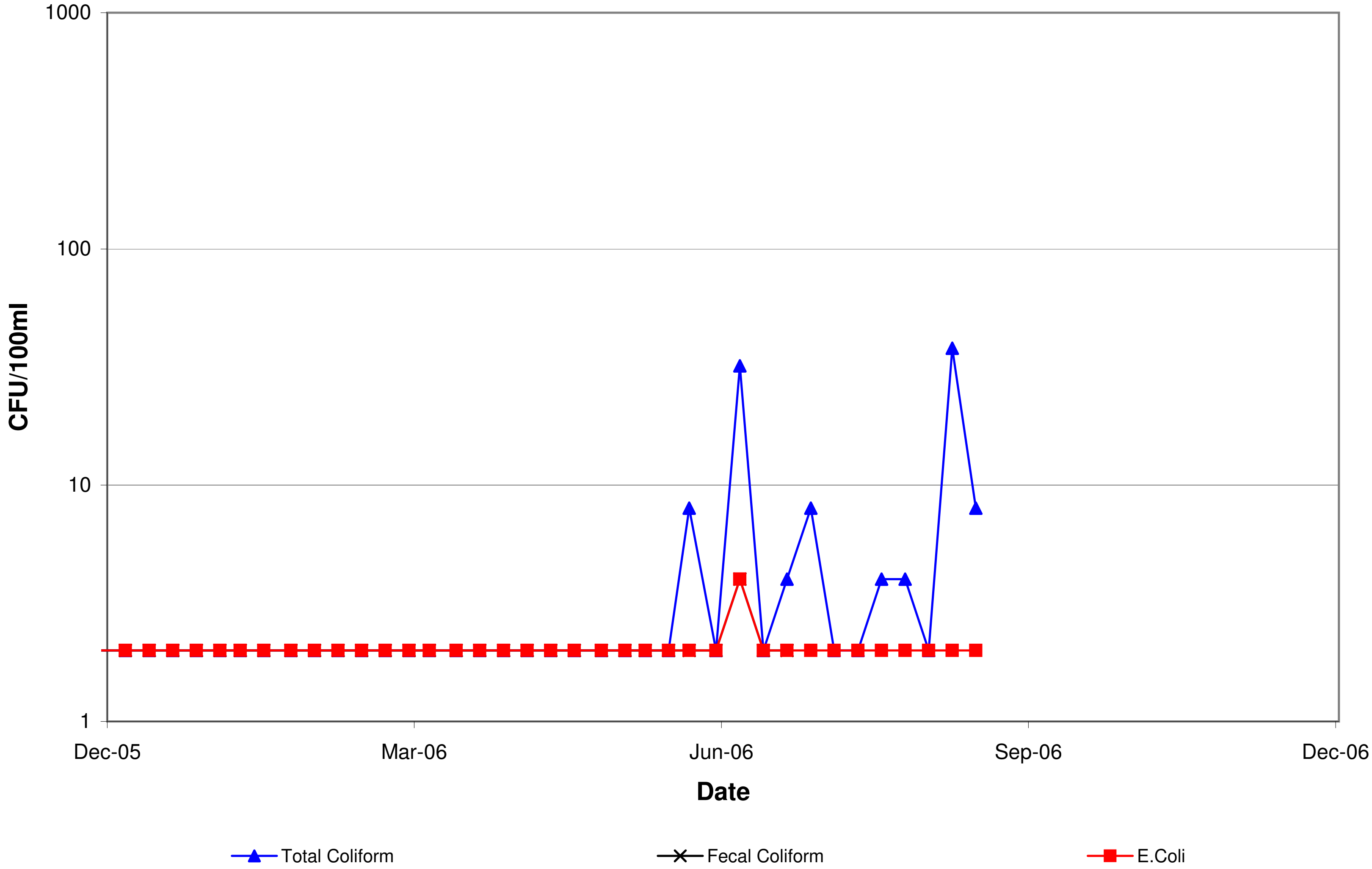


Figure D-22 DWSP
Aluminum (Operational Guideline 100 µg/L)

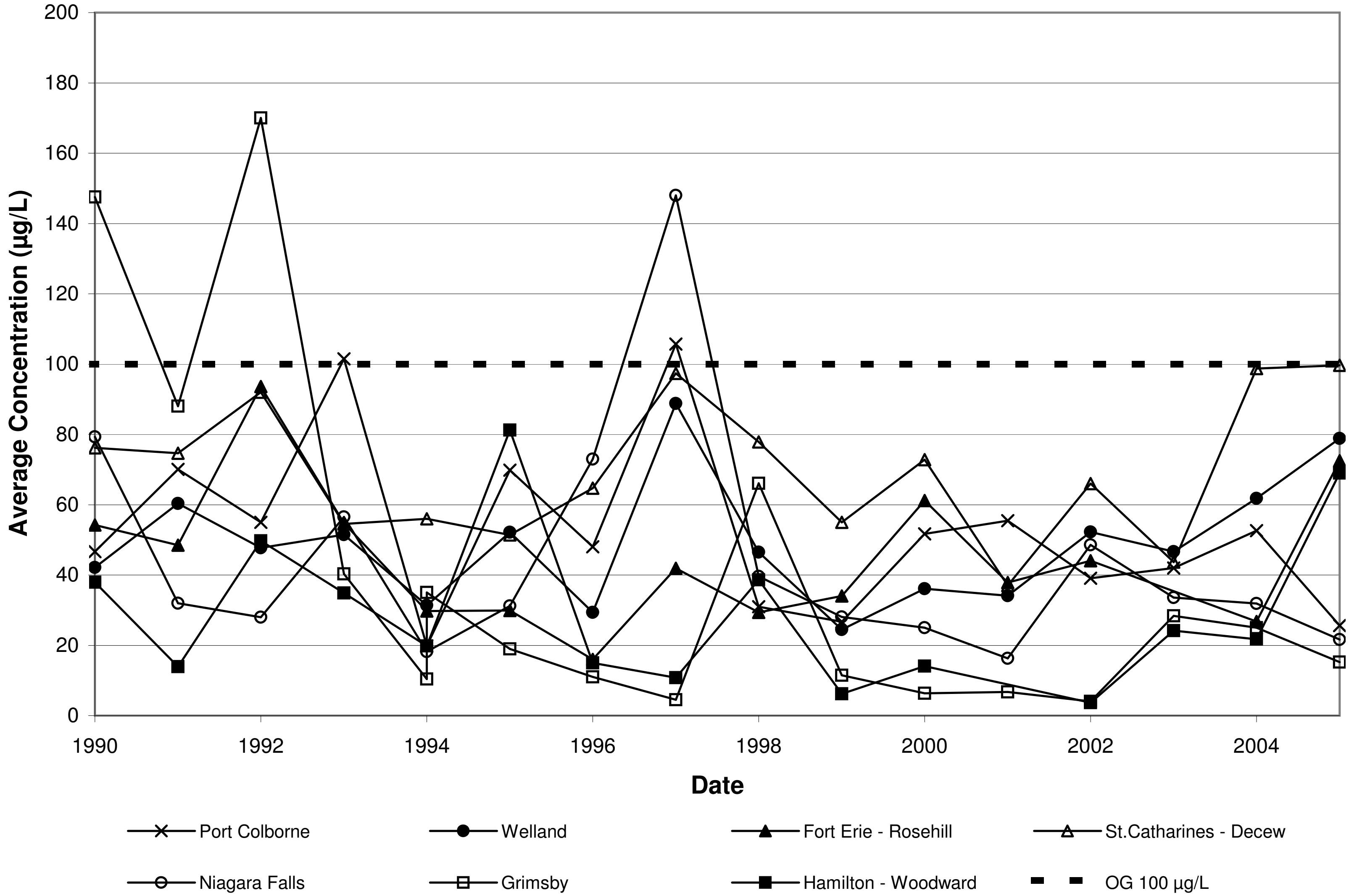


Figure D-23 DWSP
Arsenic (Interim Maximum Acceptable Concentration 25 µg/L)

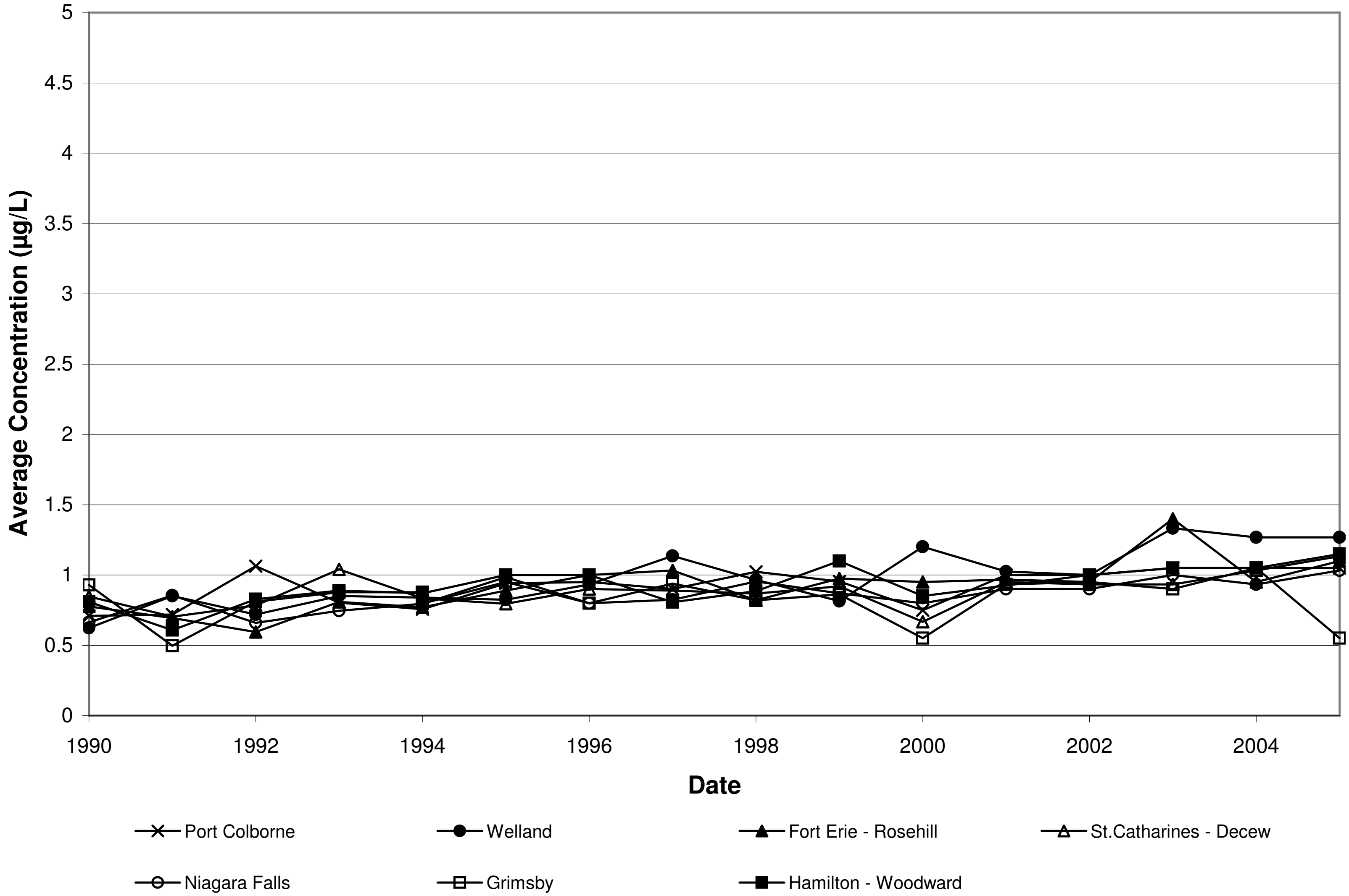


Figure D-24 DWSP
Atrazine (Interim Maximum Acceptable Concentration 5,000 ng/L)

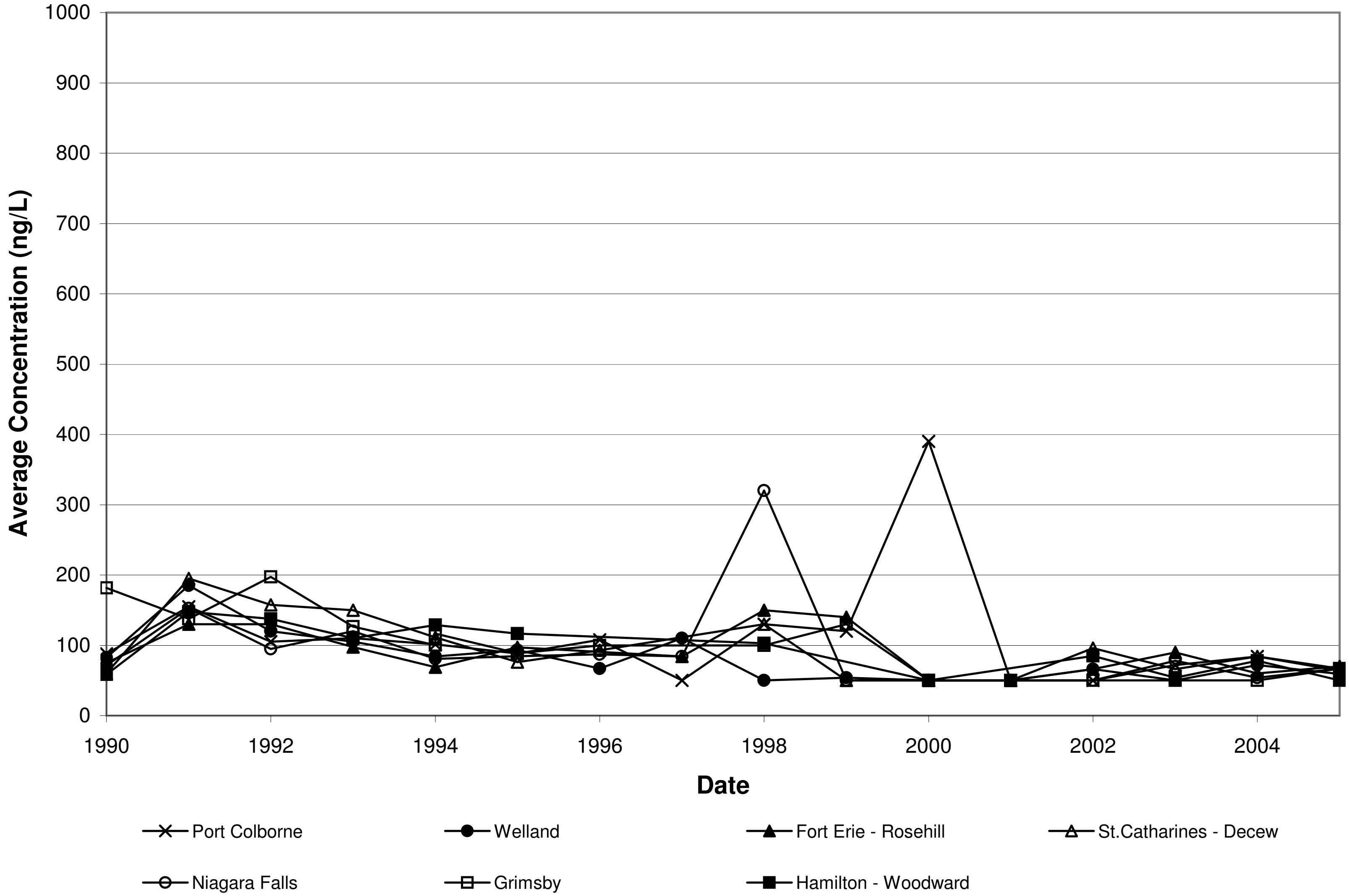


Figure D-25 DWSP
Chloride (Aesthetic Objective 250 mg/L)

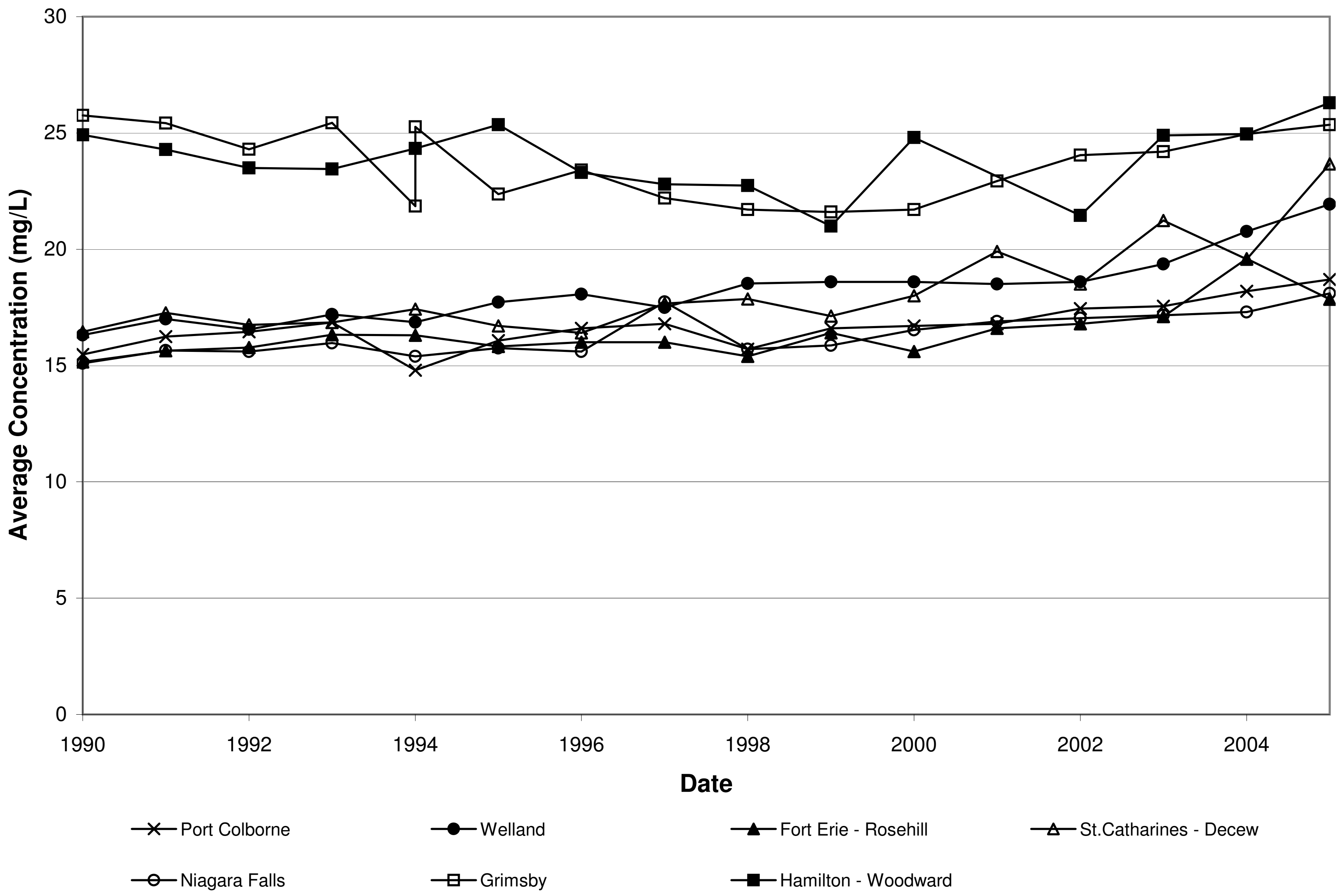


Figure D-26 DWSP
Colour (Aesthetic Objective 5 TCU)

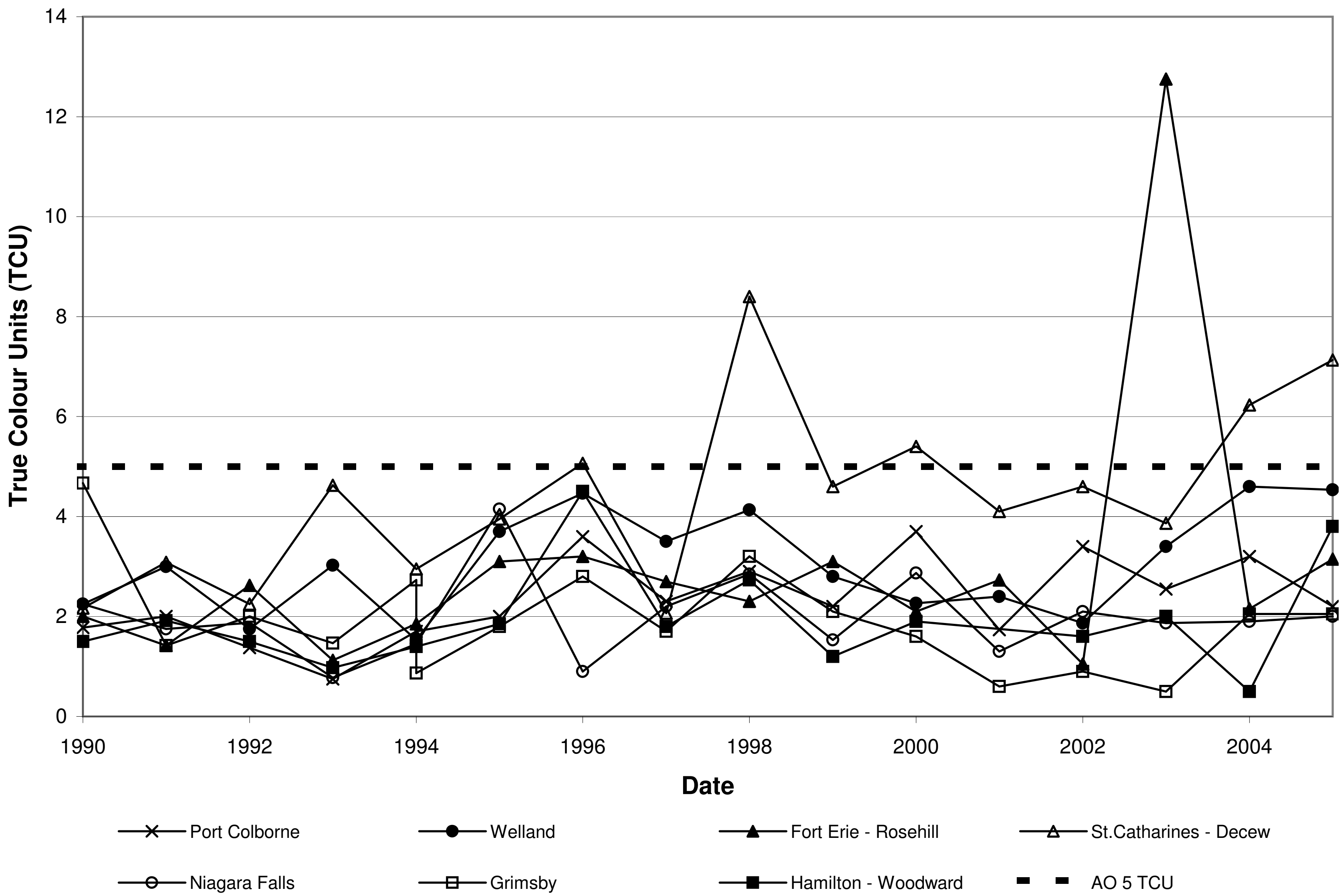


Figure D-27 DWSP
Copper (Aesthetic Objective 1,000 µg/L)

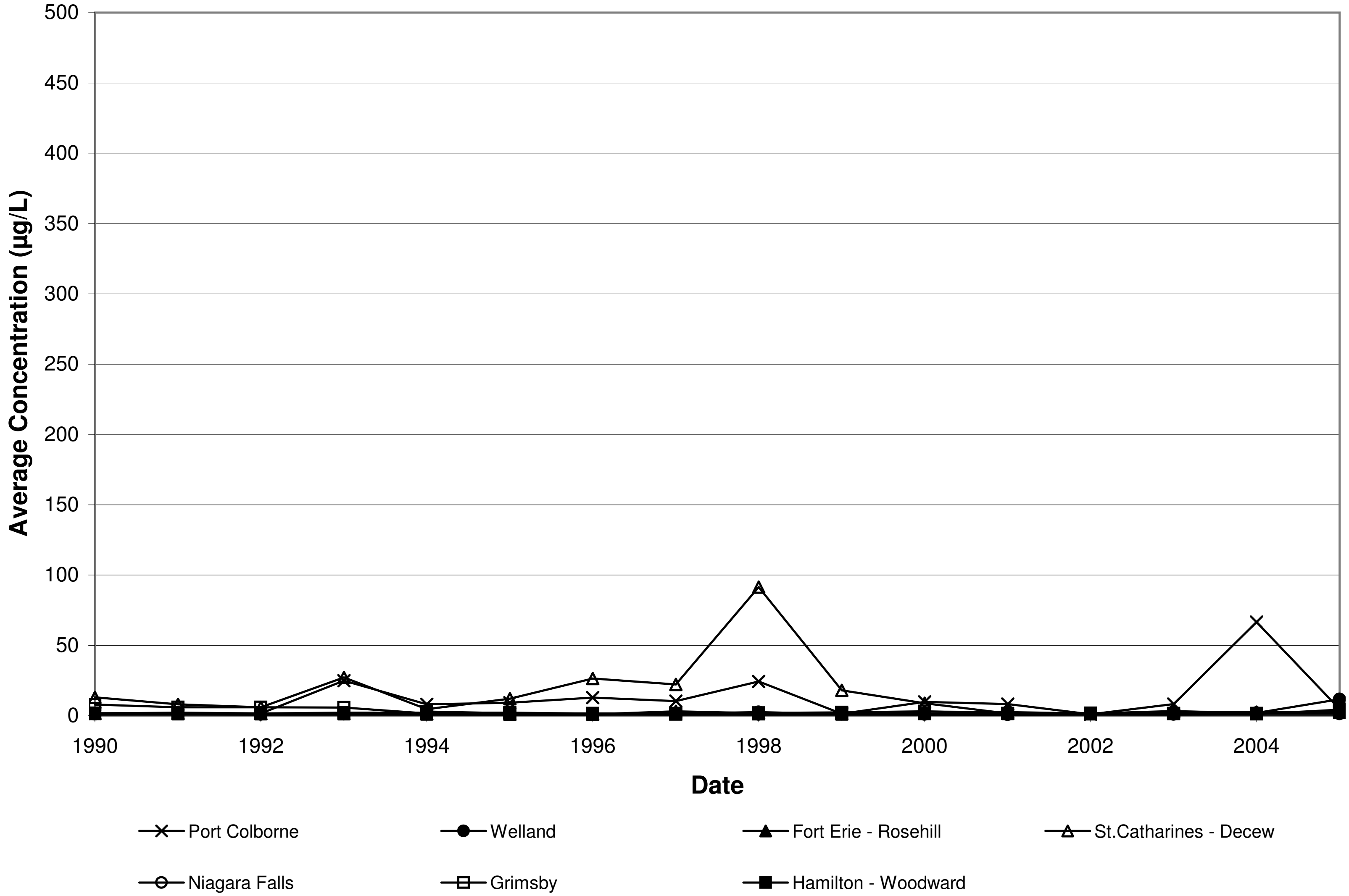


Figure D-28 DWSP
Geosmin

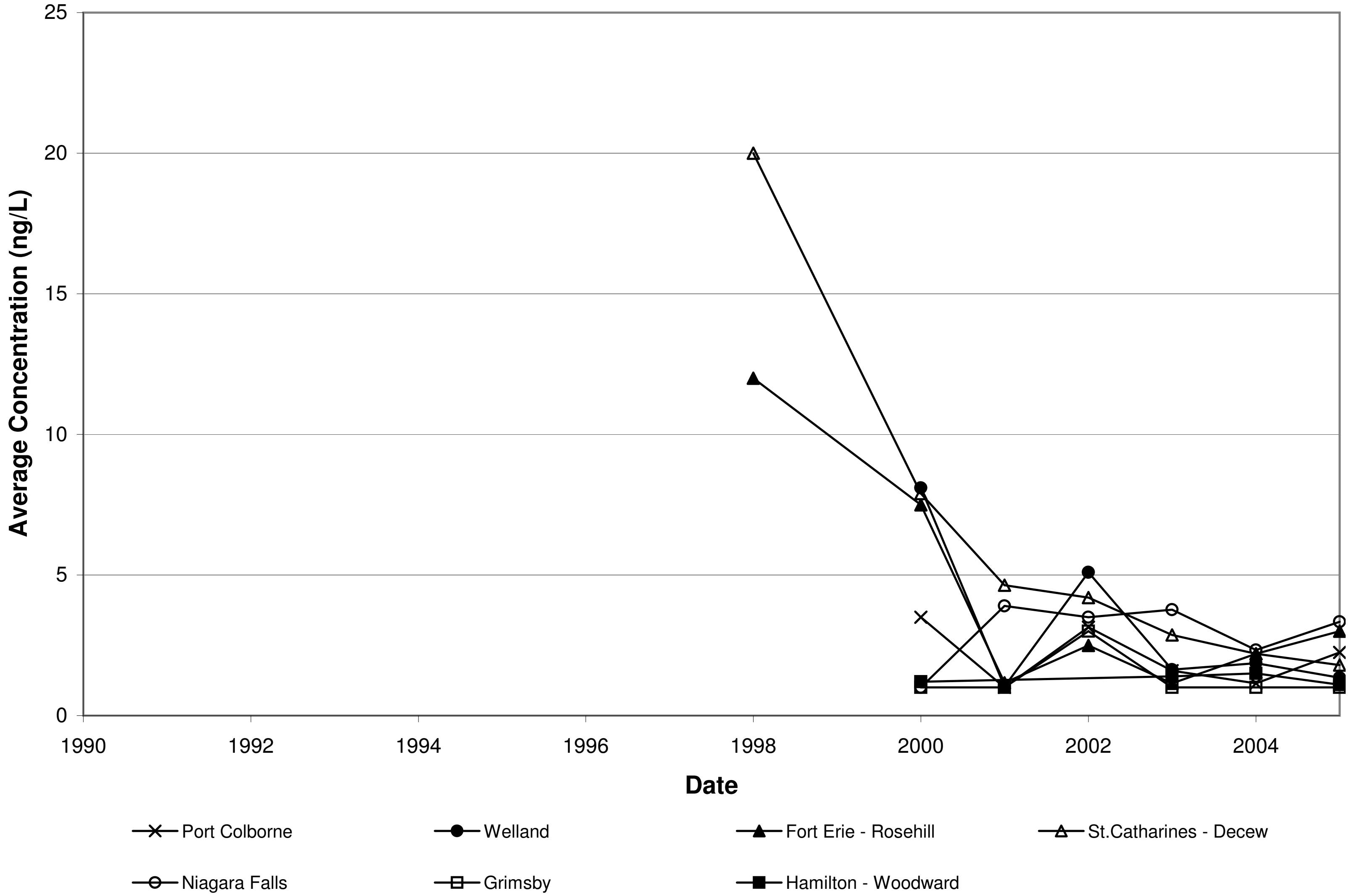
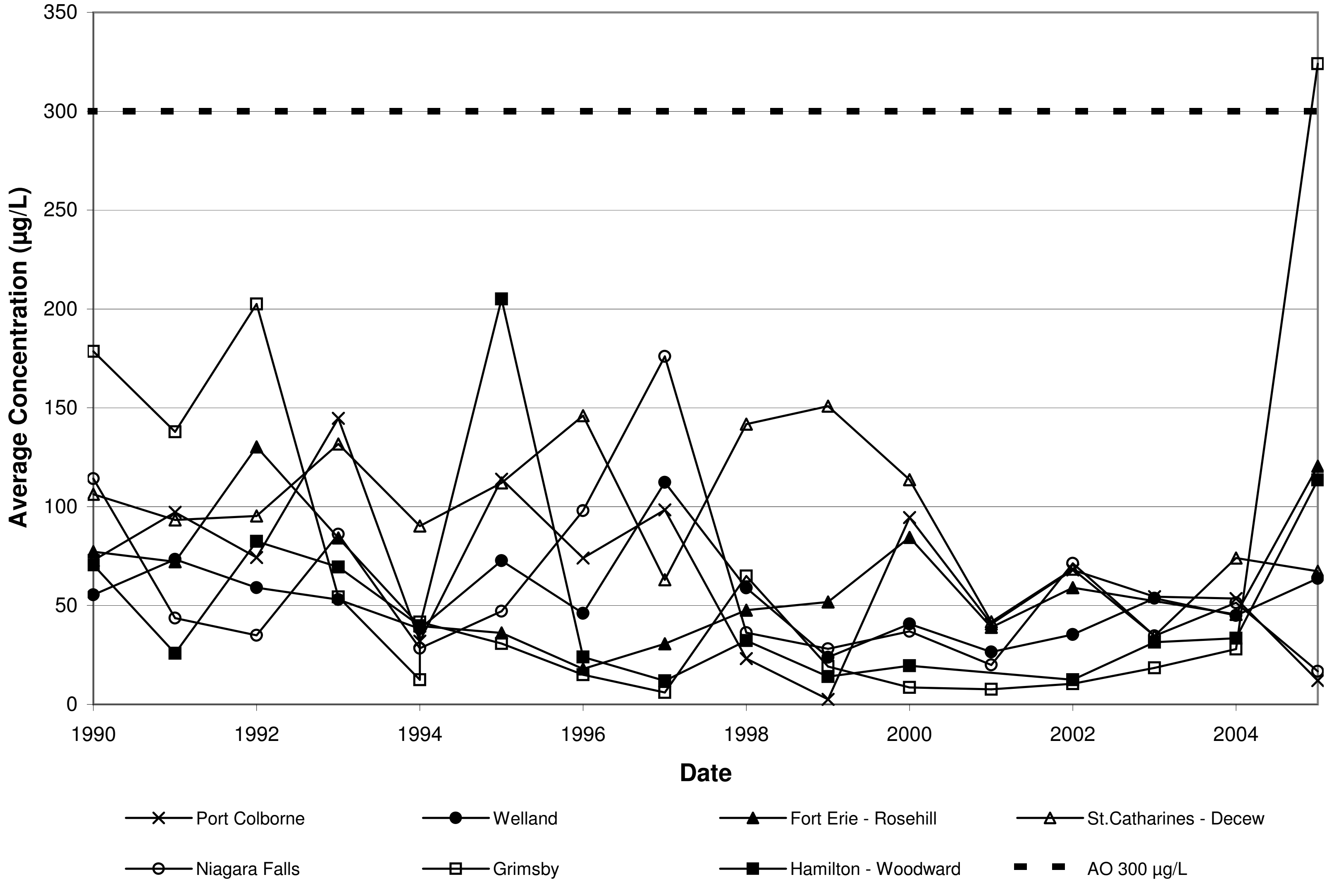


Figure D-29 DWSP
Iron (Aesthetic Objective 300 µg/L)



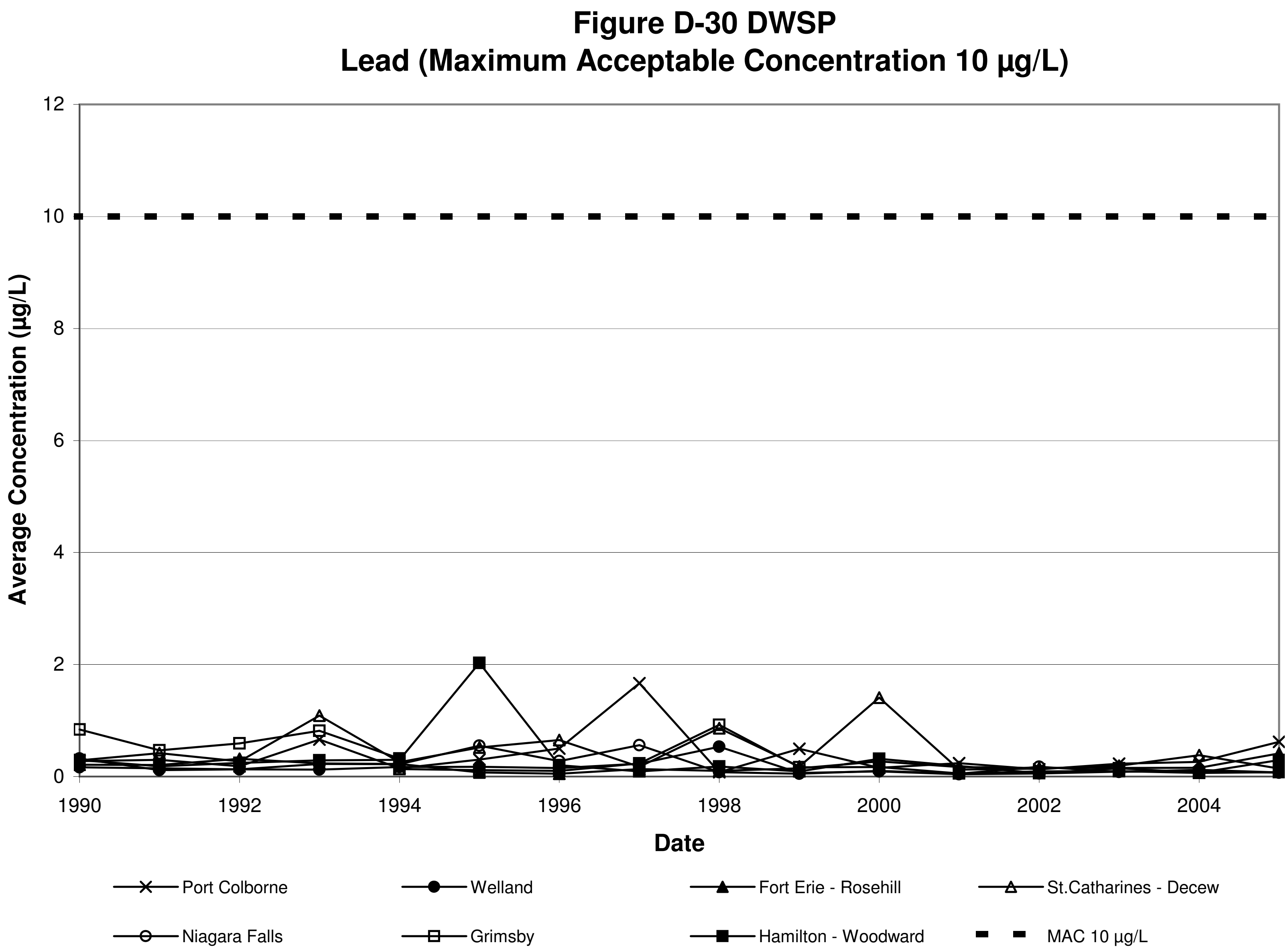
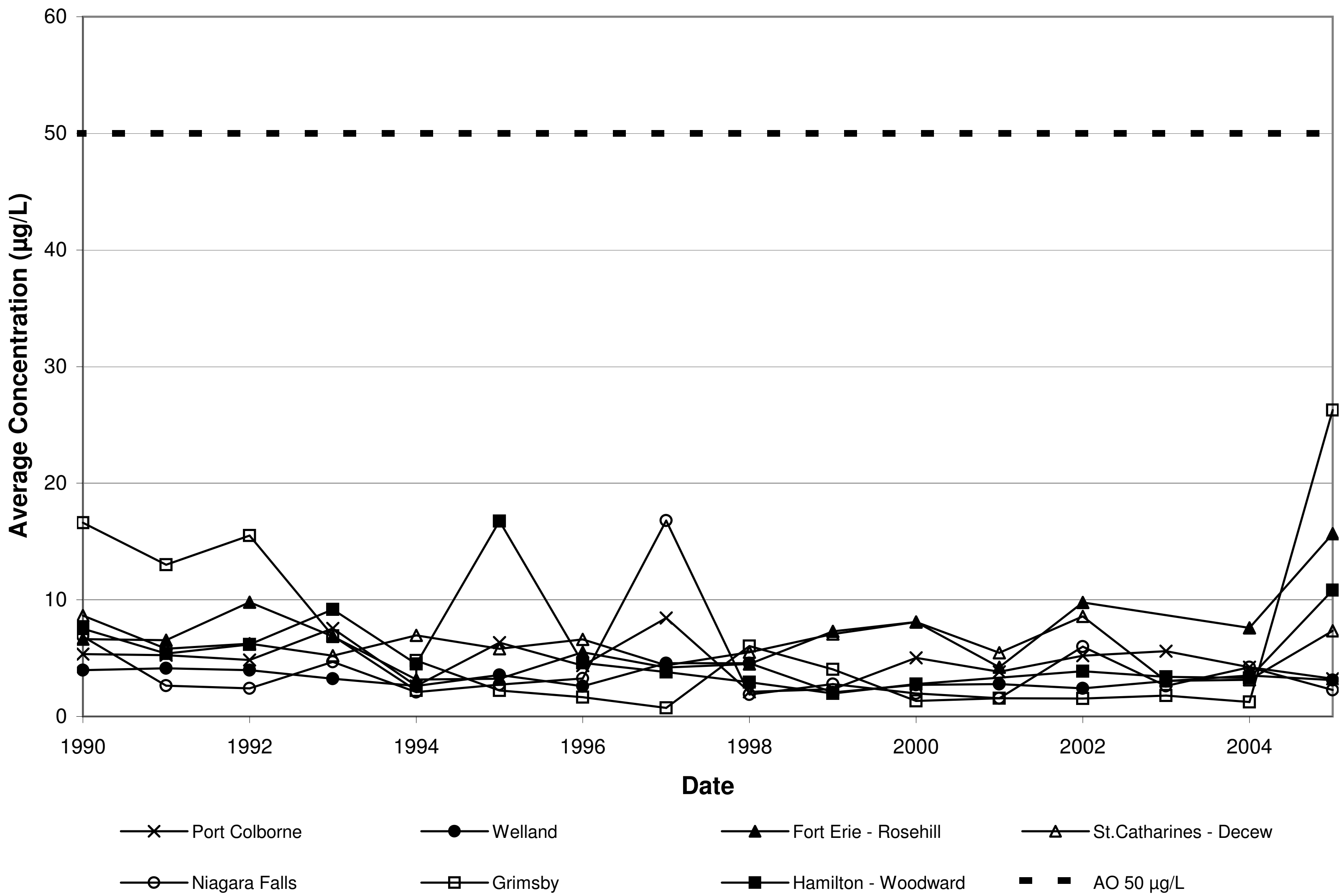


Figure D-30 DWSP
Lead (Maximum Acceptable Concentration 10 µg/L)
Average Concentration (µg/L)
0
2
4
6
8
10
12
1990
1992
1994
1996
1998
2000
2002
2004
Date
Port Colborne
Welland
Fort Erie - Rosehill
St.Catharines - Decew
Niagara Falls
Grimsby
Hamilton - Woodward
MAC 10 µg/L

Figure D-31 DWSP
Manganese (Aesthetic Objective 50 µg/L)



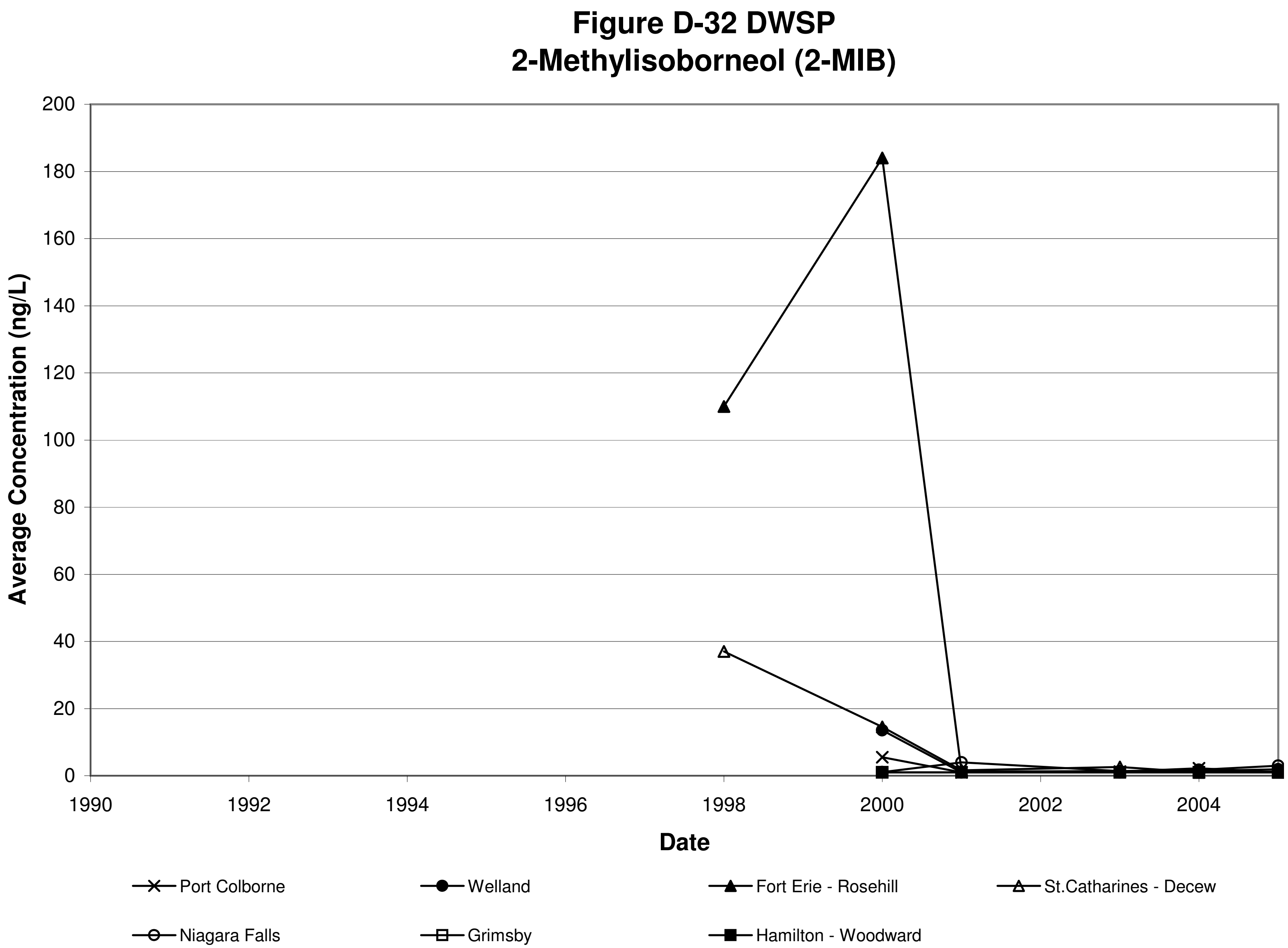


Figure D-32 DWSP
2-Methylisoborneol (2-MIB)
Average Concentration (ng/L)
200
180
160
140
120
100
80
60
40
20
0
1990
1992
1994
1996
1998
2000
2002
2004
Date
Port Colborne
Welland
Fort Erie - Rosehill
St.Catharines - Decew
Niagara Falls
Grimsby
Hamilton - Woodward

Figure D-33 DWSP
pH (Operational Guideline 6.5-8.5)

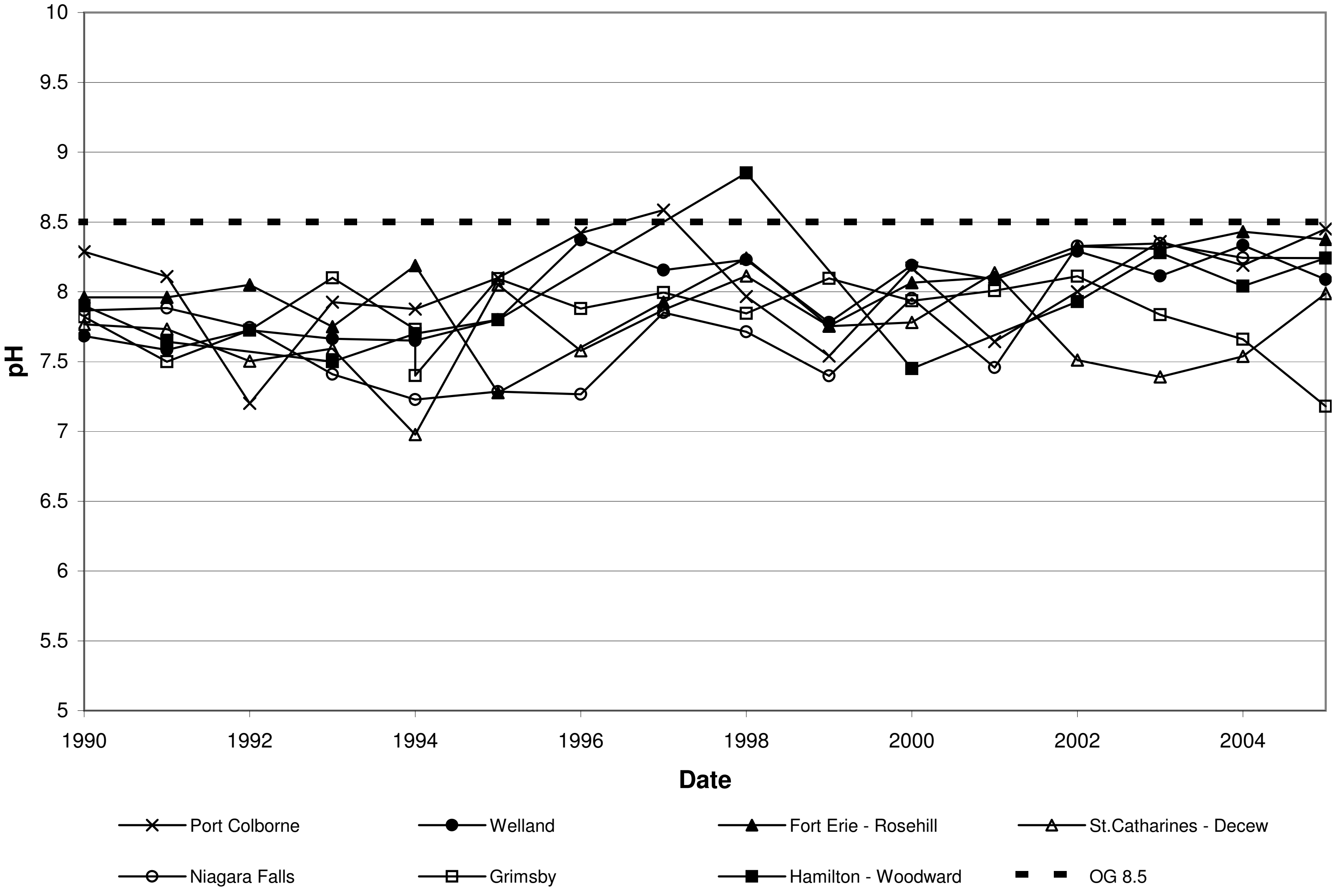


Figure D-34 DWSP
Temperature (Aesthetic Objective 15 degrees C)

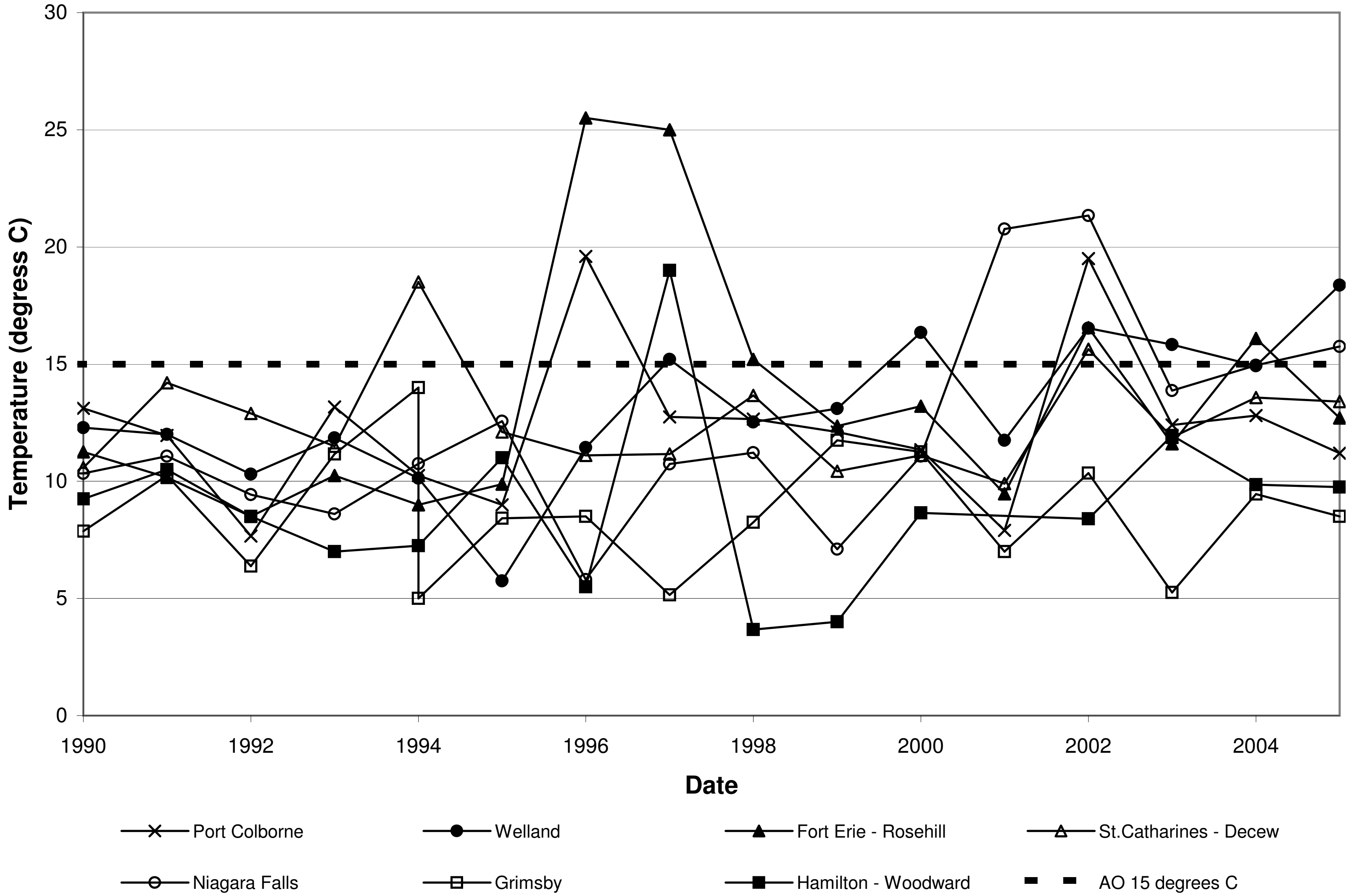


Figure D-35 DWSP
Turbidity (Aesthetic Objective 5 NTU)

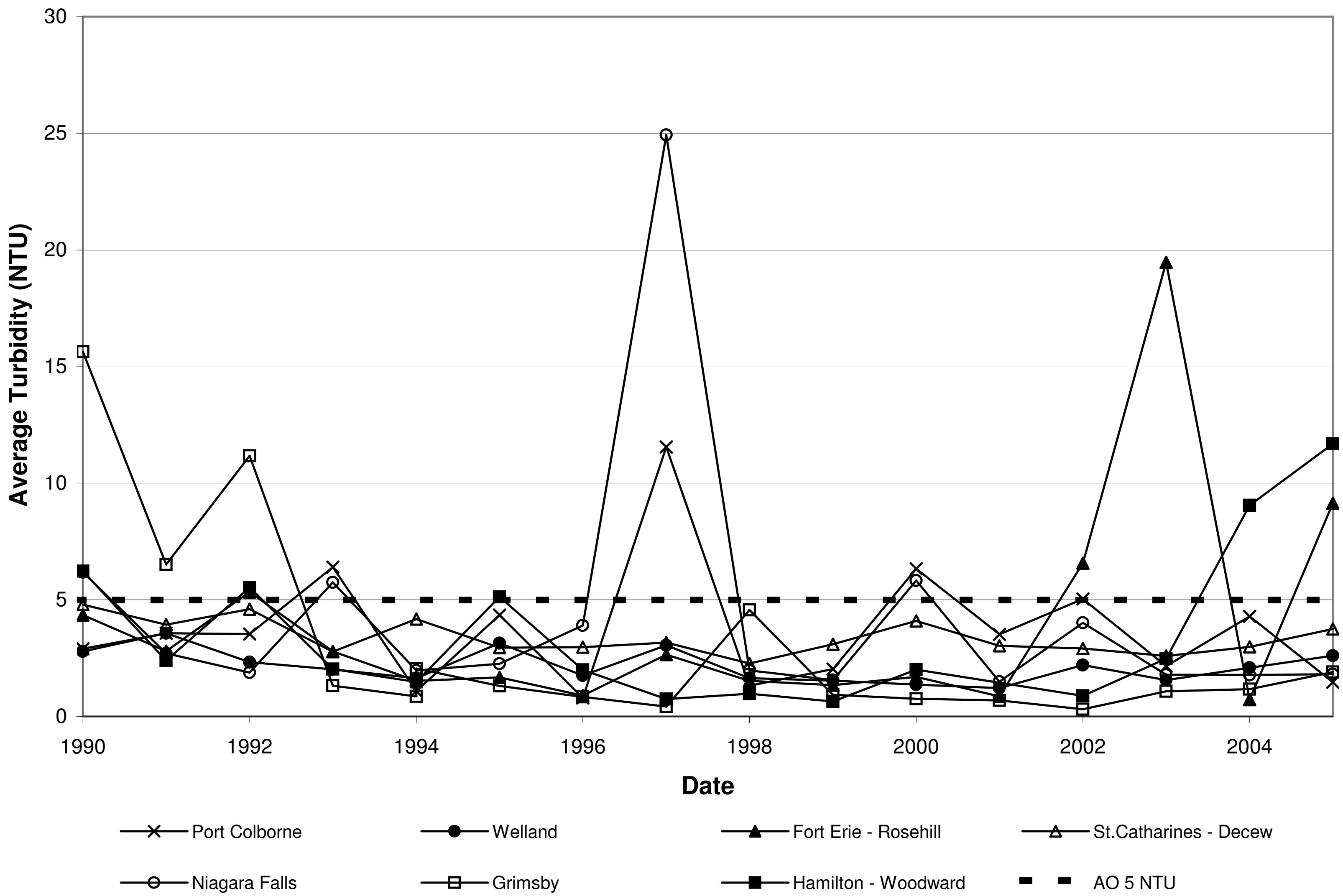


Figure D-36 DWSP
Organic Nitrogen (Operational Guideline 0.15 mg/L)

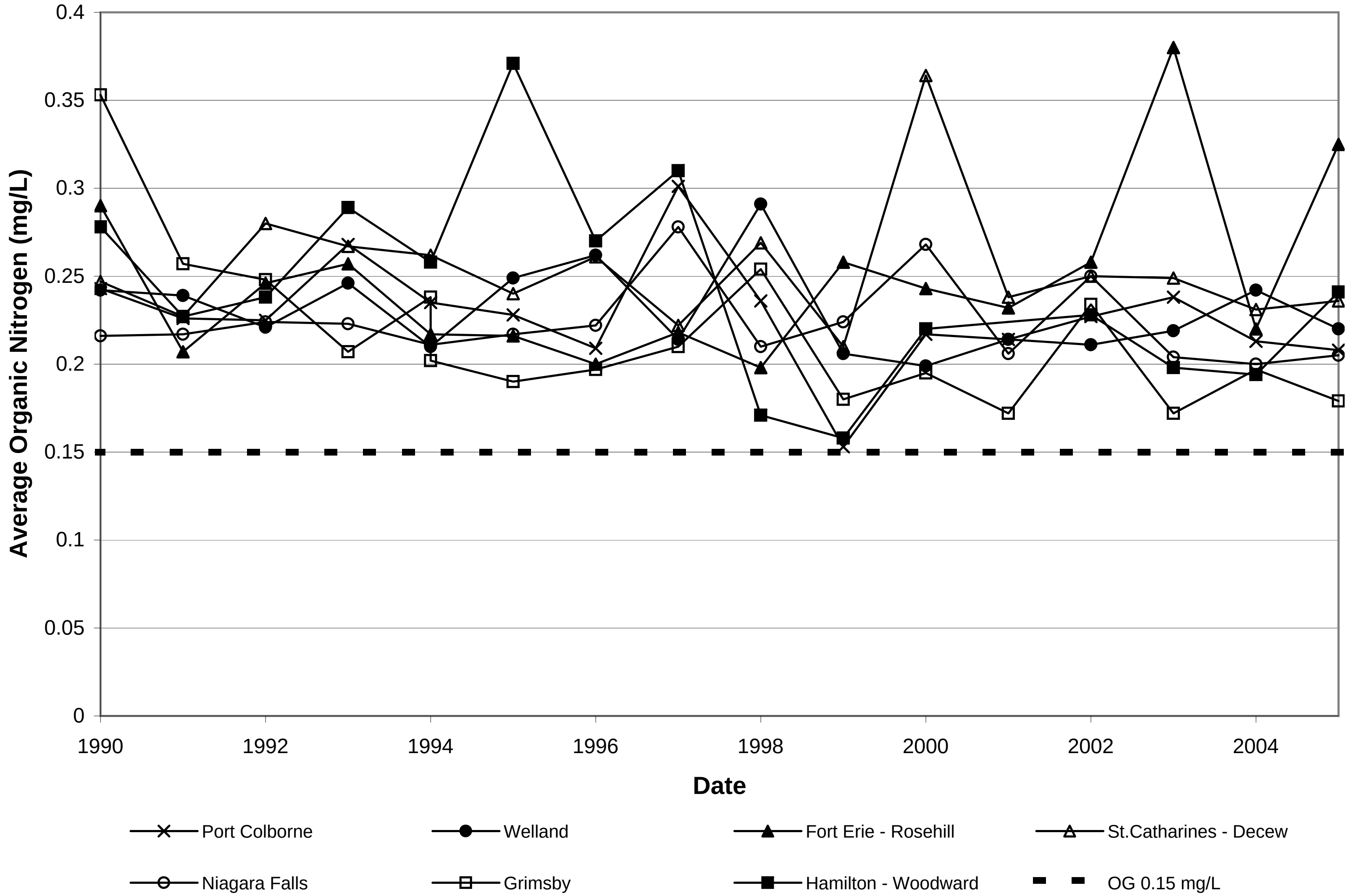


Figure D-37 DWSP
Phosphorus (Provincial Water Quality Objective 0.01 mg/L or 0.02 mg/L)

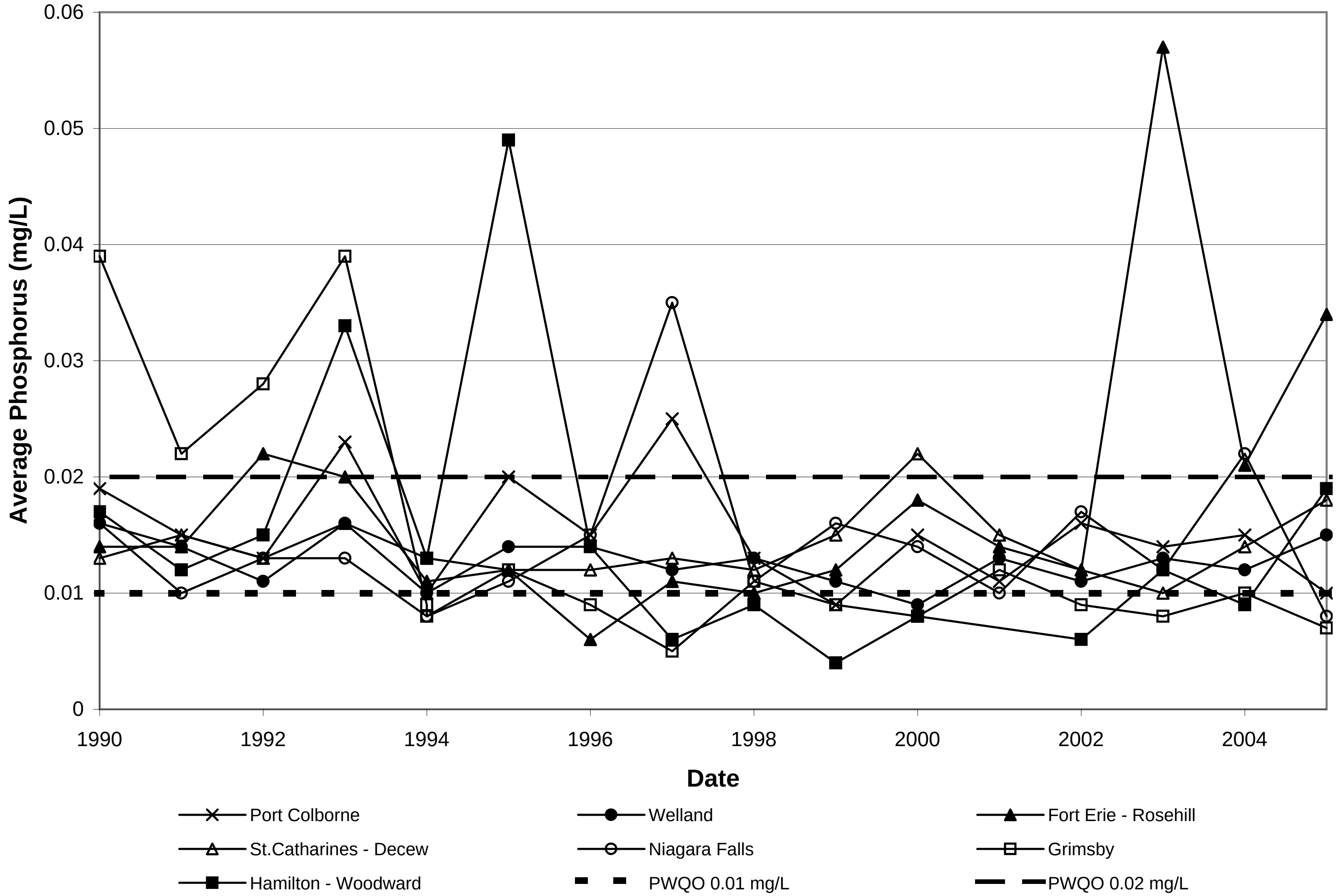


Figure D-38
Organic Nitrogen (Operational Guideline 0.15 mg/L)

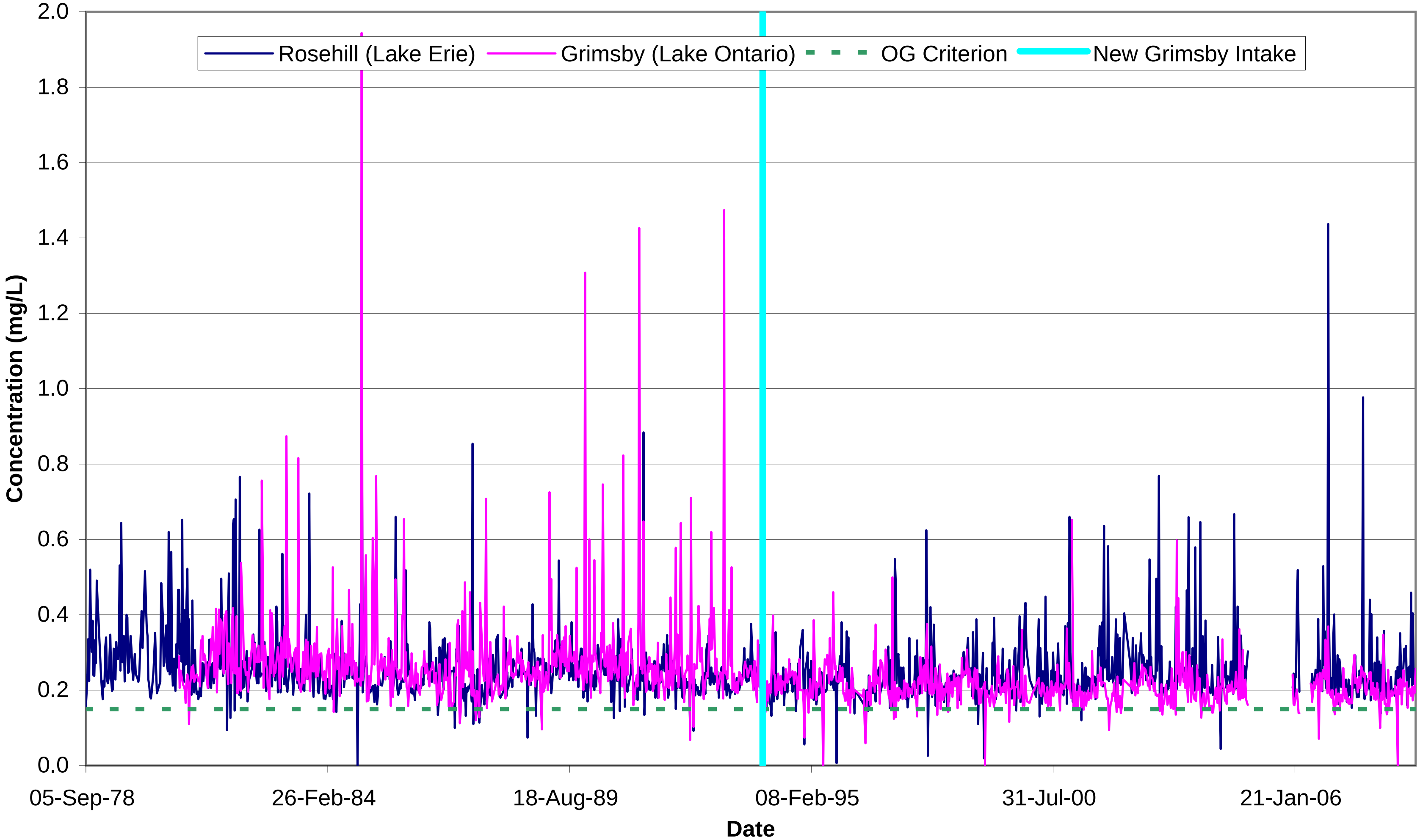


Figure D-39
Grimsby (Lake Ontario) Water Treatment Plant - Phosphorus

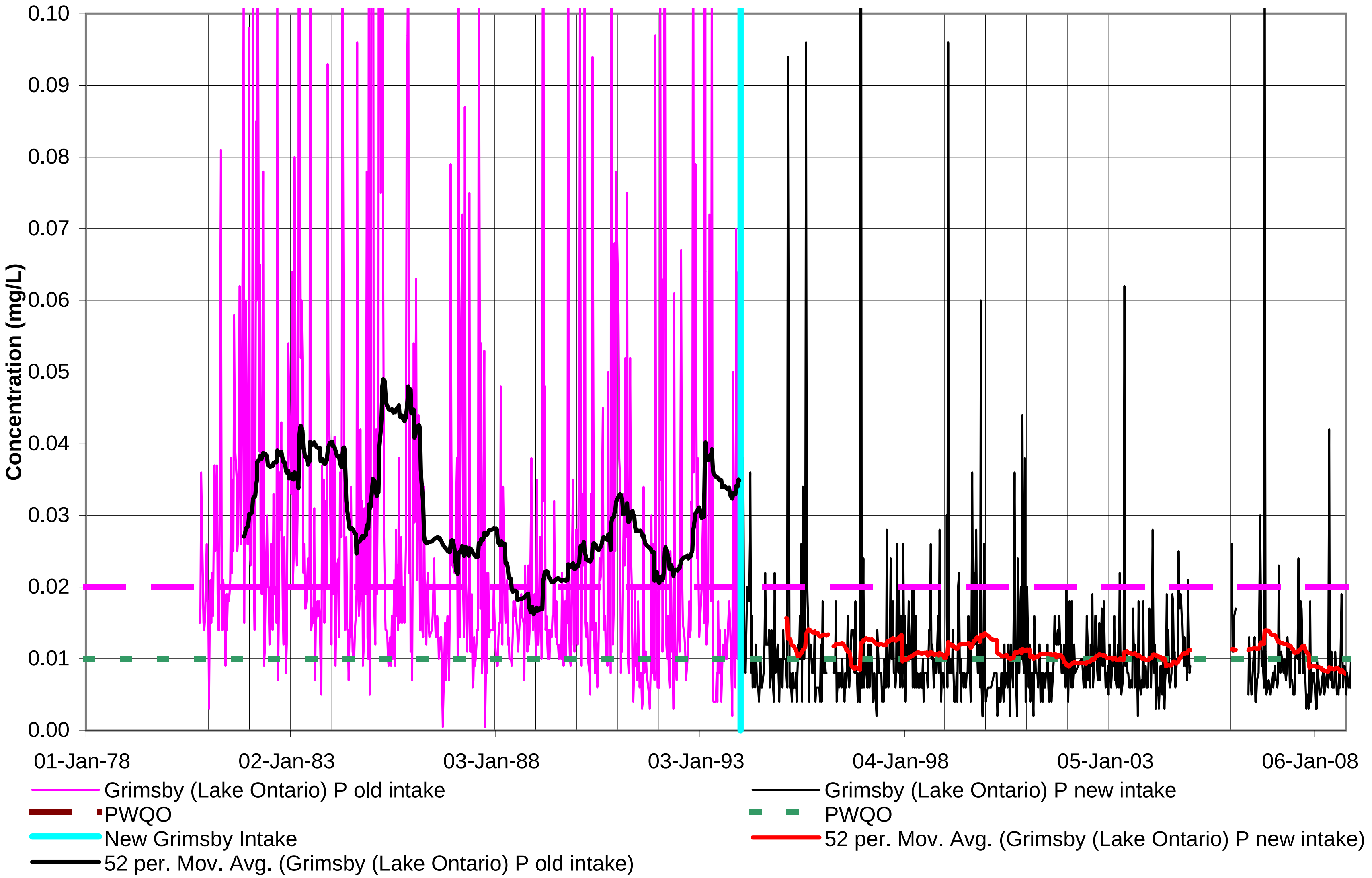
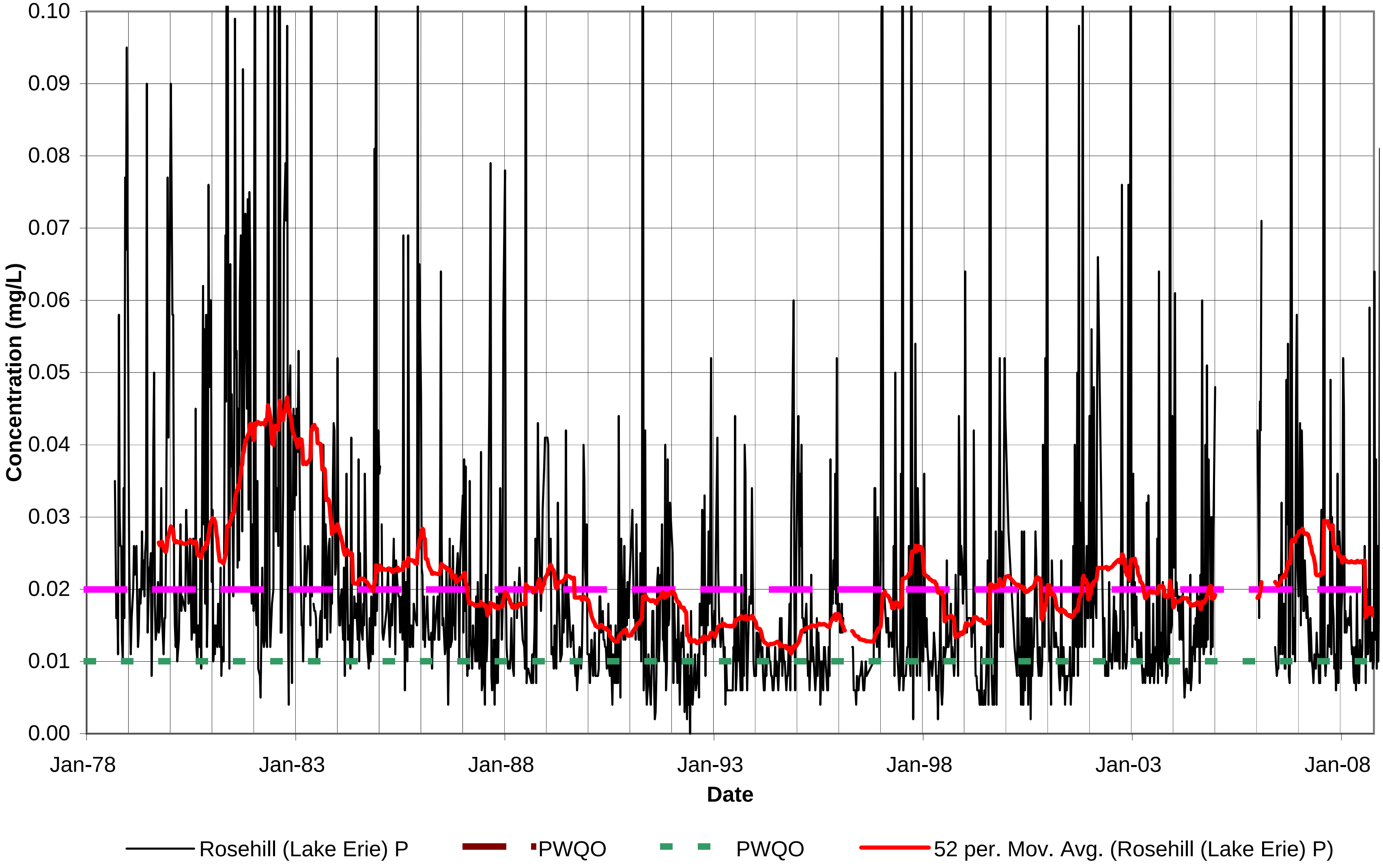


Figure D-40
Rosehill (Lake Erie) Water Treatment Plant - Phosphorus



APPENDIX E

Supporting Documentation

List of Documents in Appendix E

1. Source Water Protection, Watershed Regions Southern Ontario, by MOE, 2006.

2. Regional Geology Conceptual Model A-A', NPCA Groundwater Study, 2005,

3. Regional Geology Conceptual Model B-B', NPCA Groundwater Study, 2005,

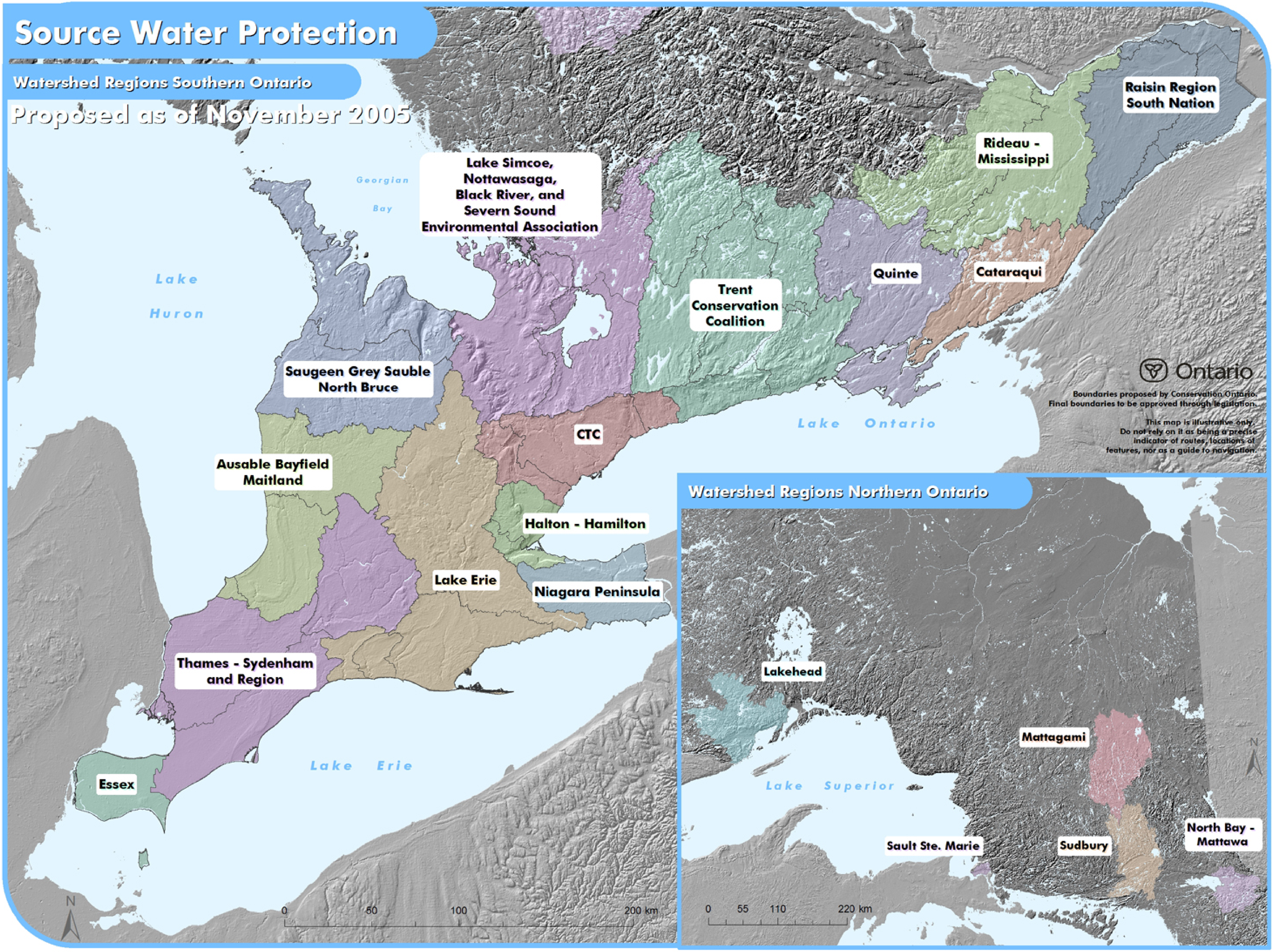
4. Regional Geology Conceptual Model C-C', NPCA Groundwater Study, 2005,

5. Figure 3.22A Potential Contaminant Sources, City of Hamilton Groundwater Resources Characterization and Wellhead Protection Study, prepared by SNC Lavalin, 2006.

6. Figure 12, Salt Vulnerability Mapping, Identification of Salt Vulnerable Areas, Niagara Region/Environment Canada Study, prepared by Ecoplans Limited.

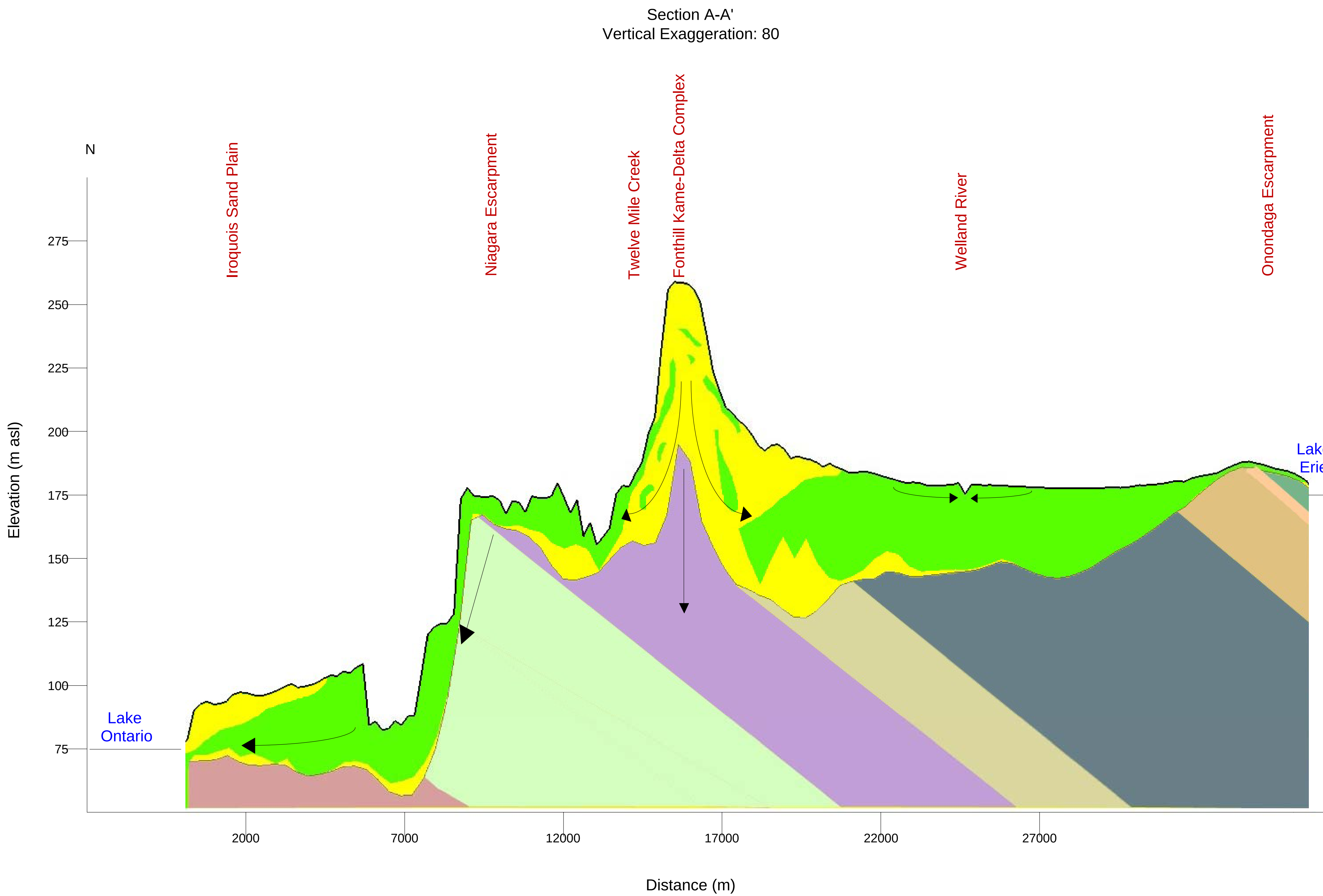
7. NPCA Watershed Plans by Priority by Year.

8. Local Management Area (LMA) Index Map, Niagara Water Quality Protection Strategy.



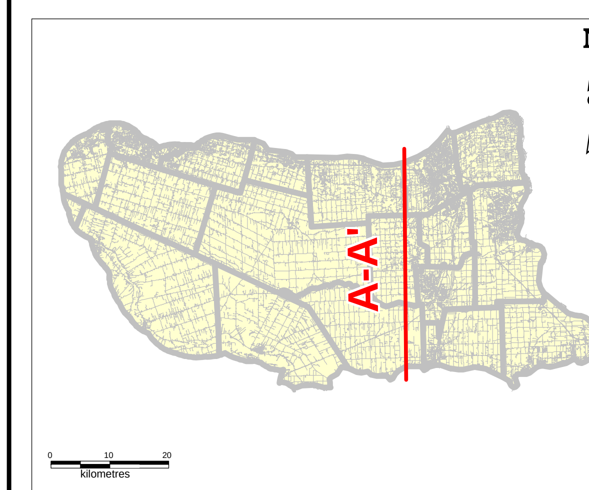
Source Water Protection
Watershed Regions Southern Ontario
Proposed as of November 2005
Georgian Bay
Lake Huron
Lake Simcoe, Nottawasaga, Black River, and Severn Sound Environmental Association
Raisin Region South Nation
Rideau - Mississippi
Quinte
Cataraqui
Trent Conservation Coalition
Saugeen Grey Sauble North Bruce
CTC
Lake Ontario
Ontario
Boundaries proposed by Conservation Ontario.
Final boundaries to be approved through legislation.
This map is illustrative only.
Do not rely on it as being a precise indicator of routes, locations of features, nor as a guide to navigation.
Ausable Bayfield Maitland
Halton - Hamilton
Lake Erie
Niagara Peninsula
Thames - Sydenham and Region
Essex
Lake Erie
N
0 50 100 200 km
Watershed Regions Northern Ontario
Lakehead
Mattagami
Lake Superior
Sault Ste. Marie
Sudbury
North Bay - Mattawa
N
0 55 110 220 km

NPCA Groundwater Study



Legend

- Glaciolacustrine (fine)
- Lacustrine (coarse)
- Queenston Formation
- Clinton Group
- Lockport Formation
- Guelph Formation
- Salina Formation
- Bertie Formation
- Bois Blanc Formation
- Onondaga Formation
- Interpreted Groundwater Flow Directions



Disclaimer: This map is intended for illustrative purposes only. This figure is to be read in conjunction with the Niagara Peninsula Conservation Authority Groundwater Study

Digital Mapping Sources: Base Mapping features - Ministry of Natural Resource
Water Well Information: Ministry of the Environment.

Date: February, 2005

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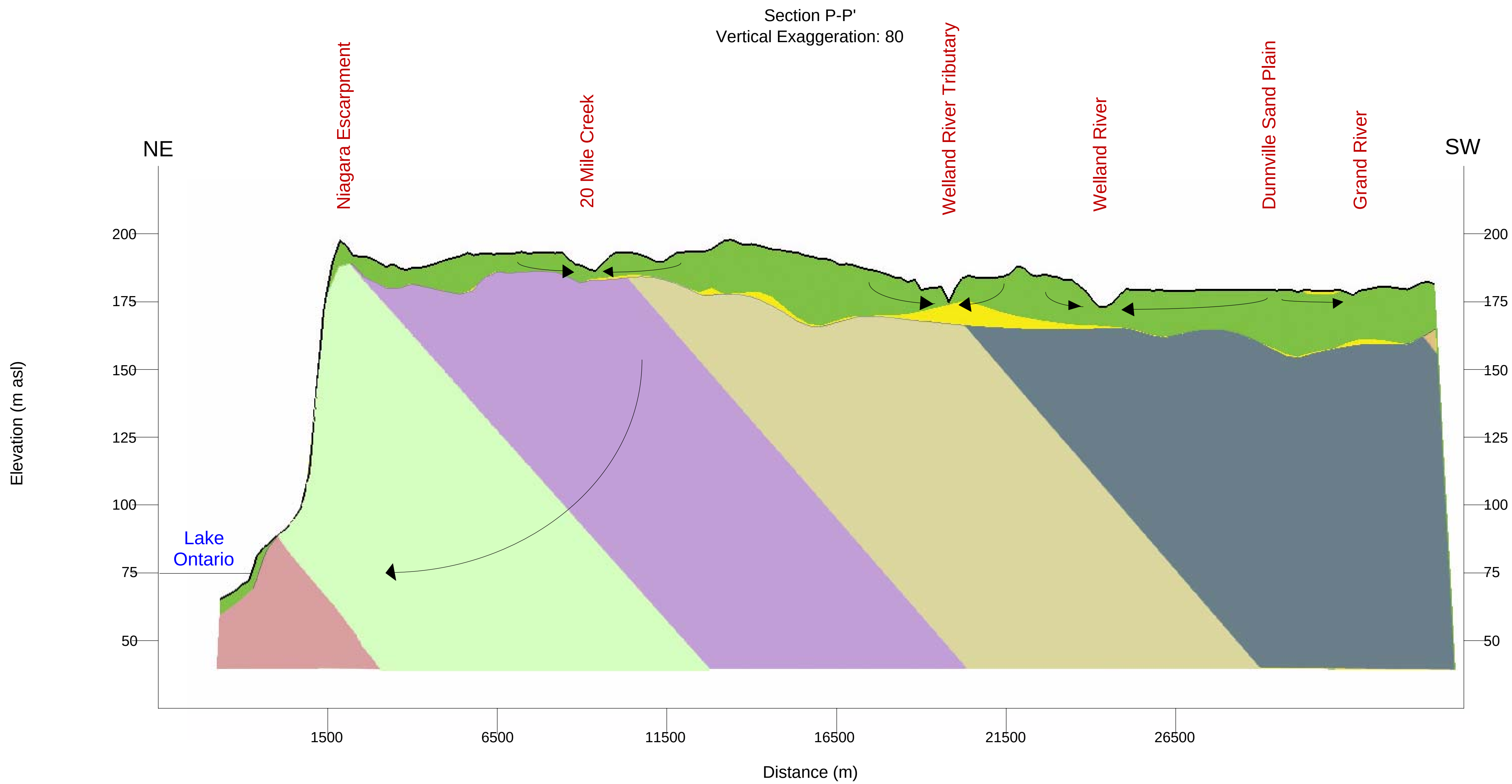
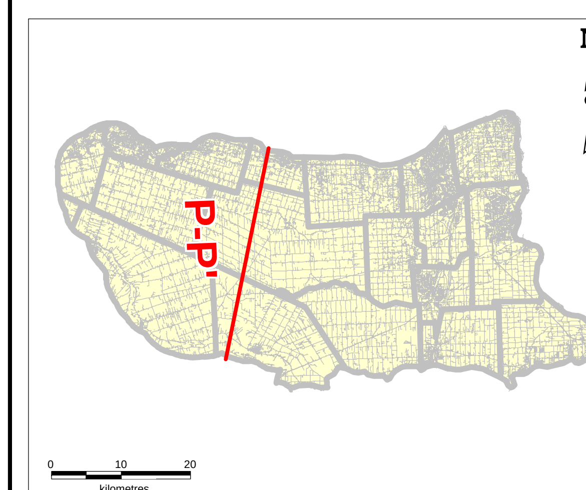
Figure 2-53: Regional Conceptual Model (A-A')

NPCA Groundwater Study

Legend

- Glaciolacustrine (fine)
- Lacustrine (coarse)
- Queenston Formation
- Clinton Group
- Lockport Formation
- Guelph Formation
- Salina Formation
- Bertie Formation
- Bois Blanc Formation
- Onondaga Formation





Disclaimer: This map is intended for illustrative purposes only. This figure is to be read in conjunction with the Niagara Peninsula Conservation Authority Groundwater Study

Digital Mapping Sources: Base Mapping features - Ministry of Natural Resource
Water Well Information: Ministry of the Environment.

Date: February, 2005

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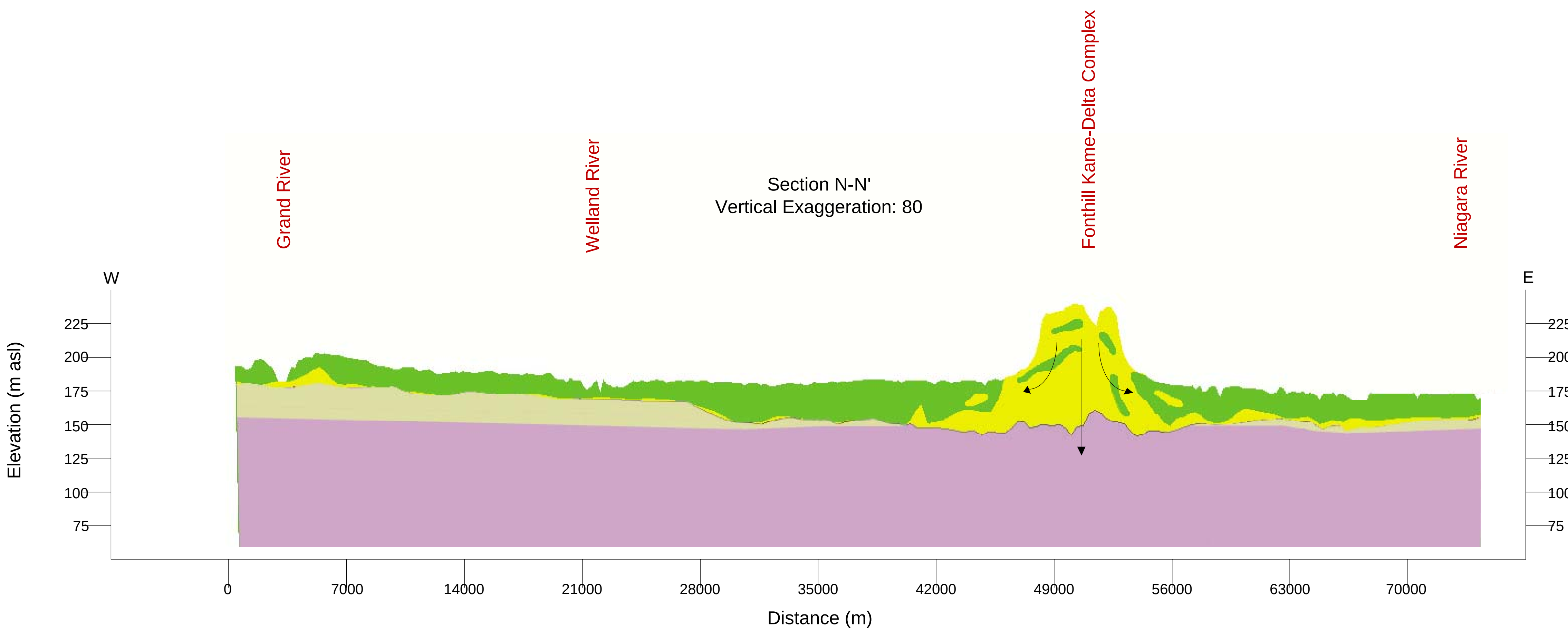
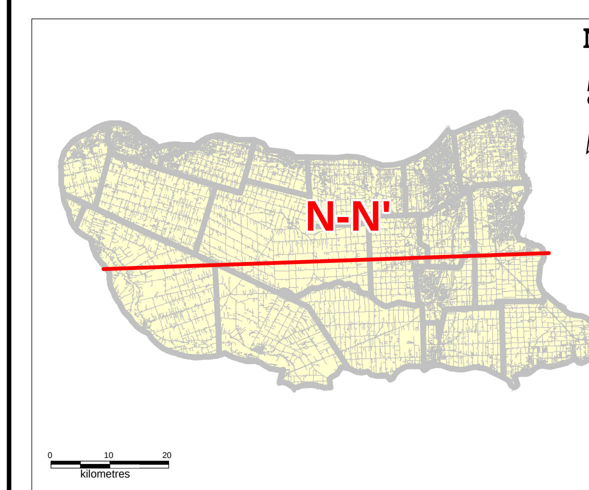
Figure 2-54: Regional Conceptual Model (P-P')

NPCA Groundwater Study



Legend

- Glaciolacustrine (fine)
- Lacustrine (coarse)
- Queenston Formation
- Clinton Group
- Lockport Formation
- Guelph Formation
- Salina Formation
- Bertie Formation
- Bois Blanc Formation
- Onondaga Formation



Disclaimer: This map is intended for illustrative purposes only. This figure is to be read in conjunction with the Niagara Peninsula Conservation Authority Groundwater Study

Digital Mapping Sources: Base Mapping features - Ministry of Natural Resource
Water Well Information: Ministry of the Environment.

Date: February, 2005

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Figure 2-55: Regional Conceptual Model (N-N')

Figure 3.22A

Potential Contaminant Sources

(Above Niagara Escarpment)

- National PCB Database
- Scott's Manufacturing Directory
- National Pollution Release Inventory
- Ontario Waste Receivers Summary
- Ontario Underground Storage Tanks
- Ontario Certificates of Approval
- Occurrence Reporting Information
- Ontario Pesticide Register
- Retail Fuel Storage Tanks
- Andersons Waste Disposal Sites

Waste Disposal Site Inventory (MOE)

- Closed
- Open

- Municipal Well
- Town/Village
- Niagara Escarpment
- Major Highway
- Highway
- Road
- Municipal Boundary
- Watercourse
- Study Area
- Built -Up Area
- Waterbody

1000 0 1000 2000 3000 4000 5000 Meters

City of Hamilton Groundwater Resources Characterization and Wellhead Protection Study

Hamilton

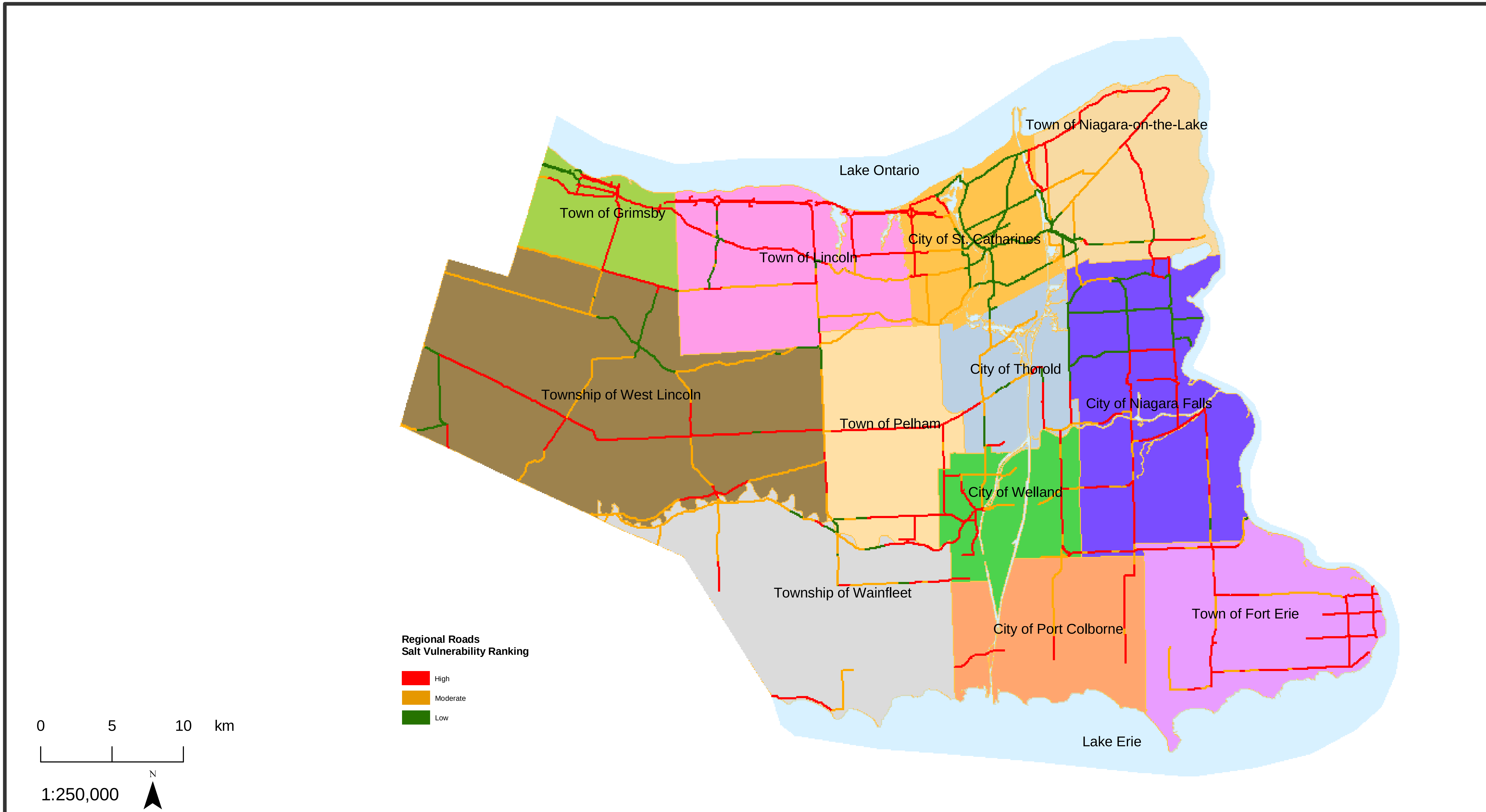
Contaminant point source information Access Database provided by MOE (2002)
Base Data - Natural Resources and Values Information System [NRVIS computer file]. Toronto, Ontario: The Ontario Ministry of Natural Resources, [2002].

The information conveyed by this map is regional in nature and is not suitable for use in site specific evaluations. The map should be interpreted in conjunction with the accompanying written report.

N

SNC•LAVALIN Engineers and Constructors

Charlesworth & Associates



ecoplans

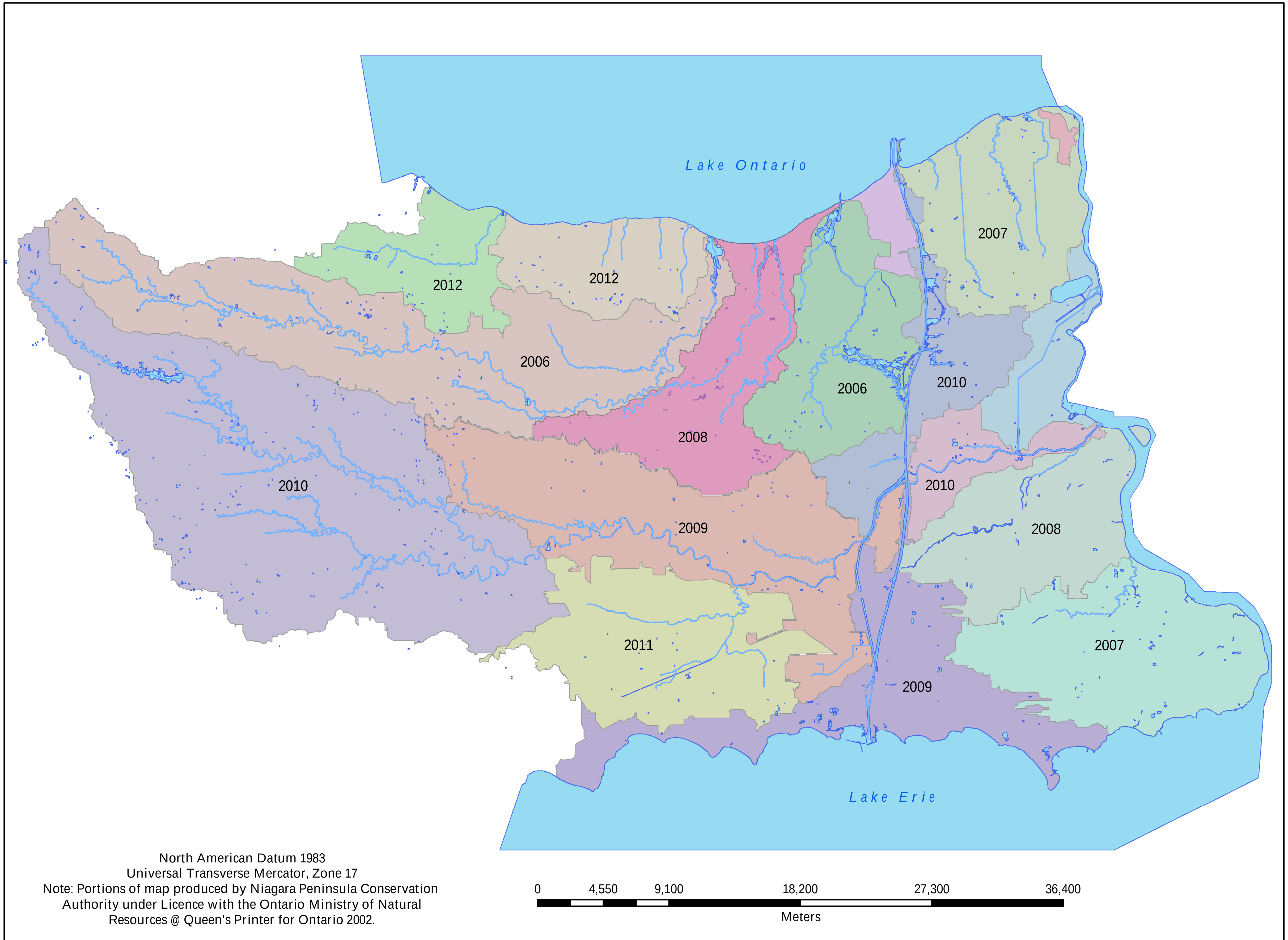
Niagara Region

Environment Canada Environnement Canada

Identification of Salt Vulnerable Areas

Figure 12 - Salt Vulnerability Mapping

Watershed Priority Areas: Yearly Plans



Legend

- Watercourse
- Waterbody

Watershed

Name

- Beaverdams and Shriners Creeks
- Big Forks Creek and Feeder Canal
- Central Welland River
- Fifteen and Sixteen Mile Creeks
- Fort Erie
- Grimsby
- Lake Erie North Shore
- Lincoln
- Lower Welland River
- Niagara Falls Urban
- Niagara-on-the-Lake (minus One Mile)
- One Mile Creek/ Epps Drain
- South Niagara Falls (Lyons and Usshers Creeks)
- St. Catharines East Urban
- Twelve Mile Creek
- Twenty Mile Creek
- Upper Welland River
- Export_Output_3

1:278,320

NIAGARA PENINSULA CONSERVATION AUTHORITY

Niagara Peninsula Conservation Authority
250 Thorold Road West, 3rd Floor
Welland, Ontario L3C 3W2
(905) 788-3135

Legend

NPCA Lumped Subwatershed
1. Lake Ontario
2. Niagara River
3. Lake Erie
Lake or River
Stream
Road
Municipal Boundary

Disclaimer: This figure was prepared for illustration purposes only and should not be relied upon by other parties other than for its intended purpose.

References:
Ontario Base Mapping obtained from MNR NRVIS. Projection is UTM Zone 17, NAD83.
Subwatershed shapefile (modified) from NPCA.
Municipal Boundaries from Regional Municipality of Niagara AutoCAD drawing file.

Completed by: MacViro Consultants Inc.

1.1 - Upper 20 Mile Creek
1.2 - Grimsby
1.3 - Beamsville
1.4 - Pelham Union
1.5 - Jordan Station
1.6 - St. Catharines West
1.7 - Effingham
1.8 - St. Catharines East
1.9 - Thorold
1.10 - Niagara-on-the-Lake
2.1 - Binbrook
2.2 - Empire Corners
2.3 - Canborough
2.4 - Welland River West
2.5 - Caistor
2.6 - Bismark
2.7 - Welland River Central
2.8 - Cambers Corner
2.9 - Wainfleet
2.10 - Pelham
2.11 - Port Robinson
2.12 - Welland City
2.13 - Stevensville
2.14 - Netherby
2.15 - Welland River East
2.16 - Niagara Falls
2.17 - Chippewa
2.18 - Old Fort Erie North
3.1 - Lowbanks
3.2 - Port Coulborne
3.3 - Gasline
3.4 - Old Fort Erie South

Local Management Areas Index Map

Region of Niagara
Niagara Water Quality Protection Strategy

2 0 2 4 6 8 10 Km
Scale 1 : 270,000

October 2, 2003

APPENDIX F
Species at Risk in the NPSP Area

The Ontario Species at Risk List includes any native plant or animal that is at risk of extinction or of disappearing from the province. The list contains species that are Extirpated (EXP), Endangered (END), Threatened (THR) and Special Concern (SC). Extirpated species no longer exist in the wild in Ontario but still occur elsewhere. Endangered species face imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's ESA. Threatened species are at risk of becoming endangered in Ontario if limiting factors are not reversed. Special Concern Species have characteristics that make it sensitive to human activities.

The S_RANK column denotes whether a species is S1 (Critically Imperiled), S2 (Imperiled), S3 (Vulnerable), S4 (Apparently Secure), SH (Possibly Extirpated), SX (Presumed Extirpated), SNA (Not Applicable), and SU (Unrankable). When the letter B follows the rank, this is to denote that the species was found breeding.

Plants				
Scientific Name	**Common Name**	**Habitat**	**S_RANK**	**MNR_STATUS**
Arisaema dracontium	Green Dragon	damp deciduous forests and along streams	S3	SC
Betula lenta	Cherry Birch	moist, well-drained soils, but also found on coarse-textured or rocky shallow soils	S1	END
Castanea dentata	American Chestnut	deciduous forest communities	S2	END
Chimaphila maculata	Spotted Wintergreen	sandy habitats in dry-mesic oak-pine woods	S1	END
Cornus florida	Eastern Flowering Dogwood	understory or on the edges of mid-age to mature, deciduous or mixed forests	S2?	END
Cypripedium candidum	Small White Lady's-slipper	prairie openings in wooded grasslands	S1	END
Eurybia divaricata	White Wood Aster	open, dry, deciduous forests	S2	THR
Frasera caroliniensis	American Columbo	open deciduous forested slopes	S2	END
Gymnocladus dioicus	Kentucky Coffee-tree	open areas of floodplains and the edges of wetlands	S2	THR
Hibiscus moscheutos	Swamp Rose-mallow	open, coastal marshes, but it is also sometimes found in open wet woods, thickets and drainage ditches	S3	SC
Juglans cinerea	Butternut	deciduous stands, but large pure populations exist on certain flood plains	S3?	END
Justicia americana	American Water-willow	shorelines and sometimes in nearby wetlands, as well as along streams	S1	THR
Liparis liliifolia	Purple Twayblade	open oak savannah and secondary successional, deciduous or mixed forest	S2	END
Magnolia acuminata	Cucumber Tree	forest with openings, such as wet woods with scattered pools	S2	END
Morus rubra	Red Mulberry	moist forest habitats	S2	END
Phegopteris hexagonoptera	Broad Beech Fern	shady areas of beech and maple forests where the soil is moist or wet	S3	SC
Polygala incarnata	Pink Milkwort	open, mesic to dry mesic sand prairie	S1	END

Ptelea trifoliata	Common Hoptree	sandy soils in areas with a lot of natural disturbance	S3	THR
Quercus shumardii	Shumard Oak	open woodlots with a past history of grazing by dairy cattle, and along fencerows and roadsides	S3	SC
Smilax rotundifolia	Round-leaved Greenbrier	moist to wet shaded woodland habitats	S2	THR
Trillium flexipes	Drooping Trillium	dry, sandy loam, non-acidic soils of mature, deciduous woodlands that are usually associated with watercourses	S1	END
Vaccinium stamineum	Deerberry	dry open woods	S1	THR
Viola pedata	Bird's-foot Violet	Black Oak savannahs within deciduous forests	S1	END

Mosses				
Scientific Name	**Common Name**	**Habitat**	**S_RANK**	**MNR_STATUS**
Bryoandersonia illecebra	Spoon-leaved Moss	soil that is in or near flat, low-lying, seasonally wet areas	S1	END

Birds				
Scientific Name	**Common Name**	**Habitat**	**S_RANK**	**MNR_STATUS**
Ammodramus henslowii	Henslow's Sparrow	open fields	SHB	END
Asio flammeus	Short-eared Owl	extensive stretches of relatively open habitat	S2N,S4B	SC
Charadrius melodus	Piping Plover	sandy or gravelly beaches, gravel shores of shallow, saline lakes and on sandy shores of larger prairie lakes	S1B	END
Chlidonias niger	Black Tern	marshes along the edges of the Great Lakes	S3B	SC
Colinus virginianus	Northern Bobwhite	open habitats that provide a mixture of grasslands, croplands and brush	S1	END
Dendroica cerulea	Cerulean Warbler	mature deciduous forests	S3B	SC
Empidonax virescens	Acadian Flycatcher	large areas of mature undisturbed forest	S2S3B	END
Falco peregrinus	Peregrine Falcon	open habitats such as wetlands, tundra, savanna, sea coasts and mountain meadows	S3B	THR
Haliaeetus leucocephalus	Bald Eagle	n/a	S1S2N,S4B	END
Icteria virens	Yellow-breasted Chat	successional habitats of thick shrubbery	S2B	SC
Ixobrychus exilis	Least Bittern	Ixobrychus exilis	S4B	THR
Lanius ludovicianus	Loggerhead Shrike	open ranges with occasional trees and shrubs	S2B	END
Protonotaria citrea	Prothonotary Warbler	deciduous swamp forests or riparian floodplain forests	S1B	END
Seiurus motacilla	Louisiana Waterthrush	mature forests along steeply sloped ravines adjacent to running water	S3B	SC
Tyto alba	Barn Owl	low-elevation, open country	S1	END
Wilsonia citrina	Hooded Warbler	mature hardwood forests with tall trees and a well-closed canopy	S3B	THR

Mammals

Scientific Name	Common Name	Habitat	S_RANK	MNR_STATUS
Microtus pinetorum	Woodland Vole	deciduous forests in areas of soft, friable, often sandy soil beneath deep humus	S3?	SC
Taxidea taxus	American Badger	Open habitats, whether natural (grasslands) or man-made (agricultural fields, road right-of-ways, golf courses)	S2	END
Urocyon cinereoargenteus	Common Gray Fox	deciduous forests and marshes	SNA	THR

Molluscs

Scientific Name	Common Name	Habitat	S_RANK	MNR_STATUS
Pleurobema sintoxia	Round Pigtoe	small to large rivers	S1	END
Ptychobranchus fasciolaris	Kidneyshell	small to medium-sized rivers and streams	S1	END

Reptiles

Scientific Name	Common Name	Habitat	S_RANK	MNR_STATUS
Apalone spinifera	Spiny Softshell	marshy creeks, swift-flowing rivers, lakes, impoundments, bays, marshy lagoons, ditches and ponds near rivers	S3	THR
Crotalus horridus	Timber Rattlesnake	forested areas with rocky outcrops	SX	END
Elaphe obsoleta pop. 2	Eastern Ratsnake - Carolinian Population	wooded areas, although they may be found in meadows and fields	S1	THR
Emydoidea blandingii	Blanding's Turtle	lakes, permanent or temporary pools, slow-flowing streams, marshes and swamps	S3	THR
Eumeces fasciatus pop. 1	Five-lined Skink - Carolinian Population	rocky outcrops, dunes, fields, and deciduous forests	S2	SC
Graptemys geographica	Northern Map Turtle	lakes and rivers	S3	SC
Lampropeltis triangulum	Milksnake	rural areas, prairies, pastures, and hayfields, to rocky hillsides and a wide variety of forest types	S3	SC
Sistrurus catenatus	Massasauga	different habitats across their range — from tall grass prairie to cedar bogs to shorelines	S3	THR
Sternotherus odoratus	Stinkpot	shallow water	S3	THR
Thamnophis sauritus	Eastern Ribbonsnake	edges of shallow ponds, streams, marshes, swamps, or bogs bordered by dense vegetation that provides cover	S3	SC

Amphibians

Scientific Name	Common Name	Habitat	S_RANK	MNR_STATUS
Ambystoma jeffersonianum	Jefferson Salamander	deciduous forests with suitable breeding areas like limestone sinkhole ponds, kettle ponds and other natural basins	S2	THR
Bufo fowleri	Fowler's Toad	sand dune and lake shore habitats	S2	THR
Desmognathus fuscus	Northern Dusky Salamander	streams in the Niagara Gorge	S1	END

Desmognathus ochrophaeus	Allegheny Mountain Dusky Salamander	forested brooks, mountain cascades, springs, or seeps	S1	END
Gyrinophilus porphyriticus	Spring Salamander	cool, clear streams in forested mountain regions	SX	EXP

Fish				
Scientific Name	**Common Name**	**Habitat**	**S_RANK**	**MNR_STATUS**
Clinostomus elongatus	Redside Dace	pools and slow flowing areas of small headwater streams	S2	THR
Coregonus kiyi	Kiyi	deep waters of large, freshwater lakes	S3?	SC, EXT
Erimyzon sucetta	Lake Chubsucker	heavily vegetated, stagnant bays, channels, ponds and swamps.	S2	THR
Ictiobus cyprinellus	Bigmouth Buffalo	bottom of shallow lakes, ponds, pools of large streams and man-made impoundments	SU	SC
Moxostoma carinatum	River Redhorse	moderate to large rivers	S2	SC
Notropis photogenis	Silver Shiner	moderate to large, deep, relatively clear streams	S2S3	SC

	Watershed Characterization Deliverables shown in MOE Guidance Module 1	Provincial Data Sets Available	Data Gap Problem	Comment	Guidance Module Section #
1	Produce a map (map 10) or maps that illustrate, at a minimum, the existing and future land uses described in the following sections (of the Gudiance Module 1)	Official Plan (Future)	Out of date	Haldimand's draft OP needs provincial approval before being release.	2.6.2 Land Use
2	Produce a map (map 13) or maps that illustrate the locations of groundwater source infrastructure including municipal wells and/or well fields, communal wells, and associated treatment facilities.	1)Other Wellhead Capture Zones 2)Annual Compliance Report/DWIS 3) Certificate of Approval Database (CofA) (IDS)	1) Not populated 2) Partially populated 3) Not populated	**Data Gap.** No information on Communal wells.	2.7.3
3	Identify riparian areas upstream of WTPs.		Does not exist	**Data Gap.** Need IPZ delineation	2.4.2 Woodlands and Vegetated Riparian Areas
4	Produce a map showing locations of known Brownfields sites.	1) Environmental Site Registry (RSC) 2) Abandoned Industrial Sites	1) Partially populated 2) Not populated/does not exist	**Data Gap.** MOE website contains only recent RSC data approvals.	2.6.4 Brownfields
8	Produce maps, graphics, and tables illustrating the highlights from the data analysis to illustrate surface water and groundwater conditions and prevailing trends.	Microbiological sampling & Analysis	Not populated	Information not received from Reg'd Health Units.	3.4 Raw water characterization for DW intakes
9	Produce maps, graphics, and tables illustrating the highlights from the data analysis to illustrate surface water and groundwater conditions and prevailing trends.	Non-Compliance Reports/Control Orders	Not populated	Dataset not yet received.	3.4 Raw water characterization for DW intakes
10	Produce maps, graphics, and tables illustrating the highlights from the data analysis to illustrate surface water and groundwater conditions and prevailing trends.	Annual Compliance Report/DWIS	Partially populated	No information on Communal wells.	3.4 Raw water characterization for DW intakes
11	Produce maps, graphics, and tables illustrating the highlights from the data analysis to illustrate surface water and groundwater conditions and prevailing trends.	Private Water Testing	Not populated	Dataset not yet received.	3.4 Raw water characterization for DW intakes

	Watershed Characterization Deliverables shown in MOE Guidance Module 1	Provincial Data Sets Available	Data Gap Problem	Comment	Guidance Module Section #
	Produce a written description of the evaluation and identify potential climatic predictive models.	Canadian Daily Climate data (CDCD)	Too sparse	More climate normals are needed to adequately cover the SWP area.	2.3.5
	Produce a map (map 5) or maps that illustrate significant hydrologic features. Record the material composition, properties, and depositional environment of major aquifers		Does not exist. Not required under current wording of G.Module 1 (Oct'06).	Better delineate overburden and bedrock aquifers and their physical properties.	2.3.2 & 2.3.3
	`Produce a written description which characterizes the stream network within the watershed.	CA Gauge Stations 2) Water Survey of Canada (WSC)/HYDAT	Too sparse	Need more surface water flow stations to cover ungauged eastern portions of the NPSWP authority.	
	Produce a map (map 17) or maps that illustrate the well(s) and/or well field(s), including wellhead protection areas as defined by the municipal groundwater studies where they exist.	Water Well Information System (WWIS)		Approximately 6,500 water well records cannot be accurately located.	
	Produce a map (map 5) or maps that illustrate significant hydrologic features.	Tile Drains Municipal Drains	Partially populated	The locations of many tile-drained fields are not identified.	
	Produce maps, graphics, and tables illustrating the highlights from the data analysis to illustrate surface water and groundwater conditions and prevailing trends.	DWSP	Partially populated	Conversion of DWSP dioxin data to toxic equivalents per litre to compare to ODWQS	3.4
	Produce maps, graphics, and tables illustrating the highlights from the data analysis to illustrate surface water and groundwater conditions and prevailing trends.	Unserviced Areas - Septic fields	Not populated/Does not exist.	NPCA does not have a septic fields database across the whole jurisdiction.	3.4
	Produce a written description of the “specific threats” in the source water protection region.		Does not exist	Evaluation and Audit of Sanitary Combined Sewer Overflows report is being currenlty drafted	6.2
	Produce a written description of the “specific threats” in the source water protection region.		Does not exist	Existing St. Lawrence Seaway information, i.e. Welland Canal sediment deposition quality	6.2
	Produce a written description of the “specific threats” in the source water protection region.		Does not exist	Biosolids mapping for City of Hamilton and Haldimand County	6.2
	Produce a written description of the “specific threats” in the source water protection region.		Does not exist	Water Pollution Contol Plant discharge information	6.2
	Produce a written description of the “specific threats” in the source water protection region.		Does not exist	Large animal feed lots.	6.2

	Watershed Characterization Deliverables shown in MOE Guidance Module 1	Provincial Data Sets Available	Data Gap Problem	Comment	Guidance Module Section #
	Produce a written description of the “specific threats” in the source water protection region.	Patrol Yards (salt storage domes)	Not populated	Road salt storage areas and snow dumps for municipal and provincial governments.	6.2