NIAGARA PENINSULA CONSERVATION AUTHORITY

FIFTEEN-SIXTEEN-EIGHTEEN MILE CREEK WATERSHED PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

INTRODUCTION

The need for a Watershed Plan for the Fifteen, Sixteen and Eighteen Mile Creeks watershed has been identified in the *Niagara Water Quality Protection Strategy* (NWQPS) (Regional Municipality of Niagara 2003). The *NWQPS* was based on 32 Local Management Areas (LMAs). The Fifteen, Sixteen and Eighteen Mile Creeks watershed is located entirely in LMA 1.5, which forms the boundary of this watershed (Figure 1).

The Fifteen-Sixteen-Eighteen Mile Creeks watershed is considered an important watershed for many reasons. This watershed is primarily agricultural, including areas of vineyards and orchards below the Niagara Escarpment. Above the escarpment, livestock based agriculture and general field crops dominate the landscape. Geologically, portions of the Fifteen-Sixteen-Eighteen Mile Creeks watershed have been designated as an Area of Natural and Scientific Interest due to an excellent representation of drowned rivermouths at Fifteen and Sixteen Mile Creeks, as well as 2 of the 12 major incised valleys found on the Niagara Peninsula. Rockway waterfall, which plunges 18.3 metres over the Niagara Escarpment is also found in this watershed.

The historic Rockway Salt Mines also add to the unique character of the watershed. The salt mines began operation in the late 1790s and produced the best quality and quantity of salt in all of Upper Canada. The salt was used to cure meat, tan hides, set dyes and for the usual table uses. Remnants of the mine can still be found in the Rockway Conservation Area today. A large portion of the watershed (65 percent) is located within the Provincial Greenbelt Plan area. A watershed management plan for the Fifteen-Sixteen-Eighteen Mile Creeks watershed will aid in protecting and enhancing these distinctive resources in the watershed.

WATERSHED PLANNING AND THE FIFTEEN-SIXTEEN-EIGHTEEN MILE CREEKS WATERSHED

A watershed, also referred to as a catchment basin, is an area of land from which surface runoff (water, sediments, nutrients and contaminants) drain into a common water body (e.g., Fifteen Mile Creek, Sixteen Mile Creek, Eighteen Mile Creek). Watersheds include all water and water-dependent features such as wetlands, forests, urban areas, and agriculture (Pollution Probe 2004).

A watershed management plan is a proactive document created cooperatively by government agencies and the community to manage the water, land/water interactions, aquatic life and aquatic resources within a particular watershed to protect the health of the ecosystem as land uses change (Ministry of Environment and Energy and Ministry of Natural Resources 1993). The Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan provides a systematic strategy to guide development, identify and recommend alternative and preferred restoration programs, and strengthen stewardship and partnerships in the watershed. Completed in 2 phases, the Watershed Plan consists of:

- background data collection in the form of a watershed characterization;
- a summary of the key issues in the watershed;
- completion of any additional studies to fill in data gaps in the study area;
- identification and suitability of restoration sites, landowner incentive programs, and land acquisition based on key issues in the watershed; and
- creation of an implementation plan including a monitoring component.

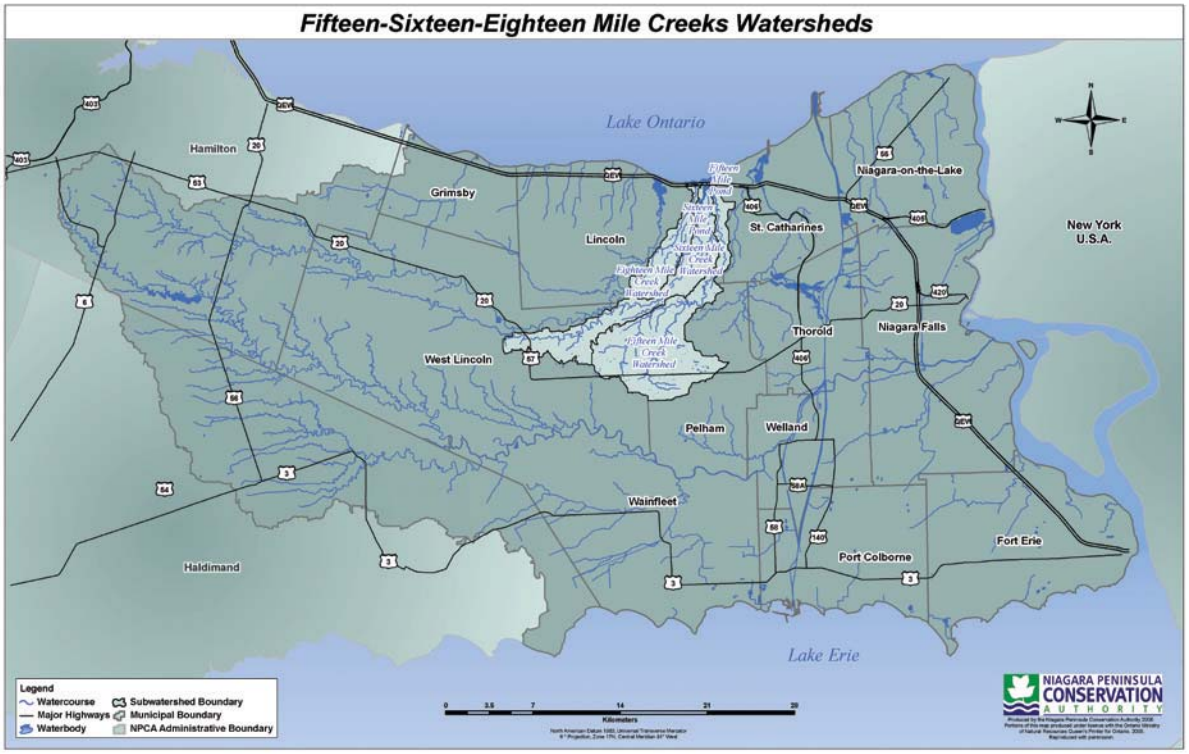


FIGURE 1: GEOGRAPHIC LOCATION

Completed over a 24 month period, the watershed planning process follows several steps including numerous opportunities for public involvement through open houses, workshops, and an agricultural land use survey (Figure 2). The Phase 1 watershed characterization contains a detailed background report including a description of the watershed's physiography, soils, land use, ecological, cultural and natural heritage, as well as a description of surface and groundwater resources. Phase 2 of the watershed planning process provides a set of watershed objectives that are linked to a comprehensive list of watershed issues derived from the *NWQPS* (Regional Municipality of Niagara 2003), and public events. Issues specific to agriculture were gathered through the *Land Management Issues and Agricultural Best Management Practices* survey (Appendix A), which was distributed to Ontario Federation of Agriculture members through a partnership with the Niagara Peninsula Conservation Authority. Any issues derived from these documents and public venues form the foundation of the watershed strategy and subsequent action plan, which are the focus of Phase 2 of the watershed planning process.

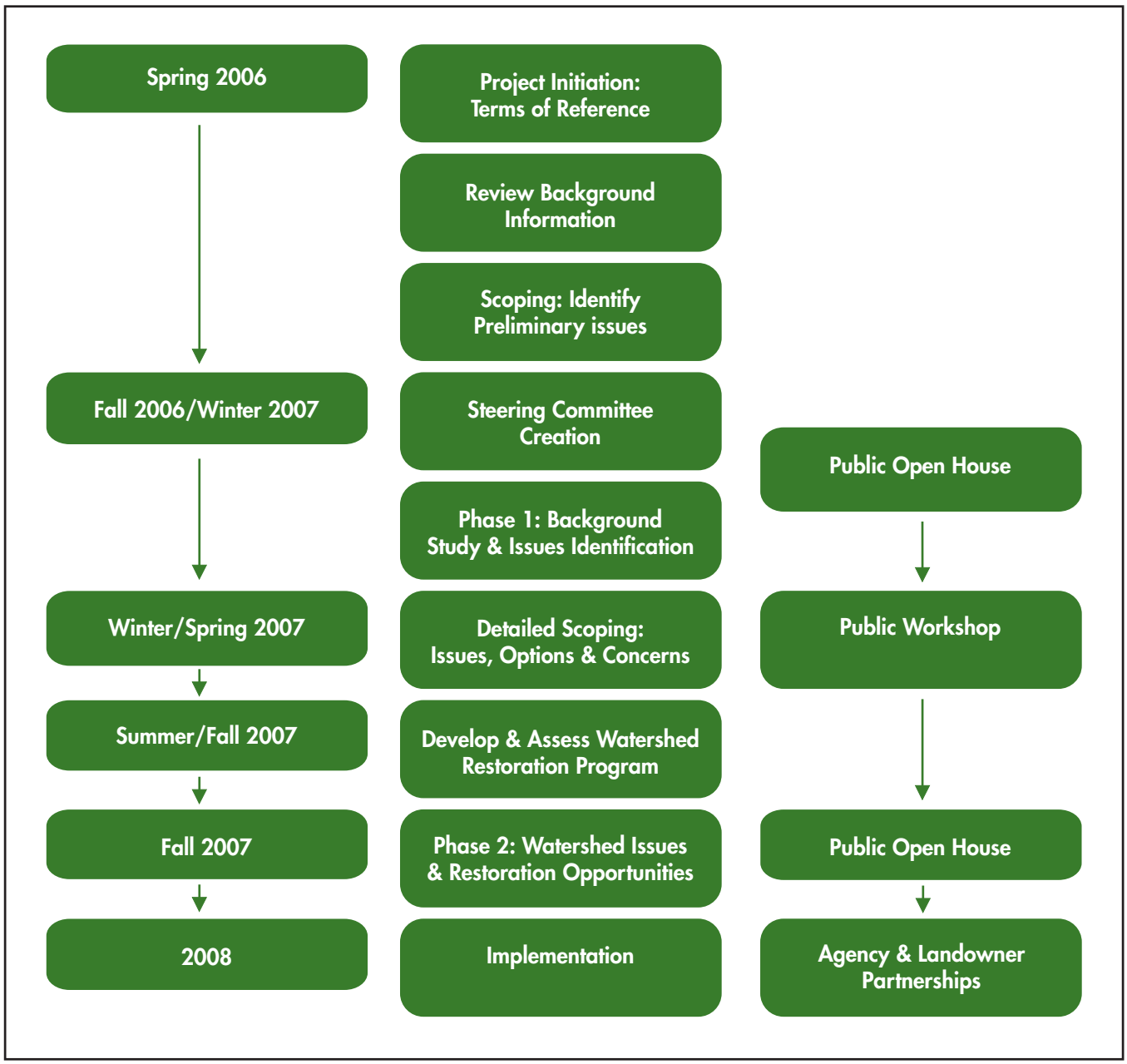


FIGURE 2: WATERSHED PLANNING FRAMEWORK

WATERSHED VISION

Under the Conservation Authorities Act (R.S.O. 1990, c.C27), the mandate of the Niagara Peninsula Conservation Authority (NPCA) is to establish and undertake programs designed to further the conservation, restoration, development and management of natural resources. In keeping with the mandate of the NPCA, *NWQPS* (Regional Municipality of Niagara 2003), and the watershed challenges and issues, residents of the Fifteen-Sixteen-Eighteen Mile Creeks watershed envision the following:

The Fifteen-Sixteen-Eighteen Mile Creeks watershed and its surrounding watersheds will support healthy natural areas, farms, watercourses, and habitat for a diversity of flora and fauna. The preservation, conservation and restoration of the watershed's ecosystem will protect society's resource needs by sustaining the ecological processes that naturally protect air, water, and land resources. Environmental stewardship, achieved through a collaborative approach to conservation that respects landowners, will help create a healthy watershed ecosystem and exciting opportunities for education and recreation for all citizens in the Fifteen-Sixteen-Eighteen Mile Creeks watershed.

WATERSHED OBJECTIVES

Each watershed in the Niagara Peninsula Conservation Authority's jurisdiction is unique, having its own set of watershed planning objectives. The watershed objectives for the Fifteen-Sixteen-Eighteen Mile Creeks watershed have been categorized based on the watershed's resource components, including the social and built environment. In accordance with the Provincial Policy Statement (Ontario Ministry of Municipal Affairs and Housing 2005a), Growth Plan for the Greater Golden Horseshoe (Ontario Ministry of Public Infrastructure Renewal 2006), Regional Policy Plan (Regional Municipality of Niagara 2007), Greenbelt Plan (Ontario Ministry of Municipal Affairs and Housing 2005b) and public input, natural resources will be managed on a watershed scale in the Fifteen-Sixteen-Eighteen Mile Creeks watershed to:

WATER RESOURCES

- maintain, enhance or restore natural stream processes to support human uses, agricultural needs and ecological functions in accordance with Ontario Water Quality Objectives;
- protect, improve or restore all vulnerable areas (surface and groundwater features that can be easily changed or impacted by activities or events);
- ensure the equitable distribution and sustainable use of available surface and groundwater to protect water quality and quantity, aquatic and terrestrial ecosystems, and human health and to supply existing and planned uses including municipal drains;
- ensure that storm water management practices minimize storm water volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces;
- manage and mitigate flooding risks to human life and property within acceptable limits;
- minimize erosion caused by human activity through the establishment and implementation of a comprehensive, priority based erosion control program; and
- maintain, improve and provide opportunities for farm-related infrastructures such as drainage and irrigation.

FISH AND AQUATIC HABITAT

- protect, enhance and restore populations of native species and their habitats in the watershed.

NATURAL HERITAGE AND RESOURCES

- protect, enhance and restore the health, diversity and ecological functions of the natural heritage systems in the watershed and their linkages to natural heritage systems in adjoining watersheds;
- maintain, restore and improve the linkages among surface water features, groundwater features, hydrologic functions and natural heritage features and areas, and their ecological functions;
- preserve all wetlands in the watershed; and
- research and recommend management practices for invasive species (flora and fauna).

COMMUNICATION AND EDUCATION

- foster and develop partnerships between and amongst agencies, interest groups and landowners;
- promote awareness of the linkages between healthy water, healthy lifestyles and economic viability of rural and urban land uses;
- promote the wise use of groundwater and surface water resources in terms of human, agricultural and ecological needs; and
- maintain, create and promote existing and new outdoor recreational areas.

DEVELOPMENT

- promote environmentally-sound land use decision making in the watershed for current and future urban development and rural/agricultural land use.

WATERSHED CHARACTERIZATION

LOCATION AND GENERAL DESCRIPTION OF THE FIFTEEN, SIXTEEN AND EIGHTEEN MILE CREEKS WATERSHED

The Fifteen, Sixteen and Eighteen Mile Creeks watershed includes all of Local Management Area 1.5 as identified in the NWQPS (Regional Municipality of Niagara 2003), including a portion of the Town of Lincoln, Township of West Lincoln, Town of Pelham and a very small area of the City of St. Catharines. Several subwatersheds form LMA 1.5 including Fifteen Mile

Creek, Sixteen Mile Creek, Eighteen Mile Creek as well as Lake Ontario 27, 28 and 29 (Figure 1). Surface water flows through a 291 km watercourse network with several outfalls to Lake Ontario. The major concentration of urban land uses (residential, commercial, industrial) is within the Lake Ontario 27 subwatershed with a small concentration of urban use in Fenwick and the Town of Pelham.

FIFTEEN MILE CREEK

Fifteen Mile Creek originates above the Niagara Escarpment in a predominately agricultural area. The creek then flows over the Niagara Escarpment at Rockway Falls and into a long pond measuring 1 kilometre in length that is separated from Lake Ontario by a vegetated sand bar. Fifteen Mile Creek has a natural meandering form, and this subwatershed drains approximately 42.5 square kilometres of land. Above the escarpment, field crops dominate the landscape, whereas below the escarpment fruit trees are most common. In many areas above the escarpment a vegetative buffer is lacking. However, the majority of the creek is protected by a vegetative buffer below the escarpment. An Area of Natural and Scientific Interest is located in the Fifteen Mile Creek valley due to its excellent representation of Niagara Escarpment and associated lake plain features including a major incised valley. The Rockway Conservation Area (126 hectares), managed by the Niagara Peninsula Conservation Authority, is also located in this subwatershed. Two waterfalls are located in Rockway Conservation Area. The waterfalls are located in the southwest region of the Conservation Area. The larger waterfall plunges 18.3 metres and the smaller waterfall drops 12.2 metres over a series of rapids (NPCA 1982).

SIXTEEN MILE CREEK

Like Fifteen Mile Creek, Sixteen Mile Creek begins above the Niagara Escarpment in a predominately agricultural area. Sixteen Mile Creek also flows over the escarpment and then flows into a pond measuring 2.5 kilometres in length that is separated from Lake Ontario by a vegetated sand bar. The drainage area for this subwatershed is approximately 64 square kilometres. Below the escarpment, the creek has a natural meandering form. Fruit trees are the main agricultural crop below the escarpment and above the escarpment field crops dominate. Most of the creek is protected below the escarpment by a vegetated buffer. However, above the escarpment the creek is protected by little vegetation with many cropped areas encroaching upon the streambank. The Louth Conservation Area (62 hectares), managed by the Niagara Peninsula Conservation Authority, is also located in this subwatershed. This conservation area also contains two waterfalls; the upper falls plunges 3.7 metres and the lower falls drops 7.9 metres (NPCA 1982).

EIGHTEEN MILE CREEK

Eighteen Mile Creek originates above the escarpment, drops over the Niagara Escarpment and eventually outlets to Lake Ontario. Draining approximately 17 square kilometres, this subwatershed consists mainly of agricultural areas with field crops above the escarpment and fruit trees below. The creek has a natural meandering form through forested areas; however, there is little vegetative buffer along the creek above the escarpment and there are many areas without a buffer below the escarpment. Like the Fifteen and Sixteen Mile Creeks subwatersheds, there are two waterfalls in this subwatershed. The upper falls drops 3.4 metres and the lower falls cascades 1.8 metres.

LAKE ONTARIO SUBWATERSHEDS 27, 28 AND 29

Lake Ontario Subwatersheds 27, 28 and 29 are very small subwatersheds located along the shoreline of Lake Ontario. Located in St. Catharines, Subwatershed 27 is primarily urban. The Lake Ontario shoreline is experiencing mild to moderate erosion in these subwatersheds (*NWQPS* Regional Municipality of Niagara 2003).

NIAGARA ESCARPMENT FEATURES

The Niagara Escarpment is a prominent feature in the Fifteen, Sixteen and Eighteen Mile Creeks watershed.

The Niagara Escarpment extends 725 kilometres from Queenston on the Niagara River to Tobermory, located at the tip of the Bruce Peninsula. The origin of the Niagara Escarpment dates back to approximately 450 million years when the escarpment lay under a shallow warm sea, now referred to as the Michigan Basin. Rivers flowing into this ancient sea carried sand, silt and clay that were eventually deposited as thick layers of sediment along with lime-rich organic material from decomposing sea life. Over millions of years, these materials were compressed into considerable layers of sedimentary rocks and ancient reef structures, some still visible along the escarpment. Some of the rock layers also consist of soft shales and sandstones, and others contain more durable rock layers comprised of dolostone.

Over the past 405 million years, glaciation, water flow, and freeze-thaw cycles have eroded back and cut into the face of the escarpment. The harder layers including the Lockport-Amabel Formation that caps the Niagara Escarpment are carbonate rocks (limestone and dolostone). These resistant rocks break-off in vertical slabs forming the main cliff-face, subsidiary cliffs and a rubble slope commonly referred to as "talus" (Ontario Ministry of Natural Resources1992), which is evident in the Fifteen-Sixteen-Eighteen Mile Creeks watershed.

TOPOGRAPHY

The topography of the Fifteen-Sixteen-Eighteen Mile Creeks watershed is characterized by a gently rolling to flat topography above the Niagara Escarpment before the Fifteen, Sixteen and Eighteen Mile Creeks flow over the escarpment (figure 3). The Fifteen Mile Creek flows over the escarpment at Rockway Conservation Area, and Sixteen Mile Creek flows over the escarpment at Louth Conservation Area. As noted above, the Niagara Escarpment is the dominant landform feature in the watershed. Below the escarpment the Fifteen, Sixteen and Eighteen Mile Creeks flow over relatively flat terrain before they outlet to Lake Ontario; both Fifteen and Sixteen Mile Creeks flow through ponds measuring 1 kilometre and 2.5 kilometres respectively, before emptying into Lake Ontario.

PHYSIOGRAPHY AND GEOLOGY

Above the Niagara Escarpment, Fifteen, Sixteen and Eighteen Mile Creeks and their tributaries originate in the Haldimand Clay Plain, with the exception of a small eastern portion of the Fifteen Mile Creek that flows off the west side of the Fonthill Kame. Below the escarpment, a band of glacial shorecliff underlying old Highway 8 cuts across the clay plain. The remainder of the watershed, below the escarpment, is comprised of Lake Iroquois Sand Plain to the Lake Ontario shoreline. The physiography and geology of the Fifteen-Sixteen-Eighteen Mile Creeks watershed are illustrated on Figures 4 and 5.

FIFTEEN AND SIXTEEN MILE CREEK VALLEYS

The Fifteen and Sixteen Mile Valleys Area of Natural and Scientific Interest (ANSI) includes a 3.5 kilometre stretch of escarpment slope and plain. The main escarpment slope varies between 10 to 30 metres high and is capped by 1 to 3 metres of dolostone cliffs of the Lockport Formation. One of the largest terrace complexes on the Niagara Escarpment can be found in this ANSI below the main escarpment slope. The terraces range between 110 to 150 metres above sea level and are underlain by resistant dolostones and sandstones of the Irondequoit and Whirlpool Formations with intervening softer shales of the Cabot Head and Grimsby Formations (Riley and others 1996).

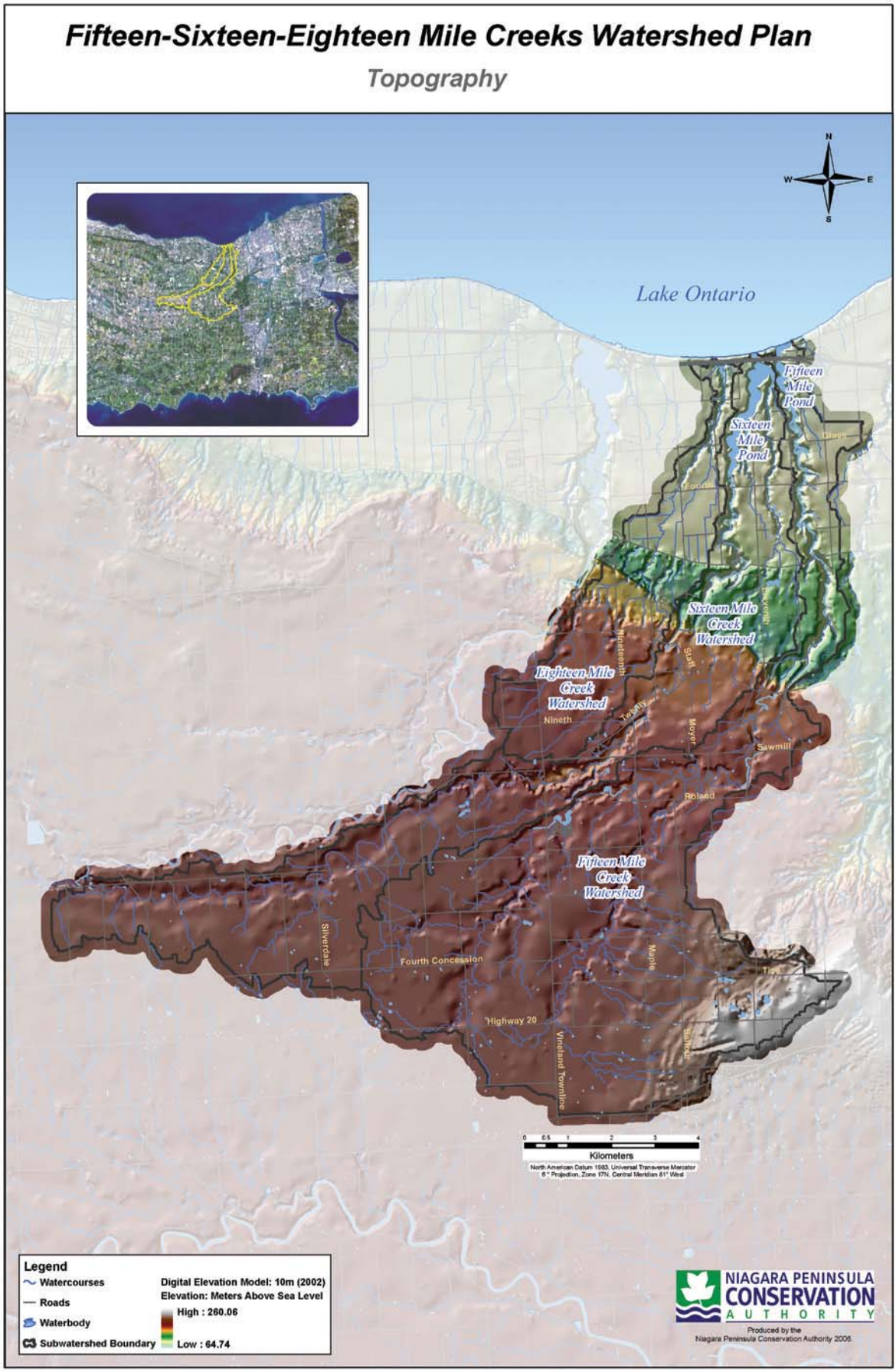


FIGURE 3: TOPOGRAPHY

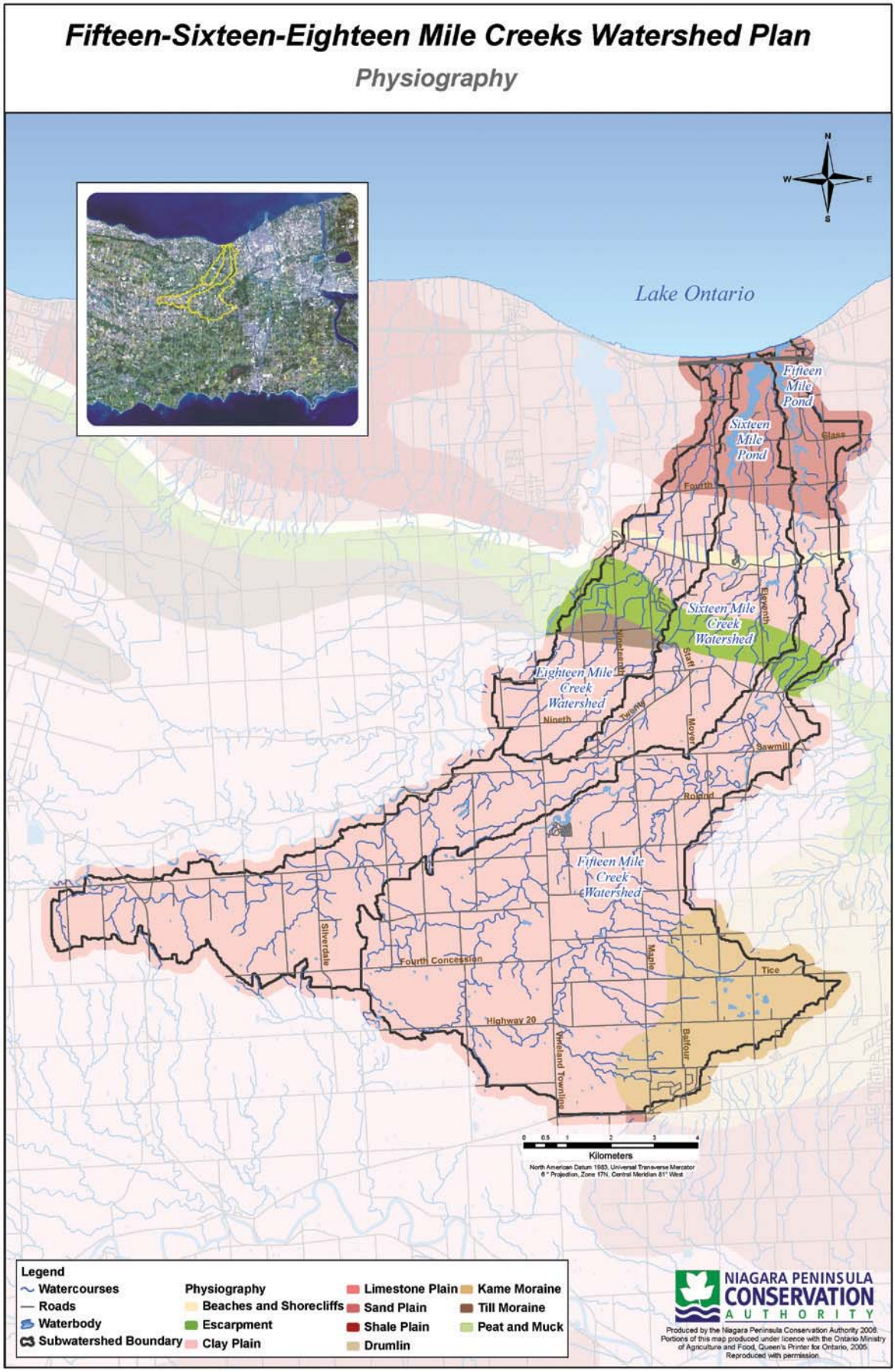


FIGURE 4: PHYSIOGRAPHY

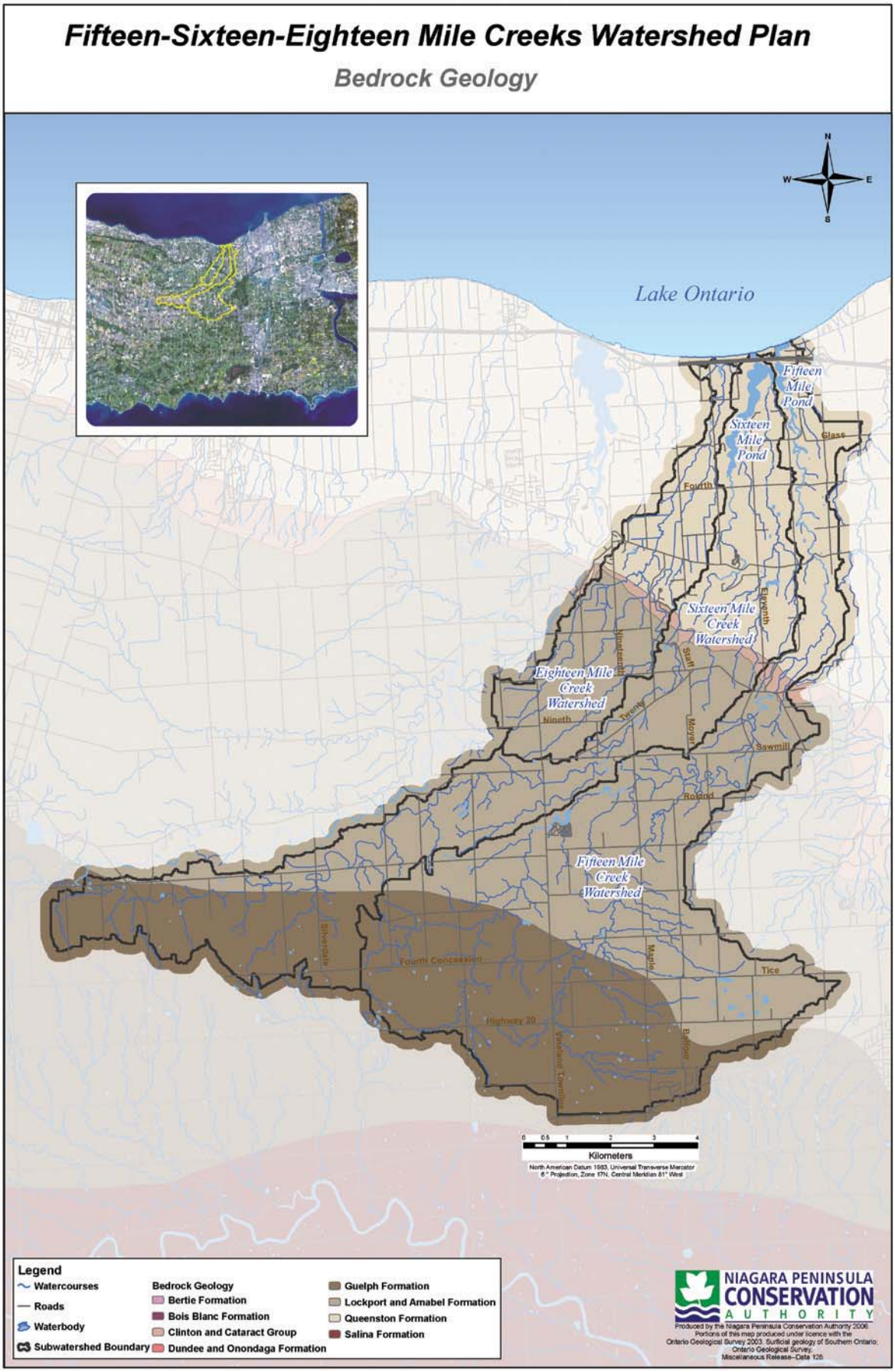


FIGURE 5: BEDROCK GEOLOGY

The Fifteen and Sixteen Mile Creeks Valleys have been designated as an ANSI in part due to the excellent example of twin "drowned" rivermouths. The mouths of the creeks are separated from Lake Ontario by a barrier bar. The drowned rivermouth feature was created by isostatic rebound in the eastern portion of Lake Ontario, resulting in the west side of the peninsula to become submerged with water. The Fifteen Mile Creek gorge is 30 metres deep and 250 metres long, and the Sixteen Mile gorge is 25 metres deep and 710 metres long (Ontario Ministry of Natural Resources1992). Downstream of the Fifteen and Sixteen Mile Creek bottomlands, the creeks cut through the Whirlpool Formation to form steep valleys of 250 and 450 metres wide and 25 to 35 metres deep in glacial sediments underlain by soft shales of the Queenston Formation (Ontario Ministry of Natural Resources1992).

In addition to the 2 major incised valleys in the Fifteen and Sixteen Mile Creek Valleys ANSI, there are 8 minor valleys incised into the escarpment cap rock of Fifteen and Sixteen Mile Creeks. The gorges of these minor valleys are up to 100 metres long and 20 metres deep, with cliffs and talus slopes.

ROCKWAY FALLS

Rockway Falls has also been denoted as an ANSI due to its unique earth science features. The Rockway Falls ANSI encompasses an erosional "notch" at the edge of the Niagara Escarpment that was likely created by the solution of major structural elements in Silurian bedrock, enhanced by glacial and glaciofluvial erosion through several glacial periods. The falls drop 18.3 metres into a bowl shaped amphitheatre with a plunge basin over 3 metres deep at the bottom of the falls. A smaller falls, downstream of the main falls, has a height of approximately five metres and a plunge pool measuring 0.6 metres.

The bedrock walls of the gorge reveal a vertical section of rock representing Silurian stratigraphy typical of the western edge of the Appalachian basin including the following formations, moving from the bottom of the gorge to the top:

- **Grimsby Formation** (Lower Silurian): red shale with varying amounts of interbedded red sandstone with minimal fossil remains.

- **Thorold Formation** (Middle Silurian): Light to dark grey, fine-grained sandstone and siltstone with thin shale partings with a notable colour change from the underlying red Grimsby sandstone.
- **Neahga Formation** (Middle Silurian): black to grey, platy shale with minor grey limestone including platelets of soft, green-brown shale.
- **Reynales Formation** (Middle Silurian): thick-bedded, light grey dolostone with some fossil traces restricted to the base of the gorge.
- **Irondequoit Formation** (Middle Silurian): massive, white to light grey in colour, typified by crystals in a porous limestone.
- **Rochester Formation** (Middle Silurian): thin-bedded, grey and black shale and siltstone with imbedded layers of thin, dark grey limestone.
- **DeCew Formation** (Middle Silurian): dark grey dolostone with white markings throughout located near the top section of the gorge.
- Lockport Formation (Gasport Member, Middle Silurian): this layer of rock is thin bedded near the top and becomes thicker, with a blocky fracture pattern through its middle and lower portions. It is a highly fossiliferous blue-grey dolostone and limestone.

SIXTEEN MILE CREEK DIVERSION

The flow of Sixteen Mile Creek was diverted during the Holocene period (last 10 000 years). The following description of what likely caused the diversion is provided by Tinkler (1994).

North Creek was once the headwaters for Sixteen Mile Creek. North Creek is located 4 kilometres east of Smithville and it is presently a tributary of Twenty Mile Creek. At the site where the diversion took place, the valley of former Sixteen Mile Creek was unusually narrow and shallow (300 metres wide and 3 metres deep). Twenty Mile Creek, located immediately across the divide to the north, was approximately 3 metres lower. Thus, water was able to spill across the clay divide to create a channel from which the stream did free itself, thereby reducing the basin size of Sixteen Mile Creek by almost half.

The cause of the overspill is unknown. However, the landscape was forested at the time, and it is possible that a blockage in the channel, such as a beaver dam, heavy treefall from a severe windstorm, or exceptional ice conditions in the river could have caused the diversion. Another hypothesis suggests that a discharge equivalent to the Hurricane Hazel storm (85 cubic metres per second) and very slow flowing water in the main channel (0.3 metres per second) would be enough to cause the entire valley to fill and breach the divide.

LAKE ONTARIO SHORELINE

The Fifteen-Sixteen-Eighteen Mile Creeks watershed contain approximately 8.24 kilometres of Lake Ontario shoreline. The *Lake Ontario Shoreline Management Plan* (1994) has divided the shoreline into 14 sectors; the shoreline in the Fifteen-Sixteen-Eighteen Mile Creeks watershed falls entirely within Sector 6, which also includes a portion of the Twenty Mile Creek Watershed.

The shoreline in this area is characterized by barrier beaches located at the mouth of both Fifteen and Sixteen Mile Creeks. Approximately 47 percent of the shoreline still remains in its natural state with minimal to narrow beaches. The near shore bottom is described as containing glacial material with some boulders and cobbles as well as a significant area of sand located east of Fifteen and Sixteen Mile Creeks (M.M. Dillon and Atria Engineering Hydraulics 1994).

The *Lake Ontario Shoreline Management Plan* (M.M. Dillon and Atria Engineering Hydraulics 1994) reported that there were no buildings subject to flooding under the 100-year storm conditions. Urban development is limited along the shoreline and the erosion rate is considered moderate. However, a fairly significant number of existing residential buildings are within the Regulation Erosion Standard (defined as the approved standard[s] used to define shoreland erosion limits, based on recession rates, for regulatory purposes) west of where Sixteen Mile Creek outlets to Lake Ontario.

SOILS

The soils in the niagara region were resurveyed and documented in a report entitled *The Soils of Regional Niagara* (kingston and present 1989) by the ontario ministry of agriculture and food and agriculture canada. This study included geological and physiological features; soil groups and types; soil moisture characteristics; drainage and variability; common properties of soil groups; as well as information related to agricultural soil use and classification. The following soil descriptions and associated map (figure 6) are derived primarily from this document.

Above the escarpment, several soil groups supporting field crops and tender fruit dominate the landscape in the fifteen-sixteen-eighteen mile creeks watershed. For example, the beverly soil group are imperfectly drained and groundwater can be found in the surface horizons for a period of time each year. They are usually composed of silty clay loam textures, and typically these soils have a high clay content. As a result, beverly soils are mainly used for corn, small grains and forage crops. Near the niagara escarpment, this soil group is also used for hardier fruit crops such as labrusca grapes, apples and pears. Steeper slopes with beverly soils are very susceptible to water erosion and erosion works are needed.

Brantford soils are moderately well-drained. Although these soils have relatively high water-holding capacities, they can exhibit summer drought. Surface runoff from brantford soils is generally rapid. This clayey soil group is often used for field crops such as soybeans, winter wheat and spring grains. However, like beverly soils, brantford soils can also be used to grow some hardy fruits like apples, pears, and some grape crops near the escarpment. Water erosion on slopes is a hazard on these moderately erodible soils.

Haldimand soils are also found above the escarpment in the fifteen-sixteen-eighteen mile creeks watershed. These soils are imperfectly drained and slowly permeable, which means that there is usually some temporary perching of groundwater in the upper soil horizons. Surface runoff is usually rapid, except where the surface is dry and contains numerous soil cracks. These predominately clay soils are used for field crops

Morley soils are poorly drained and therefore require tile drainage before they are suitable for agricultural use. Due to their location below the niagara escarpment and as a result of a favourable microclimate for fruit crops in this watershed, morley soils are used almost exclusively for grapes and hardy fruit trees.

Jeddo soils are poorly drained, slowly permeable and saturated by groundwater most of the year. Therefore, these soils require tile drainage and continued maintenance, in part, due to high degrees of compaction. In the fifteen-sixteen-eighteen creeks watershed, jeddo soils are used fairly extensively for grapes.

Vineland soils are also found below the escarpment. These soils are imperfectly drained and moderately to rapidly permeable. Vineland soils are highly suitable for most agricultural crops. However, in the niagara region they are used almost exclusively for growing fruit crops. With tile drainage and irrigation, these soils have good suitability for peaches, apricots, sour cherries, vinifera grapes, apples, strawberries and raspberries. Erosion is a concern for these soils.

Grimsby soils are usually well-drained and quite permeable. These soils are prime soils for tender fruit and vegetable crops. However, these sandy soils do require irrigation.

LAND USE

The Fifteen-Sixteen-Eighteen Mile Creeks watershed is characterized largely by agricultural land use. The most prominent feature in the watershed is the Niagara Escarpment, which cuts through the more northern portion of the watershed and contains exceptional examples of escarpment features and Carolinian flora. Above the Niagara Escarpment, the topography is flat consisting of agricultural operations and below the escarpment Fifteen and Sixteen Mile Creeks meander to outlet to Lake Ontario through Fifteen Mile Pond and Sixteen Mile Pond. The Queen Elizabeth Way highway cuts across the watershed along Lake Ontario where the creeks outlet. Land use in the Fifteen-Sixteen-Eighteen Mile Creeks watershed is illustrated on Figure 7, which has been derived from Official Plan mapping.

The Fifteen-Sixteen-Eighteen Mile Creeks watershed spans the Township of West Lincoln (33 percent), Town of Lincoln (30 percent), Town of Pelham (28 percent) and the City of St. Catharines (9 percent). The majority of land use in the watershed is agriculture. However, urban areas are located in a portion of Fenwick and Jordan. Little development is anticipated in the watershed due to the limitations imposed by the Province's *Greenbelt Plan* (Ontario Ministry of Municipal Affairs and Housing 2005b).

Agricultural areas include areas of vineyards and orchards, a significant component of greenhouse production and, in the upper portion of the watershed above the Niagara Escarpment, livestock based agriculture and general field crops dominate the landscape. The *Regional Agricultural Economic Impact*

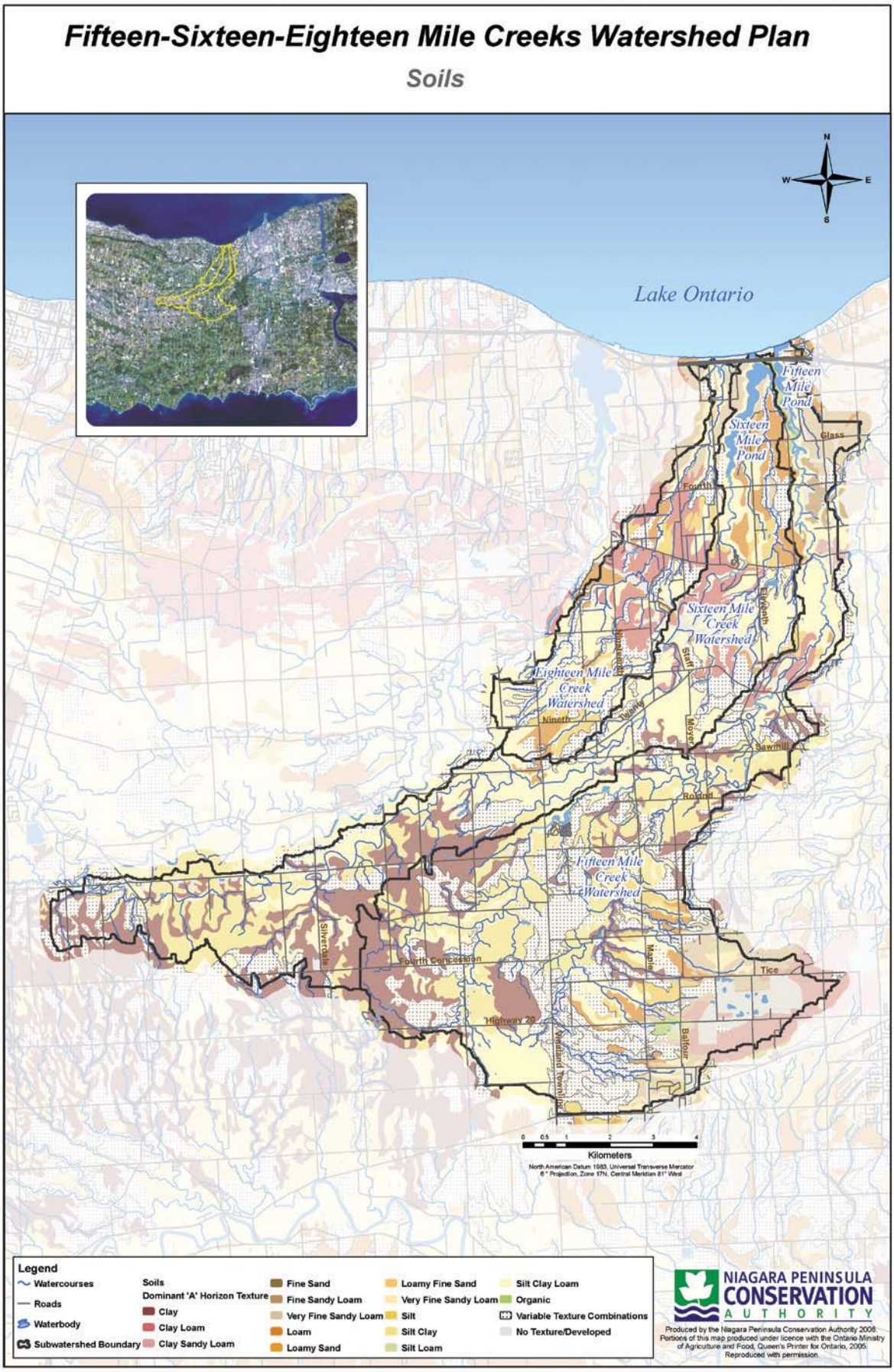


FIGURE 6: SOILS

Study (Regional Municipality of Niagara 2003) ranked the top 12 agricultural commodity groups in Niagara (based on 2001 Statistics Canada data). In terms of the watershed municipalities, the main commodity groups are:

- Township of West Lincoln: poultry and egg, dairy, and cattle;
- Town of Lincoln: fruit, miscellaneous speciality (e.g., greenhouse, horse and pony, and nursery), and poultry and egg;
- Town of Pelham: miscellaneous speciality, fruit, and grain and oilseed; and
- City of St. Catharines: fruit and miscellaneous speciality.

Recreational opportunities also abound in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. There are 3 golf courses in the watershed including The Links of Rockway Glen, Peninsula Lakes and Sawmill. The N.E.T. campground on Fifteen Mile Creek is located in the watershed, and Big Valley campground is located on Sixteen Mile Creek. Charles Daley Park located on the shores of Lake Ontario and Sixteen Mile Pond also offers outdoor recreational opportunities.

The Niagara Peninsula Conservation Authority operates 2 conservation areas in this watershed. Rockway Conservation Area is located along Fifteen Mile Creek near the City of St. Catharines. This conservation area is 126 hectares in size and it protects a portion of the Niagara Escarpment, Rockway Falls, and the diverse flora and fauna of the Carolinian Forest. Louth Conservation Area is also located in this watershed along Sixteen Mile Creek in the Town of Lincoln. This 62 hectare site preserves a portion of the Niagara Escarpment and it provides access to the Bruce Trail.

HISTORICAL LAND USE

THE ROCKWAY AREA SETTLEMENT

Settlers began to migrate to the Niagara Frontier in 1781, and there was a great influx of settlers all along the Canadian-American border in 1784. Those looking for land often explored the forest many miles back in search of choice locations. Several communities formed, one being Rockway, which is cited as being one of the oldest communities in Louth Township (Rennie, 1966). However, according to Rennie (1966), due to its location, Rockway would never be the shipping or manufacturing centre that Jordan was, or the railroad shipping centres that Vineland Station and Jordan Station grew to be.

Prior to 1791, the province of Ontario was regarded and governed as an extension of the province of Quebec. However, in 1791 the Canada Bill positioned what is now Ontario in English Upper Canada. Colonel John Graves Simcoe, first Lieutenant Governor of Upper Canada, divided the province into 19 counties. He named Lincoln County after its English counterpart, and each of its 12 townships, including Louth, after towns in Lincoln County, England (Town of Lincoln Library, No Date).

FIFTEEN MILE CREEK SALT MINES

Deputy surveyor at Niagara, Augustus Jones traveled with Angus Macdonell, described as "a chemist of sorts", to search for salt mines in 1792 in what was by then called Louth Township. Although there were numerous settlers in all of the lakeshore townships by this time, there were no roads other than Indian paths or pack-horse trails (Burghardt 1969). Thus, it is presumed that Jones led his party in batteau and skirted along the coast of Lake Ontario to the mouth of Fifteen Mile Creek, and then rowed up the creek for 2 miles, which was as far as the boats could go. From this point, his crew still had about 2.5 miles of forest to negotiate. Their journey led them to the Rockway salt springs, which they found in the level floor of the valley of Fifteen Mile Creek. Measuring 15 feet long, 5 feet wide and 11 feet deep, the salt springs provided the best quality and quantity of brine in the province as well as serving as a local source for salt, which was both costly and scarce. The first salt was produced a year later in July 1793 (Ontario Historical Society 1930).

The salt was used locally to cure meat, tan hides, set dyes, and for the usual table uses. It is interesting to note that the Fifteen Mile Creek salt well and surrounding territory was considered sacred ground by both the "white men and the Indians" (Rennie 1966). As a result, no fighting was allowed near the salt well.

LAND USE IN THE ROCKWAY AREA

At the time of settlement, the principal agrarian pursuit was cattle raising, and dairy farming followed shortly thereafter. According to Rennie (1966), the first grapes in the area were grown in some time around 1900 at the Adam Haines farm on Fifth Street Louth.

Rennie (1966) has also reported that a sawmill on Fifteen Mile Creek, which began operating in the latter 19th Century operated in the area until World War I. The mill produced lumber for many of the farm buildings near Rockway.

The landscape changed with the construction of the Queen Elizabeth Way (QEW). The QEW was considered one of the first areas in Canada to have a "superhighway". In 1937, the Ontario government began buying cottages at the Fifteen, Sixteen and Twenty beaches for the development of the highway (Rennie 1966). Two years later construction of the QEW began, altering the landscape and ecological function of the Fifteen-Sixteen-Eighteen Mile Creeks watershed.

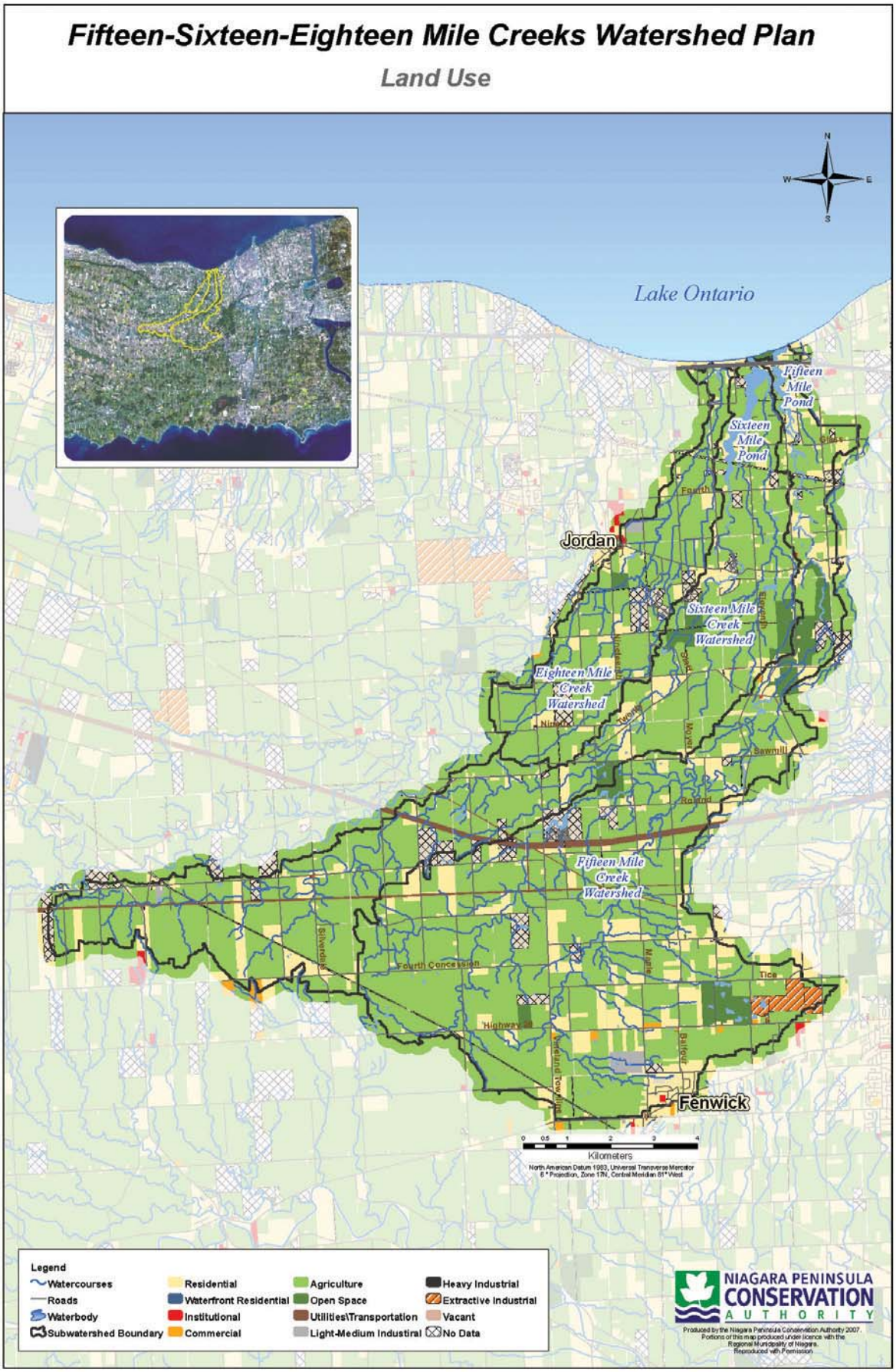


FIGURE 7: LAND USE

NATURAL HERITAGE RESOURCES

The percentage of upland forest cover, wetlands, and riparian habitat in the Fifteen-Sixteen-Eighteen Mile Creeks watershed are recorded in Table 1. These figures will be assessed based on the targets set by Environment Canada (2004c) as part of the restoration strategies in the watershed plan.

All of the natural heritage areas including wetlands, woodlots, Areas of Natural and Scientific Interest and Environmentally Sensitive/Significant Areas are illustrated on Figures 8 and 9 respectively, and described below. This information was complied as a joint initiative by the Ministry of Natural Resources, Regional Municipality of Niagara and the Niagara Peninsula Conservation Authority. Currently the Niagara Peninsula Conservation Authority is undergoing a Natural Heritage Areas Inventory and the following information will be updated to reflect the projects findings.

FIFTEEN AND SIXTEEN MILE CREEK VALLEYS ANSI

The Fifteen and Sixteen Mile Creek valleys have been identified as an Area of Natural and Scientific Interest (ANSI) due to the excellent representation of Niagara Escarpment features and associated lake plain features found in this area. The Fifteen and Sixteen Mile Creek Valleys ANSI are located primarily in the Town of Lincoln, with the north eastern section of the Fifteen Mile Creek valley located in the City of St. Catharines. Measuring 343 hectares, this horseshoe shaped site features the following natural heritage features:

- Open water riverine, open water, submerged and floating aquatics, shallow emergent marshes, several meadow marshes, and broadleaf swamps of Red Maple, Red Maple-Red Oak, and White Elm representing 1.7 percent of the ANSI;
- Terrestrial forests including many stands in an old-growth state, and a few thickets that comprise 77.5 percent of the ANSI;
- Primary communities including broadleaf forests of Sugar Maple and drier forests of Red Oak make up 12.9 percent of the ANSI; and
- Anthropogenic communities such as regenerating fields, old orchards, trails and paths represent 7.8 percent of the ANSI (Ontario Ministry of Natural Resources 1992).

The Fifteen and Sixteen Mile Creek Valleys ANSI have been subdivided into 5 areas based on physiographic features (Ontario Ministry of Natural Resources 1992).

The **Fifteen Mile Creek Lake Plain Valley** consists of the Fifteen Mile Creek valley north of the Niagara Escarpment. This portion of the ANSI contains an excellent representation of tableland, valley slope and bottomland vegetation communities on the lake plain. This area also contains most of the ANSI's wetland communities including the nationally rare Pin Oak - Red Oak - Red Maple swamp.

The **Fifteen Mile Creek Escarpment Incised Valleys** contain the Niagara Escarpment and escarpment related vegetation communities of the Fifteen Mile Creek valley including the adjacent incised escarpment valley of a tributary located east of Fifteen Mile Creek. The Fifteen Mile Creek valley is one of 12 major incised valleys on the Niagara Peninsula, and it contains excellent representations of an incised valley slope, talus, as well as bottomland and escarpment cliff face communities. This section of the ANSI also contains Rockway Falls.

The **Niagara Escarpment Connector** is characterized by three kilometres of Niagara Escarpment rim, plain and talus communities on rock substrates and deeper soils. This section of the ANSI acts as a natural corridor between Fifteen Mile and Sixteen Mile Creek valleys.

The **Sixteen Mile Creek Escarpment Incised Valley** is characterized by escarpment plain, rim, slope and terrace communities. The complex of escarpment features found in this section of the ANSI extends north from the main escarpment and consists of broad terraces and talus slopes. This site is unique because few other areas on the Niagara Peninsula support such a high diversity of escarpment features such as extensive terraces, which are some of the largest on the peninsula. Like the Fifteen Mile Creek incised valley, the Sixteen Mile Creek valley is also one of 12 major incised valleys on the peninsula.

The **Sixteen Mile Creek Lake Plain Valley** system dissects the lake plain north of the escarpment. It is characterized by an extensive bottomland and valley slopes of a successional nature, which ranges from regenerating field to young forest. In addition, several more mature broadleaf stands are also found in this portion of the ANSI, particularly on the drier upper slopes.

Approximately 96 percent of the ANSI falls within the Niagara Escarpment Plan area. A small portion of the ANSI, where the Fifteen Mile Creek valley extends north of Regional Road 81, extends beyond the Plan area. However, this portion of the ANSI falls within the Provincial Greenbelt Plan area.

SIGNIFICANT FLORA

The flora of the Fifteen-Sixteen Mile Creek Valleys ANSI is representative of the deciduous forest region commonly referred to as the Carolinian life zone. The Carolinian life zone stretches across southwestern Ontario and extends south into the United States (Figure 10). Nearly one-third of Canada's

TABLE 1: NATURAL HERITAGE RESOURCES

NATURAL HERITAGE RESOURCE	CURRENT %	GUIDELINE (MINIMUM)
UPLAND FORESTS	17.5	30
WETLANDS	3	10
RIPARIAN HABITAT	31	75

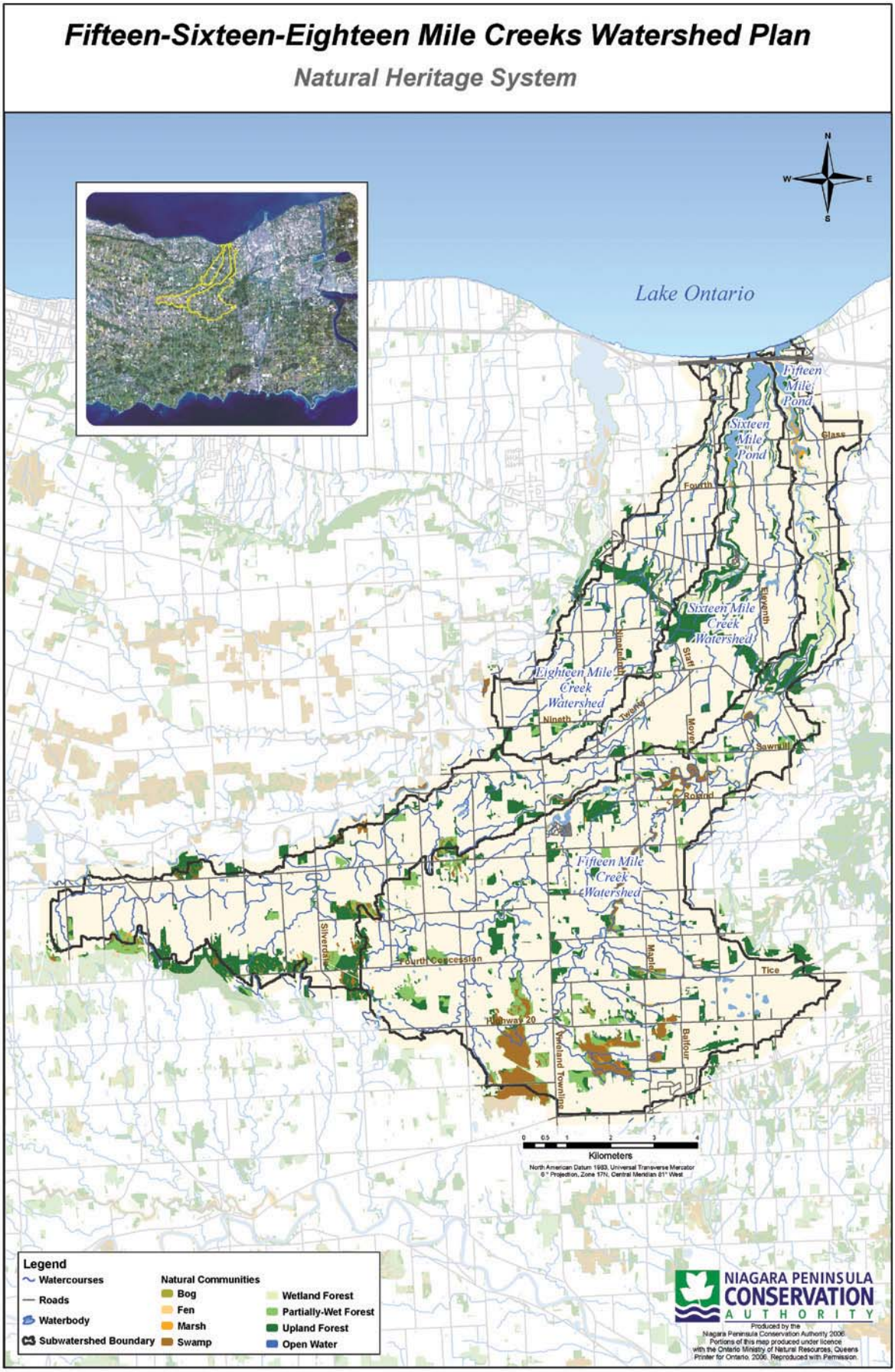


FIGURE 8: NATURAL HERITAGE AREAS

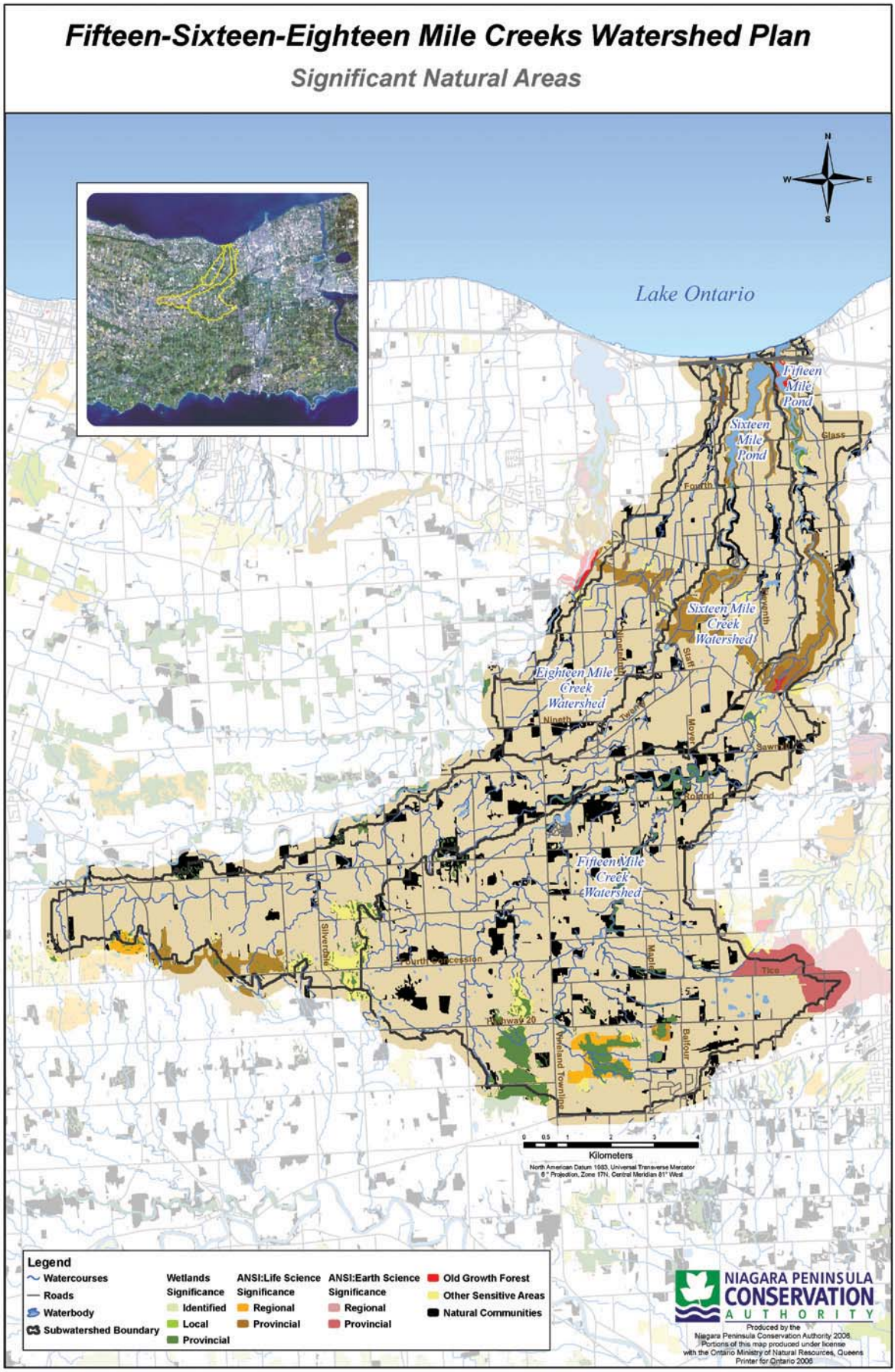


FIGURE 9: SIGNIFICANT NATURAL AREAS

NATIONALLY AND PROVINCIALLY RARE	REGIONALLY RARE
Small Beggarticks	Yellow Giant Hyssop
Pignut Hickory	Ebony Spleenwort
Wild Chestnut	Wild Yam
Tulip Tree	Hairy Wild-rye
Pin Oak	Muhly Grass
Provincially Rare	Virginia Creeper
Sedge (Carex artitecta)	Chinquapin Oak
Sedge (Carex hirsutella)	Water Pimpernel

TABLE 2: SIGNIFICANT FLORA

rare and endangered species are found in the Carolinian life zone (Johnson 2005). The ANSI supports 60 southern species, with most of these species entirely or largely confined to the Carolinian life zone. For example, typical Carolinian species include Sassafras, Wild Yam, Shagbark Hickory, Pignut Hickory, Wild Chestnut, Tulip Tree, Pin Oak, Black Oak, and Flowering Dogwood, which tend to occur on sites with warmer microclimates such as south and west facing slopes.

In 1992, a total of 482 species of vascular plants were reported in the Fifteen-Sixteen Mile Creek Valleys ANSI of which 360 species are native and 122 species are introduced. In addition, the ANSI supports rare and otherwise significant flora. Five species are considered nationally and provincially rare and 2 species are provincially rare. Another 8 species are considered rare in the Ministry of Natural Resources "old" Central Region (OMNR 1992) in this portion of the watershed. An additional 23 species are considered locally significant, which means there are 5 or less stations in Regional Niagara. All rare and significant species are reported in Table 2 (after Ontario Ministry of Natural Resources 1992).

The **Upper Rockway Escarpment** is an environmentally sensitive area that is part of the Fifteen and Sixteen Mile Creek Valleys ANSI. Located on the Niagara Escarpment, it provides a linkage to other escarpment sites. Numerous and diverse biological communities related to a series of geomorphological features and associated habitats, such as upland forest, successional margin and exposed bedrock scarp characterize the area. The Upper Rockway Escarpment site contains a waterfall measuring approximately 8 metres high. This 295 hectare site contains 24 different tree species. Some of the more notable species that make up this diverse area include Eastern Cottonwoods, Hemlock and White Pine. Other species include Black Walnut, Butternut, Juniper, Black Cherry, Pin Cherry, Yellow Birch, Black Ash, Red Ash, White Ash, Rock Elm, Sugar Maple and Red Oak.

Rockway Falls is also part of the Fifteen and Sixteen Mile Creek Valleys ANSI. This site contains one of the best terrace-valley complexes on the Niagara Peninsula. Measuring approximately 105 hectares, Rockway Falls is part of the continuous forested area of the Upper Rockway Escarpment Environmentally Sensitive Area. The valley is dominated by a Maple/Hickory association and a Maple/Beech association is common above. Other species found in this part of the ANSI include Butternut, Basswood, White Elm, Slippery Elm, White Oak, Red Oak, White Birch, Eastern Red Cedar, Pignut Hickory, Black Willow, Flowering Dogwood, Sugar Maple, Black Cherry and the rare Canada Plum.

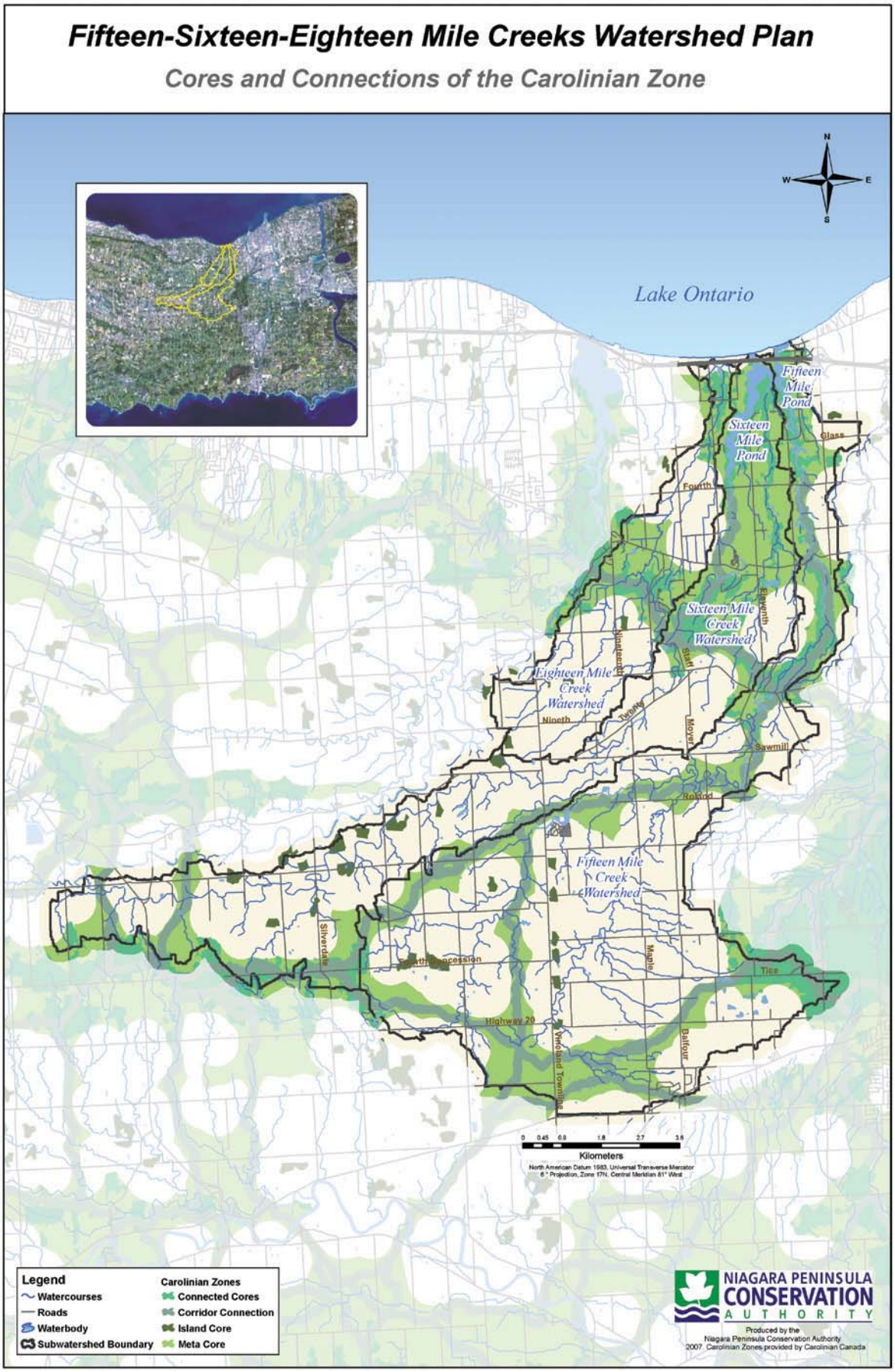


FIGURE 10: CORES AND CONNECTIONS OF CAROLINIAN CANADA

OTHER NATURAL HERITAGE RESOURCE SITES

Boye's Woodlot contains 2 woodlots; one large lot and a much smaller one. The larger woodlot is drained by a tributary of Fifteen Mile Creek, and the smaller lot acts as a catchment basin for the surrounding farmland. The total size of Boye's Woodlot is 81 hectares. The dominant vegetation throughout this site includes Eastern Hemlock, White Birch, Sugar Maple and American Beech. Other vegetation found in the woodlot are White Pine, White Oak, Swamp White Oak, Bur Oak, Yellow Birch, Red Maple, Rock Elm, Slippery Elm, Black Cherry, Choke Cherry, Red Ash, White Ash, Pignut Hickory, Bitternut Hickory, Sassafras and Basswood. The woodlot is significant because it serves as a recharge area for Fifteen Mile Creek (Brady 1980).

Frost Bush is a 70 hectare site containing a wetland that is drained by a tributary of Sixteen Mile Creek. The dominant vegetation association in Frost Bush are Sugar Maple, American Beech, and White Ash. Other species include Silver Maple, Red Maple, Shagbark Hickory, White Elm, Hop-hornbeam, Swamp White Oak and Black Oak. This area of the watershed is considered hydrologically important in the watershed because Frost Bush acts as a flow regulator for a tributary of Sixteen Mile Creek (Brady 1980).

Myer's Bush is a small bush (5 hectares) crossed by an intermittent stream draining north into Lake Ontario. The dominant species at this site include Red Ash, White Oak, and Shagbark Hickory. Less abundant canopy species found here are Bitternut Hickory, Butternut, Slippery Elm, Red Maple, Black Maple, Basswood, Red Oak, Swamp White Oak, Yellow Birch and Hop-hornbeam (Brady 1980).

WETLANDS

The Provincial Wetland Classification system designates wetlands as "provincially significant" or "other" (not provincially significant). The Ministry of Natural Resources mapped wetland areas in the Fifteen-Sixteen-Eighteen Mile Creek watershed as provincially significant and locally significant evaluated wetlands.

Approximately 524 hectares of the 11 731 hectares of land area in the Fifteen-Sixteen-Eighteen Mile Creek watershed is classed as wetlands. One of the provincially significant evaluated wetlands in the watershed is located below the Niagara Escarpment where the Fifteen and Sixteen Mile Creeks outlet to Lake Ontario. Two other wetlands are located above the Niagara Escarpment on Fifteen Mile Creek. One of these wetlands forms the headwaters of Fifteen Mile Creek. A description of each of these areas follows.

The **Fifteen Mile Creek Marshes** are a Life Science ANSI comprised of a series of drowned, steep-sided meander valleys on the Lake Ontario Plain. The total site including forested valley sides measures 1200 hectares, which also includes the wetland areas. The marshes are contained between Fifteen Mile Creek and Sixteen Mile Creek. At this location, Sixteen Mile Creek is almost completely occupied by an open, shallow pond. Fifteen Mile Creek has a small valley mouth pond, which transitions into alluvial plain marshes and scrubland features with a series of levees and moderately developed meander patterns. Vegetation patterns in the valleys include submergent and emergent aquatic meadows, marshes of *Typha/Calamagrostis/Polygonum/Salix/Cornus*, levee groves and thickets of Salix, as well as valley bottom seepage and swamp forests of *Ulmus/Frxinus/Salix*. The pond slope forests are generally dry mesic, sandy loam *Quercus/Acer/Pinus* complex with *Acer/Fraxinus/Fagus* patterns occurring on the narrower valleys (MNR no date).

Above the Escarpment the **Fifteen Mile Creek Wetland** measures approximately 53.5 hectares. This provincially significant wetland is comprised of 20 individual wetlands of 2 types: 62 percent swamp and 38 percent marsh. Kwicinski and Littleton (1989) have recorded an abundance of vegetation communities at this site including, for example, floating plants, submergent plants, deciduous trees, grasses, sedges, mixed herbs, as well as many others.

The **Fifteen Mile Creek Headwaters Wetland** is a provincially significant wetland complex, made up of 33 individual wetlands consisting of 94.2 percent swamp and 5.8 percent marsh. Numerous wetland plant communities have been identified at this 0.2 hectare site by Kwicinski and Thomas (1987). For example, emergents such as cattails and grasses; tall shrubs including meadowsweet, buttonbush, winterberry, and blueberry; ferns; free floating plants such duckweed; and deciduous trees including willow, white oak and red maple are found at this wetland complex.

AQUATIC HABITAT

FISH COMMUNITY STUDIES

Fifteen, Sixteen and Eighteen Mile Creeks have a diverse warm water fish community. Fish sampling studies conducted by various agencies reported 31 different species in the Fifteen-Sixteen-Eighteen Mile Creeks watershed above and below the Niagara Escarpment. Fish migration is likely from Lake Ontario to the Niagara Escarpment, and the embayments at Lake Ontario may be used for spawning by white sucker and lake chub (NWQPS 2003). However, the Niagara Escarpment acts as a natural barrier to fish movement in the watershed.

FIFTEEN MILE CREEK

The Department of Fisheries and Oceans (DFO) conducted a fish survey on Fifteen Mile Creek below the Niagara Escarpment in 2005. The sampling procedure for the 2005 study involved electrofishing for a total of 300 metres upstream of the Queen Elizabeth Way (QEW) along the west bank. A second site was also sampled using electrofishing technology for a total of 300 metres from the mouth of the creek at Charles Daley Park. A total of 19 species were recorded in the lower portion of the creek during this survey. In 2006, the NPCA sampled various locations above and below the Niagara Escarpment on Fifteen Mile Creek using a seine net. A total of 14 species were recorded above the escarpment and 10 were captured and identified below the escarpment. The species found during the 2005 and 2006 samples are recorded in Table 3.

SIXTEEN MILE CREEK

The Department of Fisheries and Oceans (DFO) also conducted a fish survey on Sixteen Mile Creek below the Niagara Escarpment at the Queen Elizabeth Way (QEW) in 2005. The sampling procedure for the 2005 study involved electrofishing. A total of 15 species were recorded in the lower portion of the creek during this survey. In 2006, the NPCA sampled various locations above and below the Niagara Escarpment on Sixteen Mile Creek using a seine net. A total of 12 species were recorded above the escarpment and 8 were captured and identified below the escarpment. The species found during the 2005 and 2006 samples are recorded in Table 3.

EIGHTEEN MILE CREEK

The Ministry of Natural Resources (MNR) conducted a fish survey on Eighteen Mile Creek below the Niagara Escarpment at the QEW in 1996. The sampling procedure for the 1996 study involved electrofishing, and 2 species were identified; white sucker and gizzard shad, both of which have also been recorded in Fifteen and Sixteen Mile Creeks. In 2006, the NPCA sampled various locations below the Niagara Escarpment on Eighteen Mile Creek using a seine net. Several attempts were made to carry out sampling above the escarpment. However, for the most part, the creek was dry and sampling was not feasible. A total of 10 species were captured and identified below the escarpment.

SIGNIFICANT FISH SPECIES

None of the fish species currently identified in the Fifteen-Sixteen-Eighteen Mile Creeks watershed are considered "at risk". This means that none of the species are at risk of extinction, extirpation or endangerment in Ontario (MNR No Date). However, fish habitat must still be maintained for the fish present in the system. Fish habitat is classified based on MNR (2000) protocol as identified below.

The fish species found in 1996, 2005 and 2006 are representative of an intermediately tolerant fish community.

FISH HABITAT

Fish habitat falls into 1 of 3 categories in Niagara: Type 1, Type 2 or Type 3 (MNR 2000). Habitat type is based on the sensitivity and significance of current or potential habitats in a water body. Type 1 habitat is the most sensitive habitat of the 3 types. As a result, it requires the highest level of protection. Examples of Type 1 habitat include critical spawning and rearing areas, migration routes, over-wintering areas, productive feeding areas and habitats occupied by sensitive species. Type 2 habitat is less sensitive and requires a moderate level of protection. These areas are considered "ideal for enhancement or restoration projects" and include feeding areas for adult fish and unspecialized spawning habitat. The third habitat type is considered marginal or highly degraded and does not contribute directly to fish productivity. Examples of Type 3 habitat include channelized streams and artificially created watercourses (MNR 2000).

Fish habitat type in the Fifteen-Sixteen-Eighteen Mile Creeks watershed has been delineated according to the Ministry of Natural Resources stream classification data. These areas are depicted on Figure 11 as critical habitat (Type 1), important habitat (Type 2) and marginal habitat (Type 3). As illustrated, Fifteen Mile Creek and Sixteen Mile Creek and many of their tributaries have been classed primarily as critical fish habitat, and Eighteen Mile Creek has been classed as important fish habitat.

MUNICIPAL DRAINS

Under the Ontario Drainage Act (R.S.O. 1990, Chapter D.17) drainage works "include a drain constructed by any means, including the improving of a natural watercourse, and includes works necessary to regulate the water table or water level within

or on any lands or to regulate the level of the waters of a drain, reservoir, lake or pond, and includes a dam, embankment, wall, protective works or any combination thereof."

Two drains exist in the Fifteen-Sixteen-Eighteen Mile Creeks watershed (Figure 12). Even though their purpose is to remove excess water from the land, municipal and agricultural drains do contain fish habitat. To better manage these drains, Fisheries and Oceans Canada has developed a classification system that identifies municipal drains as Types A through F using variables such as flow conditions, temperature, fish species present, and the length of time since the last clean out (Fisheries and Oceans Canada No Date). For example, a Class A drain has permanent flow with cold or cool water temperature

TABLE 3: FISH SPECIES IN THE FIFTEEN-SIXTEEN-EIGHTEEN MILE CREEKS WATERSHED

FISH SPECIES	FIFTEEN MILE CREEK	SIXTEEN MILE CREEK	EIGHTEEN MILE CREEK
White Sucker	✓	✓	✓
White Crappie	✓	✓	
Common Carp	✓	✓	
Pumpkin Seed	✓	✓	✓
Green Sunfish		✓	
Yellow Perch	✓	✓	
Brown Bullhead	✓	✓	
Freshwater Drum	✓	✓	
Gizzard Shad		✓	
White Perch	✓	✓	
Mirror Carp		✓	
Largemouth Bass	✓	✓	
Bluegill	✓	✓	✓
Emerald Shiner	✓	✓	
Channel Catfish		✓	
Golden Shiner	✓	✓	
Rainbow Smelt	✓		
Round Goby	✓		
Brassy Minnow			✓
Finescale Dace			✓
Bluntnose Minnow	✓		✓
Fathead Minnow	✓	✓	✓
Blacknose Dace	✓		✓
Longnose Dace	✓		
Creek Chub		✓	✓
Northern Hog Sucker			✓
Central Mudminnow	✓	✓	
Brook Stickleback		✓	
Rock Bass	✓		
Black Crappie	✓		
Johnny Darter	✓		
Number of Species	**22**	**20**	**10**

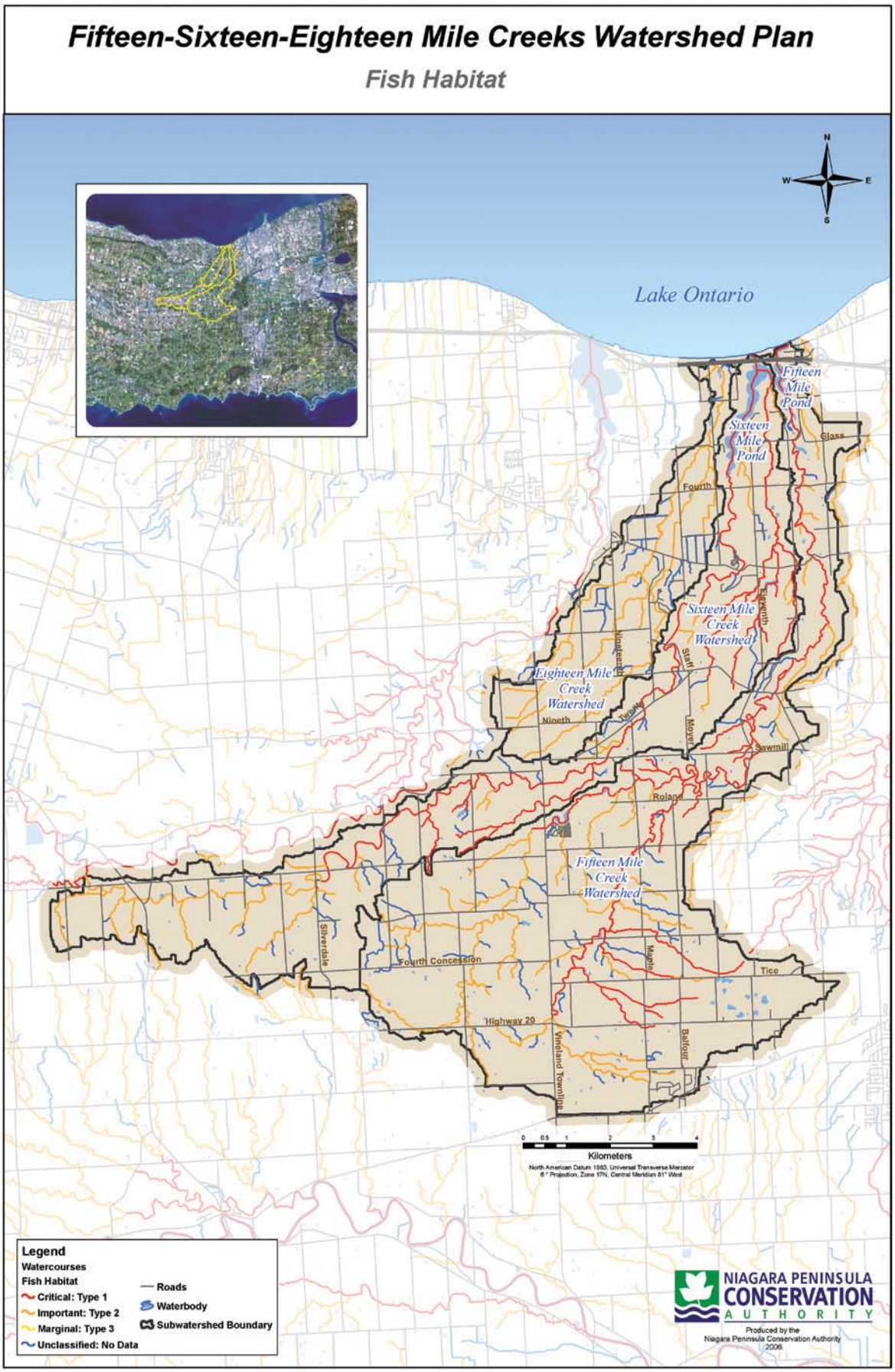


FIGURE 11: FISH HABITAT CLASSIFICATION

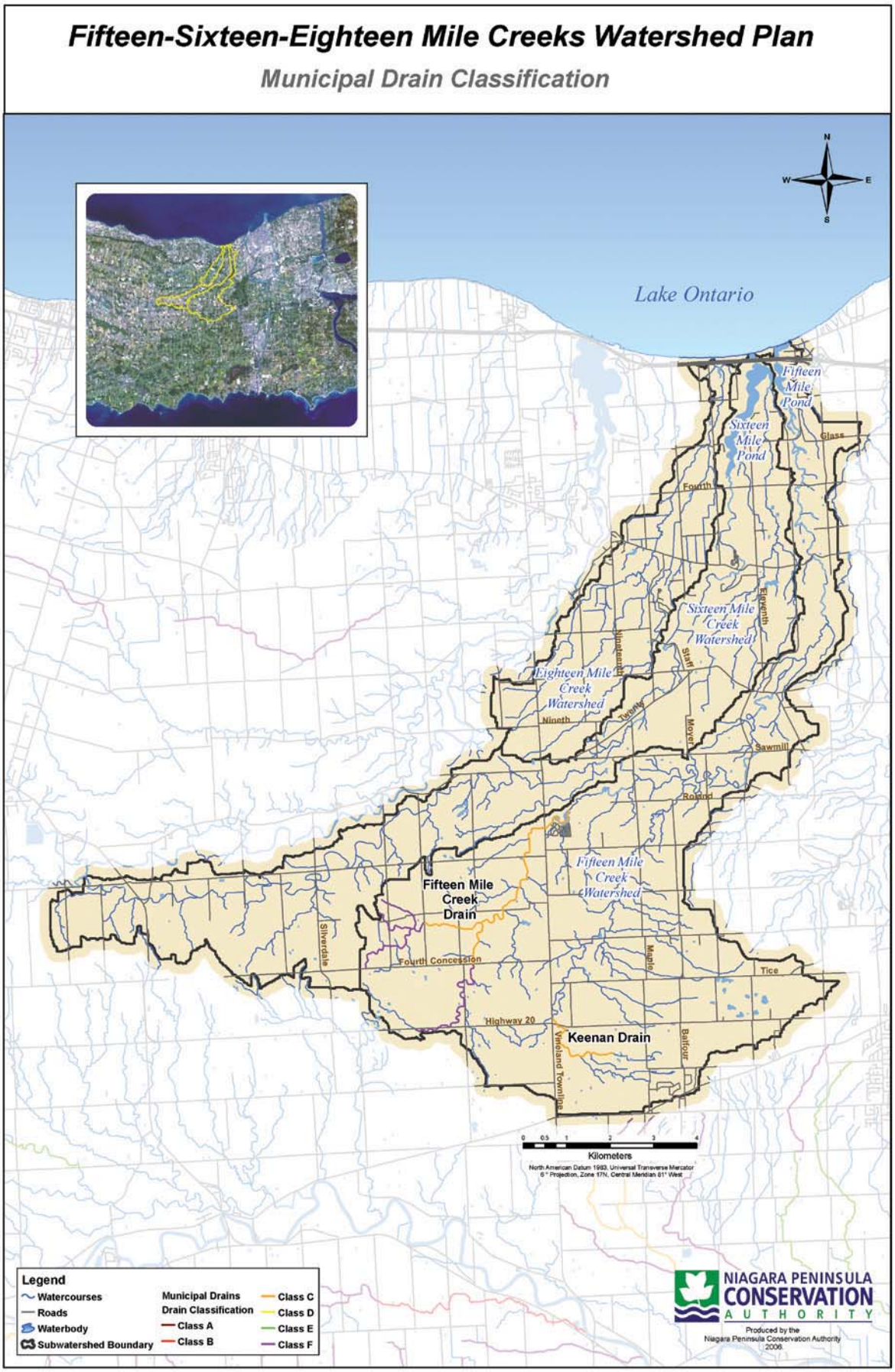


FIGURE 12: MUNICIPAL DRAINS

and no presence of trout or salmon present. A Type E drain also has a permanent flow with warm water temperatures and top predators (e.g., largemouth bass, northern pike, muskellunge and crappie) present in the drain. Type F drains are characterized by intermittent flow (Fisheries and Oceans Canada No Date). This classification system has been created for use by municipal drainage superintendents for the purpose of drain maintenance. Therefore, the classification assigned to a drain is subject to change frequently.

As illustrated on Figure 12 the drains in the Fifteen-Sixteen-Eighteen Mile Creeks watershed include Keenan Drain, which has been classed as a Type C drain and the Fifteen Mile Creek Drain system is currently classed as both Type C and F.

WATER QUALITY

Surface water quality is monitored by the NPCA in the Fifteen-Sixteen-Eighteen Mile Creeks watershed through the collection of grab samples on a monthly basis during the ice-free season and analyzed for several parameters including nutrients, metals, bacteria, suspended solids, and general chemistry. The indicator parameters summarized in Table 4 are the most useful in assessing relative stream quality. They include: total phosphorus, nitrate, copper, lead, zinc, *Escherichia coli*, chloride, suspended solids and benthic invertebrates (NPCA 2006).

Monthly grab samples are collected at 3 monitoring stations located at the outlet of each watershed to capture cumulative water quality impacts. These stations are Fifteen Mile Creek station FF001, Sixteen Mile Creek station SX001, and Eighteen Mile Creek station ET001 (Table 5). Monthly grab sampling at station FF001 was initiated in 2003, and monthly grab samples at stations SX001 and ET001 was initiated in 2006. The locations of the water quality monitoring stations are illustrated on Figure 13.

TABLE 4: WATER QUALITY PARAMETERS (AS MODIFIED FROM NPCA 2006)

CATEGORY	INDICATOR PARAMETER	OBJECTIVE	REFERENCE
Nutrients	Total Phosphorus	0.03 mg/L	PWQO (MOE 1994)
Nutrients	Nitrate	13 mg/L	CWQG (CCME 2003)
Metals	Copper	0.005 mg/L	PWQO (MOE 1994)
Metals	Lead	0.005 mg/L	PWQO (MOE 1994)
Metals	Zinc	0.02 mg/L	PWQO (MOE 1994)
Microbiological	*Escherichia coli*	100 counts/100mL	PWQO (MOE 1994)
Other	Chloride	100 mg/L	CWQG (CCME 1995)
Other	Suspended Solids	25 mg/L	BC MOE (2001)
Biological	Benthic Invertebrates	Unimpaired	BioMAP (Griffiths 1999)

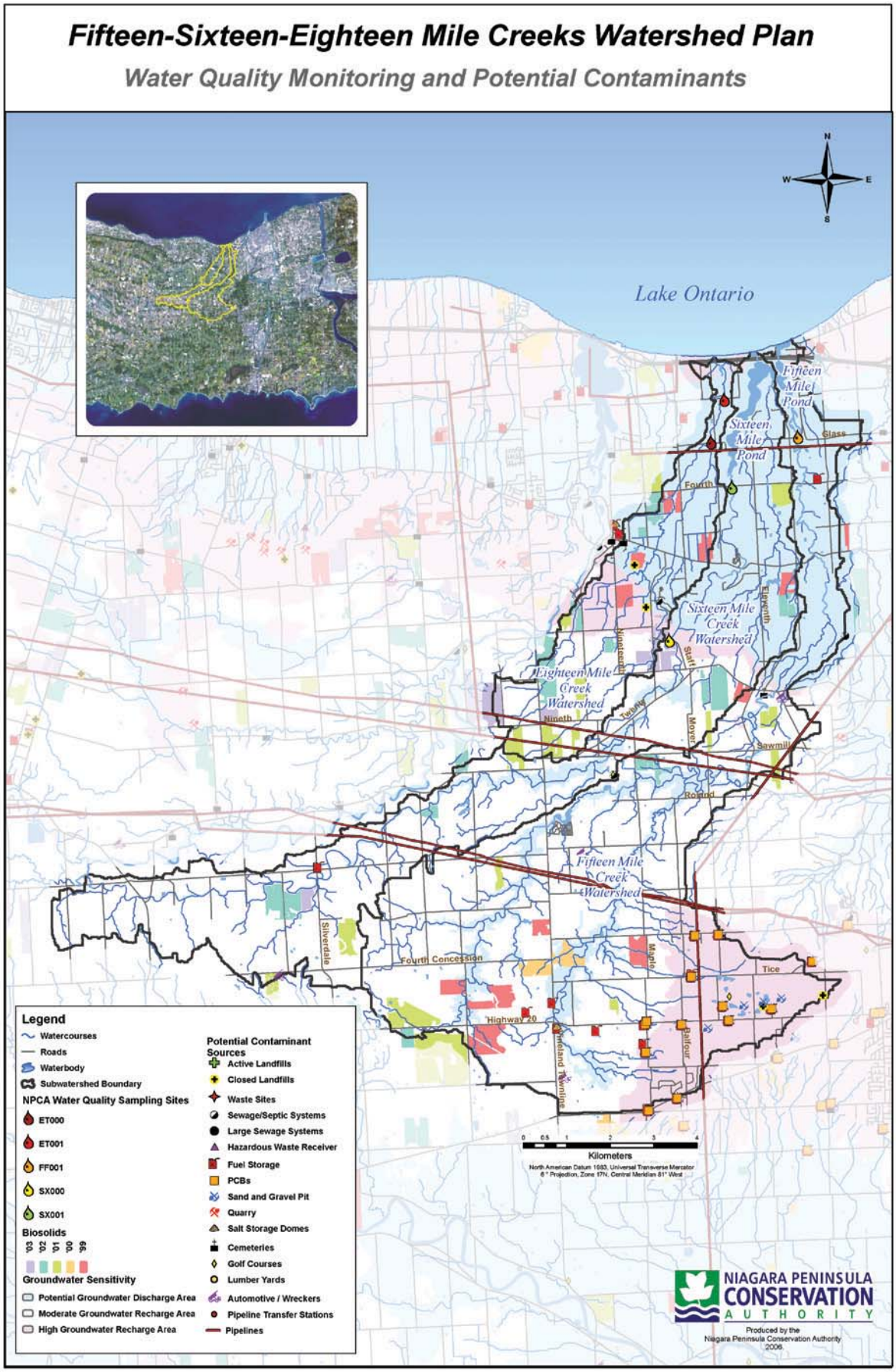


FIGURE 13: WATER QUALITY SAMPLING AND POTENTIAL CONTAMINANTS

TABLE 5: WATER QUALITY DATA MONITORED BY THE NPCA (2006)

STATION	WATER QUALITY RATING	BIOMAP RATING	FACTORS AFFECTING WATER QUALITY
Fifteen Mile Creek	Poor	Impaired	• Exceedances of total phosphorus and suspended solids • Algae observed during summer months
Sixteen Mile Creek	Poor	Impaired	• Exceedances of total phosphorus, nitrate, suspended solids and *E. coli*
Eighteen Mile Creek	Poor	Impaired	• Exceedances of total phosphorus and *E. coli* • Low density of invertebrates despite a relative abundance of habitat

Based on the data collected between 2003 and 2006 at station FF001, water quality in Fifteen Mile Creek is poor primarily due to high nutrient concentrations. For example, concentrations of total phosphorus obtained from station FF001 routinely exceed the Provincial Water Quality Objective of 0.03 mg/L (MOE 1994). Sources of nutrient enrichment include rural and agricultural runoff, and faulty septic systems. Erosion and sediment loading also result in elevated concentrations of suspended solids in Fifteen Mile Creek. Water quality results also indicate poor overall water quality in Sixteen Mile Creek. For example, exceedances of phosphorus, nitrate, suspended solids and *E. coli* were observed. Water quality sampling in Eighteen Mile Creek revealed similar results with an overall poor rating and reports of total phosphorus and *E. coli* exceeding Provincial Water Quality Objectives.

BIOLOGICAL MONITORING AND ASSESSMENT PROGRAM

Benthic macroinvertebrate sampling has been completed at surface water quality monitoring stations using the BioMAP (Biological Monitoring and Assessment Program) protocol. Benthic macroinvertebrates are defined as the larger organisms inhabiting the substrate of waterways for at least part of their life cycle. Benthic macroinvertebrate species that are commonly found in the Niagara Peninsula include clams, snails, leeches, worms, and the larval stages of dragonflies, stoneflies, caddisflies, mayflies and beetles. At sites where water quality is impaired, the organisms found are less sensitive and therefore more tolerant to environmental stresses than organisms that would have historically occurred. The benthic population at an impaired site would typically be dominated by these more tolerant species, and as a result, biodiversity at the site would be quite low.

BioMAP assessments were completed in 2006 in Fifteen, Sixteen and Eighteen Mile Creeks at stations FF001, SX001 and ET001, respectively (Figure 14). Results from all three stations indicate that water quality is impaired due to nutrient enrichment. In the Eighteen Mile Creek watershed benthic invertebrate sampling was deemed impaired due to a low density of invertebrates despite a relative abundance of habitat, thereby indicating poor water quality as the contributing factor (Table 5).

HISTORICAL WATER QUALITY DATA

The NPCA in conjunction with the Welland District Office of the Ministry of Environment and Energy (MOEE) conducted an environmental assessment of water quality conditions for several Lake Ontario tributaries. Water quality in the study area was evaluated using selected chemical, physical, and microbiological parameters as well as rainfall distribution data. Water samples were collected bi-weekly at 17 stations located throughout the study area from March 1995 to November 1995. Results confirmed that water quality impairment is a concern throughout the study area, with elevated levels of total phosphorus, turbidity, suspended solids, total Kjeldahl nitrogen, nitrite, and *E. coli* at all stations sampled. Results also confirmed a correlation between peak concentrations and rainfall events.

The 1996 monitoring program had 3 stations on Fifteen Mile Creek, 4 stations on Sixteen Mile Creek, and 2 stations on Eighteen Mile Creek. Total phosphorus concentrations at all stations exceeded the Provincial Water Quality Objective in almost all samples collected (Forsey 1996).

GROUNDWATER RESOURCES

A *Groundwater Study* (Waterloo Hydrogeologic Inc. 2005) has been completed for the land area within the jurisdiction of the NPCA. The study includes a series of maps illustrating recharge/discharge areas, well locations, overburden thickness, bedrock

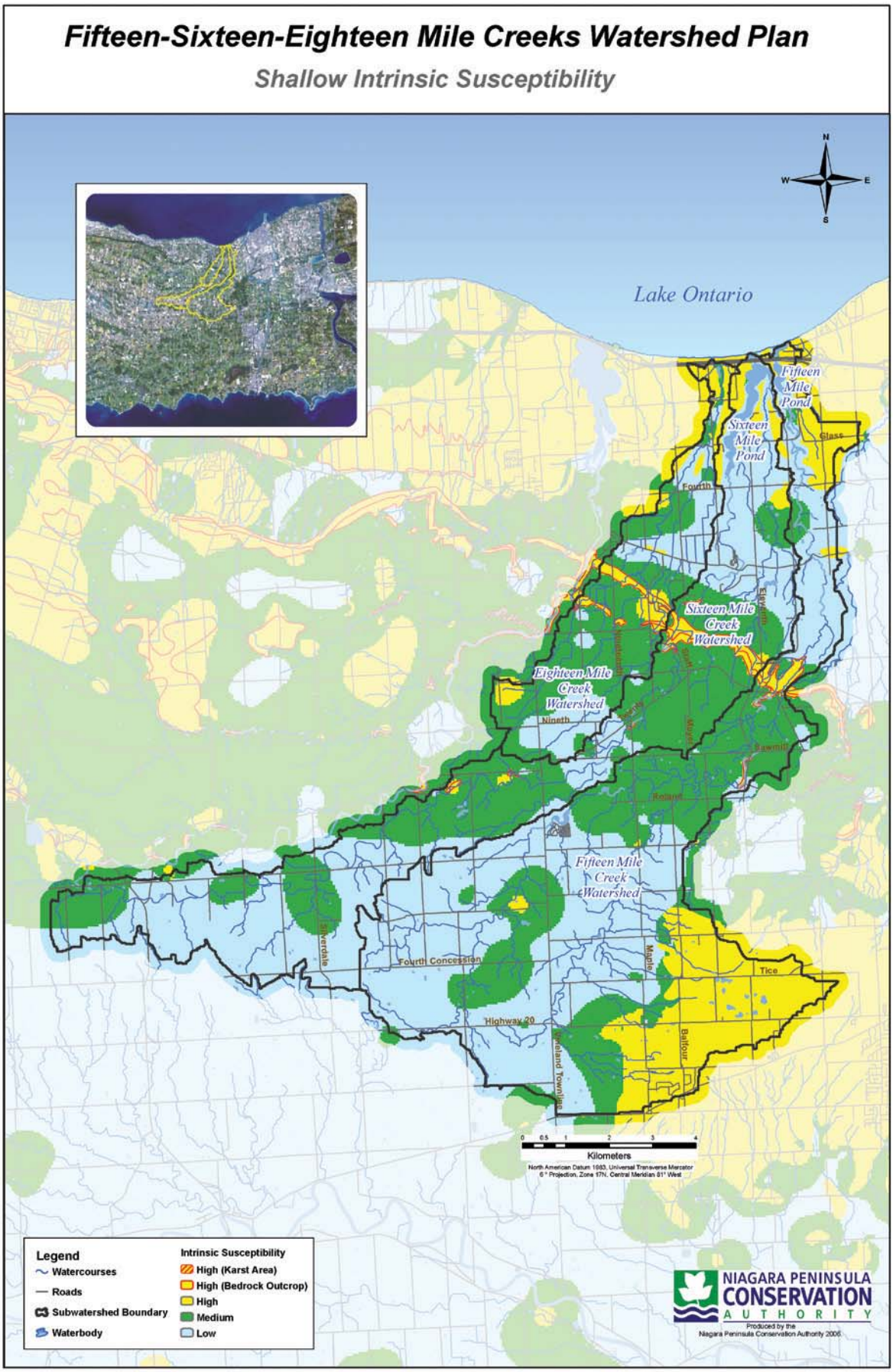


FIGURE 14: SHALLOW INTRINSIC SUSCEPTIBILITY

types, groundwater use, contaminant sources, and groundwater susceptibility to contamination.

Potential groundwater recharge and discharge areas are identified on Figure 13. Discharge areas are locations where groundwater leaves the aquifer and flows to the surface. Groundwater discharge occurs where the water table (or potentiometric surface) intersects the land surface. Potential discharge areas have been identified on and below the Niagara Escarpment in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Additional potential groundwater discharge areas have been identified above the escarpment along Fifteen and Sixteen Mile Creeks. The potential height of the water table ranges between 0 and 50 metres below the ground surface at these sites.

Groundwater recharge areas are locations where water is transmitted downward to an aquifer. The amount of water that infiltrates to the water table depends on, for example, vegetation cover, slope, soil composition, surficial geology, and depth to the water table. In the Fifteen-Sixteen-Eighteen Mile Creeks watershed potential recharge areas are located along the Niagara Escarpment and in the small portion of the Fonthill Kame Delta Complex that is located in the south eastern portion of the watershed. Water that infiltrates to the water table may carry contaminants with it. Therefore, these areas are considered groundwater sensitive.

Figure 14 illustrates areas with high, medium and low shallow intrinsic susceptibility. Areas along the Niagara Escarpment where there are bedrock outcrops and karst features have been delineated as having a high shallow intrinsic susceptibility because the exposed bedrock at ground surface can allow for the direct passage of surface water and contaminants to deeper aquifers. Below the escarpment shallow intrinsic susceptibility is primarily high or low with some small areas of medium susceptibility. Above the escarpment, shallow intrinsic susceptibility rated as medium with areas of low susceptibility. The yellow and green areas illustrated on Figure 14 are considered vulnerable to groundwater contamination due to the presence of permeable soils and/or the shallow depth of the groundwater table.

CHALLENGES AND OPPORTUNITIES IN THE FIFTEEN-SIXTEEN-EIGHTEEN MILE CREEKS WATERSHED

The *NWQPS* (Regional Municipality of Niagara 2003) summarized a list of key water protection issues in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Additional issues have been identified by residents living in the watershed via public open houses and workshops during the Fall of 2006 and early in 2007. A *Land Management and Agricultural Best Management Practice* survey (Appendix A) helped to identify land and water management issues in rural areas of the watershed. A description of the challenges facing the Fifteen-Sixteen-Eighteen Mile Creeks watershed are reported here.

EROSION AND SEDIMENTATION

Above the Niagara Escarpment sediment accumulation (aggradation) along the streambed and a lack of a sufficient riparian buffer are a dominant concern for the Fifteen-Sixteen-

Eighteen Mile Creeks watershed. Possible causes and sources of aggradation in the Fifteen-Sixteen-Eighteen Mile Creeks watershed include:

- runoff from agricultural fields,
- lack of vegetated buffer adjacent to the stream (farms with livestock, cropland, and residential properties are often without adequate buffers),
- allowing livestock to access the stream,
- farm crossings that run through the creek channel,
- roadside ditches connecting to the creek channel, and
- low creek channel slope common throughout the watershed limits sediment transport capacity (NPCA 2006b).

Below the Niagara Escarpment erosion is the main concern for the Fifteen-Sixteen-Eighteen Mile Creeks watershed. The channel slope is high as it flows down the escarpment, which contributes to higher shear stresses thereby increasing the potential for erosion depending on the composition of the bed and banks. For example, according to the *MTO Drainage Management Manual* (Ministry of Transportation, 1995) silt loam and silty clay loam have a high susceptibility to erosion and silty clay has a medium susceptibility to erosion. These soil types can be found throughout the Fifteen-Sixteen-Eighteen Mile Creeks watershed. In addition, some areas below the escarpment lack adequate buffers. A summary of the stream reaches assessed in the Fifteen-Sixteen- Eighteen Mile Creeks watershed are presented in the individual restoration strategies included in this Watershed Plan and in Appendix B.

SEPTIC SYSTEMS

A well designed septic system can function properly for years. The basic design of a septic system includes a septic tank and a drainage field. Wastewater from toilets, bathtubs, sinks and other drains flows into the tank where bacteria that is naturally found in the wastewater breaks down any solid material. The liquid effluent travels through the perforated distribution pipes to the leaching bed. The water is then absorbed and filtered by the ground in the drainage field. Problems with septic tanks often stem from improper use and maintenance. Faulty septic

systems can create serious local contamination problems with the potential to contaminate groundwater wells (Pollution Probe 2004).

Faulty or improperly maintained septic systems have been reported as a moderate concern in the *Land Management Issues and Agricultural Best Management Practices* survey. A septic system maintenance and education program could improve local septic system operation and well water quality for groundwater users in the watershed. The watershed strategy will put forth a set of recommendations for this type of watershed initiative.

LANDFILL SITES

Four known closed dump/fill sites in the Fifteen-Sixteen-Eighteen Mile Creeks watershed were identified in the *Groundwater Study* (Waterloo Hydrogeologic Inc. 2005). Landfill sites labelled as "old dump/fill sites" are areas that were once used as a dump or landfill. The locations of the dump/fill sites are as follows; below the Niagara Escarpment south of King Street and between Nineteenth and Seventeenth Streets; above the escarpment on Seventeenth Street adjacent to Louth Conservation Area; the third and fourth sites are both on Highway 20 between Centre Street and Lookout Street (Figure13). No other known dump/fill sites are located in the watershed.

ROAD SALT

Originating from salt storage and snow disposal sites as well as from runoff, road salts are an environmental concern because they are known to have an adverse effect on freshwater ecosystems, soil, vegetation and wildlife (Environment Canada 2004a). In April 2004, Environment Canada produced a *Code of Practice for the Environmental Management of Road Salts*. The *Code of Practice* recommends that all road authorities prepare and implement salt management plans that incorporate the implementation of best management practices (BMP) for salt application, salt storage and handling, and snow disposal. The benefits of improved salt management include:

- a reduction in corrosive damage to salt application equipment, vehicles, and infrastructure such as concrete sidewalks and steps;
- a reduction in salt damage to vegetation and surrounding roads and walkways;
- reduced salt releases to surrounding waterways; and
- an overall, more efficient and effective service resulting in safer roads and sidewalks for users (Environment Canada 2004b).

The Regional Municipality of Niagara undertook a *Salt Vulnerability Study*, which was completed by Ecoplans Ltd (2005). The study identified vulnerable areas for land use, groundwater, surface water, and natural areas. In the Fifteen-Sixteen-Eighteen Mile Creeks watershed, the roads between Lake Ontario and the Niagara Escarpment are within the climate zone that supports the growth of tender fruit. Regional roads in this portion of the watershed are classed as having a moderately high ranking for land use based primarily on agricultural land uses. In terms of salt vulnerability and groundwater resources in the Fifteen-Sixteen-Eighteen Mile Creeks watershed, Regional roads above and below the escarpment are ranked as having a high vulnerability to groundwater contamination due to the location of groundwater discharge areas resulting from the sandy soils found here, and the proximity to bedrock outcrop and/or karst areas. Surface water risk from salt along Regional roads above and below the escarpment is considered moderate to moderately low in the Fifteen-Sixteen-Eighteen Mile Creeks watershed (Ecoplans Ltd. 2005).

It is important to note that the Regional Niagara salt vulnerability study only assessed risk for Regional roads. Municipal roads should also be assessed to better identify salt vulnerable areas in the watershed.

KARST ENVIRONMENTS

The *NWQPS* (Regional Municipality of Niagara 2003) identified the potential threat to water quality due to karst environments found within the Fifteen-Sixteen-Eighteen Mile Creeks watershed. A karst environment is defined as a terrain typically underlain by limestone or dolomite whereby the topography is primarily formed by the dissolving of rock which may be characterized by sinkholes, sinking streams, closed depressions, subterranean drainage and caves (Monroe 1970). Conservation Authorities are in the process of identifying karst environments as hazard lands which the Provincial Policy Statement (Ontario Ministry of Municipal Affairs and Housing 2005a) requires municipalities to protect due to the potential problems related to flooding, surface collapse, and water quality. For example, karst areas are susceptible to contamination from surface sources due to the fractured nature of the overburden and high susceptibility in areas where bedrock outcrops at the surface.

The *Niagara Escarpment Planning and Development Act* (Ontario Ministry of Natural Resources, R.S.O. 1990, Chapter N.2) has eliminated the potential for serious problems to occur within the area designated as the "Plan Area" along the Niagara Escarpment including the portion that falls within the Fifteen-Sixteen-Eighteen Mile Creeks watershed. An area of karst has been identified in the watershed within the Niagara Escarpment Plan Area (Terra-Dynamics Consulting Ltd. 2005). As reported in Terra-Dynamics Consulting Ltd. (2005), Tinkler (1994) has identified a good example of rock collapse, sinkpoints and a cave located approximately 30 metres east of Sixteen Mile Creek at the brow of the Niagara Escarpment along Staff Avenue in Jordan. Terra-Dynamics Consulting Ltd. (2005) confirmed the large rock collapse features at this site to measure approximately 100 metres by 10 metres located within 30 metres south of Staff Avenue. In addition, this site includes a cave at the discharge point just below the brow of the escarpment. Terra-Dynamics Consulting Ltd. (2005) has also noted a good example of karst pavement located northeast of the collapse and cave features within Louth Conservation Area. This feature is described as "a large section of bare rock (clints) and solutionally-enlarged joints (grikes) with the prominent joint or fracture trending southwest to northeast with a secondary perpendicular trend".

NUTRIENT MANAGEMENT

Ensuring proper nutrient management in the Fifteen-Sixteen-Eighteen Mile Creeks watershed was addressed in the NWQPS (Regional Municipality of Niagara 2003) and in the *Land Management and Agricultural Best Management Practices* survey distributed to agricultural land owners. Nutrients derived from manure and chemical fertilizers are necessary for farm production. However, the improper use of nutrients can result in soil-nutrient imbalances and it can impair water quality locally and downstream of a farm. In order to maintain soil and water quality, the Ontario government introduced the *Nutrient Management Act* in 2002. Under this Act, farms must develop and implement a nutrient management strategy or a nutrient management plan. A nutrient management strategy is completed by non-agricultural and manure generators to manage the production, storage and use of manure and other nutrients produced and used on a farm. Nutrient management plans are completed for agricultural operations that apply nutrients to the land (OMAFRA and OMOE 2003). The purpose of proper nutrient management is to protect surface and ground water from contamination.

IRRIGATION WATER

Irrigation water shortages have been reported through the *Land Management and Agricultural Best Management Practices Survey* that was distributed to Ontario Federation of Agriculture members as well as through the NWQPS (Regional Municipality of Niagara 2003) and the Feasibility Study – Raw Water for Agricultural Irrigation Purposes (Stantec 2005). The Regional feasibility study pertaining to taking raw water supplies for irrigation investigated 4 districts in Regional Niagara requiring additional irrigation water. Two of these sites are located in the Fifteen-Sixteen-Eighteen Mile Creeks watershed (Figure 15).

The West District is comprised of lands below the Niagara Escarpment (Site A) and above the Niagara Escarpment (Site B). Several options for this district have been presented based on cost. The most costly alternative for the Fifteen-Sixteen-Eighteen Mile Creeks watershed recommends taking water from Lake Ontario and/or Jordan Harbour. A pipeline distribution system with an intake from Lake Ontario has also been presented as an option. A third and least costly alternative is to create off stream reservoirs close to major water sources (Lake Ontario). For the lands above the Niagara Escarpment, groundwater wells are not a suitable option. Because groundwater sources are limited, off-stream reservoirs are recommended.

The recommendations presented in the feasibility study will impact surface and ground water resources and ecological systems in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Therefore, additional studies in Phase 2 of the Irrigation Study will have to be conducted prior to the implementation of any alternative to ensure a sustainable supply of water for human and ecological use in the watershed.

URBAN DEVELOPMENT, PROVINCIAL GREENBELT AND THE PROTECTED COUNTRYSIDE

Urban encroachment has been identified as an issue in this watershed in the NWQPS (Regional Municipality of Niagara 2003). This issue was identified as a serious concern by the members of the agricultural community that participated in the *Land Management and Agricultural Best Management Practices* survey. Survey participants were very concerned about the loss of agricultural land and the loss of natural areas to urban development.

The Provincial Greenbelt Plan (Ontario Ministry of Municipal Affairs and Housing 2005b) has been created to provide permanent protection to the agricultural land base and the ecological features and functions by designating areas where urbanization should be limited. In the Fifteen-Sixteen-Eighteen Mile Creeks watershed, Provincial Greenbelt areas include lands within the Niagara Escarpment Plan area as well as "Protected Countryside" lands. Lands within the Niagara Escarpment Plan are managed under the Niagara Escarpment Planning and Development Act (1990). The Protected Countryside lands are intended to enhance the spatial extent of agriculturally and environmentally protected lands within the Niagara Escarpment Plan area as well as enhance linkages with surrounding major lake systems and watersheds. The Niagara Escarpment Plan area and Provincial Greenbelt lands including the

Protected Countryside are depicted on Figure 16 for the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Approximately 65 percent of the watershed falls within the Provincial Greenbelt and of this roughly 15 percent falls within the Niagara Escarpment Plan Area. As a result, development in this watershed is limited and does not warrant great concern.

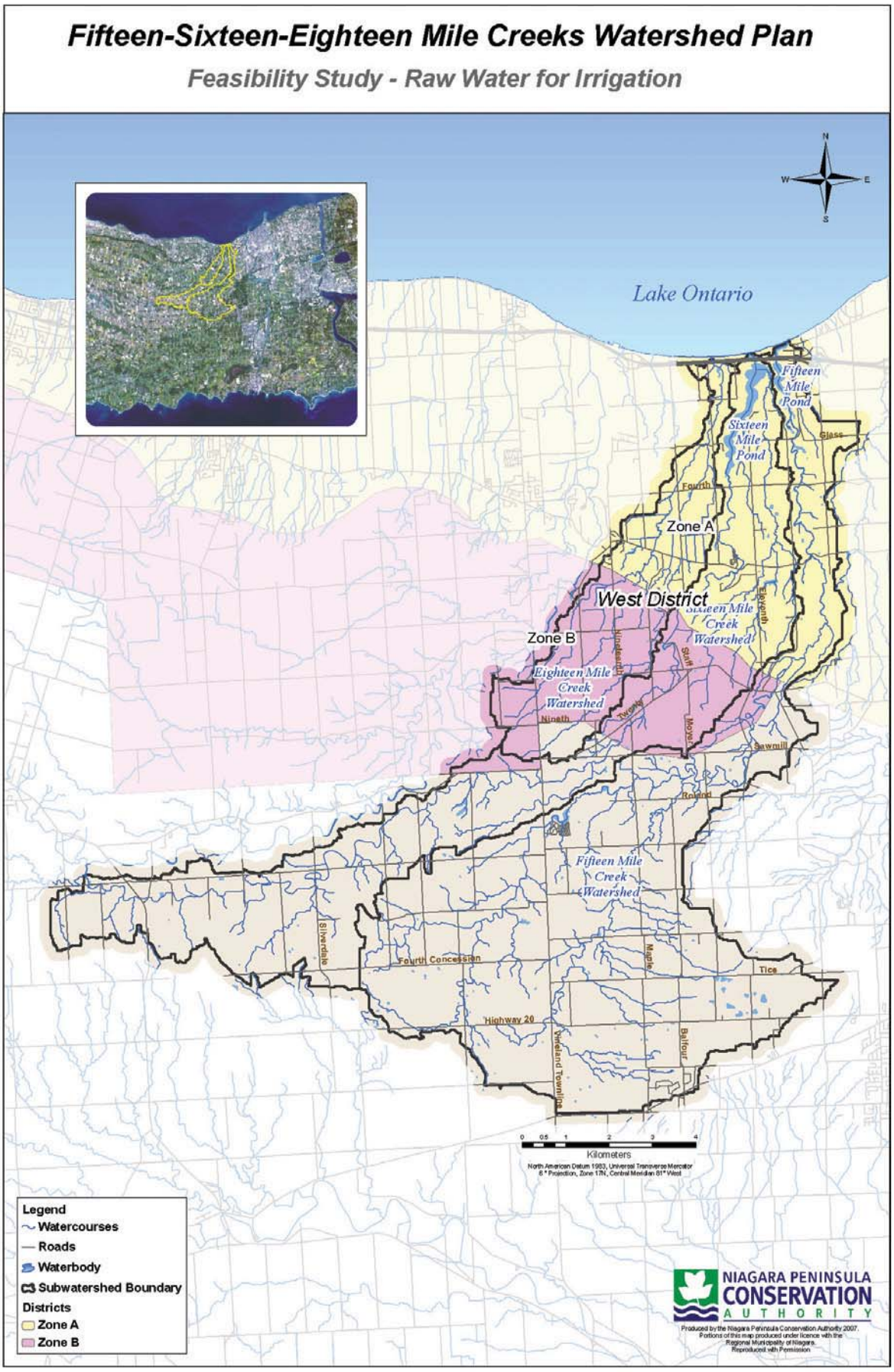


FIGURE 15: RAW WATER FOR IRRIGATION STUDY AREA

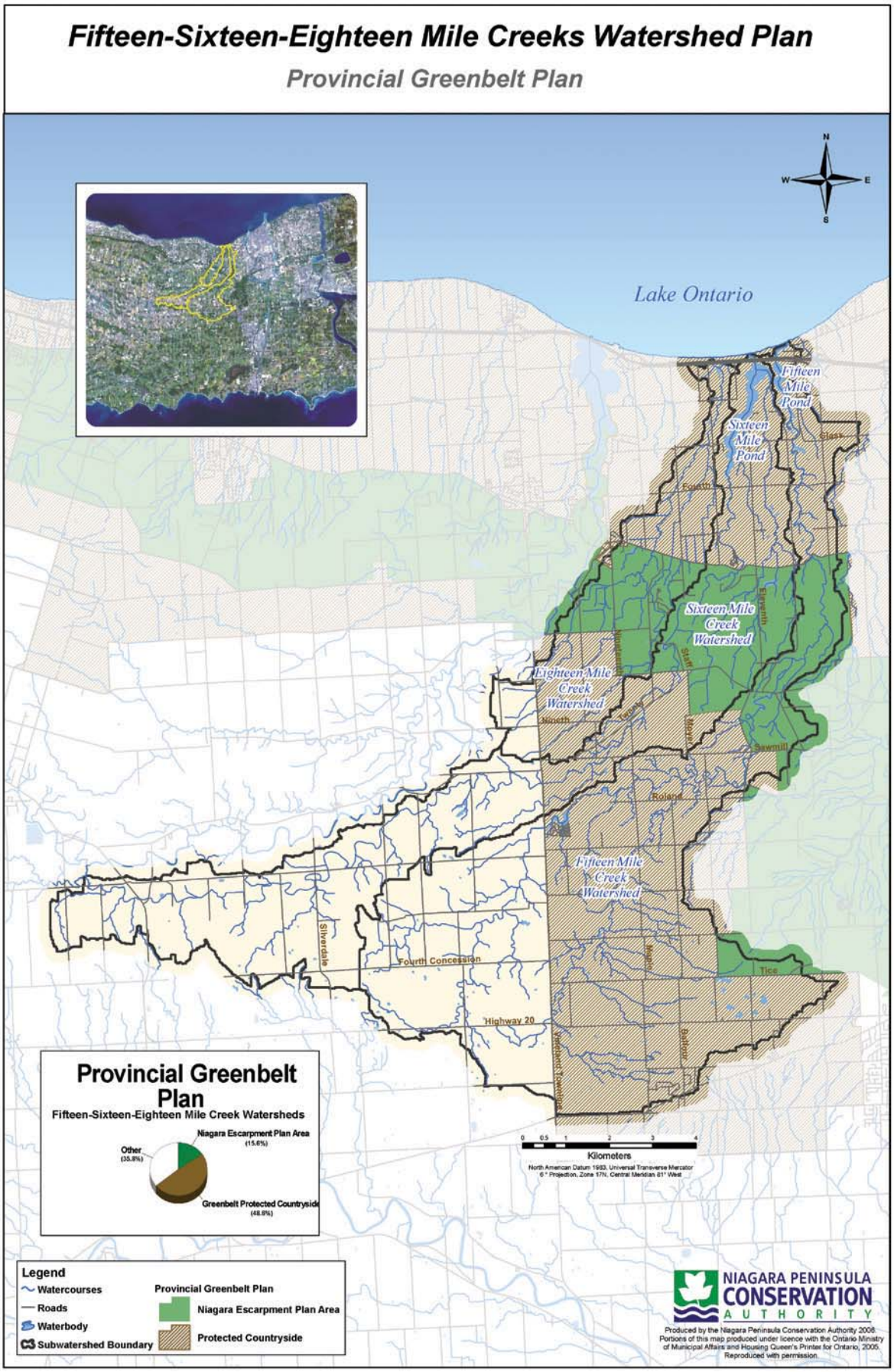


FIGURE 16: PROVINCIAL GREENBELT PLAN AND NIAGARA ESCARPMENT PLAN AREA

NIAGARA TO GTA CORRIDOR STUDY AREA (www.niagara-gta.com)

URBAN STORM WATER MANAGEMENT

Only a very small portion of the watershed is urban along the Lake Ontario waterfront in the subwatershed referred to as Lake Ontario-27, which does contain one known storm sewer outfall to Lake Ontario (Regional Municipality of Niagara 2003).

During a rain event, stormwater remains on the surface collecting contaminants instead of seeping into the ground as it would in a natural system. As a result, stormwater accumulates and runs off in great amounts, creating the potential for flooding and erosion (Pollution Probe 2004).

Several strategies can be implemented to achieve stormwater management that aims to reduce stormwater runoff. One method involves storing excess water on or near the site, and releasing it slowly over a long period of time. Detention basins are used to slow the rate of delivery of stormwater by discharging the captured water at a specified rate to receiving water bodies. Another method involves returning the excess water to the ground where it would have gone prior to development. Additional stormwater management methods will be identified as part of the watershed strategy.

MUNICIPAL DRAIN MAINTENANCE

Two municipal drains are located in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Drain maintenance has been raised as an issue by residents in the watershed. The Fifteen Mile Creek drain was cleaned out in the spring 2007 and Keenan Drain is not scheduled to be cleaned out in the near future.

NIAGARA TO GTA CORRIDOR

The Ontario Ministry of Transportation (MTO) has initiated Phase I of the Niagara to Greater Toronto Areas (GTA) Corridor Planning and Environmental Assessment Study. The need for the Niagara to GTA Corridor was identified in the Growth Plan for the Greater Golden Horseshoe (Ministry of Public Infrastructure and Renewal 2006). The purpose of the Phase I study is to address existing and future anticipated transportation capacity deficiencies, for instance problems and opportunities, within the Niagara to GTA corridor by providing additional capacity for a 30 year planning horizon and beyond. Although the Niagara to GTA Corridor assessment is still in its infancy, the proposed study area does extend into the Fifteen-Sixteen-Eighteen Mile Creeks watershed.

NATURAL HERITAGE AND RESOURCES

Although municipal official plans include the protection of environmentally significant areas, the loss of natural features still occurs with development. Natural features include, for example, wetlands, forests, and riparian stream cover, and they provide many ecological functions in the Fifteen-Sixteen-Eighteen Mile Creeks watershed in terms of protecting water quality, moderating water quantity and providing habitat. In natural areas, stormwater is more or less infiltrated where it falls, allowing most of the pollutants to be filtered through soils. When these areas are lost, and their functions not replaced with infiltration, detention or restoration measures, receiving watercourses are negatively affected with increased flows and pollutant loads. Low wetland extent and a lack of tributary buffers have been identified as issues in the watershed (Regional Municipality of Niagara 2003).

WETLAND HABITAT

Wetlands provide very important water quality and ecological functions in a watershed. Currently, the percent of wetland cover in the Fifteen-Sixteen-Eighteen Mile Creeks watershed is low (Regional Municipality of Niagara 2003). Means to increase the numbers and/or size of wetlands in the watershed as well as wetland preservation are included in the watershed strategy because wetlands:

- naturally filter water resources thereby improving water quality,
- act like sponges, slowing the flow of water which reduces the impact of flooding and allows for groundwater recharge,
- help to prevent soil erosion, and
- augments low-flow by raising local water tables, which helps to maintain base flows.

RIPARIAN COVER

Riparian cover in the watershed is very low, especially above the Niagara Escarpment. Like wetlands, riparian buffers also improve water quality. For example, riparian buffers:

- remove sediment and pollution such as chemicals, fertilizers, pesticides, bacteria and road salt before they reach surface water,

- reduce the impacts of flooding,
- prevent erosion,
- improve water clarity, and
- provide shade and cooler water temperatures for fish and other aquatic organisms (NPCA 2003).

FOREST HABITAT AND MEADOWS

The amount of forest cover in a watershed determines its ability to support species diversity. Although the Niagara Escarpment portion of the Fifteen-Sixteen-Eighteen Mile Creeks watershed contains considerable forest cover, the rest of the watershed is well below adequate levels to protect water quality and provide habitat (Regional Municipality of Niagara 2003). Forest cover is beneficial because it:

- reduces flooding and low flow events by intercepting runoff thereby encouraging infiltration,
- improves water quality by slowing the rate of runoff to watercourses, and trapping, using or breaking down some of the pollutants and nutrients found in runoff water,
- improves water quality by lowering water temperatures and shading water courses,
- improves groundwater quality by increasing the amount of rainfall that percolates to the groundwater table,
- reduces soil erosion, and
- preserves and increases flora and fauna diversity.

In addition, meadows also play an important role in creating habitat diversity and foraging areas for wildlife. Therefore, they should be given consideration in habitat creation and restoration actions in the Fifteen-Sixteen-Eighteen Mile Creeks watershed.

FISH AND AQUATIC HABITAT

The fish community in the Fifteen-Sixteen-Eighteen Mile Creeks watershed is representative of a tolerant warm water fishery. Different species of fish have varying tolerances to environmental change; therefore, they are considered valuable indicators of environmental and ecosystem health (Nottawasaga

Valley Conservation Authority 1995). The protection and improvement of critical and important fish habitat has been identified as an issue in this watershed (Regional Municipality of Niagara 2003).

Fish habitat consists of areas that fish need, whether directly or indirectly in order to carry out their life processes including spawning grounds, nursery, rearing, food supply, and migration areas. Broadly defined, wetlands, groundwater recharge areas, aquifers, and the quantity and quality of groundwater and surface water are all important factors for maintaining the quality and quantity of fish habitat. Development activities, structures, changes in land use, and alteration to hydrology can all impact fish and fish habitat. Fish habitat can be damaged in numerous ways including:

- dredging and filling near spawning and nursery habitat,
- loss of riparian vegetation,
- stream alterations including fish barriers,
- poorly managed stormwater runoff,
- impaired water quality (e.g., sediment and nutrient loadings, increased temperature), and
- loss of groundwater recharge capability (Fisheries Act, Section 34).

The watershed strategy will focus on preserving Type 1 fish habitat in the watershed, and it will suggest restoration alternatives to maintain and improve Type 2 fish habitat.

CLIMATE CHANGE

Most climatologists agree that climate change and warming of the Earth's atmosphere is occurring. In addition, there is also broad agreement that human activities are primarily responsible for the changes to global climate that have been observed during the last half of the twentieth century (de Loë and Berg 2006). As reported by de Loë and Berg (2006) some of the predicted impacts to water resources in the Great Lakes Basin include, for example:

- Winter runoff is expected to increase, but total runoff is expected to decrease, thus summer and fall low flows are expected to be lower and longer lasting;
- Groundwater recharge is expected to decrease due to a greater frequency of droughts and extreme precipitation events. As a result, shallow aquifers will be more sensitive to these changes than deeper wells; and
- Water temperature in rivers and streams is expected to rise as air temperatures rise, and as summer baseflow is reduced.

These modeled or predicted impacts to water resources will affect society as well as ecosystems. Societal water use issues may arise because decreased runoff may lead to reduced water quality, resulting in increased water treatment costs and greater competition and conflict for water resources during low water or drought conditions. Ecologically, changes to wetland form and function may also experience change due to the impacts of climate change. For example, a reduction in groundwater discharge and an increase in surface water temperature will stress fish and fish habitat (de Loë and Berg 2006).

ECOLOGICAL RESTORATION AND ENVIRONMENTAL PLANNING TOOLS

COMMUNICATION AND EDUCATION

Watersheds often span numerous political boundaries. Therefore, agency, non-governmental partnerships, and citizen involvement is essential to the successful implementation of the Fifteen-Sixteen-Eighteen Mile Creeks watershed strategy. To facilitate communication between citizens and agencies in the watershed, a list of the major water resources legislation and agencies governing water management in Ontario is provided in Table 6. In addition to partnering on public and private lands, policy tools can be employed to foster environmentally responsible land and water management in the watershed.

POLICY TOOLS

Policy tools related to water quality and quantity protection can be implemented at the local or regional levels of government in the watershed. Designed to allow for continued development, these tools ensure that water quality and quantity issues are taken into consideration throughout the development process. Water protection policy tools might include municipal policies, incentive-based tools as well as other water conservation related tools. Specific examples of these policy tools are presented here.

TABLE 6: MAJOR WATER RESOURCES LEGISLATION GOVERNING WATER MANAGEMENT IN ONTARIO

LAW	FEDERAL LEGISLATION: DESCRIPTION (RELATED TO WATER PROTECTION)	GOVERNMENT AGENCY
Fisheries Act	Protects fish and fisheries habitat.	Fisheries and Oceans Canada
Environmental Contaminants Act	Prevents dangerous contaminants from entering the environment.	Environment Canada
Canada Shipping Act	Controls water pollution from ships by imposing penalties for dumping pollutants or failing to report a spill.	Transport Canada
Canada Water Act	Authorizes agreements with provinces for the designation of water quality and quantity management.	Environment Canada
Canadian Environmental Protection Act	Controls the manufacture, transportation, use, disposal of chemicals and waste that is not adequately regulated by other legislation.	Environment Canada
Pest Control Products Act	Regulates products used to control pests through a registration process based on prescribed standards.	Agriculture Canada
Navigable Waters Protection Act	Prohibits construction in navigable waters.	Transport Canada
International Rivers Improvement Act	Prohibits damming or changing the flow of a river flowing out of Canada.	Foreign Affairs and Environment Canada
	PROVINCIAL LEGISLATION	
Ontario Water Resources Act	Protects the quality and quantity of Ontario's surface and ground water resources (includes Permits to Take Water).	Ministry of the Environment
Clean Water Act	Protects the natural sources of drinking waters. Sources of drinking water are to be mapped by municipalities and conservation authorities, especially vulnerable areas that require protection.	Ministry of the Environment
Environmental Protection Act	Protects Ontario's land, water, and air resources from pollution (includes Certificates of Approval for landfills, sewage treatment, etc.).	Ministry of the Environment
Environmental Assessment Act	Requires an environmental assessment of any major public or designated private undertaking.	Ministry of the Environment
Pesticides Act	Protects Ontario's land, and surface and ground water resources from damage due to improper use of pesticides.	Ministry of the Environment
Nutrient Management Act	The purpose of the Act is to provide for the management of materials, containing nutrients in ways that will enhance protection of the natural environment and provide a sustainable future for agricultural operations and rural development.	Ministry of the Environment
Conservation Authorities Act	Ensures the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs (includes floodplains).	Conservation Authorities
Lakes and Rivers Improvement Act	Ensures flow and water level characteristics of lakes and rivers are not altered to the point of disadvantaging other water users.	Ministry of Natural Resources
Planning Act	Provides for and governs land use planning including the provision of statements of provincial interest to be regarded in the planning process.	Ministry of Municipal Affairs and Housing
Municipal Act	Grants municipalities the power to pass bylaws related to water resources (e.g., bylaws that prohibit negative impacts on drains, dam construction and operation, and straightening of watercourses).	Ministry of Municipal Affairs and Housing
Public Lands Act	Protects and perpetuate public lands and waters for the citizens of Ontario.	Ministry of Natural Resources
Public Utilities Act	Empowers municipalities to acquire and operate water works and divert a lake or river for their purposes.	Ministry of Municipal Affairs and Housing
Drainage Act	Facilitates the construction, operation and maintenance of rural drainage works.	Ministry of Agriculture, Food and Rural Affairs
Tile Drainage Act	Provides for low interest loans to farmers from municipalities for tile drainage on their property.	Ministry of Agriculture, Food and Rural Affairs

- STORMWATER MANAGEMENT POLICIES require the control and treatment of stormwater discharges to prevent flooding, minimize downstream channel erosion, and protect water quality. The NPCA is currently developing a set of Stormwater Policies for its jurisdiction.

- RIPARIAN BUFFER POLICIES protect watercourses and maintain aquatic habitat. Riparian buffer guidelines should take into account the amount of natural vegetation adjacent to a stream, the width of the vegetated buffer, total suspended solid concentrations, percent imperviousness in urbanizing watersheds, and fish communities (Environment Canada 2004c). Riparian Buffer Policies are addressed by the NPCA (1993 as amended in 2003 and 2005).

- ALTERNATIVE SUBDIVISION DESIGN encourage the development of subdivisions whereby houses are clustered and open space is protected. Conventional subdivisions spread development evenly throughout a parcel of land. However, conservation subdivisions are considered "density neutral", which means that the same number of lots can fit on a parcel of land, but the arrangement of the houses are clustered. The clustered arrangement helps to protect water quality.

- INCENTIVE-BASED TOOLS such as Water Conservation Programs aid in the protection of water quality, quantity and aquatic habitat by maintaining instream flows. Thus, the natural hydrology of streams is protected during peak water demand.

- ALTERNATIVE LAND USE SERVICES (ALUS) is a program whereby agricultural producers offer Canadians an environmental partnership opportunity by contributing the use of a portion of their land, plus labour, equipment, fuel, and money to produce environmental benefits, while encouraging investments from the rest of society to manage these benefits.

- LAND ACQUISITION PROGRAMS can help to protect water quality, especially if large areas of undeveloped land are purchased. Maintaining the natural condition of land around watercourses is an ideal approach to enhance water quality protection. In a situation where the municipality does not have an interest in obtaining valleylands, stream corridors and/or floodplains for public open space purposes the NPCA will consider assuming the dedicated lands when they meet at least one of the following criteria:

  (a) the valleylands, stream corridor and/or floodplain are contiguous with lands currently owned by the Conservation Authority or another public body;

  (b) the valleylands, stream corridor and/or floodplain are within an area that are eligible for tax incentive programs; and

  (c) where the valleylands, stream corridors and/or floodplain are adjacent to another natural area (NPCA 1993 as amended 2003 and 2005).

These tools, in addition to a comprehensive public education program will continue the line of communication with participating stakeholders that has been developed through the watershed planning process.

WATERSHED BEST MANAGEMENT PRACTICES

A best management practice (BMP) is a land management practice implemented to control sources or causes of pollution. The 3 types of BMPs that treat, prevent, or reduce water pollution include:

- Structural BMPs are practices that require construction activities such as stormwater basins, grade stabilization structures, and crib walls.

- Vegetative BMPs use plants, including grasses, trees and shrubs to stabilize erosion sites.

- Managerial BMPs involve policy changes or operating procedures at a site (Brown and others 2000).

It is important to note that BMPs are available for both urban and rural areas. A brief description of urban and rural BMPs follow and a more complete list of structural, vegetative and managerial BMPs are provided in Appendix C.

URBAN BEST MANAGEMENT PRACTICES

Urban BMPs are designed to redirect water from impervious surfaces to infiltration areas such as lawns, gardens, or forested areas. Residential landowners can minimize outdoor water consumption; plant drought-tolerant vegetation; capture rainwater for outdoor watering; avoid clearing vegetation around streams, riparian zones or floodplains; avoid channelizing streams or channels that connect to streams; avoid filling in floodplain or riparian zone areas; and discontinue the use of chemical fertilizers on their lawns and gardens. In addition to landowner BMPs in urban areas, BMPs can also be employed by local and regional governments to reduce the impacts to water quality and quantity from stormwater.

STORMWATER BEST MANAGEMENT PRACTICES

Stormwater BMPs are techniques, measures, or structural controls that are used to manage the quantity and improve the quality of stormwater runoff in a cost effective manner (EPA 2004). Offline infiltration basins are an example of a structural stormwater BMP. Stormwater is diverted into the infiltration basin where it is retained to slowly infiltrate into the soil; it is not part of the main channel. Wet ponds are similar to off-line infiltration ponds. However, stromwater is retained

for 2 to 3 weeks to allow for the absorption of pollutants and nutrients and then the water is released to the receiving watercourse. Managerial BMPs can also be achieved through municipalities. Municipalities can encourage and/or regulate land use planning and management by developing ordinances to manage stormwater impacts by limiting pavement, preserving open space, and delineating areas in the watershed for more on-site stormwater management facilities. Additional examples of structural, managerial and vegetative BMPs can be found in Appendix C.

AGRICULTURAL BEST MANAGEMENT PRACTICES

BMPs can improve rural non-point source pollution problems. For example, a lack of tributary buffers, and nutrient management have been identified in the watershed (Regional Municipality of Niagara 2003). Sediment control BMPs, water quality BMPs and nutrient management BMPs can be employed to mitigate the impacts of these activities on watercourses and wetlands. Examples of agricultural BMPs are provided below and a more thorough list of agricultural BMPs can be found in Appendix C.

SEDIMENT CONTROL BEST MANAGEMENT PRACTICES

Conservation tillage results in minimum soil disturbance by leaving at least 30 percent of the soil surface covered with crop residue immediately after planting. It is estimated that conservation tillage reduces soil loss by 50-95 percent and is effective in improving water quality. Windbreaks also control sediment and simply consist of rows of trees planted around the edge of fields to reduce soil erosion by wind.

WATER QUALITY BEST MANAGEMENT PRACTICES

Tailwater recovery ponds are located at the base of a drainage area. They are designed to intercept runoff before it enters a stream to treat and remove sediment and nutrients from the water. These ponds can also be used as a source of irrigation water. Contour farming involves ploughing furrows perpendicular to the contour of the land, which allows water to be captured between the furrows to prevent the formation of erosion rills down the slope. This method also helps minimize the volume of water that is applied to the field thereby reducing sediment washoff. Buffer strips represent a third example of agricultural BMPs to protect water quality. Vegetation planted along a watercourse ensure bank stability and provide shade to the stream. Buffer strips also act to trap sediment and filter nutrients out of runoff from agricultural fields.

NUTRIENT MANAGEMENT PRACTICES

The objective of nutrient management in Ontario is to use nutrients wisely for optimum economic benefit, while minimizing the impact on the environment (OMAF 1996). A nutrient management plan provides direction on how nutrients are to be applied to a given land base to optimize the use of nutrients by crops in order to minimize environmental impacts. In addition to nutrient management plans, fertilizer storage BMPs can also be implemented on a farm to ensure storage facilities are placed in appropriate areas (e.g., impermeable areas, away from wells).

FUNDING SOURCES FOR ENVIRONMENTAL PROJECTS

Several funding sources and land management tax incentive programs are available for landowners and non-profit organizations for creating, enhancing and preserving natural heritage. A description of known programs follows.

WATER QUALITY IMPROVEMENT PROGRAM

The Niagara Peninsula Conservation Authority provides landowners with up to 75 percent cost-share funding (depending on the eligible project) through its Water Quality Improvement Program. Participating landowners are responsible for any remaining costs through cash and in-kind contributions. To qualify for funding the following criteria must be met:

- projects must be within the NPCA's jurisdiction;
- projects must demonstrate an improvement to local surface and/or groundwater quality;
- the landowner must demonstrate good land stewardship practices;
- the landowner must contribute financially to the project in some capacity; and
- the landowner must complete a water quality improvement application and sign a project agreement form (NPCA 2003).

Eligible projects are related to woodland, wetland and riparian habitat restoration; manure and nutrient management; milkhouse washwater treatment and disposal; livestock restriction, alternate watering systems and crossings; and conservation farm practices.

CONSERVATION LAND TAX INCENTIVE PROGRAM

The Conservation Land Tax Incentive Program (CLTIP) was established in 1998 to recognize, encourage and support the long-term private stewardship of Ontario's provincially significant conservation lands. This program provides property tax relief (100 percent for the eligible portion of the property) to landowners and non-profit organizations who agree to protect the natural heritage values of their property. Eligible lands consist of provincially significant areas identified by the Ministry of Natural Resources, and include: provincially significant wetlands; provincially significant Areas of Natural and Scientific Interest; endangered species habitats; lands designated as escarpment natural areas in the Niagara Escarpment Plan; and community conservation lands, which are natural areas of significance owned by non-profit charitable conservation organizations and conservation authorities. Landowners whose land is eligible for this program are automatically notified by the MNR during the summer before each new tax year (MNR 2004).

THE MANAGED FOREST TAX INCENTIVE PROGRAM

The Managed Forest Tax Incentive Program (MFTIP) was established in 1998 to recognize the social and ecological benefits of forest lands. Privately owned forest land is eligible to be taxed at 25 percent of the municipal tax rate set for residential properties provided the property has at least 4 hectares of forest, is owned by a Canadian citizen, and has a Managed Forest Plan approved by a consultant designated by the MNR (Ontario Woodlot Association 2005).

FARM PROPERTY CLASS TAX RATE

Under the Farm Property Class tax rate, farm properties that satisfy the eligibility requirements will be taxed at 25 percent of the municipal residential rate. However, the farm residence and 1 acre of land surrounding the residence will be taxed as part of the residential class. In order to be eligible for the Farm Property Class tax rate all of the following criteria must be satisfied:

- the property must be assessed as farmland;
- the property must be used as part of a farming operation generating Gross Farm Income of at least $7,000 as reported to the Canada Revenue Agency for income tax purposes;
- a valid Farm Business Registration number is required for the business operating on the land; and
- the property must be owned by a Canadian citizen or a permanent resident of Canada (OMAFRA 2004).

WATER WELL DECOMMISSIONING PROGRAM

The NPCA (2007) has launched a water well decommissioning granting program for qualifying landowners with lands located within the NPCA jurisdiction. To qualify for current funding the following criteria must be met:

- grants are available for the decommissioning of unused water wells only. Oil wells, gas wells and cisterns are not eligible under this program;
- the proposed work must be completed by a water well contractor licensed by the Ministry of the Environment (MOE) as set out in Ontario Regulation 903 of the Ontario Water Resources Act;
- the proposed work must comply with MOE procedures for plugging or abandoning unused water wells according to Ontario Regulation 903. Details of the procedure must be documented on the water well record and submitted to the MOE by the hired water well contractor upon completion;
- a copy of the water well record must also be submitted to the NPCA by the landowner or the hired water well contractor upon completion;
- priority will be given to:
  - hydrogeologically sensitive areas (based on NPCA Groundwater Study or other studies as endorsed by NPCA),
  - projects located in areas with a high density of domestic water wells, and
  - areas where watershed plans have been completed or are on-going; and
- all proposals are subject to review and approval by NPCA staff.

Under this grant program, applicants must apply and be approved prior to initiating their project. Projects already underway or completed without NPCA approval are not eligible. Eligible costs include those incurred by a licensed contractor and/or licensed technician fees or water well decommissioning (as approved by the NPCA). The Grant will cover 90 percent of well decommissioning costs to a maximum of $2,000 per well (limit of two wells per property). This is a reimbursement program; the landowner will pay the full cost to the contractor, and will be reimbursed for 90 percent of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.

WATERSHED HABITAT RESTORATION

Environment Canada (2004c) in its *How Much Habitat is Enough?* document puts forth restoration guidelines for wetland, riparian, and forest habitat. This framework provides "science-based information and general guidelines to assist government and non-government restoration practitioners, planners and others involved in natural heritage conservation and preservation by ensuring there is adequate riparian, wetland and forest habitat to sustain minimum viable wildlife populations and help maintain selected ecosystem functions and attributes". Given the breadth of science used to generate this framework, its guidelines will serve as the basis for the Fifteen-Sixteen-Eighteen Mile Creeks watershed strategy. A summary of the riparian, wetland and forest habitat restoration guidelines have been reproduced in Appendix D.

WATERSHED RESTORATION TARGETS

Environment Canada (2004c) has created a set of guidelines for wetland, riparian and forest habitat restoration that identify targets for each habitat type in a watershed (Appendix D). These targets are scientifically-based, and therefore have been adopted for this watershed plan. The guidelines recommend the following:

- Wetlands: Greater than 10 percent of each major watershed in wetland habitat; greater than 6 percent of each subwatershed in wetland habitat; or restore to original percentage of wetlands in the watershed.
- Forest: At least 30 percent of the watershed should be in forest cover.
- Riparian: 75 percent of stream length should be naturally vegetated.

The Fifteen-Sixteen-Eighteen Mile Creek watershed currently contains approximately 3 percent wetland cover and approximately 17.5 percent forest cover. Based on the above guidelines, an additional 7 percent of wetland cover is required to create minimum desirable habitat proportions in the Fifteen-Sixteen-Eighteen Mile Creek watershed. Forest cover is at approximately 17.5 percent in the watershed. Therefore, measures to create new upland areas, as well as protect and enhance existing forest cover should be implemented to ensure no net loss of forest cover. Riparian cover in the watershed is approximately 31 percent in the watershed. Based on this percentage approximately 44 percent of the watershed requires a vegetative buffer. The guidelines represent minimum desirable habitat proportions for riparian, wetland and upland forest habitat. Additional restoration above the minimum target is encouraged once these targets have been met. Existing natural heritage features and areas in the watershed should be preserved and enhanced whenever possible to improve water quality, ecological uses and human uses of the natural features.

WATERSHED STRATEGY

For convenience, and to make restoration recommendations more manageable and easier to implement, the watershed planning strategy has been divided into separate restoration plans for each of the three watersheds including Fifteen Mile Creek, Sixteen Mile Creek and Eighteen Mile Creek. Restoration areas have been identified based on riparian, wetland and upland restoration suitability mapping produced by the NPCA; Carolinian Canada's 'Big Picture' corridors; and Regional Niagara's Core Natural Heritage System mapping (Figure 17). Carolinian Canada's 'Big Picture' identifies existing natural cores, corridors and potential linkages in Canada's Carolinian life zone while Regional Niagara's Core Natural Heritage System consists of core natural areas to Niagara Region and potential linkages to areas identified as core areas.

The criteria for each restoration category (riparian, wetland and upland) were derived from several sources including Environment Canada's (2004c) framework for guiding habitat rehabilitation (Appendix D).

Each type of habitat restoration (riparian, wetland, upland) has been prioritized as most suitable, moderately suitable or least suitable. Areas suitable for riparian, wetland and upland habitat restoration may overlap on the following watershed restoration strategy maps due to the methodology from which they were derived. When this occurs, the most suitable restoration project should be implemented based on field verification, available project funding, landowner partnerships as well as the opportunity to enhance ecological linkages.

RESTORATION SUITABILITY MAPPING

The criteria used to create the restoration suitability mapping were derived from several sources (Appendix E). The criteria for each restoration category (riparian, wetland and upland) vary and have been weighted differently based on the suitability of the land for habitat creation. A complete list, including the rationale, methodology and reference for each criterion used in the suitability analysis are presented in Appendix E, and the top three criteria for each restoration category are presented below.

The criteria used to identify riparian habitat suitability include, for example, stream bank erosion rates. This criterion is used because riparian areas identified as having high erosion rates resulting from an upslope contributing area and slope gradient analysis are most suitable to restoration with bioengineering. The proximity to a watercourse or waterbody identified riparian suitability because these areas contribute to both riparian buffers and floodplains, and restoration in these areas will improve the hydrological, habitat and water quality functions in the watershed. Land use type is ranked third in terms of identifying suitable areas for riparian restoration. Areas classified as scrub, low intensity agriculture, or natural areas are much more suitable to restoration than areas classified as industrial or urban.

The criteria used to identify wetland habitat suitability include, for example, soil drainage because the drainage class of an underlying soil determines the amount of water the soil can receive and store before runoff. The more poorly drained the underlying soil, the more suitable the area is for wetland restoration. The wetness index predicts zones of water saturation where steady-state conditions and uniform soil properties are assumed. Similar to riparian restoration, land use type plays a role in determining areas suitable for wetland restoration.

Upland habitat restoration suitability is also evaluated based on land use type. Wetland buffer habitat thresholds (0-240m) are also used, which include areas within the 0-240 metre span of a wetland because they contribute to a range of habitat functions when vegetated. Vegetation within the closest proximity to a wetland provides the greatest benefit to that wetland. The third

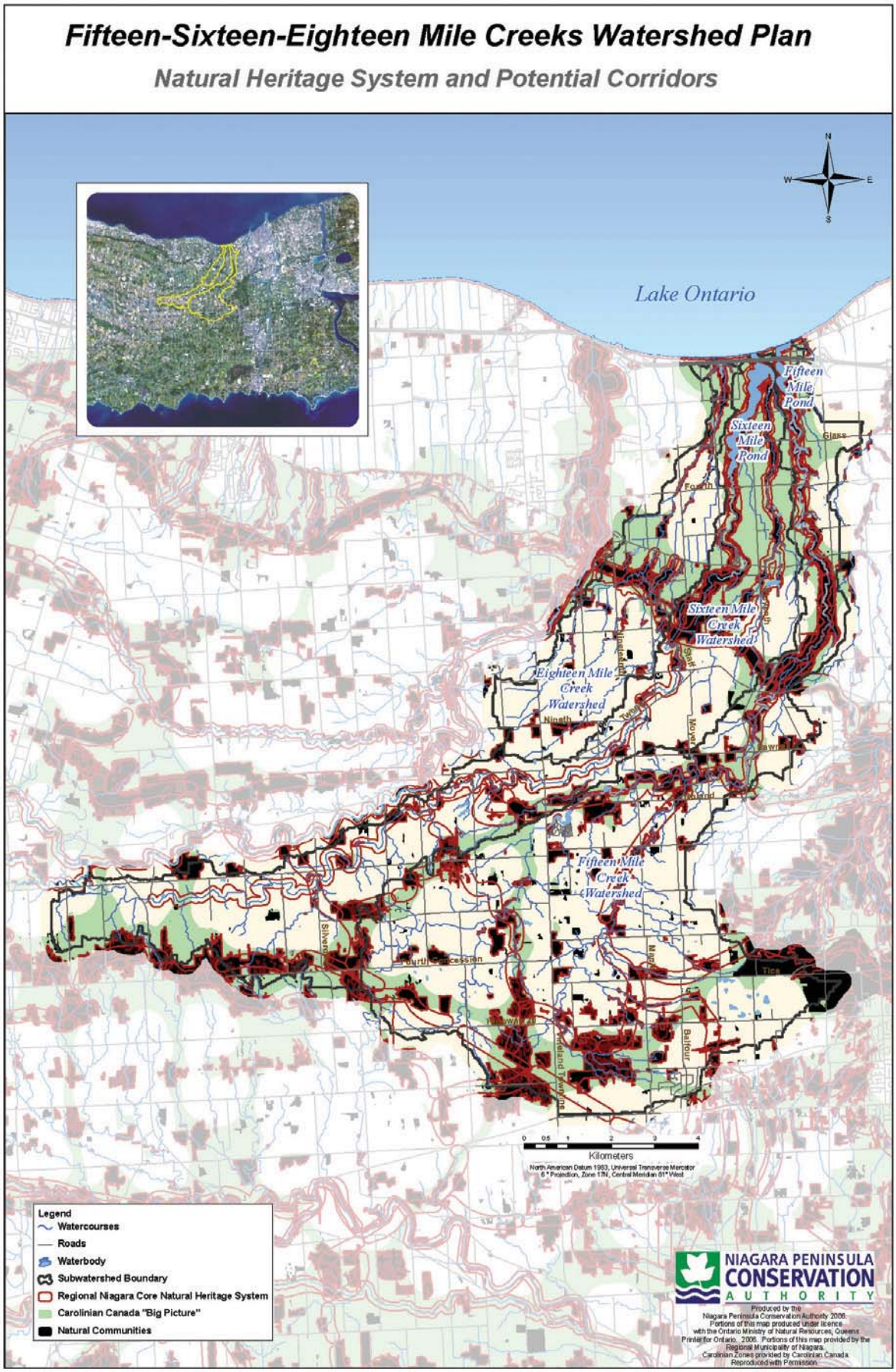


FIGURE 17: NATURAL HERITAGE SYSTEM AND POTENTIAL CORRIDORS

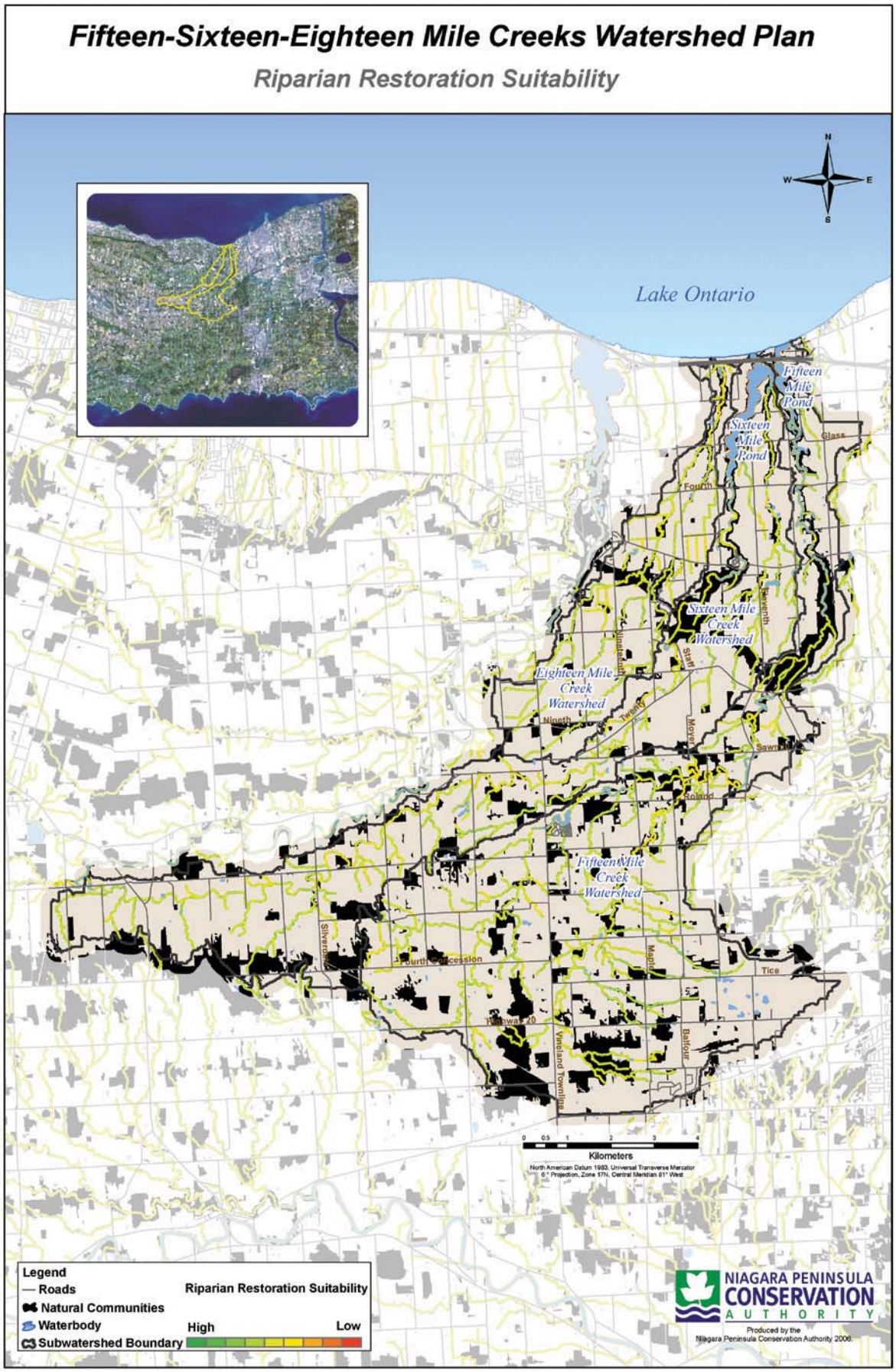


FIGURE 18: RIPARIAN SUITABILITY MAPPING

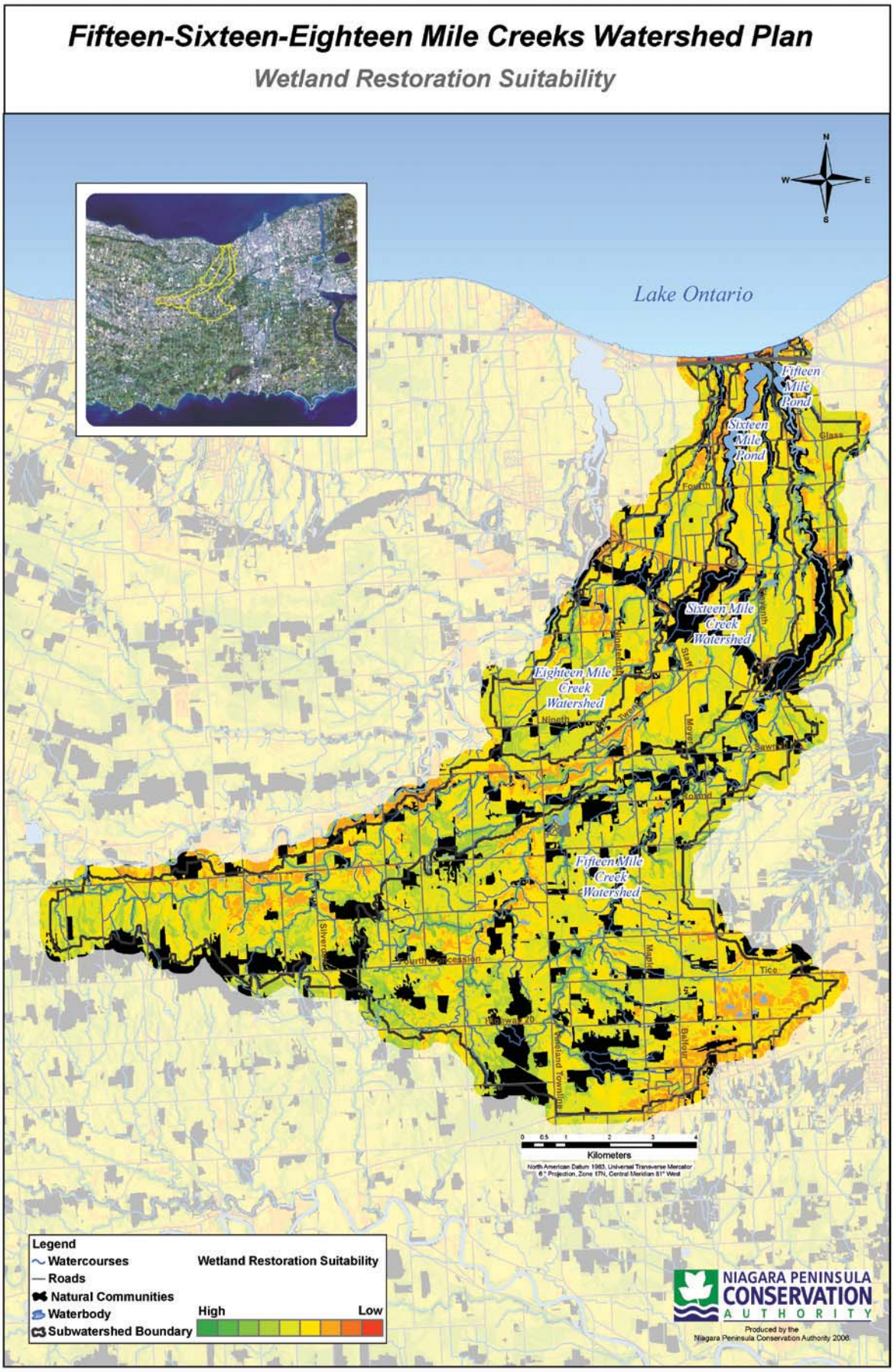


FIGURE 19: WETLAND RESTORATION SUITABILITY

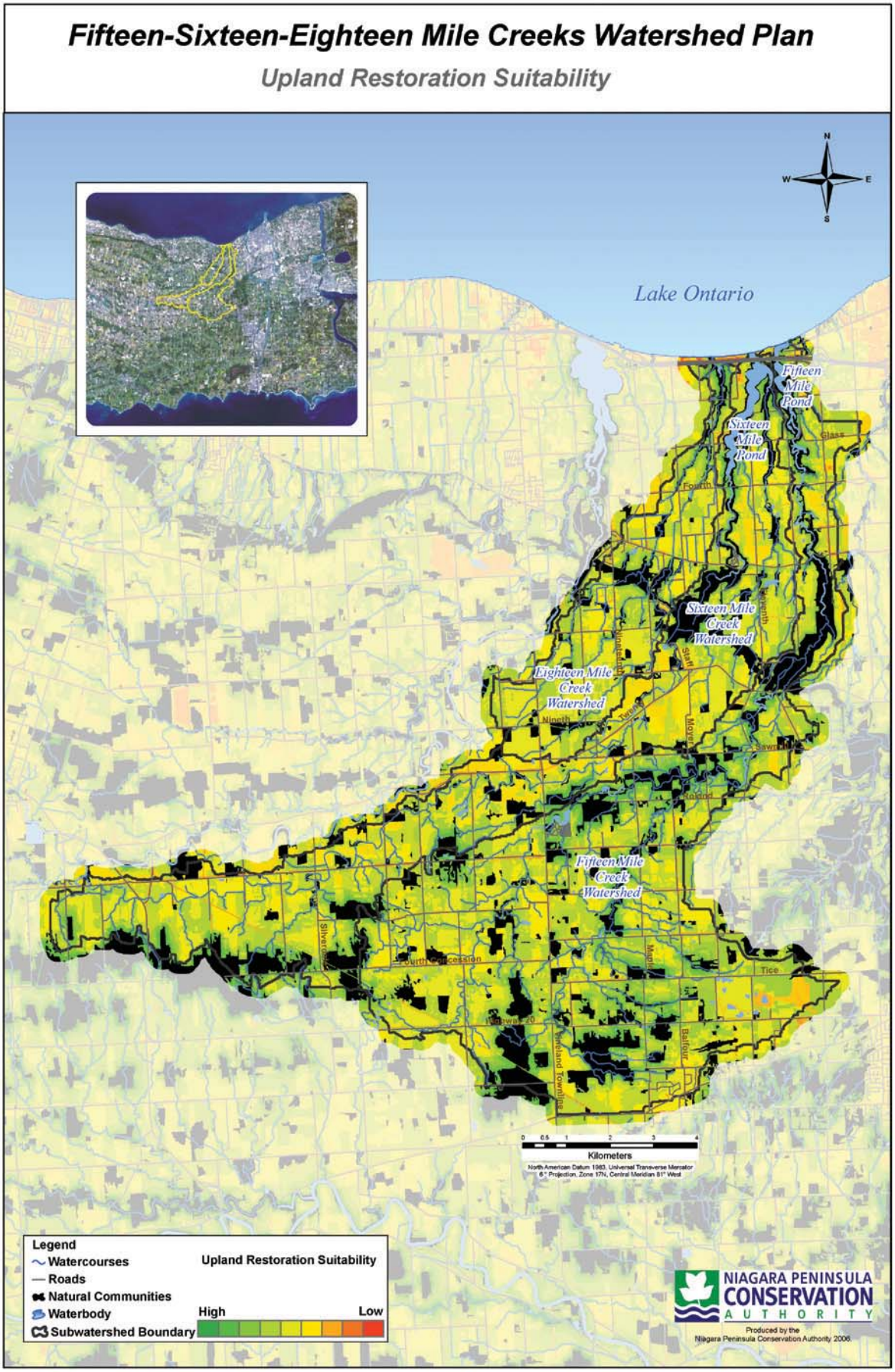


FIGURE 20: UPLAND RESTORATION SUITABILITY

criterion for determining upland suitability is the proximity of an area to a significant patch. Areas within the closest proximity to existing forest patches with the highest Natural Heritage Score, or core size, are considered the most suitable for upland restoration because these sites will increase interior habitat. Additional criteria and the weighting scheme are presented in Appendix E. A series of habitat restoration suitability maps are provided (Figures 18 - 20).

FIFTEEN MILE CREEK RESTORATION STRATEGY

The Fifteen Mile Creek watershed offers numerous opportunities for ecological restoration in terms of riparian, wetland, and upland restoration and enhancement. For example, riparian buffers are lacking in the upper portion of this watershed (above the Niagara Escarpment) (NPCA 2006b). Therefore, numerous suitable areas have been identified for riparian restoration in this portion of the watershed. In addition, wetland suitability is highest above the Niagara Escarpment, especially in the western portion of the watershed. Upland restoration suitability dominates the Fifteen Mile Creek watershed with ample suitable areas above and below the Niagara Escarpment, which is especially important for creating ecological linkages between existing natural areas for the movement of wildlife, and to enhance habitat diversity. Opportunities for ecological restoration and enhancement are abundant in the Fifteen Mile Creek watershed provided public and private partnerships can be established in the watershed. Maintaining and enhancing the integrity of the Carolinian forest community is also a priority in this watershed.

The Fifteen Mile Creek Watershed Restoration Strategy identifies four zones with specific stewardship and restoration recommendations (Table 7).

1) FIFTEEN MILE CREEK BELOW THE NIAGARA ESCARPMENT: For the most part, streams in this portion of the watershed have well established riparian buffers with the exception of some tributaries that flow through agricultural fields. Opportunities for upland and wetland restoration and enhancement are more prominent. For example, natural areas around Fifteen Mile Pond would benefit from extending the buffer to create a larger upland area for habitat diversity, to create an ecological linkage to the adjacent Sixteen Mile Pond, and to protect the wetland ecosystem in the Fifteen Mile Creek Pond. The wetland ecosystem would also benefit from further study and follow up restoration measures to enhance wetland features such as aquatic habitat. All wetland areas in this portion of the watershed would benefit from ecological enhancement and protection because this area has been delineated as a potential groundwater discharge area (Figure 13).

2) FIFTEEN MILE CREEK: Niagara Escarpment Corridor: A large section of this portion of the Fifteen Mile Creek watershed falls within the Fifteen-Sixteen Mile Creek Valleys Area of Natural and Scientific Interest (ANSI), and riparian and upland areas are well established in the ANSI. However, opportunities do exist to expand the size of existing upland areas to increase natural heritage core areas and ecological linkages along the Niagara Escarpment. Wetland suitability is low due to the topography and physiography found in this section of the watershed.

3) FIFTEEN MILE CREEK HEADWATERS: The boundary of the headwaters area of the Fifteen Mile Creek watershed are defined as the area south of Fourth Concession Road, south of Metler Road and extending to the watershed boundary. Opportunities for riparian restoration and enhancement are numerous in this portion of the watershed, and establishing a healthy riparian buffer is especially important in the headwaters because the headwater wetlands and tributaries form the starting point of Fifteen Mile Creek. Poor water quality in the headwaters can potentially impact all downstream ecological and human uses of the creek's water. In addition, the headwaters in the eastern portion of this watershed flow from the Fonthill Kame-Delta Complex, which means that tributaries originating here are likely groundwater fed, and would therefore have cooler water temperatures. Cool water temperatures in this section of the watershed provide suitable temperatures for a diversity of aquatic life.

Wetland suitability is also high in the headwaters portion of the watershed. An extensive area of high wetland suitability along the east branch of Fifteen Mile Creek and its tributaries exists in an area bounded by Metler Road, Maple Road, Regional Road 20 and Vineland Townline Road. Suitability in this portion of the watershed is also high because it is a potential groundwater discharge area (Figure 13). Upland restoration suitability is also high in this portion of the watershed. However, upland restoration should focus on sites adjacent to existing natural heritage areas to create larger contiguous areas to increase ecological habitat and for the movement of wildlife. Given the lack of buffers (NPCA 2006b) in this portion of the watershed, riparian restoration and cattle fencing should be a priority to enhance water quality in the headwaters.

4) FIFTEEN MILE CREEK ABOVE THE NIAGARA ESCARPMENT (REMAINDER OF THE WATERSHED): The Fifteen Mile Creek watershed above the Niagara Escarpment contains many areas with high to moderate suitability for riparian restoration. In its Fifteen-Sixteen-Eighteen Mile Creeks Watershed Geomorphic Assessment (NPCA 2006b), the NPCA reported that farm level crossings are in very poor condition in this portion of the watershed, and vegetative buffers in both urban and rural areas are lacking, which is contributing to erosion, sedimentation and poor water quality. As a result, priority should be placed on riparian restoration in this section of the watershed to improve stream morphology and improve water quality through the reduction of sediment entering the stream. High to moderate restoration suitability is also found throughout the Fifteen Mile Creek watershed for wetland and upland restoration. However, given the results of the Geomorphic Assessment (NPCA 2006b) for this watershed, attention should first be placed on riparian creation to improve water quality.

TABLE 7: FIFTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND AND ECOLOGICAL LINKAGES
BELOW THE NIAGARA ESCARPMENT (INCLUDING FIFTEEN MILE POND)	• Many sections of Fifteen Mile Creek and its tributaries run through agricultural lands with little or no buffers; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat along the length of the watercourse before discharging to Fifteen Mile Pond and Lake Ontario	• Enhance existing wetlands as natural flood storage reservoirs • Enhance Fifteen Mile Pond wetland communities • Create new wetlands in areas where the wetness index and soil drainage permit (e.g., high wetland suitability along western bank of the main branch of Fifteen Mile Creek below the escarpment)	• highly suitable upland restoration areas adjacent to the main branch of Fifteen Mile Creek, Fifteen Mile Pond and adjacent to existing natural areas • Create and enhance Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187 identified ecological corridors along the main branch of Fifteen Mile Creek extending to the Niagara Escarpment • Carolinian and native species should be used in all restoration projects
NIAGARA ESCARPMENT CORRIDOR	• Riparian habitat is well established in this section of the watershed; focus should be on maintenance and enhancement, and protecting Carolinian and rare species in the Fifteen-Sixteen Mile Creek Valleys ANSI	• Wetland suitability is low due to topography and physiography in this section of the watershed	• Upland suitability mapping indicates a high suitability for upland restoration adjacent to natural heritage areas; focus should be on increasing core size of natural heritage areas, filling in gaps between adjacent areas and creating ecological linkages with adjacent watersheds that are consistent with Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187(e.g., enhance and join cluster of natural areas between Sherk and Bossart Roads. A possible contiguous extending from north of Baker Street north to Miller Street in Usshers Creek subwatershed) • Carolinian and native species should be used in all restoration projects

TABLE 7: FIFTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND AND ECOLOGICAL LINKAGES
ABOVE THE NIAGARA ESCARPMENT - HEADWATERS	• High to moderate suitability for riparian restoration in the headwaters portion of the watershed • Many sections of the headwater tributaries run through agricultural lands with little or no buffers; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat • Given the lack of buffers in this portion of the watershed, riparian restoration and cattle fencing should be a priority to improve water quality in the headwaters	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit	• High suitability for upland plantings in this portion of the watershed • Restoration should focus on areas adjacent to existing natural heritage areas to create larger contiguous forested areas, and along the tributaries of Fifteen Mile Creek to buffer the creek and create ecological corridors that are consistent with Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187 identified ecological connections to link the Fifteen Mile Creek headwaters with the Sixteen Mile Creek headwaters • Carolinian and native species should be used in all restoration projects
ABOVE THE NIAGARA ESCARPMENT – REMAINDER OF THE WATERSHED	• High to moderate suitability for riparian restoration in this portion of the watershed • Many sections of stream running through agricultural lands with little or no buffer; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit; priority should be given to areas where wetlands already exist or adjacent to forested areas to create larger contiguous habitat areas (e.g., in the southern portion of the watershed above the Niagara Escarpment along the tributaries of the west branch of Fifteen Mile Creek)	• High suitability for upland restoration in this portion of the watershed; focus should be on sites adjacent to existing natural heritage areas to create larger contiguous forested areas, and along the tributaries of Fifteen Mile Creek to buffer the creek and create ecological corridors consistent with Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187 identified ecological corridors • Carolinian and native species should be used in all restoration projects

TABLE 7: FIFTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
GEOMORPHIC ASSESSMENT STUDY (NPCA 2006)	The Fifteen-Sixteen-Eighteen Mile Creeks Watershed Geomorphic Assessment (NPCA 2006b) identified several erosion and sediment accumulation sites in the Fifteen Mile Creek Watershed (Appendix B): 1. Tice Road/Brady Street – Headwaters (Reach 15MCETc): Sediment is accumulating along the bed at this site, and there is a lack of large woody vegetation adjacent to the channel with small buffers downstream. Recommendations for this site include enhancing the size of the riparian buffer. The type and variety of vegetation found within the riparian zone should also be increased. 2. Balfour Road/Metler Road – Headwaters (Reach 15MCETh): This reach flows through a residential area and there is little to no buffer present along the length of the creek. Sediment is accumulating along the streambed, which is likely resulting from upstream agriculture. Recommendations for this site include planting a riparian buffer in the residential area where lawns are mowed to the edge. 3. Roland Road/Balfour Road (Reach 15MCETi): The slope of the streambed is flat at this reach and sediment is accumulating on the streambed as a result. Cattle have access to the stream where there is no riparian vegetation and manure was present on the stream bank during the field investigation. Recommendations for this site include planting a riparian buffer and installing livestock fencing to stabilize the bank and prevent cattle access. 4. Regional Road 20 – Headwaters (Reach 15MCMa): The riparian buffer at this site consists of long grasses. Sediment is accumulating along the streambed and when it is disturbed, it has a strong odour. The channel at this reach has been altered but the old channel has not been filled in properly. Recommendations for this site include establishing a proper buffer (not just grasses) adjacent to the stream and properly filling in old channel if no longer in use. 5. Pond at N.E.T. Campground (Reach 15MCMk): A small riparian buffer with little vegetation variety is present around this online pond. A dam, located at the outlet of the pond, acts as a fish barrier, and sediment is accumulating on the bed of the pond. Recommendations at this site include planting a more diverse and wider riparian buffer around the pond. The landowners have also indicated that they would like to dredge the pond at some point in the future. It is recommended that the landowners contact the NPCA and obtain all required permits from the Ministry of Natural Resources prior to dredging the pond. 6. Sixteen Road – Headwaters (Reach 15MCMm): This reach does not contain any riparian buffer or channel canopy along the length of the stream. In addition, there are no deep pools located in the channel, and three tractor crossings were present within the 500 metre span of this reach. Recommendations for this site include establishing a riparian buffer along the length of the stream, and limiting the number of farm crossings by creating a proper crossing at this site. 7. Rockway Conservation Area at Ninth Avenue (Reach 15MCMs): The slope of the Niagara Escarpment at this site can lead to high shear stresses and as a result the bank soils have a high susceptibility to erosion. The recommendation for this site is to establish vegetation along the stream bank where soil is exposed and where slumping of the bank is occurring. 8. Fourth Avenue/Ninth Avenue (15McMt): This reach is in fairly good shape. However, the left bank is kept groomed by the property owners. The recommendation for this site is to increase the size of the riparian buffer and increase the diversity of native species in the buffer. Sediment accumulation has been identified along the stream bed in some of the reaches. Possible sources of excess sediment include: severe bank erosion; no vegetative buffer zone adjacent to streams in agricultural fields; improperly built crossings; and cattle accessing the stream bank. By identifying these sources, either by visual inspection in the field or through the use of computer programs such as AGNPS, restoration techniques can be applied. Restoration priorities for the Fifteen Mile Creek Watershed include enhancing the size of the riparian buffer and increasing the variety and diversity of native plant species(provide habitat, prevent erosion, control sediment entering the stream from runoff and filter any chemicals); construct proper stream crossings; and prevent cattle from entering the stream.

TABLE 7: FIFTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
WILDLIFE CORRIDOR ENHANCEMENT OF THE FIFTEEN, SIXTEEN, AND EIGHTEEN MILE CREEKS	The Wildlife Corridor Enhancement Project of the Fifteen, Sixteen and Eighteen Mile Creeks is currently underway in the watershed. This project is lead by the Niagara Restoration Council (NRC) and the NPCA is one of the project partners. This project commenced in the Fall 2005, and in conjunction with its project partners, the NRC will plant 50,000 native trees in the watershed. The goals of this project are to restore forest habitat through the connection of existing forest patches; protect and conserve existing forests via various land conservation tools, including tax incentive programs for landowners; and participate in informational events to educate the public and landowners about the significance of forests.
QUARRY – REGIONAL ROAD 20	Quarry operations significantly alter the landscape and hydrological system. Therefore, it is important to ensure that all quarry restoration plans and the Fifteen Mile Creek restoration actions are congruent. Opportunities for the NPCA and the quarry operator to partner on rehabilitation plans and implementation should also be developed.
REGIONAL ROADS -ROAD SALT IMPACTS	The Regional Municipality of Niagara has completed a Salt Study for its Regional Roads (Ecoplans Ltd. 2005). Regional roads below the escarpment are ranked as having a high vulnerability due to the location of groundwater discharge areas resulting from sandy soils. Surface water risk from salt along Regional roads above and below the escarpment is considered moderate to moderately low in the Fifteen-Sixteen-Eighteen Mile Creeks watershed (Ecoplans Ltd. 2005). Riparian restoration should be targeted at watercourses and wetlands along regional roads to lessen the impacts from road salt on water quality and aquatic habitat. In addition, areas that support natural heritage features and agricultural areas should also be investigated and remediated to lessen the impacts of salt on these land features/uses.
FISH BARRIER REMOVAL	Dams, weirs, floodgates, and road crossings act as barriers to fish passage. They block the channel and can make areas of habitat inaccessible to all aquatic organisms, thereby reducing breeding opportunities for many native species, and they can cause an increase in competition and predation. As part of the Fifteen-Sixteen-Eighteen Mile Creek Watershed Geomorphic Assessment (NPCA 2006), several human-made fish barriers have been identified. These sites should be reviewed and where possible, the barrier should be removed to optimize the passage of fish. An additional study should also be conducted to determine all barriers to fish movement in the Fifteen Mile Creek watershed.
SPECIAL STUDIES	**RECOMMENDATIONS FOR FURTHER STUDY**
FIFTEEN MILE POND FISH AND AQUATIC HABITAT STUDY	Additional studies pertaining to fish species and aquatic habitat would be beneficial to determine the health of the pond and wetland, and to determine the effects of Lake Ontario on the fish population, any impacts resulting from the Queen Elizabeth Way (QEW), and suitable restoration actions for Fifteen Mile Pond (Barrett, Personal Communication). Once completed, recommendations from this study should be implemented to improve water quality and fish habitat especially in known fish spawning areas.
MUNICIPAL DRAIN MAINTENANCE BEST MANAGEMENT PRACTICES	The Fifteen Mile Creek Watershed contains two municipal drains; Keenan Drain and Fifteen Mile Creek Drain. Best Management Practices for drain maintenance should be developed in consultation with the Ministry of Natural Resources, Department of Fisheries and Oceans, NPCA, municipalities and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain.
MUNICIPAL ROADS ROAD SALT IMPACT STUDIES	The Regional Municipality of Niagara has already completed a Salt Vulnerability Study for its roads (see above). It is recommended that local municipalities complete similar studies to determine the impacts from road salt applications on municipal roads to groundwater sensitive areas, surface water resources, natural heritage areas and agricultural crops.

TABLE 7: FIFTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

SPECIAL STUDIES	RECOMMENDATIONS FOR FURTHER STUDY
REGIONAL NIAGARA IRRIGATION STUDY	The Regional Niagara Raw Water for Irrigation Feasibility Study (Stantec Consulting Ltd) commenced in 2005. The Fifteen Mile Creek watershed falls within the West District of this study including the lands below the Niagara Escarpment and above the Niagara Escarpment. Recommendations for irrigation water takings include taking water from Lake Ontario and/or Jordan Harbour; a pipeline distribution system with an intake from Lake Ontario; and the creation of off stream reservoirs close to major water sources (Lake Ontario). Additional studies are underway by Regional Niagara to determine a suitable alternative for irrigation water in this area. Any recommendations from the Irrigation Study should be reviewed prior to implementation to ensure a sustainable supply of water for human and ecological use in the watershed.
GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES	The Groundwater Study (2005) has identified several areas with high intrinsic susceptibility (Figure 14). The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Additional studies should be conducted in this watershed to ensure that current and future land uses do not conflict with the protection of groundwater resources in susceptible areas as part of the NPCA's Groundwater Study (2005) and proposed Source Water Protection Plan.
RIPARIAN BUFFER EDUCATION PROGRAM	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
SEPTIC SYSTEM EDUCATION AND FUNDING PROGRAM	Improperly maintained septic systems have been identified as a concern in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Improperly functioning septic systems and abandoned septic systems are a known threat to water quality. A septic system education and funding program should be developed and implemented to ensure that private septic systems are functioning properly, and to ensure that abandoned systems are decommissioned.
ABANDONED WELL DECOMMISSIONING PROGRAM	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). In the Fifteen Mile Creek subwatershed, any abandoned wells on the Fonthill Kame and along bedrock outcrops south of Ellis Street should be given priority for decommissioning. Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
AGRICULTURAL BEST MANAGEMENT PRACTICES PROGRAM	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted in the Fifteen Mile Creek subwatershed. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA has developed stormwater management policies for its jurisdiction for use by Regional Niagara and its municipalities.

SIXTEEN MILE CREEK RESTORATION STRATEGY

Like the Fifteen Mile Creek watershed, the Sixteen Mile Creek watershed offers numerous opportunities for ecological restoration in terms of riparian, wetland, and upland restoration and enhancement. For example, like the Fifteen Mile Creek watershed, riparian buffers are lacking in the upper portion of this watershed (above the Niagara Escarpment) (NPCA 2006b). Numerous suitable areas have been identified for riparian restoration in this portion of the watershed, primarily in rural and agricultural areas. In addition, wetland suitability is highest above the Niagara Escarpment, in the western portion of the watershed along the main branch of Sixteen Mile Creek. Wetland suitability is also high surrounding Sixteen Mile Pond including the lands adjacent to Eighteen Mile Pond to the west. Upland restoration suitability dominates this watershed with ample suitable areas above and below the Niagara Escarpment, which is especially important for creating ecological linkages between existing natural areas for the movement of wildlife, and to enhance habitat diversity. Opportunities for ecological restoration and enhancement are abundant in the Sixteen Mile Creek watershed provided public and private partnerships can be established in the watershed. Maintaining and enhancing the integrity of the Carolinian forest community is also a priority in this watershed.

The Sixteen Mile Creek Watershed Restoration Strategy identifies four zones with specific stewardship and restoration recommendations (Table 8).

1) SIXTEEN MILE CREEK BELOW THE NIAGARA ESCARPMENT: The streams in the lower portion of the watershed have, for the most part, well established riparian buffers, with the exception of some tributaries that flow through agricultural fields along the east branch of Sixteen Mile Creek and its tributaries. Like the Fifteen Mile Creek watershed below the Niagara Escarpment, opportunities for wetland and upland restoration and enhancement are more prominent than riparian creation. For example, wetland and upland restoration around Sixteen Mile Pond has the potential to create ecological linkages between Fifteen Mile Pond and Eighteen Mile Pond while enhancing the existing wetland communities located in the ponds. In addition, habitat diversity will be enhanced by creating a larger upland area. Wetland systems in and adjacent to Sixteen Mile Pond would benefit from further study and a prescribed restoration and enhancement program. All wetland areas in this portion of the watershed would benefit from ecological enhancement and protection because this area has been delineated as a potential groundwater discharge area (Figure 13).

2) SIXTEEN MILE CREEK — NIAGARA ESCARPMENT CORRIDOR: A large section of this portion of the Sixteen Mile Creek watershed falls within the Fifteen-Sixteen Mile Creek Valleys Area of Natural and Scientific Interest (ANSI), and riparian and upland areas are well established in the ANSI. However, opportunities do exist to increase the size of existing upland areas to increase natural heritage core areas and ecological linkages along the Niagara Escarpment. Wetland suitability is low due to the topography and physiography found in this portion of the Sixteen Mile Creek watershed.

3) SIXTEEN MILE CREEK HEADWATERS: The boundary of the headwaters area of the Sixteen Mile Creek watershed are defined as the area south of Sixteen Road and extending to the watershed boundary. Riparian restoration suitability is high to moderate for this portion of the watershed. Numerous headwater tributaries that flow through agricultural areas are lacking a riparian buffer in this section of the watershed, thereby contributing to sediment and agricultural runoff to watercourses. Establishing a healthy riparian buffer is especially important in the headwaters area because the headwater wetlands and tributaries form the starting point of Sixteen Mile Creek. Poor water quality in the headwaters can potentially impact all downstream ecological and human uses of the creek's water

Wetland suitability is also high south of the main branch of Sixteen Mile Creek in the headwaters portion of this watershed. Several small wetlands already exist in the headwater section of the Sixteen Mile Creek watershed. Therefore, the focus should be on enhancement and protection of the existing wetlands as well as wetland creation along the headwater tributaries to create ecological linkages between wetlands and enhance water quality. Upland restoration suitability is also high to moderate in this portion of the watershed. However, upland restoration should focus on areas adjacent to existing natural heritage areas to create larger contiguous areas to increase ecological habitat and for the movement of wildlife. Given the lack of buffers (NPCA 2006b) in this portion of the watershed, riparian restoration and cattle fencing should be a priority to enhance and protect water quality in the headwaters.

4) SIXTEEN MILE CREEK ABOVE THE NIAGARA ESCARPMENT (REMAINDER OF THE WATERSHED): The Sixteen Mile Creek watershed above the Niagara Escarpment contains many areas with high to moderate suitability for riparian restoration. Many of the stream courses without riparian buffers traverse agricultural fields including pasture land. In its Fifteen-Sixteen-Eighteen Mile Creeks Watershed Geomorphic Assessment (NPCA 2006b), the NPCA reported that farm level crossings are in very poor condition in this section of the watershed, and vegetative buffers in both urban and rural areas are lacking, which is contributing to erosion, sedimentation and poor water quality. As a result, priority should be placed on riparian restoration in this portion of the watershed to improve stream morphology and improve water quality through the reduction of sediment entering the stream. High to moderate restoration suitability is also found throughout this portion of the Sixteen Mile Creek watershed for wetland and upland restoration. However, given the results of the Geomorphic Assessment (NPCA 2006b) for this watershed, attention should first be placed on riparian creation to improve water quality.

TABLE 8: SIXTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND AND ECOLOGICAL LINKAGES
BELOW THE NIAGARA ESCARPMENT (INCLUDING SIXTEEN MILE POND)	• Many sections of the eastern branch of Sixteen Mile Creek and its tributaries run through agricultural lands with little or no buffers; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat along the length of the watercourse before discharging to Lake Ontario • Riparian restoration should focus on the east branch and its tributaries that traverse agricultural fields and flow directly into Sixteen Mile Pond to improve water quality	• Enhance existing wetlands as natural flood storage reservoirs • Enhance Sixteen Mile Pond wetland communities	• Highly suitable upland restoration areas adjacent to the main branch of Sixteen Mile Creek and Sixteen Mile Pond, which will enhance the existing riparian buffer thereby improving water quality, habitat diversity and protect the wetland communities in Sixteen Mile Pond • Maintain and enhance ecological corridor from Niagara Escarpment to Sixteen Mile Pond • Create and enhance Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187 identified ecological connections along the western branch of Sixteen Mile Creek extending to the Niagara Escarpment • Carolinian and native species should be used in all restoration projects
NIAGARA ESCARPMENT CORRIDOR	• Riparian habitat is well established in this section of the watershed; focus should be on maintenance and enhancement and protecting Carolinian and rare species in the Fifteen-Sixteen Mile Creeks Valleys ANSI	• Wetland suitability is low due to topography and physiography in this section of the watershed	• Upland suitability mapping indicates a high suitability for upland restoration adjacent to natural heritage areas; focus should be on increasing core size of natural heritage areas, filling in gaps between adjacent areas and creating ecological linkages with adjacent watersheds that are consistent with Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187(e.g., enhance and join cluster of natural areas between Sherk and Bossart Roads. A possible contiguous extending from north of Baker Street north to Miller Street in Usshers Creek subwatershed) • Carolinian and native species should be used in all restoration projects

TABLE 8: SIXTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND AND ECOLOGICAL LINKAGES
ABOVE THE NIAGARA ESCARPMENT - HEADWATERS	• High to moderate suitability for riparian restoration in the headwaters portion of this watershed • Many sections of the headwater tributaries run through agricultural lands with little or no buffers; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat • Given the lack of buffers in this portion of the watershed, riparian restoration and livestock fencing should be a priority to improve water quality in the headwaters	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit	• High suitability for upland plantings in this portion of the watershed, which are concentrated adjacent to existing natural heritage areas and along watercourses • Restoration should focus on areas adjacent to existing natural heritage areas to create larger contiguous forested areas, and along the tributaries of Sixteen Mile Creek to buffer the creek and create ecological corridors consistent with Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187 identified ecological connections along the western branch of Sixteen Mile Creek linking the Sixteen Mile Creek headwaters with the Fifteen Mile Creek headwaters • Carolinian and native species should be used in all restoration projects
ABOVE THE NIAGARA ESCARPMENT – REMAINDER OF THE WATERSHED	• High to moderate suitability for riparian restoration in this portion of the watershed • Many sections of stream running through agricultural lands with little or no buffer; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat • Riparian buffers in rural estate areas are also lacking and riparian habitat should be established in these areas	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit; priority should be given to areas where wetlands already exist or adjacent to forested areas to create larger contiguous habitat areas (e.g., in the southern portion of the watershed above the Niagara Escarpment along tributaries north of Sixteen Road)	• High suitability for upland restoration is this portion of the watershed adjacent to existing natural heritage areas (concentrated just north of Sixteen Road) to create larger contiguous forested areas, and along the tributaries of Sixteen Mile Creek to buffer the creek and create ecological corridors consistent with Carolinian Canada's "Big Picture" and Regional Niagara's Regional Policy Plan Amendment 187)identified ecological corridors • Carolinian and native species should be used in all restoration projects

TABLE 8: SIXTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
GEOMORPHIC ASSESSMENT STUDY (NPCA 2006)	The Fifteen-Sixteen-Eighteen Mile Creek Watersheds Geomorphic Assessment (NPCA 2006b) identified several erosion and sediment accumulation sites in the Sixteen Mile Creek Watershed (Appendix B): 1. Fourth Avenue/Eleventh Avenue (Reach 16MCEe): This reach is located adjacent to residential properties and it contains a small area with no riparian buffer. Sediment deposits in the creek are present and a large number of debris jams were identified in the creek, which can cause lateral adjustments to the channel. Recommendations for this site include establishing a riparian buffer adjacent to the residential properties. 2. King Street/Ninth Avenue (Reach 16MCEtb): A lack of a riparian buffer adjacent to residential properties exists at this site, and the slope of the streambed is likely to contribute to bank erosion. A fish barrier is located at this site in the form of an earthen berm impoundment with a spillway. The recommendation for this site includes increasing the size of the riparian buffer. 3. King Street/Eleventh Avenue (Reach 16MCEtd): Channel erosion has created a fish barrier at the King Street culvert at this site. The slope of the Niagara Escarpment is likely to lead to high shear stresses and the bank soils have a high susceptibility to erosion. The riparian buffer is also not very wide adjacent to residential properties at this site. Recommendations for this reach include increasing the width and diversity of species in the riparian buffer, and repairing the depth of the King Street culvert so that it no longer acts as a fish barrier. 4. Moote Road/Twenty Mile Road (Reach 16MCMc): Sediment has accumulated along the streambed of this reach. In addition, downstream of Moote Road there is only a few scatterings of woody vegetation along the banks of the creek. Recommendations for this site include increasing the width and diversity of the riparian buffer. 5. Maple Street/Twenty Mile Road (Reach 16MCMe): The streambed is flat at this site and sediment deposition is occurring upstream. Evidence of planimetric form adjustment (e.g., flood chute, large depositional feature) is evident in the upstream portion of this reach. This degree of sediment accumulation can cause lateral channel adjustments. Recommendations for this reach include further investigation of upstream reaches to determine where sediment may be entering the channel. 6. Adjacent to Staff Avenue (Reach 16MCMf): The main concern for this reach is the accumulation of sediment along the streambed which may have an impact on fish and invertebrates due to the large quantity of sediment found here. It is recommended that potential upstream sources of sediment be determined so remedial actions can be initiated. 7. Louth Conservation Area (Reach 16MCMg): Water quality was the main concern identified during field work for this site due to the presence of algae on boulders/cobbles on the streambed. Therefore, it is recommended that water quality continue to be monitored in this watershed. 8. King Street – Big Valley Campground (Reach 16MCMh): The slope of the Niagara Escarpment at this site may lead to high shear stresses, and bank soils have high susceptibility to erosion. Very little riparian vegetation is present at this site as well. The double culvert located here may act as a fish barrier. Recommendations for this site include encouraging the landowner to stop mowing the grass to the edge of the creek, and try to establish a riparian buffer. The double culvert should also be replaced. 9. Silverdale Road (Reach 16MCMta): This headwaters stream has a number of debris jams in the channel, but this reach still lacks deep pools, boulders/cobbles, and other features needed for fish/invertebrate habitat that should otherwise occur here. Restoration at this site should focus on improving fish and invertebrate habitat. Sediment accumulation has been identified along the stream bed in some of the reaches. Possible sources of excess sediment include: severe bank erosion; no vegetative buffer zone adjacent to streams in agricultural fields; improperly built crossings; and cattle accessing the stream bank. By identifying these sources, either by visual inspection in the field or through the use of computer programs such as AGNPS, restoration techniques can be applied. Restoration priorities for the Sixteen Mile Creek Watershed include enhancing the size of the riparian buffer and increasing the variety and diversity of native plant species. This will help prevent bank erosion, control the amount of sediment entering the stream from runoff, and filter any pollutants that may enter the stream. Fish barriers should be removed if they are impacting fish movement throughout the watershed and cattle should be prevented from entering the stream. Water quality should continue to be monitored in this watershed.

TABLE 8: SIXTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
WILDLIFE CORRIDOR ENHANCEMENT OF THE FIFTEEN, SIXTEEN, AND EIGHTEEN MILE CREEKS	The Wildlife Corridor Enhancement Project of the Fifteen, Sixteen and Eighteen Mile Creeks is currently underway in the watershed. This project is lead by the Niagara Restoration Council (NRC) and the NPCA is one of the project partners. This project commenced in the Fall 2005, and in conjunction with its project partners, the NRC will plant 50,000 native trees in the watershed. The goals of this project are to restore forest habitat through the connection of existing forest patches; protect and conserve existing forests via various land conservation tools, including tax incentive programs for landowners; and participate in informational events to educate the public and landowners about the significance of forests.
REGIONAL ROADS - ROAD SALT IMPACTS	The Regional Municipality of Niagara has completed a Salt Study for its Regional Roads (Ecoplans Ltd. 2005). Regional roads below the escarpment are ranked as having a high vulnerability due to the location of groundwater discharge areas resulting from sandy soils. Surface water risk from salt along Regional roads above and below the escarpment is considered moderate to moderately low in the Fifteen-Sixteen-Eighteen Mile Creeks watershed (Ecoplans Ltd. 2005). Riparian restoration should be targeted at watercourses and wetlands along regional roads to lessen the impacts from road salt on water quality and aquatic habitat. In addition, areas that support natural heritage features and agricultural areas should also be investigated and remediated to lessen the impacts of salt on these land features/uses.
FISH BARRIER REMOVAL	Dams, weirs, floodgates, and road crossings act as barriers to fish passage. They block the channel and can make areas of habitat inaccessible to all aquatic organisms, thereby reducing breeding opportunities for many native species, and they can cause an increase in competition and predation. As part of the Fifteen-Sixteen-Eighteen Mile Creek Watershed Geomorphic Assessment (NPCA 2006), several human-made fish barriers have been identified. These sites should be reviewed and where possible, the barrier should be removed to optimize the passage of fish. An additional study should also be conducted to determine all barriers to fish movement in the Sixteen Mile Creek watershed.
SPECIAL STUDIES	**RECOMMENDATIONS FOR FURTHER STUDY**
SIXTEEN MILE POND FISH AND AQUATIC HABITAT STUDY	Additional studies pertaining to fish species and aquatic habitat would be beneficial to determine the health of the pond and wetland, and to determine the effects of Lake Ontario on the fish population, any impacts resulting from the Queen Elizabeth Way (QEW), and suitable restoration actions for Sixteen Mile Pond (Barrett, Personal Communication). Once completed, recommendations from this study should be implemented to improve water quality and fish habitat especially in known fish spawning areas.
MUNICIPAL DRAIN MAINTENANCE BEST MANAGEMENT PRACTICES	A portion of Sixteen Mile Creek in the vicinity of St. Ann's has been dredged in the past, and there are future plans to dredge this portion of the creek again (Johnson, Personal Communication). Best Management Practices for drain maintenance should be developed in consultation with the Ministry of Natural Resources, Department of Fisheries and Oceans, NPCA, municipalities and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain.
MUNICIPAL ROADS ROAD SALT IMPACT STUDIES	The Regional Municipality of Niagara has already completed a Salt Vulnerability Study for its roads (see above). It is recommended that local municipalities complete similar studies to determine the impacts from road salt applications on municipal roads to groundwater sensitive areas, surface water resources, natural heritage areas and agricultural crops.

TABLE 8: SIXTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

SPECIAL STUDIES	RECOMMENDATIONS FOR FURTHER STUDY
REGIONAL NIAGARA IRRIGATION STUDY	The Regional Niagara Raw Water for Irrigation Feasibility Study (Stantec Consulting Ltd) commenced in 2005. The Sixteen Mile Creek watershed falls within the West District of this study including the lands below the Niagara Escarpment and above the Niagara Escarpment. Recommendations for irrigation water takings include taking water from Lake Ontario and/or Jordan Harbour; a pipeline distribution system with an intake from Lake Ontario; and the creation of off stream reservoirs close to major water sources (Lake Ontario). Additional studies are underway by Regional Niagara to determine a suitable alternative for irrigation water in this area. Any recommendations from the Irrigation Study should be reviewed prior to implementation to ensure a sustainable supply of water for human and ecological use in the watershed.
GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES	The Groundwater Study (NPCA 2005) has identified several areas with high intrinsic susceptibility (Figure 14). The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Additional studies should be conducted in this watershed to ensure that current and future land uses do not conflict with the protection of groundwater resources in susceptible areas as part of the NPCA's Groundwater Study (2005) and proposed Source Water Protection Plan.
RIPARIAN BUFFER EDUCATION PROGRAM	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
SEPTIC SYSTEM EDUCATION AND FUNDING PROGRAM	Improperly maintained septic systems have been identified as a concern in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Improperly functioning septic systems and abandoned septic systems are a known threat to water quality. A septic system education and funding program should be developed and implemented to ensure that private septic systems are functioning properly, and to ensure that abandoned systems are decommissioned.
ABANDONED WELL DECOMMISSIONING PROGRAM	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). In the Sixteen Mile Creek subwatershed, any abandoned wells along bedrock outcrops south of Tintern Street should be given priority for decommissioning. Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
AGRICULTURAL BEST MANAGEMENT PRACTICES PROGRAM	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted in the Sixteen Mile Creek subwatershed. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA has developed stormwater management policies for its jurisdiction for use by Regional Niagara and its municipalities.

EIGHTEEN MILE CREEK RESTORATION STRATEGY

The Eighteen Mile Creek watershed is relatively small in comparison to the Fifteen and Sixteen Mile Creek watersheds. However, riparian, wetland and upland restoration opportunities abound in this small watershed. For example, like the Fifteen and Sixteen Mile Creek watersheds, numerous agricultural areas are without riparian buffers, with the greatest need for riparian cover located above the Niagara Escarpment (NPCA 2006b). Wetland suitability is also highest above the Niagara Escarpment, although the extent of wetland suitability is not as great in comparison to the other two watersheds. Several areas of upland restoration suitability exist in this watershed with ample suitable areas above and below the Niagara Escarpment, which is especially important for creating ecological linkages between existing natural areas for the movement of wildlife and to enhance habitat diversity. Opportunities for ecological restoration and enhancement are abundant in the Eighteen Mile Creek watershed provided public and private partnerships can be established in the watershed. Maintaining and enhancing the integrity of the Carolinian forest community is also a priority in this watershed.

The Eighteen Mile Creek Watershed Restoration Strategy identifies three zones with specific stewardship and restoration recommendations (Table 9).

1) EIGHTEEN MILE CREEK BELOW THE NIAGARA ESCARPMENT: The streams in the lower portion of the watershed do not have adequate riparian buffers. Most of the streams in this portion of the watershed flow through agricultural fields. Riparian buffers will enhance water quality by reducing the amount of sediment and agricultural runoff entering Eighteen Mile Creek and its tributaries. Wetland suitability is not high in this portion of the Eighteen Mile Creek watershed. However, wetland enhancement and creation is suitable near the mouth of the Eighteen Mile Creek pond where the QEW crosses over the pond. All wetland areas in this portion of the watershed would benefit from ecological enhancement and protection because this area has been delineated as a potential groundwater discharge area (Figure 13). Upland restoration is most suitable north of Fourth Avenue in this portion of the watershed. Given the predominately rural/agricultural nature of this watershed, reforestation should focus on retired agricultural lands.

2) EIGHTEEN MILE CREEK - NIAGARA ESCARPMENT CORRIDOR: Given the high forest cover on the Niagara Escarpment, riparian cover in this section of the Eighteen Mile Creek watershed is well established. Wetland suitability is low due to the physiography and topography of the Niagara Escarpment. Upland suitability is high for the escarpment portion of the watershed, and it is especially important to establish a diversity of habitat, larger contiguous forested areas for the movement of wildlife, and to enhance ecological corridors along the Niagara Escarpment.

3) EIGHTEEN MILE CREEK ABOVE THE NIAGARA ESCARPMENT (REMAINDER OF THE WATERSHED): The Eighteen Mile Creek watershed above the Niagara Escarpment contains many areas with high to moderate suitability for riparian restoration. Many of the stream courses without riparian buffers traverse agricultural fields including pasture land. In its Fifteen-Sixteen-Eighteen Mile Creeks Watershed Geomorphic Assessment (NPCA 2006b), the NPCA reported that farm level crossings are in very poor condition in this portion of the watershed, and vegetative buffers in rural areas are lacking, which is contributing to erosion, sedimentation and poor water quality. As a result, priority should be placed on riparian restoration in this section of the watershed to improve stream morphology and improve water quality through the reduction of sediment entering the stream. High to moderate restoration suitability is also found throughout this portion of the Eighteen Mile Creek watershed for wetland and upland restoration. However, given the results of the Geomorphic Assessment (NPCA 2006b) for this watershed, attention should first be placed on riparian creation to improve water quality.

TABLE 9: EIGHTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND AND ECOLOGICAL LINKAGES
BELOW THE NIAGARA ESCARPMENT	• Many sections of the main branch of Eighteen Mile Creek and its tributaries run through agricultural lands with little or no buffers; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat along the length of the watercourse before discharging to Lake Ontario	• Enhancement of the wetland near the QEW • An area of wetland suitability exists south of Honsberger Avenue that is currently under cultivation	• Highly suitable upland restoration areas north of Fourth Avenue • Create an ecological corridor from Niagara Escarpment to the outlet of Eighteen Mile Creek at Lake Ontario • Carolinian and native species should be used in all restoration projects
NIAGARA ESCARPMENT CORRIDOR	• Riparian habitat is well established in this section of the watershed; focus should be on maintenance and enhancement of existing riparian habitat	• Wetland suitability is low due to topography and physiography in this section of the watershed	• High suitability for upland restoration adjacent to natural heritage areas; focus should be on increasing core natural heritage areas and ecological linkages along the Niagara Escarpment with adjacent watersheds • Carolinian and native species should be used in restoration projects
ABOVE THE NIAGARA ESCARPMENT – REMAINDER OF THE WATERSHED	• High to moderate suitability for riparian restoration in this portion of the watershed • Many sections of stream running through agricultural lands with little or no buffer; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit; priority should be given to areas where wetlands already exist or adjacent to forested areas to create larger contiguous habitat areas (e.g., high suitability south of Ninth Avenue near existing woodlots as well as west of Twenty-first Street)	• High suitability for upland restoration scattered throughout this portion of the watershed adjacent to existing natural heritage areas • Focus should be on creating larger contiguous forested areas, and along the tributaries of Eighteen Mile Creek to buffer the creek and create ecological corridors • Given the lack of riparian buffers in this portion of the watershed, attention should be given to suitable areas with watercourses flowing through them • Carolinian and native species should be used in all restoration projects

TABLE 9: EIGHTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
GEOMORPHIC ASSESSMENT STUDY (NPCA 2006)	The Fifteen-Sixteen-Eighteen Mile Creek Watersheds Geomorphic Assessment (NPCA 2006b) identified several erosion and sediment accumulation sites in the Eighteen Mile Creek watershed (Appendix B): 1. Below the Escarpment at King Street (Reach 18MCMc): Agricultural fields upstream from this reach may contribute to the presence of algae noted during the site visit in 2006. In addition, the riparian buffer lacks variety and is not very wide at this site. The slope of the Niagara Escarpment is high and bank soils have a high susceptibility to erosion as a result. Due to the presence of algae and the possibility of upstream agricultural runoff, it is recommended that water quality continue to be monitored in this watershed. In addition, the width of the riparian buffer should be increased and the variety of species should also be increased to create a more diverse ecological habitat. Two severe erosion sites found in this reach should be monitored and additional engineering studies to stabilize the banks should be undertaken. 2. Fourth Avenue/Fifteenth Street (Reach 18MCMd): Agricultural fields upstream from this reach may contribute to the presence of algae noted during the site visit in 2006. In addition, the riparian buffer lacks variety and is not very wide. A stone weir located within this reach acts as a grade control, but it may also act as a barrier to fish movement. Due to the presence of algae and the possibility of upstream agricultural runoff, it is recommended that water quality continue to be monitored in this watershed. In addition, the width of the riparian buffer should be enhanced and the variety of species should be increased to create a more diverse ecological habitat. The stone weir should also be removed if it is acting as a barrier to fish movement. 3. Red Maple Avenue (Reach 18MCMf): This reach represents the confluence of the west and east branches of Eighteen Mile Creek. The bank soils in this reach have a high susceptibility to erosion, and this instability is causing vegetation to collapse into the stream, which is creating debris jams. The channel is incised and flows cannot access the floodplain. Therefore, the energy within the flow is contained in the channel. Recommendations for this site include developing and installing structural measures to deflect water flow from the stream banks. For example, weirs can be placed along the bed to reduce stream flow velocity. Living cribwalls may also have to be constructed on the outside bends of the stream bank due to the severe erosion that is taking place. 4. Downstream of Nineteenth Street (Ball's Falls property) (Reach 18MCWc): Agricultural fields upstream from this reach may contribute to the presence of algae noted during the site visit in 2006. This site has some bank erosion present in its upstream section likely due to the soils having a medium susceptibility to erosion. Recommendations for this site include continuing to monitor water quality and plant native species that have deeper and stronger root systems along the stream bank. Restoration priorities for the Eighteen Mile Creek Watershed include enhancing the size of the riparian buffer and increasing the variety and diversity of native plant species. This will help to prevent bank erosion, control the amount of sediment entering the stream from runoff, and filter any pollutants that may enter the stream. Fish barriers should be removed if they are impacting fish movement throughout the watershed. Water quality should continue to be monitored in this watershed.
WILDLIFE CORRIDOR ENHANCEMENT OF THE FIFTEEN, SIXTEEN, AND EIGHTEEN MILE CREEKS	The Wildlife Corridor Enhancement Project of the Fifteen, Sixteen and Eighteen Mile Creeks is currently underway in the watershed. This project is lead by the Niagara Restoration Council (NRC) and the NPCA is one of the project partners. This project commenced in the Fall 2005, and in conjunction with its project partners, the NRC will plant 50,000 native trees in the watershed. The goals of this project are to restore forest habitat through the connection of existing forest patches; protect and conserve existing forests via various land conservation tools, including tax incentive programs for landowners; and participate in informational events to educate the public and landowners about the significance of forests.

TABLE 9: EIGHTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
REGIONAL ROADS -ROAD SALT IMPACTS	The Regional Municipality of Niagara has completed a Salt Study for its Regional Roads (Ecoplans Ltd. 2005). Regional roads below the escarpment are ranked as having a high vulnerability due to the location of groundwater discharge areas resulting from sandy soils. Surface water risk from salt along Regional roads above and below the escarpment is considered moderate to moderately low in the Fifteen-Sixteen-Eighteen Mile Creeks watershed (Ecoplans Ltd. 2005). Riparian restoration should be targeted at watercourses and wetlands along regional roads to lessen the impacts from road salt on water quality and aquatic habitat. In addition, areas that support natural heritage features and agricultural areas should also be investigated and remediated to lessen the impacts of salt on these land features/uses.
FISH BARRIER REMOVAL	Dams, weirs, floodgates, and road crossings act as barriers to fish passage. They block the channel and can make areas of habitat inaccessible to all aquatic organisms, thereby reducing breeding opportunities for many native species, and cause an increase in competition and predation. As part of the Fifteen-Sixteen-Eighteen Mile Creek Watershed Geomorphic Assessment (NPCA 2006), several human-made fish barriers have been identified. These sites should be reviewed and where possible, the barrier should be removed to optimize the passage of fish. An additional study should also be conducted to determine all barriers to fish movement in the Eighteen Mile Creek watershed.
SPECIAL STUDIES	**RECOMMENDATIONS FOR FURTHER STUDY**
MUNICIPAL ROADS ROAD SALT IMPACT STUDIES	The Regional Municipality of Niagara has already completed a Salt Vulnerability Study for its roads (see above). It is recommended that local municipalities complete similar studies to determine the impacts from road salt applications on municipal roads to groundwater sensitive areas, surface water resources, natural heritage areas and agricultural crops.
REGIONAL NIAGARA IRRIGATION STUDY	The Regional Niagara Raw Water for Irrigation Feasibility Study (Stantec Consulting Ltd) commenced in 2005. The Eighteen Mile Creek watershed falls within the West District of this study including the lands below the Niagara Escarpment and above the Niagara Escarpment. Recommendations for irrigation water takings include taking water from Lake Ontario and/or Jordan Harbour; a pipeline distribution system with an intake from Lake Ontario; and the creation of off stream reservoirs close to major water sources (Lake Ontario). Additional studies are underway by Regional Niagara to determine a suitable alternative for irrigation water in this area. Any recommendations from the Irrigation Study should be reviewed prior to implementation to ensure a sustainable supply of water for human and ecological use in the watershed.
GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES	The Groundwater Study (NPCA 2005) has identified several areas with high intrinsic susceptibility (Figure 14). The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Additional studies should be conducted in this watershed to ensure that current and future land uses do not conflict with the protection of groundwater resources in susceptible areas as part of the NPCA's Groundwater Study (2005) and proposed Source Water Protection Plan.
RIPARIAN BUFFER EDUCATION PROGRAM	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.

TABLE 9: EIGHTEEN MILE CREEK WATERSHED RESTORATION ACTIONS

SPECIAL STUDIES	RECOMMENDATIONS FOR FURTHER STUDY
SEPTIC SYSTEM EDUCATION AND FUNDING PROGRAM	Improperly maintained septic systems have been identified as a concern in the Fifteen-Sixteen-Eighteen Mile Creeks watershed. Improperly functioning septic systems and abandoned septic systems are a known threat to water quality. A septic system education and funding program should be developed and implemented to ensure that private septic systems are functioning properly, and to ensure that abandoned systems are decommissioned.
ABANDONED WELL DECOMMISSIONING PROGRAM	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). In the Eighteen Mile Creek subwatershed, any abandoned wells along bedrock outcrops north of Seventh Avenue should be given priority for decommissioning. Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
AGRICULTURAL BEST MANAGEMENT PRACTICES PROGRAM	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted in the Eighteen Mile Creek subwatershed. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA has developed stormwater management policies for its jurisdiction for use by Regional Niagara and its municipalities.

IMPLEMENTATION RESPONSIBILITIES AND RECOMMENDED MANAGEMENT ACTIONS

The above Fifteen-Sixteen-Eighteen Mile Creeks restoration strategy is of no use unless it is guided by an implementation framework. An implementation framework follows that has been designed to account for the watershed plan objectives, which were derived from key issues in the watershed and extensive public input. The implementation framework is guided by the Government of Canada's vision for integrated community sustainability planning, which envisions all parties involved to focus limited financial and human resources in ways that well best serve common objectives at all levels of government (Godfrey 2005). To this end, the implementation framework identifies project stakeholders (e.g., provincial agencies, regional government watershed municipalities, public interest groups and landowners), and recommended management actions for each watershed plan objective.

IMPLEMENTING THE RECOMMENDED ACTIONS

Lead project stakeholders and those who should be involved in the project have been identified in the following framework. The recommended management actions for the Fifteen-Sixteen-Eighteen Mile Creeks watershed include planning and regulatory actions (e.g., Official Plan amendments), project opportunities on private and public lands (e.g., riparian buffer planting, wetland creation), and areas requiring additional research and monitoring (e.g., ecological linkages, geomorphic assessments) in the watershed. The cost of most projects is identified in the table. If the project is identified as ongoing then it is likely an action that requires continual updating such as the five year review process for regional and municipal Official Plans, which is not allocated a dollar amount. If an existing program already has funding, and the project and funding have a termination date, then these projects have a specific dollar amount attached to them. In addition, funds allocated as part of annual budgeting have also been assigned dollar amounts.

The recommended actions have also been identified in terms of their implementation. Green denotes short term implementation, yellow represents medium term implementation and red is used to indicate long term implementation. For example, projects that are ongoing are almost always implemented over the long term and are therefore, represented in red. Projects that have specific funding requirements or require approvals, for example, are often represented in green and yellow, thereby indicating short term or medium term implementation respectively.

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS											RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
WATER RESOURCES	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Maintain, enhance or restore natural stream processes to support human uses, agricultural needs and ecological functions in accordance with Ontario Water Quality Objectives		▲	▲									Include water quality protection in regional and municipal planning documents		ONGOING
	▲	●	●	▲	●			●				Continue to restrict no new on-line pond construction		ONGOING
	▲	▲	▲			●	●		●	●	●	Continue to monitor water quality to achieve Ontario Water Quality Objectives		6,000/yr
Protect, improve or restore all vulnerable areas (surface and groundwater features that can be easily changed or impacted by activities or events)	▲	●	●	●	●	●	●		●	●		Develop and implement a Source Water Protection Plan		EXISTING FUNDING
	▲	●	●		●	●	●					Implement the Groundwater Management and Protection Strategy proposed in the Groundwater Study (NPCA 2005)		EXISTING PROGRAM
	▲	●	●		●	●	●					Develop and implement a specific Groundwater and Management Protection Strategy for medium and high susceptibility areas identified in the Groundwater Study (NPCA 2005)		EXISTING FUNDING
	▲	●	●			●				●	●	Continue to implement the water well decommissioning program in the Fifteen-Sixteen-Eighteen Mile Creeks watershed		EXISTING FUNDING
	▲	●	▲			●						Identify and map surface and groundwater "hot spots" to determine areas with poor water quality including salt vulnerable areas		EXISTING FUNDING
		▲	▲						●		●	Develop and adopt by-laws for the elimination of lawn fertilizers, pesticides and herbicides		ONGOING
	▲		▲						●	●	●	Implement a septic system awareness and educational program		15,000/yr**
	▲			●	●	●						Examine the ongoing effect of quarries on groundwater, the impacts when they cease dewatering, and the potential for long-term augmentation of base flows		ONGOING
	●	▲	▲									Incorporate surface and groundwater protection policies into regional and municipal planning documents		ONGOING
Ensure the equitable distribution and sustainable use of available surface and groundwater to protect water quality and quantity, aquatic and terrestrial ecosystems, and human health and to supply existing and planned uses including municipal drains	●	●	●			▲			●	●	●	Improve monitoring of base flows and water use (e.g., Permit to Take Water)		ONGOING
	▲	●	●		●	●	●					Subwatershed scale data input (e.g. continuous surface water flows) for calibration of the Source Water Protection Water Budget and Balance		50,000/yr
	▲	●	▲		●			●		●		Review and thoroughly investigate the recommendations from the second phase of the Feasibility Study – Raw Water for Agricultural Irrigation Purposes		EXISTING PROGRAM

LEGEND

▲ LEAD STAKEHOLDER
● INVOLVED STAKEHOLDER
SHORT TERM
MEDIUM TERM
LONG TERM

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS											RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
WATER RESOURCES	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Ensure that storm water management practices minimize storm water volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces		▲	▲									Implement NPCA Stormwater Policies and BMPs into regional and municipal planning documents		ONGOING
		▲									●	Implement downspout disconnection by-laws for settlement areas in the Town of Lincoln, Town of Pelham and Township of West Lincoln		100/downspout 600/home
		▲	▲								●	Create, fund and implement an urban rain barrel program for settlement areas		60/home
Manage and mitigate flooding risks to human life and property within acceptable limits	▲	●	●	●						●	●	Continue to permit no new development in the 1 in 100 year floodplain		ONGOING
	▲	●	●									Maintain NPCA flood warning system		ONGOING
	▲	●	●							●	●	Continue to implement regulations adopted under Section 28 of the Conservation Authorities Act		ONGOING
Minimize erosion caused by human activity through the establishment and implementation of a comprehensive, priority based erosion control program	▲	●	●		●				●	●	●	Implement the recommended restoration actions outlined in the Fifteen-Sixteen-Eighteen Mile Creeks Watershed Geomorphic Assessment (NPCA 2006		10,000/yr
Maintain, improve and provide opportunities for farm-related infrastructures such as drainage and irrigation	▲				▲			▲			●	Where legislation permits, maintain stream flows by removing debris and sediment in watercourses		2,400/yr**
FISH & AQUATIC HABITAT														
Protect, enhance and restore populations of native species and their habitats in the watershed	▲	●	●		●			●	▲	●	●	Remove barriers to fish movement		20,000
	▲	●	●		●			●	●			Develop a Fisheries Management Plan for the Fifteen-Sixteen-Eighteen Mile Creeks watershed		45,000
	●			▲	▲	▲		●	●	●	▲	Where possible, remove, relocate or modify online ponds		10,000
	▲								●	●	▲	Plant riparian buffer strips around watercourses and wetlands		12,000/yr (5,000/250m)**

LEGEND

▲ LEAD STAKEHOLDER
● INVOLVED STAKEHOLDER
SHORT TERM
MEDIUM TERM
LONG TERM

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS											RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
NATURAL HERITAGE AND RESOURCES	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Protect, enhance and restore the health, diversity and ecological functions of the natural heritage systems in the watershed and their linkages to natural heritage systems in adjoining watersheds	▲	●	●	●	●				▲		●	Complete a comprehensive biological inventory and map of natural heritage areas including wetlands		EXISTING FUNDING
	▲								▲	▲	▲	Implement the upland reforestation program based on upland suitability mapping targeting interior forest expansion, and ecological linkage opportunities		25,500/yr (1,500/acre)**
Maintain, restore and improve the linkages among surface water features, groundwater features, hydrologic functions and natural heritage features and areas, and their ecological functions	▲	▲	▲	●					●	●	●	Utilize conservation easements, land dedication and acquisition to secure critical linkages as desired lands become available for purchase		EXISTING FUNDING
	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲		Continue partnership building with public interest groups to access funding for reforestation programs (e.g., NRC)		ONGOING
Preserve all wetlands in the watershed	▲	▲	▲	▲								Continue review of new developments and building permits; ensure compliance with PPS and NPCA Generic Regulations		ONGOING
	▲	●	●		▲			●	▲	▲	▲	Create new wetlands or enlarge existing wetlands based on wetland suitability mapping		15,000/yr 15,000/project**
Research and recommend management practices for invasive species (flora and fauna)	▲	●	●	▲	▲				▲		●	Identify the extent of both flora and fauna invasive species in the Fifteen-Sixteen-Eighteen Mile Creeks watershed and make scientific recommendations for their removal		ONGOING
COMMUNICATION, EDUCATION AND RECREATION														
Foster and develop partnerships between and amongst agencies, interest groups and landowners	▲	●	●						●	●	●	Continue to recognize groups and individuals for their environmental efforts in the Fifteen-Sixteen-Eighteen Mile Creeks watershed		ONGOING
	▲	●	●									Present Watershed Plan findings and successes to regional and municipal government officials and policy makers		ONGOING
	▲	●	●	●	●	●	●	●	●	●	●	Develop communication networks with agricultural groups, Niagara College, Brock University, and others for information sharing and project implementation		ONGOING
	▲								●	●	●	Continue the NPCA's Water Quality Improvement Program whereby landowners are provided with incentives to carry out projects on their lands		120,000/yr**
	▲	●	●	●	●				●	●	●	Assemble and meet with a Watershed Plan Implementation Committee made up of local representation (government agencies, organizations, landowners) to annually re-evaluate the Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan's components, and provide input on new or revised restoration initiatives in the watershed		ONGOING

LEGEND

▲ LEAD STAKEHOLDER
● INVOLVED STAKEHOLDER
SHORT TERM
MEDIUM TERM
LONG TERM

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS											RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
COMMUNICATION, EDUCATION AND RECREATION	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Promote awareness of the linkages between healthy water, healthy lifestyles and economic viability of rural and urban land uses Promote the wise use of groundwater and surface water resources in terms of human, agricultural and ecological needs	▲										▲	Continue creating demonstration sites to educate landowners about the water quality benefits of riparian buffers, wetlands and upland restoration		EXISTING PROGRAM
	●	▲	▲						▲		●	Disseminate material pertaining to alternative fertilizer use for residential lawns		EXISTING PROGRAM
	▲											Create and disseminate a Watershed Report Card highlighting restoration initiatives in the watershed after 3 to 5 years watershed plan implementation		12,000/Report Card
Maintain, create and promote existing and new outdoor recreational opportunities and areas	▲	▲	▲						▲			Seek partnerships with local recreation groups to determine suitable areas in the Fifteen-Sixteen-Eighteen Mile Creeks watershed for outdoor recreation opportunities		ONGOING
	▲	▲	▲						▲			Seek partnerships with public interest groups to improve natural heritage features and recreational opportunities in local parks (e.g., Friends of Charles Daley Park)		ONGOING
DEVELOPMENT														
Promote environmentally-sound land use decision making in the watershed for current and future urban development and rural/agricultural land use	●	▲	▲	●	●							Identify and incorporate significant natural areas and ecological linkages into planning documents and policies to ensure they are buffered from development		ONGOING
	▲	▲	▲	▲								Continue to implement NPCA Plan Input and Review Policies (NPCA 1993 as amended in 2003; 2005)		ONGOING

LEGEND

▲ LEAD STAKEHOLDER
● INVOLVED STAKEHOLDER
SHORT TERM
MEDIUM TERM
LONG TERM

* Includes project costs and NPCA salaries
** Based on grant ceiling under NPCA's Water Quality Improvement Program for landowners

MONITORING

Monitoring serves two purposes in watershed planning. Monitoring is required to update the watershed plan as land uses change and new issues are identified, and monitoring also serves to measure the success of restoration projects in terms of enhancing and protecting water quality for all users in a watershed. Monitoring the achievement of a watershed plan's objectives involves continually reviewing the Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan. The Plan will be reviewed by the NPCA Restoration Team and the Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan Implementation Committee (comprised of citizen, public interest groups, watershed municipalities, and agency representatives) annually. As part of the review process, the plan will be amended whenever necessary to reflect the changing environmental, economic, technical, or social trends within the jurisdiction of the NPCA, and more specifically within the Fifteen-Sixteen-Eighteen Mile Creeks watershed. A complete review and necessary revisions will occur ever 5 years.

In addition to monitoring the objectives or outcomes of the Watershed Plan, the monitoring process includes measuring the performance and success of the management actions used to achieve the objectives. In this regard, monitoring serves to collect and analyze aquatic, terrestrial and socio-economic data to identify changes in the watershed; both from restoration activities, and growth and development. This component of the monitoring program should include:

- Water quality sampling, benthic studies (BioMap), and water temperature monitoring through the NPCA's Water Quality Monitoring Program. This data can be used as an indicator of whether or not the recommendations provided in the Watershed Plan have maintained and/or improved the physical and chemical characteristics of water quality in the watershed. Continued groundwater monitoring should also be included as part of the water quality monitoring program.

- On-going classification of vegetative communities using standardized protocols (Ecological Land Classification). These habitat areas are recorded as Geographic Information System layers and are updated bi-annually to evaluate changes in community composition, habitat size and fragmentation.

- Biological life assessments (qualitative and quantitative) such as insects/pollinators, fish and birds.

- A compilation of the number and location of BMPs implemented in the watershed. This will also include pollutant loading reduction measurements. This information will be housed in a restoration database and updated as projects are completed.

- Watershed landowners should also be surveyed (at least every 5 years prior to the Watershed Plan review) to help watershed planners and the restoration team identify new watershed issues, and evaluate changes in knowledge and behaviour.

Land use and land use change in the watershed will also be evaluated. This can be completed using the Agricultural Non-Point Source Pollution (AGNPS) model. AGNPS is a computer model that is used for evaluating the effect of management decisions impacting a watershed system, such as predicting nonpoint source pollutant loadings within agricultural watersheds. For example, AGNPS can simulate the effects of various management practices on pollution in the watershed. The model can predict where runoff from rain, snowmelt, or irrigation may carry pesticides, fertilizers, or sediment throughout a watershed. The AGNPS model should be amended as land use change occurs, especially when those changes do not coincide with future land use planning.

The overall objectives of the Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan monitoring program are to:

- continually evaluate and amend the watershed plan whenever necessary to reflect changing environmental, economic, technical, or social trends;

- continually assess the overall health and water quality of watercourses;

- improve the AGNPS model calibration; and

- gauge the success of the restoration action plans in protecting and improving water quality and aquatic health.

TABLE 10: WATERSHED MONITORING SCHEDULE

TIME FRAME	ACTION
Monthly during ice free season(March-October)	Surface water quality sampling
Yearly	Project Monitoring: photos and notes of restoration projects are taken to document status of project (i.e., improvements, growth, change)
Typically every 3 years (spring and fall)	Biological Monitoring and Assessment Program sampling
5 Year Review	Review of the watershed plan: Investigation of identified issues and status of recommended actions is completed. Any new issues will be identified and an updated restoration strategy will be created.
Continuous Monitoring	Landowners are given a monitoring journal to document any changes they observe occurring in the project area.
Continuous Monitoring	Update Natural Heritage Information Database and GIS layers to reflect Natural Heritage Areas Inventory field surveys and project findings.

CONCLUSION

The Fifteen-Sixteen-Eighteen Mile Creeks watershed is a distinct watershed representing both an agricultural land base and unique Niagara Escarpment features. A wide-ranging set of watershed issues have been gathered resulting in a comprehensive set of watershed objectives that includes water resources; fish and aquatic habitat; natural heritage and resources; communication, education and recreation; and development.

The watershed objectives have formed the basis of restoration strategies at the watershed level for riparian, wetland and upland habitat that have been derived from detailed restoration suitability mapping. In addition, project opportunities on private and public lands have been identified such as erosion control and upland forest restoration to create ecological linkages between existing forested areas. Special studies, including policy tools and urban water conservation programs, have also been proposed.

The implementation plan identifies responsible stakeholders for each recommended management action. The recommended management actions have been organized to include riparian, wetland and upland restoration and creation to enhance water quality, fish habitat and recreation; specific policy tools including municipal and regional official plan amendments; outreach and communication for various aspects of water resources management; and research and monitoring programs to obtain additional data from which the Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan can be updated and revised every 5 years.

The Niagara Peninsula Conservation Authority will oversee the implementation of the Fifteen-Sixteen-Eighteen Mile Creeks watershed strategy and recommendations made in this report with the assistance of the Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan Implementation Committee, which is comprised of public interest groups, watershed municipalities, agencies and landowners. Watershed plan progress will be communicated annually by means of a qualitative report card that details progress in the watershed.

Together the watershed strategy and recommended management actions aim to contribute to supporting healthy natural areas, farms, watercourses, and habitat for a diversity of flora and fauna. Through this plan, the preservation, conservation and restoration of the watershed's ecosystem will protect society's resource needs by sustaining the ecological processes that naturally protect air, water and land resources. All of this will be achieved through environmental stewardship that fosters a collaborative approach to conservation that respects landowners while providing exciting opportunities for education and recreation for all citizens in the Fifteen-Sixteen-Eighteen Mile Creeks watershed.

REFERENCES

Brady, R.F. 1980. *Regional Municipality of Niagara Environmentally Sensitive Areas*. St. Catharines, Ontario: Department of Geography, Brock University.

British Columbia Ministry of the Environment, Environmental Protection Division. 2001. *British Columbia Approved Water Quality Guidelines (Criteria)*. British Columbia, Canada

Brown, E. A. Peterson, R. Kline-Robach, K. Smith and L. Wolfson. 2000. Developing a *Watershed Management Plan for Water Quality: An Introductory Guide.* Michigan Department of Environmental Quality, Surface Water Quality Division, Michigan.

Burghardt, A.F. 1969. The Origin and Development of the Road Network of the Niagara Peninsula, Ontario, 1770-1851. *Annals of the Association of American Geographers.* 59(3): 417-440.

Canadian Council of Ministers of the Environment. 1995. *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses.* Canadian Environmental Quality Guidelines.

Canadian Council of Ministers of the Environment. 2003. *Canadian Water Quality Guidelines for the Protection of Aquatic Life.* Canadian Environmental Quality Guidelines.

de Loë, R. and A. Berg. 2006. *Mainstreaming Climate Change in Drinking Water Source Protection Planning in Ontario.* Pollution Probe.

Ecoplans Limited. 2005. *Identification of Salt Vulnerable Areas, Regional Municipality of Niagara.* Prepared for the Regional Municipality of Niagara, Ontario.

Environment Canada. 2004a. *Code of Practice for the Environmental Management of Road Salts.* EPS 1/CC/5: Her Majesty the Queen in Right of Canada.

Environment Canada. 2004b. *Best Management Practices for Salt Use on Private Roads, Parking Lots and Sidewalks.* Her Majesty the Queen in Right of Canada.

Environment Canada. 2004c. *How Much Habitat is Enough?* Ministry of Public Works and Government Services Canada. Her Majesty the Queen in Right of Canada.

Fisheries and Oceans Canada. No Date. Working Around Water: A Class Authorization System for Agricultural Municipal Drains in the Southern Ontario Region. Canada.

Forsey, J. 1996. Lake Ontario Tributary Water Quality Monitoring Program For Twelve Mile Creek, Richardson Creek, Grapeview Creek, Fifteen Mile Creek, Sixteen Mile Creek, Eighteen Mile Creek and Twenty Mile Creek. Niagara Peninsula Conservation Authority, Allanburg, Ontario.

Godfrey, J. 2005. Integrated community sustainability planning: Bringing sustainable development to our cities and communities. *Municipal World*: November: 5-7.

Griffiths, R.W. 1999. BioMAP: *Bioassessment of Water Quality.* The Centre for Environmental Training, Niagara College. Niagara-on-the-Lake, Ontario.

Johnson, L. 2005. *Carolinian Canada: Signature Sites.* Carolinian Canada Coalition, London, Ontario. 79 pages.

Kingston, M.S. and E.W. Presant. 1989. *The Soils of the Regional Municipality of Niagara Volumes 1 and 2.* Report No. 60 of the Ontario Institute of Pedology. Ministry of Agriculture and Food and Agriculture Canada.

Kwicinski, J. and J. Littleton. 1989. *Wetland Data Record and Evaluation – 15 Mile Creek Above Escarpment.* Second Edition. Ministry of Natural Resources.

Kwicinski, T. and B. Thomas. 1987. *Wetland Data Record and Evaluation – Fifteen Mile Creek Headwaters.* Second Edition. Ministry of Natural Resources.

M.M. Dillon Ltd. and Atria Engineering Hydraulics. 1994. *Lake Ontario Shoreline Management Plan.* Prepared for the Niagara Peninsula Conservation Authority.

Monroe, W.H. 1970. *A Glossary of Karst Terminology.* U.S. Geological Survey, Water Supply Paper 1899.

Niagara Peninsula Conservation Authority. 1982. Master Plan: Beamer Memorial Conservation Area, Louth Conservation Area, Mountainview Conservation Area, Rockway Conservation Area, Woolverton Conservation Area, Allanburg, Ontario.

Niagara Peninsula Conservation Authority. 1993. *Resources Planning Program, Plan Input and Review Policies and Guidelines.* With amendments 2003 and 2005. Welland, Ontario.

Niagara Peninsula Conservation Authority. 2003. *Buffers are Better.* Brochure.

Niagara Peninsula Conservation Authority. 2006. *NPCA Water Quality Monitoring Program:* 2005 Annual Report. Welland, Ontario.

Niagara Peninsula Conservation Authority. 2006b. Fifteen-Sixteen-Eighteen Mile Creeks Watershed Geomorphic Assessment. Welland, Ontario.

Niagara Peninsula Conservation Authority. 2007. Application Form: *Water Well Decommissioning Program.* Welland, Ontario

Nottawasaga Valley Conservation Authority. 1995. *Nottawasaga Valley Watershed Plan.* Utopia, Ontario.

Ontario Historical Society. 1930. *The Search for Salt in Upper Canada.* Papers and Records, Vol. XXVI, Toronto, Ontario.

Ontario Ministry of Agriculture and Food. 1996. *10 Steps to Complete a Nutrient Management Plan for Livestock and Poultry Manure.* Queen's Printer for Ontario, Ontario.

Ontario Ministry of Agriculture and Food and Ontario Ministry of the Environment. *Nutrient Management Act.* S.O. 2002, Ontario Regulation 267/03.

Ontario Ministry of Agriculture, Food and Rural Affairs and Ontario Ministry of the Environment. 2003. N*utrient Management Protocol – Part 4, Introduction to Nutrient Management Strategies and Plans.* Queen's Printer for Ontario, Ontario, Canada.

Ontario Ministry of Agriculture, Food and Rural Affairs. 2004. *2004 Farm Class Property Class Tax Rate.* Queen's Printer for Ontario, Ontario, Canada.

Ontario Ministry of the Environment and Energy and Ontario Ministry of Natural Resources. 1993. *Water Management on a Watershed Basis: Implementing an Ecosystem Approach.* Queen's Printer for Ontario: Ontario, Canada.

Ontario Ministry of the Environment. *1994 Water Management, Policies, Guidelines and Provincial Water Quality Objectives.* Government of Ontario, Toronto

Ontario Ministry of Municipal Affairs and Housing. 2005a. *Provincial Policy Statement.* Queen's Printer for Ontario.

Ontario Ministry of Municipal Affairs and Housing. 2005b. *Greenbelt Plan.* Queen's Printer for Ontario.

Ontario Ministry of Public Infrastructure Renewal. 2006. *Places to Grow: A Guide to the Growth Plan for the Greater Golden Horseshoe.* Queen's Printer for Ontario.

Ontario Ministry of Natural Resources. No date. Natural Heritage Information Centre. Accessed online: nhic.mnr.gov.on.ca/MNR/nhic/areas, 18 May 2006.

Ontario Ministry of Natural Resources. No Date. *Significant Wetlands and the Ontario Wetland Evaluation System* Fact Sheet

Ontario Ministry of Natural Resources. *Niagara Escarpment Planning and Development Act.* R.S.O. 1990, Chapter N.2.

Ontario Ministry of Natural Resources. 1992. *Biological Inventory and Evaluation of the Fifteen and Sixteen Mile Creek Valleys Area of Natural and Scientific Interest.* Ministry of Natural Resources, Toronto, Ontario.

Ontario Ministry of Natural Resources. 2000. *Niagara Regional Municipality Fish Habitat Types with Management Rationale.* Niagara Area, Guelph District.

Ontario Ministry of Natural Resources. 2004. *Conservation Land Tax Incentive Program.* Backgrounder.

Ontario Ministry of Transportation. 1995. *MTO Drainage Management Manual Part 3/4.* Chapter 10: Introduction to Soil Bioengineering. Drainage and Hydrology Section. Transportation Engineering Branch, Quality and Standards Division.

Ontario Woodlot Association. 2005. *Success at Last! Changes to the Managed Forest Tax Incentive Program Reward Woodlot Owners.* News Release.

Pollution Probe. 2004. *The Source Water Protection Primer.* Written in partnership with the Ontario Ministry of Environment. Toronto, Ontario.

Regional Municipality of Niagara. 2003. *Regional Municipality of Niagara Regional Agricultural Economic Impact Study.* Prepared for the Regional Municipality of Niagara by Planscape in association with Regional Analytics Incorporated, B. Donald, Riley and Associates, and DBH Soil Services Incorporated.

Regional Municipality of Niagara. 2003. *Niagara Water Quality Protection Strategy, Final Technical Report (Volume 2).* Prepared for the Regional Municipality of Niagara by MacViro, Philips Engineering and CH2MHill.

Regional Municipality of Niagara. 2007. *Regional Niagara Policy Plan,* Thorold, Ontario

Rennie, A.J. 1966. *Corporation of the Township of Louth.* Louth Township Citizens Centennial Committee.

Riley, J.L., M.J. McMurtry, P.J. Sorrill, T.D. Sorrill, and J. Henson. 2003. *Big Picture 2002: Identifying Key Natural Areas and Linkages in Southern Ontario.* compact disc and poster. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario, and Nature Conservancy of Canada, Toronto, Ontario.

Stantec Consulting Limited. 2005. *Feasibility Study – Raw Water for Agricultural Irrigation Purposes, Project Report.* Prepared for the Regional Municipality of Niagara.

Terra-Dynamics Consulting Inc. 2005. *Geologic Hazard Mapping, Karst Topography Phase 1.* Fonthill, Ontario.

Tinkler, K.J. 1994. The Downfall of Niagara as a Chronometer, 1845-1941, in *Niagara's Changing Landscapes.* Gayler, H.J. (Ed.) Carleton University Press, Ottawa. pp. 81-110.

Town of Lincoln Public Library. No date. *A Brief History of the Town of Lincoln.* Accessed Online: www.lincoln.library.on.ca/townhistory.htm, 11 July 2007.

Waterloo Hydrogeologic, Inc., Blackport and Associates, Blackport Hydrogeology Inc., CH2M Hill Canada Ltd., K. Bruce MacDonald Consulting, MacViro Consultants Inc., and Philips Engineering Ltd. 2005. *Niagara Peninsula Conservation Authority Groundwater Study Final Report*. Prepared for Niagara Peninsula Conservation Authority, Regional Municipality of Niagara, City of Hamilton and Haldimand County

ACRONYMS

ALUS: Alternate Land Use Services
ANSI: Area of Natural and Scientific Interest
BIOMAP: Biological Monitoring and Assessment Program
BMP: Best Management Practice
CLTIP: Conservation Land Tax Incentive Program
DFO: Department of Fisheries and Oceans
E. COLI: *Escherichia coli*
EPA: Environmental Protection Agency
GTA: Greater Toronto Area
LMA: Local Management Area
MFTIP: Managed Forest Tax Incentive Program
MNR: Ministry of Natural Resources
MOE: Ministry of the Environment
MOEE: Ministry of Environment and Energy
MTO: Ontario Ministry of Transportation
NPCA: Niagara Peninsula Conservation Authority
NWQPS: Niagara Water Quality Protection Strategy
OFA: Ontario Federation of Agriculture
OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs
OMNR: Ontario Ministry of Natural Resources
OMOE: Ontario Ministry of the Environment
PPS: Provincial Policy Statement
PSW: Provincially Significant Wetland
QEW: Queen Elizabeth Way

GLOSSARY

AREA OF NATURAL AND SCIENTIFIC INTEREST: Areas of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education (Provincial Policy Statement 2005).

BEST MANAGEMENT PRACTICE: A land management practice implemented to control sources or causes of pollution. The 3 types of Best Management Practices that treat, prevent, or reduce water pollution include: structural, vegetative and managerial.

BIOENGINEERING: Combination of vegetative and structural practices to prevent erosion or stabilize slopes or streambanks

ECOLOGICAL FUNCTION: The natural processes, products, or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes. These may include biological, physical and socio-economic interactions (Provincial Policy Statement 2005).

ELECTROFISHING: An in-stream fish sampling technique that uses an electric current and an electric field to temporarily immobilize fish allowing capture.

FISH HABITAT: means spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes (Fisheries Act, Section 31 (5)).

GEOMORPHIC: Relates to the physical properties of the rock, soil, and water in and around the stream.

INCISED VALLEY: A valley created by the downcutting of a river through the river bed.

INTRINSIC SUSCEPTIBILITY: The vulnerability of the groundwater system to potential contamination from surface sources.

ISOSTATIC REBOUND: The upward movement of the earths crust following an increase of weight on the crustal surface from the weight of the glacier.

KARST ENVIRONMENT: Terrain typically underlain by limestone or dolomite whereby the topography is primarily formed by the dissolving of rock which may be characterized by sinkholes, sinking streams, closed depressions, subterranean drainage and caves (Monroe 1970).

KAME: A hill or mound consisting of sand and gravel deposited during the melting of glacial ice

LOCAL MANAGEMENT AREA: As part of the Niagara Water Quality Protection Strategy, Niagara Peninsula Conservation Authority's district was divided into 32 Local Management Areas, each representing an ecologically valid and functioning water management unit derived from the over 140 subwatersheds in its jurisdiction.

MUNICIPAL DRAIN: Municipal drains can be either open watercourses or closed systems buried in the ground (i.e., tiles, pipes) designed and constructed to primarily improve drainage of agricultural lands, but also improve drainage of roads and rural lands.

NIAGARA WATER QUALITY PROTECTION STRATEGY: The strategy is part of a multi-stakeholder and multi-jurisdictional effort to work towards the common goal of management, restoration and protection of water resources across Niagara's watershed.

NUTRIENT MANAGEMENT ACT: Under this Act, farms must develop and implement a nutrient management strategy or a nutrient management plan. A nutrient management strategy is completed by non-agricultural and manure generators to manage the production, storage and use of manure and other nutrients produced and used on a farm. Nutrient management plans are completed for agricultural operations that apply nutrients to the land (OMAFRA and OMOE 2003). The purpose of proper nutrient management is to protect surface and ground water from contamination.

PHYSIOGRAPHY: The natural configuration of the landscape.

POTENTIOMETRIC SURFACE: The area where the ground surface intersects the water table

PROVINCIAL SIGNIFICANCE: Important on a provincial scale; this may refer to a species; a habitat; or a natural area.

PROVINCIALLY SIGNIFICANT WETLAND: Those areas identified by the province as being the most valuable. They are determined by a science-based ranking system known as the Ontario Wetland Evaluation System. The Ministry of Natural Resources framework provides a standardized method of assessing wetland functions and societal values, which enables the province to rank wetlands relative to one another. This information is provided to planning authorities to support the land use planning process (Significant Wetlands and the Ontario Wetland Evaluation System Fact Sheet)

TALUS: A sloping mass of coarse rock fragments accumulated at the base of a slope or cliff.

TERRACE COMPLEX: A nearly flat portion of a landscape terminated by a steep edge.

WATERSHED: An area of land from which surface runoff (water, sediments, nutrients and contaminants) drain into a common water body.

WATERSHED MANAGEMENT PLAN: A proactive document created cooperatively by government agencies and the community to manage the water, land/water interactions, aquatic life and aquatic resources within a particular watershed to protect the health of the ecosystem as land uses change (Ministry of Environment and Energy and Ministry of Natural Resources 1993).

WETLANDS: Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens (Provincial Policy Statement 2005).

WILDLIFE HABITAT: Areas where plants, animals and other organisms live, and find adequate amounts of food, water, shelter and space needed to sustain their populations. Specific wildlife habitats of concern may include areas where species concentrate at a vulnerable point in the annual or life cycle; and areas which are important to migratory or non-migratory species (Provincial Policy Statement 2005).

WOODLANDS: Treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as erosion prevention, hydrological and nutrient cycling, provision of clean air and the long-term storage of carbon, provision of wildlife habitat, outdoor recreational opportunities, and the sustainable harvest of a wide range of woodland products (Provincial Policy Statement 2005).

ACKNOWLEDGEMENTS

Steering Committee:

Norm Johnson: Chair

Craig Larmour: Director of Planning Services, Pelham

Derek Witlib: Senior Planner, Town of Lincoln

Don and Sue Minchin: Peninsula Field Naturalists

Cory Burant: Niagara Restoration Council

Don Campbell: Planning and Development Department;
Regional Municipality of Niagara

Brian Treble: Director of Planning, Township of West Lincoln

Chris Vanrooy: Ontario Federation of Agriculture – South

Suzanne McInnis: Watershed Planning Coordinator:
Niagara Peninsula Conservation Authority

NIAGARA PENINSULA CONSERVATION AUTHORITY

FIFTEEN-SIXTEEN-EIGHTEEN MILE CREEK APPENDICES

APPENDIX A

LAND MANAGEMENT ISSUES AND AGRICULTURAL BEST MANAGEMENT PRACTICES

Please complete the following survey and return in the self-addressed, stamped envelope.

"The Niagara Peninsula Conservation Authority collects and uses your personal information pursuant to Section 29(2) of the Municipal Freedom of Information Act 1991, and under the legal authority of the Conservation authorities Act R.S.O. 1990 as amended." Questions regarding the policy or its administration should be directed to: Niagara Peninsula Conservation Authority, 250 Thorold Rd. W., 3rd Floor, Welland, ON L3C 2W3, Attn. Privacy Officer.

BACKGROUND INFORMATION

1. Please indicate the municipality in which you live.

❑ Fort Erie ❑ Niagara Falls ❑ Niagara-on-the-Lake ❑ Thorold ❑ Welland ❑ _____

2. Please indicate, based on the map provided, the watershed in which you live.

❑ Fort Erie Creeks ❑ Niagara-on-the-Lake ❑ South Niagara Falls

3. Please indicate the title that best describes your situation.

❑ Non-farm Landowner
❑ Landowner / Farm Operator
❑ Absentee Landowner
❑ Tenant Farm Operator
❑ Landowner / Farm Operator / Tenant Farm Operator
❑ Other (specify): _____

4. How much agricultural land do you currently own in the watershed? _____

5. How much agricultural land do you currently rent in the watershed? _____

6. How much land do you have in production? _____

and/or how many livestock do you have? _____

7. What type of agricultural commodity(s) do you produce? _____

8. Are you a member of any agricultural associations?

❑ Yes ❑ No

If yes, please specify the name of the organization(s): _____

9. Do you make land management decisions for property that borders a stream or creek?

❑ Yes ❑ No ❑ Not Sure

10. What is the source of your drinking water (e.g., water well, cistern)? _____

11. Do you rely on a septic system for wastewater treatment?

❑ Yes ❑ No

LAND MANAGEMENT ISSUES AND CONCERNS

12. Please rank your top three concerns related to your land.

A rank of 1 would represent your most important concern, a rank of 2 would represent your next most important concern, and a rank of 3 would represent the least of your top three most important concerns.

FIRST CONCERN: _____

_____

_____

SECOND CONCERN: _____

_____

_____

THIRD CONCERN: _____

_____

_____

13. Please estimate how much of a problem you think each of the following issues will be in the next 5 to 10 years.

ISSUE	NOT A PROBLEM	SLIGHT PROBLEM	MODERATE PROBLEM	SERIOUS PROBLEM	DO NOT KNOW
A. NITRATE, PHOSPHATE AND BACTERIA LEVELS IN STREAMS, RIVERS, AND LAKES	☐	☐	☐	☐	☐
B. NITRATE, PHOSPHATE AND BACTERIA LEVELS IN GROUNDWATER	☐	☐	☐	☐	☐
C. PESTICIDE LEVELS IN STREAMS, RIVERS AND LAKES	☐	☐	☐	☐	☐
D. PESTICIDE LEVELS IN GROUNDWATER	☐	☐	☐	☐	☐
E. SOIL DEPOSITION IN STREAMS, RIVERS AND LAKES	☐	☐	☐	☐	☐
F. DRINKING WATER QUALITY	☐	☐	☐	☐	☐
G. SOIL LOSS FROM AGRICULTURAL FIELDS	☐	☐	☐	☐	☐

APPENDIX A

ISSUE	NOT A PROBLEM	SLIGHT PROBLEM	MODERATE PROBLEM	SERIOUS PROBLEM	DO NOT KNOW
H. RIVERS AND STREAMS WITH ERODING BANKS	☐	☐	☐	☐	☐
I. SMELLS, NOISE, OR DUST FROM LIVESTOCK OPERATIONS	☐	☐	☐	☐	☐
J. SMELLS, NOISE OR DUST FROM NON-AGRICULTURAL BUSINESS	☐	☐	☐	☐	☐
K. SEEPAGE FROM SEPTIC TANKS ISSUE	☐	☐	☐	☐	☐
L. SOLID WASTE DISPOSAL	☐	☐	☐	☐	☐
M. FREQUENCY OF FLOODING	☐	☐	☐	☐	☐
N. ECONOMIC LOSSES DUE TO FLOODING	☐	☐	☐	☐	☐
O. ECONOMIC COSTS OF COMPLYING WITH LANDUSE REGULATIONS	☐	☐	☐	☐	☐
P. LOSS OF WETLANDS	☐	☐	☐	☐	☐
Q. LOSS OF FORESTED OR WOODED AREAS	☐	☐	☐	☐	☐
R. LOSS OF AGRICULTURAL LAND TO DEVELOPMENT	☐	☐	☐	☐	☐
S. LOSS OF AGRICULTURAL LAND TO NATURAL LAND	☐	☐	☐	☐	☐
T. LOSS OF NATURAL LAND TO DEVELOPMENT	☐	☐	☐	☐	☐
U. LOSS OF NATURAL LAND TO AGRICULTURAL PRODUCTION	☐	☐	☐	☐	☐
V. WELLS DRYING UP	☐	☐	☐	☐	☐
W. LOW SURFACE WATER CONDITIONS (DROUGHT)	☐	☐	☐	☐	☐
X. OTHER (PLEASE SPECIFY):	☐	☐	☐	☐	☐

_____

BEST MANAGEMENT PRACTICES AND RESTORATION RESOURCES

14. Which of the following Best Management Practices (BMPs) do you currently use?
Please select all that apply and specify the specific BMP.

- ❑ Tillage and seeding practices: _____
- ❑ Erosion control: _____
- ❑ Crop rotations: _____
- ❑ Residue management: _____
- ❑ Nutrient management: _____
- ❑ Pest management and pesticides: _____
- ❑ Irrigation: _____
- ❑ Other (please specify): _____

15. In your opinion, how would you rate the availability of restoration / conservation resources in the watershed?

ISSUE	BAD	POOR	FAIR	GOOD	EXCELLENT	DO NOT KNOW
A. THE AVAILABILTY OF RESTORATION/ CONSERVATION FUNDING PROGRAMS	❑	❑	❑	❑	❑	❑
B. THE AVAILABILTY OF RESTORATION/ CONSERVATION TECHNICAL ASSISTANCE	❑	❑	❑	❑	❑	❑

16. List the restoration/conservation funding programs that you are aware of:

_____

_____

_____

_____

17. If funding was available, would you be interested in pursing a project on your property?
If yes, please identify the type of project you would be interested in.

_____

_____

_____

_____

_____

_____

APPENDIX A

COMMUNICATION

18. How do you prefer to obtain information about watershed planning in your watershed? Please select all that apply.

- ❑ Local newspaper (please indicate which newspaper) _____
- ❑ Direct mail newsletter
- ❑ Email
- ❑ Website
- ❑ Meetings of local groups and organizations
- ❑ Other (please specify): _____
- ❑ None

19. Please provide any additional comments:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

THANK YOU

APPENDIX B

SCORING DESCRIPTIONS FOR STREAM VISUAL ASSESSMENT PROTOCOL

Below are the scoring descriptions for the Visual Assessment taken directly from the protocol (United States Department of Agriculture and Natural Resources Conservation Service, 1998).

CHANNEL CONDITION

Natural channel; no structures, dikes. No evidence of downcutting or excessive lateral cutting	Evidence of past channel alteration, but with significant recovery of channel and banks. Any dikes or levies are set back to provide access to an adequate flood plain.	Altered channel; <50% of the reach with riprap and/ or channelization. Excess aggradation: braided channel. Dikes or levees restrict flood plain width.	Channel is actively downcutting or widening. >50% of the reach with riprap or channelization. Dikes or levees prevent access to the flood plain.
10	**7**	**3**	**1**

HYDROLOGIC ALTERATION

Flooding every 1.5 to 2 years. No dams, no water withdrawals, no dikes or other structures limiting the stream's access to the flood plain. Channel is not incised.	Flooding occurs only once every 3 to 5 years; limited channel incision. **or** Withdrawals, although present, do not affect available habitat for biota.	Flooding occurs only once every 6 to 10 years; channel deeply incised. **or** Withdrawals significantly affect available low flow habitat for biota.	No flooding; channel deeply incised or structures prevent access to flood plain or dam operations prevent flood flows. **or** Withdrawals have caused severe loss of low flow habitat. **or** Flooding occurs on a 1 Year rain event or less.
10	**7**	**3**	**1**

RIPARIAN ZONE

Natural vegetation extends at least two active channel widths on each side.	Natural vegetation extends one active channel width on each side. **or** If less than one width, covers entire flood plain.	Natural vegetation extends half of the active channel width on each side.	Natural vegetation extends a third of the active channel width on each side. **or** Filtering function moderately compromised.	Natural vegetation less than a third of the active channel width on each side. **or** Lack of regeneration. **or** Filtering function severely compromised.
10	**8**	**5**	**3**	**1**

BANK STABILITY

Banks are stable; banks are low (at elevation of active flood plain): 33% or more of eroding surface area of banks in outside bends is protected by roots that extend to the base-flow elevation.	Moderately stable; banks are low (at elevation of active flood plain): less than 33% of eroding surface area of banks in outside bends is protected by roots that extend to the baseflow elevation.	Moderately unstable; banks may be low, but typically are high (flooding occurs 1 year out of 5 or less frequently); outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into stream annually, some slope failures apparent).	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream annually, numerous slope failures apparent).
10	**7**	**3**	**1**

APPENDIX B

WATER APPEARANCE

Very clear, or clear but tea-coloured; objects visible at depth 3 to 6 feet (less if slightly coloured); no oil sheen on surface; no noticeable film on submerged objects or rocks.	Occasionally cloudy, especially after storm event, but clears rapidly; objects visible at depth 1.5 to 3 feet; may have slightly green color; no oil sheen on water surface.	Considerable cloudiness most of the time; objects visible to depth 0.5 top 1.5 feet; slow sections may appear pea-green; bottom rocks or submerged objects covered with heavy green or olive-green film **or** Moderate odor of ammonia or rotten eggs.	Very turbid or muddy appearance most of the time; objects visible to <0.5 feet; slow moving water maybe bright-green; other obvious water pollutants; floating algal mats, surface scum, sheen or heavy coat of foam on surface. **or** Strong odor of chemicals, oil, sewage, other pollutants.
10	**7**	**3**	**1**

NUTRIENT ENRICHMENT

Clear water along entire reach; diverse aquatic plant community includes low quantities of many species of macrophytes; little algal growth present.	Fairly clear or slightly greenish water along entire reach; moderate algal growth on stream substrates.	Greenish water along entire reach; overabundance of lush green macrophytes; abundant algal growth, especially during warmer months.	Pea-green, gray, or brown water along entire reach; dense stands of macrophytes clog stream; severe algal blooms create thick algal mats in stream.
10	**7**	**3**	**1**

BARRIERS TO FISH MOVEMENT

No barriers	Seasonal water withdrawals inhibit movement within the reach	Drop structures, culverts, dams, or diversions (<1 foot drop) within the reach	Drop structures, culverts, dams or diversions (>1 foot drop) within 3 miles of the reach	Drop structures, culverts, dams, or diversions (>1 foot drop) within the reach
10	**8**	**5**	**3**	**1**

INSTREAM FISH COVER

>7 cover types available	6 to 7 cover types available	4 to 5 cover types available	2 to 3 cover types available	None to 1 cover type available
10	**8**	**5**	**3**	**1**

Cover types: Logs/large woody debris, deep pools, overhanging vegetation, boulders/cobble, riffles, undercut banks, thick root mats, dense macrophye beds, isolated/backwater pools

other: _____

POOLS

Deep and shallow pools abundant; greater than 30% of the pool bottom is obscure due to depth, or the pools are least 5 feet deep	Pools present, but not abundant; from 10 to 30% of the pool bottom is obscure due to depth, or the pools are at least 3 feet deep	Pools present, but shallow; from 5 to 10% of the pool bottom is obscure due to depth, or the pools are less than 3 feet deep	Pools absent, or the entire bottom is discernible
10	**7**	**3**	**1**

APPENDIX B

INSECT/INVERTEBRATE HABITAT

At least 5 types of habitat available. Habitat is at a stage to allow full insect colonization (Woody debris and logs not freshly fallen)	3 to 4 types of habitat. Some potential habitat exists, such as overhanging trees, which will provide habitat, but have not yet entered the stream	1 to 2 types of habitat. The substrate is often disturbed, covered or removed by high stream velocities and scour or by sediment deposition	None to 1 type of habitat
10	**7**	**3**	**1**

Cover types: Fine woody debris, submerged logs, leaf packs, undercut banks, cobble, boulders, coarse gravel,

other: _____

CANOPY COVER (IF APPLICABLE)
WARMWATER FISHERY

25 to 90% of water surface shaded; mixture of conditions	>90% shaded; full canopy; same shading condition throughout the reach		<25% water surface shaded in reach
10	**7**		**1**

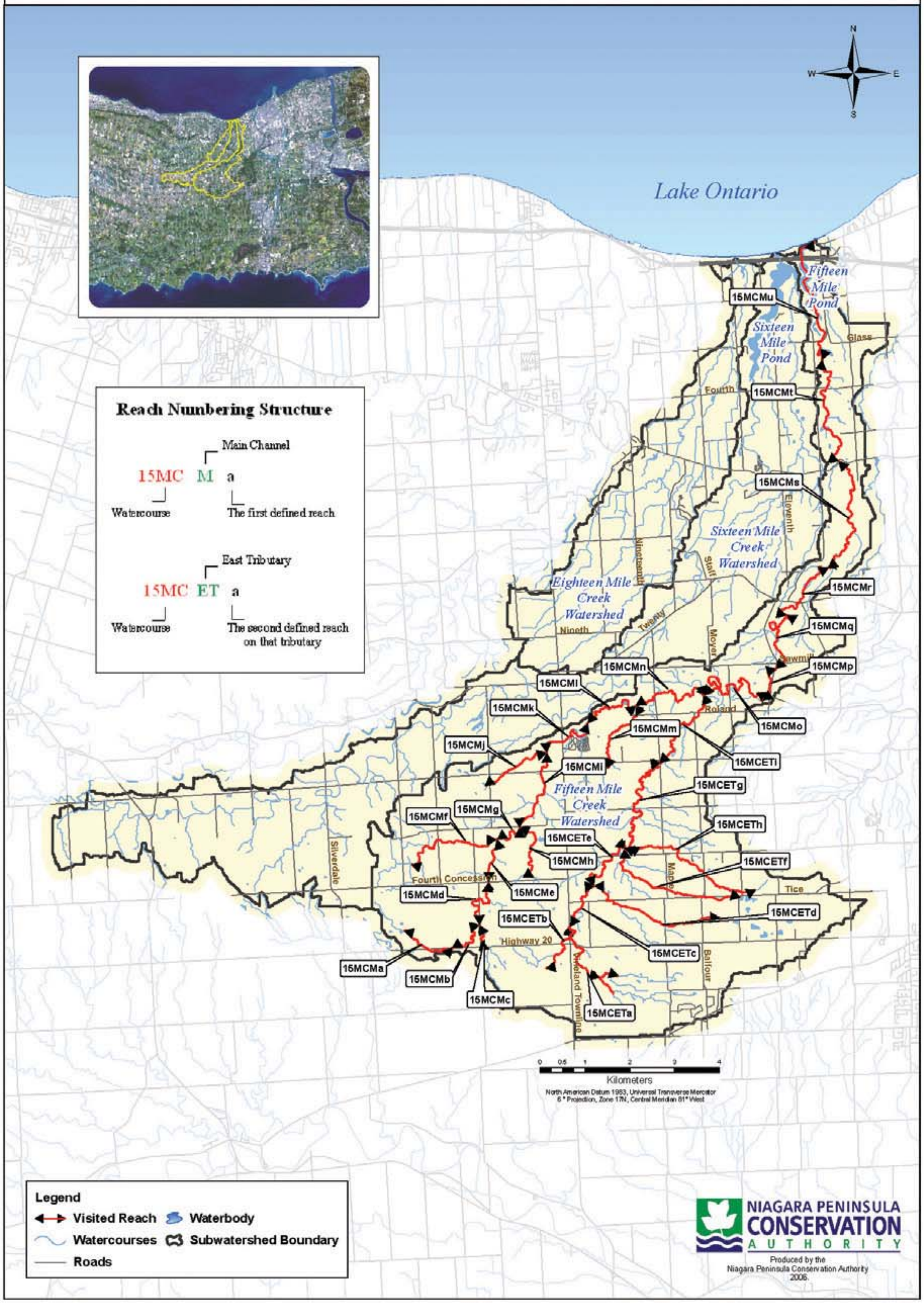
REACH NUMBER:	GENERAL LOCATION IN WATERSHED:	CHANNEL CONDITION:	HYDROLOGIC ALTERATION:	RIPARIAN ZONE:	BANK STABILITY:	WATER APPEARANCE:	NUTRIENT ENRICHMENT:	BARRIERS TO FISH MOVEMENT:	INSTREAM FISH COVER:	POOLS:	INVERTEBRATE HABITAT:	CANOPY COVER:	MANURE PRESENCE:	RIFFLE EMBEDDEDNESS:	OVERALL SCORE (TOTAL DIVIDED BY NUMBER SCORED)	RANK	SUSPECTED CAUSES OF OBSERVED PROBLEMS	RECOMMENDATIONS
15MCETc	Tice Road/ Brady Street (headwaters)	10	7	10	8	3	7	10	3	5	1	1	n/a	n/a	5.9	Poor	Sediment accumulation along the bed; Odour emitted when sediment disturbed (possible decaying vegetation); Lack of large woody vegetation adjacent to channel; Small buffers in downstream section	Increase the size of the buffer and the variety of vegetation found within it; monitor sediment accumulation along the bed
15MCETh	Balfour Road/ Metler Road	10	8	5	10	10	8	10	1	3	1	1	n/a	n/a	6.1	Fair	Flows through residential area and there is little to no buffer present; Sediment is accumulating along the streambed possible sources could be upstream agriculture	Plant buffer in residential zone where the lawn is mowed to the edge; monitor sediment accumulation
15MCETi	Roland Road/ Balfour Road	7	10	10	7	7	7	10	10	7	10	10	3	n/a	8.2	Good	The slope of the stream bed is flat; Sediment is accumulating on the bed; Cattle have access to the stream where no buffer exists; Manure present on banks	Plant buffer or build fence adjacent to channel so cattle can not access the stream
15MCMc and Mb	Highway Twenty (headwaters)	10	6	3	7	5	7	10	3	4	3	1	n/a	n/a	5.3	Poor	Riparian buffer consists of long grasses; Sediment accumulated along streambed ; Odour emitted when sediment disturbed (possible decaying vegetation); Channel has been altered but not filled in on the property	Plant proper buffer adjacent to stream; Monitor sediment accumulation; Fill old channel if no longer used
15MCMk	Pond at N.E.T. Campground	7	7	3	7	5	7	1	3	10	5	1	n/a	n/a	5.1	Poor	Small buffer with little variety of vegetation present around the pond; Dam present at outlet which acts as a fish barrier; Sediment accumulating on stream bed	Plant larger buffer around pond; The landowner would like to dredge the pond at some point in the future
15MCMm	Sixteen Road (headwaters)	10	9	3	10	n/a	n/a	10	1	1	1	1	n/a	n/a	5.1	Poor	No riparian zone surrounding stream; No deep pools present; No channel canopy; 3 tractor crossings present within 500m	Plant a riparian buffer adjacent to the stream; Limit the number of tractor crossings and make sure they are in appropriate locations along the stream
15MCMs	Rockway Conservation Area (Nineth Avenue)	8	7	10	4	6	7	3	8	7	7	10	n/a	10	7.3	Fair	The slope of the escarpment can lead to high shear stresses and the bank soils have a high susceptibility to erosion; Natural fish barrier present upstream (waterfall)	Vegetation planted along the streambank where bare soil and slumping exist

REACH NUMBER:	GENERAL LOCATION IN WATERSHED:	CHANNEL CONDITION:	HYDROLOGIC ALTERATION:	RIPARIAN ZONE:	BANK STABILITY:	WATER APPEARANCE:	NUTRIENT ENRICHMENT:	BARRIERS TO FISH MOVEMENT:	INSTREAM FISH COVER:	POOLS:	INVERTEBRATE HABITAT:	CANOPY COVER:	MANURE PRESENCE:	RIFFLE EMBEDDEDNESS:	OVERALL SCORE (TOTAL DIVIDED BY NUMBER SCORED)	RANK	SUSPECTED CAUSES OF OBSERVED PROBLEMS	RECOMMENDATIONS
15MCMt	Fourth Avenue/ Nineth Avenue	10	8	5	7	7	8	10	10	8	10	10	n/a	n/a	8.4	Good	Left bank property is kept groomed by property owners	Increase the size and the amount of native species found within the buffer
16MCEe	Fourth Avenue/ Eleventh Avenue	10	8	10	8	9	10	10	10	7	10	10	n/a	10	9.3	Excellent	Adjacent to residential property a small area with no buffer; Sediment deposits, a large number of debris jams present (can cause lateral adjustments)	Plant buffer adjacent to residential properties; Monitor sediment deposition and debris jams for any future problems
16MCEtb	King Street/ Nineth Avenue	10	10	5	8	7	8	1	10	3	10	10	n/a	10	7.6	Good	Lack of riparian zone adjacent to residential properties; Slope of the streambed can contribute to erosion; Fish barrier present in the form of an earthen berm impoundment with spillway	Increase the size of the buffer on the residential properties
16MCEtd	King Street/ Eleventh Avenue	5	5	5	3	3	4	1	10	7	10	7	n/a	10	5.8	Poor	Channel incision has created a fish barrier at the King Street culvert; The slope of the escarpment can lead to high shear stresses and the bank soils have a high susceptibility to erosion; Buffer zone is small adjacent to residential properties	Increase buffer zone; Make changes to the culvert so that it no longer acts as a fish barrier
16MCMc	Moote Road/ Twenty Mile Road	10	7	8	8	8	9	10	5	7	7	10	n/a	n/a	8.1	Good	Sediment has accumulated along the streambed; Downstream of Moote Road there is few woody vegetation present along the banks	Plant woody vegetation along the banks; Monitor sediment accumulation
16MCMe	Maple Street/ Twenty Mile Road	10	7	7	8	9	9	10	10	7	10	10	n/a	n/a	8.8	Good	Bed is flat; sediment deposition occurring upstream; Evidence of planimetric form adjustment (flood chute, large depositional feature) in upstream reach; Sediment accumulation can cause lateral channel changes	Identify possible upstream locations where sediment may be entering the channel and monitor sediment accumulation along the bed
16MCMf	Flows adjacent to Staff Avenue	10	8	9	7	8	8	10	10	7	10	10	n/a	n/a	8.8	Good	A concern identified along this field site includes the accumulation of sediment along the bed which may have an impact on fish and invertebrate	Long term monitoring of sediment accumulation; Determine possible upstream sources of sediment

REACH NUMBER:	GENERAL LOCATION IN WATERSHED:	CHANNEL CONDITION:	HYDROLOGIC ALTERATION:	RIPARIAN ZONE:	BANK STABILITY:	WATER APPEARANCE:	NUTRIENT ENRICHMENT:	BARRIERS TO FISH MOVEMENT:	INSTREAM FISH COVER:	POOLS:	INVERTEBRATE HABITAT:	CANOPY COVER:	MANURE PRESENCE:	RIFFLE EMBEDDEDNESS:	OVERALL SCORE (TOTAL DIVIDED BY NUMBER SCORED)	RANK	SUSPECTED CAUSES OF OBSERVED PROBLEMS	RECOMMENDATIONS
16MCMg	Louth Conservation Area (entered off Fifteenth Street)	10	7	10	8	7	7	1	10	7	10	10	n/a	10	8.1	Good	Natural fish barrier (waterfall); There was some algae present on boulders/cobbles present along the streambed	Monitor water quality
16MCMh	King Street (Big Valley Campground)	10	6	5	3	5	5	5	10	7	10	10	n/a	10	6.9	Fair	Slope of escarpment can lead to high shear stresses, bank soils have high susceptibility to erosion; Very little riparian vegetation present; Although not part of visual assessment the upstream property contains cattle; Double culvert may act as fish barrier	Stop mowing to edge and create adequate buffers; Cattle in upstream section need to be prevented from accessing the stream possibly with fencing or vegetation; Double culvert should be replaced
16MCMta	Flows adjacent to Silverdale Road	10	9	8	7	n/a	7	10	3	1	3	10	n/a	n/a	6.8	Fair	A headwater stream that has a number of debris jams present but lack pools, boulders/cobbles, and other features for fish /invertebrate habitat	Create additional fish/invertebrate habitat
18MCMc	Below the Escarpment at King Street (main branch)	7	7	5	3	5	6	10	10	10	10	10	n/a	10	7.3	Fair	Agricultural fields upstream may contribute to algae presence; Small width and lack of variety of vegetation found in buffer zone; Slope of escarpment is high and bank soils have high susceptibility to erosion	Monitor water quality; Increase buffer size and variety of native plant species within it; Two severe erosion areas should be monitored and/or protected by appropriate structures
18MCMd	Fourth Avenue/ Fifteenth Street	10	7	8	3	3	8	4	10	6	10	10	n/a	10	7.4	Fair	Agricultural fields upstream may contribute to algae presence; There are areas where the buffer width is small and lacks variety of vegetation; Stone weir potentially acts as grade control and barrier to fish movement	Monitor water quality; Increase buffer size and variety of native plant species within it; Remove stone weir if impacting fish habitat and movement
18MCMf	Red Maple Avenue	1	3	5	1	8	8	10	10	7	10	10	n/a	10	6.9	Fair	Confluence; Bank soils have a high susceptibility to erosion; Instability causes vegetation to collapse into stream creating debris jams; The channel is incised and flows cannot access floodplain, the energy within the flow is contained within channel	Deflect water from banks to stabilize and plant vegetation; Weirs can be placed along bed to reduce velocity; Cribwalls may have to be built on outside of bends due to severe erosion
18MCWc	Downstream of Nineteenth Street (Balls Falls property)	8	7	10	7	3	4	1	10	6	10	10	n/a	n/a	6.9	Fair	Agricultural fields upstream may contribute to algae; Waterfall acts as natural fish barrier; Some bank erosion present in upstream section, the bank material here has a medium susceptibility to erosion	Monitor water quality; Plant vegetation along the bank with deeper and stronger root system

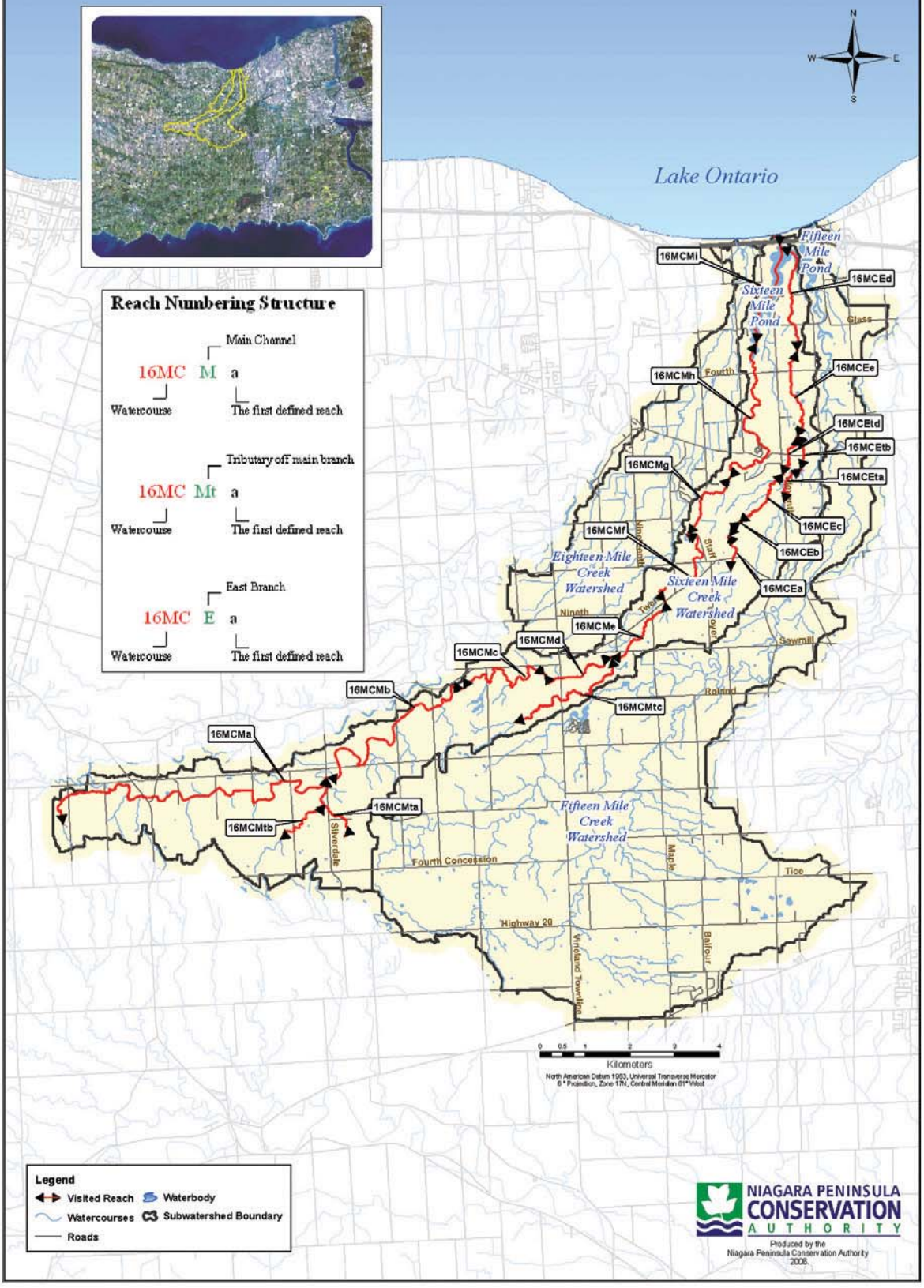
Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan

Fifteen Mile Creek Reach Locations



Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan

Sixteen Mile Creek Reach Locations



Fifteen-Sixteen-Eighteen Mile Creeks Watershed Plan

Eighteen Mile Creek Reach Locations

Reach Numbering Structure

Main Channel
18MC M a
Watercourse — The first defined reach

West Branch
18MC W a
Watercourse — The first defined reach

East Branch
18MC E a
Watercourse — The first defined reach

Lake Ontario

18MCMf
18MCMe
18MCMd
18MCWd
18MCMc
18MCWc
18MCMb
18MCWb
18MCWa
18MCMa
18MCEe
18MCEd
18MCEc
18MCEb
18MCEa

Fifteen Mile Pond
Sixteen Mile Pond
Sixteen Mile Creek Watershed
Eighteen Mile Creek Watershed
Fifteen Mile Creek Watershed

Glass
Fourth
Eleventh
Winterton
Ninth
Twenty
Moyer
Sawmill
Roland
Silverdale
Fourth Concession
Maple
Tice
Highway 20
Vinelland Township
Balfour

0 0.5 1 2 3 4
Kilometers
North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West

Legend
Visited Reach
Watercourses
Roads
Waterbody
Subwatershed Boundary

NIAGARA PENINSULA CONSERVATION AUTHORITY

Produced by the Niagara Peninsula Conservation Authority 2006.

APPENDIX C

The following is a list of potential best management practices for the 15-16-18 Mile Creeks watershed. For further information on Niagara Region's and NPCA's policies regarding stormwater management, please refer to *Stormwater Management, Erosion, and Sediment Policies and Criteria: Draft Report March 2007.*

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
STORMWATER BEST MANAGEMENT PRACTICES	
RETROFIT EXISTING STORMWATER BASINS	Modify older basins that were designed to control only the 100-year storm into multi-functional stormwater wetlands or conventional wet ponds.
RETROFIT EXISTING DETENTION DEVICES	Modify to incorporate forebays. Sediment forebays allow polluted sediments to settle out before water is discharged into the detention pond, thereby increasing treatment time and capacity.
RETROFIT INFILTRATION DEVICES	Where soil permeability and depth to groundwater are sufficient, infiltration measures such as permeable pavement and infiltration trenches should be considered for introduction.
INFILTRATION TRENCH OR DRY WELL	Design new developments to include an infiltration trench, which receives runoff in a shallow excavated trench that has been backfilled with stone to form a below-grade reservoir. Water can then slowly infiltrate into the soil.
OFF-LINE INFILTRATION BASIN	In new development areas design drainage corridors to include an infiltration basin which is not part of the main channel to capture water and allow it to slowly infiltrate into the soil.
EXTENDED DETENTION DRY BASIN	Design new developments to include stormwater basins that capture water and detain it for 24-40 hours before releasing it.
CATCH BASINS	Catch basins hold sediment as it enters the stormwater pipe system, but once it becomes full of sediment, it can no longer catch sediment. Therefore, basins should be cleaned twice annually.
PERVIOUS CATCH BASINS	These are normal catch basins with a large sump connected to an exfiltration storage area. The storage area may be located either directly below the catch basin floor through a series of holes or beside the catch basin where low flows discharge through the wall of the catch basin into the exfiltration storage area.
WET POND	In new development areas. include wet ponds that use a permanent storage pool to capture or transform dissolved pollutants, thereby holding water and releasing it slowly back to the environment. Wet ponds also reduce peak flows and assist in sedimentation control.
DRY PONDS	Dry ponds only contain water during runoff events and for the length of time it takes for draw down. Dry ponds also provide storage, reduce peak flows, as well as assist in sedimentation control and pollutant removal.
SAND FILTERS	Sand filters can be used for smaller developments and urban areas with limited open space. This system uses sand in an underground catchment to filter stormwater.
GREEN PARKING LOTS	Install new bioretention areas, infiltration areas, underground vaults, or other practices to detain and clean parking lot storm water before discharging. Encourage businesses to share parking space, require that vegetated spaces in parking lots be used to treat stormwater, encourage mass transit, encourage permeable spillover parking.
POROUS PAVING FOR LOW TRAFFIC ROADWAYS AND PATHWAYS	Parking areas, fire lanes, and bicycle paths that consists of open-graded asphalt on a crushed stone base are capable of absorbing water, reducing the amount of runoff entering the storm sewers.

APPENDIX C

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
STORMWATER BEST MANAGEMENT PRACTICES	
"DAYLIGHTING" STORM SEWERS	Eliminate a storm sewer or culvert and replace it with an open, vegetated channel.
VEGETATED SWALES VS. CURB AND GUTTER	Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff instead of curb and gutter systems.
VEGETATED SWALE	Compared to storm sewers, overland flow offers longer contact time with the soil and allows settling of pollutants, nutrient uptake by vegetation and complete infiltration of smaller events.
ROAD AND HIGHWAY RUNOFF IMPROVEMENTS	Construct stormwater wetlands, pond systems, grassed swales, natural vegetation in highway rights-of-way open space.
RURAL/URBAN BEST MANAGEMENT PRACTICES	
CONSERVATION TILLAGE/AGRICULTURAL FILTER STRIPS/BUFFER AND FILTER STRIPS	Alter agricultural practices to encourage naturally vegetated buffers/filters around streams and rivers. Discourage landowners adjacent to watercourse from mowing to streambank.
LAWN DEBRIS MANAGEMENT	Grass trimmings and leaf litter can be controlled by composting or by community curb side collection programs. Compost can be converted to mulch, which when applied in lieu of fertilizer, can reduce nutrient excess into watercourses.
PROTECT RECEIVING WATERS FROM BANK EROSION	Stabilize existing steep slopes with bioengineering methods, and preserve and plant trees along streams to reduce bank erosion.
STREAM CHANNEL RESTORATION/STABILIZATION	Construct pipe outlets and bank stabilization measures to prevent streambank erosion due to excessive discharge velocities (usually bioengineered).
CONSTRUCTED WETLAND	Build wetlands to capture pollutants from runoff draining urban and agricultural areas. Wetlands differ from basins in that they are shallower, and are planted with wetland plants to filter the water.
RAIN BARRELS	Rain barrels can be used to catch rooftop runoff for later use (e.g. watering gardens and lawns)
DOWNSPOUT DISCONNECTION	Disconnecting downspouts from storm drains or directing them away from paved surfaces that lead directly to the stormwater system allows water to infiltrate into unpaved soils. An education and incentive program should also be created for this alternative.
NATIVE LANDSCAPING AND/OR TREE PLANTING	This measure includes planting street trees, and planting trees and plants in parking lot medians or in other landscapes. They can be designed so water flows into these areas before flowing into the stormwater system. Native plants do not need fertilizers, irrigation, or mowing, which can reduce phosphorus and possibly runoff.
ENCOURAGE DIVERSE NON-TURF VEGETATION AT STORMWATER BASIN EDGES	Educate landowners to allow long grasses and wetland plants to flourish in stormwater basins to filter the waste of, and discourage large populations of, waterfowl.

APPENDIX C

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
PLANNING AND DEVELOPMENT	
ESTABLISH BETTER ENFORCEMENT, FINES TO ENSURE COMPLIANCE	May include hiring more staff to inspect and enforce regulations.
IMPROVE SEPTIC SYSTEM MAINTENANCE	Require septic system inspection and compliance at point-of-sale; encourage regular maintenance through incentive and/or education programs. Identify any currently failing systems so they can be fixed.
NEW/REVISED ZONING BY-LAWS	If necessary, a zoning by-law should be created, or revised, to meet water quality/quantity needs so that planning decisions based on that by-law are defensible.
CONDUCT ZONING BY-LAW REVIEW	Establish a committee to conduct a formal review of zoning by-laws from a planning perspective for open space and natural features protection/restoration.
ADOPT STORMWATER POLICIES FOR NEW DEVELOPMENTS	This policy tool can be used to control and treat stormwater discharges whereas stormwater management must be addressed before building permits are issued.
ENCOURAGE AND/OR REGULATE LANDUSE PLANNING AND MANAGEMENT	Develop policies limiting pavement, preserving open space, defining locations for more on-site storm water management facilities, and zoning/sizing criteria for on-site facilities.
INTEGRATE NATURAL FEATURES INTO THE PLANNING PROCESS	Through overlay zoning and other methods, valuable natural features should be taken into account when zoning and making planning decisions where such policies are not present. Coordination with municipalities in this area is necessary to preserve systems of open space, and reduce fragmentation of the natural complex of woodlands, prairies and other natural water filtering systems.
ENCOURAGE OPEN SPACE SITE DESIGN	Reduction in lot size to preserve common open space of woodlands and wetlands; shared driveways, chipped paths, swales, reduction in road widths, and so forth.
NEW/REVISED MASTER PLANS	If substantial changes are made to implement stormwater quantity and quality measures, the master plan should be revisited so that it upholds the changes in natural features inventories, zoning priorities and so forth to ensure that stormwater measures are not in conflict with the master plan.
DOWNZONING	Changes an established zone to a lower density level or less intense use. Can be used on strips of land adjacent to waterways to provide a buffer between industrial sites and the streambank or on a whole area surrounding a water body to reverse or prevent pollution.
ENCOURAGE AND/OR REGULATE LAND USE PLANNING AND MANAGEMENT	Develop policies limiting pavement, preserving open space, defining locations for more on-site storm water management facilities, and zoning/sizing criteria for on-site facilities.
PUBLIC EDUCATION AND PARTICIPATION	
STORM DRAIN STENCILLING PROGRAM – TROUT UNLIMITED "YELLOW FISH" PROGRAM	Residents are frequently unaware that materials dumped down storm drains may be discharged to a local water body. Stencilling can create awareness and prevention.
CITIZEN MONITORING (ADOPT-A-STREAM PROGRAM)	Citizen groups can collect valuable information on basic parameters – they can monitor and identify problems, collect surface water samples, and measure turbidity.

APPENDIX C

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
PUBLIC EDUCATION AND PARTICIPATION	
PROMOTION OF NPCAs WATER QUALITY IMPROVEMENT PROGRAM AND FUNDING OPPORTUNITIES FOR LANDOWNERS	This program guides restoration activities in the watershed, educates land-owners on how to do restoration and/or manage their land, organizes volunteers, and encourages stewardship.
PROMOTE INCENTIVE PROGRAMS FOR PRESERVATION OF FARMLAND, WOODED AREAS AND OPEN SPACE	Work with agencies, organizations and individuals to promote incentive programs such as Conservation Land Tax Incentive Program, Managed Forest Tax Incentive Program and Farm Property Tax Class Tax Rate.
REDUCE EXCESS FERTILIZER NUTRIENTS APPLIED TO LAWNS	Change excessive homeowner and golf course lawn fertilizer application habits by educating homeowners and managers about proper soil testing and lawn care practices.
REDUCE/APPLY ONLY APPROPRIATE LEVEL OF FERTILIZER TO FARM FIELDS	Educate farmers and/or offer incentives to have soils tested for the appropriate application of fertilizers.
DEVELOP AN EDUCATION PROGRAM TO ENCOURAGE PROPER SEPTIC SYSTEM MAINTENANCE	Proper maintenance of septic systems is essential in preventing septic failure, which pollutes natural water systems. Landowners must refrain from inappropriate plantings and uses on the septic field, and periodically arrange for the removal of solids from the system.
UTILIZE PARKS AND PUBLIC LAND FOR HANDS-ON EDUCATIONAL PROJECTS	Public places, especially along a watercourse/wetland, provide opportunities for public involvement and education. Projects could include streambank stabilization, native planting, invasive plant removal, logjam removal, wetland creation and so forth.
USE RECREATIONAL AREAS AS DEMONSTRATION/EDUCATION OPPORTUNITIES	In park areas, develop educational signage (watershed awareness, natural vegetation and so forth) and/or create a demonstration/interpretive area to illustrate natural landscaping, detention basin landscaping, and wetlands to teach about best management practices.
WATERSHED SIGNS/PROJECT SIGNS	Signs can be used to mark watershed boundaries, identify critical areas, promote specific behaviours in specific places, identify co-operators in a project, explain a project and its BMPs, and provide interpretive natural resources information.
NEWSPAPER ARTICLES	Newspaper articles provide detail about local success stories, photos of citizen activities, and feature stories which provide information about problems and solutions. They can also be used to announce meetings or public involvement opportunities.
NEWSLETTERS	Newsletters are a good way to provide key messages and contribute a series of watershed management articles. They can also be used to announce meeting times and dates, update information on actions already taken, and list issues to be discussed at upcoming meetings.
MEETINGS/OPEN HOUSES	Public gatherings, club meetings, special conferences, and workshops can be used to explain a program and receive input, share information, plan actions, and evaluate progress.
EVENTS	Watershed displays should be set up at every opportunity: fairs, local Earth Day events, conferences, and school events.
AWARDS	Recognize good work and gain a variety of advocates for your program though conservation awards for young people, public service awards, and participation and sponsorship awards.

APPENDIX C

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
PUBLIC EDUCATION AND PARTICIPATION	
USE A WEBSITE TO HOST INFORMATION	Develop a 15-16-18 Mile Creeks Watershed website to keep agencies, organizations, and others updated about restoration programs.
TRAINING/WORKSHOPS/ PRESENTATIONS	Many times, people do not change their habits and behaviours because they do not know what to do instead (composting, native landscaping, no-phosphorus lawn care, and so forth).
INVOLVE SCHOOLS	Make presentations to classes or conduct field trips. Find out what schools are already doing and see how water quality education can fit into the curriculum.
FORM A COMMITTEE/TASK FORCE OF CITIZENS	Create a committee to work on specific aspects of the watershed program; try to include representatives from all interest groups.

APPENDIX D

Restoration guidelines for riparian, wetland and forest habitat as recommended by Environment Canada (2004c) in its 'How Much Habitat is Enough?' document. This framework was used as a guideline in the 15-16-18 Mile Creeks Watershed Restoration Strategy.

RIPARIAN HABITAT GUIDELINES	
PARAMETER	GUIDELINE
PERCENT OF STREAM NATURALLY VEGETATED	75 percent of stream length should be naturally vegetated.
AMOUNT OF NATURAL VEGETATION ADJACENT TO STREAMS	Streams should have a minimum 30 metre wide naturally vegetated adjacent-lands area on both sides; Greater depending on site-specific conditions.
TOTAL SUSPENDED SEDIMENTS	Where and when possible, suspended sediment concentrations should be below 25 milligrams/litre or be consistent with Canadian Council of Ministers of the Environment (1999) guidelines.
PERCENT OF AN URBANIZING WATERSHED THAT IS IMPERVIOUS	Less than 10 percent imperviousness in an urbanizing watershed should maintain stream water quality and quantity, and preserve aquatic species' density and biodiversity. An upper limit of 30 percent represents the threshold for degraded systems.
FISH COMMUNITIES	Watershed guidelines for fish communities can be established based on knowledge of underlying characteristics of a watershed (e.g., drainage area, surficial geology, flow regime), historic and current fish communities, and factors (and their relative magnitudes) that currently impact the system.

APPENDIX D

WETLAND HABITAT GUIDELINES	
PARAMETER	GUIDELINE
PERCENT WETLANDS IN WATERSHEDS AND SUBWATERSHEDS	Greater than 10 percent of each major watershed in wetland habitat; greater than 6 percent of each subwatershed in wetland habitat; or restore to original percentage of wetlands in the watershed.
AMOUNT OF NATURAL VEGETATION ADJACENT TO THE WETLAND	For key wetland functions and attributes, the identification and maintenance of the Critical Function Zone and its protection, along with an appropriate Protection Zone is the primary concern. Where this is not derived from site-specific characteristics, the following are minimum guidelines: Bog – the total catchment area Marsh – 100 metres Fen – 100 metres or as determined by hydrogeological study Swamp – 100 metres
WETLAND TYPE	The only 2 wetland types suitable for widespread rehabilitation are marshes and swamps.
WETLAND LOCATION	Wetlands can provide benefits anywhere in the watershed, but particular wetland functions can be achieved by rehabilitating in key locations, such as headwater areas for groundwater discharge and recharge, flood plains for flood attenuation, and coastal wetlands for fish production. Special attention should be paid to historic wetland locations or site and soil conditions.
WETLAND SIZE	Wetland of a variety of sizes, types, and hydroperiods should be maintained across a landscape. Swamps and marches of sufficient size to support habitat heterogeneity are particularly important.
WETLAND SHAPE	As with upland forests, in order to maximize habitat opportunities for edge-tolerant species, and where the surrounding matrix is not natural habitat, swamps should be regularly shaped with minimum edge and maximum interior habitat.

APPENDIX D

FOREST HABITAT GUIDELINES	
PARAMETER	GUIDELINE
PERCENT FOREST COVER	At least 30 percent of the watershed should be in forest cover.
SIZE OF LARGEST FOREST PATCH	A watershed or other land unit should have at least one 200 hectare forest patch that is a minimum 500 metres in width.
PERCENT OF WATERSHED THAT IS FOREST COVER 100 METRES AND 200 METRES FROM FOREST EDGE	The proportion of the watershed that is forest cover 100 metres or further from the forest edge should be greater than 10 percent. The proportion of the watershed that is forest cover 200 metres further from the forest edge should be greater than 5 percent.
FOREST SHAPE	To be of maximum use to species such as forest-breeding birds that are intolerant to edge habitat, forest patches should be circular or square in shape.
PROXIMITY TO OTHER FORESTED PATCHES	To be of maximum use to species such as forest-breeding birds, forest patches should be within 2 to 1 kilometre of one another or other supporting habitat features.
FRAGMENTED LANDSCAPES AND THE ROLE OF CORRIDORS	Connectivity width will vary depending on the objectives of the project and the attributes of the nodes that will be connected. Corridors designed to facilitate species movement should be a minimum of 50 metres to 100 metres in width. Corridors designed to accommodate breeding habitat for specialist species need to be designed to meet the habitat requirements of those target species.
FOREST QUALITY – SPECIES COMPOSITION AND AGE STRUCTURE	Watershed forest cover should be representative of the full diversity of forest types found at that latitude.

RESTORATION SUITABILITY CRITERIA: RIPARIAN HABITAT

HABITAT: RIPARIAN	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: PROXIMITY TO WATERCOURSE/WATERBODY *(edgedr)* 3 ≤ 30m 2 > 30m & < 50m 1 ≥ 50m	Areas within closest proximity to watercourses or waterbodies will be most suitable to restoration. These areas contribute to both riparian buffer and floodplain. Restoration in these areas will improve hydrological, habitat and water quality functions.	Generate straight line distance surface from watercourses and waterbodies. Reclassify surface values where lowest distances have highest suitability values, reflecting riparian and floodplain location.	Niagara River AOC RAP Riparian Habitat Guidelines
CRITERIA: LAND USE TYPE *(lurwood)* 3 Woodland, Wetland, Scrub, Low Intensity Agriculture 2 Recreational, Residential, High Intensity Agriculture 1 Industrial, Built Up Urban	In terms of potential conflict, existing land use type is scaled in terms of suitability to restoration. Areas classified as scrub, low intensity agriculture, or natural are much more suitable to restoration than areas classified as industrial or built-up urban.	Generate Land Use surface on Land Use Type value. Reclassify Land Use values where low conflict land use types have higher suitability values than high conflict land use types.	Niagara Peninsula Conservation Authority
CRITERIA: SLOPE *(slopedr)* 3 ≥ 10 degrees 2 < 10 degrees 1 0 degrees	Considers the presence of vegetation in terms of hydrological and mechanical contribution to bank stability and erosion control. As slope increases, restoration suitability increases.	Generate slope surface from DEM. Reclassify surface where higher slope values have higher suitability values.	Niagara Peninsula Conservation Authority
CRITERIA: FISH HABITAT CLASSIFICATION OF CATCHMENT *(catchfhr)* 3 Critical 2 Important 1 Marginal	Catchments which drain to watercourses classified as Fish Habitat are considered more suitable, as restoration projects will contribute to food, shelter, temperature moderation and oxygen production.	Generate surface from catchment polygons on fish habitat classification value. Reclassify values according to restoration suitability.	Niagara Peninsula Conservation Authority
CRITERIA: STREAM ORDER OF CATCHMENT *(catchsor)* 3 intermittent flow (1st & 2nd order) 2 intermittent / permanent flow (3rd order) 1 permanent flow (> 3rd order)	Catchments which drain to watercourses in headwater streams are considered more suitable for restoration than those that drain to higher ordered streams in terms of water quality improvement.	Generate surface from catchment polygons on stream order value. Reclassify values according to restoration suitability.	Niagara River AOC RAP Riparian Habitat Guidelines
CRITERIA: FOREST COVER *(coverwor)* 3 woodland not present 2 planting site 1 woodland present	It is more suitable to restore habitat where vegetation does not presently exist, or where infilling may be necessary from a previous restoration project.	Generate surface from natural vegetation polygons based on vegetation type. Reclassify cells lacking forest cover as highest suitability values.	Niagara River AOC RAP Riparian Habitat Guidelines

RESTORATION SUITABILITY CRITERIA: RIPARIAN HABITAT

HABITAT: RIPARIAN	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: STREAMBANK EROSION RATES *(Wetness Index)* (ripwir) 3 High (10-21) 2 Mid (5-10) 1 Low (0-5)	Riparian areas identified as having high erosion rates resulting from upslope contributing area and slope gradient analysis are most suitable to restoration with bioengineering.	Generate wetness index surface from topographic analysis. Reclassify surface where highest erosion rates have highest suitability values.	Niagara Peninsula Conservation Authority
CRITERIA: PROTECTED AREA *(careasdr)* 3 within conservation area boundary 2 ≤ 30m from conservation area boundary 1 > 30m from conservation area boundary	Areas within C.A. boundaries are protected from development pressure and destruction. Areas in close proximity to these boundaries are good areas to restore in terms of establishing connectivity.	Generate straight line distance surface from Conservation Area boundary polygons. Reclassify surface values according to restoration suitability.	Niagara Peninsula Conservation Authority

RESTORATION SUITABILITY CRITERIA: WETLAND HABITAT

HABITAT: WETLAND	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: PROXIMITY TO EXISTING SIGNIFICANT PATCH (SIZE) *(wecoredr)* 3 ≤ 50m 2 > 50m & < 100m 1 ≥ 100m	Areas within closest proximity to existing wetland patches of highest Natural Heritage Score (core size) will be most suitable to restoration of increased interior habitat.	Select existing patches with highest size significance value. Generate distance surface from selected patches. Reclassify surface values where lowest distances have highest suitability values.	Niagara River AOC RAP Wetland Extent Guidelines
CRITERIA: PROXIMITY TO SIGNIFICANT EXISTING PATCH *(wenndr)* 3 ≤ 50m 2 > 50m & < 100m 1 ≥ 100m	Areas within closest proximity to existing wetland patches of highest Natural Heritage score (nearest neighbor) will be most suitable to restoration.	Select existing patches with highest size significance value. Generate distance surface from selected patches. Reclassify surface values where lowest distances have highest suitability values.	Niagara River AOC RAP Wetland Extent Guidelines
CRITERIA: PROXIMITY TO WATERCOURSE / WATERBODY *(edgedr)* 3 ≤ 30m 2 > 30m & < 50m 1 ≥ 50m	Areas within closest proximity to watercourses or waterbodies will be most suitable to restoration. These areas contribute to both riparian buffer and floodplain. Restoration in these areas will improve hydrological, habitat and water quality functions.	Generate straight line distance surface from watercourses and waterbodies. Reclassify surface values where lowest distances have highest suitability values, reflecting riparian and floodplain location.	Niagara River AOC RAP Wetland Extent Guidelines
CRITERIA: SOIL DRAINAGE *(sdrainr)* 3 Alluvial Soil 2 Very Poorly and Poorly Drained 1 Imperfectly Drained	The drainage class of the underlying soil determines the amount of water the soil can receive and store before runoff. The more poorly drained the underlying soil, the more suitable the area to wetland restoration.	Generate surface from OMAF soil polygons based on drainage class. Reclassify surface according to suitability values.	North Carolina Coastal Region Evaluation of Wetland Significance
CRITERIA: LAND USE TYPE *(lurwood)* 3 Woodland, Wetland, Scrub, Low Intensity Agriculture 2 Recreational, Residential, High Intensity Agriculture 1 Industrial, Built Up Urban	In terms of potential conflict, existing land use type is scaled in terms of suitability to restoration. Areas classified as scrub, low intensity agriculture, or natural area are much more suitable to restoration than areas classified as industrial or built-up urban.	Generate Land Use surface on Land Use Type value. Reclassify Land Use values where low conflict land use types have higher suitability values than high conflict land use types.	Niagara Peninsula Conservation Authority
CRITERIA: FISH HABITAT CLASSIFICATION OF CATCHMENT *(catchfr)* 3 Critical 2 Important 1 Marginal	Catchments which drain to watercourses classified as Fish Habitat are considered more suitable, as restoration projects will contribute to food, shelter, temperature moderation and oxygen production.	Generate surface from catchment polygons on fish habitat classification value. Reclassify values according to restoration suitability.	Niagara Peninsula Conservation Authority

RESTORATION SUITABILITY CRITERIA: WETLAND HABITAT

HABITAT: WETLAND	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: STREAM ORDER OF CATCHMENT *(catchsor)* 3 intermittent flow (1st & 2nd order) 2 intermittent / permanent flow (3rd order) 1 permanent flow (> 3rd order)	Catchments which drain to watercourses in headwater streams are considered more suitable for restoration than those that drain to higher ordered streams in terms of water quality improvement.	Generate surface from catchment polygons on stream order value. Reclassify values according to restoration suitability.	Niagara River AOC RAP Wetland Extent Guidelines
CRITERIA: WETNESS INDEX (TOPOGRAPHIC POSITION/SLOPE) *(wetindr)* 3 high (10-21) 2 mid (5-10) 1 low (0-5)	The wetness index equation predicts zones of water saturation where steady-state conditions and uniform soil properties are assumed. It is a function of upslope contributing area and slope gradient. Areas of highest W.I. values are most suitable to wetland restoration.	Generate wetness index surface from slope gradient and flow accumulation. Reclassify surface where highest Wetness Index values have highest suitability values.	Niagara Peninsula Conservation Authority
CRITERIA: FOREST COVER *(coverwer)* 3 Forest cover present 2 Planting site present 1 Forest cover present	Where forest cover is already present, restoration is more suitable, particularly in terms of the establishment of swamp habitat.	Generate surface from woodland polygons. Reclassify values according to suitability value.	Niagara Peninsula Conservation Authority
CRITERIA: PROTECTED AREA *(careasdr)* 3 within conservation area boundary 2 ≤ 30m from conservation area boundary 1 > 30m from conservation area boundary	Areas within C.A. boundaries are protected from development pressure and destruction. Areas in close proximity to these boundaries are more suitable to restore in terms of establishing connectivity.	Generate straight line distance surface from Conservation Area boundary polygons. Reclassify surface values according to restoration suitability.	Niagara Peninsula Conservation Authority

RESTORATION SUITABILITY CRITERIA: UPLAND HABITAT

HABITAT: UPLAND FOREST	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: PROXIMITY TO SIGNIFICANT PATCH (CoreSize) *(wocoredr)* 3 ≤ 50m 2 > 50m & < 100m 1 ≥ 100m	Areas within closest proximity to existing forest patches of highest of Natural Heritage Score (core size) will be most suitable to restoration increased interior habitat.	Select existing patches with highest size significance value. Generate distance surface from selected patches. Reclassify surface values where lowest distances have highest suitability values.	Niagara River AOC RAP Evaluation of Upland Habitat
CRITERIA: PROXIMITY TO SIGNIFICANT PATCH (Connectivity) *(wonndr)* 3 ≤ 50m 2 > 50m & < 100m 1 ≥ 100m	Areas within closest proximity to existing forest patches of highest Natural Heritage score (nearest neighbor) will be most suitable to restoration of wildlife corridors.	Select existing patches with highest proximity significance value. Generate distance surface from selected patches. Reclassify surface values where lowest distances have highest suitability values.	Niagara River AOC RAP Evaluation of Upland Habitat
CRITERIA: PROXIMITY TO WATERCOURSE / WATERBODY *(edgedr)* 3 ≤ 30m 2 > 30m & < 50m 1 ≥ 50m	Areas within closest proximity to watercourses or waterbodies will be most suitable to restoration. These areas contribute to both riparian buffer and floodplain. Restoration in these areas will improve hydrological, habitat and water quality functions.	Generate straight line distance surface from watercourses and waterbodies. Reclassify surface values where lowest distances have highest suitability values, reflecting riparian and floodplain location.	Niagara River AOC RAP Riparian Habitat Guidelines
CRITERIA: LAND USE TYPE *(lurwood)* 3 Woodland, Wetland, Scrub, Low Intensity Agriculture 2 Recreational, Residential, High Intensity Agriculture 1 Industrial, Built Up Urban	In terms of potential conflict, existing land use type is scaled in terms of suitability to restoration. Areas classified as scrub, low intensity agriculture, or natural area are much more suitable to restoration than areas classified as industrial or built-up urban.	Generate surface from 1992 Landsat 7 Landuse Classification on Land Use Type value. Reclassify Land Use values where low conflict land use types have higher suitability values than high conflict land use types.	Niagara Peninsula Conservation Authority

RESTORATION SUITABILITY CRITERIA: UPLAND HABITAT

HABITAT: UPLAND FOREST	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA:FISH HABITAT CLASSIFICATION OF CATCHMENT *(catchfhr)* 3 Critical 2 Important 1 Marginal	Catchments which drain to watercourses classified as Fish Habitat are considered more suitable, as restoration projects will contribute to food, shelter, temperature moderation and oxygen production.	Generate surface from catchment polygons on fish habitat classification value. Reclassify values according to restoration suitability.	Niagara Peninsula Conservation Authority
CRITERIA:STREAM ORDER OF CATCHMENT *(catchsor)* 3 intermittent flow (1st & 2nd order) 2 intermittent / permanent flow (3rd order) 1 permanent flow (> 3rd order)	Catchments which drain to watercourses in headwater streams are considered more suitable for restoration than those that drain to higher ordered streams in terms of water quality improvement.	Generate surface from catchment polygons on stream order value. Reclassify values according to restoration suitability.	Niagara River AOC RAP Evaluation of Upland Habitat
CRITERIA:0-240M WETLAND BUFFER HABITAT THRESHOLDS *(sigwetdr)* 3 < 50m 2 50m - 120m 1 120m - 240m	Areas within these buffer distances contribute to a range of habitat functions when vegetated. Vegetation within closest proximity to the wetland provides the greatest benefit to that wetland. These areas are thus considered most suitable to restoration.	Generate straight line distance surface from wetlands. Reclassify surface values where habitat threshold distances have highest suitability value.	Niagara River AOC RAP Wetland Extent Guidelines
CRITERIA:PROTECTED AREA *(careasdr)* 3 within conservation area boundary 2 ≤ 30m from conservation area boundary 1 > 30m from conservation area boundary	Areas within C.A. boundaries are protected from development pressure and destruction. Areas in close proximity to these boundaries are good areas to restore in terms of establishing connectivity.	Generate straight line distance surface from Conservation Area boundary polygons. Reclassify surface values according to restoration suitability.	Niagara Peninsula Conservation Authority
CRITERIA:SLOPE *(slopedr)* 3 ≥ 10 degrees 2 < 10 degrees 1 0 degrees	Considers the presence of forest cover in terms of hydrological and mechanical contribution to slope stability and erosion control. As slope increases, restoration suitability increases.	Generate slope surface from DEM. Reclassify surface where higher slope values have higher suitability values.	North Carolina Coastal Region Evaluation of Wetland Significance
CRITERIA:FOREST COVER *(coverwor)* 3 woodland not present 2 planting site 1 woodland present	The amount of forest cover must be increased in order to meet habitat targets. It is obviously more suitable to restore forest habitat where it does not presently exist, or where infilling may be necessary from a previous restoration site.	Generate surface from natural vegetation polygons based on vegetation type. Reclassify areas lacking forest cover as highest suitability values.	Niagara River AOC RAP Evaluation of Upland Habitat

RIPARIAN

PAIRWISE IMPORTANCE								
	WATER	LANDUSE	SLOPE	FISH HC	STREAM O	COVER	WET INDEX	C.A.'S
WATER	1.00	5.00	5.00	2.00	1.00	2.00	0.20	9.00
LANDUSE	0.20	1.00	7.00	2.00	2.00	4.00	0.33	9.00
SLOPE	0.20	0.14	1.00	0.20	0.14	0.50	0.20	5.00
FISH HC	0.50	0.50	5.00	1.00	0.33	3.00	0.20	9.00
STREAM O	1.00	0.50	7.00	3.00	1.00	4.00	0.25	9.00
COVER	0.50	0.25	2.00	0.33	0.25	1.00	0.14	9.00
WET INDEX	5.00	3.00	5.00	5.00	4.00	7.00	1.00	9.00
C.A.'S	0.11	0.11	0.20	0.11	0.11	0.11	0.11	1.00
SUM	**8.51**	**10.50**	**32.20**	**13.64**	**8.84**	**21.61**	**2.44**	**60.00**

BACKGROUND INFORMATION

IMPORTANCE LEVEL	RATING
Equally Important	1.00
Equally To Moderately More Important	2.00
Moderately More Important	3.00
Moderately To Strongly More Important	4.00
Strongly More Important	5.00
Strongly To Very Strongly More Important	6.00
Very Strongly More Important	7.00
Very Strongly To Extremely More Important	8.00
Extremely More Important	9.00

1 - 1 = 1	2 - 1 = 4	3 - 1 = 7	4 - 1 = 9
1 - 2 = X	2 - 2 = 1	3 - 2 = 4	4 - 2 = 7
1 - 3 = X	2 - 3 = X	3 - 3 = 1	4 - 3 = 4
1 - 4 = X	2 - 4 = X	3 - 4 = X	4 - 4 = 1

****TO USE THIS INFO IN SUITABILITY ANALYSIS:

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   ie. (S1*W1 + S2*W2 + S3*W3 + ...) / (W1 + W2 + W3 + ...)
3. Compare result to manual weighting result

RIPARIAN

NORMALIZED VALUES										
	WATER	LANDUSE	SLOPE	FISH HC	STREAM O	COVER	WET INDEX	C.A.'S	SUM	WEIGHT
WATER	0.12	0.48	0.16	0.15	0.11	0.09	0.08	0.15	**1.33**	**11.30**
LANDUSE	0.02	0.10	0.22	0.15	0.23	0.19	0.14	0.15	**1.18**	**10.01**
SLOPE	0.02	0.01	0.03	0.01	0.02	0.02	0.08	0.08	**0.29**	**2.44**
FISH HC	0.06	0.05	0.16	0.07	0.04	0.14	0.08	0.15	**0.74**	**6.30**
STREAM O	0.12	0.05	0.22	0.22	0.11	0.19	0.10	0.15	**1.15**	**9.78**
COVER	0.06	0.02	0.06	0.02	0.03	0.05	0.06	0.15	**0.45**	**3.83**
WET INDEX	0.59	0.29	0.16	0.37	0.45	0.32	0.41	0.15	**2.73**	**23.16**
C.A.'S	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.02	**0.12**	**1.00**
SUM	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**		**67.82**

BACKGROUND INFORMATION

IMPORTANCE LEVEL	RATING
Equally Important	1.00
Equally To Moderately More Important	2.00
Moderately More Important	3.00
Moderately To Strongly More Important	4.00
Strongly More Important	5.00
Strongly To Very Strongly More Important	6.00
Very Strongly More Important	7.00
Very Strongly To Extremely More Important	8.00
Extremely More Important	9.00

1 - 1 = 1	2 - 1 = 4	3 - 1 = 7	4 - 1 = 9
1 - 2 = X	2 - 2 = 1	3 - 2 = 4	4 - 2 = 7
1 - 3 = X	2 - 3 = X	3 - 3 = 1	4 - 3 = 4
1 - 4 = X	2 - 4 = X	3 - 4 = X	4 - 4 = 1

*Min. Value

****TO USE THIS INFO IN SUITABILITY ANALYSIS:

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   ie. (S1*W1 + S2*W2 + S3*W3 + ...) / (W1 + W2 + W3 + ...)
3. Compare result to manual weighting result

WETLANDS

PAIRWISE IMPORTANCE										
	PROX (NN)	PROX (CS)	WATER	SOIL	LAND USE	FISH HC	STREAM O	WET INDEX	COVER	C.A.'S
PROX (NN)	1.00	7.00	0.33	0.11	0.14	0.33	0.14	0.11	5.00	7.00
PROX (CS)	0.14	1.00	0.25	0.14	0.14	1.00	0.20	0.11	1.00	7.00
WATER	3.00	4.00	1.00	0.50	0.50	5.00	3.00	0.14	7.00	7.00
SOIL	9.00	7.00	2.00	1.00	3.00	6.00	5.00	2.00	7.00	9.00
LAND USE	7.00	7.00	2.00	0.33	1.00	7.00	5.00	1.00	7.00	7.00
FISH HC	3.00	1.00	0.20	0.17	0.14	1.00	0.33	0.14	5.00	5.00
STREAM O	7.00	5.00	0.33	0.20	0.20	3.00	1.00	0.20	7.00	7.00
WET INDEX	9.00	9.00	7.00	0.50	1.00	7.00	5.00	1.00	9.00	9.00
COVER	0.20	1.00	0.14	0.14	0.14	0.20	0.14	0.11	1.00	3.00
C.A.'S	0.14	0.14	0.14	0.11	0.14	0.20	0.14	0.11	0.33	1.00
SUM	**39.49**	**42.14**	**13.40**	**3.21**	**6.41**	**30.73**	**19.96**	**4.93**	**49.33**	**62.00**

BACKGROUND INFORMATION

IMPORTANCE LEVEL	RATING
Equally Important	1.00
Equally To Moderately More Important	2.00
Moderately More Important	3.00
Moderately To Strongly More Important	4.00
Strongly More Important	5.00
Strongly To Very Strongly More Important	6.00
Very Strongly More Important	7.00
Very Strongly To Extremely More Important	8.00
Extremely More Important	9.00

1 - 1 = 1	2 - 1 = 4	3 - 1 = 7	4 - 1 = 9
1 - 2 = X	2 - 2 = 1	3 - 2 = 4	4 - 2 = 7
1 - 3 = X	2 - 3 = X	3 - 3 = 1	4 - 3 = 4
1 - 4 = X	2 - 4 = X	3 - 4 = X	4 - 4 = 1

****TO USE THIS INFO IN SUITABILITY ANALYSIS:

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   ie. (S1*W1 + S2*W2 + S3*W3 + ...) / (W1 + W2 + W3 + ...)
3. Compare result to manual weighting result

WETLANDS

NORMALIZED VALUES												
	PROX (NN)	PROX (CS)	WATER	SOIL	LAND USE	FISH HC	STREAM O	WET INDEX	COVER	C.A.'S	SUM	WEIGHT
PROX (NN)	0.03	0.17	0.02	0.03	0.02	0.01	0.01	0.02	0.10	0.11	**0.53**	**3.95**
PROX (CS)	0.00	0.02	0.02	0.04	0.02	0.03	0.01	0.02	0.02	0.11	**0.31**	**2.33**
WATER	0.08	0.09	0.07	0.16	0.08	0.16	0.15	0.03	0.14	0.11	**1.08**	**8.05**
SOIL	0.23	0.17	0.15	0.31	0.47	0.20	0.25	0.41	0.14	0.15	**2.46**	**18.41**
LANDUSE	0.18	0.17	0.15	0.10	0.16	0.23	0.25	0.20	0.14	0.11	**1.69**	**12.63**
FISH HC	0.08	0.02	0.01	0.05	0.02	0.03	0.02	0.03	0.10	0.08	**0.45**	**3.36**
STREAM O	0.18	0.12	0.02	0.06	0.03	0.10	0.05	0.04	0.14	0.11	**0.86**	**6.41**
WET INDEX	0.23	0.21	0.52	0.16	0.16	0.23	0.25	0.20	0.18	0.15	**2.28**	**17.09**
COVER	0.01	0.02	0.01	0.04	0.02	0.01	0.01	0.02	0.02	0.05	**0.21**	**1.58**
C.A.'S	0.00	0.00	0.01	0.03	0.02	0.01	0.01	0.02	0.01	0.02	**0.13**	**1.00**
SUM	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**		**74.82**

BACKGROUND INFORMATION

IMPORTANCE LEVEL	RATING
Equally Important	1.00
Equally To Moderately More Important	2.00
Moderately More Important	3.00
Moderately To Strongly More Important	4.00
Strongly More Important	5.00
Strongly To Very Strongly More Important	6.00
Very Strongly More Important	7.00
Very Strongly To Extremely More Important	8.00
Extremely More Important	9.00

1 - 1 = 1	2 - 1 = 4	3 - 1 = 7	4 - 1 = 9
1 - 2 = X	2 - 2 = 1	3 - 2 = 4	4 - 2 = 7
1 - 3 = X	2 - 3 = X	3 - 3 = 1	4 - 3 = 4
1 - 4 = X	2 - 4 = X	3 - 4 = X	4 - 4 = 1

* Min. Value

****TO USE THIS INFO IN SUITABILITY ANALYSIS:

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   ie. (S1*W1 + S2*W2 + S3*W3 + ...) / (W1 + W2 + W3 + ...)
3. Compare result to manual weighting result

WOODLANDS

PAIRWISE IMPORTANCE										
	PROX(NN)	PROX(CS)	WATER	LANDUSE	FISHHC	STREAMO	HABTHRESH	C.A.'S	SLOPE	COVER
PROX(NN)	1.00	5.00	3.00	0.14	7.00	2.00	0.14	9.00	7.00	1.00
PROX(CS)	0.20	1.00	0.25	0.13	1.00	0.14	0.14	9.00	3.00	1.00
WATER	0.33	4.00	1.00	0.20	4.00	1.00	1.00	9.00	7.00	1.00
LANDUSE	7.00	8.00	5.00	1.00	7.00	6.00	4.00	9.00	7.00	1.00
FISH HC	0.14	1.00	0.25	0.14	1.00	0.50	0.14	7.00	3.00	1.00
STREAM O	0.50	7.00	1.00	0.17	2.00	1.00	0.33	9.00	7.00	1.00
HABTHRESH	7.00	7.00	1.00	0.25	7.00	3.00	1.00	9.00	7.00	1.00
C.A.'S	0.11	0.11	0.11	0.11	0.14	0.11	0.11	1.00	0.20	0.20
SLOPE	0.14	0.33	0.14	0.14	0.33	0.14	0.14	5.00	1.00	1.00
COVER	1.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00	1.00	1.00
SUM	**17.43**	**34.44**	**12.75**	**3.28**	**30.48**	**14.90**	**8.02**	**72.00**	**43.20**	**9.20**

BACKGROUND INFORMATION

IMPORTANCE LEVEL	RATING
Equally Important	1.00
Equally To Moderately More Important	2.00
Moderately More Important	3.00
Moderately To Strongly More Important	4.00
Strongly More Important	5.00
Strongly To Very Strongly More Important	6.00
Very Strongly More Important	7.00
Very Strongly To Extremely More Important	8.00
Extremely More Important	9.00

1 - 1 = 1	2 - 1 = 4	3 - 1 = 7	4 - 1 = 9
1 - 2 = X	2 - 2 = 1	3 - 2 = 4	4 - 2 = 7
1 - 3 = X	2 - 3 = X	3 - 3 = 1	4 - 3 = 4
1 - 4 = X	2 - 4 = X	3 - 4 = X	4 - 4 = 1

****TO USE THIS INFO IN SUITABILITY ANALYSIS:

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   ie. (S1*W1 + S2*W2 + S3*W3 + ...) / (W1 + W2 + W3 + ...)
3. Compare result to manual weighting result

WOODLANDS

NORMALIZED VALUES												
	PROX(NN)	PROX(CS)	WATER	LANDUSE	FISHHC	STREAMO	HABTHRESH	C.A.'S	SLOPE	COVER	SUM	WEIGHT
PROX (NN)	0.06	0.15	0.24	0.04	0.23	0.13	0.02	0.13	0.16	0.11	**1.26**	**10.63**
PROX (CS)	0.01	0.03	0.02	0.04	0.03	0.01	0.02	0.13	0.07	0.11	0.46	**3.90**
WATER	0.02	0.12	0.08	0.06	0.13	0.07	0.12	0.13	0.16	0.11	**0.99**	**8.39**
LANDUSE	0.40	0.23	0.39	0.30	0.23	0.40	0.50	0.13	0.16	0.11	**2.86**	**24.13**
FISH HC	0.01	0.03	0.02	0.04	0.03	0.03	0.02	0.10	0.07	0.11	**0.46**	**3.88**
STREAM O	0.03	0.20	0.08	0.05	0.07	0.07	0.04	0.13	0.16	0.11	**0.93**	**7.86**
HAB THRESH	0.40	0.20	0.08	0.08	0.23	0.20	0.12	0.13	0.16	0.11	**1.71**	**14.45**
C.A.'S	0.01	0.00	0.01	0.03	0.00	0.01	0.01	0.01	0.00	0.02	**0.12**	**1.00**
SLOPE	0.01	0.01	0.01	0.04	0.01	0.01	0.02	0.07	0.02	0.11	**0.31**	**2.64**
COVER	0.06	0.03	0.08	0.30	0.03	0.07	0.12	0.07	0.02	0.11	**0.90**	**7.56**
SUM	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**		**84.43**

BACKGROUND INFORMATION

IMPORTANCE LEVEL	RATING
Equally Important	1.00
Equally To Moderately More Important	2.00
Moderately More Important	3.00
Moderately To Strongly More Important	4.00
Strongly More Important	5.00
Strongly To Very Strongly More Important	6.00
Very Strongly More Important	7.00
Very Strongly To Extremely More Important	8.00
Extremely More Important	9.00

1 - 1 = 1	2 - 1 = 4	3 - 1 = 7	4 - 1 = 9
1 - 2 = X	2 - 2 = 1	3 - 2 = 4	4 - 2 = 7
1 - 3 = X	2 - 3 = X	3 - 3 = 1	4 - 3 = 4
1 - 4 = X	2 - 4 = X	3 - 4 = X	4 - 4 = 1

* Min Value

****TO USE THIS INFO IN SUITABILITY ANALYSIS:

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   ie. (S1*W1 + S2*W2 + S3*W3 + ...) / (W1 + W2 + W3 + ...)
3. Compare result to manual weighting result

NIAGARA PENINSULA CONSERVATION AUTHORITY

250 Thorold Road West, 3rd Floor Welland, ON L3C 3W2
Phone: 905.788.3135 • Fax: 905.788.1121 • www.conservation-niagara.on.ca